

Environmental Impact Assessment

Payara Development Project

Esso Exploration and Production Guyana Limited

Volume II

July 2020
Revision 4

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Volume II of this Environmental Impact Assessment is hereby submitted by Esso Exploration and Production Guyana Limited (EEPGL).

EEPGL Country Manager _____ July 20, 2020

Alistair Routledge Date

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APPENDIX A

List of Preparers

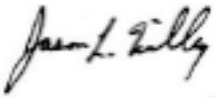
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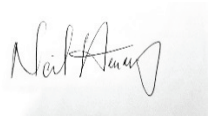
LIST OF PREPARERS



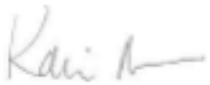
Todd Hall, ERM: Partner-in-Charge



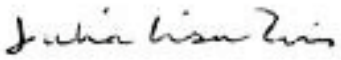
Jason Willey, ERM: Project Manager, Biological Resource Specialist t



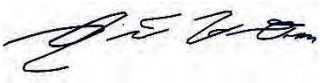
Neil Henry, ERM: Local Coordinator



Karin Nunan, ERM: Socioeconomic, Stakeholder Engagement, and Ecosystems Services Specialist



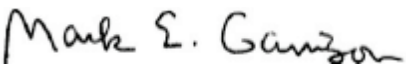
Julia Tims, ERM: Biological Resource Specialist



Rick Osa, ERM: Air Quality and Noise Monitoring Specialist



Shwet Prakash, ERM: Water Quality Specialist



Mark Garrison, ERM: Air Quality Modeling Specialist



Charles Ceres, Senior Technical Advisor



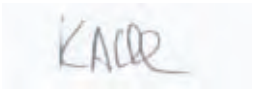
Hance Thompson, Senior Environmental Specialist



Raeburn Jones, GSEC: Forest Resource Specialist



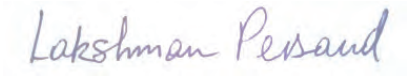
Shyam Nokta, EMC: Strategic Oversight and Coordination—Socioeconomic and Stakeholder Engagement



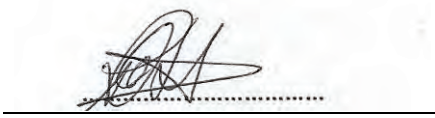
Khalid Alladin, EMC Project Manager



Andrew Bishop, EMC: Technical Lead for Socioeconomic Component



Richard Persaud, EMC: Technical Lead for Stakeholder Engagement



Romeo De Freitas, EMC: Technical Lead for Stakeholder Engagement

APPENDIX B

EIA Team Curricula Vitae

Resubmitted without changes

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Todd H. Hall, P.E.

Partner-in-Charge



Mr. Todd Hall is a Principal Partner with ERM based in Denver, Colorado. He has over 21 years of experience in environmental consulting, focusing on environmental, social and health impact assessment, management plan development, multi-media permitting, site planning & licensing, remediation, and risk assessment.

Mr. Hall's primary focus is on the energy sector, with expertise in power generation and transmission; mining operations; downstream, midstream, and upstream oil and gas facilities; and petrochemical complexes. He has prepared environmental, social and health impact assessments, and management plans for dozens of development projects in North America, Asia/Pacific, Africa, the Middle East, and South America.

Mr. Hall has conducted impact assessments in accordance with international best practice, U.S. National Environmental Policy Act (NEPA), client-specific methodologies, and ERM standard methodology (led the development of the ERM Impact Assessment Standard). He has provided lifecycle support services for energy facilities and organizations, including sustainability advisory, regulatory compliance assurance, remediation and risk assessment, stakeholder engagement, and environmental and social performance monitoring.

Professional Affiliations & Registrations

- Registered Professional Engineer – Texas
- National Society of Professional Engineers
- International Association for Impact Assessment

Fields of Competence

- Environmental, social and health impact assessment and management plan development
- International Best Practice (EP, IFC PS, etc.) requirements
- National Environmental Policy Act (NEPA) requirements
- Environmental planning, siting, and licensing for U.S. and international energy projects
- Multi-media environmental permitting
- Environmental engineering design
- Site investigation and remediation
- Risk assessment (human and ecological)
- Regulatory compliance assessment

Education

- M.E. Civil (Environmental) Engineering, Texas A&M University, 1995
- B.S. Civil Engineering, Texas A&M University, 1994

Languages

- English, native speaker

Key Industry Sectors

- Mining
- Oil and Gas
- Power

Key Projects

Project Director and Environmental Lead for an Environmental, Social and Health Impact Assessment (ESHIA) and associated Environmental and Social Action Plan (ESAP) prepared in accordance with international best practice (EBRD and ADB) standards for the Ukhaa Khudag (UHG) Project, including a coal mine, coal-fired power generation facilities, a groundwater abstraction field and other supporting facilities in southern Mongolia. Project activities included extensive social and environmental baseline data gathering, air dispersion modeling and noise modeling, and support of stakeholder engagement and consultation activities. Additional project support activities included preparation of Railway Construction Ecological Best Practices and Resettlement Best Practices white papers, and completion of environmental and social action plan monitoring and evaluation.

Project Director and Environmental Lead for the proposed Hyperion Energy Center project, a proposed greenfield petroleum refinery and integrated power plant in South Dakota. Project activities included completion of an environmental critical issues analysis, preparation of a permitting strategy, completion of an ecological reconnaissance, wetland delineation, and cultural resources intensive survey, preparation for and participation in public open houses and public zoning board hearings, preparation of draft re-zoning language, completion of a socioeconomic baseline study and economic impact analysis, and preparation of a human health risk assessment regarding forecasted air emissions from the facility.

Project Manager for an Environmental Impact Assessment for the proposed Ras Tanura Refinery Expansion Project in the Kingdom of Saudi Arabia, including completion of extensive CALPUFF air dispersion modeling.

Project Manager for an Environmental Impact Assessment for the proposed Wasit Gas Plant Project in the Kingdom of Saudi Arabia, including completion of extensive CALPUFF air dispersion modeling.

Project Director for a Phase I HSEIA under ADNOC's Code of Practices for the Integrated Gas Development – Project Habshan Platforms located in the Umm Shaif Field offshore Abu Dhabi.

Project Director for air dispersion modeling conducted in support of the Saudi Kayan Petrochemical Complex development project in Jubail Industrial City, Saudi Arabia.

Project Director for preparation of the environmental component of a Public Utility Commission application for construction of a transmission line project from east Texas into the Houston area. Project involved completion of intensive environmental field surveys and preparation of an Environmental Assessment triggered from the project crossing Federal lands.

Project Director for provision of support to the regulatory approvals process for LNG Canada's proposed LNG export terminal in western British Columbia. Prepared Environmental Assessment (EA) summary documentation to aid in dissemination of EA findings and proposed mitigations to internal and external stakeholders and interested parties. Provided advice related to project design alternatives with respect to air quality regulatory ramifications. Assisted with GHG management strategy including support for lifecycle analysis and development of recommendations for use in influencing and managing emerging GHG regulations applicable to the BC LNG industry.

Project Director for environmental site assessment and licensing for the Golden Pass LNG Terminal and associated Golden Pass Pipeline system in East Texas and Northwest Louisiana. Activities included development of permitting and development strategies, preparation of Environmental Resource Reports to be submitted with separate Natural Gas Act Section 3(a) and Section 7(c) applications to FERC, and preparation of related Federal, State, and local environmental permit applications. Coordinated ancillary studies to support the application (e.g., traffic study, bird strike monitoring). Directed field activities in support of licensing, including extensive field wetland delineation and archaeological surveys.

Project Director for completion of a socio-economic baseline study for a series of Texas counties and Louisiana parishes along the U.S. Gulf Coast. The study involved collection of an extensive socio-economic data set and creation of a methodology to 'rate' a number of socio-economic aspects of each parish/county with respect to their development needs and the degree to which they are expected to support future oil and gas development growth in the region.

Project Director for development of environmental management plan, waste management plan, regulatory compliance plan, and environmental monitoring plan for the Golden Pass LNG regasification terminal and pipeline's transition from development/construction to operations. Led development of a detailed Compliance Register identifying all environmental, health and safety regulations applicable to terminal and pipeline operations, the basis for applicability, and the specific actionable requirements stemming from these regulations.

Project Director for an environmental feasibility study conducted for development of a liquefaction facility in the Caribbean Islands. Project involved rating and ranking of several candidate sites based on environmental and social impact criteria.

Project Director for an Environmental, Social and Health Impact Assessment (ESHIA) for the proposed Congo River Crossing Canyon Project offshore Angola.

Project Director for an Environmental and Social Impact Assessment for a 370km segment of a proposed crude oil pipeline in Colombia, including preparation of a gap analysis between local licensing requirements and the requirements that would apply under an international financing approach. Project included extensive primary data collection, identification of and socialization of planned Project details with stakeholder groups including protected communities, and completion of a topographic and geotechnical survey of the pipeline segment route.

Senior Technical Reviewer for social and health impact assessment for unconventional production operations across a >100,000 acre shale gas formation in the Eagle Ford formation.

Project Director for completion of three separate hazard studies conducted to assess the risk associated with operation of flares on gas production platforms offshore Equatorial Guinea.

Project Manager for completion of an Environmental and Social Due Diligence Assessment for the proposed 'farm-in' acquisition of unconventional natural gas production operations in Eastern Louisiana. The Project involved completion of a Risk Analysis transaction, and included interviews with the firm's management and other personnel at the firm's headquarters, as well as site visits to representative facilities summary of findings, and included an assessment of the priority of findings based on a risk categorization structured to inform decision making.

Project Director for development of environmental control design philosophy, oil and hazardous materials spill response philosophy, environmental management plan, environmental monitoring plan, waste management plan and regulatory compliance plan for a component of the Barzan gas development project offshore Qatar.

Project Director for preparation of a Waste Management Plan for oil and gas operations in the Western Desert of Egypt.

Project Director for environmental and regulatory framework assessment for the area of a proposed exploration and production effort offshore Barbados.

Senior Technical Reviewer for a desktop environmental, regulatory, and social review and ecological resource assessment for an exploration and production area of interest in Colombia.

Project Director for an Environmental Impact Assessment for a proposed offshore natural gas pipeline in Angola and for three separate Supplemental EIAs for offshore oil and gas developments offshore Angola.

Project Director for several Environmental Impact Assessments for proposed exploratory drilling projects offshore Angola. Project activities included completion of social baseline data gathering, oil spill modeling, cuttings discharge modeling, and regulatory licensing support.

Project Director for an Environmental Impact Assessment for proposed production platform expansions offshore Angola.

Project Director for a seismic exploration campaign offshore Angola.

Project Director for an air modeling study conducted for a proposed floating production, storage, and offloading facility offshore Angola. Modeling utilized the Offshore Coastal Dispersion Model to predict transport of air pollutant concentrations from offshore sources to onshore receptors.

Part of the senior technical advisory team for preparation of a preliminary Environmental and Social Impact Assessment (ESIA) for a major copper/gold mine in Alaska. Provided strategic direction relative to the ESIA approach and conducted technical reviews of project deliverables.

Project Director for development of an internal Environmental and Regulatory Management Plan detailing the division of environmental and regulatory responsibilities and interfaces between exploration, geo-operations, and drilling business units within a major oil and gas company.

Project Director for an environmental and social baseline and due diligence exercise conducted for a prospective farm-in of unconventional gas production operations in East Texas and Northwest Louisiana. Activities included assessment of potential environmental and social risks associated with increased production in the area.

Project Director for a production well re-entry, Environmental Assessment (NEPA), to support development of oil and gas resources on property managed by the National Park Service (Big Thicket National Preserve).

Project Director for a project supporting preparation of a Department of Energy (DOE) Environmental Assessment and associated State-level environmental review documentation for a major solar energy development in the Northeast U.S. Project involved completion of a viewshed analysis to assess visual impacts from construction of the project.

Project Director for a project involving planning, impact assessment, and licensing of a natural gas storage cavern project in East Texas. Activities included engineering and pipeline route analysis and preparation of Environmental Resource Reports for submittal to FERC under the Natural Gas Act.

Project Director for a socioeconomic baseline and impact assessment supporting a gold mining project in Kazakhstan.

Project Director for a project supporting sustainability reporting for a major wind energy development in accordance with Global Reporting Initiative (GRI G3) guidelines. Activities involved collection of necessary reporting information, preparation of an internal reporting handbook, and development of documentation demonstrating methodology utilized for reporting.

Environmental lead on a due diligence assessment for a major petroleum refinery in the U.S. Virgin Islands. Conducted a review of investigation, remediation, permitting requirements, and status of associated refinery activities.

Project Director for over 100 site screening studies for proposed wind power projects in the U.S., each including an assessment of biological and cultural resource characteristics and concerns, and development of a permitting matrix. For some sites, studies included coordination of assessments for aviation navigation and microwave communications obstructions.

Project Director for a wind power project permitting and impact assessment project in New York State. Project involved licensing through the New York State Public Service Commission and preparation of an EIS pursuant to the State Environmental Quality Review process. Project support activities included wetland delineation, cultural resource surveys, noise surveys, and visual impact simulations.

Project Director for a project involving a hazard assessment for two proposed natural gas storage caverns in the Southwestern U.S. Activities involved development of worst-case failure scenarios and analysis of the expected consequences of the failure.

Project Director for a project involving acquisition of drilling licenses and completion of environmental impact analyses associated with a proposed production well drilling and testing project in northern Brazil.

Jason Willey

Project Manager, Biological Resource Specialist



Mr. Willey has fifteen years experience in ecology and natural resource management with specific expertise in marine and estuarine ecology. Most of his ecological work has supported environmental impact assessments and permitting projects for industrial projects, particularly for oil and gas clients. He has assessed environmental impacts of onshore and offshore components of upstream and downstream developments. various oil and gas clients in the United States and Australia for Mr. Willey works mostly in the USA, having prepared numerous impact assessments to the US National Environmental Policy Act standards, but he has also applied international environmental impact assessment protocols to projects in Southeast Asia, South America, Australia, New Zealand, Greenland, and the Caribbean.

Fields of Competence

- Environmental and Social Impact Assessment
- Aquatic and estuarine ecology, including quantitative and qualitative fish community survey methods (EPA rapid bioassessment protocol), aquatic macroinvertebrate ecology, water quality sampling, and in-stream macrohabitat assessment
- Threatened and Endangered Species Consultations (NMFS and USFWS)
- Essential Fish Habitat (EFH) assessment
- Aerial photograph, landscape feature, and habitat interpretation
- Wetland delineation and functional assessment

Education

- B.S., Biology, University of Richmond, Richmond, VA, May 1997
- M.S., Environmental Science and Policy, Johns Hopkins University, MD, May 2007

Key Projects

Environmental Impact Assessment and Permitting Support, Exploration Activities, EEPGL (ExxonMobil). Project manager for a Strategic Environmental Assessment of exploration activities in the Stabroek Block, a deepwater exploration block offshore of Guyana. Was also responsible for delivering the associated management plans and various environmental approvals for associated activities including metocean and geophysical/geotechnical surveys. Assisted ExxonMobil staff with an audit of potential service providers in Guyana and Trinidad as part of the tender evaluation process for waste management services. Has worked closely with the local Exxon affiliate in Guyana to manage several regulatory and environmental management deliverables since the inception of EEPGL's involvement in Guyana in 2013.

ION Geoventures. Managing regulatory and environmental assessment processes in Guyana, Trinidad, and Suriname for ION's planned 2D GuyanaSPAN seismic survey in October 2013.

Environmental Impact Assessment and Planning, Woodside Energy Ltd. Provided general environmental impact assessment and planning services for several petroleum exploration and production facilities around Australia. Prepared EPBC Act (Australia) referrals and environmental management plans for offshore exploration projects in the Torosa 3 gas field offshore of Western Australia. Coordinated oil spill contingency planning and sediment transport modeling to support EIA process for another offshore project in a potentially sensitive marine environment on Scott Reef (Western Australia).

Impact Assessment and Regulatory Compliance , Bass Strait Seismic Exploration, Total. Prepared EPBC Act (Australia) referrals and environmental management plans for seismic exploration in the Bass Strait, north of Tasmanaia. Assessed the potential for acoustic impacts on marine mammals and for disturbance of seabirds and fish. Determined that the project was unlikely to cause significant impacts to marine resources and that no further environmental

assessment was necessary in order to comply with the applicable Australian regulations.

Environmental Impact Assessment, Great South Basin, ExxonMobil. Managed an EIA for a marine seismic survey in the Great South Basin off the coast of New Zealand's South Island. Key issues include potential impacts on endangered marine mammals, marine fisheries, and seabirds, as well as ecosystem-level effects on sensitive habitats including the Sub-Antarctic island archipelago. Project required collating results of recent and ongoing scientific research on the effects of vessel noise, seismic noise sources, and near- to mid-field interactions with vessels on rare, threatened, and endangered marine mammals. Impact assessment process included consultation with several key government stakeholders, and resulted in finding of no significant impacts and favorable feedback from NZ regulators.

Confidential Client. Provided on-call environmental support to an Australian engineering firm bidding on the design and construction phase of a large, confidential oil and gas production project in Western Australia. Project would involve routing four gas trunklines from offshore fields through sensitive near-shore coral reef and under sea turtle nesting beaches. Recommended several key measures that could be incorporated into the project approach and design that could maximize efficiency while avoiding or minimizing environmental impacts.

Environmental Resource Report and EIS Review, Crown Landing (BP). Fisheries and aquatic biology lead on the EIS and Federal and state permit efforts for a LNG terminal and associated pipeline connections on the Delaware River in southern New Jersey. Led consultations with NMFS regarding potential impacts of the project on marine mammals, particularly the critically endangered North Atlantic right whale and the Federally listed Atlantic and shortnose sturgeons (*Acipenser oxyrhynchus* and *A. brevirostrum*).

Environmental Impact Statement, Excelerate Energy Northeast Gateway. Lead marine biologist on an EIS for a proposed offshore natural gas offloading facility in Massachusetts waters. Key biological issues included potential effects on marine mammals, loss of ichthyoplankton to ballast intakes, and effects on shellfisheries and groundfisheries. Integrated a third-party entrainment modeling and equivalent adults assessment into the EIS for the project. Developed a life stage-specific assessment of the risks posed to vulnerable life stages of over 15 species of crustaceans, fish, and marine mammals from various project related activities based on life history parameters. Particular emphasis was placed on balancing safety concerns with minimizing impacts on key resources such as Atlantic herring (*Clupea harengus*) and American lobster (*Homarus americanus*) with seasonally-dependent sensitivities to specific project-related activities.

Environmental Resource Report and EIS Review, ExxonMobil Golden Pass. Authored the FERC aquatic resources resource report for a proposed natural gas terminal on Sabine Pass in eastern Texas. Performed a preliminary assessment of potential impacts on mud, sand, and shell-hash intertidal and sub-tidal littoral habitats on the Sabine River. Evaluated potential losses of planktonic finfish and shrimp larvae from entrainment in ballast water intakes and open-rack vaporizers. Consulted with NMFS and USFWS concerning potential effects on listed species, particularly sea turtles and Gulf sturgeon (*A. desotoi*).

Confidential Client. Lead marine biologist on the Environmental and Social Impact Assessment (ESIA) for a resort planned on New Providence Island, The Bahamas. Resources of concern included listed marine reptiles, corals, seagrasses, and commercially and recreationally important fish and invertebrates. Particular emphasis was placed on the potential effects of dredging an access channel on nearshore biological communities such as patch reef, and on water quality within the proposed marina basin. Conducted ministerial-level consultations with natural resource agencies to ensure governmental support for the ESIA.

Feasibility Assessment, Aquatic Biological Survey, and Training, Suralco, Suriname. Lead aquatic ecologist on a feasibility assessment for a bauxite mine at a greenfield site in central Suriname. Supervising a multi-year aquatic survey of high altitude streams on the Nassau plateau, a laterite capped plateau in the undeveloped interior. Responsible for training Surinamese HSE staff in low-impact ecological sampling and monitoring protocols. Replaced rotenone-based collection protocols with a combination of modern electroshocking and traditional methods.

Trained local field teams, which include scientists and native assistants in new survey protocols. ERM's low-impact survey methodologies have been highly effective; work in 2009 documented seven rare species of loricariid catfish on the plateau, including one species that is new to science.

Neil Earle Henry

Project Manager



He is an experienced environmental professional with more than 20 years of experience in the environmental field.

Mr. Neil is a Project Manager in the Guyana Office, based in Georgetown, Guyana. Neil has a breadth of experience working across several companies in environmental projects in Guyana.

Education

- Graduate Diploma: Climate Change Adaptation, University of the Sunshine Coast, (Australia), August 2008 to March 2009
- Postgraduate Diploma: Integrated Watershed Modeling and Management, International Institute For Geo-Information Science and Earth Observation (ITC), University of Twente (The Netherlands), September 2007 to June 2008.
- B. Sc Environmental Studies, University of Guyana, 2000
- Guyana Mining School

Languages

- English - fluent

Additional Courses

- Confined Space Entry (Awareness), Transportation of Dangerous Goods, Fall Protection, And Workplace Hazardous Materials Information System. August, 2013
- Canadian Standards Association: ISO 14001:2004 EMS Essential, ISO 19011 EMS & Quality Control Lead Auditor course – August
- In House Training - Supervision and Leadership training – May 2005
- Environmental Management System- Internal Auditing- March 2003
- Regional Educational Programme for Animal Health Assistants, Diploma: Animal Health and Veterinary Public Health, 1992 (Credit)
- Speech Craft Course, Georgetown Toast Master Club, 1991
- Computer Training, Completed courses in WORD Level 1, EXCEL Level 1, WINDOWS 98. Acquired working knowledge of POWER POINT and Auto Cad.
- Mackenzie High School: 1987 - Caribbean Examination Council: English Language, Mathematics, Geography, Integrated Science, Agricultural Science and Principles of Business
- One Mile Primary School, 1982
- Strategic Environmental Assessment, 2001:Caribbean Academy of Sciences
- Environmental Impact Assessment Training, June 22-24, 2006: Dr. P. Bynoe, Dr. M. Bynoe
- Guyana National Emergency Response Plan, June 26, 2006 : Dr. C. Edmonds, CEA
- National Environmental Monitoring Plan (Guyana)
- Water Quality Monitoring, June 27, 2006 :Dr. C. Edmonds, CEA
- National Environmental Monitoring Plan (Guyana) Air Pollution Index - Dr. A. Ciccone, Golder Associates
- Environmental Management Skills, July 10-13, 2006: Dr. R. Ramlogan; UWI, St. Augustine Campus
- Guyana Legality Verification System (Guyana Forestry Commission)
- Guyana Public Disclosure Program and State of the Environment Report for the Demerara Watershed, November, 2006 : SENES Consultants L Ltd.

Fields of Competence

- Surface and ground water monitoring
- Environmental impact assessment
- Environmental remediation assessment

Experience

Environmental Resources Management – Project Manager (2017 - present)

- Provided project coordination support for preparation of offshore oil and gas development and exploration project Environmental Impact Assessments and for execution of environmental field study campaigns supporting these assessments.

Guyana Industrial Minerals Inc. Subsidiary of First Bauxite Corporation - Senior Environmental and Community Relations Advisor (December 2015 to 2017)

- Responsibilities include managing all environmental matters relating to the Company's success in achieving financial closure, creating an Environmental Management System using Local and International Standards. Both office and field work.

Troy Resources - Environmental Manager (2014-2015)

- Responsibilities include managing all environmental matters relating to the Company's success in its startup of operations, creating an Environmental Management System using Local and International Standards. Both office and field work.

Guyana Industrial Minerals Inc. Subsidiary of First Bauxite Corporation. Environmental and Community Relations Officer (January 2012 to 2014)

- Responsibilities include managing all environmental matters relating to the Company's success in achieving financial closure, implementing the Equator Principle Financial Institutions by applying the International Financial Corporation/World Bank Standards. Both office and field work.

Environmental Management Consultants, 60 Area H Ogle, ECD Environmental Inspector (April 2010 to December 2012)

- As a team member of the consultant group working on environmental projects; (a) environmental monitoring of the Amaila Falls Hydro Access Road, (b) environmental management plans, (c) environmental monitoring of the Ministry of Public Works and Communications Bridges Rehabilitation Program-Phase 11 Rehabilitation of Lot II – Lot A1 and Lot A2 Structures.

Director on the Guyana Geology and Mines Commission's Board (2006- 2007)

Guyana Environmental Protection Agency, Environmental Officer II (April 2006-2007)

- Responsible for all environmental issues that fall under the Mining, Forestry and Tourism sectors, ensuring that developers adhere to the Environmental Protection Act No. 11 of 1996 and all Regulations made under the Act.

Omai Gold Mines Ltd, Environmental Officer September (January 2000 to July 2005)

- Responsible for coordinating all activities relative to the effective management of environmental activities at Omai Gold Mines Limited. Technical duties include, implementing surface and ground water monitoring program, implementing the ISO14001 Standards, providing environmental training for Omai's employees. Management duties include supervising subcontractors and consultants working at Omai, representing Omai's interests at meeting with the government regulators as well as professional and industrial association.

Linden Mining Enterprise Ltd, Summer Job (1997, 1998, 1999)

- Special Projects – Conducted site inspections, progressive reclamation through the use of native plants in Linden, and water quality and erosion control in mined-out areas

Ministry of Agriculture, Livestock Division. (1993-1996)

- Provided extension services to the Linden community.

Special Assignments

- Hydro-meteorological Analysis of Lake Naivasha, Kenya and Lake Buurse, The Netherlands
- A Strategic Approach to Solid Waste Disposal in McKenzie, Linden.
- Environmental Inspections of the McKenzie Bauxite Plant and the East Montgomery operations Area
- Stack Dust: Health effects on Lindeners.
- Water Quality in the Northeast Kara Kara Mined-out area.
- The use of indigenous plants as a method of erosion control in mined affected areas.

Reclamation Activities

- Supervise re-vegetation of mine-out areas (approximately 188 hectares).
- Liaise with personnel during sloping, grading, and back filling of mined- out areas.
- Participate in an aquatic monitoring programme at Omai Gold Mines Limited (Aug. 2003).
- Assist and monitor University of Guyana students conducting special projects at Omai Gold Mines Limited.

Environmental Impact Assessment

- Assisted with the accumulation of baseline data for Gross Rosbel's EIA
- Assisted with the accumulation of baseline data for Linmine's EIA
- Trained in ambient dust sampling using the MiniVol dust sampling equipment;
- Trained in ambient noise sampling using the Quest noise level meter

Environmental Audits

- (External Audits) Consultants-Lakefield Research-November, 2000- February, 2003
- SGS ISO 14001 audits
  - Registration Audit- January 2001
  - Maintenance Audit- February 2002
  - Maintenance Audit- March 2003
  - Re-certification Audit- March 2004
  - (Internal Audits)
  - Consultants-G. Amyot- October 2001
  - D. Therrien- January 2003
  - G. Amyot- January 2004

Karin K. Nunan

Socioeconomic and Stakeholder Engagement Lead;
Ecosystems Services Specialist



Ms. Karin Nunan is a Principal Consultant within ERM based in Washington DC and coordinating the Human Rights working group for North America. She has over 20 years of experience in the fields of human rights, social performance, stakeholder engagement, diplomacy and government affairs. Over the past several years, Karin has been providing extractives clients with project management and technical support on social performance, with a focus on human rights impact assessments and training; social impact assessment and auditing; policy development and management planning; stakeholder engagement; CSR programs; OHS and labor and working conditions audits; and overall E&S lender compliance for international financing, including IFC PS, World Bank EHS, EP III, FMO, MCC, JBIC, USAID, OPIC, ADB, AfDB, and EBRD. In this capacity, she has acted as both the lender and client representative for E&S due diligence of project financing.

Prior to consulting, Karin was in the oil and gas sector where she spent several years in the social performance departments within the HSEE departments of two major US oil and gas companies working on development and production projects for social issues in Europe and the Middle East. During this time she developed and implemented social performance policies, standards and audit procedures; created KPIs; and ensured projects complied with all social corporate guidelines and international best practice. She worked closely with the legal, procurement, human resources, and public affairs functions on issues pertaining to human rights implementation and compliance.

Fields of Competence

- Human Rights
- Social Performance
- Environmental and Social Lender Due Diligence
- Environmental and Social Impact Assessments
- Community Health, Safety and Security
- Labor and Working Conditions
- Community Investment Planning
- Stakeholder Engagement

Key Industry Sectors

- Oil and Gas
- Mining

Education

- MSc, International Relations and Conflict Resolution, AMU, 2012
- MBA, International Business, UMass, 2000
- BSc, Civil Engineering, Norwich University, 1994

Professional Affiliations & Registrations

- Society of Petroleum Engineers
- Chevron Qualified Environmental Facilitator (QEF)
- US Institute for Peace Certification in Conflict Analysis, 2010
- US Government Human Rights Officer Training and Trafficking in Persons training 2002 - 2007

Languages

- English, native speaker
- Russian, intermediate
- French, Arabic, beginner

Key Recent Projects

Human Rights and Supply Chain Due Diligence, Israel, Confidential Client

Led social impact assessment due diligence for all offshore and onshore existing and planned operations. Conducted gap assessment of oil and gas company's principles and policies on social issues including labor management, supply chain and human rights against international standards. Made recommendations to align policies more closely with international standards and reduce non-technical risks of operations.

Stakeholder Engagement and Social and Health Impact Assessment, Nicaragua, HKND

Led senior review and preparation of the social impact assessment for a major infrastructure development crossing the country of Nicaragua. Assessed a suite of social and health impacts related to labor, human rights, influx, conflict, health, natural resource, livelihoods and project security linked to development and operations. Developed management plans pertaining to influx, stakeholder engagement, and indigenous people.

South Stream Pipeline Project, Russia, Bulgaria, Turkey, SSTTBV

Technical editor for three lender ESHIAs and three national ESIAs for all three countries. Worked alongside the South Stream ESIA teams to lead the issues-based Human Rights Due Diligence and Impact Assessment process for Bulgaria, Russia and Turkey. Educated the client's key departments, including HSE, Procurement, HR and Security, on the importance of adhering to international Human Rights standards as outlined by ILO, WB, IFC and other IOs. Developed Project-wide standards and a Human Rights tool kit and due diligence method which can be applied on a regular basis to ensure constant improvement and continuous adherence.

Masela Offshore LNG Facility, Indonesia, INPEX

Provided social performance expertise to an ESHIA submission for an offshore LNG facility in Indonesia being developed by an O&G major. Provided input into the feasibility study, scoping report, ESMP framework, health impact due diligence, human rights due diligence and social impact baseline. Developed human rights and supply chain auditing procedures.

Oil Refinery Expansion, Venezuela, PDVSA

Responsible for conducting E&S due diligence focused on Social Performance for the expansion to an existing oil refinery in Venezuela with significant social challenges. Project included ESIA due diligence, SIA management plan, Human Rights Impact Assessment and management recommendations, Human Rights due diligence workshop development and supply chain audits.

Offshore LNG Facility, Louisiana

Provided social consulting for a major oil and gas client looking to build an offshore LNG facility with associated facilities onshore. Managed the E&S Due Diligence process. Despite US FERC approval, conducted analysis to ensure the project met its Lender financing requirements – including IFC, WB EHS, JBIC, and EP.

LNG Import Project, Benin, UK-based gas company

Managed a project to provide support for the development of company and project E&S standards, policies, plans, and procedures to meet Lenders review expectations and allow for the company to receive fast tracked Lenders approval for Projects. Responsible for managing the creation of Corporate Social Responsibility policies (including human rights); Social Performance KPIs; ESAP and ESMP to meet IFC standards.

Oil Export Feasibility Study, E. Africa, O&G Major

Provided the social expertise for expertise to an oil and gas major investigating potential locations along the Tanzania and Kenyan coastline for an oil export terminal and SPM. This involved identifying significant positive and negative social constraints along the coastlines and likely mitigation measures which will ultimately contribute to the ESIA.

Subsea Systems Plant, Angola, BP

Conducted a social risk assessment and socioeconomic expertise as part of the official submission for a Subsea Systems Plant located off of the coast of Angola. Provided input into the Social Impact Baseline and Assessment chapters and conducted technical editing and peer review for the entire submission.

Previous Related Experience

Socioeconomics Manager, ExxonMobil Iraq
Working under the Safety, Health and Environment Manager, created procedures and processes for social performance, socioeconomic investment, human rights impact assessments, grievance resolution, community engagement, and land management related to a $4b operation in Southern Iraq. Also managed the socioeconomic portion of the ESHIA submission, as well as oversaw site-specific stakeholder engagement, corporate social responsibility planning and strategic community investment. Developed and provided human rights training for various functions within the development and production functions.

Socioeconomics Advisor, ExxonMobil Development Company
Developed corporate guidelines and frameworks for global social performance, and participated in development of human rights monitoring plans, CSR frameworks, grievance management mechanisms, gender equality, stakeholder engagement review and ESAPs for development projects, including those with significant stakeholder opposition.

Regional Analyst, Chevron Middle East/North Africa
Assisted in creation of stakeholder engagement mapping, planning, and interaction for various Chevron Middle East projects in the development phase. Conducted initial Human Rights due diligence assessments and identified potential socioeconomic and community investment projects, including health, education and job training/placement programs with a focus on disenfranchised groups. Worked on internal SIA and social management plans.

Technical Manager for USAID programs, Chemonics, Middle East
As technical manager for MENA projects, assisted with design of project scopes for various development initiatives funded by USAID related to community engagement and capacity building of community action groups, local governments, and civil society. Focused on integrating gender and human rights into project scopes and implementation.

Voluntary Principles on Security and Human Rights policy development, extractives sector
As a senior manager for a global risk company, provided social risk planning, with a focus on the development of VPSHR corporate standards and policies for several major mining companies headquartered in the US and Europe with operations in Africa and Latin America. Developed management guidelines for regional operations.

Social Development Advisor, Confidential
As part of a non-profit Board membership, worked on behalf of several O&G companies to prepare tactical, ground-level community investment plans in the WASH, health and education sectors in Vietnam, Thailand, Tanzania, Kenya, Zambia, Ghana, and Sierra Leone. Work included stakeholder analysis and mapping, project benchmarking and feasibility, community needs assessments, stakeholder engagement, and project management of smaller corporate strategic investments conducted as part of larger social risk mitigation programs. This included managing a dam and watershed project in northern Kenya, health and environmental surveys in southern Sudan, sanitation and hygiene programs throughout schools and refugee camps in Sierra Leone, and clean drinking water initiatives and job creation programs in urban communities throughout East Africa.

Political Officer, US Embassy, Baghdad, Iraq
Prepared country-specific input into the annual Human Rights Report. Developed professional relationships with Iraqi political and religious leaders to promote U.S. policy objectives; reported to senior U.S. policymakers on the changing political and security climate; spearheaded counterinsurgency and counterterrorism initiatives in coordination with USAID and local NGOs.

Political Officer, U.S. Embassy, Almaty, Kazakhstan
As Human rights officer, prepared country-specific input into the annual Human Rights Report, which included working with civil society and local NGOs to document and investigate where possible Human Rights abuses; assisted with supervision of joint DoS and USAID projects in remote areas; reported to senior U.S. policymakers on the political and economic climate; monitored Central Asia, China, and Russia's regional partnerships.

Energy and Policy Officer, US Government
Based in Washington, D.C. and in Baghdad, Iraq, acted as Liaison to the U.S. Department of Energy; focused on analyzing international O&G policy implications, primarily in the Middle East, Caspian region, and Africa; provided regional assessments on energy security and geopolitical machinations; responsible for coordinating O&G sector analysis across various U.S. Government entities.

International Airport Affairs Manager, American Airlines/United Airlines
Lobbied domestic and international governments, political leaders, airport authorities, airlines and businesses to promote corporate expansion programs and strategic planning inititiatives; managed all legal aspects of corporate properties; responsible for design, construction, and ESIA new build and expansion projects in 30 major international cities in Asia and Europe; managed teams of designers, engineers, contractors and administrative staff globally.

Julia L. Tims

Biological Environment Lead, Avian and Terrestrial Wildlife Specialist



Ms. Tims is a professional ornithologist with twenty five years of experience specializing in terrestrial biodiversity and technical leadership for international Environmental and Social Impact Assessment (ESIA) projects around the world, primarily within the energy, mining, and infrastructure sectors. Ms. Tims has extensive experience in ESIA best practice and international standards, including IFC Performance Standards, IDB Safeguard Policies, Equator Principals, and other lender standards. Ms. Tims has particular expertise in terrestrial biodiversity baseline study design and execution, impact assessment, and designing management programs to minimize impacts or improve biodiversity values. Ms. Tims regularly provides technical biodiversity expertise involving protected areas and leads consultations with NGOs and other stakeholders regarding sensitive biodiversity issues.

Fields of Competence

- Environmental due diligence
- Environmental impact assessment
- Terrestrial biodiversity baseline study design and execution
- Biodiversity management, and monitoring
- International standards, including Equator Principles, IFC Performance Standards, and others
- Application of the mitigation hierarchy
- Biodiversity offsets
- Ecosystem services assessment
- Project permitting and documentation
- Endangered Species Act Section 7 Consultation
- Peer review/expert support
- Project planning/design to address ecological issues
- Wetland delineation and permitting
- Stakeholder engagement
- Alternatives analysis
- Cumulative impact assessment

Professional Affiliations

- American Ornithologist's Union
- The Wildlife Society
- Waterbird Society
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Key Industry Sectors

- Energy, particularly renewables
- Oil and gas development
- Infrastructure (transportation and pipelines)
- Agriculture
- Government (National and local)

Credentials

- M.S., Natural Resources Management/Ecology, Cornell University, 1999, With Distinction
- B.S., Entomology and Applied Ecology/Wildlife Conservation, University of Delaware, 1990
- Habitat Evaluation Procedures (HEP), U.S. Fish and Wildlife Service

Select Experience

Environmental and Social Impact Assessment, Nicaragua Canal Project, Nicaragua. Led the biodiversity component of the ESIA for the world's largest infrastructure project, the proposed Nicaragua Canal. Developed specialist team of over 100 Nicaraguan and international experts to conduct marine, terrestrial, and freshwater biodiversity studies across the country and led wet and dry season field surveys. Led the data analysis and terrestrial biodiversity impact assessment and prepared detailed biodiversity and protected areas management plans and offsetting proposals and developed the environmental and biodiversity components of the ESMS. Key issues included loss of primary rainforest, impacts to sea turtles, impacts to over 80 rare species, habitat fragmentation, impacts to protected areas and the Mesoamerican Biological Corridor, and impacts to critical habitat. Led the Ramsar consultation regarding impacts to the San Miguelito Wetland Ramsar site, including a site visit with Ramsar Headquarters staff and development of the mitigation and offset proposal for submittal to Ramsar.

Environmental and Social Impact Assessment, Offshore Oil Exploration Project, Guyana. Led the avian component of the ESIA for an offshore oil exploration project in Guyana. Conducted a baseline assessment focusing on seabirds and waterbirds and assessed the potential impacts of the proposed project, including unplanned events such as oil spills, on bird populations in the Caribbean region, including rare species.

Crown Landing Liquefied Natural Gas Environmental Studies and Permitting. Logan Township, NJ. Technical lead for endangered species and terrestrial ecological issues associated with a proposed liquefied natural gas (LNG) import terminal located on the Delaware River in New Jersey. Conducted terrestrial investigations at the site including wetland delineation, vegetation community characterization, wildlife habitat assessment, and threatened and endangered species investigations. Prepared Federal Energy Regulatory Commission (FERC) resource reports and worked closely with client to address ecological issues associated with the project and provided guidance for potential avoidance and mitigation measures to offset potential impacts of the project. Primary ecological issues with the project included impacts to wetlands, bald eagles, and other listed species. Addressed ecological issues with the regulatory agencies and prepared state and federal permit applications for the project.

Biological Assessment for Texas LNG, Brownsville, TX. Prepared the Biological Assessment pursuant to the Endangered Species Act for FERC to assess the potential impacts of the proposed Texas LNG project on 16 federally listed species. The assessment covered marine and terrestrial species, with particular emphasis on wintering shorebirds that concentrate in coastal Texas during winter, northern Aplomado falcon, ocelot, and gulf coast jaguarundi. The project was precedent setting in that is was one of the first in Texas to consider compensatory mitigation (i.e., offset or conservation bank) for wetlands and listed species (red knot, piping plover, ocelot, and jaguarondi) in one integrated offset/conservation bank. Consultation with USFWS and COE regarding mitigation requirements and offsetting options is ongoing.

Environmental Impact Assessment for Golden Pass LNG, Sabine Pass, TX. Technical lead for ecological issues associated with a LNG import terminal located along the Port Arthur Ship Channel in Jefferson County, Texas. Assessed the ecological impacts of the proposed project on tidal and freshwater wetlands, coastal plain habitats, migratory birds, endangered species, and habitat connectivity. Prepared FERC Resource Reports detailing existing conditions at the site and the potential effects of the project on these resources. Significant issues included large-scale impacts to freshwater and tidal wetlands and the removal and disturbance of critical migratory bird stopover habitat.

Environmental Impact Assessment for Camelia Bay LNG, Mobile, AL. Technical lead for ecological issues on a feasibility assessment for development of a LNG import terminal at a former Navy facility located on Mobile Bay, AL. Conducted wetland and terrestrial habitat investigations and identified environmental constraints to development at the site. Primary issues at the site involved impacts to a large, ecologically significant wetland located adjacent to Mobile Bay that provided breeding habitat for colonial waterbirds and significant nursery habitat for fish.

Environmental and Social Feasibility Study of Proposed Industrial Sites, Trinidad and Tobago. Project manager and environmental specialist on an industrial siting project in Trinidad. The objective of this assessment was to determine the suitability of

four sites for a major industrial development project from environmental and social perspectives and to compare the assets and liabilities of each site to rank them in terms of environmental and social considerations. The study resulted in a preferred alternative and ranking of options based on environmental, social, and engineering inputs.

Massachusetts Division of Fisheries and Wildlife Tern Restoration Project, Buzzards Bay, MA. Lead researcher on a long term population biology and demographics study of roseate and common terns nesting on several islands in Buzzards Bay, MA. The islands are protected by the state as part of the Wildlife Management Area system, which allows some recreational use of selected sites. Developed the management plan for the islands, which involved an assessment of the potential effects of different types of recreational use of the islands on the nesting birds and their habitats. The study determined that recreational use was incompatible with the waterbird nesting and made specific recommendations that were adopted and incorporated in the management plan which is in effect today.

Environmental and Social Impact Assessment, St. Vincent Geothermal Project, St. Vincent and the Grenadines. Led the biodiversity and stakeholder engagement components of the ESIA for a geothermal energy project on the island of St. Vincent. Cooperated with local experts to conduct terrestrial and aquatic biodiversity baseline studies and water resource assessments. Led the stakeholder engagement aspects of the ESIA, including government communication and coordination and execution of the public meetings and focus group discussions in relation to the ESIA. The ESIA was conducted on budget, under an expedited 4-month timeframe, and was unanimously approved by the Government of St. Vincent and the Grenadines.

Environmental and Social Impact Assessment, Alcoa Chatham Aluminum Smelter, Trinidad and Tobago. Led the environmental portion of the ESIA for a proposed aluminum smelter in southwestern Trinidad. The key environmental issues with the project included potential impacts to groundwater, habitat fragmentation, and changes in land use from agricultural to industrial. The project involved significant stakeholder consultation, including consultation with Trinidad's Environmental Management Authority regarding the scope of the ESIA and related public consultations. The project was highly controversial and put on hold before the publication of the ESIA. Based on the history of the project, ERM developed a lessons learned document that outlined recommendations for strategic approaches to the project if it is reactivated.

Environmental and Social Impact Assessment, Staatsolie Sugarcane to Ethanol Project, Suriname. Project manager and lead biodiversity specialist for the ESIA for Staatsolie's proposed sugarcane to ethanol project located in Wageningen, northwestern Suriname. The 15,000 hectare site is bordered to the north, east, and south by nature reserves and undeveloped land, and to the west by rice fields. The project contains agricultural (sugarcane plantation) and industrial (ethanol and sugar processing and production facility) components. ERM developed the ESIA to conform with Suriname National Institute for Environmental and Development Standards (NIMOS) and IFC Performance Standards. Key issues addressed in the ESIA included impacts to biodiversity, forest loss, water quality, water use/demands from the project and other users, impacts to nationally registered historic sites, impacts to protected areas, maintenance of ecosystem services, land use management and ownership, and greenhouse gas (GHG) production. Prepared various environmental management plans for the Project, which included a Coastal Management Plan to address the project's water management needs and climate change-related issues including sea level rise, salt intrusion into estuarine and freshwater wetlands and Suriname's coastal agricultural zone, and drought.

Environmental Assessment of Demolition and Reconstruction of Port Facilities, Jamaica. Led the environmental assessment of proposed demolition and reconstruction activities at Alcoa Jamaica's (Jamalco) port facilities, following extensive damage imposed by Hurricane Dean in late 2007. Developed and executed a plan to assess the nature of the hurricane damage to the port facilities and the shoreline, to evaluate the potential environmental impacts associated with the reconstruction of damaged facilities, and to recommend measures to avoid or minimize potential negative environmental impacts to the region caused by reconstruction activities. Worked closely with the project's engineering team to evaluate several reconstruction options and determine what design offered the best engineering solution with the least environmental damage.

Environmental and Social Impact Assessment, Suralco Aluminum Refinery, Suriname. Led the biodiversity aspects of the ESIA related to a proposed expansion of Alcoa's aluminium refinery in northeastern Suriname. Led an international team of biodiversity experts to conduct a rapid assessment biodiversity survey of the undeveloped area surrounding the refinery. The survey assessed the biological condition and value of the site based on: 1) habitat heterogeneity; 2) a preliminary survey of the organisms that characterize each of the habitats; and 3) the intactness of the habitats, and their capacity to support important biological resources and ecological processes. The results of the survey were used to evaluate the impact of the proposed refinery expansion on the local ecology and to recommend ways to minimize adverse effects on sensitive habitats and species.

Sustainable Development and Ecotourism Assessment, Haiti. Led the natural resources component of a sustainable development assistance project in Haiti that assessed opportunities and challenges of sustainable development in the central and western portions of the country, a major component of which was consideration of threats from climate change and the country's adaptability to current and future changes and the resources needed to address the threats.

Rick Osa

Air Quality Monitoring Lead



Mr. Richard H. Osa, QEP is a Senior Consultant within ERM's North American operations. He has over 30 years of experience in the fields of air quality and environmental management.

Mr. Osa has obtained air emission source permits (construction and operating) for over 200 facilities (major, minor, synthetic minor) in 17 states and seven EPA regions. Facilities were located in attainment and non-attainment areas, and some were subject to MACT for control of Hazardous Air Pollutants.

He has developed greenhouse gas inventory algorithms and a management system for long-haul freight network and facilitated executive-level "sustainability" workshops and needs analyses.

Mr. Osa is expert in a broad range of air management topics, having performed Clean Air Act legislative and regulatory analyses—as well as compliance planning and implementation.

In the area of environmental management systems, he has managed the development of over 150 procedures, work instructions, and standardized forms in support of a Fortune 100 company's environmental management system. He provides training in the development, implementation, and auditing of environmental management systems.

Mr. Osa has supported biogas, wind, biomass, and other renewable energy facilities with environmental permitting and monitoring.

Professional Affiliations & Registrations

- Qualified Environmental Professional—Institute for Professional Environmental Practice
- Air & Waste Management Association
- American Counsel of Engineering Companies—Energy and Environmental Committee

Fields of Competence

- Air emission source permitting
- Ambient air monitoring
- Atmospheric dispersion modeling
- Noise monitoring and modeling
- Environmental management systems

Key Industry Sectors

- Electric power
- Natural gas processing and transmission
- Food processing
- Manufacturing
- Pulp and paper
- Iron and steel
- Ethanol manufacturing
- Nonmetallic mining

Education

- Master of Engineering Management, Northwestern University, 1992
- Graduate Studies, Environmental Engineering, Illinois Institute of Technology, 1976 - 1978
- Bachelor of Science, Physics, Illinois Institute of Technology, 1976

Languages

- English, native speaker

Publications

R.H. Osa and T. Palmer: *Analysis of EPA's Proposed Clean Air Restrictions on Oil and Gas Operations*, World Oil Online, December, 2011.

R.H. Osa: *The New Transformer Sequel: Transportation Engineer Becomes Atmospheric Scientist*, presented at: Mn/DOT – ACEC/MN Annual Consultant Conference, March 1, 2011, Earle Brown Heritage Center, Minneapolis MN.

R.H. Osa et al.: *Can I Get Credit For These GHG Emission Reductions?*, presented at the 102nd annual meeting and exhibition of the Air and Waste Management Association, Detroit, MI, June, 2009.

R.H. Osa: *Residuals Management: A Key To Shrinking Your Mill's "Carbon Footprint"*, Lake States TAPPI Symposium on the Management and Utilization of Paper Mill Residuals, Green Bay, WI, February, 2008.

R.H. Osa: *Residuals Management: A Key To Shrinking Your Mill's "Carbon Footprint"*, Lake States TAPPI Symposium on the Management and Utilization of Paper Mill Residuals, Green Bay, WI, February, 2008.

R.H. Osa and D. Hermann: *Carbon Sequestration in the Heartland*, 11th Annual Electric Utility Environmental Conference, Tucson, AZ, January, 2008.

R.H. Osa, R. Paine, and W. Campbell: *New Source Review Permitting Challenges*, 11th Annual Electric Utility Environmental Conference, Tucson, AZ, January, 2008.

R.H. Osa: *Environmental Compliance – The EMS Approach to Regulatory Assurance*, Invited Presentation: Acordia-Wells Fargo Risk Management Seminar, January 25, 2006.

R.H. Osa: *BART and LAER – Clean Air Requirements, Handle with CAIR*, presented at the annual meeting of the Recycled Paperboard Technical Association, February 10, 2005.

R.H. Osa et al.: *Constructing an Objective Environmental Aspect Ranking System,* presented at the 96th annual meeting and exhibition of the Air and Waste Management Association, San Diego, CA, June, 2003.

R.H. Osa: *Mercury Source-Receptor Relationships Expert Panel: Proceedings*, Electric Power Research Institute, EPRI 1000632, October 2000.

R.H. Osa: *Mercury Toxicity,* presented at the Air and Waste Management Association "Mercury in the Environment" Specialty Conference, Minneapolis-St. Paul, MN, September, 1999.

R.H. Osa: *Natural Gas Environmental Research & Development: A Market Analysis*, Electric Power Research Institute: EPRI TR-109895, December 1997.

R.H. Osa, and C. Hakkarinen: *PRIME – An Improved Downwash Model*, presented at the 21st NATO/CCMS International Technical Meeting on Air Pollution Modeling and its Application, Baltimore, MD, November 6-10, 1995.

R.H. Osa et al.: *Environmental Consequences of FERC Order No. 636*, Gas Research Institute: GRI-95/0048, September 1994.

R.H. Osa: *Mercury Atmospheric Processes: A Synthesis Report*, workshop proceedings from the Expert Panel on Mercury Atmospheric Processes, Tampa, FL, March 16-18, 1994.

R.H. Osa, R.I. Sykes and C. Hakkarinen: *Applications of Advanced Plume Modeling Techniques to Combustion Turbines*, presented at the 9th World Clean Air Congress & Exhibition, Montreal, Canada, August 30-September 4, 1992.

R.H. Osa and G.R. Retzlaff: *Proceedings: Photochemical Modeling Workshop*, workshop held in Cambridge, MA, August, 1992.

R.H. Osa and H. Chromy: *Clean Air Compliance Framework: A Tool for Compliance Planning*, presented at the 85th annual meeting and exhibition of the Air and Waste Management Association, Kansas City, MO, June, 1992.

R.H. Osa: *Implications of 1990 Clean Air Act Amendments*, presented at the 2nd Annual International Maintenance Institute Exposition, Racine, WI, May, 1990.

Key Projects

Ambient Air and Meteorological Monitoring Program, Convent, LA, Nucor Steel Louisiana, LLC
Designed, installed, commissioned, and am managing data collection at this multi-year, three site pre-construction monitoring network. Measured parameters consit of $PM_{2.5}$, SO_2, NO_2, CO, wind speed, wind direction, sigma theta, and ambient temperature. Data are digitally recorded onsite and telemetered to ERM office via wireless modem.

Ambient Air Total Particulate, Manganese, Particulate Mercury, and Meteological Monitoring Program, Marion, OH, Nucor Steel Marion, LLC
Designed, installed, commissioned, and am managing data collection at this multi-year, two site monitoring network. Manual (filter-based) and continuous automated particulate matter samplers are employed to document ambient air concentrations. Wind speed and direction observations will be used to identify culpable source(s) in the event of high concentrations.

Ambient PM10 Monitoring, New Auburn, WI, Superior Silica Sand
Designed, installed, commissioned, and managed a one site PM_{10} program for a non-metallic mining operation. Data quality was certified by Wisconsin DNR.

Title V Operating Permits, Multiple Locations (Iowa, North Dakota, Illinois, Ohio, Indiana), Archer Daniels Midland Company
Developed initial Title V operating permit applications for grain processing and oil extraction and refining facilities. Responsibilities included developing detailed emissions inventories of point and fugitive emission sources, defining alternative operating scenarios, identifying applicable Clean Air Act requirements, and preparing applications in accordance with guidance of the permitting authority.

Shwet Prakash

Water Quality Assessment Lead



Shwet Prakash is a senior consultant who has been managing and delivering water resources and modeling services to the oil & gas, power and manufacturing industry. He has been involved in developing state of the art chemical fate and transport models for a variety of water quality and transport applications. His experience over the last 10 years includes managing projects that include hydrodynamic studies, accidental oil spill studies, sediment transport and scour studies, TMDL development and regulatory permitting. Mr. Prakash has provided these services to most of the major oil & gas companies (ExxonMobil, BP, Shell, Chevron, Hess) and power companies (Exelon, PSE&G, Luminant, Progress Energy, Nebraska Public Power District) amongst others. The project site footprint includes Americas (US, Canada, Mexico, Brazil), Europe (Norway, Sweden, Turkey), Africa (Ghana, Angola, Sierra Leone, Uganda), Asia (Qatar, Saudi Arabia, Brunei, Malaysia, Indonesia, Thailand, China, Bangladesh) and Australia.

Fields of Competence

- Computational fluid dynamics
- 1-D, 2-D and 3-D numerical modeling of coastal and shelf processes including hydrodynamics and waves
- Chemical transport and fate and water quality modeling
- Ecological risk assessment
- Sediment transport modeling
- Particle tracking and entrainment modeling
- Groundwater modeling
- Programming in FORTRAN, C, Visual Basic and HTML
- Field data processing and analysis

Credentials

- M.S. (Civil Engineering), University at Buffalo, State University of New York, NY, February 2004
- B.S. (Civil Engineering), Indian Institute of Technology, Bombay, India, May 2001
- Watershed Management Training Certificate, The Watershed Academy, EPA
- Professional Development courses in Environmental Hydrodynamics and Sediment Transport Modeling with POM and ECOMSED, Stevens Institute of Technology, Hoboken, NJ

Key Industry Sectors

- Oil and Gas
- Electric Utility (fossil fuel, nuclear and hydropower)
- Harbors and Ports
- Industrial and Chemical
- Water supply and Wastewater Treatment
- Mining
- Marina design and water quality

Key Projects

Oil & Gas

Water Quality Impact Assessment from Onshore LNG Terminal Expansion, BP, Indonesia.
Managed a comprehensive modeling exercise to quantify environmental impacts related to expansion of an onshore LNG facility in Indonesia. Environmental risks associated to wastewater discharge, dredging, drill cuttings and mud discharge and pipeline hydrotesting were estimated using a 3-D hydrodynamic and transport model. Individual wastewater components were modeled and evaluated against relevant ambient water quality standards.

NRDA Computations, Gulf of Mexico, Confidential Client.

Oil Spill Response Planning and Impact Assessment for various clients and fields, offshore Malaysia.
Currently developing models to estimate the environmental impacts from accidental spills during the

operations of MOPUs and FSOs offshore Malaysia. Responsibilities include overall project management of these modeling projects that include three individual clusters.

Oil Spill Impact Assessment for confidential field development, offshore Western Australia.
Currently developing models to estimate the environmental impacts from accidental spills during the operations of MOPUs and FSOs offshore Australia. Responsibilities include overall project management of these modeling projects that include three individual clusters.

Sunrise Floating LNG Terminal, offshore Western Australia
Involved in modeling the environmental impacts from the operations associated with the proposed Sunrise floating LNG terminal located off the coast of Australia. Involvement included managing the modeling tasks that included thermal discharge modeling, oil spill modeling, PFW discharge modeling and water quality modeling. Findings of the modeling were submitted in a report for agency approval.

Prelude Floating LNG Terminal, offshore Western Australia
Involved in modeling the environmental impacts from the operations associated with the proposed Prelude floating LNG terminal located off the coast of Australia. Involvement included managing the modeling tasks that included thermal discharge modeling, oil spill modeling, PFW discharge modeling and water quality modeling. Findings of the modeling were submitted in a report for agency approval.

Keith Lake drilling fluid discharge model
Involved in the development of a near field Sediment Transport and Hydrodynamic model for Keith Lake, TX. The model application was aimed at analyzing the fate of drilling fluid released into the discharge pits as a result of Horizontal Directional Drilling (HDD) operation. The work included development of modeling cohesive sediment capabilities into GEMSS-STM. The analysis comprised of performing comparative study of the resulting turbidity plume for a varied set of lake flows, lake depths and material properties.

Entrainment Modeling for BP's Crown Landing Regassification Facility, New Jersey. BP proposed development of an LNG import terminal at Crown Landing on the Delaware River in Gloucester County, NJ. During vessel unloading while at berth, LNG carriers take on about 30,000 m^3 of water to maintain hydraulic stability when empty. Concerns exist regarding the entrainment effects and possible fishery losses due to this ballast water intake. Striped Bass, White Perch and Bay Anchovy are the species of concern since they consistently dominate the ichthyoplankton population in the Delaware River. ERM simulated intake effects using a high resolution hydrodynamic model to estimate entrainment rates for various life stages of these species of concern. These rates were used to estimate the loss of equivalent adults using a specialized module developed by ERM.

Buzzards Bay, MA Oil Spill modeling
Involved in development of an oil spill fate model for Buzzards Bay oil spill of April 27, 2003. The model was developed using GEMSS-COSIM (Chemical and Oil Spill Impact Module). The study required analysis of oil spill fate and its shoreline interaction under varying meteorological and hydrodynamic conditions.

Residual LNG Chlorine Study, ExxonMobil Research Qatar (EMRQ), Qatar. A residual chlorine discharge limit of 0.15 mg/L at the outfall was previously permitted by the Supreme Council for the Environment (SCE). At the edge of the mixing zone the residual chlorine concentration is not to exceed 0.01 mg/L limit. ERM was tasked to create a model simulating the chlorine plume discharged from the facility under these new conditions to verify compliance with standards and to modeling of residual chlorine and 15 chlorine by products discharged from the RasGas, Qatargas and RLCC outfalls into the Arabian Gulf. The chlorine model was successfully validated with an extensive field data set.

Mining

Water Quality Modeling for Diamond Mine Support in Snap Lake. ERM's Surfacewater Modeling Group developed hydrodynamic and water quality model for Snap Lake diamond mining operations. Modeling included past and future water quality impacts due to mining operations. Ice conditions were implemented to reproduce winter freeze and affects on the lake water quality.

Surfacewater Modeling for Support for Alberta Tar Sands Impact Assessment. ERM's Surfacewater

Modeling Group provided custom programming through its GEMSS modeling system to allow Cumulative Environmental Management Association (CEMA) estimate recovery time for tailings ponds. Key issues were rate of compaction, resulting morphodynamic changes and transfer of contaminants to surface waters.

Surfacewater Impacts for Marampa Iron Mine, Sierra Leone. ERM provided environmental impact assessment studies for the phased development planned for the Marampa iron ore mine proposed by London Mining. Project involved quantifying impacts due to dredging, minewater runoffs and accidental scenarios due to mining operations.

Water Quality

Lake Whatcom, Washington
ERM was tasked by Brown and Caldwell with evaluating the performance of the reservoir model component of the Lake Whatcom Nutrient Response Model (LWNRM). The LWNRM consists of the reservoir model (CE-QUAL-W2) and the watershed model (HSPF), which provides tributary flows and nutrient loads to the reservoir model. This model had been used to simulate nutrient water quality in the Lake for the two-year period 2002-2003, first to reproduce existing conditions (the calibration), then to simulate natural conditions, and finally to develop the Total Maximum Daily Load (TMDL). Because the TMDL process looks forward in time to predict improvements in water quality, ERM tested the model against field data for 2007-2008 and developed an alternative TMDL using loads for this two-year period. To do so, ERM developed new input files, made specific improvements in DO. It was desirable, therefore, to evaluate the model's performance against a dataset for another period. ERM performed the TMDL analysis for this new period to evaluate the projection capability of these TMDL estimates in to the future.

Budd Inlet Water Quality Modeling
Involved in the development of a carbon based water quality model for Budd Inlet and Capitol Lake, WA. ERM had done a similar study in 1998 for the Lacey, Olympia, Tumwater and Thurston County (LOTT) partnership for wastewater permitting. Current work includes improvement in the water quality calibration performed during the previous study along with the inclusion of Capitol Lake in the modeling domain.

Lower Passaic River Superfund Site Hydrodynamic and Contaminated Sediment Transport Modeling. This confidential study included analysis of current meter and water surface elevation data and modeling of the hydrodynamics and transport of sediments. The purpose of the study was to support our client, a PRP, in the interim allocation process and to help establish the magnitude of dispersal of material introduced into the prominent Newark Bay river-estuary system. This effort also included review of EPA- and Cooperating Parties Group-generated documents and datasets (particularly EPA's Framework Document and modeling reports), submission of comments, and attendance at Technical Committee meetings.

Delaware Bay TMDL
Developed and applied a hydrodynamic, transport and water quality model for Delaware Inland Bays. The objective of the study was to determine the TMDLs for the impaired waters on the State's 303(d) list for nitrogen, phosphorus, and DO within the Inland Bays of southern Delaware. These water bodies included Rehoboth Bay, Indian River, Little Assawoman Bay, and the surrounding tributaries and ponds. This analysis was accomplished using a hydrodynamic and water quality model GEMSS to verify the effectiveness of prescribed point and non-point source load reductions to meet the TMDL objectives.

Hydrodynamic Mixing Zone modeling of the confluence of the Nottawasaga River with Nottawasaga Bay
Involved in performing the hydrodynamic mixing analysis of Nottawasaga River with Nottawasaga Bay using GEMSS-HDM & GEMSS-WQM in support of developing future TMDL for the waterbodies. The work includes estimation of near field mixing zone and its effects on the local water quality. Study will also be done on estimating the extent of the Nottawasaga River mixing zone on various River loading conditions and the subsequent water quality in the near field Bay region.

Janey run mixing zone modeling
Involved in performing mixing zone analysis for a mine tailings discharge into Janey Run, MD. CORMIX was used to estimate the extent of the mixing zone during different tidal and non tidal conditions.

Charlotte Harbor water quality modeling

Involved in development of a Charlotte Harbor water quality model using GEMSS to analyze the relationship between physical and biochemical processes in the estuary. The analysis included study of phytoplankton effect on dissolved oxygen and investigation of the occurrence of hypoxia in the deeper regions of the harbor.

Roxboro power station thermal modeling
Involved in development of a hydrodynamic and thermal plume model for Lake Hyco, SC to analyze the thermal discharge from Progress Energy - Roxboro Generating Station. Updated GEMSS transport module with higher order transport schemes such as QUICKEST and QUICKEST+ULTIMATE to better estimate the stratification.

South Seas Marina Flushing Study
Modeled the South Seas marina for exchange of water with the open seas. It was found that the marina in its planned configurationdid not flush (replace) 90% of the water within 24 hours. Several improvements to the marina configuration were proposed and evaluated. It was found that a combination of widening and deepening of entry channel along with opening of one design breakwater will improve the flushing and increase the degree of exchange with the open sea.

Flushing and Water Quality Study for South Bethany
Assessed improvements to DO, nutrient levels, and other potential changes to the environment due to increasing ocean flushing into Delaware's Inland Bays (Indian River, Rehoboth Bay, and Little Assawoman Bay) using GEMSS HDM and WQM modules. Various methods of providing the flushing improvements and increasing the degree of exchange were examined including tidally driven inlets and pumping systems. Final recommendations were provided along with a cost-benefit analysis for the various options.

Monitoring of Harmful Algal Bloom (HAB) for Lake Ontario
Developed a three-dimensional free surface sigma co-ordinate hydrodynamic model for Lake Ontario based on Princeton Ocean Model (POM) for NOAA: MERHAB Lower Great Lakes. Also developed a Random walk particle-tracking model, to link with the hydrodynamic data to track the movement of algal blooms. Project also included analyzing the impact of Niagara River flow on the southern coastal region of the lake and on bloom movements. The overall goal was to setup a web page for real time simulations, where a user can specify the current bloom location and then monitor the trajectory.

Algae Transport & Water Quality model for Lake Ontario
Developed a FORTRAN based two-dimensional Dissolved Oxygen (DO) and algae transport model for Lake Ontario as a part of the Rochester Harbor project for the US Army Corps of Engineers (USACE) and URS Corporation. The models were developed to monitor the water quality and algae fate for analyzing the efficiency of "herd and pump" approach adopted to solve the algae accumulation at the Ontario beach. Also performed calibrations for the dispersion values in the lake using conductivity data. Submitted a final report on the analysis results to URS suggesting preferred pumping locations.

Sediment Transport

Purari Hydropower Sediment Transport Modeling.
Developed a hydrodynamic model in support of styding sediment transport in Purari River due to the construction of the hydropower facility. Modeling included assessment of net sediment fluxes, impacts on turbidity and evaluation of floodplain erosion.

Lower Passaic River Superfund Site Hydrodynamic and Contaminated Sediment Transport Modeling. This confidential study included analysis of current meter and water surface elevation data and modeling of the hydrodynamics and transport of sediments. The purpose of the study was to support our client, a PRP, in the interim allocation process and to help establish the magnitude of dispersal of material introduced into the prominent Newark Bay river-estuary system. This effort also included review of EPA- and Cooperating Parties Group-generated documents and datasets (particularly EPA's Framework Document and modeling reports), submission of comments, and attendance at Technical Committee meetings.

Thermal Modeling

Salem Generating Station Cooling Water Intake System improvements.
Salem Generating Station (SGS) withdraws water from Delaware Estuary its cooling water (CW) . Detrital material suspended in the Estuary is also drawn into the CW system. ERM's Surfacewater Modeling Group developed a high resolution hydrodynamic and particle

tracking model simulate the movement of detritus. It was found that approximately 40% of the grass collected at the intake structure comes from the grass disposed at the ends of the intake structure. Moving the disposal point from the ends of the intake structure to the CW outfall provided a large reduction in recirculation of grass. It was found that less than 5% of the disposed grass is recirculated to the intakes when it is disposed through the CW outfall. This result reflects an improvement of almost 90% compared to the current procedure (40% down to 5%).

Thermal Plume Modeling, RasGas LNG, Qatar. RasGas operates a liquefied natural gas (LNG) facility on the northeast coast of Qatar, discharging cooling water into the Arabian Gulf through an open canal. The RasGas facility originally consisted of a single LNG train that nominally circulates 27,500 m3/hr of seawater for heat exchanger cooling at a temperature rise of 10°C. RasGas subsequently added a second LNG train and proposed two additional trains. The objectives of this study were to model the thermal plume under existing and proposed operations including for model verification and mixing zone specification for the cooling water discharge plume. Model results showed that the thermal plume was vertically stratified, with a relatively large area on the surface and a relatively small bottom contact area. The advantage of the design was that it maximized heat exchange with the atmosphere, while protecting the benthic organisms from the temperature increase.

Susquehanna River hydrothermal modeling
Involved in the development of hydrodynamic model for Susquehanna River Brunner Island power plant using GEMSS-HDM in support of 316(a) renewal for the PPL Services Corporation, PA. Updated the GEMSS-HDM module for sigma stretching in vertical direction and model several connected waterbodies to accommodate for highly varying surface elevations. Also developed higher order turbulence closure schemes for vertical diffusion.

Ghana Thermal Modeling
Developed and applied a thermal discharge model, GEMSS®-TAM for the proposed TEMA Power Project located in an industrial area near Tema on the coast of Ghana. The Ghana Environmental Protection Agency (EPA) was imposes restrictions on the extent of the 3°C temperature rise isotherm which was modeled for three different plant configurations (two gas fired and one distillate fired). A probabilistic approach was applied to estimate the 3°C temperature rise isotherm under transient tidal conditions. Further model confirmation was done by setting up CORMIX in the near field. It was found that the maximum temperature rise at the surface was always less than 1°C. The 3°C temperature rise isotherm was found to be limited within the 8 m of the discharge port. Under all the proposed configurations, the plant did not violate the regulations imposed by the Ghana EPA.

Jobos Bay hydrothermal and entrainment modeling
Involved in development of a hydrodynamic model for Jobos Bay, Puerto Rico using GEMSS-HDM (Generalized Environmental Modeling System for Surface waters – HydroDynamic Module). The purpose of the modeling was to characterize the thermal plume from Aquirre Power station in support of <316(a)> study and to quantify entrainment rates of ichthyoplanktons in support of <316(b)> study. GEMSS-ENTM (Entrainment Module) was used for the 316(b) entrainment studies.

Temperature Forecasting System
Involved in the development of a temperature forecasting system for Nebraska Public Power District (NPPD), Sutherland, NE. NPPD has wells around its cooling water discharge canal that brings cold groundwater to reduce the heated cooling water used in power generating station. The temperature forecasting system was developed to help NPPD manage the operations of these wells based on the predicted temperature at the end of the canal. The forecasting system was an excel based software that takes waste heat load, flow, meteorological data and well flow data to predict temperatures.

Squaw Creek reservoir hydrothermal modeling
Involved in the development of hydrodynamic model for Comanche Peak Steam Electric Station located at Squaw Creek Reservoir, TX using GEMSS-HDM. The study was oriented towards evaluating the current and historical conditions during the plant full load and identifies different alternatives to decrease the intake water temperature. Several alternatives such as Spray modules, cooling towers and water garden steps were evaluated. Several enhancements to GEMSS were done to include modeling of such alternatives and analyzing their efficiency.

Hydropower

Purari Hydro Project, Papua New Guinea
Purari Hydro Project is a proposed hydroelectric power project aimed at providing electricity to Papua New Guinea, north and far north Queensland, and Australia's National Electricity Market. The project will have a capacity of 1,800 MW of baseload electricity. ERM is currently developing models to asses the impacts related to the development of reservoir on downstream water quality, sediment and hydrodynamic characteristics. The modeling work involves connecting in-reservoir models developed by Électricité de France and downstream impact models developed by ERM. The study is currently underway with models being developed in conjunction with field data collection.

World Bank, Trung Son Reservoir CE-QUAL-W2 Model Application and Software Training, Vietnam
Trung Son Reservoir is a proposed hydroelectric power project on the Trung Son River in central Vietnam for Vietnam Electric Utility (EVU). The client requested assistance with development and training with the 2-dimensional hydrodynamic and water quality model, CE-QUAL-W2. The goal was to assess the water quality of the proposed reservoir and the management options for clearing the flooded areas. The technology transfer took place as a 6-day intensive workshop presented in Nha Trang, Vietnam. The workshop achieved two objectives: the model was fully customized to the Tung Son Reservoir problem definition, and the client (fifteen engineers and scientists) were trained in the use and theory of the model.

Baynes Reservoir, Cunene River, Angola-Zambia
ERM applied two reservoir models to assess potential environmental impacts from the construction and operation of the Baynes Hydroelectric Reservoir on the Cunene River between Angola and Zambia. The primary impacts are (1) the change in the water temperatures in the reservoir and immediately downstream of the dam and (2) the potential for eutrophication in the reservoir. The U.S. Army Corps of Engineers CE-QUAL-W2 model was chosen to assess the impacts of the Project on the temperature structure of the Baynes Reservoir. The U.S. Army Corps of Engineers BATHTUB model was used to estimate its trophic status. Results of the models identified the range of surface water elevations through the year, vertical water temperature distribution and behavior, monthly average discharge water temperatures, and the effectiveness of discharge structure placement. The trophic status of the reservoir was projected to be oligotrophic due to the low level of nutrient loading.

Kalivaç Reservoir, Albania
ERM applied two reservoir models to assess potential environmental impacts from the construction and operation of the Kalivaç Hydroelectric Reservoir in Albania. The primary impacts are (1) the change in the water temperatures in the reservoir and immediately downstream of the dam and (2) the potential for eutrophication in the reservoir. The Generalized Environmental Modeling System for Surface Waters (GEMSS®) model was chosen to assess the impacts of the Project on the temperature structure of the Kalivaç Reservoir. The U.S. Army Corps of Engineers BATHTUB model was used to estimate the trophic status of Kalivaç Reservoir.

Publications

Prakash, S., Kolluru, V. and Young, C. "*Evaluation of the Zone of Influence and Entrainment Impacts for an Intake Using a 3-Dimensional Hydrodynamic and Transport Model*". Journal of Marine Science and Engineering 2014. Vol. 2, 306-325.

Febbo, E., Duggan, J., Kolluru, V. and Prakash, S. "*Integration of a Geospatial Framework with a Suite of Numerical Models for Operational, Environmental and Regulatory Aspects of Cooling Water Usage*". Proceedings of the 2014 International Petroleum Technology Conference, held January 20–22, 2014, in Doha, Qatar.

Mathur, Dilip, Royer, D.R., Long, K, Matty, R.M., Sullivan, T.J., Prakash, S. and Buchak, E.M. "*Retrospective analysis to quantify migration of American Shad in an impondment on the lower Susquehanna River*". Proceedings of the 2013 Georgia Water Resources Conference, held April 10–11, 2013, at the University of Georgia.

Saeed, S., Deb, N., Campbell, R., Prakash, S., Kolluru, V. and Febbo, E. "*Laboratory Experiments to Validate 3D Numerical Modeling of Chlorine Decay in Industrial Cooling Water Discharge*". SETAC Europe 23rd Annual Meeting. May 12th to May 16th, 2013. Glasgow, UK.

Prakash, S., Kolluru, V. and Tutton, P. "*Semi-Lagrangian Approach to Stydying Grassing Issue on a Nuclear Power*

Plant Cooling Water Intake". Proceedings of 10th International Conference on Hydroscence and Engineering. Nov. 4-7, 2012, Orlando, Florida.

Febbo, E.J., Kolluru, V.S. and S. Prakash. "*Numerical Modeling of Thermal Plume and Residual Chlorine Fate in Coastal Waters of the Arabian Gulf*". Society of Petroleum Engineering International Conference 2012. September 11-13. Perth, Australia.

Kolluru, V.S., S. Prakash and E. Febbo. 2012. "*Modeling the Fate and Transport of Residual Chlorine and Chlorine By-Products (CBP) in Coastal Waters of the Arabian Gulf*". The Sixth International Conference on Environmental Science and Technology 2012. June 25-29. Houston, Texas, USA.

Prakash, Shwet, J.A. Vandenberg and E. Buchak. 2012. "*CEMA Oil Sands Pit Lake Model".* CONRAD 2012 Water Conference. April 20-22. Edmonton, Alberta.

Kolluru, V.S. and S. Prakash. 2012. "*Source Water Protection: Protecting our drinking waters"*. India Water Week 2012. April 10-14. New Delhi, India.

Long, K., R.M. Matty, D. Mathur, D. R. Royer, T. Sullivan, S. Prakash and E. Buchak. 2011. "*Assessment of effects of interaction of pumped storage station operations and thermal plume on migration of American Shad (Alosa Sapisissuma) in the Lower Susquehanna River*. EPRI 2011. Third Thermal Ecology and Regulation Workshop. October 11-12, 2011. Maple Grove, Minnesota.

Prakash, S., J.A. Vandenberg and E. Buchak. 2011. "*The Oil Sands Pit Lake Model - Sediment Diagenesis Module."* MODSIM 2011. Modelling and Simulation Society of Australia and New Zealand, December 12-16, 2011. Perth, Australia.

Vandenberg, J.A., S. Prakash, N. Lauzon and K. Salzsauler. 2011. "*Use of water quality models for design and evaluation of pit lakes."* Australian Center for Geomechanics. Mine Pit Lakes: Closure and Management. Page 63-81.

Prakash, Shwet, Atkinson, Joseph F. and Mark L. Green. "*A Semi-Lagrangian study of Circulation and Transport in Lake Ontario*". Journal of Great Lakes Research. Volume 33, Issue 4, 2007, Pages 774–790.

Kolluru, V.S., M.J. Fichera, S. Prakash. 2006. "*Multipurpose modeling tool for aquatic and sediment contaminant fate and effect assessments*". SETAC North America 27th Annual Meeting. Montreal, Canada. November 2006.

Prakash, Shwet and V.S. Kolluru, 2006. "*Implementation of higher order transport schemes with explicit and implicit formulations in a 3-D hydrodynamic and transport model*."published in the 7th International Conference on Hydroscience and Engineering (ICHE 2006), Sep 10 - Sep 13, Philadelphia, USA

Hubertz, J.M., Prakash, S., Krallis, G. and Venkat Kolluru. "*Relationship between Physical and Biochemical Processes in an Estuary"*. 7th International Marine Environmental Modeling Seminar. 2004.

Mark E. Garrison

Air Emission Modeling Lead



Mr. Garrison has more than 28 years of experience as a meteorologist and air quality dispersion modeler in the environmental consulting field, for industry, and the U.S EPA.

Mr. Garrison has several years of experience providing expert consultation related to litigation, including expert testimony. He has extensive experience in the application of air quality models to assess releases of criteria and toxic air pollutants.

Mr. Garrison has detailed knowledge of the technical, regulatory, and policy issues related to dispersion modeling of new and existing sources and modeling the effects of accidental releases of toxic chemicals; he has special expertise in modeling sources in complex terrain and in the application of advanced models (e.g., CALPUFF, AERMOD, CTDMPLUS).

Mr. Garrison has extensive experience in modeling for PSD and NA-NSR permitting, with special emphasis on electric utility power plants. He has extensive experience in modeling concentration and deposition impacts for input to risk assessment.

Mr. Garrison has served as an invited scientific peer reviewer for two new EPA models: AERMOD and CALPUFF. He is the author of numerous papers presented at technical conferences on a wide variety of modeling topics.

Registrations & Professional Affiliations

- Air and Waste Management Association
- American Meteorological Society

Fields of Competence

- Air quality dispersion modeling
- Meteorological data evaluation and processing
- Dispersion model development
- Expert testimony
- PSD and Nonattainment New Source Review (NA-NSR) modeling
- Exposure assessment and toxic pollutant impact evaluations
- Air emissions inventory development
- Ambient impact assessments of hazardous waste sites
- Clean Air Act strategic planning
- Electric utility power plant permitting
- Modeling in support of risk assessment
- Title V permitting

Education

- M.S., Environmental Science, Drexel University, 1981
- B.S., Environmental Engineering Technology, Temple University, 1977

Languages

- English, native speaker

Key Projects

Contributed to an assessment of fine particle contributions to regional haze in collaboration with the NESCAUM organization.
Work included preparation of MM5-based meteorological inputs, and modeling of several hundred coal- and oil-fired generating units in the Northeastern U.S. using the CALPUFF model.

Conducted modeling of the atmospheric transport, transformation and fate of mercury emitted by coal-fired power plants and other source types for the Maryland Department of Natural Resources Power Plant Research Program (PPRP).
Developed a speciated mercury emissions inventories for the Eastern U.S., and developed a simplified mercury transformation scheme that has been incorporated into CALPUFF. Model evaluations were performed comparing model predictions to, and analysis of data collected at Mercury Deposition Network (MDN) sites.

Conducted modeling as part of the Maryland Department of Natural Resources Power Plant Research Program (PPRP).
Review of several new power plant applications, including the use of AERMOD, and Class I AQRV analyses utilizing the CALMET/CALPUFF modeling system and the SACTI model for cooling tower impact assessment. Sources modeled included simple and combined cycle combustion turbines and coal-fired boilers.

Performed and conducting on-going modeling with CALPUFF to determine visibility impacts on Class I areas using MM5-based data for facilities in South Carolina, Pennsylvania, Nebraska, Oklahoma, and Texas.
Modeling was conducted in support of BART exemption and BART engineering analyses.

Performed a cumulative impact analysis for several new electric generation facilities in Maryland.
Utilized CALMET and CALPUFF, including the effect of multiple plants on visibility resources in the Shenandoah National Park and an assessment of ambient standards in Maryland.

Participated in scientific peer review panels for the new AERMOD and CALPUFF models at the invitation of the U.S. EPA.
Developed comments on the scientific and performance aspects of AERMOD and CALPUFF.

Conducted modeling with the Offshore Coastal Dispersion (OCD) model to evaluate the effects of drilling operations off of the coast of Angola.
Project included processing and evaluation of both land and overwater meteorological data.

Conducted extensive air quality modeling to address SO2 ambient standards compliance issues for a refinery in Oklahoma.
Work involved model evaluation comparing predicted to measured ambient concentrations. Models included AERMOD and ISCST3. Project included processing and evaluation of meteorological data for ISCST3 and AERMOD.

Performed a full-scale analysis using the CALMET/CALPUFF modeling system to assess Nitrogen deposition to the Chesapeake Bay resulting from NOx emissions from sources located up to 1000 kilometers from the Bay.
Conducted evaluations of the performance of CALPUFF and developed proposed improvements.

Performed dispersion modeling in support of accidental release assessments for Clean Air Act 112(r) Risk Management Plan for chemical, paper and other industries at over a dozen facilities using the ALOHA, SLAB, and DEGADIS models.

Conducted modeling for input to a risk assessment for a manufacturing facility in Albuquerque, New Mexico using CALPUFF for a local, complex wind application.

Prepared a comprehensive set of input files.
Included MM4, upper air, surface, precipitation, buoy, ozone, land use, and terrain and ran CALMET for Public Service Electric and Gas in New Jersey. Provided evaluation of resultant wind fields.

Conducted air quality modeling to determine exposure assessment input to a human health risk assessment, to

address impacts of airborne pollutants from a dredging operation to clean up the Grand Calumet River near a major steel plant in Gary, IN.

Conducted air quality modeling, including multi-source regional modeling, in support of a NOx PSD application for a manufacturing facility in New York State.

Provided air quality modeling inputs (ISCST3 and AERMOD-PRIME) to a human health risk assessment for a manufacturing facility in New Jersey.

Conducted air quality modeling of benzene and other pollutants released from contaminated soil at a site in Brazil; utilized emissions measured by flux chamber.

Conducted modeling to assess impacts of the excavation and off-site disposal of asbestos-containing materials at a facility in Argentina.

Conducted air quality modeling of several compounds from contaminated soil at a site in West Virginia; utilized emissions measured by flux chamber.

Conducted modeling to determine concentration and deposition impacts for a multi-pathway risk assessment for a hazardous waste incinerator in Puerto Rico.

Prepared an expert report in support of a power company defendant involving the allegation by the government of avoidance of New Source Review (NSR) requirements for a coal-fired power plant in the remedy phase; was deposed in this case.

Assisted in the preparation of an expert report in support of a power company defendant involving allegations by the government of avoidance of New Source Review (NSR) requirements for over a dozen mid-western and eastern coal-fired power plants.

Served as an expert witness and prepared an expert report in litigation involving the air quality impacts of a gasoline spill, successfully avoiding class certification.

Prepared expert reports including dispersion modeling to address exposure to airborne asbestos particles in two court cases, both of which were settled with plaintiffs prior to trial. Prepared an expert report in an additional asbestos litigation case which is ongoing.

Conducted comprehensive modeling analyses to address AB2588 and Prop 65 risk assessment requirements for facilities in Santa Clara (BAAQMD) and Downey (SCAQMD), California.

Conducted modeling to determine HF impacts from a facility in Pennsylvania, including resolution of issues related to HF reactivity and deposition with the state agency.

Performed modeling for two Pennsylvania facilities (refinery and power plant) to address attainment of SO2 NAAQS due to multiple regional sources. Developed an innovative approach to determining background concentrations that was approved by EPA Region III.

Conducted air quality modeling for an industrial facility in Utah to demonstrate compliance with PSD Increments for PM10.

Conducted air quality modeling for two manufacturing facilities in support of insignificant impact determinations of plant modifications requiring PSD review.

Performed air quality modeling of three industrial facilities in New Jersey in support of quantitative risk assessments for the facilities. Worked with NJDEP to ensure compliance with risk modeling policies.

Performed dispersion modeling to demonstrate PM10 NAAQS attainment in the vicinity of an ore mining and processing facility in Nevada.

Conducted a model intercomparison study between the newly released ISC-PRIME model and existing downwash algorithms in ISCST3 to determine regulatory implications. Principal author and programmer of the Integrated Gaussian Model (IGM), an air quality model approved as an equivalent model

by the US EPA, developed to streamline obtaining source contribution information and to efficiently implement procedures for intermediate terrain.

Performed air quality analyses to support PSD application for an 800-MW pulverized coal-fired generating station in South Central Virginia.
Contributed substantially to preparation of PSD application. Developed IGM for use in this project.

Performed dispersion modeling studies in support of present and future plans for additional generating capacity at a utility power plant, including an assessment of existing units.
Models used included IGM in the RTDM/ISCST2 mode, CTSCREEN and CTDMPLUS. Provided interface with New Jersey Bureau of Air Quality Evaluation as needed for permitting modeling support.

Conducted modeling to determine HF impacts of two glass manufacturing facilities in New York state.
Conducted a model intercomparison study between existing complex terrain models and test versions of EPA's new AERMOD model to evaluate AERMOD's performance. Recommended changes in AERMOD formulation were implemented by EPA.

Performed an in-depth analysis of modeling results produced by plaintiffs in a suit alleging wide-spread Arsenic health impacts, significantly reducing the impact area identified by plaintiffs by correcting and improving the plaintiff s modeling.

Performed a deposition modeling study of the long-term (50 years of plant operation) impacts of a pesticide manufacturing plant in New York State. Assisted in interface with NYSDEC and EPA Region II to resolve impact issues.

Served as the work assignment manager for the initial development of Superfund air pathway analysis guidance documents.

Developed and presented a two-day training course for ERM offices nationwide.
Course included modeling fundamentals, application of models in regulatory settings, and overview of models used for accidental release modeling. Managed a fugitive dust quantification study for six coal-fired power plants to identify Title V emissions fees in Pennsylvania and West Virginia.

Managed the development of Title V permit applications for eight coal-fired generating stations in Pennsylvania.

CHARLES P. CERES, PE

EDUCATION:
MS, Drexel University, Philadelphia, PA. 1991 Major: Geotechnical Engineering
B.Sc., Queen's University, Kingston, Ontario, 1979 Major: Civil Engineering
40 Hour Health and Training Certification

AFFILIATIONS

Professional Engineer, New Jersey.
Member, American Society of Civil Engineers.
Member, Association of Soil and Foundation Engineers

EXPERIENCE

1993 to Present **GROUND STRUCTURES ENGINEERING CONSULTANTS LTD, Guyana**
Managing Director

Manages a geotechnical and environmental engineering services firm involved in all aspects of geotechnical engineering, hazardous waste site investigations and the performance of environmental impact assessments and environmental audits. Provided technical review of work performed by junior engineers. Geotechnical engineering facilities include several soil boring rigs and a full service testing laboratory. Prepared project proposals, established scope and managed geotechnical engineering investigations and analyses for facilities that included coastal defence structures, electrical generation stations, transmission lines, mine tailings dams, factories, multistory buildings, bridges, ports and for a proposed space station. Developed hydrogeology of several mining areas and utilized groundwater and contaminant transport models to assess the impact of mining on groundwater quality. Performed seismic wave propagation and slope stability analyses for several municipal waste landfills to assess compliance with RCRA guidelines. Managed several environmental impact assessments (EIA) and environmental audits for existing and proposed facilities. Responsible for marketing and client development for the entire range of services provided by the firm.

1992 to 1993 **GOLDER ASSOCIATES, New Jersey, U.S.A**
Senior Project Manager

Directed geotechnical field and laboratory investigations of municipal landfill sites. Coordinated slope stability analyses of landfills. Managed and performed several parts of remedial investigations/feasibility studies (RI/FS), and remedial designs (RD), and prepared RCRA Part A and B applications for land-based disposal facilities. Prepared work plans for remedial investigations, treatability testing, and background concentration determination at hazardous waste sites. Modeled contaminant transport in groundwater, determined landfill gas concentration at off-site receptors, defined remedial objectives,

identified ARARs, and evaluated remedial alternatives at CERCLA sites. Designed sample plans using geostatistics. Prepared proposals for geotechnical investigations, and RI/FS and RD projects.

1990 to 1992: RAYTHEON ENGINEERS & CONSTRUCTORS, Philadelphia, U.S.A

Project Manager: Environmental Systems and Services Group

Managed geosciences and Phase I Environmental Site Assessments projects. Managed all aspects of geotechnical investigations for fossil fuel, chemical and food processing plants and highways. Performed hydrogeological investigations for wetlands. Managed geotechnical investigations for waste containment facilities and evaluated disposal alternatives for fossil fuel plant waste streams. Designed construction dewatering systems. Performed water resources investigations for power plant siting. Developed coupled surface water and groundwater model for power plant cooling pond to assess impact of suspended solids in plant effluent. Prepared proposals for geotechnical, hydrogeological and contaminated site investigations.

1988 to 1990: SITE ENGINEERS, New Jersey, U.S.A

Project Engineer

Managed geotechnical investigations for low and high-rise buildings. Supervised Phase I and Phase II Environmental Impact Assessments. Supervised quality control field inspectors, laboratory testing and drilling crews. Coordinated closure of RCRA landfill for a major chemical manufacturer. Performed dynamic analyses of foundations for Phalanx Tower for a major defense contractor. Performed multilayer soil deformation analyses for the Pennsylvania Convention Center. Managed groundwater resources investigations for several large office complexes in the Reading, PA. area. Prepared proposals for geotechnical and hydrogeological investigations and for environmental site assessments.

1986 to 1988: EFP ASSOCIATES, New Jersey, U.S.A

Project Engineer

Supervised all geotechnical and hydrogeological investigations for new and expanded municipal waste landfill sites. Supervised site and laboratory investigations and performed slope stability, seepage and deformation analyses for Phase II dam investigations and for several small dams, less than 50 feet high. Analyzed wave and wind records, predicted critical wave heights and performed analyses of wave-loaded piles. Created groundwater hydrology group and implemented standardized procedures for pumping and permeability tests. Modeled the impact of landfill leachate on groundwater quality using numerical and analytical groundwater flow and transport models.

1985 to 1986: WOODWARD CLYDE CONSULTANTS, New Jersey, U.S.A

Assistant Project Engineer

Supervised engineers and geologists inspecting foundation excavation and embankment construction for a 260 ft. earth and rock fill dam. Reviewed and coordinated shift activities with day shift supervisor.

1983 to 1984: GEOTECH ASSOCIATES, Trinidad, W.I.
Geotechnical Engineer

Supervised geotechnical investigations for multistory buildings, roads and housing developments. Supervised laboratory investigation for lime and cement stabilization of high plasticity clays and supervised field stabilization operations. Developed preloading scheme for embankment constructed over organic clays. Supervised quality control inspection of road construction activities including fill placement and surfacing. Supervised all laboratory soil testing activities.

1979 to 1983: GUYANA MINING ENTERPRISE, Guyana, South America
Project Engineer (1979-1981)
Senior Project Engineer (1981-1983)

Redesigned and supervised construction of mills tailings dams using coarse fraction of tailings for fill and saved $12M. Started and supervised a geosciences group two years after graduation. Analyzed slope stability of all open-pit mines and mine waste heaps. Investigated soil competence for mining equipment. Designed preload schemes for soft soils. Determined liquefaction potential of mining waste disposed in ponded water. Supervised mine dewatering investigations. Developed a generic mine drainage plan that coupled groundwater flow and precipitation. Established a soil laboratory, purchased laboratory equipment and trained technicians to perform soil laboratory tests and field quality control tests.

1972 to 1974: MINISTRY OF WORKS; Guyana, South America
Soils and Materials Technician

Performed laboratory tests to determine soils and materials parameters for pavement design and soil laboratory tests to establish parameters for building foundation and earth structure design. Tests performed included CBR, determination of Marshall Stability, Particle Size Distribution, Soil Plasticity tests, soil consolidation tests, direct shear tests, Soil triaxial tests and soil permeability tests. Supervised subsurface investigations.

HANCE THOMPSON

EDUCATION

M.Sc. in Environmental and Earth Resources Management, Kingston University, London **2006/07**
B.Sc. Biology, University of Guyana **1998-2002**

PROFESSIONAL BODIES

Graduate Member of the Institute of Environmental Management and Assessment **(IEMA)- London**

EXPERIENCE

2010 to Present: GROUND STRUCTURES ENGINEERING CONSULTANTS INC

Environmental/Biological Specialist; Responsibilities include; Coordinating and conducting Environmental and Social Impact Assessments (ESIAs); Writing ESIAs and Environmental Management Plans (EMPs); Conducting/coordinating Bio-physical Baseline Surveys; Conducting/coordinating Environmental Site Assessments. Co-coordinated and managed the following projects ; ETK ESIA at Toroparu, Strata Gold ESIA at Tassawini, Guyana Goldfields Inc. (GGI) updated ESIA baseline survey at Aurora and Sulphur Rose, GGI Rapid Biodiversity Assessment at Julian Ross Itabu, Mulgravian Inc. Environmental Liability Assessment at Five Star.

April –October 2010: SYNERGY HOLDINGS (GUYANA) INC.
(AMAILA FALLS HYDRO ACCESS ROAD PROJECT)

Environment, Health and Safety Manager; Duties included; Overall Environmental Management and Monitoring of the Project; Specific Duties included; prioritize risk management strategies with the objective of achieving acceptable environmental and health practices; enforce policy and procedures on health and safety; plan and implement training programmes; liaise with the Project Manager of the Government of Guyana, the EPA, and other regulatory bodies on environment, and health and safety management.

2003 – 2010: ENVIRONMENTAL PROTECTION AGENCY, GUYANA

Post: Senior Environmental Officer (SEO) within the Environmental Management Division (EMD) with responsibilities for Managing and Coordinating activities under the Authorisation and Research and Development Programme Areas of the Environmental Management Programme; Duties included:

SEO of Authorisation - Coordinate and manage the Environmental Authorisation Process including the Environmental Impact Assessment (EIA) Process; Conduct and coordinate the review of EIAs and EMPs; Facilitate/chair public scoping meetings; Develop and review

environmental authorisation; Coordinate and manage the screening of applications for environmental authorization; Coordinate and assist in the development and revision of guidelines, standards and procedures for environmental authorisation;

SEO Research and Development (R&D) – Developed Environmental Standards, Regulations, and Guidelines for Industry; Identify areas for development in Environmental Management in Guyana and formulated proposals for projects; Coordinated and managed the implementation of projects under the Environmental Management Programme of the EPA. These projects included; The development of a National Hazardous Waste Inventory (for year 2007) and Management Strategy for Guyana; An assessment of Marine Litter Management in Guyana; The development of a project to link National Programmes of Action (NPAs) for the Protection of Marine and Coastal Ecosystems and Water Safety Plans (WSPs), developed for the Demerara Watershed and the community of Linden. Other **R&D** duties included; Coordinated and managed the implementation of the Basel Convention on the Control of the Transboundry Movement of Hazardous Waste and their Disposal; Coordinated the preparation of EPA's Recommendation on Guyana's Ratification of the Cartegena Convention.

February, 2003 – October, 2003: GUYANA RICE DEVELOPMENT BOARD (RESEARCH STATION)

Post: Research Assistant to Chief Scientist. Duties included: Managing and planning activities of the plant pathology department; screening new rice plant varieties for resistance against major rice fungus; testing and screening new fungicides for effectiveness against major rice fungus; conducting field and laboratory diagnosis of diseased rice plants for causal pathogens.

Raeburn Anthony Jones

Email: raeburnjones@groundstructures.com

EXPERIENCE

2016 – Present Ground Strurctures Engineering Company. Liliendaal, Georgetown.

Head of Department – Enviromental Unit.

- Planning , scheduling and implementing work programs and for unit(field and office).
- Analyzing data and Preparation of reports.
- Coordinate the development of Environmental and Social Impact Assessment for clients.
- Coordinate and conduct bio – physical and social baseline surveys for ESIAs.

2009 - 2016 Forestry Consultant, Logger and Miner.

- Preparation of Forest Management and Annual Plans.
- Conducting training in Reduce Impact Logging (RIL).
- Conducting training in GPS, compass and mapping.
- Mananging small scale mining and logging operation.
- Designing and implementing forest inventories (Per -Harvest & Post – Harvest).
- Designing, aligning and constructing forest and mining road network.
- Identifying and demarcation of concession boundaries (forest and gold mining).
- Designing, planning and directing construction projects.
- Supervising daily activities of construction site, determining workforce and material demands.
- Procuring materials and ensuring these are efficiently utilized.
- Ensuring that project is completed within the budgetary requirements and on schedule.

2008 – 2009 Guyana School of Agriculture. Mon Repos, E. C. D.

Lecturer – Forestry and Agriculture

- Planning , implementing programs and schedules for students.
- Assisting in student welfare and counselling.
- Supervising subordinate technical staff and students.
- Revising the forestry syllabus to meet the needs of the forest sector.
- Serving as a panel member in both academic and admission committee.
- Lecturing courses as determined by the principal.
- Organizing field trips, laboratory and other relevant training activities.
- Assist in organizing extra curriculum activities for students and staff.
- Performing other duties as determined by the principal.

2007 - 2008 Guyana Forestry Commission. 1, Water Street Kingston, Georgetown.
Assistant Commissioner of Forests – Inventory

- Preparation of work plans and budgets for the Inventory Unit.
- Supervising state forest inventories (Per -Harvest & Post – Harvest).
- Advising communities on Participatory Forest Management.
- Implementing and supervising the Sustainable Forestry Management Program for forest dependent communities (World Wildlife Fund Project).
- Maintaining registers of all inventories on forest resources conducted in Guyana.
- Conducting field audits to verify information provided in Annual Plan of operation of all forest concessions.
- Verifying information on the log tracking database.
- Supervising state forest concession boundary demarcations.
- Supporting the allocation of forest areas for productive uses.
- Designing and implementing national forest resources management databases.
- Conducting training programs in the use of GPS, Compass & Mapping technology for the forest sector and Guyana Forestry Commission.
- Evaluating Forest Management & Annual Operation Plans.
- Working in collaboration with other natural resources agencies.
- Evaluating staff performance, ensuring the maintenance of discipline & the efficient use of resources.

2005 - 2007 Guyana Forestry Commission. 1, Water Street Kingston, Georgetown.
Assistant Commissioner of Forests – Forest Resource Planning

- Managing large concession administration database.
- The preparation of work plans and budgets for the Forest Resource Management Division.
- Advising the forest sector on matters relating to forest resource and forest management planning.
- Evaluating Forest Management & Annual Operation Plans.
- Working in collaboration with other natural resources agencies.
- Advising communities on Participatory Forest Management.
- Supervising state forest inventories (Per -Harvest & Post – Harvest).
- Supervising state forest concession boundary demarcations.
- Conducting training programs in Reduce Impact Logging (RIL) technology for the forest sector.
- Collecting information on communities, monitoring social impacts of forest operations and reporting on social issues.

- Supporting the allocation of forest areas for productive uses.
- Ensuring the participation of communities & stakeholders in forest area management planning and preparing area management plans.
- Supervising the updating of forestry concession maps.
- Compiling the Permanent Sample Plot Guidelines for Guyana.
- Conducting training programs in the use of GPS, Compass & Mapping technology for the forest sector and Guyana Forestry Commission.
- Evaluating staff performance, ensuring the maintenance of discipline & the efficient use of resources.

2003-2005 Guyana Forestry Commission. 1, Water Street Kingston, Georgetown.
Assistant Commissioner of Forests – Forest Resources Information

- Consulting with agencies responsible for natural resources information & assisting with the preparation of forest resource information.
- Supervising data analysis, evaluating resource information & preparing reports.
- Providing mapping services to the Guyana Forestry Commission and the forest sector.
- Research & advise the Guyana Forestry Commission on forest resource information & GIS/GPS & Mapping practices.
- Assisting with the preparation of work plans & budgets for the Division.
- Supporting the allocation of forest resources for productive uses.
- Conducting training programs in the use of GIS/GPS & Mapping technology for the forest sector and the Guyana Forestry Commission.
- Monitoring & evaluating staff performance, ensuring the maintenance of discipline & the efficient use of resources.

2002-2003 Guyana Forestry Commission. 1, Water Street Kingston, Georgetown.
Resource Planning Officer

- Planning forest surveys & inventory programmes.
- Assisting in establishing, training & equipping the survey & inventory field teams.
- Assisting in the procurement & management of approved materials & equipment.
- Preparing & implementing work plans for related field surveys & inventories.
- Drafting of the Code of Practice for the Harvesting of Nibi & Kufa (NTFP).
- Drafting of the Code of Practice for the Harvesting of Manicole (NTFP).
- Monitoring data collection & data processing for non timber forest products.
- Supervising the establishment of Permanent Sample Plots for Nibi & Kufa (NTFP).
- Supervising the maintenance of forest & plantation reserves.

1998-2002 Guyana Forestry Commission. 1, Water Street Kingston, Georgetown.
Senior Field Assistant

- Implementing work plans provided by the Assistant Commissioner Forests & Resource Planning Officers.
- Supervising the provision of equipment, transport & supplies for field operations.
- Managing costs to ensure field exercise objectives are achieved & executed to a high standard according to plans & procedures.
- Providing information, liaising with government agencies, communities & other stakeholders.

1994-1998 Guyana Forestry Commission. 1, Water Street Kingston, Georgetown.
Field Assistant III

- Conducting concession boundary demarcations & verifications.
- Conducting forest inventories.
- Establishing Permanent Sample Plots & assisting in research work.
- Assisting in the preparation of maps for concessionaires & field work.
- Providing training for internal & external stakeholders.

EDUCATION

BSc. Forestry (Credit) **2002**
University of Guyana

Dip. Forestry **1994**
Univesity of Guyana

CURRICULUM VITAE

NAME: SHYAM NOKTA

ADDRESS:
60 Area H Ogle
East Coast Demerara
Guyana

CONTACTS:
Tel: + 592 222 4565
Fax: + 592 222 3172
Email:shyamnokta@gmail.com
Skype: shyam.nokta1

AREAS OF EXPERTISE

- Climate Change and Green Growth Policy and Strategy Development
- Environmental Assessment and Management
- Environmental Monitoring and Auditing
- Biodiversity Assessment and Management Planning
- Ecotourism Planning and Development

QUALIFICATIONS

The University of Oxford Brookes (September 1999)
School of Planning
Masters of Science in Environmental Assessment and Management
(Pass with Distinction)

The University of Guyana (September 1997 - July 1998)
Faculty of Arts
Tourism Studies Unit
Diploma in Tourism Studies
(Pass with Distinction)

The University of Guyana (January 1994 - July 1997)
Faculty of Natural Sciences
Environmental Studies Unit
Bachelors Degree in Environmental Studies
(Pass with Distinction)

SCHOLARSHIPS AND HONORS

2003. Fulbright - OAS Ecology Initiative
Scholarship to pursue Doctoral Studies

1999. Inter-American Development Bank
Japan-IDB Scholarship Programme Award for outstanding academic performance

1998. Inter-American Development Bank
Japan-IDB Scholarship to pursue Masters Studies

University of Guyana

1997. Environmental Studies Unit Award - sponsored by the European Commission
(Best Graduating Student in the Environmental Studies Unit)

1996. Environmental Studies Unit Award
(Best Third Year Student in the Environmental Studies Programme)

1994. University of Guyana Award
(Based on outstanding performance at the Annual University Examination - Faculty of Natural Sciences to a student who obtained a GPA of not less than 2.7)

1994. The Charles - Sue - Wah - Sing Award
(Best First Year Student with a GPA of not less than 2.7 in the Faculty of Natural Sciences)

2003. Organisation of American States (OAS) -Fulbright Scholarship to pursue PhD Studies.

1999. Inter-American Development Bank (IDB), Japan-IDB Scholarship Programme Award for outstanding academic performance

1998. Inter-American Development Bank (IDB), Japan-IDB Scholarship to pursue Masters Studies

WORK EXPERIENCE

Shyam Nokta comes from a background in natural resources management with substantial experience in climate change, green growth strategy development and implementation, environmental and social impact assessments (EIAs), strategic environmental assessment (SEAs), parks and protected areas planning and management, marine turtle conservation, ecotourism planning and management, and sustainable forest management.

Mr. Nokta has accumulated over 15 years' experience from his work with local and international NGOs, Government and the Private Sector and has been associated with many of Guyana's premier climate change and conservation initiatives as well as major infrastructure and development projects. Principal among these include the Low Carbon Development Strategy (LCDS) and Norway Partnership; the National Protected Areas Act and establishment of the National Protected Areas Commission; and the management of the Iwokrama, Kaieteur National Park and Shell Beach Protected Areas.

Mr. Nokta serves as principal for one of Guyana's premier environmental consultancy firms, Environmental Management Consultants (EMC) which specializes in environmental assessments and support services and which works across a range of sectors including forestry, manufacturing, mining, agriculture, infrastructure and oil and gas.

Mr. Nokta has functioned at the policy, management and technical levels where he has managed large teams and diverse stakeholder groups. He has also worked on a number of donor supported initiatives which include The Global Environment Facility (GEF), World Bank, Inter-American Development Bank (IDB), United Nations Environment Programme (UNEP), United Nations Development Programme (UNDP), Caribbean Development Bank (CBD) among others. Mr. Nokta is familiar with all three of the Rio Conventions – the UNCBD, UNFCCC, and UNCCD, having been involved in initiatives to meet the requirements of these Conventions.

EMPLOYMENT BACKGROUND

The Energy and Resources Institute (TERI) (June 2015-Present)
Chief Representative for the Caribbean
Responsible for coordinating TERI's work in the Guyana and the wider Caribbean with specific focus on promoting energy efficiency and renewable energy development.

Office of the President (January 2014 – May 2015)
Consultant to the Office of the President (Pro Bono)
Provided advise and technical guidance on climate change with particular focus on Guyana's Low Carbon Development Strategy (LCDS) and the Partnership with the Kingdom of Norway.

Office of the President (July 2008 – December 2013)
Head, Office of Climate Change
Responsible for coordinating Guyana's response to climate change and the operations of the Office of Climate Change (OCC). Principal tasks included:

- Setting up the Office of Climate Change and overseeing the institutional arrangements and recruitment of personnel.
- Serving as Guyana's focal point to Mc Kinsey and Co. and the Clinton Foundation to develop Guyana's Low Carbon Development Strategy (LCDS) and to coordinate its launch, national stakeholder awareness and engagement, implementation and subsequent revisions and updates.
- Serving as Guyana's Focal Point to the United Nations Convention on Climate Change (UNFCCC) and the Designated National Authority (DNA) to the Clean Development Mechanism (CDM).
- Coordinated the preparation of Guyana's 2nd National Communication to the United Nations Framework Convention on Climate Change (UNFCCC)
- Provided technical support for the preparation of Guyana's R-PIN and R-PLAN for the World Bank financed Forest Carbon Partnership Facility (FCPF).
- Establishing formal links with The Energy and Resources Institute (TERI) through an MoU with the Government of Guyana and which has facilitated technical support to Guyana in energy efficiency, transfer of technology.
- Serving as Convenor of the Steering Committee for Guyana's Low Carbon Development Strategy.
- Serving as Guyana's representative on the High Level Advisory Committee of the UN-ECLAC funded project *A Review of the Economics of Climate Change in the Caribbean.*
- Serving as Guyana's representative on the Board of the Caribbean Climate Change Centre (CCCCC). (October 2013 to May 2015).

Environmental Management Consultants (March 2003 - present)
Principal & Natural Resources and Environment Specialist
Responsible for establishing EMC and overseeing its growth as one of Guyana's leading environmental consultancies offering a range of environmental and other support services to Government, NGOs and the private sector.

Served as project principal for the following consultancies.

Environmental and Social Impact Assessment Studies (ESIAs)	
TOURISM	***Adam Development/Urbahn Associates (ADUA)*** ESIA for Georgetown Marriott Hotel, Casino and Entertainment Complex, Kingston, Georgetown
	BK International ESIA for Agriculture and Tourism Project at Saxacalli, Essequibo River.
FORESTRY	***Simon & Shock International Logging Inc. (SSILI)*** ESIA for Logging and Sawmilling operation in the Upper Essequibo Region.
	CPT Incorporated ESIA for Logging and Sawmilling operation in the Cuyuni District.
	Barama Housing Incorporated ESIA for Logging operation in the Cuyuni-Mazaruni District.
	Demerara Timbers Limited ESIA for Logging operation in the Siparuni District.
	Timber Trader S.A. Incorporated ESIA for Logging and processing operation in the Mazaruni-Puruni District.
	Garner Forest Industries Incorporated ESIA for Logging and processing operation in the Puruni District.
	Jaling Forest Industries Incorporated ESIA for Logging and processing operation in the North West District.
MANUFACTURING	***Rudisa International Guyana Limited*** ESIA for Cement Bagging Facility at Supply, East Bank Demerara.
INFRASTRUCTURE	***Marcel Gaskin & Associates Limited*** ESIA and Environmental Management Plan for the Rehabilitation of the West Coast Demerara Road.
	CEMCO-ND LEA Provided support for the ESIA for the Berbice River Bridge Project.
ENERGY	***ACORN International LLC - Anadarko Petroleum Corporation*** In country partner for Environmental Impact Studies for the Roraima Block, offshore Guyana.
	Environmental Sciences Limited (ESL)- REPSOL N.V In country partner for Environmental Impact Studies for the Jaguar 1 well.
	PMO Global Services - REPSOL N.V In country partner for the SEA for REPSOL's Georgetown Block.
	PMO Global Services - CGX Resources Inc. In country partner for the SEA for CGX's Corentyne Block.
MINING	***Guyana Industrial Minerals Inc. (GINMIN)*** ESIA Addendum and EMP for mining in Bonasika Reserves 1, 2 and 5, Right Bank Essequibo River, construction of the Haul Road and construction and operation of the Processing Facility at Sand Hills on the Demerara River.
	Linden Quarries Incorporated ESIA for stone uarry operations at Arimai Landing, R. B. Mazaruni River, Essequibo.
	Bauxite Company of Guyana Inc. (subsidiary of RUSAL) ESIA for mining operations at 22 Kurubuka, Berbice

Environmental Management Plans (EMP) and Assessment Studies	
TOURISM	***Caribbean Environmental Management Consultants Inc. (CEMCO Inc.)*** Preliminary Environmental Scoping Study: Cricket World Cup 2007 Host Venue Selection Bid Book.
	Celine Atlantic View Resort EMP – Restaurant and Bar at Kitty Seawall, Georgetown.
FORESTRY	***Barama Company Limited*** EMP – Logging operations at Left Bank Amakura River, Left Bank Yarakita River, Left Bank Anabisi River, Right Bank Kaituma River, North West District, Regions 1 & 7.
	The World Bank & Guyana Forestry Commission Revised and Updated the Report *'Law Compliance and Prevention and Control of Illegal Activities in the Forest Sector of Guyana'.*
	Guyana Forestry Commission Community Forest Management Plans for Batavia and Kwebanna.
	Barama Company Limited Road Management Plan for Compartment 5 of Barama Company's operations.
	Barama Company Limited EMP – Sawmill and Plywood Factory operations at Land of Canaan, East Bank Demerara.
	Barama Company Limited Report on the Actions to Address Corrective Action Requests for FSC Forest Management Certification – Compartment 5.
	Guyana Forestry Commission Sector Environmental Assessment of Guyana's Forestry Industry.
FISHERIES	***Shakoor's Trading*** EMP – Salted Fish Processing Plant, Eccles Industrial Site, East Bank Demerara.
	L&T Seafoods EMP – Shark Fin and Fish Glue Processing Plant, Eccles Industrial Site, East Bank Demerara.
MANUFACTURING	***Sterling Products Limited (SPL)*** EMP – Manufacturing Facility at Providence, East Bank Demerara.
	Comfort Sleep EMP – Foam Manufacturing Plant at 49 Eccles Industrial Estate, East Bank Demerara.
	Demerara Distillers Limited EMP – Alcohol Distillery Plant and Waste Treatment and Biomethanisation Plant at Plantation Diamond, East Bank Demerara.
	Avisha Readymix (Guyana) Inc. Readymix and Cement block making facility at Soesdyke, East Bank Demerara.
INFRASTRUCTURE	***Surrey Paving & Aggregates Co. Ltd. & BK International Inc.*** EMP – Rehabilitation of the West Coast Demerara Road.
	Central Housing & Planning Authority (CH&PA) EMP – East Coast–East Bank Road Linkage.
	Marcel Gaskin & Associates Limited EMP – East Coast Demerara Four Lane Extension.
	CGX Resources Inc. EMP – Wharf, Logistics Yard and Storage Facility, Crab Island, Berbice River.

Environmental Management Plans (EMP) and Assessment Studies	
	CEMCO-ND LEA Environmental Assessment component of a Feasibility Study of the Southern Approach Corridor from the Cheddi Jagan International Airport to Georgetown.
	Royal Haskoning – IDB In-country partner for the Strategic Environmental Assessment (SEA) of Transport Infrastructure Initiatives (focus on IIRSA Corridors) in Guyana.
PHARMACEUTICAL	***Essential Supplies Incorporated*** EMP – Pharmaceutical Manufacturing Complex, Eccles Industrial Site, East Bank Demerara.
HOUSING	***VIKAB Consultants*** Environmental Assessment study of the Bartica 4-mile, Good Hope, and Hope Experiment-Waterloo Low Income Housing Development Project.
	CEMCO Inc. Environmental Assessment study of the Diamond Low Income Housing Development Project.
ENERGY	***Shawnee Service Station Inc.*** EMP – Service Station at Block X Soesdyke, East Bank Demerara.
	Demerara Oxygen Company Limited EMP - DOCOL operations at Old Road Eccles, East Bank Demerara.
	Vreed-en-Hoop Service Station EMP – Fuel Station at Vreed-en-Hoop, West Coast Demerara.
	Linden Gas Station EMP – Supermarket, Fuel Station and Wash Bay at Mackenzie, Linden Region 10.
	Eccles Service Station EMP – Fuel Station at Eccles, East Bank Demerara.
	AM Khan Filling Station EMP – Fuel Station at Anna Regina, Essequibo Coast.
	Two Brother's Incorporated EMP – Fuel Bulk Terminal at Parika, East Bank Demerara, Guyana and Service Station, Hotel, Food Restaurant and Convenience Store at Land of Canaan, East Bank Demerara.
	Scott's Service Station EMP – Fuel Service Station at 1st Street, Bartica.
	DELTA Caribbean N.V. EMP - Wind Farm at Hope Beach.
DRAINAGE AND IRRIGATION	***CEMCO Inc.*** Environmental Assessment for the East Demerara Water Conservancy Northern Relief Structure at Hope/Doch Four.
	Ministry of Agriculture/ Agriculture Sector Development Unit (ASDU) Preparation of Environmental/Social Assessment for the Rehabilitation of the Cunha Canal.
	Mott Mc Donald-CEMCO Environmental Assessment component of the Feasibility Study for the Rehabilitation of Guyana's Drainage and Irrigation System.
	CEMCO Terms of Reference for the Environmental Assessment Studies required for the Canje Irrigation Project and the Cozier Dam.

Environmental Management Plans (EMP) and Assessment Studies	
AGRICULTURE	***Ministry of Agriculture/ National Drainage & Irrigation Authority (NDIA)*** EMP – Aurora Land Development Project on the western Essequibo Coast.
	Standard Agro-Forestry Inc. EMP – Integrated Farm Project at the Intermediate Savannahs, Region 10.
	Blue Wave Plantations Inc. EMP – Integrated Farm Project at the Intermediate Savannahs, Regions 6 & 10.
	Santa Fe Inc. EMP – Integrated Farm Project (Crops and Livestock Farming) at the North Rupununi Savannahs, Region 9.
	CEMCO Inc. Conducted an environmental performance analysis of GUYSUCO's Factory Operations including environmental performance and an environmental feasibility of the proposed Skeldon Expansion Project.
MINING	***Benjamin Stone Quarry*** EMP – Stone Quarry at Itaka, East Bank Essequibo.
	Bauxite Company of Guyana Inc. EMP – Bauxite mining at 22 Kurubuka Deposit.
	Bauxite Company of Guyana Inc. EMP – Bauxite mining at Block 38 Cocorite Deposit.
	Guyana Industrial Minerals Inc. (GINMIN) EMP – Bauxite mining in Bonasika 6 and 7 Deposits, Right Bank Essequibo River and Left Bank Demerara River.
	Bauxite Company of Guyana Inc. EMP – Bauxite mining at 2 Manaka and Block 5 North East Deposits.
HEALTH	***Inter-American Development Bank (IDB)*** Environmental and Social Analysis (ESA) including an Environmental and Social Management Plan for the project "Support to Improve Maternal Child Health".

Closure and Decommissioning Plan (CDP)	
MINING	***Bauxite Company of Guyana Inc.*** CDP for bauxite mining at Block 5 North East Deposit.
	Bauxite Company of Guyana Inc. CDP for bauxite mining at Bissaruni and West Pit.

Other Project Areas	
TOURISM	***Amazon Cooperation Treaty Organisation (ACTO)*** Compilation of Guyana data for Amazon-Caribbean Tourism Trail.
PROTECTED AREAS	***Environmental Protection Agency*** Assisted in preparing the National Strategy for the Establishment of a System of Protected Areas in Guyana.
	Iwokrama International Centre for Rainforest Conservation and Development Assessed Iwokrama's potential for nomination as a World Heritage Site or Biosphere Reserve.
WILDLIFE & BIODIVERSITY	***Troy Resources Guyana Inc. (TRGI)*** Prepared Biodiversity Management Plan for TRGI Project Areas.

Other Project Areas	
	Stronghold Guyana Inc. Conducted Baseline Biodiversity and Surface Water Assessment at Eagle Mountain concession.
	Guyana Industrial Minerals Inc. (GINMIN) Prepared Biodiversity Management Plan for GINMIN Project Areas.
	GINMIN Conducted Biodiversity Monitoring at GINMIN Project Areas.
	Saxacalli Rainforest Centre Managing the Centre which promotes environmental awareness and biodiversity research.
	Guyana Sugar Corporation Inc. (GUYSUCO) Conducted a Rapid Biodiversity Assessment of Halcrow and GUYSUCO Conservancies.
RISK MAPPING	***OXFAM*** Conducted flood vulnerability assessment and developed flood risk maps for 20 communities along the lower East Coast Demerara.
ENVIRONMENTAL MONITORING AND AUDITING	***Troy Resources Guyana Inc. (TRGI)*** Conducting Environmental Monitoring for gold mining and processing activities within the Hicks/Kaburi Concession situated at Black Water Creek, Kaburi Area, and Region 7.
	Noble House Seafoods Ltd (NHSL) Conducting Environmental Monitoring for seafood harvesting and processing operation at Block 'X', Eccles, East Bank Demerara.
	Surrey Paving & Aggregates Co. Ltd. & BK International Inc. Conducting Environmental Monitoring for the rehabilitation of the West Coast Demerara Road.
	University of Guyana Conducting Environmental Monitoring for Component 2: Infrastructure Rehabilitation under the University of Guyana Science & Technology Support Project.
	DIPCON Engineering Services Limited (DIPCON) Conducted Environmental Monitoring for the Expansion of the East Coast Demerara Public Road Four Lane (Mon Repos to Triumph) Lot 5.
	Barama Company Limited Conducted Environmental Compliance Monitoring for Land of Canaan and Buckhall Operations.
	GINMIN Conducting Environmental Monitoring at GINMIN Project Areas.
	DIPCON Conducted Environmental Monitoring for the Expansion of the East Bank Demerara Public Road Four Lane (Providence to Diamond) Lot 1.
	CEMCO Inc. Conducted Environmental Monitoring for the Community Roads Improvement Project (CRIP)
	CEMCO Inc. Conducted Environmental Monitoring for the Construction of the East Demerara Water Conservancy Northern Relief Structure and Associated Drainage and Irrigation Canals at Hope/Doch Four.
	SRK'Ngineering Conducted Environmental Monitoring for SRK'Ngineering for the Rehabilitation of the East and West Canje Roads.

Other Project Areas	
	CGX Resources Inc. Conducted Environmental Monitoring of operations of the Wharf, Logistics Yard and Storage Facility at Crab Island, Berbice River.
	CGX Resources Inc. Conducted Environmental Monitoring of Eagle 1 well, including assisting in plans preparation, monitoring of both onshore and offshore activities, and report preparation to ensure regulatory and permitting compliance.
	R. Bassoo & Sons Construction Company Conducted Environmental Monitoring for R. Bassoo & Sons Construction Company on the Rehabilitation of Lot II Structure - Lot A2 project.
	Courtney Benn Contracting Services Limited Conducted Environmental Monitoring for Courtney Benn Contracting Services Limited on the Rehabilitation of Lot II Structure - Lot A1 project.
	Barama Company Limited Conducted Environmental Monitoring for Barama Land of Canaan and Buckhall Operations.
	Bauxite Company of Guyana Inc. Conducting Environmental Monitoring of existing operations at Aroaima and Kwakwani
	Marudi Creek Resort Conducted environmental audit of operations as a requirement of the Environmental Protection Agency.
TRAINING	***Environmental Protection Agency*** Conducted a three-day training workshop on 'Strengthening the capacity of EPA Field Officers to facilitate greater oversight of gold mining operations'.
	Hydroplan Ing. – Solid Waste Management Training Conducted training sessions and prepared manuals for the courses Occupational Health and Safety; Hazardous Waste Management; and Registration of Industrial Waste Generators as part of Georgetown Solid Waste Management Programme.
	Institute for International Cooperation in Agriculture (IICA) Developed and Implemented Awareness Programme on Environmental Issues and Environmental Management within the Tri-Lakes Communities of Mainstay/Whyaka, Tapakuma and Capoey
	Linden Economic Advancement Programme (L.E.A.P.) Conducted a two-day training workshop titled *'Tourism and Environmental Management – A Focus on Region 10'.*
	Bauxite Company of Guyana Inc. Conducted a training programme on environmental awareness and best-practice for BCGI's existing bauxite operations at Aroaima and Kwakwani, Berbice.
	THAG-CPEC Conducted a Tourism Awareness Programme on community-based tourism for communities in the North Rupununi.

Programme Reviews, Proposal Preparations and Technical Assistance	
TOURISM	***Ministry of Tourism, Industry and Commerce*** Providing technical advise to the Minister of Tourism, Industry and Commerce of Guyana on tourism and environment issues and the implementation of the Ministry's Work Programme.
	Grand Coastal Inn Prepared application for Environmental Permits.
	L&D North West Resort Inc.

Programme Reviews, Proposal Preparations and Technical Assistance	
	Prepared a project proposal for the establishing of a small hotel (Georgetown) and interior resort (North West District).
	Wilderness Lodge Assisted in securing Environmental Permit.
ENVIRONMENT	***Environmental Protection Agency*** Conducted Second and Third External Review of Inter-American Development Bank's Environmental Management Programme – Phase II Project to the EPA.
	Environmental Protection Agency Conducted External Review of Inter-American Development Bank's Environmental Management Programme – Phase II Project to the EPA.
MINING	***Aroaima Mining Company Inc. & Bauxite Company of Guyana Inc.*** Provided technical assistance in preparing and submitting its applications for environmental authorization for bauxite mining.
ENERGY	***CGX Resources Inc.*** Provided technical assistance in preparing and submitting its applications for environmental authorization for seismic and exploratory drilling.

Multilateral Environment Agreements (MEAs) and GEF Funded Initiatives	
Biodiversity (UNCBD)	***Environmental Protection Agency*** Prepared the Third National Report on the implementation of the Cartagena Protocol on Biosafety under the United Nations Convention on Biological Diversity.
	Environmental Protection Agency Prepared the Third, Fourth and Fifth National Reports to the United Nations Convention on Biological Diversity.
	Environmental Protection Agency Prepared the Third Phase of Guyana's National Biodiversity Strategy & Action Plan.
	Environmental Protection Agency Prepared the Second Phase of Guyana's National Biodiversity Action Plan
	Environmental Protection Agency Assessed Capacity Building Needs for Initial Assessment and Monitoring, including Taxonomy as part of the Assessment of Capacity Building Needs for National Biodiversity Priorities Project.
	Environmental Protection Agency Conducted Stocktaking of Existing Capacity and Mechanisms as part of the Assessment of Capacity Building Needs for National Biodiversity Priorities Project.
	Environmental Protection Agency Supported the integration of UN Convention Activities into Annual Work Programmes of Agencies as part of the UNDP funded National Capacity Self-Assessment Project (NCSA).
Desertification (UNCCD)	***Guyana Lands & Surveys Commission*** Provided technical support for the aligning of Guyana's National Action Plan to the United Nations Convention to Combat Desertification's 10 Year Strategy (2008-2018)
	Guyana Lands & Surveys Commission Prepared Guyana's Fourth National Report to the United Nations Convention to Combat Desertification.

Multilateral Environment Agreements (MEAs) and GEF Funded Initiatives	
	United Nations Development Programme Prepared a Medium Size Project (MSP) Proposal for Sustainable Land Management.
	Guyana Lands & Surveys Commission Prepared the National Action Programme for the United Nations Convention to Combat Desertification.
	Guyana Lands & Surveys Commission Prepared Guyana's Third National Report to the United Nations Convention to Combat Desertification.
	Environmental Protection Agency Conducted a Stocktaking and Thematic Assessment of the United Nations Convention to Combat Desertification as part of the UNDP funded National Capacity Self-Assessment Project.
Water Resources Management	***Ministry of Housing & Water (MoHW)/ Guyana Wastewater Revolving Fund (GWRF)*** Prepared the Wastewater Management Strategy for Guyana under the GEF CReW Project "*Strengthening policy and institutional frameworks while building capacity for wastewater management in Guyana".*

Ministry of Tourism, Industry and Commerce (November 2002 – April 2009)
Tourism Technical Consultant to the Minister
Providing technical and strategic planning advise to the Minister on tourism and environment issues and the implementation of the Ministry's Tourism Work Programme with the principal achievements being the development and passage of legislation to establish a Tourism Authority and overseeing the setting up of the Authority.

Fauna & Flora International (September 2002 – October 2005)
In-Country Representative
Responsible for coordinating and providing technical guidance and input to activities of the Darwin Initiative Project, funded by the UK Government and with emphasis on training, capacity building and institutional strengthening for Guyana's Protected Areas System with focus on Shell Beach. Principal achievement included the coordination and execution of a series of training workshops on protected areas planning and management.

- Financing Protected Areas – Options for Guyana (30th & 31st March 2005)
- Techniques in Community Resource Evaluation – A Focus on Shell Beach (6th – 9th Sept 2004)
- Management Planning for Protected Areas (9th – 12th Aug 2004)
- Biodiversity Rapid Assessment – A Focus on Shell Beach (15th & 16th April 2004)
- Concepts, Methods and Processes for Community Education and Awareness – A Focus on the Shell Beach Protected Area Process and the Work of the GMTCS CEW's (6th & 17th March 2004)
- Developing a Public Awareness Strategy for Guyana's Protected Areas – A Focus on Shell Beach (3rd – 5th Nov 2003)
- Protected Areas Categories and their Management Implications: A Focus on Shell Beach (29th Sept – 1st Oct 2003)
- Community Consultation Processes: Designing A Model for Shell Beach (19th -21st May 2003)
- Project Management and Administration: A Smorgasbord of the Essentials (9th – 11th April and 14th – 16th April 2003)
- Protected Areas Management in Guyana – Institutional Management, Roles and Responsibilities (2nd – 4th Dec 2002)

World Wildlife Fund (WWF) Protected Areas Project (January 2003 – September 2003)
Project Director
Responsible for the implementation of the WWF funded project focused on the establishment and management of the Shell Beach Protected Area.

The Guyana Marine Turtle Conservation Society (August 2000 – September 2003)
Technical Director
Overall responsible for providing technical guidance to the Society and planning, overseeing and implementing the Society's programmes and activities for education and awareness, community empowerment, research, and protected areas.

The Iwokrama International Rainforest Programme (November 1999 – October 2001)
Professional Development Fellow – Protected Area Management
Responsible for assisting the Iwokrama Forest Manager and Human Resources Development Specialist to prepare and implement management plans for the Wilderness Preserve and other high amenity areas within the Iwokrama Forest; prepare guidelines for rangers and other staff with regard to working with national agencies and local communities in relation to patrolling and law enforcement within the Reserve and along the rivers and transport corridors that pass through the Reserve or form its boundaries; and planning and implementing a 2-year comprehensive ranger-training programme for Iwokrama rangers.

The University of Guyana (September 1999 – July 2001) Faculty of Arts – Department of Caribbean and Tourism Studies
Part-Time Lecturer on Ecotourism and Sustainable Tourism

The Environmental Protection Agency of Guyana (EPA) (August 1997 - June 1998)
Environmental Officer
Directly responsibility for biodiversity, natural resource management and tourism issues at the EPA and represented the EPA on the Natural Resources Management Project (NRMP).

Ministry of Public Works and Communications (July 1994 -August 1995) - Environment Division; Project Executing Unit.
Part - time assistant to the Environmental Officer

PROFESSIONAL DEVELOPMENT TRAINING

2000. November. New York, USA.
Completed the training course *'The Essentials for Successful Project Management'* conducted by Cornell University.

2001. July. Georgetown, Guyana.
Attended the training course *Biodiversity Protection in Forest Concession Area'* conducted by The Tropenbos Guiana Programme.

1999. December. Belem, Brazil.
December 1st – 15th, 1999
Completed the training course '*Techniques in Reduced Impact Logging'* conducted by the Tropical Forest Foundation (TFF).

1998. May. Georgetown, Guyana
Participated in the Inbound Ground Tour Operations Training Programme conducted by the Caribbean Tourism Organization (CTO).

1997. October. Georgetown, Guyana
Participated in the Training Programme on Sustainable Forest Management held by the

Environmental Protection Agency, Guyana Forestry Commission and ORGUT Consulting AB and sponsored by the Government of Guyana and the Inter-American Development Bank

BOARDS AND COMMITTEES

March 2013 to May 2014
Member of the Board of the Caribbean Climate Change Centre (CCCCC).

May 2009 to January 2014
Convenor of the Multi-Stakeholder Steering Committee for Guyana's Low Carbon Development Strategy (LCDS), the body responsible for overseeing the LCDS preparation and implementation.

January 2013 to May 2015
Chairman of the Board of the Protected Areas Commission, the body responsible for overseeing the planning and development of urban parks and protected areas in Guyana.

January 2011 to June 2012
Member of the Board of the Guyana Water Inc.

April 2003 – October 2011
Chairman of the Board of the Kaieteur National Park, the body with overall responsibility for the planning and management of the Park.

January 2004 – December 2005
Member of the Board of the National Trust of Guyana.

August 2002 – December 2003
Member of the Board of Guyana Tourism Authority, the body responsible for overseeing the work of the semi-autonomous Tourism Authority.

July 2001- August 2002
Chairman of the Ministerial Advisory Committee on Tourism (MACT) responsible for advising the Minister of Tourism on tourism and tourism related issues.

January 2001 – July 2001
Coordinator of a National Task Force established to assist the Minister of Tourism and Industry to develop the tourism sector in Guyana.

AFFILIATIONS

Registered Consultant with the Environmental Protection Agency of Guyana
Member of the International Association for Impact Assessment (IAIA)

MEETINGS, SEMINARS AND WORKSHOPS

2015. February. New Delhi, India.
Participated as a member of the Government of Guyana delegation to the 15th Delhi Sustainable Development Summit (DSDS) `*Sustainable Development Goals and Dealing with Climate Change.'*

2014. November. Georgetown, Guyana.
Participated in the workshop *Sharing Experiences on the FLEGT VPA Process* convened by Tropenbos International, Guyana Forestry Commission and other partners.

2014. June. Rome, Italy.
Participated as a member of Guyana's delegation to the 22nd Session of the Food and Agriculture Organisation (FAO) Committee on Forestry (COFO).

2014. February. Buccament, St. Vincent and the Grenadines.
Participated as a member of Guyana's delegation to the 25th Inter-sessional Meeting of the Conference of Heads of Government of the Caribbean Community.

2014. February. Washington, USA.
Participated as Guyana's representative to the Special Meeting of the Organisation of American States (OAS) Committee on Hemispheric Security titled *The Link between Security and Development in the Caribbean.*

2014. February. New Delhi, India.
Participated as a member of the Government of Guyana delegation to the 14th Delhi Sustainable Development Summit (DSDS) `*Attaining Energy, Water and Food Security for All*'.

2013. November. Warsaw Poland.
Participated as a member of the Government of Guyana's delegation at the High Level Segment of the 19th Conference of Parties Meeting of the United Nations Convention on Climate Change (UNFCCC).

2013. August. Paramaribo, Suriname.
Participated as a member of Guyana's delegation to the 3rd International Congress on Biodiversity of the Guiana Shield.

2013. February. New Delhi, India.
Participated as a member of the Government of Guyana delegation to the 13th Delhi Sustainable Development Summit (DSDS) `*The Global Challenge of Resource Efficient Growth and Development*'.

2012. November. London, United Kingdom.
Participated as a member of the Government of Guyana delegation to meeting convened by His Royal Highness Prince of Wales on Forests and Climate Change.

2012. September. Jeju, South Korea.
Participated as a member of Guyana's delegation to the 2012 IUCN World Conservation Congress.

2012. June. Rio De Janeiro, Brazil.
Participated as a member of the Government of Guyana delegation to the Rio+20 Earth Summit.

2012. April. Georgetown, Guyana.
Participated as a member of the Government of Guyana delegation to the 13th Annual Caribbean Conference on Sustainable Tourism Development *"Keeping the Right Balance: Sustaining Our Resources"*.

2012. March. Bonn, Germany.
Participated as Guyana's representative to the 113th Meeting of the United National Convention on Climate Change (UNCCD) CDM-DNA Training Forum and the 1st Sustainable Development Mechanism Joint Coordination Workshop.

2012. February. New Delhi, India.
Participated as a member of the Government of Guyana delegation to the 12th Delhi Sustainable Development Summit (DSDS) `*Protecting the Global Commons: 20 Years Post Rio*'.

2011. February. New Delhi, India.
Participated as Guyana's representative to the 11th Delhi Sustainable Development Summit (DSDS) `*Tapping Local Initiatives and Tackling Global Inertia*'.

2010. December. Cancun, Mexico.
Participated as a member of the Government of Guyana's delegation at the High Level Segment of the 16th Conference of Parties Meeting of the United Nations Convention on Climate Change (UNFCCC).

2010. November. The Hague, Netherlands.
Participated as Guyana's representative to the Global Conference on Agriculture, Food Security and Climate Change organized by the Dutch Government in collaboration with the World Bank and FAO.

2010. November. Georgetown, Guyana.
Participated as a member of the Government of Guyana Delegation to the 4th Ordinary Meeting of the Council of Heads of State and Government of the Union of South American Nations (UNASUR).

2010. February. Washington, USA.
Participated in Forest Carbon Finance 2010 – *Getting to Scale, Getting Results.* Sponsored by WWF, Duke University and Harvard Law School.

2009. December. Copenhagen, Denmark.
Participated as a member of the Government of Guyana's delegation at the High Level Segment of the 15th Conference of Parties Meeting of the United Nations Convention on Climate Change (UNFCCC).

2009. November. Manaus, Brazil.
Participated as a member of Guyana's delegation to the Meeting of Heads of States of the Amazon Countries and Preparatory Meeting of Chief Negotiators on Climate Change.

2009. March. Capitol Hill, Washington USA.
Attended as part of the Government of Guyana's delegation, the forum *"Forests, Finance, People and Climate Change: International Perspectives for US Legislation"* convened by US Congressman Jay Inslee and Senator Robert Menendez.

2009. March. Washington, USA.
Participated in Forest Carbon Finance 2009 – *Making Forest Carbon Markets Work.* Sponsored by WWF, Duke University and Harvard Law School.

2008. December. Posnan, Poland.
Participated as a member of the Government of Guyana's delegation at the High Level Segment of the 14th Conference of Parties Meeting of the United Nations Convention on Climate Change (UNFCCC).

2008. January. Santo Domingo, Dominican Republic.
Represented Guyana at the *16th Meeting of the Forum of Ministers* of Latin America and the Caribbean.

2007. December. Bali, Indonesia.
Participated as Technical Team of the Government of Guyana's delegation at the 13th Conference of Parties Meeting of the United Nations Convention on Climate Change (UNFCCC).

2007. November. New York, USA.
Participated as a member of the Government of Guyana delegation to the High Level Event *The Future in our Hands – Addressing the Leadership Challenge of Climate Change* convened by the

UN Secretary General.

2000 August. Georgetown Guyana.
Attended the 4th Sea Turtle Symposium of the Guianas held to bring together organization and individuals working on marine turtle conservation in the Guianas.

2000 March. Salvador Brazil.
Participated in World Ecotour 2000, An international gathering of professionals from around the world to discuss issues related to ecotourism planning, operation and management.

2000 April. Georgetown Guyana.
Consultation Workshop on National Environmental Action Plan (NEAP) for Guyana (2000 – 2004)

1999 July. Tokyo, Japan.
Three Day Seminar conducted by the IDB Tokyo Office on the role of the IDB and the Japan-IDB Scholarship Program in the IDB Member Countries.

1998 January. Santo Domingo, Dominican Republic.
Regional Expert Workshop on Biodiversity Strategies and Action Plans to assess and identify support activities to be included in the GEF Global Support Programme for Enabling Activities. Global Environment Facility (GEF) in collaboration with United Nations Development Programme (UNDP).

1997. Mon-Repos, Guyana.
Workshop on Sustainable Forest Management and Monitoring in Tropical Forests.
ORGUT in collaboration with the Guyana Forestry Commission and the Environmental Protection Agency.

1997. Georgetown, Guyana.
Ecological and Economic Zoning Workshop for the Americas. Government of Guyana/Amazon Co-operation Treaty (ACT)/Inter-American Development Bank (IDB).

1996. Georgetown, Guyana.
National Environmental Education Workshop to finalise the National Environmental Education and Awareness Strategy.Co-ordinated by the Office of the President.

1995. Georgetown, Guyana.
A Series of Seminars and Workshops to develop a Draft National Biodiversity Strategy of Guyana. Co-ordinated by the Office of the President.

REFERENCES

Available upon request.

CURRICULUM VITAE

NAME:
Khalid Alladin

POSITION:
Projects Manager

ADDRESS:
60 Area H Ogle
East Coast Demerara
Guyana

CONTACTS:
Tel: + 592 222 4565
Fax: + 592 222 3172
Email: khalidalladin@gmail.com

EDUCATION

The University of Guyana (1996 - 2000)
Bachelors of Arts Degree: Major – Geography, Minor – Law (Best Graduating Student)

WORK EXPERIENCE

February 2009 - present – Projects Manager, Environmental Management Consultants
Responsible for managing projects executed by the firm, including the following specific projects:

Environmental and Social Impact Assessments (EIAs) – Contributed to the following ESIA's preparation:

- Participating in the conduct of the **ESIA for Esso Exploration and Production Guyana Ltd. Liza 2 Project**. (January 2018 to present)
- Participating in the conduct of the **Risk Assessment for Schlumberger Guyana Inc. Drilling Fluids and Dry Bulking Production and Storage Facility** at Houston, EBD. (2017- present)
- Participating in the conduct of the **Ecosystem Services Survey for Esso Exploration and Production Guyana Ltd. Liza 1 Project**. (2017- present)
- Participated in the conduct of the **EIA for Tullow Oil Guyana (Tullow)** 3D seismic operations in the Orindiuk Block Area, offshore Guyana. (2016)
- Participated in the conduct of the **Environmental and Social Analyses** of Component 1 of the project to **Support and Improve Maternal and Child Health** supported by the IDB. (2016)
- Technical Team Leader for the conduct of the **EIA for Simon and Shock International Logging Inc. Logging and Sawmilling Operations** in the North Rupununi Area. (2010 to 2013)
- Technical Team Leader for the preparation of the **EIA for Anadarko Petroleum Corporation Roraima Block** within the offshore Georgetown Concession in collaboration with ACORN International. (2013)
- Technical Team Leader for the preparation of the **ESIA for the West Demerara Road Rehabilitation Project** in collaboration with Marcel Gaskin & Associates Ltd. (2012)
- Participated in the conduct of a **Coastal Sensitivity Survey** for Repsol/ESL (2011)
- Technical Team Leader for the preparation of the **EIA Addendum and Environmental Management Plan for the Bonasika Bauxite Mine and Sand Hills sintered Bauxite Production Plant and Supporting Infrastructure** for Guyana Industrial Minerals Inc. (GINMIN). (2009-2011)
- Technical team Leader for the preparation of the **EIA for Repsol proposed Jaguar 1 Exploratory Drilling Well** within the offshore Georgetown Concession in collaboration with Environmental Sciences Limited. (2010-2011)
- Technical Team Leader for the conduct of the **EIA for CPT Inc. Logging and Sawmilling Operations** in the Pomeroon Area. (2010-2011)
- Technical Team Leader for the preparation of the Environmental and Social Impact Assessment for the Ministry of Agriculture **Cunha Canal Rehabilitation Project.** (2009-2010).
- Technical Team Leader for the revision of the **EIA for the Marriot Hotel**, Kingston, Georgetown. (2010-2011)

- Conducted consultations with Government Agencies and Institutions for the preparation of the **Strategic Environmental Assessment (SEA) for CGX Offshore Exploratory Drilling Activities**. (2009)

Environmental Management Plans (EMPs) – Technical Team Leader for the preparation of the following Management Plans:

- Troy Resources Guyana Inc. Environmental Monitoring Protocols (2018)
- Edward B Beharry & Company Ltd Manufacturing Facility – Mandela Avenue (2017)
- V P Baichan Quarry – Corentyne River (2017)
- Innovative Mining Inc. Airstrip – Aramatta (2017)
- Suresh Jagmohan Asphalt Plant - Timehri (2016)
- Dr. Balwant Singh Hospital (2016)
- Troy Resources Guyana Inc. Biodiversity Management Plan (2016)
- Troy Resources Guyana Inc. Environmental Monitoring Plan (2016)
- Kilroy Mining Inc. Mining Operations at Eagle Mountain (2015-2016)
- Benjamin Stone Quarry at Itaka, Essequibo River (2015)
- Central Housing & Planning Authority East Coast–East Bank Road Linkage (2015)
- Noble House Seafood Ltd Waste Management Plan for Seafood Processing (2015)
- Sterling Products Limited Manufacturing and Processing Operations (2015)
- Ministry of Agriculture/ National Drainage & Irrigation Authority (NDIA) Aurora Land Development Project on the western Essequibo Coast (2014)
- Standard Agro-Forestry Inc. Integrated Farm Project, Intermediate Savannahs, Region 10 (2014)
- Barama Company Limited Logging Operations (2013-2014)
- Blue Wave Plantations Inc. Integrated Farm Project, Intermediate Savannahs, Region 6 & 10 (2013)
- Stronghold Guyana Inc. Baseline Biodiversity & Surface Water Assessment at Eagle Mountain Concession (2013)
- GINMIN Biodiversity Management Plan (2012)
- East Coast Demerara Roadway Four Lane Extension – Better Hope to Belfield (2012-2013)
- Santa Fe Agricultural Project, North Rupununi (2011)
- East Demerara Water Conservancy Northern Relief Structure at Hope/Dochfour, East Coast Demerara. (2010-2011)
- GINMIN Bauxite Mining within the Waratilla – Cartwright Concession (2010-2011)
- CGX Resources Inc at Crab Island, Berbice (2009-2010)
- Demerara Distillers Limited at Pln Diamond, East Bank Demerara (2010)
- Comfort Sleep at Eccles Industrial Estate, East Bank Demerara (2009-2010)
- Shawnees Service Station at Soesdyke, East Bank Demerara (2009)
- Bauxite Company of Guyana Inc. (BCGI) for mining of 2 Manaka and Block Five Deposit in the Berbice area (2009-2010), mining in Block 38 Cocorite Deposit (2012), and mining of the 22 Kurubuka deposit.

Closure and Decommissioning Plan (CDP) - Contributed to the preparation of the following:

- Troy Resources Guyana Inc. Reclamation Plan (2017-present)
- Bauxite Company of Guyana Inc. (BCGI) mining operations at Block Five Deposit in the Berbice area. (2013-2014)
- Bauxite Company of Guyana Inc. (BCGI) mining operations at West Pit and Bissaruni in the Berbice area. (2010-2011)

Environmental Compliance and Biodiversity Monitoring – Coordinated and involved in the Environmental and Biodiversity Monitoring of the following projects:

- **Sterling Products Ltd** manufacturing operation (2017-present)
- **Edward B Beharry & Company Ltd Manufacturing Facility** – Mandela Avenue (2017-present)

- **Agriculture Sector Development Unit** World Bank supported Flood Risk Management Project and the Rehabilitation of the Cunha Canal Relief Channel and Structures projects (2017-present).
- Biodiversity Monitoring for **Troy Resources Guyana Inc.** (2017-2018)
- **Noble House Seafood Ltd** Seafood Processing (2016-present)
- **Troy Resources Guyana Inc.** Environmental Compliance of Mining Operations (2015 - present)
- **University of Guyana** World Bank Supported Science and Technology Support Project (2014-2016).
- Rehabilitation of the **West Coast Demerara Road** (2015-2017)
- **BCGI mining and processing operations** at Aroaima, Kurubuka and Kwakwani (2012 to present).
- **Construction of the East Bank Four Lane Road** for DIPCON Engineering Services Ltd (2013-2015).
- **Construction of the East Coast Four Lane Road** for DIPCON Engineering Services Ltd (2013-2015).
- **Community Roads Improvement Project** executed by the Ministry of Housing and Water**.** (2012-2014)
- Environmental Compliance Monitoring at **Bonasika Deposits for GINMIN** (2012- present)
- Construction of the **Hope-Dochfour Canal and Structures** (2011 to 2014)
- **Crab Island Wharf for CGX Resources Inc.** (2010 to present).
- Biodiversity Monitoring at **Bonasika Deposits for Guyana Industrial Minerals Inc. (GINMIN)** (2010 to 2013 and 2017)
- **Amaila Falls Hydropower Access Road** for SRKN'gineering (2010-2012)
- Rehabilitation of **East and West Canje Roads** for SRKN'gineering (2010 to
- Rehabilitation of **Roadway Structures (Bridges) from Timehri-Rosignol Lot II A2** for R. Bassoo & Sons Construction Company (2009-2012).
- Rehabilitation of **Roadway Structures (Bridges) from Timehri-Rosignol Lot II A1** for Courtney Contracting Services Ltd (2009-2012).

Environmental Reports – *Coordinated the preparation environmental reports including the following:*
- Edward B Beharry & Company Ltd Manufacturing Facility Environmental Report (2017)
- Bauxite Company of Guyana Inc. Environmental Reports (2012-2017)
- CGX Wharf and Logistics Yard Environmental Reports (2011-2017)
- Guyana Industrial Minerals Inc. Environmental Reports (2012-2017)
- Troy Resources Guyana Inc. Environmental Reports (2015-2017)
- Noble House Seafoods Limited Environmental Reports (2015-2017)
- Comfort Sleep Inc. Consolidated Environmental Report (2015)
- Shawnees Service Station Annual Environmental Report. (2013)
- Two Brothers Gas Stations Annual Environmental Reports. (2012)
- Marudi Resort Annual Environmental Report. (2012)
- Barama Company Limited Annual Environmental Reports for Buckhall Complex and Land of Canaan. (2012)

Environmental Audits – Conducted Environmental Audit of Bosai Minerals Bauxite Mining and Processing Operations at Linden (2014)

Natural Resource Management – Participated in the execution of the following projects:
- Contributed to the project **Support the Strengthening of Monitoring and Enforcement of Mining Regulations.** (2017)
- Contributed to the preparation of **Guyana's National Wastewater Management Strategy.** (2015)
- Contributed to the Stocktaking and Preparation of the **Outline for the Aligned National Action Programe to Combat Land Degradation.** (2014-2015)

- Contributed to the preparation of **Guyana's Fifth National Report for the United Nations Convention on Biological Diversity**. (2014)
- Contributed to the preparation of **Guyana's Third National Biodiversity Strategy & Action Plan**. (2014)
- Contributed to the preparation of **Guyana's Fourth National Report for the United Nations Convention on Combating Desertification**. (2011)
- Served as a member of the team conducting a **Stocktaking of Existing Capacity and Mechanisms** for the Assessment of Capacity Building Needs for National Biodiversity Priorities Project. (2009)
- Served as a member of the team **Assessing Capacity Building Needs for Initial Assessment and Monitoring Programmes, including Taxonomy** for the Assessment of Capacity Building Needs for National Biodiversity Priorities Project. (2009)

Training Conducted in Environmental Management - Contributed to the preparation of training manual and delivering of the following training exercises:

- ***Training to Strengthen the Capacity of EPA Field Officers to facilitate greater oversight of the Gold Mining Sector –*** Organised by the Ministry of Natural Resources and funded by GEF with support from UNDP. (2016)
- ***Environmental Awareness and Best Practices Training –*** conducted for Bauxite Company of Guyana Inc.'s personnel in Region 10. (2015)
- ***Georgetown Solid Waste Management Training*** - This was done as part of the Georgetown Solid Waste Management Programme. (2009)
- ***Tourism and Environmental Management Training –*** Organized by Linden Economic Advancement Programme for a group of tourism stakeholders in Region 10.

Tourism

- Contributed to the preparation of the **Guyana Tourism Manual** for Guyana Tourism Authority/Amazonia Cooperation Treaty Organisation. (2011)

February 2009 – Present – Independent Consultant

- **Iwokrama –** Coordinated the conduct of a **Social Impact Assessment** of the Forest Operations. (2017-2018)
- **Basic Needs Trust Fund –** Contributed to the preparation of the 2016-2017 Annual Environmental Report (2017-2018)
- **GuyGas LPG Bottling Plant –** Prepared the Consolidated Annual Environmental Report for 2013-2016. (2017)
- **Iwokrama** – preparation of Environmental Management Plan for Mill Site (2016)
- **Iwokrama** – revision of Closure and Decommissioning Plan for Mill Site (2016)
- **J and R Ranch Environmental and Social Management Plan -** contributed to the preparation of the ESMP for the Ranch and Aqua Farm in the North Rupununi (2015-2016)
- **Energy Plus Service Station Consolidated Environmental Report** – Prepared the Consolidated Environmental Report for the Service Station at Chateau Margot (2014)**.**
- **Stockholm Convention Enabling Activities Project –** Served as National Consultant responsible for the preparation of the Contaminated Sites Inventory and the conduct of the Capacity Assessment (2011 to 2012).
- **Energy Plus Service Station Environmental Management Plan** – Prepared the Environmental Management Plan for the Service Station at Chateau Margot (2012)**.**
- **Durban Quarries** – Coordinated the revision of the Environmental Impact Assessment and Management Plan for the Quarry (2011-2012).
- **GuyGas LPG Bottling Plant –** Prepared the Annual Environmental Report for 2011-2012. (2012)
- **Tigerwoods Guyana Inc. –** Conducted Annual Compliance Audit of the Mill Site within the Iwokrama Forest (2010).
- **GuyGas LPG Bottling Plant –** Prepared Environmental Management Plan for the Bottling Plant at Lan of Canaan, East Bank Demerara (2010).

- **Hazardous Waste Inventory and Strategy for Region 4 –** Served as local consultant to SENES Consulting Firm which is conducted an inventory and developed a strategy for Hazardous Waste Management in Region 4 (2009-2010).
- **TCL Cement Bagging Plant –** Assisted in conducting compliance audit required by the Environmental Protection Agency for the Bagging Plant (2009-2010).
- **Iwokrama –** Conducted an Environmental Assessment for the Permanent Mill Site within the Iwokrama Forest (2009).
- **Port Kaituma Water Safety Plan (WSP) –** Contributed to the preparation of the WSP for the community for Ministry of Health and Pan-American Health Organisation (PAHO) identifying the various risk and problems and recommending measures for improvement (2009).
- **Nauth Service Station Environmental Management Plan** - Contributed to the preparation of an Environmental Management Plan for the Service Station at Unity, Mahaica (2009)**.**

June 2008 to January 2009 – Director (ag) – Environmental Management Division - Environmental Protection Agency
Was responsible for managing the Environmental Management Division, the core Division of the Environmental Protection Agency which consisted of four programme areas of Authorisations, Complaints and Response, Monitoring and Enforcement and Research and Development. The Division consisted of eighteen (18) staff and responsibilities included developing and managing the Environmental Quality Control (EQC) and Environmental Monitoring and Enforcement (EMS) systems, including appropriate regulations, developing and managing the emissions discharge licensing and permitting system, including appropriate procedures, developing and implementing of environmental emergency response procedures, directing the further development of the EIA process, managed its implementation, and provided technical advice and support to the Environmental Assessment Board in conducting its duties, supervising Senior Environmental Officers responsible of the four programme areas. Was responsible for developing and maintaining linkages with Sectoral Agencies, local government and non-governmental organisations and international organizations, prepared environmental programmes including work programmes and budgets, coordinated the development of environmental standards and codes of practice, coordinated and implemented environmental and other programmes for the Agency with assistance from donors included IDB, UNDP and UNEP.

August 2007 to June 2008 - Senior Environmental Officer – Authorisation - Environmental Protection Agency
Was responsible for managing and overseeing the Environmental Authorisations process. This includes coordinating the Environmental Impact Assessment Process, negotiating with staff in developing of annual work plans and budget, developing and implementing training programmes for staff of the division, investigating reports of suspected violations of environmental permits and or hazards to the environment and the development of technical material for environmental awareness and participate in such activities. Also includes effective assigning of resources to achieve results based on the work plan, supporting the work of the Environmental Assessment Board and develop relationship with external and internal stakeholders. Represented the Agency and Guyana at regional and international forums.

February 2006 to July 2007 – Senior Environmental Officer – Research and Development - Environmental Protection Agency
Was responsible for coordinating all research and development activities of the Environmental Management Division which included the development of environmental standards, regulations, and guidelines for industry and natural resources, environmental management instruments and procedures and protocols for their use (e.g. strategic environmental assessments, identifying of areas for development in environmental management and formulate proposals for projects, provide on-going recommendations to improve the EPA's compliance and complaints monitoring and enforcement protocols and programmes, recommend conditions to attach to an environmental authorization pertaining to environmental monitoring, management and emergency response plans and develop field protocols to ensure compliance, review sectoral projects reports and registers of information to evaluate the adequacy and make recommendations to improve value. Also included

the preparation of the annual work plan, budget and annual reports, develop and implement training programmes for officers, develop technical material for environmental awareness, assist in the implementation of the solid and hazardous waste programme, coordinate all activities relating to international conventions and multilateral environmental agreements and coordinate any other programmes in relation to the environment. Managed a consultancy to produce a State of the Environment Report and a Public Disclosure Programme for Guyana. Coordinated projects relating to Hazardous Waste Management including conducting a National Hazardous Waste Inventory.

November 2000 to January 2006 – Environmental Officer Environmental Protection Agency, Guyana (*Environmental Officer - November 2000 to October 2002, Environmental Officer II - November 2002 to January 2006)*
Screened proposed projects to determine significant impacts and reviewed environmental impact assessments, environmental management plans, environmental management systems and social impact assessments for projects including Amaila Falls Hydro Power Project, Camboir Bauxite Mining Project, Marudi Mountain Gold Mining Project, Maple Creek Diamond Mining Project, Case Timbers Logging Project, Iwokrama Timbers Project and Conservation International Conservation Concession. Monitored and reviewed monitoring reports of permitted operations including Omai Gold Mines Ltd and Splashmins Fun Park. Worked closely with sectoral agencies including the Guyana Geology and Mines Commission, Guyana Forestry Commission, Guyana Lands and Surveys Commission and the Central Housing and Planning Authority in the execution of duties. Contributed to the development of environmental regulations, standards and codes of practice including the Environmental Protection Regulations, Mining Environmental Regulations, National Forest Management Standards, Environmental Standards, Codes of Practice for Forest Operations, Sand and Saprolite Mining, Nibi and Kufa Harvesting, and Small Scale Gold Mining. Served as EPA Counterpart to two Hazardous Waste Management Consultancies. Served on several committees including one that recommended the Interim TSS discharge level from mining activities. Organised and executed a Field Training Exercise for the technical staff of the Agency. Trained new staff, developed Training Manual. Prepared Guidelines for Eco Tourism Projects, Wood Working Operations, Abattoirs, Slaughter Houses, Poultry Processing, etc. Developed research programmes for University of Guyana student's final year projects. Conducted a Water Quality Survey of the Essequibo/Konawaruk Rivers. Assisted the Education, Information and Training Division with organizing Environmental Exhibitions, Mining Exhibitions, Green Walks, Calendars, and other public awareness activities and developing public awareness materials. Served as EPA representative on the CIDA funded Guyana Environmental Capacity Development Project which objective was to develop environmental capacity in the mining sector.

PROFESSIONAL DEVELOPMENT

Training

International
Integrated Environmental Planning and Management
Exposure to environmental planning and management in Malaysia and other Third World countries and provided a forum of sharing knowledge and experiences.
National Institute of Public Administration, Kuala Lumpur, Malaysia 28 June – 23 July 2004

Environmental Policy and Environmental Management Systems
Exposure to measures used by Japan to address various environmental problems.
Japan International Cooperation Agency/ Global Environment Centre/ Environment and Sewerage Bureau of Osaka City, Japan, 21 May – 08 July 2003

Environmental Management Systems Internal Auditors Course
Training on conducting audits to determine compliance with ISO Environmental Management Standards, New Japan Certification Service Co., Ltd, Japan, 23-25 June 2003

Environmental Management Systems Implementation Course
Training on Implementing ISO Environmental Management Standards.
New Japan Certification Service Co., Ltd, Japan, 18-20 June 2003

National/Local

Joint Demonstration Project Linking a National Programme of Action with a Water Safety Plan
NOAA, CDC, CEHI, USGS and PAHO. 8th – 9th May 2007

Forest Landscape Restoration
ITTO Guidelines for rehabilitation, restoration and management of degraded tropical forest.
World Conservation Union and International Tropical Timber Organisation. 13th -17th March 2006

Communication and Conflict Resolution Skills
Arthur Lok Jack Graduate School of Business, University of the West Indies.
23rd January – 3rd February 2006

Pollution Abatement for Priority Sectors in Guyana
Training in methods for pollution abatement in the rice, wood, tourism, energy and mining sectors
Clint Edmonds and Associates, Environmental Protection Agency, 2005

Environmental Economics
Exposure to Economic Tools/Instruments that can be used to aid Environmental Management
Environmental Protection Agency – March 2004 - March 2005

Cumulative Environmental Impact Assessment – A Practical Exercise
Training on Conducting Cumulative Impacts Assessments. Executed a Cumulative Environmental Impact Assessment for the Mahdia Area – a gold mining community in Guyana
GENCAPD, Hotel Tower, 26-30 January 2004

Code of Practice for Small Scale Gold Mining
Training on Developing Code of Practices for the Mining Sector. Developed a Code of Practice for small scale gold and diamond mining operations in Guyana.
GENCAPD, Georgetown Club, 21-27 November 2003

Principles in the Development of Code of Practices
Training on Developing Code of Practices. GENCAPD, Hotel Tower, 30 September 2003

Hydro-sedimentology Survey
Survey of the Potaro River, Guyana. Trained in the collection, preservation, storing and analysis of water and sediment samples. Also trained in the recording, reporting and presenting data collected.
Richard Couture, GENCAPD, Potaro River -15th – 20th March 2002

Training for Trainers
Training in the preparation and presentation of environmental related issues to various target groups. Environmental Protection Agency/ UNDP, Plaza Hotel – 9th February 2002

Global Positioning System
The use of GPS devices. Collection storing, analysis and use of GPS data.
GENCAPD, Ocean View International, 6th-9th November 2001.

Use of Environmental Monitoring Equipment
Training on the use of various environmental monitoring equipment for collection and analysis of various samples and parameters. Environmental Management Division
Environmental Protection Agency, Camp Kayuka, Soesdyke, 19th -21st October 2001

Decision Making Environment
Deciding on the most appropriate measures in solving Environmental Conflicts and making Important Environmental Decision, Dr. Clinton Edmonds - SENES Consultant Ltd. EPA/ IAST Boardroom, 19th July 2001

Environmental Information Management Systems
Managing Environmental Data efficiently by the use of appropriate software, etc.
Dr. Clinton Edmonds - SENES Consultant Ltd. EPA/IAST Boardroom, 18th July 2001

Environmental Management Instruments
Techniques used in Environmental Management.
Dr. Clinton Edmonds - SENES Consultant Ltd. EPA/IAST Boardroom, 17th July 2001

Air Quality Management
Managing air quality, standards development, monitoring modeling, collection and analysis of air quality data. Dr. James Young – SENES Consultant Ltd. EPA/IAST Boardroom, 3rd July 2001.

Strategic Environmental Assessment Workshop
Preliminary course on the basics and importance for conducting a Strategic Environmental Assessment. Dr. Maria Partidario, Caribbean Academy of Sciences/University of Guyana/International Association of Impact Assessment. Hotel Tower, June 2001.

Compliance Monitoring and Enforcement
Training on Methodologies of working with non-complying Operators/Developers, Rights and Jurisdiction of Environmental Officers, Evidence Collection and Penalties for non-compliance.
Judy Daniels- International Consultant and Lead Auditor, EPA/IAST Boardroom, May 2001

Environmental Authorisation Writing
Training on Legalities and Pre-requisites of Environmental Authorisations.
Judy Daniels- International Consultant and Lead Auditor, EPA/IAST Boardroom, March 2001

Advance Sectoral EIA Training
Training in the execution of Sectoral EIAs. Worked on a Sectoral EIA for Sand and Saprolite Mining in the Linden- Soesdyke Area, Guyana.
GENCAPD, Ocean View International, March 2001

Introductory Course to Sectoral EIA
Preliminary course on the basics and importance for conducting a Sectoral Environmental Assessment. GENCAPD, Ocean View International February 2001

First Aid Training
Basic training in First Aid, Red Cross International, October 2005

Workshops/Seminars/Conferences
International/Regional

Sixth Session of the Open-Ended Working Group of the Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal
Represented the Government of Guyana. Geneva, Switzerland – September 3rd – 7th 2007

Second Intergovernmental Review Meeting of the Global Programme of Action for the Protection of the Marine Environment from Land-Based Activities (GPA)
Represented the Government of Guyana. Beijing, China - October 16th-20th

Regional Promotional Workshop on the Protocol Concerning Pollution from Land Based Sources and Activities for the English Speaking Caribbean Countries
Represented the Government of Guyana. St Lucia – July 24th -26th 2006
Reducing Mercury Use in Products in the Americas
Represented the Government of Guyana. Yucatan, Mexico, February 21-23 2006

Regional Awareness Raising Workshop on Mercury Pollution
Represented the Government of Guyana. Trinidad and Tobago January 18th -21st 2005

National/Local
Bio-safety Framework
Workshop to discuss Guyana's Draft Bio-safety Framework under the Cartagena Protocol of the CBD Convention. Environmental Protection Agency, Global Environmental Facility and United Nations Environment Programme, Hotel Tower – 27th November 2006

Sustainable Forest Management Indicators
Identifying indicators for sustainable forest management through the ACTO/TAREPOTO Process
ACTO/Guyana Forestry Commission, 17-19th August 2005

Hazardous Waste Management
Developing Priorities for Implementation of the Hazardous Waste Regulations 2000
Sam Wright – International Consultant - EPA/IAST Boardroom – 26th October 2004

Quarrying Workshop
Regularizing the Quarrying Sector in Guyana. Developing strategies to assist the quarrying sector to comply with national requirements. Guyana Geology and Mines Commission, 30th May 2002

Forest Management Standard Retreat
A technical review of the Draft National Standards for Forest Management. A member of the National Working Group on Forest Certification., Profor (UNDP), GFC, Tropenbos
Emerald Tower – 29-30 Nov and 1 December 2001

Forest Management Standards Workshop
Issues relating to forest certification in Guyana and the experiences of other countries in this process. Tropenbos/ Forest Stewardship Council/ Guyana Forestry Commission – Guyana, Cara Inn, 20th -22nd November 2001.

Forest Certification Workshop
Gap analysis of what is required to achieve certification of one of the pilot certification project in Guyana. Tropenbos, Bamboo Landing, Berbice River, 7th -8th November 2001

Hazardous Waste Management Workshop
Issues relating to Hazardous Waste Management with reference to Guyana
Dr. Murali Ganapathy - SENES Consultant Ltd. EPA/IAST Boardroom, 9th – 10th July 2001

Environmental Impact Assessment Workshop
Requirements of the EIA Process in Guyana for Environmental Consultants
EPA, EPA/IAST Boardroom, December 2000

Land Tenure Regularisation in Guyana
Guyana Land Administrative Support Programme (GLASP), Guyana Lands and Surveys Commission, NARI, Mon Repos, November 2000.

Good Practices in Mining /Gold Recovery Workshop
Demonstration on the Use of Retort for Mercury Recovery and Sluice Boxes in Small Scale Gold Mining. GENCAPD (Guyana Environmental Capacity Development Project), November 2000

BOARDS AND COMMITTEES

National Science and Technology Council
Served as a member of the Council (2014-2015).

Board of Directors – Central Housing and Planning Authority
Served as a member of the Board of Directors of the Authority (January 2008 to January 2009).

Board of Directors - Guyana Forestry Commission
Served as a member of the Board of Directors of the Commission (July 2005 to January 2009).

Board of Directors - National Standards Council, Guyana National Bureau of Standards
Served as Member of the National Standards Council (February 2006 to October 2007).

Guyana Local Organising Committee for Cricket World Cup 2007
Served as a member of the Health and Emergency Committee in preparation for hosting of the World Cup games (January 2005 to March 2007).

Guyana National Initiative on Forest Certification
Served as a member throughout the process of developing a National Standard for Forest Management for endorsement by the Forest Stewardship Council (2000-2004).
Geographical Association of Guyana -1996 to 2000
Served as Vice President (1998 - 2000) and Executive Member (1996 -1998).

University of Guyana Student Society
Served as an Executive Member, Faculty of Arts Representative, the Head of the Publication Unit and a Member of the Sports Committee (1999-2000).

AWARDS

Exceptional Employee of the Year Award (Team Spirited) - Environmental Protection Agency-2001

Bartholomew Atlas Prize – Best Graduating Student Geography – University of Guyana – 2000

CURRICULUM VITAE

NAME:
Andrew Bishop

DESIGNATION:
Land Policy & Planning, Environment and Climate Change Specialist

ADDRESS:
60 Area H Ogle
East Coast Demerara
Guyana

CONTACTS:
Tel: + 592 222 4565
Fax: + 592 222 3172
Email: emc@emcguyana.com

EDUCATION

University of Waterloo (1978)
Ph.D. programme – Geography/Regional Development
All But Dissertation

University of Waterloo (1976)
M.A. Geography/Regional Development

York University, Toronto Canada (1973)
B.A. Geography; Economics minor

KEY QUALIFICATIONS

Climate Change/Forests

- Chief negotiator for Guyana under the UNFCCC 2008 – 2015.
- Expert competence in REDD Plus and forest mitigation, high competence in other mitigation, adaptation, technology transfer and climate finance.
- Principal author of country negotiation briefs and position papers.
- Contributing author of Guyana's climate related policy and strategy documents.
- Trustee, Iwokrama International Center for Rainforest Conservation 2007-2013.
- Guyana Forestry Commission Board: Chairman 1996-1999; Member 2007-2014.

Environmental Management and Policy

- As Chairman of Board of Directors of the EPA 2004-2011, oversaw environmental management at the country level.
- As member of Cabinet Subcommittee on Natural Resources and Environment 2005-2011, deliberated on environment policy and management matters at the national level.
- As Planner in San Diego's California's Department of Planning and Land use, reviewed several EIA's.
- Contributing author, Protected Areas legislation.

Land Planning/Land Management/Administration

- Led the modernization of the land management and administration Agency in Guyana (The Guyana Lands and Surveys Commission).
- Chartered land use planner.
- Academic training in Urban Geography and Urban economics.
- Focal Point, UNCCD for 6 years.

- Oversaw preparation of Guyana's National Action Plan under UNCCD, including Sustainable Land Management.
- Team leader and final drafter of four Regional Land Use Plans for Guyana.
- Team leader, principal writer of one Regional Land Use Plan for Guyana.
- Senior land use planner and project manager in California, USA for 7 years.
- Former Member of Guyana Lands and Surveys Commission Board.
- Former Member of Mahaica Mahaicony Abary Agricultural Development Authority Board (MMA) and Chairman of MMA land sub- committee, for 7 years.

Policy Analysis and Development

- Principal author of draft National Land Use Policy for Guyana.
- Contributing drafter of GIS Policy, Land Tenure Policy, Agriculture Policy, Fisheries Policy.

WORK EXPERIENCE

Climate Change, Land policy, Land Planning, Land Management & Environment (2015 – Present)
Private Consultant

Office of the President (now Ministry of the Presidency), Government of Guyana (2009-2015)
Chief Negotiator in the UNFCCC
- Negotiated positions in REDD Plus, including MRV, Reference levels, safeguards systems.
- Attended several REDD Plus workshops.
- Prepared country position statements.
- Contributed to Guyana's Low Carbon Development Strategy and its REDD Plus component.
- Authored Guyana's INDC which included a REDD Plus component.

Guyana Lands and Surveys Commission, Government of Guyana (2001-2008)
Commissioner of Lands and Surveys
- Established a policy and planning programme which included a sustainable land management project.
- Oversaw the development of a national Land Use Plan, regional land use plans.
- Authored a national land use policy

Guyana Forestry Commission, Guyana
- Chairman Board of Directors (1996-2000)
- Member, Board of Directors (2000-2015)

Oversaw the formulation of the Forest Policy, sustainable forest management code of conduct, MRV system and Reference level.

Guyana Geology and Mines Commission, Guyana
- **Chairman Board of Directors (1996-2000)**
- **Member, Board of Directors (2000-2007)**

Deliberated on mining policy, including environmental aspects, among other things.

BOARDS AND COMMITTEES

2000 - 2015
Member, Board of Directors of the Guyana Forestry Commission

2000-2007
Member, Board of Directors of the Guyana Geology and Mines Commission

1996 - 2000
Chairman Board of Directors of the Guyana Forestry Commission

1996 - 2000
Chairman Board of Directors of the Guyana Geology and Mines Commission

Current Membership in Professional Societies:
Environmental Protection Agency (EPA) of Guyana
American Institute of Certified Planners (AICP)
Fellow of the Royal Geographical Society (FRGS)

REFERENCES

Available upon request

CURRICULUM VITAE

NAME:
Lakshman Richard Persaud

POSITION:
Environmental and Social Consultant

ADDRESS:
60 Area H Ogle
East Coast Demerara
Guyana

CONTACTS:
Tel: + 592 222 4565
Fax: + 592 222 3172
Email: lakshmanpersaud@gmaill.com

QUALIFICATIONS

University of Nicosia, Cyprus (currently pursuing)
Master of Business Administration, MBA (Online)

The University of Guyana (1999)
Post Graduate Diploma: *Development Studies*

The University of Guyana (1997)
Bachelor of Arts: *Geography/Economics*

WORK EXPERIENCE

April – August 2016 & June 2014 – August 2015 - (Consultant) Project Community Liaison Officer with CEMCO/MMM for the East Bank Demerara Four Lane Extension Road Project

August 2009 - present – Environment and Social Consultant, Environmental Management Consultants

Worked on the following specific projects:

Environmental & Social Impact Assessments (EIAs) – Contributed to the preparation of the following:

- ESIA for the West Demerara Road Rehabilitation Project in collaboration with Marcel Gaskin & Associates Ltd.
- ESIA Addendum and Environmental Management Plan for the Bonasika Bauxite Mine and Sand Hills sintered Bauxite Production Plant and Supporting Infrastructure for Guyana Industrial Minerals Inc. (GINMIN).
- Assisted in the preparation of the EIA in collaboration with Environmental Sciences Limited for REPSOL proposed Jaguar 1 Exploratory Drilling Well within the offshore Georgetown Concession.
- ESIA for CPT Inc. Logging and Sawmilling Operations in the Pomeroon Area.
- ESIA for Simon and Shock International Logging Inc. Logging and Sawmilling Operations in the North Rupununi Area.

Environmental Management Plans (EMPs) - Contributed to the preparation of the following:

- EMP for Central Housing & Planning Authority East Coast–East Bank Road Linkage.
- EMP for Ministry of Agriculture/ National Drainage & Irrigation Authority (NDIA) Aurora Land Development Project on the western Essequibo Coast.
- EMP for Standard Agro-Forestry Inc. Integrated Farm Project, Intermediate Savannahs, Region 10.
- EMP for Santa Fe Inc Integrated Farm Project – Rupununi Savannahs, Region 9

- Environmental Assessment for the East Demerara Water Conservancy (EDWC) Northern Relief Structure at Hope/Dochfour, East Coast Demerara.

Closure and Decommissioning Plan (CDP) - Contributed to the preparation of the following:
- Bauxite Company of Guyana Inc. (BCGI) mining operations at Block Five Deposits in the Berbice area.

Natural Resource Zoning & Mapping

Expertise includes community resource mapping, population density studies, gathering data for land use maps and application of spatial data using satellite and GIS technologies. A few completed works includes:
- Satellite imagery verification by on the ground location analysis and mapping of biomass resource type
- Community resource mapping for communities of Deep South Rupununi
- Mapping of land use types for the 63 Beach and adjoining areas as part of the *Caribbean Regional Environmental Program* Amenity Areas; Demonstration Project – No. 43-74 Villages, Corentyne Coast, and
- Development of village maps for specific areas on the Essequibo Coast.

December 2010 - October 2013 (Consultant) - Community Development Specialist for the Development of Land Use Planning (DULP) Project

The DULP Project is funded by the EU in partnership with the GoG represented by the Guyana Lands and Surveys Commission (GL&SC). The project was hosted by the GL&SC implemented by HTSPE Limited in association with Infoterra and SRKN'gineering.

2011 - Ministry of Agriculture & United Nations Framework Convention on Climate Change Short-term Technical Assistant to the International Consultant in the Enabling Activity for the Preparation of Guyana's Second National Communication to the UNFCCC.

2010- Consultant - World Wildlife Fund Guianas

2008 – 2009 - UNDP Guyana- Special Services Agreement
Project Coordinator – Guiana Shield Initiative Phase II Pilot Project, Iwokrama

2006 – 2007 - Monitoring and Evaluation Specialist, The Poor Rural Communities Support Services Project. Key Responsibilities:

- Monitor Project Implementation and provide status reports to Project Manager and Unit Heads
- Evaluate completed Sub-projects in preparation for Post Project Evaluations
- Conduct resource assessments for completed Sub-project
- Prepare Monthly – Annual Reports for Project (for **2007**)
- Coordinate Project Activities as instructed by Project Manager
    - Sub-project Beneficiary Activities
    - World Food Day
    - Staff Exchange Visits
    - Staff Social & Staff Moral Building Activities
    - Systematization Workshop
    - Project Completion Workshop
- Provide Technical Training to Beneficiary and Staff in Project M&E
- Design and Conduct the Post Project Impact Evaluations
- Design and conduct social surveys as necessary for impact and implementation evaluations
- Provide Technical Support to the Project as required by Unit Heads and Project Manager.

2002 – 2006 - Environmental Officer II – Protected Areas Unit - Natural Resources Management Division, Environmental Protection Agency. Key Responsibilities:

- Monitoring of proposed sites for protection using sustainable use and conservation guidelines;
    - Conduct quarterly site visits to proposed and established sites
- Counterpart Officer for the IDB Phase II ***"Investment Priorities Project";***
    - Conduct investigation along with consultant into possible project proposals for Natural Resources and Environmental Management
- Division representative for the IDB Phase II ***"Capacity Building for Key Stakeholders in Environment and Natural Resources Management"***;
    - Contribute to the Logistics, Planning and delivery of Training Workshops
    - Prepare and Deliver the Training Module as related to Natural Resources Management
- Project Officer (EPA) for the Caribbean Regional Environmental Program Amenity Areas; Demonstration Project – No. 43-74 Villages, Corentyne Coast
    - Contributed to the redefinition of the project
    - Implementation Officer for the project of the EPA
- Operations Officer for the Environmental Protection Agency /Fauna & Flora International Darwin Initiative Project "***Capacity building for Guyana's Protected Areas System"***;
    - Contributed to the planning and organization of Capacity Building workshops, including presenting and facilitating working group sessions
    - Participated in project review and monitoring of project impact on stakeholder communities
    - Contributed to preparation of monthly project financial and technical reports
- Contributed to the development of key documents of the Guyana Protected Areas System Project for the Lead Agencies, The World Bank and KfW;
- Conduct Education & Awareness sessions identifying and educating stakeholders, based on needs analysis of priority conservation sites;
    - Conduct Site visits with project teams including the World Bank, FFI, etc
    - Conduct Needs Analysis for community education programs
    - Prepare presentations for Amerindian communities on Protect Areas and conservation, monitor levels of success of information dissemination and redesign presentations to allow for greater levels of participation
- Facilitate training of local Amerindian Communities of three demographic regions of Guyana in environmental management, sustainable utilization of natural resources and conservation practices;
    - Participate in the planning and training sessions including facilitation of working groups for the development of a Community Based Natural Resource Management Plan for the Communities of the North Rupununi
    - Conduct community consultations representing the EPA in the Amerindian Communities of Regions 1 & 9 for the Guyana Protected Areas System Project
    - Represent the Government of Guyana in the development of the Southern Region Guyana as a Community Conservation Area to be managed by the Wai Wai community of Masakinari.
- Provide key inputs to the preparation of Monthly, Quarterly and Annual Technical and Financial Reports for the Protected Areas Unit, the NRMD and assigned projects; and
    - Monthly Unit Reports
    - Divisional Reports
    - Quarterly Unit and Division Reports
    - Half Year Progress Reports for Unit and Division
    - Annual Report, Workplan, Budget and Technical Submission to the Office of the President
- Support day to day activities of the Natural Resources Management Division.

PROFESSIONAL DEVELOPMENT

Section Four: Technical Qualification by Training & Participation
Global Health eLearning Center
2010

Mapping Biodiversity to assess Carbon densities using Radar Imagery
Sarvision, Netherlands
October-November 2009

Latin America Symposium on REDD
REDD Secretariat, Manaus, Brazil
September 2009

Payment for Ecosystem Services
Global Canopy Program, Grupo de Trabalho Amazônico (GTA) and Manaus Institute of Permacultura, Manaus, Brazil
September 2009

Applied Environmental Economics: Costs of Land Degradation & Benefits of Land management
Dr. Lars Hien
2-6 March, 2009

Systematization of Local Experiences
Brenda Lora, Consultant to IFAD
18-22 June, 2007

Monitoring & Evaluations Training Course - Public Sector Investment Management System
Jorge Max Fernandes, Consultant to the IDB
12-16 March, 2007

Communication and Conflict Resolution Skills
Arthur Lok Jack Graduate School of Business, University of the West Indies
23 January – 3 February 2006

Environmental Economics
Exposure to Economic Tools/Instruments that can be used to aid Environmental Management
Environmental Protection Agency – March 2004 - March 2005

Pollution Abatement for Priority Sectors in Guyana
Training in methods for pollution abatement in the rice, wood, tourism, energy and mining sectors
Clint Edmonds and Associates, Environmental Protection Agency, 2005

First Aid Training
Basic training in First Aid, Red Cross International, March 2005

Financing Protected Areas: Options for Guyana
Environmental Protection Agency/Fauna & Flora International (EPA/FFI)
March 2005

Development of Community Based Natural Resources Management Plan
United Nations Development Program's Capacity Building Project
February 2005

Practical Approaches to Participatory Project Management
Caribbean Regional Environmental Program (CREP)
8-13 October, 2004

Techniques in Community Resource Evaluations
EPA/FFI
6-9 September, 2004

Supervisory Management Course
Levi Lynch Association
30 August – 3 September, 2004

Protected Areas Management
CREP/Caribbean Conservation Association (CCA) Trinidad & Tobago
2-8 May, 2004

Biodiversity Assessment Training Workshop
EPA/FFI
15-25 April, 2004

Community Environmental Workers Training
EPA/FFI
16-17 March, 2004

Developing A Public Awareness Strategy for Guyana's Protected Areas
EPA/FFI
3-5 December, 2003

Project Implementation Workshop
CREP St. Michaels, Barbados
19-21 November, 2003

Protected Areas Categories and their Management Implications
EPA/FFI
29 September – 1 October, 2003

Participatory Planning & Collaborative Management
CREP/CCA Castries, St. Lucia
15-19 September, 2003

Community Consultations Process
EPA/FFI
19-24 May, 2003

Project Management &Project Proposal Preparation
EPA/FFI
11-16 April, 2003

Protected Areas Management in Guyana: Institutional Roles & Responsibilities
EPA/FFI
4-6 December, 2002

CURRICULUM VITAE

NAME:
Romeo H. De Freitas

DESIGNATION:
Field Manager

ADDRESS:
60 Area H Ogle
East Coast Demerara
Guyana

CONTACTS:
Tel: + 592 222 4565
Fax: + 592 222 3172
Email: emc@emcguyana.com

EDUCATION

Santa Rosa Primary Senior (Community High) School (1983-1988)
High School Diploma

Conservation International (2003)
Rapid Assessment Program (RAP) Training

French Guiana and Suriname (2001 and 2002)
Passive Integrated Transponder (PIT) Tag Training

Iwokrama International Centre for Rainforest Conservation and Development (2000)
Ranger Training in the following areas:

- Tourist Guide
- Bird Spotting and Data Collection
- Forestry
- Fresh water turtle monitoring and research
- Caiman spotting and data collecting
- Community development and management

Chelonian Research Institute (1994 and 2009)
Freshwater Turtle Research in the Rupununi (Guyana)

WORK EXPERIENCE

2017 – present – Field Manager - Environmental Management Consultants (EMC)

- Stakeholder engagements in Region 1 in collaboration with Environmental Resources Management Inc. (ERM) for the Ecosystem Services Survey for Esso Exploration and Production Guyana Ltd. Liza 1 Project.
- Coordinating the turtle telemetry exercise in Region 1 in collaboration with ERM.

2016 – Advisor to The Coordinator - Protected Area Commission – marine Turtle Project Shell Beach

2007- 2015 – Coordinator Guyana Marine Turtle Conservation Society (GMTCS) – CRI, WWF, SOL Inc. KfW, Eeripami German and Repsol Exploration Inc. funded - Marine Turtle Project

Responsible for the following activities as the coordinator:

- Planning and ensuring all activities undertaken by GMTCS were completed.
- Compiling all marine turtle data
- Preparing all technical reports.
- Representing GMTCS at Local, Regional and International meetings/symposiums.
- Fund raising and proposal writing for GMTCS.

2000 – 2007 - GMTCS - Marine Turtle (MT) Project – Field supervisor on the marine turtle Monitoring Site (Shell Beach, Guyana)

- Recruiting and ranger training.
- Coordinate and facilitate MT education camp on the beach.
- Participate in meetings, learning exchanges, and monitoring activities on data collection, data analysis and interpretation, and dissemination.
- Responsible for the collection of monitoring data.
- Plan and prepare for visits to different monitoring sites around Guyana.
- Plan, take part and supervise beach patrol and monitoring activities

1988 – 2000 - Boat Captain for the Guyana Marine Turtle Project (now GMTCS)

- Conduct ocean patrols
- Facilitate marine turtle education camp at Shell Beach
- Marine Turtle monitoring: Measuring, tagging (flipper and PIT), recording all nesting activities.
- Egg relocating, hatchery monitoring, releasing hatchling etc.
- Report to Dr. Peter CH Pritchard (CRI) and Florida Audubon Society seasonally

Protected Area – Shell Beach

Contributed to the following activities:

- Delineation of Shell Beach Protected Area (2009/10)
- Resource mapping (2009-2011)
- Biodiversity assessment of Shell Beach Proposed Protected Area (2007)
- Represent Almond Beach Community on consultation of Shell Beach Protected Area (2001-2014)
- Fresh water species assessment – World Wildlife Fund (2010)

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APPENDIX C

Offshore Ambient Air Quality Monitoring Report

Resubmitted without changes

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Esso Exploration and Production Guyana Limited

Offshore Ambient Air Quality Monitoring Report

Payara Development Project

July 2019

Project No.: 0484443

The business of sustainability

ERM

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Figure 8: Chromatogram of April 23 Summa Sample 13

Acronyms and Abbreviations

Name	Description
µg/m^3	micrograms per cubic meter
BTEX	benzene, toluene, ethylbenzene, and xylenes
CO	carbon monoxide
ERM	Environmental Resources Management
GC	gas chromatography
GPS	Global Positioning System
H_2S	hydrogen sulfide
in	inches
ND	not detected (i.e., below applicable laboratory reporting level)
NO_2	nitrogen dioxide
PDA	Payara Project Development Area
PM	particulate matter
$PM_{2.5}$	fine particulate matter (with an aerodynamic diameter of less than 2.5 micrometers)
PM_{10}	inhalable particulate matter (with an aerodynamic diameter of less than 10 micrometers)
ppb(v)	parts per billion by volume
ppm	parts per million
ppm(v)	parts per million by volume
QA	quality assurance
QC	quality control
SO_2	sulfur dioxide
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WHO	World Health Organization

EXECUTIVE SUMMARY

Environmental Resources Management (ERM) conducted an offshore ambient air quality monitoring campaign to characterize existing air pollutant concentrations in the vicinity of the Payara Project Development Area (PDA). Monitored air pollutants included inhalable particulate matter with an aerodynamic diameter of less than 10 micrometers (PM_{10}), fine particulate matter with an aerodynamic diameter of less than 2.5 micrometers ($PM_{2.5}$), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). To mitigate the inherent challenges posed by shipboard monitoring, ERM employed multiple redundant measurement methods, duplicate sampling, and concurrent meteorological and geographic position measurements. This redundancy allowed the campaign to meet all its data collection objectives despite some instrument failures, which are common in an offshore deployment.

During the campaign, five sets of 24-hour integrated passive samples were collected for laboratory analysis, with the exception of PM_{10} and $PM_{2.5}$, for which a single 5-day integrated passive sample was collected for each parameter. These samples were submitted for laboratory analysis. Additionally, supplementary continuous electrochemical measurements of each parameter were taken during the monitoring campaign; these continuous measurements are considered to be indicative (as opposed to quantitative) and were collected to identify any periods during which onboard emission sources may have been significantly biasing the reference measurements, so that suspect samples could be scrutinized for possible invalidation.

The laboratory-reported analytical results documented that ambient concentrations of the monitored air pollutants in the vicinity of the Payara PDA are generally very low—below reporting limits for most samples. PM_{10}, $PM_{2.5}$, and VOCs were the only air pollutants consistently detected above laboratory reporting limit. H_2S and NO_2 each had a single laboratory-reported concentration above their respective reporting limits.

The laboratory-reported PM_{10} concentration was 32 micrograms per cubic meter ($\mu g/m^3$); this is a 120-hour average, and is therefore not directly comparable to the World Health Organization's (WHO's) guideline concentration of 50 $\mu g/m^3$, which is expressed as a 24-hour average (WHO 2005). Supplementary chemical analyses demonstrated that the largest measured individual components of PM_{10} were sodium and chlorine, most likely in the form of sodium chloride, from sea salt.

The laboratory-reported $PM_{2.5}$ concentration was 15 $\mu g/m^3$; this is also a 120-hour average, and is therefore not directly comparable to the WHO's guideline concentration of 25 $\mu g/m^3$, which is expressed as a 24-hour average (WHO 2005). Supplementary chemical analyses demonstrated that the largest individual components of measured $PM_{2.5}$ were sodium and chlorine—again, most likely in the form of sodium chloride, from sea salt.

Laboratory-reported concentrations of total non-methane VOCs ranged from 83 parts per billion by volume (ppb(v)) to a maximum of 4,533 ppb(v) (reported as toluene)—considerably higher than the concentrations measured from prior offshore ambient air quality monitoring campaigns conducted in support of the Liza Phase 1 and Liza Phase 2 Environmental Impact Assessments. Laboratory-reported concentrations of total benzene, toluene, ethylbenzene, and xylenes (a subset of total non-methane VOCs) ranged from non-detect to 331 ppb(v).

Air quality monitoring data are summarized in Table 1.

Table 1: Laboratory-Reported Monitoring Results

Sample Date	Laboratory-Reported Concentration [ppb(v)]						Laboratory-Reported Concentration (µg/m³)	
	H_2S	NO_2	SO_2	CO	Total VOCs [(ppb(v), as Toluene]	Total BTEX Compounds	PM_{10}	$PM_{2.5}$
21-April-19	3	132	ND	ND	101	ND	32.0	15.0
22-April-19	ND	ND	ND	ND	4,533	200		
23-April-19	ND	ND	ND	ND	1,040	55		
24-April-19	ND	ND	ND	ND	1,413	331		
25-April-19	ND	ND	ND	ND	83	ND		

BTEX = benzene, toluene, ethylbenzene, and xylenes; ND = not detected (i.e., below applicable reporting level)

1. INTRODUCTION

Environmental Resources Management (ERM) conducted an offshore ambient air quality monitoring campaign to characterize existing air pollutant concentrations in the vicinity of the Payara Project Development Area (PDA). Monitored air pollutants included inhalable particulate matter with an aerodynamic diameter of less than 10 micrometers (PM_{10}), fine particulate matter with an aerodynamic diameter of less than 2.5 micrometers ($PM_{2.5}$), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). To mitigate the inherent challenges posed by shipboard monitoring, ERM employed multiple redundant measurement methods, duplicate sampling, and concurrent meteorological and geographic position measurements. This redundancy allowed the campaign to meet all its data collection objectives despite some instrument failures, which are common in an offshore deployment.

This report summarizes the methodology and results of the monitoring campaign.

2. METHODOLOGY

2.1 Monitoring Periods

The monitoring campaign was conducted from 20 to 26 April 2019. The host vessel was the 34-meter offshore support vessel, *Captain Grady*. PM_{10}, $PM_{2.5}$, SO_2, H_2S, NO_2, CO, and VOC monitoring instruments were mounted on the bridge deck, along the starboard and port rails, forward of the bridge. The *Captain Grady* sailed from Georgetown, Guyana on 20 April 2019, arriving in the vicinity of the PDA on 21 April 2019 at approximately 5:00 a.m. Sampling commenced and continued until 26 April 2019 at approximately 5:00 a.m., at which time the vessel returned to shore. The *Captain Grady* returned to port at Georgetown at approximately 5:15 a.m. on 27 April 2019.

2.2 Monitoring Approach

During the course of the air monitoring campaign, the helmsperson endeavored to maintain the bow in an upwind direction to the extent practicable in order to reduce the potential bias of the air samples by onboard emission sources, such as the ship's engines.

Measurements relied primarily on a set of passive samplers, which collected air samples for subsequent laboratory analysis. Collocated real-time sensors were also deployed in order to provide semi-quantitative

measurements at 10-minute intervals. In addition to air quality parameters, the following meteorological parameters were measured:

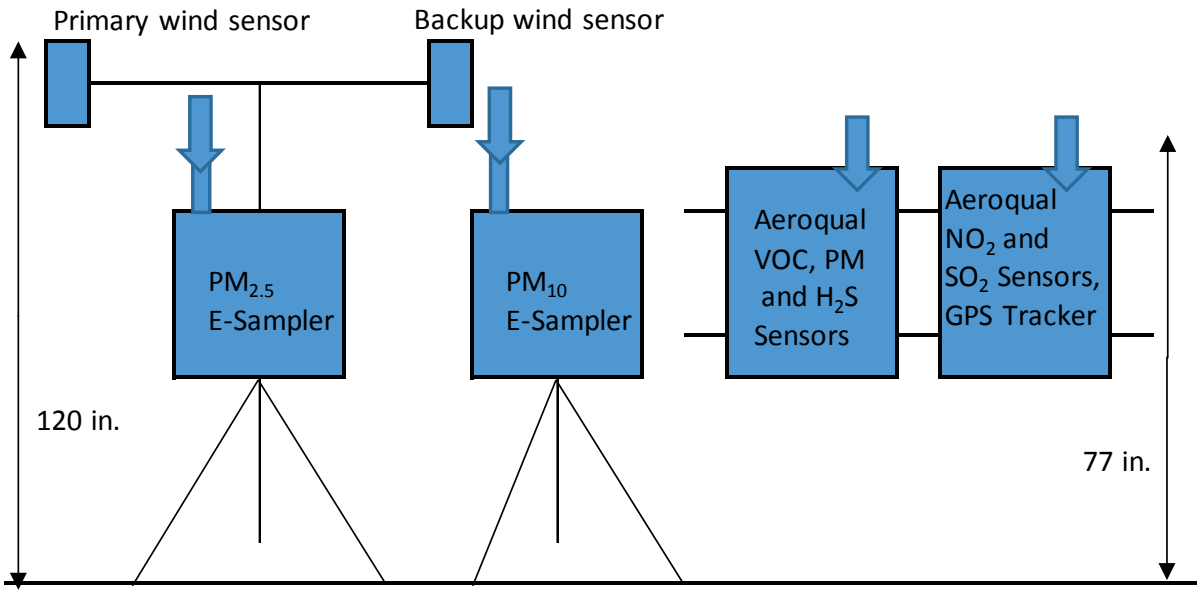
- Relative wind speed and direction
- Temperature
- Relative humidity

The location of the vessel (and therefore, the sampling equipment) was continuously tracked by a GPS logger.

Upon the survey's conclusion, passive samples were retrieved and shipped for laboratory analysis. The real-time air quality, meteorological, and GPS data were downloaded from the instruments for further interpretation. Data processing consisted of using the laboratory analytical data to validate and adjust the raw air quality sensor data.

2.3 Instrumentation

Air quality, meteorological, and miscellaneous instrumentation used for the monitoring campaigns are described below. Figure 1 illustrates the physical configuration of the instruments. Photographs of the installations are presented in Figures 2 through 7.



in = inches

Figure 1: Payara Offshore Instrumentation Configuration

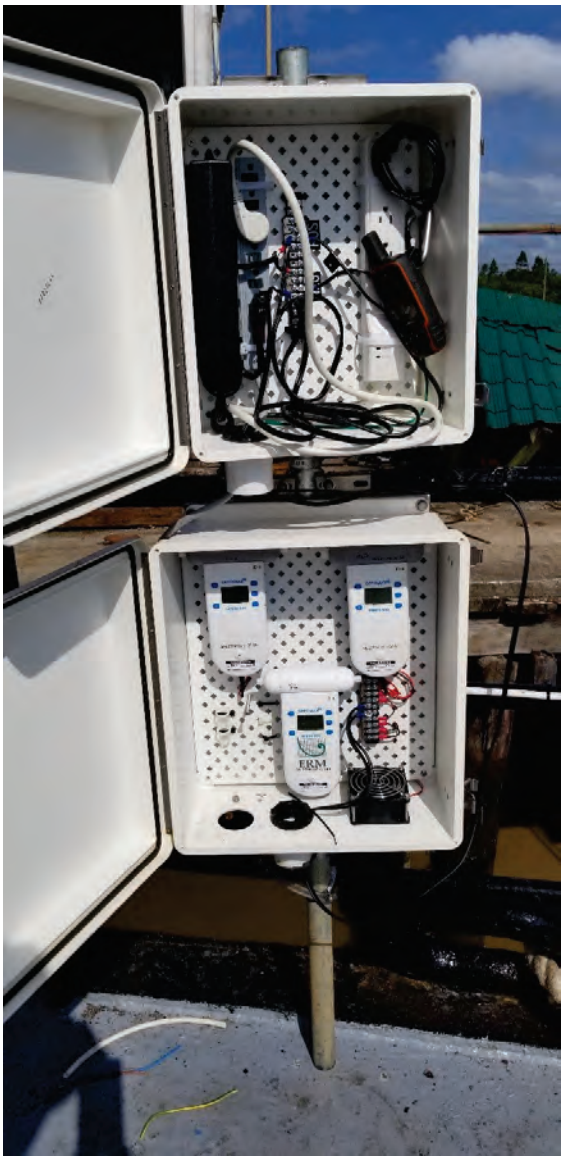


Figure 2: *Captain Grady* Installation—Aeroqual Sensor Shelter Boxes



Figure 3: *Captain Grady* Installation—Particulate Matter E-Sampler Analyzers



Figure 4: *Captain Grady*—Aeroqual Sensors



Figure 5: *Captain Grady* Installation—Particulate Matter E-Sampler and Wind Speed/Direction Sensors



Figure 6: *Captain Grady* Air Monitoring Equipment—View from Inside the Bridge



Figure 7: *Captain Grady* Air Monitoring Equipment—Full Complement of Monitoring Equipment

2.4 Air Quality Parameters

The campaign measured ambient concentrations of SO_2, H_2S, NO_2, CO, VOCs, PM_{10}, and $PM_{2.5}$ with passive samplers that collected samples for subsequent laboratory analysis. Additionally, continuous monitoring for these parameters was conducted using electrochemical sensors. The laboratory results are considered more reliable than the continuous monitoring data, and served as the “reference values” for the program. They were used to adjust the continuous monitoring data, as appropriate. The primary purpose for the continuous sensor data was to identify any periods during which onboard emission sources may have been significantly biasing the reference measurements, so that suspect samples could be scrutinized for possible invalidation.

Details of the sampling for each pollutant are presented below.

2.4.1 Sulfur Dioxide

SKC passive sampling badges (SKC UMEx 200) and an Aeroqual Model 500 monitor equipped with a 0 to 10 parts per million (ppm) SO_2 sensor were used to measure ambient concentrations during the campaign. Five 24-hour integrated passive samples were collected during the campaign. Additionally, the Aeroqual monitor was configured to continuously collect data, recording data at 10-minute intervals throughout the campaign. Each sample badge was exposed for approximately 24 hours, prior to being sealed for subsequent analysis and replaced with a fresh badge. This continued throughout the monitoring period, with each badge exposed sequentially.

2.4.2 Hydrogen Sulfide

Radiello passive sampling tubes (Sigma Aldrich RAD1236) and an Aeroqual Model 500 monitor equipped with a 0 to 10 ppm H_2S sensor were used to measure ambient concentrations during the campaign. Five 24-hour integrated passive samples were collected during the campaign. Additionally, the Aeroqual monitor was configured to continuously collect data, recording data at 10-minute intervals throughout the campaign. Each sample tube was exposed for approximately 24 hours, prior to being sealed for subsequent analysis and replaced with a fresh tube. This continued throughout the monitoring period, with each tube exposed sequentially.

2.4.3 Nitrogen Dioxide

The same SKC passive sampling badges used to measure SO_2 concentrations were also used to measure NO_2 concentrations. As discussed above, sample badges were exposed for approximately 24 hours, prior to being sealed for subsequent analysis and replaced with a fresh badge. This continued throughout the monitoring period, with each badge exposed sequentially. An Aeroqual Model 500 monitor was also configured to continuously collect data, recording data at 10-minute intervals throughout the campaign.

2.4.4 Volatile Organic Compounds

Passivated stainless steel ("Summa®") canisters[1] and an Aeroqual Model 500 monitor equipped with a 0 to 25 ppm VOC sensor were employed to measure ambient concentrations. During the campaign, five 24-hour integrated ambient air samples were collected using flow-controlled evacuated Summa canisters. The Summa canisters were configured to draw their samples from within the enclosure housing for an Aeroqual Model 500 VOC monitor.

At the conclusion of each 24-hour integrated sampling period, the Summa canister was capped and stored for subsequent laboratory analysis, a fresh canister was installed, and another integrated sample collection was initiated. At the laboratory, each canister was analyzed for speciated VOCs by gas chromatography/mass spectrometry (GC/MS), in accordance with U.S. Environmental Protection Agency (USEPA) Method TO-15 (USEPA 1999b). The Aeroqual monitor was also configured to continuously collect data, recording data at 10-minute intervals throughout the campaign.

2.4.5 Carbon Monoxide

The same Summa canister samples (i.e., the same as those used for VOC analysis) were also analyzed in the laboratory for CO concentrations. An Aeroqual Model 500 monitor was also configured to continuously collect data, recording data at 10-minute intervals throughout the campaign.

[1] Summa canisters are specially treated to make them chemically non-reactive with specific air pollutants so that collected whole air samples do not degrade significantly during the interval between sampling and analysis.

2.4.6 Particulate Matter Less than 10 Micrometers in Diameter

During the campaign, a Met One Instruments E-Sampler measured PM_{10} using the following methods:

- A single multi-day integrated sample was collected on a Teflon filter for subsequent laboratory gravimetric and elemental analysis using USEPA Method IO 3.3 (X-ray fluorescence) (USEPA 1999a).
- The E-Sampler also contained a nephelometer. This provided a continuous signal, proportional to ambient PM_{10} concentrations. Due to the nature of the optical system employed, the continuous readings required adjustment for the nature of the specific particulate matter being measured. The filter's gravimetric analysis results were used to calculate a "k-factor[2]," which was then used to adjust the raw nephelometer data.
- An optically-based Aeroqual Model 500 particulate matter (PM) sensor was configured to continuously monitor both coarse (PM_{10}) and fine ($PM_{2.5}$) particulate matter, recording values at 10-minute intervals.

2.4.7 Particulate Matter Less than 2.5 Micrometers in Diameter

The $PM_{2.5}$ instrument complement was identical to that employed for PM_{10}, except that a sharp-cut 2.5 micron inlet cyclone was installed on the E-Sampler to limit measurement to just the fine particulate matter fraction.

2.5 Meteorological and Locational Parameters

Wind speed, wind direction (relative to the ship's bow-to-stern axis), relative humidity, and temperature were continuously monitored by two redundant sets of sensors. The resulting data were logged by the two E-Samplers' internal data loggers. The wind data were collected to ascertain whether ship emission sources may have biased air quality measurements. Relative humidity and temperature data were used to identify any periods during which the air quality sensors were operating outside their control limits. These meteorological parameters were used as part of the data validation process.

A Garmin GPS logger was used to identify the location of the instrument package at each point in time throughout the monitoring.

2.6 Quality Assurance/Quality Control

Air monitoring on board an ocean-going vessel introduces numerous challenges to obtaining reliable ambient air quality measurements. These include:

- Potential uncertainty regarding the location at which a measurement is made;
- Exposure to weather that may damage instruments or bias their measurements;
- No access to spare or replacement parts, or skilled technician;
- Potential measurement bias due to impacts from onboard emission sources; and
- Reliability of electrical power with which to operate the monitoring instruments.

The constraints of offshore operation (particularly limited electrical power and instrument climate control constraints) necessitated compromises that resulted in some data loss. Electrochemical sensors

[2] The "k-factor" is a numerical value used to adjust E-Sampler nephelometer values to more accurately represent ambient concentrations. It is computed as the ratio of the concentration measured gravimetrically, using the E-Sampler's sample filter, and the average of the contemporaneous E-Sampler's nephelometer response.

(Aeroqual Model 500 monitors) were employed since they could be supported with the onboard infrastructure. While the above-referenced challenges reduced the quantity of continuous monitoring data collected, they did not significantly reduce data quality.

The campaign's passive sampling equipment proved to be largely resilient to the challenges encountered at sea, with some exceptions. The H_2S electrochemical sensor failed prior to reaching the monitoring area, requiring that ERM rely solely upon the passive samples for characterizing H_2S concentrations. The NO_2 electrochemical sensor also failed prior to arriving at the monitoring area, but ERM's onboard staff was able to successfully troubleshoot the instrument and restore it to operation by 8:00 a.m. on 23 March 2019.

The E-Sampler design incorporates a filter sampling mechanism in addition to the nephelometer. Each of the E-Samplers deployed for the campaign were programmed to collect 5-day integrated filter samples. Five days was selected to provide sufficiently high-resolution results to serve as a basis for correcting the continuous measurements. Both of the reference filter samples (PM_{10} and $PM_{2.5}$) yielded valid samples, in the form of roughly 5-day average values. The PM optical sensor failed prior to reaching the monitoring area, and the continuous nephelometers on both the PM_{10} and $PM_{2.5}$ E-Samplers failed to provide valid data. Accordingly, the only valid PM data values are the 5-day integrated results, which provide sufficient information to meet data quality objectives.

The campaign's primary quality assurance mechanism was the teaming of passive samplers (with associated laboratory analysis) of known reliability with the real-time measurements of electrochemical air quality sensors—whose performance quality offshore is less reliable. As noted above, the vessel's helmsmen endeavored to maintain the bow of the vessel in the upwind direction, to the extent practicable, to minimize the potential bias of the air samples by onboard emission sources. The absence of detectable CO concentrations in the passive samples indicates this approach was effective.

The Summa canister samples collected arrived at the laboratory within 14 days of shipment, consistent with protocol for maintaining data integrity. The SO_2, NO_2, and H_2S passive samples, and the PM_{10} filter sample were hand-carried back to the United States and express-shipped to the laboratories, arriving at the laboratory within 6 days of the ship's return to port. Laboratory analyses were all performed within 4 days of arrival at the laboratory.

The program also relied on traditional quality assurance/quality control (QA/QC) measures such as the use of laboratory blanks, duplicate samples, chain of custody documentation, and periodic calibrations against certified standards. Additionally, two-point (zero and span) calibrations were performed on each Aeroqual monitor prior to and following the monitoring campaign. These calibrations were performed using a dynamic dilution calibrator and USEPA "protocol" calibration gas standards. Staff training and reliance on Standard Operating Procedures rounded out the overall QA/QC program.

Despite the above-referenced instrument failures, adequate valid data were collected to characterize ambient concentrations of all seven target pollutants in the vicinity of the Payara PDA.

3. RESULTS

In general, concentrations of the monitored air contaminants in the vicinity of the Payara PDA were found to be very low when compared with levels typically found in onshore developed environments. All measured concentrations were below international ambient air quality guidelines.

There were no identified periods of apparent continuous sensor bias from onboard emissions, based on concurrent measurement of wind direction. While no data were invalidated due to apparent bias from onboard emission sources, there was a single sample that was invalidated by nature of it being an "outlier." This is further discussed below.

The results for the various air pollutants measured are discussed below. Validated data results are tabulated in Attachment 1.

3.1 Sulfur Dioxide

Analysis of the 24-hour integrated passive SO_2 samples yielded laboratory-reported values that were all below the laboratory's 4 ppb(v) reporting limit. This reporting limit is below the WHO 24-hour average SO_2 guideline concentration value of 7.6 ppb(v) (WHO 2005). Since the reported passive sample concentrations were all below the laboratory's reporting limit, it was not possible to adjust the Aeroqual sensor data to align with the reference method. However, the highest raw (i.e., unadjusted) 24-hour average Aeroqual SO_2 concentration value was 0.0 ppb(v), in general agreement with the corresponding laboratory-reported passive sample values.

Since the non-detectable passive sample values did not provide a basis for adjusting the continuous sensor values, the raw Aeroqual data presented in Attachment 1 should be considered qualitative only.

3.2 Hydrogen Sulfide

Analysis of the 24-hour integrated passive H_2S samples yielded one laboratory-reported detection of 3 ppb(v). The other four laboratory-reported values were all below the laboratory's 0.6 ppb(v) reporting limit. For comparison purposes, the WHO 24-hour average guideline concentration is 110 ppb(v) (WHO 2000).

As discussed in Section 2.6, the continuous Aeroqual H_2S sensor failed prior to reaching the monitoring area, so no continuous data were collected to supplement the passive sample measurements.

3.3 Nitrogen Dioxide

Analysis of all but one of the 24-hour integrated passive samples yielded laboratory-reported values that were below the laboratory's 3 ppb(v) reporting limit. One sample had a laboratory-reported value of 132 ppb(v). As noted in Section 2.6, the continuous electrochemical sensor was inoperable during the first two monitoring days. Once the Aeroqual sensor came back on line, its maximum 24-hour NO_2 measurement was 25 ppb(v).

The single laboratory-reported NO_2 concentration exceeding the laboratory reporting limit occurred for the sample that was exposed from 5:38 a.m. on 21 April 2019 to 5:50 a.m. on 22 April 2019. The Aeroqual NO_2 sensor was inoperable during that time period, but the CO sensor had no elevated readings during that time, indicating that the source of the high NO_2 value was evidently neither from onboard combustion sources nor from external combustion sources (since combustion CO emission rates are almost always significantly higher than corresponding NO_2 emission rates). ERM therefore considers this value to be an outlier, possibly due to sampling or laboratory contamination.

Since the validated passive sampler results collected when the electrochemical sensor was operating were all below the laboratory's reporting limit, it was not possible to adjust the Aeroqual sensor data to align with the reference method. Accordingly, while the Aeroqual sensor data are provided herein (as measured), the data should be considered qualitative only.

For comparison, the WHO 1-hour and annual average guideline concentrations are 106 ppb(v) and 21.3 ppb(v), respectively (WHO 2005). WHO has not established a 24-hour average guideline concentration for NO_2. Other than the one passive sample outlier, all measurements - both passive sampler and electrochemical sensor - were below the WHO 24-hour average guideline concentration.

3.4 Carbon Monoxide

Analysis of the 24-hour integrated passive samples yielded laboratory-reported values that were all below the laboratory's 0.7 parts per million by volume (ppm(v)) reporting limit. The corresponding 24-hour raw electrochemical measurements ranged from 0.00 to 0.02 ppm(v). Since the passive sampler results were all below the laboratory's reporting limit, it was not possible to adjust the Aeroqual sensor data to align with the reference method. Accordingly, while the Aeroqual sensor data are provided herein (as measured), the data should be considered qualitative only.

For comparison purposes, the WHO guideline concentrations are 26.2 ppm(v) and 8.7 ppm(v) for 1-hour and 8-hour averages, respectively; WHO does not publish a 24-hour average guideline concentration for CO (WHO 2000).

3.5 Volatile Organic Compounds

The Summa canisters were analyzed for total non-methane VOC compounds and 75 specific VOC species. Results are presented as volumetric concentrations, with concentration calculated as toluene[3], in accordance with USEPA Method TO-15 (USEPA 1999b). The analytical system was comprised of a GC/MS interfaced to a whole-air pre-concentrator.

Laboratory analysis of the 24-hour integrated passive samples yielded laboratory-reported non-methane VOC concentrations ranging from 83 to 4,533 ppb(v). Most of the 75 individual VOC species quantified were below their respective laboratory reporting limits. The WHO has not developed guideline concentrations for VOCs, which are generally regulated as precursors to ozone formation.

Of the quantified species, only acetone, 2-butanone, ethanol, and tetrahydrofuran were consistently measured above reporting limits in all five samples. The measured concentrations of the sum of the BTEX compounds (benzene, toluene, ethylbenzene, and xylenes—compounds associated with petroleum products) ranged from non-detect up to 331 ppb(v).

The Aeroqual VOC sensor operated concurrently with the passive sampling. An "adjustment factor" of 0.18 was employed to make the sensor data consistent with the Summa canister sample analysis reference values.

The relatively high total non-methane VOC measurements were unexpected and are not readily explainable. Previous offshore monitoring conducted in the vicinities of the Liza Phase 1 and Phase 2 PDAs yielded total non-methane VOC concentrations in the range of 2 to 290 ppb(v). Three of the current campaign's five samples were significantly higher than the maximum of the previous measurements. Since these values were unexpected, ERM employed a number of quality assurance checks to confirm their accuracy.

[3] The GC/MS yields a mass concentration (i.e., $\mu g/m^3$). To convert to a volumetric concentration (parts per billion), a molecular weight of the specific compound is required. Toluene (molecular weight of 92.14) is generally used for this conversion.

First, potential onboard emission sources were excluded as potential source of bias by reviewing the contemporaneous relative wind direction and the continuous measurements of CO and NO_2—indicators of engine exhaust contamination. This investigation indicated no apparent onboard emissions bias.

Next, the contract laboratory was engaged to confirm that laboratory QA and QC results were all within tolerance and that no unusual conditions had been encountered during the analytical process. The laboratory confirmed that their procedures were within standard QA/QC tolerances and that no unusual conditions had been encountered.

Finally, the actual chromatograms were examined for indication of analytical artifact. Figure 8 provides an illustrative chromatogram. Examination of this and the other chromatograms confirmed the conclusion that the instrument was operating properly.

While the limitations of the current effort do not allow identification of the VOCs dominating the non-methane VOC total, ERM is able to definitively conclude that collectively, the 75 individual compounds speciated only account for 60 percent of the total reported concentration (for the sample with the highest reported concentration). The 40 percent of of the total reported VOC concentration that is unaccounted for is therefore concluded to not be composed of compounds commonly associated with industrial activities, since the standard 75-compound scan is design to quantify concentrations of those compounds.

3.6 Inhalable Particulate Matter

A single, integrated PM_{10} filter sample was collected during the campaign. As noted in Section 2.6, both the E-Sampler's continuous nephelometer and the Aeroqual PM sensor malfunctioned, so no valid continuous data were collected.

The laboratory-reported PM_{10} concentration was 32.0 micrograms per cubic meter ($\mu g/m^3$), representing an average over roughly 120 hours. For comparison purposes, the WHO 24-hour average guideline concentration is 50 $\mu g/m^3$ (WHO 2005).

Based upon elemental analysis of particulate matter collected on the PM_{10} filter, sodium and chlorine (most likely as sodium chloride, from sea salt) constituted the largest component (approximately 18 percent) of the measured PM_{10}. Other significant elemental constituents were the crustal components silicon and aluminum, which jointly account for another 12 percent of the particulate matter mass.

3.7 Fine Particulate Matter

A single, integrated $PM_{2.5}$ filter sample was collected during the campaign. As noted in Section 2.6, both the E-Sampler's continuous nephelometer and the Aeroqual PM sensor malfunctioned, so no valid continuous data were collected.

The laboratory-reported $PM_{2.5}$ concentration was 15.0 $\mu g/m^3$, representing an average over roughly 120 hours. For comparison purposes, the WHO 24-hour average guideline concentration is 25 $\mu g/m^3$ (WHO 2005).

Based upon elemental analysis of particulate matter collected on the $PM_{2.5}$ filter, sodium and chlorine (most likely as sodium chloride, from sea salt) constituted approximately 3 percent of the measured $PM_{2.5}$. Other significant elemental constituents were the crustal components silicon and aluminum, which jointly account for another 2 percent of the particulate matter mass.

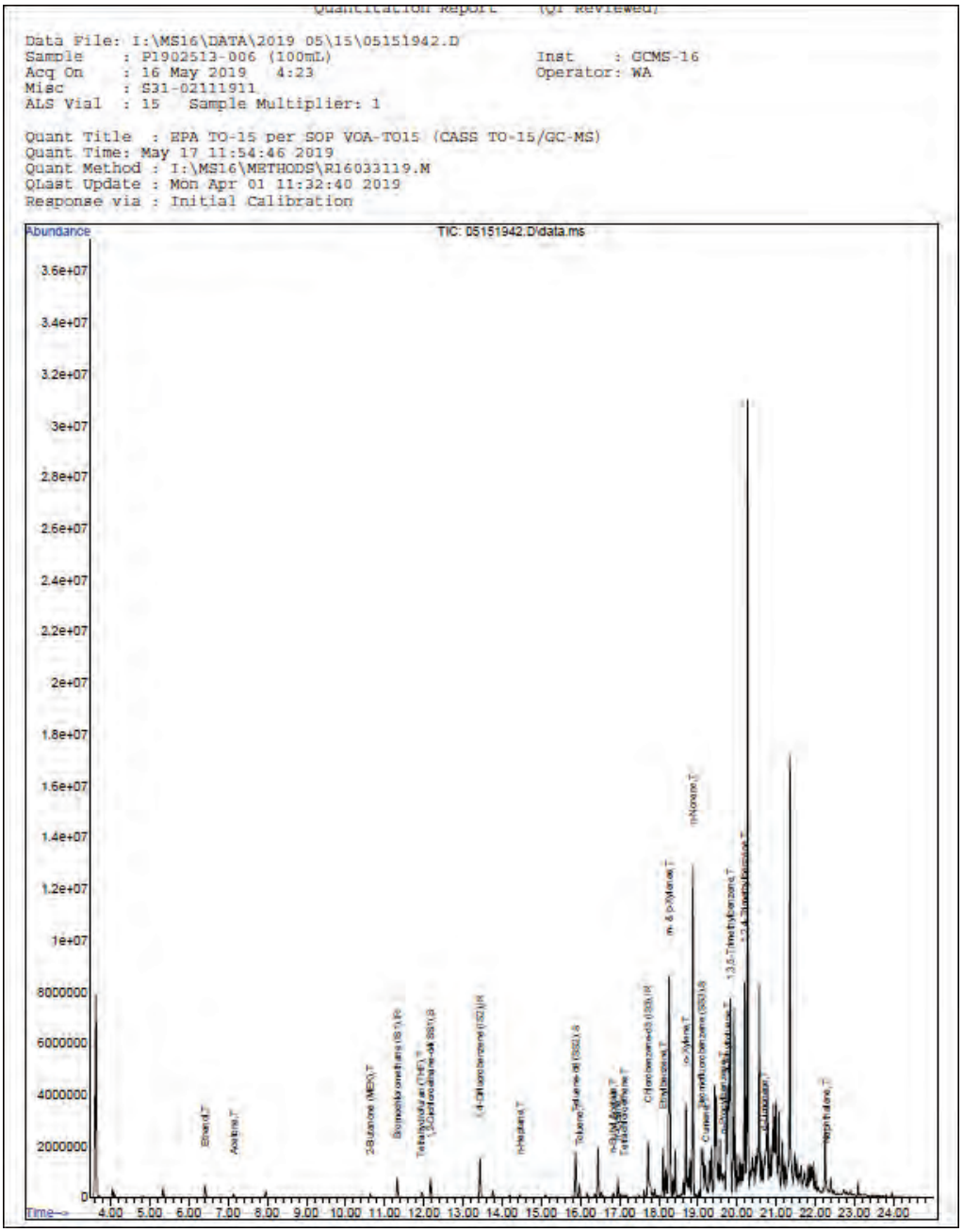


Figure 8: Chromatogram of April 23 Summa Sample

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ATTACHMENT 1 VALIDATED DATA RECORD

A. Sulfur Dioxide Monitoring Data

B. Hydrogen Sulfide Monitoring Data

C. Nitrogen Dioxide Monitoring Data

D. Carbon Monoxide Monitoring Data

E. Volatile Organic Compounds Monitoring Data

F. Inhalable Particulate Matter Monitoring Data

G. Fine Particulate Matter Monitoring Data

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Attachment 1.A: Sulfur Dioxide Monitoring Data

On		Off		Laboratory-Reported Concentration (ppb)	24-hour Average Aeroqual Sensor Measurement (ppb)
Date	Time	Date	Time		
21-April-19	05:38	22-April-19	05:50	ND	0
22-April-19	05:55	23-April-19	05:38	ND	0
23-April-19	05:41	24-April-19	05:44	ND	0
24-April-19	06:00	25-April-19	05:40	ND	0
25-April-19	05:50	26-April-19	05:42	ND	0

ND = not detected (below reporting level of 4 ppb); ppb = parts per billion

Attachment 1.B: Hydrogen Sulfide Monitoring Data

On		Off		Laboratory-Reported Concentration (ppb)	24-hour Average Aeroqual Sensor Measurement (ppb)
Date	Time	Date	Time		
21-April-19	05:30	22-April-19	05:48	3	NS
22-April-19	05:53	23-April-19	05:40	ND	NS
23-April-19	05:43	24-April-19	05:45	ND	NS
24-April-19	05:59	25-April-19	05:40	ND	NS
25-April-19	06:00	26-April-19	05:42	ND	NS

ND = not detected (below reporting level of 0.6 ppb); NS = not sampled (no valid results); ppb = parts per billion

Attachment 1.C: Nitrogen Dioxide Monitoring Data

On		Off		Laboratory-Reported Concentration (ppb)	24-hour Average Aeroqual Sensor Measurement (ppb)
Date	Time	Date	Time		
21-April-19	05:38	22-April-19	05:50	132	NS
22-April-19	05:55	23-April-19	05:38	ND	NS
23-April-19	05:41	24-April-19	05:44	ND	22
24-April-19	06:00	25-April-19	05:40	ND	22
25-April-19	05:50	26-April-19	05:42	ND	25

ND = not detected (below reporting level of 3 ppb); NS = not sampled (no valid results); ppb = parts per billion

Attachment 1.D: Carbon Monoxide Monitoring Data

On		Off		Laboratory-Reported Concentration (ppm)	24-hour Average Aeroqual Sensor Measurement (ppm)
Date	Time	Date	Time		
21-April-19	05:38	22-April-19	05:50	ND	0.01
22-April-19	05:55	23-April-19	05:38	ND	0.02
23-April-19	05:41	24-April-19	05:44	ND	0.02
24-April-19	06:00	25-April-19	05:40	ND	0
25-April-19	05:50	26-April-19	05:42	ND	0.02

ND = not detected (below reporting level of 0.7 ppm); ppm = parts per million

Attachment 1.E: Volatile Organic Compounds Monitoring Data

Start		Stop		Concentration [ppb(v)]																																						
				24-hour Average Aeroqual Sensor Measurement Total VOCs (ppb)		Laboratory-Reported																																						
Date	Time	Date	Time	Uncorrected	Corrected	Total (75 Target VOCs) (µg/m³)	Total (75 Target VOCs) [(ppb(v), as toluene]	Total BTEX Compounds	Acetone	Acetonitrile	Acrolein	alpha-Pinene	Benzene	2-Butanone (MEK)	n-Butyl Acetate	Chloroform	Cumeme	Cyclo-hexane	1,2-Dichloro-propane	Ethanol	Ethyl-Acetate	Ethylbenzene	4-Ethyl-toluene	n-Heptane	n-Hexane	d-Limonene	Methylene Chloride	Methyl Methacrylate	4-Methyl-2-pentanone	Naphthalene	n-Nonane	n-Octane	2-Propanol (Isopropyl Alcohol)	Propene	n-Propyl-benzene	Styrene	Tetrachloroethene	Tetra-hydrofuran (THF)	Toluene	1,2,4-Trimethyl-benzene	1,3,5-Trimethyl-benzene	m,p-Xylenes	o-Xylene
21-April-19	05:38	22-April-19	05:50	6,575	1,173	380	101		7.0		1.1			1.1						15.0																	5.1					
22-April-19	05:55	23-April-19	05:38	6,969	1,243	17,000	4,533	200	58.0					11.0	5.0		2.0			22.0		24.0	9.7	2.8		1.4				1.4	150.0	12.0			5.7		1.2	2.7	8.3		34.0	130.0	38.0
23-April-19	05:41	24-April-19	05:44	11,390	2,031	3,900	1,040	55	79.0		2.6		6.2	6.3		84.0		5.3	1.1	330.0	25.0	3.8	1.2	6.1	7.3	1.3	3.5				3.8	2.4	11.0						1.3	40.0	3.4			5.2
24-April-19	06:00	25-April-19	05:40	8,176	1,458	5,300	1,413	331	17.0	1.3	2.9	1.6	2.2	10.0	1.7	1.4		8.1	1.1	270.0	20.0	5.8	2.0	7.5	11.0	4.3	4.8	8.2	1.6	1.1	6.2	3.9	39.0	4.2	1.3	1.4			2.1	290.0	6.2	2.1	24.0	8.5
25-April-19	05:50	26-April-19	05:42	7,097	1,266	310	83		79.0		1.0			1.6						4.6																	2.0					
							Laboratory Reporting Limit		2.8	0.4	0.5	0.1	0.2	0.4	0.1	0.1	0.1	0.4	0.1	3.4	0.4	0.2	0.1	0.2	0.2	0.1	0.2	0.3	0.2	0.1	0.1	0.1	1.1	0.4	0.1	0.2	0.1	0.2	0.2	0.1	0.1	0.3	0.2
					Maximum	17,000	4,533		79	1	3	2	6	11	5	84	2	8	1	330	25	24	10	8	11	4	5	8	2	1	150	12	39	4	6	1	1	5	290	6	34	130	38
					Average	5,378	1,434		40	1	2	1	3	5	2	29	1	5	1	108	15	8	3	4	6	2	3	4	1	1	40	5	17	2	2	1	1	2	85	3	12	51	13

BTEX = benzene, toluene, ethylbenzene, and xylenes; blank cells indicated “ND” (not detected above laboratory reporting limit); NS = no valid sample; ppb = parts per billion; ppb(v) = parts per billion by volume; VOCs = volatile organic compounds

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Aeroqual Sensor Results

Date Time	Monitor ID	Location ID	VOC (ppm)
21-April-19	7	1	8.4
21-April-19	7	1	8.2
21-April-19	7	1	8.6
21-April-19	7	1	7.9
21-April-19	7	1	7.5
21-April-19	7	1	7.1
21-April-19	7	1	6.8
21-April-19	7	1	7.3
21-April-19	7	1	7.5
21-April-19	7	1	7.1
21-April-19	7	1	6.4
21-April-19	7	1	6.6
21-April-19	7	1	6.8
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.8
21-April-19	7	1	6.6
21-April-19	7	1	6.6
21-April-19	7	1	6.8
21-April-19	7	1	6.8
21-April-19	7	1	6.8
21-April-19	7	1	6.6
21-April-19	7	1	6.8
21-April-19	7	1	6.6
21-April-19	7	1	6.6
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.8
21-April-19	7	1	7.1
21-April-19	7	1	7.1
21-April-19	7	1	6.8
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.6
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.1
21-April-19	7	1	6.3
21-April-19	7	1	6.4
21-April-19	7	1	6.3

Date Time	Monitor ID	Location ID	VOC (ppm)
21-April-19	7	1	6.3
21-April-19	7	1	6.8
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.6
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.6
21-April-19	7	1	6.8
21-April-19	7	1	6.6
21-April-19	7	1	6.4
21-April-19	7	1	6.6
21-April-19	7	1	6.6
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	6.4
21-April-19	7	1	8.4
21-April-19	7	1	14.8
21-April-19	7	1	9.4
21-April-19	7	1	7.5
21-April-19	7	1	6.6
21-April-19	7	1	6.3
21-April-19	7	1	6.3
21-April-19	7	1	6.4
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	6.4
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	5.7
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	5.7

Date Time	Monitor ID	Location ID	VOC (ppm)
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.7
22-April-19	7	1	5.7
22-April-19	7	1	5.7
22-April-19	7	1	5.9
22-April-19	7	1	5.5
22-April-19	7	1	5.7
22-April-19	7	1	5.7
22-April-19	7	1	5.9
22-April-19	7	1	5.7
22-April-19	7	1	5.7
22-April-19	7	1	5.7
22-April-19	7	1	5.7
22-April-19	7	1	6.1
22-April-19	7	1	6.3
22-April-19	7	1	6.4
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	6.3
22-April-19	7	1	6.1
22-April-19	7	1	6.3
22-April-19	7	1	5.9
22-April-19	7	1	6.3
22-April-19	7	1	6.4
22-April-19	7	1	6.3
22-April-19	7	1	6.6
22-April-19	7	1	6.6
22-April-19	7	1	6.8
22-April-19	7	1	6.6
22-April-19	7	1	6.4
22-April-19	7	1	6.8
22-April-19	7	1	6.4
22-April-19	7	1	7.7
22-April-19	7	1	7.5
22-April-19	7	1	7.5
22-April-19	7	1	7.5
22-April-19	7	1	7.5
22-April-19	7	1	7.9
22-April-19	7	1	7.9
22-April-19	7	1	7.9
22-April-19	7	1	8.6
22-April-19	7	1	7.1

Date Time	Monitor ID	Location ID	VOC (ppm)
22-April-19	7	1	6.6
22-April-19	7	1	6.3
22-April-19	7	1	6.1
22-April-19	7	1	6.3
22-April-19	7	1	6.1
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.4
22-April-19	7	1	6.4
22-April-19	7	1	6.6
22-April-19	7	1	6.4
22-April-19	7	1	6.4
22-April-19	7	1	6.6
22-April-19	7	1	6.4
22-April-19	7	1	6.6
22-April-19	7	1	7.9
22-April-19	7	1	14.8
22-April-19	7	1	13.8
22-April-19	7	1	17.4
22-April-19	7	1	15.9
22-April-19	7	1	16.3
22-April-19	7	1	13.8
22-April-19	7	1	15.5
22-April-19	7	1	13.8
22-April-19	7	1	14.8
22-April-19	7	1	14.8
22-April-19	7	1	12.5
22-April-19	7	1	11.3
22-April-19	7	1	10.2
22-April-19	7	1	8.6
22-April-19	7	1	7.3
22-April-19	7	1	7.1
22-April-19	7	1	6.4
22-April-19	7	1	6.6
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.3
22-April-19	7	1	6.4
22-April-19	7	1	6.4
22-April-19	7	1	6.4
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	5.7
22-April-19	7	1	5.9
22-April-19	7	1	5.7

Date Time	Monitor ID	Location ID	VOC (ppm)
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.5
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.7
22-April-19	7	1	6.1
22-April-19	7	1	5.7
22-April-19	7	1	6.1
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	5.7
22-April-19	7	1	5.9
22-April-19	7	1	5.5
22-April-19	7	1	5.9
22-April-19	7	1	5.7
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	5.9
22-April-19	7	1	6.1
22-April-19	7	1	6.1
22-April-19	7	1	5.9
22-April-19	7	1	5.9
22-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	5.7
23-April-19	7	1	5.9
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	5.7
23-April-19	7	1	5.9
23-April-19	7	1	5.5
23-April-19	7	1	5.7
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	5.9

Date Time	Monitor ID	Location ID	VOC (ppm)
23-April-19	7	1	5.7
23-April-19	7	1	5.7
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	5.7
23-April-19	7	1	5.9
23-April-19	7	1	6.1
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	6.1
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	5.9
23-April-19	7	1	6.1
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	5.7
23-April-19	7	1	5.9
23-April-19	7	1	5.5
23-April-19	7	1	5.7
23-April-19	7	1	6.1
23-April-19	7	1	5.7
23-April-19	7	1	6.1
23-April-19	7	1	5.9
23-April-19	7	1	6.1
23-April-19	7	1	6.1
23-April-19	7	1	6.1
23-April-19	7	1	6.6
23-April-19	7	1	6.4
23-April-19	7	1	6.4
23-April-19	7	1	6.4
23-April-19	7	1	39.8
23-April-19	7	1	30.1
23-April-19	7	1	24.1
23-April-19	7	1	21.3
23-April-19	7	1	19.5
23-April-19	7	1	18.3
23-April-19	7	1	16.7
23-April-19	7	1	16.3
23-April-19	7	1	15.9
23-April-19	7	1	14.8
23-April-19	7	1	14.8
23-April-19	7	1	13.8

Date Time	Monitor ID	Location ID	VOC (ppm)
23-April-19	7	1	14.1
23-April-19	7	1	13.8
23-April-19	7	1	14.5
23-April-19	7	1	13.8
23-April-19	7	1	12.5
23-April-19	7	1	12.5
23-April-19	7	1	12.2
23-April-19	7	1	11.9
23-April-19	7	1	12.2
23-April-19	7	1	12.2
23-April-19	7	1	11.6
23-April-19	7	1	11.9
23-April-19	7	1	11.9
23-April-19	7	1	12.2
23-April-19	7	1	11.6
23-April-19	7	1	12.2
23-April-19	7	1	12.2
23-April-19	7	1	11.6
23-April-19	7	1	11.9
23-April-19	7	1	11.6
23-April-19	7	1	11.6
23-April-19	7	1	11.6
23-April-19	7	1	11
23-April-19	7	1	10.7
23-April-19	7	1	11
23-April-19	7	1	11
23-April-19	7	1	11.3
23-April-19	7	1	11
23-April-19	7	1	11
23-April-19	7	1	10.7
23-April-19	7	1	11
23-April-19	7	1	11
23-April-19	7	1	10.7
23-April-19	7	1	10.4
23-April-19	7	1	10.2
23-April-19	7	1	11.6
23-April-19	7	1	11.9
23-April-19	7	1	17.4
23-April-19	7	1	17.8
23-April-19	7	1	18.7
23-April-19	7	1	18.7
23-April-19	7	1	29.5
23-April-19	7	1	33.8
23-April-19	7	1	24.1
23-April-19	7	1	21.7
23-April-19	7	1	19.9
23-April-19	7	1	20.8

Date Time	Monitor ID	Location ID	VOC (ppm)
23-April-19	7	1	17.8
23-April-19	7	1	17.8
23-April-19	7	1	13.5
23-April-19	7	1	11.6
23-April-19	7	1	10.4
23-April-19	7	1	10.2
23-April-19	7	1	9.9
23-April-19	7	1	10.2
23-April-19	7	1	9.6
23-April-19	7	1	9.6
23-April-19	7	1	9.4
23-April-19	7	1	9.4
23-April-19	7	1	9.1
23-April-19	7	1	9.1
23-April-19	7	1	9.4
23-April-19	7	1	9.4
23-April-19	7	1	9.1
23-April-19	7	1	9.4
23-April-19	7	1	8.9
23-April-19	7	1	9.1
23-April-19	7	1	9.1
23-April-19	7	1	9.1
23-April-19	7	1	9.1
23-April-19	7	1	8.6
23-April-19	7	1	9.1
23-April-19	7	1	9.1
23-April-19	7	1	9.1
23-April-19	7	1	8.9
23-April-19	7	1	8.6
23-April-19	7	1	8.6
23-April-19	7	1	8.6
23-April-19	7	1	8.9
23-April-19	7	1	8.6
23-April-19	7	1	8.4
23-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.2

Date Time	Monitor ID	Location ID	VOC (ppm)
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	8.2
24-April-19	7	1	8.2
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	8.2
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	8.6
24-April-19	7	1	8.9
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	8.2
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	8.2
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.9

Date Time	Monitor ID	Location ID	VOC (ppm)
24-April-19	7	1	8.4
24-April-19	7	1	8.9
24-April-19	7	1	8.2
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.9
24-April-19	7	1	8.9
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	8.9
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.4
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	10.2
24-April-19	7	1	9.6
24-April-19	7	1	9.1
24-April-19	7	1	9.4
24-April-19	7	1	9.1
24-April-19	7	1	9.4
24-April-19	7	1	9.4
24-April-19	7	1	9.4
24-April-19	7	1	9.4
24-April-19	7	1	9.4
24-April-19	7	1	9.4
24-April-19	7	1	9.6
24-April-19	7	1	9.4
24-April-19	7	1	9.1
24-April-19	7	1	9.1
24-April-19	7	1	8.9
24-April-19	7	1	9.1
24-April-19	7	1	8.9
24-April-19	7	1	8.9
24-April-19	7	1	9.1
24-April-19	7	1	8.6
24-April-19	7	1	8.6
24-April-19	7	1	8.4
24-April-19	7	1	8.9
24-April-19	7	1	8.4
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	7.7

Date Time	Monitor ID	Location ID	VOC (ppm)
24-April-19	7	1	7.5
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.9
24-April-19	7	1	7.9
24-April-19	7	1	7.7
24-April-19	7	1	7.9
24-April-19	7	1	7.7
24-April-19	7	1	7.9
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.5
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.5
24-April-19	7	1	7.5
24-April-19	7	1	7.9
24-April-19	7	1	7.9
24-April-19	7	1	7.9
24-April-19	7	1	8.2
24-April-19	7	1	7.9
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	8.2
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.9
24-April-19	7	1	8.4
24-April-19	7	1	7.9
24-April-19	7	1	7.5
24-April-19	7	1	7.7
24-April-19	7	1	7.7
24-April-19	7	1	7.3
24-April-19	7	1	7.7
25-April-19	7	1	7.5
25-April-19	7	1	7.7
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.7
25-April-19	7	1	7.3
25-April-19	7	1	7.1
25-April-19	7	1	7.5

Date Time	Monitor ID	Location ID	VOC (ppm)
25-April-19	7	1	7.3
25-April-19	7	1	7.7
25-April-19	7	1	7.3
25-April-19	7	1	7.3
25-April-19	7	1	7.3
25-April-19	7	1	7.5
25-April-19	7	1	7.3
25-April-19	7	1	7.5
25-April-19	7	1	7.3
25-April-19	7	1	7.3
25-April-19	7	1	7.1
25-April-19	7	1	9.6
25-April-19	7	1	8.4
25-April-19	7	1	7.9
25-April-19	7	1	7.7
25-April-19	7	1	7.3
25-April-19	7	1	7.7
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.3
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.1
25-April-19	7	1	8.9
25-April-19	7	1	8.4
25-April-19	7	1	8.2
25-April-19	7	1	8.4
25-April-19	7	1	8.4
25-April-19	7	1	8.2
25-April-19	7	1	8.4
25-April-19	7	1	7.7
25-April-19	7	1	7.9
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	8.4
25-April-19	7	1	7.7
25-April-19	7	1	7.5
25-April-19	7	1	7.7
25-April-19	7	1	7.7
25-April-19	7	1	7.7
25-April-19	7	1	7.1
25-April-19	7	1	7.3
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.7
25-April-19	7	1	7.7

Date Time	Monitor ID	Location ID	VOC (ppm)
25-April-19	7	1	7.7
25-April-19	7	1	7.9
25-April-19	7	1	7.7
25-April-19	7	1	7.7
25-April-19	7	1	7.7
25-April-19	7	1	8.2
25-April-19	7	1	7.5
25-April-19	7	1	7.9
25-April-19	7	1	7.9
25-April-19	7	1	7.5
25-April-19	7	1	7.7
25-April-19	7	1	7.5
25-April-19	7	1	7.5
25-April-19	7	1	7.9
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	7.9
25-April-19	7	1	7.9
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	8.4
25-April-19	7	1	8.2
25-April-19	7	1	7.9
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	8.4
25-April-19	7	1	8.4
25-April-19	7	1	8.2
25-April-19	7	1	8.2
25-April-19	7	1	7.9
25-April-19	7	1	7.7
25-April-19	7	1	7.7
25-April-19	7	1	7.5
25-April-19	7	1	7.3
25-April-19	7	1	6.8
25-April-19	7	1	7.3
25-April-19	7	1	7.3
25-April-19	7	1	8.6
25-April-19	7	1	7.9
25-April-19	7	1	7.5
25-April-19	7	1	7.3
25-April-19	7	1	6.6
25-April-19	7	1	6.8
25-April-19	7	1	6.8

Date Time	Monitor ID	Location ID	VOC (ppm)
25-April-19	7	1	6.8
25-April-19	7	1	6.6
25-April-19	7	1	6.4
25-April-19	7	1	6.6
25-April-19	7	1	6.8
25-April-19	7	1	6.6
25-April-19	7	1	6.3
25-April-19	7	1	6.4
25-April-19	7	1	6.4
25-April-19	7	1	6.6
25-April-19	7	1	6.6
25-April-19	7	1	6.4
25-April-19	7	1	6.6
25-April-19	7	1	6.4
25-April-19	7	1	6.8
25-April-19	7	1	6.4
25-April-19	7	1	6.4
25-April-19	7	1	6.6
25-April-19	7	1	6.3
25-April-19	7	1	6.4
25-April-19	7	1	7.1
25-April-19	7	1	6.8
25-April-19	7	1	6.8
25-April-19	7	1	7.3
25-April-19	7	1	6.8
25-April-19	7	1	6.8
25-April-19	7	1	6.6
25-April-19	7	1	7.1
25-April-19	7	1	7.1
25-April-19	7	1	6.6
25-April-19	7	1	6.6
25-April-19	7	1	6.6
25-April-19	7	1	6.4
25-April-19	7	1	6.4
25-April-19	7	1	6.8
25-April-19	7	1	6.6
25-April-19	7	1	6.6
25-April-19	7	1	6.4
25-April-19	7	1	6.4
25-April-19	7	1	6.4
25-April-19	7	1	6.4
26-April-19	7	1	6.4
26-April-19	7	1	7.1
26-April-19	7	1	6.6
26-April-19	7	1	6.8
26-April-19	7	1	6.4
26-April-19	7	1	6.4

Date Time	Monitor ID	Location ID	VOC (ppm)
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.4
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6

Date Time	Monitor ID	Location ID	VOC (ppm)
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	7.3
26-April-19	7	1	7.3
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.4
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	6.4
26-April-19	7	1	6.4
26-April-19	7	1	7.1
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.6
26-April-19	7	1	6.8
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	7.1
26-April-19	7	1	6.8
26-April-19	7	1	6.8
26-April-19	7	1	6.4
26-April-19	7	1	6.3

Date Time	Monitor ID	Location ID	VOC (ppm)
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	5.9
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.3
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	8.4
26-April-19	7	1	8.4
26-April-19	7	1	8.2
26-April-19	7	1	7.5
26-April-19	7	1	8.6
26-April-19	7	1	7.5
26-April-19	7	1	7.3
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	7.1
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.3
26-April-19	7	1	6.6
26-April-19	7	1	6.3
26-April-19	7	1	6.1
26-April-19	7	1	6.3
26-April-19	7	1	6.6
26-April-19	7	1	6.6
26-April-19	7	1	6.4
26-April-19	7	1	6.4
26-April-19	7	1	6.3
26-April-19	7	1	5.9
26-April-19	7	1	6.1
26-April-19	7	1	6.1
26-April-19	7	1	5.9
27-April-19	7	1	6.1
27-April-19	7	1	5.7
27-April-19	7	1	5.7

Date Time	Monitor ID	Location ID	VOC (ppm)
27-April-19	7	1	5.7
27-April-19	7	1	5.9
27-April-19	7	1	5.5
27-April-19	7	1	6.3
27-April-19	7	1	5.9
27-April-19	7	1	6.1
27-April-19	7	1	6.1
27-April-19	7	1	6.3
27-April-19	7	1	8.2
27-April-19	7	1	7.5
27-April-19	7	1	7.5
27-April-19	7	1	6.8
27-April-19	7	1	7.1
27-April-19	7	1	6.4
27-April-19	7	1	7.3
27-April-19	7	1	8.6
27-April-19	7	1	7.7
27-April-19	7	1	6.4
27-April-19	7	1	8.2
27-April-19	7	1	14.8
27-April-19	7	1	12.8
27-April-19	7	1	11.6
27-April-19	7	1	12.2
27-April-19	7	1	12.2
27-April-19	7	1	13.8
27-April-19	7	1	14.1
27-April-19	7	1	13.8
27-April-19	7	1	14.1
27-April-19	7	1	14.1
27-April-19	7	1	14.8
27-April-19	7	1	14.5
27-April-19	7	1	11.9
27-April-19	7	1	11.6
27-April-19	7	1	10.7
27-April-19	7	1	14.5
27-April-19	7	1	16.3
27-April-19	7	1	15.5
27-April-19	7	1	13.8
27-April-19	7	1	15.9
27-April-19	7	1	14.5
27-April-19	7	1	15.2
27-April-19	7	1	15.9
27-April-19	7	1	15.9
27-April-19	7	1	15.5
27-April-19	7	1	14.5
27-April-19	7	1	14.5
27-April-19	7	1	23.2

Date Time	Monitor ID	Location ID	VOC (ppm)
27-April-19	7	1	27.3
27-April-19	7	1	25.2
27-April-19	7	1	26.2
27-April-19	7	1	23.7
27-April-19	7	1	28.4
27-April-19	7	1	32.5
27-April-19	7	1	27.8
27-April-19	7	1	33.1
27-April-19	7	1	36.4
27-April-19	7	1	33.1
27-April-19	7	1	30.1
27-April-19	7	1	36.4
27-April-19	7	1	33.8
27-April-19	7	1	28.4
27-April-19	7	1	28.4
27-April-19	7	1	31.3
27-April-19	7	1	30.7
27-April-19	7	1	42.8
27-April-19	7	1	21.3
27-April-19	7	1	14.8
27-April-19	7	1	12.2
27-April-19	7	1	11.6
27-April-19	7	1	12.2
27-April-19	7	1	11.6
27-April-19	7	1	9.6
27-April-19	7	1	9.4
27-April-19	7	1	10.2
27-April-19	7	1	11
27-April-19	7	1	11.3
27-April-19	7	1	8.6
27-April-19	7	1	10.7
27-April-19	7	1	8.4
27-April-19	7	1	10.7
27-April-19	7	1	28.4
27-April-19	7	1	72.1
27-April-19	7	1	70
27-April-19	7	1	117.1
27-April-19	7	1	100.8
27-April-19	7	1	64.7
27-April-19	7	1	34.4
27-April-19	7	1	45.1
28-April-19	7	1	19.1
28-April-19	7	1	12.5
28-April-19	7	1	8.9
28-April-19	7	1	8.6
28-April-19	7	1	529.3
28-April-19	7	1	2098

Date Time	Monitor ID	Location ID	VOC (ppm)
28-April-19	7	1	200.3

Attachment 1.F: Inhalable Particulate Matter Monitoring Data

Gravimetric Analysis

Start		Stop		Laboratory-Reported PM_{10} Concentration ($\mu g/m^3$)
Date	Time	Date	Time	
21-April-19	05:30	26-April-19	05:43	32.0

$\mu g/m^3$ = micrograms per cubic meter; PM_{10} = inhalable particulate matter with an aerodynamic diameter of < 10 micrometers

Elemental Analysis

Element(s)	Sample Mass (µg)	Percent
Total Mass	462	100
Sodium, Chlorine	80.6	17.5
Silicon, Aluminum	53.2	11.5

µg = microgram

Attachment 1.G: Fine Particulate Matter Monitoring Data

Gravimetric Analysis

Start		Stop		Laboratory-Reported $PM_{2.5}$ Concentration ($\mu g/m^3$)
Date	Time	Date	Time	
21-April-19	05:30	26-April-19	05:43	15.0

$\mu g/m^3$ = micrograms per cubic meter; $PM^{2.5}$ = fine particulate matter with an aerodynamic diameter of < 2.5 micrometers

Elemental Analysis

Element(s)	Sample Mass (µg)	Percent
Total Mass	216	100
Sodium, Chlorine	7.0	3.2
Silicon, Aluminum, Iron	4.1	1.9

µg = microgram

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APPENDIX D

Onshore Ambient Air Quality Monitoring Report

Resubmitted without changes

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Onshore Ambient Air Quality Monitoring Report

Esso Exploration and Production Guyana Limited

Guyana – 15 August 2018 through 12 June 2019

July 2019

Project No.: 0484443

The business of sustainability

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Acronyms and Abbreviations

Name	Description
µg/m^3	micrograms per cubic meter
BTEX	benzene, toluene, ethylbenzene, and xylenes
CO	carbon monoxide
EEPGL	Esso Exploration and Production Guyana Limited
ERM	Environmental Resources Management
H_2S	hydrogen sulfide
NA	not applicable
ND	below laboratory minimum reporting level
NO_2	nitrogen dioxide
PM	particulate matter
$PM_{2.5}$	fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers)
PM_{10}	inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers)
ppb	parts per billion
ppb(v)	parts per billion by volume
ppm	parts per million
SO_2	sulfur dioxide
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound
WHO	World Health Organization

EXECUTIVE SUMMARY

Environmental Resources Management (ERM) conducted an onshore ambient air quality monitoring program at three sites in Guyana over the period of 15 August 2018 through 12 June 2019. The monitoring program was designed to characterize existing onshore ambient air quality conditions at selected onshore locations. In the absence of applicable Guyana regulatory guidance, ERM used standard methods for selecting air pollutants to monitor, selecting monitoring sites, and establishing other program parameters. Resulting measurements have been compared to the World Health Organization's (WHO's) Air Quality Guideline Values or, in the absence of WHO guidance, criteria from the U.S. Environmental Protection Agency (USEPA).

At least six weeks of monitoring data were collected at each of three sites: Rose Hall Estate in New Amsterdam, Berbice; Carifesta, just off the sea wall in Georgetown; and New Guyana School (also in Georgetown), near the east bank of the Demerara River. Figure 1 illustrates the locations of the three monitoring sites.

Monitored air quality parameters included inhalable and fine particulate matter (PM_{10}[1] and $PM_{2.5}$[2], respectively), sulfur dioxide (SO_2), hydrogen sulfide (H_2S), nitrogen dioxide (NO_2), carbon monoxide (CO), and selected volatile organic compounds (VOCs).

At the Carifesta and New Amsterdam sites, local meteorological conditions were monitored by a third-party using equipment co-located with the air quality monitoring equipment. The meteorological data were made available to ERM for use in data validation and interpretation. At the New Guyana School site, ERM operated a tripod-mounted instrument to monitor local wind speed and wind direction.

In general, measured gaseous pollutant concentrations were quite low in absolute terms, as well as in comparison to applicable criteria. Particulate matter concentrations (both PM_{10} and $PM_{2.5}$) were near or exceeded applicable criteria at all three monitoring sites. The only measured exceedance of a gaseous pollutant criterion was for 24-hour average benzene levels at the Carifesta monitoring site.

Table 1 summarizes the ambient air quality measurements at the Carifesta, New Amsterdam, and New Guyana School sites, and compares them to applicable criteria.

[1] Inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers)

[2] Fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers)



Figure 1: Onshore Ambient Air Quality Monitoring Locations

Table 1: Summary of Ambient Air Quality Monitoring Data—Carifesta

Pollutant	Units	Averaging Time [a]	Maximum Measured Value			Criterion [b]	Notes
			Carifesta	New Amsterdam	New Guyana School		
PM_{10}	$\mu g/m^3$	24-Hour	154.2	39.8	47.6	50	
		Annual	27.9	20.6	27.1	20	Measured value represents the average for the duration of monitoring and is indicative, not a true annual average.
$PM_{2.5}$	$\mu g/m^3$	24-Hour	53.1	13.5	16.4	25	
		Annual	10.8	6.8	9.9	10	Measured value represents the average for the duration of monitoring and is indicative, not a true annual average.
CO	ppm	1-Hour	1.90	1.1	1.2	26.2	
		8-Hour	1.6	0.7	1.1	8.7	
NO_2	ppb	1-Hour	15.0	4.6	12.2	106.4	
		Annual	4.6	-1.4[c]	4.2	21.3	Measured value represents the average for the duration of monitoring and is indicative, not a true annual average.
SO_2	ppb	1-Hour	7.2	-0.1[c]	11.7	75*	
		24-Hour	0.3	-1.0[c]	1.7	7.6	
H_2S	ppb	24-Hour	1.9	0.4	16.0	107.6	
Benzene	ppb	24-Hour	155.8	0.4	0.7	9.4*	
Toluene	ppb	1-Week	20.7	5.0	6.0	59	
Ethyl-benzene	ppb	Annual	0.08	0.0	ND	0.23*	Measured value represents the average for the duration of monitoring and is indicative, not a true annual average.
Xylene	ppb	24-Hour	12.3	0.9	0.42	100*	

$\mu g/m^3$ = micrograms per cubic meter; ppb = parts per billion; ppm = parts per million
[a] Averaging time corresponds to the measured value and criterion unless otherwise noted.
[b] Listed criteria are WHO Guideline Values, unless marked with an "*" (indicating USEPA criteria).
[c] Negative values result when ambient concentrations are very low and normal instrument drift results in a negative value. This is consistent with accepted reporting convention. If drift is excessive—usually due to instrument malfunction—negative values are invalidated

PM_{10}, and to a lesser extent $PM_{2.5}$, is generated by physical operations such as grinding, cutting, etc. It is likely that the elevated concentrations monitored at all three sites were significantly influenced by vehicle traffic (engine emissions, rubber tire dust, resuspended road dust) and open burning. The Carifesta site may have also received significant sea salt inputs due to its proximity to the coast. The sources of New Amsterdam PM_{10} ambient air impacts likely included agricultural emission sources (tilling, harvesting, and residue burning).

In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning are probably also significant $PM_{2.5}$ emission sources impacting the three monitoring sites.

It should be noted that the comparison between the full monitoring period average and the annual WHO Guideline Values should be considered indicative rather than directly comparable, as the WHO Guideline Values are for annual averages, and the monitoring duration at each of the three sites was less than 365 days. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases.

The high benzene values measured at the Carifesta site were not observed at the other two monitoring sites. It is likely that vehicle emissions (a common source of airborne benzene) were responsible for these high measurements, given that the Carifesta site is situated between two roadways that are often busy and sometimes congested.

1. AIR MONITORING PROGRAM DESCRIPTION

Environmental Resources Management (ERM) conducted an onshore ambient air quality monitoring program on behalf of Esso Exploration and Production Guyana Limited (EEPGL) over the period of 15 August 2018 through 12 June 2019 at three sites in Guyana: Rose Hall Estate in New Amsterdam, Berbice (the "New Amsterdam" site); Carifesta, just off the sea wall in Georgetown (the "Carifesta" site); and New Guyana School, also in Georgetown, near the east bank of the Demerara River (the "New Guyana School" site).

1.1. Monitored Air Quality Parameters

The monitored air pollutants and rationale for their inclusion in the program are:

- Particulate Matter—two size ranges:
  - PM_{10} (inhalable particulate matter with aerodynamic diameter of less than 10 micrometers)
  - $PM_{2.5}$ (fine particulate matter with aerodynamic diameter of less than 2.5 micrometers)
- Carbon monoxide (CO)
- Sulfur dioxide (SO_2)
- Hydrogen sulfide (H_2S)
- Nitrogen dioxide (NO_2)
- Selected volatile organic compounds (VOCs)[3]:
  - Benzene
  - Toluene
  - Ethylbenzene
  - Xylenes

Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment were those established by the World Health Organization (WHO) in *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005* (WHO 2005), except for toluene, CO, and H_2S, for which WHO guidelines were published in WHO's *Air Quality Guidelines for Europe, 2nd edition, 2000* (WHO 2000). Since ozone is a secondary pollutant not directly emitted by industrial sources, it was not included in the suite of monitored parameters. While no WHO guidelines have been published for benzene, ethylbenzene, or xylenes, criteria for these species have been established by the U.S. Environmental Protection Agency (USEPA) and these were used for the assessment of results (USEPA 2019c).

1.2. Monitoring Sites

The monitoring sites were selected based on the sites' ability to characterize existing ambient air quality in areas upwind and downwind of urban Georgetown (where urban emission levels are anticipated to be highest).

Historical climatological data (such as prevailing wind patterns) and USEPA siting criteria were also considered in selecting specific sites. Finally, site accessibility and availability of power supply were factored into the final site selection.

The Carifesta monitoring site was established adjacent to Guyana Telephone & Telegraph's Carifesta Avenue location. See Figure 2 for a map of the Carifesta monitoring site. The New Amsterdam monitoring

[3] As noted in the report, an electrochemical sensor was employed to measure total VOC during the period when the gas chromatograph that normally measures speciated BTEX was out of service. While this sensor does not speciate VOCs, the total VOC measurements represent a maximum limit on the sum of the BTEX compounds' concentrations.

site was established at Rose Hall Estate, adjacent to the Rose Hall Sugar Factory in New Amsterdam, Berbice, as shown on Figure 3.

The New Guyana School monitoring site was established in Georgetown, on the school's property, near the east bank of the Demerara River. Figure 4 illustrates the location of this site.

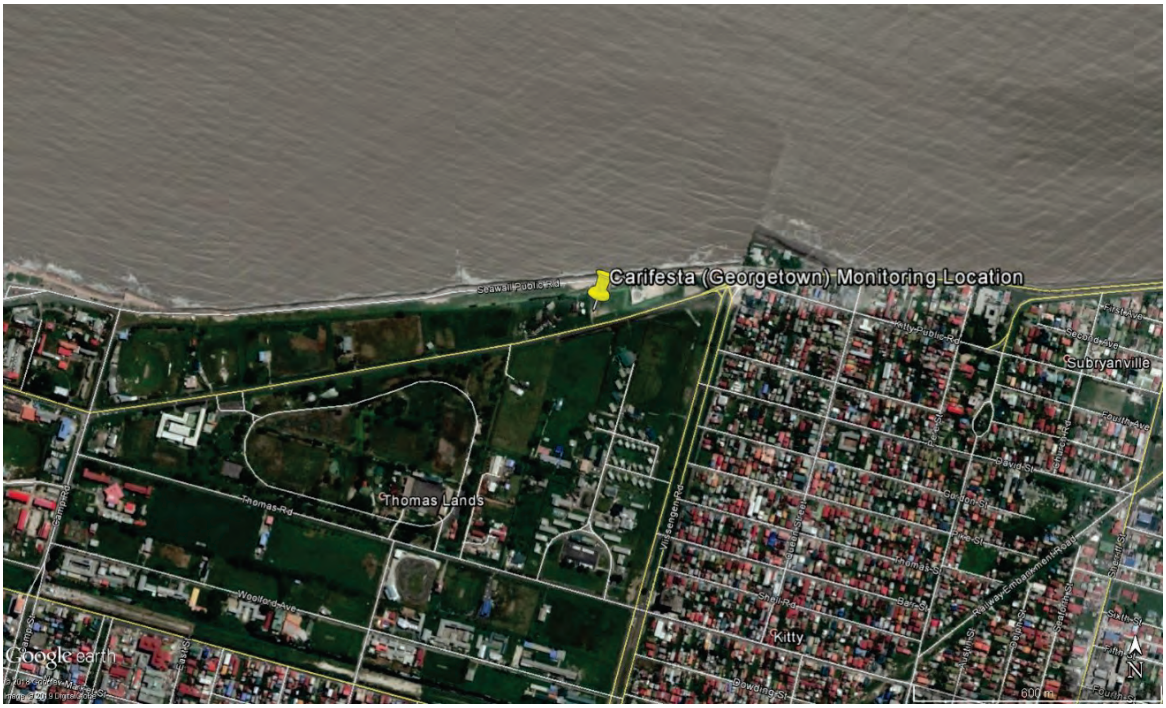


Figure 2: Carifesta (Georgetown) Monitoring Site Location



Figure 3: New Amsterdam (Berbice) Monitoring Site Location



Figure 4: New Guyana School (Georgetown) Monitoring Site Location

At each location, the air quality analyzers were housed in a climate-controlled shelter, with ambient air drawn in for analysis through sample inlets. For PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and H_2S measurements, ambient air was analyzed using continuous analyzers. Data from these continuous analyzers were reduced to 1-minute averages for storage and use in averaged concentration calculations. The VOC analyzer operated semi-continuously, with measurements recorded once every 6 minutes. The 6-minute data were then reduced to hourly averages.

An electrochemical total VOC sensor was used at the New Guyana School site, as the VOC analyzer was out of service during the New Guyana School site monitoring period as described in Section 3). The sensor provided continuous output data. In conjunction with use of the total VOC sensor, four passivated, evacuated Summa® canisters[4] were used to sequentially collect 24-hour integrated whole air samples for subsequent laboratory analysis via USEPA Method TO-15 (gas chromatography/mass spectrometry). These samples were analyzed for a suite of 75 organic compounds, including benzene, toluene, ethylbenzene, and xylenes (BTEX).

Monitoring at the Carifesta site began on 15 August 2018 and concluded on 3 October 2018. Monitoring at the New Amsterdam site began on 15 October 2018 and concluded on 3 December 2018. A second Carifesta monitoring period was conducted from 11 December 2018 through 21 March 2019. The New Guyana School site monitoring commenced on 12 April 2019 and was continuing as of the writing of this report; this report provides data and analysis for New Guyana School site monitoring through 12 June 2019.

ERM considers 6 weeks (1,008 hours) of ambient air quality monitoring to be adequate to characterize baseline air quality in environments where there are relatively few major emission sources, the topography is simple, and climatology lacks significant seasonality. The quantity of data exceeded this objective by more than 10 percent at each of the monitoring sites.

2. MONITORING RESULTS

2.1. PM_{10} Monitoring Results

Ambient concentrations of PM_{10} were measured continuously by a Teledyne API T640X, optical aerosol spectrometer. PM_{10} valid data recovery[5] was 94 percent at the Carifesta location and 99 percent at the New Amsterdam location. Data recovery at the New Guyana School site was 98 percent through 12 June 2019. Valid data recovery is a convenient metric on which to judge a monitoring program's technical performance.

Since there are particulate matter (PM) guideline criteria for 24-hour average values, only those days for which sufficient hours of data were collected are appropriate for comparison to the 24-hour average PM criterion. ERM used a threshold of at least 75 percent of possible hours (i.e., 18 hours) to be valid for the daily average to be considered valid. At Carifesta, 141 days were designated as valid[6] for use in comparison with criteria. At New Amsterdam, 50 monitoring days were designated as valid for use in comparison with criteria. The New Guyana School program had 61 days designated as valid through 12 June 2019. The proportion of valid monitoring days provides context with which to assess whether the data are adequate for comparison with an ambient air quality criterion.

[4] Summa canisters are specially treated to make them chemically non-reactive with specific air pollutants so that collected whole air samples do not degrade significantly during the interval between sampling and analysis.

[5] Valid data recovery percentage is the number of valid hourly measurements divided by total number of hours monitored, multiplied by 100.

[6] A valid monitoring day is one that obtained data for at least 18 of the 24 monitoring hours in the day.

Valid data loss is attributable to power outage, instrument malfunction, or calibration/maintenance work that detracts from the time an instrument is measuring ambient air. Table 2 presents a summary of the results of PM_{10} monitoring at all three monitoring site locations. ERM's ambient air quality data recovery goal is 80 percent—consistent with international standard practice. All three programs exceeded this goal. Measured concentrations at the monitoring locations were compared to the 24-hour and annual WHO Guideline Values for PM_{10} (WHO 2005).

Table 2: Summary of PM_{10} Monitoring Results

Site	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Carifesta	266.7	154.2	27.9	94%	141
New Amsterdam	110.7	39.8	20.6	99%	50
New Guyana School	84.9	47.6	27.1	98%	61
Criterion	—	50 (WHO 24-hour)	20 (WHO Annual)		

$\mu g/m^3$ = micrograms per cubic meter
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts. As such, comparison between the full monitoring period average and the annual WHO Guideline Value should be considered indicative rather than directly comparable,

At Carifesta, the maximum 24-hour average concentration was approximately three times the corresponding WHO criterion, while the average over the 141-day monitoring period was about 40 percent over the annual average criterion. The New Amsterdam monitoring yielded a maximum 24-hour average concentration that was about 20 percent below the 24-hour WHO Guideline Value, while the full monitoring period average of measured concentrations was slightly above the annual WHO Guideline Value. At New Guyana School, the maximum 24-hour average was slightly below the criterion while the full monitoring period average was approximately 40 percent over the annual WHO Guideline Value.

PM_{10} is generated primarily by physical operations such as grinding, cutting, etc. It is likely that the elevated concentrations monitored at all three sites were significantly influenced by vehicle traffic (engine emissions, rubber tire dust, resuspended road dust) and open burning. Carifesta may have also received significant sea salt inputs due to its proximity to the coast. The New Amsterdam PM_{10} sources likely included a significant impact from agricultural emission sources (tilling, harvesting, and residue burning).

It should be noted that the comparison between the full monitoring period averages and the annual WHO Guideline Value should be considered indicative rather than directly comparable, as the guideline is an annual average, and the monitoring durations at all three sites were each less than 365 days. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases.

The daily monitoring statistics for all three sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.2. $PM_{2.5}$ Monitoring Results

Ambient concentrations of $PM_{2.5}$ were measured continuously by a Teledyne API T640X, optical aerosol spectrometer. $PM_{2.5}$ valid data recovery was 94 percent at the Carifesta location and 99 percent at the New Amsterdam location. New Guyana School had valid data recovery of 98 percent, through 12 June

2019. At Carifesta, 141 monitoring days were designated as valid for use in comparison with criteria. At New Amsterdam, 50 monitoring days were designated as valid for use in comparison with criteria. New Guyana School had 61 days designated as valid for comparison to criteria. Table 3 presents a summary of the results of $PM_{2.5}$ monitoring at the three monitoring site locations. Measured concentrations at all three monitoring locations were compared to the 24-hour and annual WHO Guideline Values for $PM_{2.5}$.

Table 3: Summary of $PM_{2.5}$ Monitoring Results

Location	Maximum 1-Hour Average ($\mu g/m^3$)	Maximum 24-Hour Average ($\mu g/m^3$)	Monitoring Period Average [a] ($\mu g/m^3$)	Data Recovery	Valid Monitoring Days
Carifesta	92.7	53.1	10.8	94%	141
New Amsterdam	38.3	13.5	6.8	99%	50
New Guyana School	45.8	16.4	9.9	98%	61
Criterion	—	25 (WHO 24-hour)	10 (WHO Annual)		

$\mu g/m^3$ = micrograms per cubic meter

[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts. As such, comparison between the full monitoring period average and the annual WHO Guideline Value should be considered indicative rather than directly comparable,

The Carifesta monitoring site had a maximum 24-hour average measurement that was approximately twice the corresponding WHO standard, and a monitoring period average concentration that was slightly above the WHO annual Guideline Value. The New Amsterdam maximum 24-hour average concentration was less than the corresponding WHO Guideline Value, and the monitoring period average was below the annual criterion. The New Guyana School maximum 24-hour average concentration was less than the WHO Guideline Value, and the monitoring period average was slightly below the WHO annual Guideline Value.

It should be noted that the comparison between the full monitoring period averages and the annual WHO Guideline Value should be considered indicative rather than directly comparable, as the WHO Guideline Value is an annual average, and the duration of monitoring at each of the three locations was less than a full year. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases.

In most cases, the primary source of $PM_{2.5}$ is atmospheric chemical reaction of precursor gases that forms fine particles. Common precursor gases are SO_2 and NO_2 from fuel combustion, as well as ammonia from livestock operations. Combustion emissions from vehicle engines and open burning are probably also significant $PM_{2.5}$ emission sources impacting the three monitoring sites.

The daily monitoring statistics for all three sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.3. Carbon Monoxide Monitoring Results

Ambient concentrations of CO were measured continuously by a Thermofisher Scientific Model 48i gas filter correlation analyzer. Monitored concentrations were adjusted, as needed, in post-processing based on the automated zero test of the analyzer. CO valid data recovery was 98 percent at the Carifesta location and 98 percent at the New Amsterdam location. New Guyana School data recovery was 98 percent through 12 June 2019. At the Carifesta site, 147 monitoring days were designated as valid for use in comparison with criteria; at the New Amsterdam site, 50 monitoring days were designated as valid;

and at the New Guyana School site, 61 monitoring days were designated as valid for comparison. Table 4 presents a summary of the results of CO monitoring at all three monitoring sites.

Table 4: Summary of Carbon Monoxide Monitoring Results

Location	Maximum 1-Hour Average (ppm)	Maximum 8-Hour Average (ppm)	Monitoring Period Average (ppm)	Data Recovery	Valid Monitoring Days
Carifesta	1.9	1.6	0.6	98%	147
New Amsterdam	1.1	0.7	0.4	98%	50
New Guyana School	1.2	1.1	0.4	98%	61
Criterion	26.2 (WHO 1-hour)	8.7 (WHO 8-hour)	—		

ppm = parts per million

Measured concentrations at the Carifesta site were adjusted in post-processing based on the automated zero tests of the analyzer, as necessary, to account for instrument drift. Measured concentrations at all three monitoring locations were compared to the 1-hour and 8-hour average WHO Guideline Values for CO. The maximum 1-hour and 8-hour average measured concentrations for all three sites are well below the applicable WHO Guideline Values.

The daily monitoring statistics for all the sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.4. Nitrogen Dioxide Monitoring Results

Ambient concentrations of NO_2 were measured continuously by a Thermofisher Scientific Model 42i chemiluminescent analyzer. Measured concentrations at New Amsterdam were adjusted, as necessary, in post-processing based on the automated zero and span tests of the analyzer. NO_2 valid data recovery was 98 percent at the Carifesta location, 79 percent at the New Amsterdam location, and 98 percent at the New Guyana School site through 12 June 2019.

The New Amsterdam data recovery was slightly below the data recovery goal of 80 percent. While not ideal, 79 percent data recovery is generally adequate for characterizing ambient air quality. Many governmental agencies use 75 percent as their data recovery objective.

At Carifesta, 147 monitoring days were designated as valid for use in comparison to criteria; 50 monitoring days were valid at the New Amsterdam site; and 61 monitoring days were designated as valid at the New Guyana School. Table 5 presents a summary of the results of NO_2 monitoring at all three monitoring locations.

Data recovery at the New Amsterdam location was adversely affected by the failure of the analyzer's internal pump and several instances of significant bleed-over of the automated challenge concentration. The bleed-over occurred when the air compressor that is used to supply "zero air"[7] to the calibration system was off or did not supply enough pressure to allow for the proper dilution of the calibration gas.

The maximum 1-hour average and the full monitoring period average of the measured concentrations were compared to the 1-hour and annual WHO Guideline Values, respectively, for NO_2. At all three monitoring sites, the averages are well below the applicable WHO Guideline Values.

[7] Air that has been filtered to remove the pollutant(s) being monitored. It is used directly for challenging an instrument's calibration at the zero concentration level.

Table 5: Summary of Nitrogen Dioxide Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Monitoring Period Average [a] (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	15.0	4.6	98%	147
New Amsterdam	21.7	-1.4 [b]	79%	50
New Guyana School	12.2	4.2	98%	61
Criterion	106.4 (WHO 1-hour)	21.3 (WHO Annual)		

ppb = parts per billion
[a] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts. As such, comparison between the full monitoring period average and the annual WHO Guideline Value should be considered indicative rather than directly comparable,
[b] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

It should be noted that the comparison between the full monitoring period averages and the annual WHO Guideline Value should be considered indicative rather than directly comparable, as the WHO Guideline Value is an annual average, and the duration of monitoring at each of the three sites was less than a full year. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Therefore, it is expected that actual annual average values at the sites would be even lower below the guideline value.

The daily monitoring statistics for both sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.5. Sulfur Dioxide Monitoring Results

Ambient concentrations of SO_2 were measured continuously by a Thermofisher Scientific Model 450i pulsed fluorescence analyzer. SO_2 valid data recovery was 98 percent at the Carifesta location, 95 percent at the New Amsterdam location, and 98 percent at the New Guyana School site through 12 June 2019. At the Carifesta site, 147 monitoring days were designated as valid for use in comparison to criteria; New Amsterdam had 50 days designated valid; and New Guyana School had 61 valid days. Table 6 presents a summary of the results of SO_2 monitoring at all three locations.

Table 6: Summary of Sulfur Dioxide Monitoring Results

Location	Maximum Daily 1-hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	7.2	0.3	-0.4 [a]	98%	147
New Amsterdam	-0.1 [a]	-1.0 [a]	-1.3 [a]	95%	50
New Guyana School	11.7	1.7	0.9	98%	61
Criterion	75 (USEPA 1-hour)	7.6 (WHO 24-hour)	—		

ppb = parts per billion
[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

The maximum 1-hour average and the maximum 24-hour average of the measured SO_2 concentrations at all three monitoring sites were compared to the 1-hour USEPA standard and the 24-hour WHO Guideline Value, respectively. The USEPA standard was employed because WHO has not issued a 1-hour Guideline Value. At all three monitoring sites, the averages are well below the applicable criteria.

The daily monitoring statistics for both sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.6. Hydrogen Sulfide Monitoring Results

Ambient concentrations of H_2S were measured continuously by a Thermofisher Scientific Model 450i pulsed fluorescence analyzer. H_2S valid data recovery was 98 percent at the Carifesta location, 95 percent at the New Amsterdam location, and 98 percent at the New Guyana School site. At Carifesta, 147 monitoring days were designated as valid monitoring days; 50 days were determined to be valid at the New Amsterdam site; and New Guyana School had 61 valid days. Table 7 presents a summary of the results of H_2S monitoring at all three locations.

Table 7: Summary of Hydrogen Sulfide Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	20.0	1.9	0.2	98%	147
New Amsterdam	5.7	0.4	-0.1 [a]	95%	50
New Guyana School	71.8	16.0	4.8	98%	61
Criterion	—	107.6 (WHO 24-hour)	—		

ppb = parts per billion
[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

The maximum 24-hour average of the measured concentrations at all three monitoring sites was compared to the 24-hour WHO Guideline Value for H_2S. The averages at all three sites are well below the WHO Guideline Value.

The daily monitoring statistics for all three sites are presented in Attachment A and the hourly data record is presented in Attachment B.

2.7. Benzene Monitoring Results

Ambient concentrations of benzene were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta (initial deployment only) and New Amsterdam sites. The gas chromatograph failed subsequent to the New Amsterdam deployment. In its place, four Summa air samples were collected at New Guyana School and analyzed for benzene in addition to other VOCs.

Benzene valid data recovery was 94 percent at the Carifesta location and 99 percent at the New Amsterdam location. At Carifesta, 47 monitoring days were designated as valid monitoring days; at New Amsterdam, 50 monitoring days were designated as valid monitoring days. Analyses of all four New Guyana School Summa samplers were valid. Table 8 presents a summary of the results of benzene monitoring at each location.

Table 8: Summary of Benzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	1,272.6	155.8	21.7	94%	47
New Amsterdam	7.9	0.4	0.0	99%	50
New Guyana School [a]	NA	0.7	NA	100%	4
Criterion	—	9.4 (USEPA 24-hour)	—		

NA = not applicable; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples

The maximum 24-hour average of the measured concentrations at each of the three monitoring locations was compared to the 24-hour USEPA Reference Concentration. At Carifesta, the average was significantly higher than the Reference Concentration. The maximum 24-hour average value includes a single 6-minute sample that registered well above the calibration range of the analyzer. While this anomalous measurement is considered to be an outlier, it was not invalidated since all quality control parameters were within tolerance.

Even if the outlier value is excluded, the maximum 24-hour average would still have exceeded the Reference Concentration by more than 50 percent at the Carifesta site. Motor vehicle emissions were most likely responsible for the measured values, since there are no obvious nearby stationary benzene emission sources upwind of the Carifesta site.

At the New Amsterdam and the New Guyana School monitoring sites, the maximum 24-hour average benzene measurements were significantly lower than the Reference Concentration.

The daily monitoring statistics for the Carifesta and New Amsterdam sites are presented in Attachment A and the hourly data record is presented in Attachment B. The New Guyana School measurements were limited to four values from Summa samples. The benzene results for all four samples are discussed in Section 2.11.

2.8. Toluene Monitoring Results—Carifesta and New Amsterdam

Ambient concentrations of toluene were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta (initial deployment only) and New Amsterdam sites. The four Summa air samples collected at New Guyana School were analyzed for toluene in addition to other VOCs. Toluene valid data recovery was 94 percent at the Carifesta location and 99 percent at the New Amsterdam location. Analyses of all four New Guyana School Summa samples were valid. At Carifesta, 47 monitoring days were designated as valid for comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for comparison to criteria. Table 9 presents a summary of the results of toluene monitoring at each location.

The maximum weekly averages at the Carifesta and New Amsterdam sites were compared to the WHO 1-week Guideline Value. At Carifesta and New Amsterdam, the weekly averages are below the WHO Guideline Value.

The daily monitoring statistics for all sites are presented in Attachment A and the hourly data record is presented in Attachment B.

Table 9: Summary of Toluene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	1,134.6	169.5	20.7	94%	47
New Amsterdam	6.7	5.4	5.0	99%	50
New Guyana School [a]	NA	6.0	NA	100%	4
Criterion	—	—	59 (WHO 1-week)		

NA = not applicable; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples

Due to malfunction of the VOC analyzer, New Guyana School toluene values are not available on a weekly-average basis. However, since the maximum measured 24-hour value was only about 10 percent of the WHO 1-week Guideline Value, it is likely that the weekly average would be less than 10 percent of the 1-week Guideline Value. The toluene results for all four Summa samples are discussed in Section 2.11.

2.9. Ethylbenzene Monitoring Statistics—Carifesta and New Amsterdam

Ambient concentrations of ethylbenzene were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta (initial deployment only) and New Amsterdam sites. The four Summa air samples collected at New Guyana School were analyzed for ethylbenzene in addition to other VOCs. Ethylbenzene valid data recovery was 94 percent at the Carifesta location and 99 percent at the New Amsterdam location. Analyses of all four Summa samples collected at the New Guyana School site were valid. At Carifesta, 47 monitoring days were designated as valid for comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for comparison to criteria. Table 10 presents a summary of the results of ethylbenzene monitoring at the three monitoring sites.

Table 10: Summary of Ethylbenzene Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	31.6	3.3	0.08	94%	47
New Amsterdam	0.6	0.1	0.0	99%	50
New Guyana School [a]	NA	ND	ND	100%	4
Criterion	—	—	0.23 [b] (USEPA Annual)		

NA = not applicable; ND = below minimum laboratory reporting level of 0.14 ppb by volume; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples
[b] While the monitoring period data averages are compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts.

The full monitoring period average concentrations at all three sites were compared to the USEPA annual average Reference Concentration for ethylbenzene. The monitoring period averages are well below the USEPA Reference Concentration at all three sites.

It should be noted that the comparison between the full monitoring period average and the annual USEPA Reference Concentration should be considered indicative rather than directly comparable, as the USEPA Reference Concentration is an annual average and the duration of monitoring at each site was considerably less than 365 days. The nature of atmospheric dispersion is such that average values generally decrease as the averaging period increases. Therefore, it is expected that actual annual average values at all three sites would be even further below the USEPA annual Reference Concentration.

The Carifesta and New Amsterdam daily monitoring statistics for all sites are presented in Attachment A and the hourly data record is presented in Attachment B. The New Guyana School ethylbenzene Summa results for all four samples are discussed in Section 2.11.

2.10. Xylenes Monitoring Statistics—Carifesta and New Amsterdam

Ambient concentrations of xylenes were measured semi-continuously by a Mocon Baseline Series 9100 gas chromatograph at the Carifesta (initial deployment only) and New Amsterdam sites. The four Summa air samples collected at New Guyana School were analyzed for xylenes in addition to other VOCs. Xylenes valid data recovery was 94 percent at the Carifesta location and 99 percent at the New Amsterdam location. Xylenes analyses of all four New Guyana School Summa samples were valid. At Carifesta, 47 monitoring days were designated as valid for comparison to criteria; at New Amsterdam, 50 monitoring days were designated as valid for comparison to criteria. Table 11 presents a summary of the results of xylenes monitoring at the all three locations.

Table 11: Summary of Xylenes Monitoring Results

Location	Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Monitoring Period Average (ppb)	Data Recovery	Valid Monitoring Days
Carifesta	137.1	12.3	0.4	94%	47
New Amsterdam	14.4	0.9	0.1	99%	50
New Guyana School [a]	NA	0.4	NA	100%	4
Criterion	—	100 (USEPA 24-hour)	—		

NA = not applicable; ppb = parts per billion
[a] Data from integrated 24-hour Summa samples

The maximum 24-hour averages of the measured concentrations at all three monitoring locations were compared to the 24-hour USEPA Reference Concentration. At Carifesta, New Amsterdam, and New Guyana School, the 24-hour averages are well below the USEPA Reference Concentration.

The Carifesta and New Amsterdam daily monitoring statistics for both sites are presented in Attachment A and the hourly data record is presented in Attachment B. The New Guyana School xylenes Summa results for all four samples are discussed in Section 2.11.

2.11. Total Volatile Organic Compound Sensor Monitoring and Summa Canister Analysis Statistics—New Guyana School

Quality control checks revealed that the Mocon Baseline Series 9100 gas chromatograph failed due to water condensation within the column at the beginning of the monitoring system's second Carifesta site deployment. Upon installation at the New Guyana School site, the gas chromatograph was replaced by an electrochemical total VOC sensor. While not capable of discerning between VOC species, total VOC constitutes an upper limit on the concentration of a single or combination of VOC components. The sensor provided continuous data output.

In conjunction with the use of the total VOC sensor, four passivated, evacuated Summa® canisters were used to sequentially collect 24-hour integrated whole air samples for subsequent laboratory analysis via USEPA Method TO-15 (gas chromatography/mass spectrometry). These samples were analyzed for a suite of 75 organic compounds, including the BTEX compounds. The Summa results, presented in Table 12, were used to directly compare ambient air quality to the BTEX compound criteria.

Data recovery from the total VOC sensor at the New Guyana School site was 87 percent through 12 June 2019. Table 13 presents a summary of the results of the total VOC concentrations measured at New Guyana School.

Table 12: Summary of New Guyana School Summa BTEX Monitoring Results

Sample Date	24-Hour Average Concentration [ppb(v)]			
	Benzene	Toluene	Ethylbenzene	Xylenes
16 April 2019	0.69	6.00	ND	0.42
17 April 2019	ND	3.80	ND	ND
26 April 2019	ND	0.81	ND	ND
27 April 2019	0.24	0.68	ND	ND
Maximum	**0.69**	**6.00**	**ND**	**0.42**
WHO 1-Week Average Criterion	—	59	—	—
USEPA 24-Hour Average Criterion	9.4	—	—	100
USEPA Annual Average Criterion	—	—	0.23	—

ND = below laboratory minimum reporting level; ppb(v) = parts per billion by volume
Note: Summa results are only available as 24-hour average values. Caution must be exercised in comparing these data with criteria that are stated in terms of different averaging times.

There are no generally accepted ambient air quality criteria for total VOCs. Therefore, the maximum total VOC measurements were compared to the WHO/USEPA criteria for each of the BTEX compounds. Since total VOC represents the maximum potential concentration of any single VOC compound, this assessment is conservative. The daily total VOC monitoring statistics are presented in Attachment A and the hourly data record is presented in Attachment B.

Table 13: Summary of New Guyana School Total Volatile Organic Compound Sensor Monitoring Results

		Maximum 1-Hour Average (ppb)	Maximum 24-Hour Average (ppb)	Maximum Weekly Average (ppb)	Monitoring Period Average (ppb)
Monitoring Results		89.6	10.3	8.4	4.3
Compound	**Source**	**Criteria**			
Benzene	USEPA	—	9.4	—	—
Toluene	WHO	—	—	69	
Ethylbenzene	USEPA	—	—	—	23 (annual average [a])
Xylenes	USEPA	—	100	—	—

ppb = parts per billion
[a] While the monitoring period data average is compared to the annual criterion, if monitoring were performed for a full year, the resulting average data values would likely be lower than that for just the monitoring period. This is because air quality data tend to be log-normally distributed—having many very small values, with only intermittent high impacts. As such, comparison between the full monitoring period average and the annual USEPA criterion should be considered indicative rather than directly comparable.

3. QUALITY CONTROL AND QUALITY ASSURANCE

Various quality assurance and quality control activities were performed during the monitoring periods to evaluate the performance of the monitoring analyzers and to demonstrate conformance to established criteria for data quality. These activities were performed either through automated means or manually, or were inherent to the design of the monitoring system. With the exception of NO_2 at the New Amsterdam monitoring location (discussed below), all measurements demonstrated general compliance with the established quality assurance and quality control criteria.

3.1. Quality Control Results

Automated quality control checks were initiated by the monitoring station's data logger on a weekly basis to assess the performance of the analyzers measuring CO, NO_2, SO_2, and H_2S. These precision checks assess the performance of the analyzer at or below an established air quality standard or near the expected ambient concentration. The precision value is a representation of the repeatability of the analyzer to respond accurately to the control concentration. The bias value is a representation of the analyzer's tendency to respond higher or lower than the control concentration.

Table 14 presents the precision and bias calculations for the four gaseous parameters at the Carifesta monitoring location. The results demonstrate that the analyzers were operating well within the acceptance criteria, indicating high quality, reliable data.

Table 14: Carifesta Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criterion (%)
CO	22	3.7	±3.28	± 10%
NO_2	22	4.3	±4.54	± 15%
SO_2	22	2.1	-3.2	± 10%
H_2S	22	2.5	+4.7	± 10%

Table 15 presents the precision and bias calculations for the four gaseous parameters at the New Amsterdam monitoring location. The results of these precision checks demonstrate that the CO and SO_2 analyzers were operating well within the acceptance criteria.

For H_2S, the analyzer passed the precision criterion but exceeded the bias criterion, suggesting that the measured ambient concentrations may be biased high, but the analyzer responded consistently to the changes in ambient concentration. For NO_2, the precision and bias calculations demonstrate that the analyzer was not performing within the acceptance criteria. The degradation in the analyzer's internal pump, which eventually resulted in its failure, significantly affected the analyzer's ability to respond accurately to challenge and ambient concentrations. The NO_2 data collected at the New Amsterdam location, therefore are of lesser quality and should only be used when qualified as such.

Table 16 presents the precision and bias calculations for the four gaseous parameters at the New Guyana School monitoring location. The results demonstrate that the analyzers were operating well within the acceptance criteria, indicating high quality, reliable data.

Table 15: New Amsterdam Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criterion (%)
CO	6	1.7	+2.8	± 10%
NO_2	6	20.9	-32.5	± 15%
SO_2	6	2.1	+2.9	± 10%
H_2S	6	5.2	+11.2	± 10%

Table 16: New Guyana School Quality Control Results

Parameter	Valid Challenges	Precision (%)	Bias (%)	Acceptance Criteria (%)
CO	6	8.3	-6.5	± 10%
NO_2	6	2.5	-7.2	± 15%
SO_2	6	2.3	+2.4	± 10%
H_2S	6	3.2	± 2.3	± 10%

3.2. Quality Assurance

The analyzers measuring PM_{10}, $PM_{2.5}$, CO, NO_2, SO_2, and H_2S are certified by the USEPA for use in assessing ambient air quality. All challenges of the analyzers' performance, manual or automated, were performed in general conformance to accepted quality assurance procedures. The monitoring shelter temperature was maintained within the operational assurance range.

All analyzers were calibrated prior to the start of monitoring at each location. A multipoint quality assurance verification of the analyzers immediately following calibration demonstrated that the analyzers were operating well within the acceptance criteria. With one exception, the multipoint quality assurance verifications were repeated at the conclusion of the monitoring at each location, as long as the analyzer was operational. At Carifesta, these multipoint quality assurance verifications demonstrated that the analyzers were operating within the acceptance criteria. At New Amsterdam, with the exception of NO_2, these multipoint quality assurance verifications demonstrated that the analyzers were operating within the acceptance criteria. The failure of the NO_2 analyzer prior to the conclusion of the monitoring period did not allow for a multipoint evaluation of the analyzer's performance. A final calibration of the VOC analyzer was not possible following its New Amsterdam deployment due to expected contamination of the calibration gas standard[8]. Nevertheless, data have been validated on the basis of its initial calibration and other quality control checks. These measures include frequent manual data review (at least twice per week), and monitoring and documenting instrument diagnostic parameters (column temperature, sample flow rate, etc.).

[8] Substantial SO_2 artifact was found in this tank while calibrating the H_2S analyzer. Subsequent challenge of the VOC analyzer showed apparent response shift. Based on these results, it was concluded that the tank had been contaminated with air. Rather than calibrate the VOC analyzer with a standard of uncertain quality, it was decided to rely on the installation calibration for its validation.

4. REFERENCES

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ATTACHMENT A DAILY MONITORING STATISTICS

- Attachment A-1: Carifesta Daily Monitoring Statistics
- Attachment A-2: New Amsterdam Daily Monitoring Statistics
- Attachment A-3: New Guyana School Daily Monitoring Statistics

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Attachment A-1 Carifesta Daily Monitoring Statistics

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
15/08/2018	37.3	13.1	0.32	12.8	-1.3	0.2	29.0	0.9	0.0	0.2
16/08/2018	16.6	6.2	0.32	8.9	-1.3	0.4	27.3	16.7	0.0	0.5
17/08/2018	15.2	6.3	0.27	5.9	-1.3	0.2	5.3	7.4	0.0	0.0
18/08/2018	18.9	8.8	0.48	11.3	-0.8	1.8	2.6	25.9	0.0	0.1
19/08/2018	15.4	7.5	0.32	4.6	-1.5	0.6	58.5	12.4	0.0	0.0
20/08/2018	12.7	5.3	0.32	9.5	-1.3	0.7	131.9	92.2	0.0	0.0
21/08/2018	14.4	6.5	0.33	8.8	-1.1	1.0	52.9	34.4	0.0	0.0
22/08/2018	16.5	7.8	0.29	8.7	-1.4	0.3	4.3	120.9	0.0	0.0
23/08/2018	13.3	5.4	0.26	8.0	-1.5	0.1	13.3	8.2	0.0	1.5
24/08/2018	12.6	5.3	0.33	8.1	-1.3	0.4	58	35.9	0.0	0.0
25/08/2018	13.4	6.0	0.35	5.7	-1.4	0.2	36.1	0.7	0.0	0.0
26/08/2018	16.4	7.3	0.39	6.3	-1.4	0.0	36.8	28.6	0.0	0.0
27/08/2018	16.1	7.6	0.38	7.4	-1.0	0.0	10.0	36.6	0.0	0.0
28/08/2018	15.2	5.9	0.34	10.0	-1.2	0.0	3.0	17.8	0.0	0.0
29/08/2018	18.6	8.1	0.42	8.0	-0.6	0.1	10.9	27.6	0.0	0.0
30/08/2018	12.7	5.3	0.37	7.4	-1.5	0.0	13.5	21.3	0.0	0.0
31/08/2018	16.7	6.8	0.45	10.3	-1.1	-0.1	ID	ID	ID	ID
01/09/2018	18.5	7.1	0.42	9.3	-1.3	0.0	ID	ID	ID	ID
02/09/2018	ID	ID	0.75	8.1	-0.7	0.7	ID	ID	ID	ID
03/09/2018	15.2	7.0	0.65	13.7	-1.0	1.9	47.2	17.7	0.0	0.0
04/09/2018	17.1	6.9	0.69	11.2	-0.3	0.2	23.7	11.4	0.0	0.0
05/09/2018	26.6	9.7	0.89	11.2	-0.2	1.1	13.0	5.0	0.0	0.0
06/09/2018	19.3	6.9	0.66	8.2	-0.4	0.4	5.8	5.7	0.0	0.0
07/09/2018	14.6	5.8	0.70	8.4	-1.0	0.9	6.3	52.9	0.0	0.0
08/09/2018	14.3	5.5	0.67	9.9	-1.2	0.7	16.3	7.3	0.0	0.0
09/09/2018	14.5	5.6	1.01	9.1	-1.0	0.1	1.2	0.4	0.0	0.1
10/09/2018	21.6	8.9	0.96	8.9	-0.2	0.4	18.2	9.5	0.0	0.0
11/09/2018	24.7	9.6	0.81	5.8	-1.1	0.0	1.1	10.5	0.0	0.0

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
12/09/2018	12.7	4.5	0.39	12.4	-0.5	0.5	11.8	0.0	0.0	0.0
13/09/2018	15.3	7.2	0.49	10.2	-0.3	0.7	0.5	6.4	0.0	0.0
14/09/2018	23.8	9.3	0.62	9.8	0.3	1.6	0.1	0.0	0.0	0.0
15/09/2018	18.4	7.9	0.44	7.5	-1.3	0.4	3.2	49.9	0.0	0.0
16/09/2018	13.0	5.2	0.56	6.5	-1.3	0.3	5.3	14.4	0.0	0.0
17/09/2018	14.9	6.6	0.55	15.0	-0.6	0.7	19.1	2.2	0.0	0.0
18/09/2018	13.9	6.4	0.45	11.4	-0.3	0.0	8.9	7.4	0.0	0.0
19/09/2018	15.9	5.9	0.45	8.8	-1.2	0.4	12.8	0.1	0.0	0.0
20/09/2018	29.7	11.0	0.46	10.5	-0.7	0.4	9.1	1.0	0.0	0.0
21/09/2018	17.5	7.2	0.56	11.6	-1.2	0.1	19.8	0.0	0.0	0.0
22/09/2018	ID	ID	0.44	6.3	-1.2	0.2	14.9	0.0	0.0	0.0
23/09/2018	ID	ID	0.53	3.9	-1.3	0.0	15.5	0.2	0.0	0.0
24/09/2018	ID	ID	0.41	10.3	-1.4	0.0	14.2	0.0	0.0	1.0
25/09/2018	ID	ID	0.43	9.3	-1.3	-0.1	3.8	0.0	0.0	0.3
26/09/2018	14.6	5.3	0.46	11.7	-0.1	0.9	37.2	0.0	0.0	0.1
27/09/2018	20.3	9.0	0.49	7.8	-1.2	0.2	23.6	0.0	0.0	0.0
28/09/2018	20.8	8.3	0.44	6.5	-1.3	0.1	0.6	0.0	0.0	0.0
29/09/2018	18.8	7.7	0.40	4.9	-1.5	0.0	1.0	0.7	0.0	0.1
30/09/2018	17.4	7.5	0.61	4.7	-1.2	0.0	12.3	0.6	0.0	0.0
01/10/2018	13.5	5.7	0.46	7.7	-1.4	-0.1	2.1	0.0	0.5	0.0
02/10/2018	17.1	6.4	0.50	9.2	-1.2	0.4	10.7	0.0	0.0	0.0
03/10/2018	19.8	8.5	0.43	8.5	-1.0	0.2	13.5	2.7	2.2	8.7
Carifesta (Second Deployment)										
6/12/2018	31.6	11.7	0.55	ID	0.2	-0.1				
7/12/2018	31.1	12.2	0.30	ID	-0.1	-0.1				
8/12/2018	30.0	11.9	0.40	ID	0.1	-1.5				
9/12/2018	22.6	8.5	0.40	-2.2	0.0	-1.6				
10/12/2018	16.7	5.9	0.38	4.7	0.1	-0.5				
11/12/2018	21.6	7.9	0.34	7.7	-0.1	1.0				
12/12/2018	30.4	10.6	0.29	-0.5	-0.3	0.9				

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
13/12/2018	40.3	15.6	0.33	0.7	-0.3	0.2				
14/12/2018	30.9	11.2	0.37	-0.7	-0.2	0.9				
15/12/2018	23.1	8.2	0.34	1.6	-0.3	0.3				
16/12/2018	22.8	8.6	0.41	4.6	-0.2	0.6				
17/12/2018	25.6	8.8	0.40	12.5	-0.2	0.6				
18/12/2018	18.4	6.8	0.37	5.4	-0.1	1.3				
19/12/2018	29.0	11.1	0.45	7.0	0.0	0.9				
20/12/2018	46.3	17.8	0.39	-0.3	-0.2	0.4				
21/12/2018	35.0	13.8	0.42	3.2	-0.2	0.4				
22/12/2018	23.6	7.7	0.36	-1.1	-0.4	0.0				
23/12/2018	24.1	9.0	0.47	1.7	-0.2	0.0				
24/12/2018	31.8	11.8	0.41	0.9	-0.4	0.1				
25/12/2018	31.0	12.3	0.40	-0.3	-0.4	0.0				
26/12/2018	45.3	17.8	0.41	-1.2	-0.3	0.0				
27/12/2018	44.5	16.7	0.40	-0.9	-0.3	0.0				
28/12/2018	30.8	11.6	0.40	0.8	-0.3	0.1				
29/12/2018	20.6	7.6	0.45	3.2	-0.3	0.0				
30/12/2018	16.8	6.3	0.59	5.5	-0.1	0.8				
31/12/2018	26.8	9.7	0.42	1.7	-0.2	0.0				
1/01/2019	23.2	8.6	0.50	0.4	-0.2	0.0				
2/01/2019	18.6	6.5	0.42	-1.2	-0.2	0.0				
3/01/2019	18.7	6.7	0.42	-0.6	-0.3	0.0				
4/01/2019	19.5	7.2	0.44	-1.5	-0.3	0.0				
5/01/2019	28.1	10.2	0.46	-1.6	-0.4	0.0				
6/01/2019	58.8	21.8	0.63	0.6	-0.1	0.0				
7/01/2019	49.1	20.4	0.53	0.9	-0.1	0.0				
8/01/2019	40.5	17.1	0.50	2.4	-0.2	0.0				
9/01/2019	36.0	15.1	0.51	-0.2	-0.2	-0.1				
10/01/2019	39.3	15.4	0.52	0.8	-0.3	0.0				
11/01/2019	41.4	16.1	0.53	2.6	-0.2	0.1				

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
12/01/2019	23.4	8.9	0.54	-0.4	-0.4	-0.1				
13/01/2019	26.7	13.8	0.84	1.4	-0.2	-0.1				
14/01/2019	29.2	11.7	0.54	1.0	-0.1	0.0				
15/01/2019	29.2	11.8	0.62	11.6	-0.1	0.2				
16/01/2019	27.3	11.2	0.53	-0.1	-0.4	0.0				
17/01/2019	28.9	12.1	0.81	0.5	-0.3	0.0				
18/01/2019	24.3	9.9	0.72	5.3	-0.1	0.0				
19/01/2019	29.9	11.9	0.69	-1.0	-0.2	0.0				
20/01/2019	28.0	11.4	0.77	0.7	-0.1	0.0				
21/01/2019	42.1	16.3	0.72	4.3	-0.2	0.0				
22/01/2019	31.3	12.3	0.65	2.5	-0.3	0.0				
23/01/2019	20.9	8.6	0.64	0.5	-0.3	0.0				
24/01/2019	19.3	6.9	0.62	-0.5	-0.4	0.0				
25/01/2019	16.2	6.4	0.70	10.1	-0.2	0.0				
26/01/2019	13.2	5.0	0.77	0.0	-0.2	-0.1				
27/01/2019	9.9	3.9	0.75	1.2	-0.1	0.2				
28/01/2019	16.5	6.0	0.74	6.6	-0.1	0.1				
29/01/2019	14.0	5.0	0.70	-0.4	-0.3	0.0				
30/01/2019	14.0	5.2	0.71	-0.1	-0.3	0.0				
31/01/2019	15.4	6.3	0.72	-0.5	-0.2	0.0				
1/02/2019	16.7	7.3	0.73	0.4	-0.1	-0.1				
2/02/2019	9.8	4.1	0.73	9.9	0.2	0.1				
3/02/2019	11.4	4.2	0.85	3.1	0.1	0.0				
4/02/2019	18.1	7.1	0.77	3.9	0.1	0.0				
5/02/2019	18.5	7.3	0.34	5.0	0.1	0.0				
6/02/2019	20.0	7.6	0.30	-0.4	0.0	-0.1				
7/02/2019	21.3	8.6	0.32	2.3	0.0	0.0				
8/02/2019	21.5	8.3	0.32	-0.6	-0.1	-0.1				
9/02/2019	21.7	10.3	0.40	0.2	0.0	0.0				
10/02/2019	17.2	7.4	0.42	-0.1	-0.1	0.0				

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
11/02/2019	56.7	21.6	0.35	1.8	0.1	0.0				
12/02/2019	40.8	15.3	0.36	6.4	0.1	0.1				
13/02/2019	30.2	12.0	0.40	8.2	-0.2	0.1				
14/02/2019	29.8	11.6	0.43	1.8	0.0	0.1				
15/02/2019	50.9	19.7	0.46	5.7	0.0	0.1				
16/02/2019	55.1	21.4	0.40	3.1	0.1	0.1				
17/02/2019	36.4	14.1	0.42	1.1	-0.1	-0.1				
18/02/2019	41.8	16.9	0.40	1.0	-0.2	0.0				
19/02/2019	ID	ID	0.40	0.2	0.0	-0.1				
20/02/2019	28.4	10.3	0.55	0.3	-0.1	0.0				
21/02/2019	27.8	9.7	0.46	0.0	-0.2	0.0				
22/02/2019	16.5	5.4	0.45	2.0	-0.1	0.0				
23/02/2019	23.8	10.0	0.96	2.7	0.3	-0.1				
24/02/2019	25.0	10.5	0.57	2.0	0.2	0.0				
25/02/2019	27.9	11.8	0.56	3.9	0.2	0.0				
26/02/2019	25.3	9.4	0.51	-0.4	0.0	0.0				
27/02/2019	50.8	19.1	0.52	1.0	-0.1	0.1				
28/02/2019	46.9	17.7	0.53	2.7	0.0	0.1				
1/03/2019	48.1	17.9	0.53	1.2	0.0	0.2				
2/03/2019	53.3	19.2	0.58	4.3	0.0	0.1				
3/03/2019	60.6	23.7	0.65	2.7	0.1	0.1				
4/03/2019	51.5	19.1	0.61	6.9	0.1	0.2				
5/03/2019	49.9	18.4	0.61	9.3	0.1	0.1				
6/03/2019	60.6	22.7	0.57	2.7	0.0	0.0				
7/03/2019	47.8	18.6	0.65	5.7	-0.1	0.2				
8/03/2019	31.8	12.5	0.65	7.0	-0.1	0.1				
9/03/2019	25.5	9.5	0.62	1.4	0.0	0.0				
10/03/2019	26.4	9.1	1.15	0.3	0.1	-0.1				
11/03/2019	28.0	10.2	0.60	1.2	0.1	0.0				
12/03/2019	28.6	11.0	0.73	8.5	0.1	0.2				

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
13/03/2019	23.7	9.2	0.67	6.3	0.0	0.0				
14/03/2019	22.9	8.3	0.64	8.9	-0.2	0.1				
15/03/2019	48.7	17.6	0.69	4.2	0.0	0.0				
16/03/2019	140.4	50.8	0.68	3.2	0.1	0.0				
17/03/2019	154.2	53.1	0.91	1.3	0.1	0.0				
18/03/2019	ID	ID	0.67	4.9	0.1	0.2				
19/03/2019	ID	ID	0.73	2.9	0.3	0.2				

$\mu g/m^3$ = micrograms per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = Insufficient daily data for days that do not achieve 75% (18 hours) of valid data for the day; NO_2 = nitrogen dioxide; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

Attachment A-2 New Amsterdam Daily Monitoring Statistics

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
15/10/2018	14.4	5.8	0.40	2.3	-1.0	0.0	0.0	0.0	0.0	0.0
16/10/2018	14.3	5.0	0.48	-0.8	-1.0	0.1	0.0	0.0	0.0	0.0
17/10/2018	27.9	5.8	0.39	-0.1	-1.2	0.0	0.0	0.0	0.0	0.0
18/10/2018	30.1	6.5	0.66	-1.5	-1.3	-0.2	0.0	0.0	0.0	0.0
19/10/2018	21.8	7.7	0.46	-0.9	-1.4	-0.1	0.0	0.6	0.0	0.0
20/10/2018	21.9	9.9	0.48	1.2	-1.1	0.2	0.0	1.6	0.0	0.0
21/10/2018	20.2	8.4	0.50	0.3	-1.1	0.2	0.0	1.3	0.0	0.3
22/10/2018	16.0	6.4	0.38	2.2	-1.2	-0.1	0.0	3.8	0.0	0.0
23/10/2018	14.3	5.1	0.39	1.8	-1.3	-0.1	0.0	4.7	0.0	0.7
24/10/2018	17.3	5.9	0.40	0.6	-1.3	-0.2	0.0	5.2	0.0	0.0
25/10/2018	19.3	6.2	0.42	-1.3	-1.4	-0.2	0.0	5.3	0.0	0.0
26/10/2018	13.4	3.9	0.41	0.1	-1.4	-0.2	0.0	5.4	0.0	0.0
27/10/2018	13.2	4.5	0.48	ID	-1.6	-0.1	0.0	5.3	0.0	0.0
28/10/2018	10.5	4.1	0.44	4.1	-1.5	-0.2	0.0	5.3	0.0	0.0
29/10/2018	14.2	4.6	0.57	ID	-1.5	0.2	0.0	5.4	0.0	0.1
30/10/2018	24.5	7.2	0.53	ID	-1.5	0.0	0.0	4.6	0.0	0.0
31/10/2018	28.7	7.2	0.30	3.8	-1.6	-0.2	0.0	3.8	0.0	0.0
01/11/2018	21.3	7.9	0.34	3.8	-1.6	-0.1	0.0	2.5	0.0	0.0
02/11/2018	17.1	3.8	0.30	0.3	-1.6	0.0	0.0	1.9	0.0	0.0
03/11/2018	19.5	3.5	0.32	0.7	-1.6	-0.1	0.1	0.6	0.1	0.9
04/11/2018	19.5	3.5	0.44	4.2	-1.1	0.4	0.0	0.5	0.0	0.0
05/11/2018	15.0	4.2	0.41	2.7	-1.2	0.4	0.4	0.3	0.0	0.0
06/11/2018	14.0	5.7	0.37	0.1	-1.2	0.1	0.0	0.0	0.0	0.0
07/11/2018	17.3	4.7	0.31	-0.2	-1.5	0.0	0.0	0.1	0.0	0.0
08/11/2018	17.5	5.3	0.33	0.3	-1.5	-0.1	0.0	0.0	0.0	0.0
09/11/2018	20.0	5.9	0.30	-0.5	-1.5	-0.2	0.0	0.0	0.0	0.0
10/11/2018	20.0	6.5	0.30	ID	-1.7	-0.2	0.0	0.2	0.0	0.1
11/11/2018	19.1	7.4	0.34	2.9	-1.6	0.0	0.0	0.2	0.0	0.0

Day	PM_{10} ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
12/11/2018	16.4	5.3	0.43	21.7	-1.5	0.1	0.0	0.1	0.0	0.1
13/11/2018	24.8	9.2	0.41	ID	-1.4	-0.2	0.0	0.0	0.0	0.0
14/11/2018	23.1	6.1	0.30	1.9	-1.4	-0.2	0.0	0.1	0.0	0.0
15/11/2018	30.8	10.4	0.63	0.5	-1.3	0.0	0.0	0.0	0.0	0.1
16/11/2018	20.8	7.5	0.55	1.0	-1.3	-0.1	0.0	0.0	0.0	0.0
17/11/2018	17.4	6.4	0.30	0.9	-1.3	-0.2	0.0	0.0	0.0	0.0
18/11/2018	15.1	5.7	0.26	-0.3	-1.3	-0.2	0.0	0.1	0.0	0.0
19/11/2018	18.8	6.8	0.40	-1.1	-1.2	-0.1	0.0	0.1	0.0	0.5
20/11/2018	19.0	6.8	0.34	-2.8	-1.3	-0.2	0.0	0.0	0.0	0.0
21/11/2018	20.0	6.7	0.31	-1.9	-1.2	-0.3	0.0	0.0	0.0	0.0
22/11/2018	16.4	5.8	0.28	-3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
23/11/2018	18.3	5.8	0.28	0.2	-1.1	-0.2	0.0	0.1	0.0	0.0
24/11/2018	13.8	4.8	0.30	0.3	-1.1	-0.2	0.0	0.1	0.0	0.0
2511/2018	19.5	7.1	0.39	-1.9	-1.2	-0.2	0.0	0.0	0.0	0.0
26/11/2018	24.5	9.4	0.36	-0.2	-1.1	-0.2	0.0	0.0	0.0	0.0
27/11/2018	20.6	7.5	0.45	0.7	-1.1	0.0	0.0	0.0	0.0	0.0
28/11/2018	30.2	10.6	0.33	0.6	-1.1	-0.1	0.0	0.0	0.0	0.0
29/11/2018	38.6	13.5	0.29	ID	-1.1	-0.2	0.0	0.0	0.0	0.0
30/11/2018	39.8	12.8	0.29	ID	-1.1	0.1	0.0	0.1	0.0	0.0
01/12/2018	28.2	10.1	0.26	ID	-1.1	-0.1	0.0	0.0	0.0	0.0
02/12/2018	20.6	7.4	0.25	ID	-1.3	-0.1	0.0	0.0	0.0	0.0
03/12/2018	32.4	10.6	0.30	ID	-1.1	-0.2	0.0	0.0	0.0	0.0

$\mu g/m^3$ = micrograms per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = Insufficient daily data for days that do not achieve 75% (18 hours) of valid data for the day; NO_2 = nitrogen dioxide; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

Attachment A-3 New Guyana School Daily Monitoring Statistics

Day	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
12/04/2019	27.7	9.9	0.10	2.8	0.8	5.2				
13/04/2019	45.6	15.5	0.10	3.5	1.0	9.2				
14/04/2019	44.5	15.5	0.06	2.2	0.8	6.1				
15/04/2019	38.3	13.6	0.06	3.5	0.7	0.4				
16/04/2019	47.6	16.4	0.06	4.8	1.1	6.4				
17/04/2019	39.2	14.6	0.07	5.5	1.0	9.7				
18/04/2019	33.8	13.1	0.06	2.6	1.1	14.5				
19/04/2019	37.2	15.1	0.06	1.2	1.0	12.2				
20/04/2019	32.1	12.6	0.04	2.3	1.0	12.8				
21/04/2019	34.4	12.9	0.04	1.8	0.9	9.8				
22/04/2019	36.9	13.5	0.06	3.4	1.0	4.2				
23/04/2019	31.7	11.6	0.05	4.0	0.9	3.1				
24/04/2019	23.6	11.3	0.25	2.7	0.8	2.3				
25/04/2019	23.0	9.4	0.21	7.7	1.1	9.1				
26/04/2019	38.7	14.0	0.17	3.0	0.8	3.2				
27/04/2019	24.7	8.6	0.31	5.7	1.0	3.3				
28/04/2019	24.7	9.0	0.31	5.7	1.0	0.4				
29/04/2019	24.0	9.1	0.33	6.0	1.0	0.4				
30/04/2019	21.2	7.8	0.34	5.2	1.0	1.3				
1/05/2019	27.5	11.1	0.32	1.9	0.8	3.4				
2/05/2019	33.0	12.7	0.38	5.8	0.9	2.7				
3/05/2019	37.7	13.8	0.37	3.2	0.9	3.7				
4/05/2019	31.3	11.6	0.35	4.5	0.9	5.7				
5/05/2019	18.5	7.0	0.35	5.9	1.1	16.0				
6/05/2019	20.7	8.1	0.36	2.2	1.0	10.3				
7/05/2019	29.5	10.7	0.39	3.6	0.8	8.8				
8/05/2019	30.8	11.5	0.39	2.6	0.6	6.5				
9/05/2019	38.0	13.5	0.41	2.9	0.6	3.4				

Day	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
10/05/2019	37.3	13.7	0.43	3.2	0.5	4.7				
11/05/2019	42.5	14.9	0.40	4.3	0.7	4.1				
12/05/2019	33.6	12.4	0.39	2.0	0.6	3.2				
13/05/2019	36.3	12.9	0.42	4.2	0.8	1.1				
14/05/2019	33.7	12.0	0.43	4.1	1.0	4.8				
15/05/2019	33.2	12.0	0.44	4.1	1.1	5.4				
16/05/2019	28.2	10.6	0.51	4.4	1.1	6.3				
17/05/2019	33.5	12.0	0.58	3.1	1.0	5.3				
18/05/2019	29.3	10.3	0.49	3.3	0.8	1.6				
19/05/2019	31.7	11.1	0.59	4.1	0.8	1.1				
20/05/2019	13.1	4.9	0.58	8.0	1.3	11.6				
21/05/2019	14.6	5.4	0.67	4.8	1.0	4.3				
22/05/2019	24.5	9.0	0.56	2.4	0.9	1.7				
23/05/2019	15.2	5.2	0.57	3.6	0.7	1.4				
24/05/2019	9.9	3.8	0.67	12.2	1.7	5.2				
25/05/2019	16.5	6.0	0.60	6.2	0.8	0.5				
26/05/2019	17.1	6.7	0.58	3.8	0.6	0.3				
27/05/2019	14.0	5.3	0.67	3.3	0.5	1.1				
28/05/2019	33.3	11.4	0.70	4.1	0.7	0.8				
29/05/2019	35.3	13.1	0.68	3.1	0.9	2.0				
30/05/2019	30.3	11.6	0.63	4.3	0.9	4.7				
31/05/2019	21.0	7.5	0.61	5.3	1.0	2.8				
1/06/2019	13.5	4.7	0.59	2.9	0.9	3.3				
2/06/2019	19.8	7.4	0.62	4.1	0.8	0.8				
3/06/2019	24.0	8.7	0.62	3.0	0.6	1.8				
4/06/2019	23.2	8.0	0.70	1.5	0.5	1.3				
5/06/2019	ID	ID	ID	ID	ID	ID				
6/06/2019	28.0	9.3	0.72	5.2	0.9	4.0				
7/06/2019	13.6	4.9	0.62	3.6	0.8	8.8				
8/06/2019	11.5	4.0	0.76	5.3	0.9	8.3				

Day	PM_{10} (µg/m^3)	$PM_{2.5}$ (µg/m^3)	CO (ppm)	NO_2 (ppb)	SO_2 (ppb)	H_2S (ppb)	Benzene (ppb)	Toluene (ppb)	Ethylbenzene (ppb)	Xylene (ppb)
	24-Hour Average	24-Hour Average	Maximum 8-Hour Average	Maximum 1-Hour Average	24-Hour Average [a]	24-Hour Average [a]	24-Hour Average	24-Hour Average	24-Hour Average	24-Hour Average
9/06/2019	14.9	5.3	0.70	4.3	0.8	2.9				
10/06/2019	ID	ID	0.66	3.0	1.0	5.3				
11/06/2019	ID	ID	0.81	6.7	1.1	1.7				
12/06/2019	ID	ID	0.78	10.5	1.5	2.6				

µg/m^3 = micrograms per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = Insufficient daily data for days that do not achieve 75% (18 hours) of valid data for the day; NO_2 = nitrogen dioxide; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide

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ATTACHMENT B MONITORING LOCATION DATA RECORD

- Attachment B-1: Carifesta Data Record
- Attachment B-2: New Amsterdam Data Record
- Attachment B-3: New Guyana School Data Record

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Attachment B-1 Carifesta Data Record

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
15/08/2018	1:00	20.5	7.8	0.23	0.3	ZS	ZS	0.2	0.0	0.0	0.0
	2:00	21.3	8.1	0.22	0.2	-1.8	-0.2	0.1	0.0	0.0	0.0
	3:00	28.0	10.4	0.22	0.1	-1.9	-0.2	1.7	0.0	0.0	2.7
	4:00	31.1	11.7	0.23	0.5	-1.8	-0.5	0.0	0.0	0.0	0.0
	5:00	35.0	13.4	0.23	1.6	-1.9	1.4	508.9	0.0	0.0	0.0
	6:00	36.2	13.0	0.23	1.1	-2.1	0.9	0.0	0.0	0.0	0.0
	7:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	8:00	12.6	5.2	0.67	10.8	-0.4	2.0	0.0	0.1	0.0	0.1
	9:00	17.5	6.6	0.37	1.9	-1.5	0.6	0.0	0.1	0.1	0.0
	10:00	10.6	4.5	0.42	5.6	-1.3	0.4	0.2	0.0	0.0	0.2
	11:00	6.8	3.3	0.36	12.8	4.7	-0.3	8.4	2.5	0.1	0.1
	12:00	11.7	4.7	0.29	4.3	-0.4	-0.2	0.0	0.1	0.0	0.0
	13:00	40.4	13.8	0.29	1.2	-1.7	-0.5	56.9	0.4	0.0	0.2
	14:00	50.7	17.1	0.28	1.5	-1.5	-0.5	0.0	0.2	0.1	0.0
	15:00	54.3	19.2	0.31	1.6	-1.8	-0.1	0.2	15.6	0.0	0.8
	16:00	55.2	19.0	0.27	1.2	-1.5	-0.3	0.4	1.0	0.0	0.1
	17:00	61.9	20.3	0.25	1.9	-1.8	0.1	0.1	0.0	0.0	0.0
	18:00	60.4	20.3	0.26	2.3	-1.9	0.2	0.0	0.0	0.0	0.7
	19:00	59.3	20.0	0.28	4.0	-1.7	0.2	0.2	0.1	0.0	0.1
	20:00	59.0	20.1	0.29	3.8	-1.8	0.2	0.3	0.0	0.0	0.1
	21:00	58.3	19.6	0.26	1.6	-1.8	-0.3	90.1	0.0	0.0	0.0
	22:00	46.6	15.8	0.26	2.3	-2.1	0.5	0.0	0.1	0.0	0.2
	23:00	41.6	14.1	0.26	1.9	-1.9	2.2	0.0	0.0	0.0	0.2
	0:00	39.5	13.6	0.24	1.3	-1.7	-0.2	0.0	0.0	0.0	0.1
Min		**6.8**	**3.3**	**0.2**	**0.1**	**-2.1**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**61.9**	**20.3**	**0.7**	**12.8**	**4.7**	**2.2**	**508.9**	**15.6**	**0.1**	**2.7**
Average		**37.3**	**13.1**	**0.3**	**2.8**	**-1.3**	**0.2**	**29.0**	**0.9**	**0.0**	**0.2**
16/08/2018	1:00	37.3	13.0	0.22	0.7	-1.9	-0.3	29.2	194.2	0.0	0.0
	2:00	33.5	12.0	0.21	0.6	-2.2	-0.1	0.0	0.0	0.0	0.0
	3:00	31.2	11.3	0.21	0.6	-1.9	-0.4	0.0	0.1	0.0	0.0
	4:00	28.7	10.3	0.21	0.6	-2.1	-0.2	508.8	0.0	0.0	3.9
	5:00	26.1	9.3	0.21	0.7	-1.9	6.8	0.0	1.1	0.0	0.0
	6:00	20.8	7.7	0.23	1.7	-1.9	3.2	0.0	0.0	0.0	0.0
	7:00	12.5	4.9	0.35	5.2	-1.5	0.5	0.0	0.0	0.0	0.1
	8:00	12.7	4.6	0.47	6.4	-0.8	0.3	0.2	201.2	0.0	0.1
	9:00	10.3	4.0	0.29	3.7	-1.2	-0.4	0.5	0.0	0.0	0.1
	10:00	8.4	3.5	0.27	2.4	-1.6	-0.3	0.0	0.0	0.0	0.1
	11:00	14.3	6.7	0.34	4.7	-0.9	-0.2	0.0	1.4	0.0	7.1
	12:00	19.1	9.0	0.32	4.4	-0.4	0.6	0.0	0.1	0.0	0.1
	13:00	10.2	3.7	0.27	1.7	-1.6	-0.3	0.0	0.5	0.0	0.1
	14:00	11.1	3.7	0.27	1.6	-1.8	-0.2	67.6	0.0	0.0	0.0
	15:00	9.6	3.6	0.25	1.0	-1.8	-0.3	3.5	0.0	0.0	0.0
	16:00	9.1	3.8	0.31	2.1	-1.7	-0.2	0.0	0.0	0.0	0.0
	17:00	13.6	4.2	0.37	5.7	-0.8	-0.4	0.0	2.2	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	16.0	6.0	0.42	6.6	-0.4	0.1	0.0	0.0	0.0	0.0
	19:00	22.7	7.6	0.52	8.9	0.1	0.5	0.0	0.0	0.0	0.0
	20:00	13.2	5.1	0.34	4.9	-0.5	0.0	0.0	0.0	0.0	0.0
	21:00	10.4	4.2	0.30	3.9	-1.1	0.3	45.6	0.0	0.0	0.0
	22:00	10.0	3.9	0.22	2.4	-1.6	1.0	0.0	1.2	0.0	0.0
	23:00	9.3	3.9	0.23	2.8	-1.5	0.5	0.0	0.0	0.0	0.0
	0:00	8.9	3.7	0.19	1.7	-1.6	0.3	0.0	0.0	0.0	0.0
Min		**8.4**	**3.5**	**0.2**	**0.6**	**-2.2**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**37.3**	**13.0**	**0.5**	**8.9**	**0.1**	**6.8**	**508.8**	**201.2**	**0.0**	**7.1**
Average		**16.6**	**6.2**	**0.3**	**3.1**	**-1.3**	**0.4**	**27.3**	**16.7**	**0.0**	**0.5**
17/08/2018	1:00	8.8	3.9	0.19	ZS	-1.8	0.0	0.0	0.0	0.0	0.0
	2:00	9.2	4.0	0.20	1.2	ZS	ZS	0.2	0.0	0.0	0.0
	3:00	10.3	4.3	0.21	2.0	-1.2	0.2	0.0	0.0	0.0	0.1
	4:00	11.3	4.7	0.22	3.4	-1.2	0.9	0.0	0.0	0.0	0.0
	5:00	10.6	4.8	0.21	3.4	-1.3	0.5	0.0	0.0	0.0	0.0
	6:00	15.4	6.9	0.29	4.9	-0.8	1.5	0.2	0.0	0.0	0.1
	7:00	19.4	8.7	0.44	5.9	-0.3	1.9	0.1	0.0	0.0	0.0
	8:00	14.7	6.2	0.40	4.2	-0.5	0.7	0.0	0.2	0.0	0.0
	9:00	13.5	5.7	0.34	3.6	-0.7	0.0	0.1	0.0	0.0	0.1
	10:00	16.5	5.8	0.29	3.9	-1.1	-0.1	6.8	0.0	0.0	0.0
	11:00	17.6	6.5	0.31	4.3	-1.1	0.0	0.0	0.0	0.0	0.0
	12:00	20.6	6.5	0.24	2.2	-1.3	-0.5	103.7	0.0	0.0	0.0
	13:00	17.9	6.7	0.28	2.2	-1.5	-0.2	0.0	0.0	0.0	0.0
	14:00	11.9	5.2	0.31	5.7	-1.1	0.1	0.0	1.2	0.0	0.0
	15:00	10.1	4.5	0.22	3.8	-0.9	0.2	6.6	1.0	0.0	0.0
	16:00	12.5	6.5	0.22	1.1	-1.8	0.0	0.2	0.0	0.0	0.0
	17:00	13.6	6.2	0.23	0.8	-1.6	-0.4	0.0	0.0	0.0	0.0
	18:00	17.2	7.3	0.22	1.2	-1.6	-0.4	0.0	0.0	0.0	0.0
	19:00	17.7	7.5	0.21	1.0	-1.6	-0.4	0.0	0.0	0.0	0.0
	20:00	19.3	7.8	0.20	1.1	-1.7	-0.5	5.5	0.0	0.0	0.0
	21:00	19.4	7.9	0.20	1.1	-1.6	-0.5	0.0	0.0	0.0	0.0
	22:00	19.5	8.2	0.21	1.3	-1.9	0.5	0.0	0.0	0.0	0.0
	23:00	18.7	8.1	0.25	3.2	-1.3	0.1	4.8	174.3	0.0	0.0
	0:00	18.9	8.4	0.27	ZS	-1.6	0.6	0.0	0.4	0.0	0.0
Min		**8.8**	**3.9**	**0.2**	**0.8**	**-1.9**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**20.6**	**8.7**	**0.4**	**5.9**	**-0.3**	**1.9**	**103.7**	**174.3**	**0.0**	**0.1**
Average		**15.2**	**6.3**	**0.3**	**2.8**	**-1.3**	**0.2**	**5.3**	**7.4**	**0.0**	**0.0**
18/08/2018	1:00	17.2	7.6	0.26	3.2	ZS	ZS	0.0	27.8	0.0	0.0
	2:00	16.8	6.8	0.39	7.3	-0.6	1.6	0.0	0.0	0.0	0.0
	3:00	17.6	6.7	0.47	9.4	-0.2	2.5	0.0	0.0	0.0	0.0
	4:00	18.5	7.5	0.51	10.1	0.4	4.0	1.3	0.5	0.0	0.0
	5:00	17.2	7.6	0.42	10.3	0.0	3.6	0.0	0.0	0.0	0.0
	6:00	21.0	9.3	0.54	11.3	0.5	6.9	0.0	0.2	0.0	0.0
	7:00	24.2	10.8	0.74	10.4	1.8	6.7	0.2	0.5	0.0	0.0
	8:00	24.3	10.6	0.51	7.8	0.7	1.5	0.3	0.1	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	22.8	9.9	0.37	4.8	-0.3	-0.1	0.0	0.1	0.0	0.0
	10:00	21.5	10.0	0.30	4.0	-0.9	0.4	0.0	0.0	0.0	0.0
	11:00	20.2	9.4	0.26	2.5	-1.3	2.2	0.0	0.0	0.0	0.0
	12:00	18.5	9.6	0.25	2.2	-1.5	1.3	0.0	0.0	0.0	0.0
	13:00	17.7	8.3	0.28	4.3	-1.1	0.0	11.1	0.3	0.0	0.0
	14:00	19.2	9.1	0.24	2.4	-1.2	0.2	7.6	50.8	0.0	2.7
	15:00	19.9	9.3	0.25	2.4	-1.4	1.2	0.0	0.0	0.0	0.0
	16:00	17.5	8.6	0.29	3.0	-1.4	0.9	0.2	0.0	0.0	0.0
	17:00	15.6	7.9	0.29	3.9	-1.4	1.4	38.0	0.0	0.0	0.0
	18:00	17.2	8.5	0.30	5.2	-1.2	1.1	0.0	537.5	0.0	0.0
	19:00	16.5	8.8	0.34	6.3	-1.1	0.9	0.0	0.0	0.0	0.0
	20:00	16.6	8.8	0.29	4.3	-1.3	1.2	0.0	0.0	0.0	0.0
	21:00	20.0	9.4	0.25	2.3	-1.5	0.8	0.0	0.0	0.0	0.0
	22:00	18.5	9.0	0.23	2.2	-1.6	0.7	3.5	2.9	0.0	0.0
	23:00	18.0	9.1	0.23	2.5	-1.6	1.1	0.0	0.0	0.0	0.0
	0:00	16.9	9.1	0.24	3.0	-1.5	1.0	0.0	0.0	0.0	0.0
Min		**15.6**	**6.7**	**0.2**	**2.2**	**-1.6**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.3**	**10.8**	**0.7**	**11.3**	**1.8**	**6.9**	**38.0**	**537.5**	**0.0**	**2.7**
Average		**18.9**	**8.8**	**0.3**	**5.2**	**-0.8**	**1.8**	**2.6**	**25.9**	**0.0**	**0.1**
19/08/2018	1:00	17.2	8.6	0.21	3.1	-1.6	1.4	0.0	0.0	0.0	0.0
	2:00	16.0	8.4	0.20	2.0	-1.8	1.2	0.0	0.0	0.0	0.0
	3:00	16.1	8.5	0.19	1.8	-1.6	1.2	29.4	0.0	0.0	0.0
	4:00	17.2	8.7	0.19	1.7	-1.6	0.4	0.0	0.0	0.0	0.0
	5:00	16.6	8.9	0.20	1.9	-1.5	0.4	0.0	0.0	0.0	0.0
	6:00	16.9	8.9	0.23	2.9	-1.4	0.3	0.0	0.2	0.0	0.0
	7:00	19.4	9.7	0.29	4.6	-1.2	0.7	6.9	0.0	0.0	0.0
	8:00	19.2	9.3	0.24	3.6	-1.1	0.2	0.0	0.0	0.0	0.0
	9:00	16.5	8.5	0.23	2.6	-1.4	0.3	0.0	130.6	0.0	0.0
	10:00	16.1	8.2	0.23	2.6	-1.3	0.2	0.0	0.0	0.0	0.0
	11:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	12:00	PO	PO	PO	PO	PO	PO	0.0	0.1	0.0	0.0
	13:00	15.6	7.1	0.37	2.3	-1.2	0.2	0.0	0.0	0.0	0.0
	14:00	13.9	6.7	0.34	1.6	-1.6	0.0	5.7	0.0	0.0	0.0
	15:00	12.7	6.3	0.32	1.5	-1.6	-0.2	1242.1	0.0	0.0	0.0
	16:00	13.6	6.4	0.31	1.7	-1.7	-0.2	118.1	0.0	0.0	0.0
	17:00	14.5	6.6	0.29	1.4	-1.6	-0.2	0.0	0.0	0.0	0.0
	18:00	14.0	6.7	0.32	2.1	-1.7	0.9	0.0	0.0	0.0	0.0
	19:00	15.0	7.1	0.35	2.7	-1.6	0.6	0.0	0.0	0.0	0.0
	20:00	15.5	7.0	0.35	3.3	-1.3	0.8	0.8	70.6	0.0	0.0
	21:00	13.2	5.8	0.32	3.2	-1.3	1.3	0.0	0.0	0.0	0.0
	22:00	12.8	5.6	0.31	3.0	-1.6	1.6	0.0	94.2	0.0	0.0
	23:00	13.0	5.6	0.33	2.8	-1.4	0.9	0.0	0.0	0.0	0.0
	0:00	13.1	5.7	0.28	ZS	ZS	ZS	0.0	1.7	0.0	0.0
Min		**12.7**	**5.6**	**0.2**	**1.4**	**-1.8**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**19.4**	**9.7**	**0.4**	**4.6**	**-1.1**	**1.6**	**1242.1**	**130.6**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**15.4**	**7.5**	**0.3**	**2.5**	**-1.5**	**0.6**	**58.5**	**12.4**	**0.0**	**0.0**
20/08/2018	1:00	12.6	6.1	0.30	3.7	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	12.9	6.2	0.24	2.3	-1.1	1.1	28.3	0.0	0.0	0.0
	3:00	11.9	5.9	0.23	1.8	-1.5	1.5	0.0	0.0	0.0	0.0
	4:00	12.1	6.0	0.24	1.9	-1.4	1.0	10.5	563.5	0.0	0.0
	5:00	11.9	6.1	0.23	2.4	-1.3	1.5	0.0	652.0	0.0	0.0
	6:00	13.2	6.4	0.31	5.1	-1.3	0.8	0.0	0.0	0.0	0.0
	7:00	17.3	7.5	0.51	9.5	-0.6	1.5	0.0	0.0	0.0	0.0
	8:00	17.0	6.9	0.47	7.8	-0.3	0.7	0.0	0.0	0.0	0.0
	9:00	13.7	5.7	0.39	6.0	-0.7	0.4	1272.6	9.2	0.0	0.0
	10:00	13.4	5.1	0.29	3.7	-1.0	0.1	85.1	28.7	0.0	0.0
	11:00	14.4	5.1	0.26	2.8	-1.5	0.5	0.0	0.0	0.0	0.0
	12:00	11.5	4.8	0.27	2.6	-1.5	0.1	1258.1	0.0	0.0	0.0
	13:00	13.8	4.9	0.26	2.3	-1.5	0.1	0.0	275.9	0.0	0.0
	14:00	11.2	4.5	0.26	2.6	-1.5	-0.1	174.5	1.8	0.0	0.0
	15:00	14.7	4.4	0.25	NT	-1.5	-0.1	0.0	0.0	0.0	0.0
	16:00	10.9	4.4	0.25	NT	-1.3	-0.2	0.0	681.7	0.0	0.0
	17:00	14.2	4.8	0.35	5.3	-1.2	-0.2	0.0	0.0	0.0	0.0
	18:00	11.8	4.7	0.47	7.5	-0.8	0.7	78.2	0.0	0.0	0.0
	19:00	13.0	4.8	0.24	2.3	-1.3	0.0	254.8	0.2	0.0	0.0
	20:00	11.3	4.7	0.21	1.1	-1.6	-0.2	0.0	0.0	0.0	0.0
	21:00	10.2	4.6	0.23	2.2	-1.5	1.0	0.0	0.0	0.0	0.0
	22:00	11.0	4.5	0.22	1.7	-1.5	2.0	0.0	0.0	0.0	0.0
	23:00	10.6	4.3	0.22	1.6	-1.7	1.3	0.0	0.0	0.0	0.0
	0:00	10.1	4.3	0.24	2.3	-1.8	2.0	2.9	0.0	0.0	0.0
Min		**10.1**	**4.3**	**0.2**	**1.1**	**-1.8**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**17.3**	**7.5**	**0.5**	**9.5**	**-0.3**	**2.0**	**1272.6**	**681.7**	**0.0**	**0.0**
Average		**12.7**	**5.3**	**0.3**	**3.6**	**-1.3**	**0.7**	**131.9**	**92.2**	**0.0**	**0.0**
21/08/2018	1:00	10.0	4.6	0.21	ZS	-1.7	1.7	0.0	8.0	0.0	0.0
	2:00	10.1	4.8	0.20	1.5	ZS	ZS	0.0	0.3	0.0	0.0
	3:00	9.7	4.6	0.20	1.5	-1.3	1.1	0.0	0.2	0.0	0.0
	4:00	11.4	5.1	0.21	2.0	-1.6	0.6	0.0	0.0	0.0	0.0
	5:00	20.4	9.3	0.26	4.8	-0.9	1.6	0.0	0.0	0.0	0.0
	6:00	15.2	6.9	0.36	6.4	-0.5	2.6	0.0	0.0	0.0	0.0
	7:00	15.9	6.4	0.51	8.8	0.1	2.6	0.0	0.0	0.0	0.0
	8:00	16.9	6.9	0.48	7.7	0.1	0.8	11.6	0.0	0.0	0.0
	9:00	13.1	5.9	0.32	4.4	-0.7	0.0	651.2	0.0	0.0	0.0
	10:00	14.2	5.3	0.21	1.6	-1.5	0.1	0.0	345.3	0.0	0.0
	11:00	12.5	5.4	0.22	1.5	-1.6	0.1	0.0	0.0	0.0	0.0
	12:00	14.1	5.5	0.22	1.6	-1.5	-0.2	12.9	0.3	0.0	0.0
	13:00	14.1	5.9	0.28	3.1	-1.4	0.2	12.6	0.0	0.0	0.0
	14:00	14.2	6.4	0.27	2.6	-1.4	-0.2	0.0	137.6	0.0	0.0
	15:00	13.8	6.5	0.25	2.8	-1.5	-0.1	0.0	0.0	0.0	0.0
	16:00	15.6	6.7	0.26	3.1	-1.4	-0.5	0.0	0.8	0.0	0.0
	17:00	14.5	6.8	0.33	5.2	-1.3	0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	15.0	7.1	0.36	6.3	-1.2	0.7	0.0	0.0	0.0	0.0
	19:00	15.4	7.0	0.43	8.8	-0.9	1.1	0.0	0.3	0.0	0.0
	20:00	17.6	8.7	0.41	8.1	-0.8	0.6	12.8	0.0	0.0	0.0
	21:00	15.2	7.1	0.34	6.5	-1.0	3.8	0.0	0.0	0.0	0.0
	22:00	15.0	7.1	0.28	4.3	-1.4	1.2	186.7	13.2	0.0	0.0
	23:00	14.7	7.2	0.24	2.7	-1.5	3.4	0.0	0.0	0.0	0.0
	0:00	17.3	7.6	0.23	ZS	-1.8	0.8	381.4	318.5	0.0	0.0
Min		**9.7**	**4.6**	**0.2**	**1.5**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**20.4**	**9.3**	**0.5**	**8.8**	**0.1**	**3.8**	**651.2**	**345.3**	**0.0**	**0.0**
Average		**14.4**	**6.5**	**0.3**	**4.3**	**-1.1**	**1.0**	**52.9**	**34.4**	**0.0**	**0.0**
22/08/2018	1:00	16.8	8.1	ZS	1.0	ZS	ZS	0.0	277.5	0.0	0.0
	2:00	16.1	8.3	0.22	1.1	-1.4	0.7	0.0	0.0	0.0	0.0
	3:00	15.8	8.4	0.24	2.7	-1.4	1.2	0.0	0.0	0.0	0.0
	4:00	15.7	8.5	0.22	1.7	-1.5	1.6	40.5	0.4	0.0	0.0
	5:00	15.2	8.4	0.23	3.6	-1.3	0.8	1.6	1009.3	0.0	0.0
	6:00	15.2	8.2	0.29	5.5	-1.0	0.7	0.0	0.0	0.0	0.0
	7:00	19.8	9.2	0.41	8.7	-0.7	1.7	0.0	0.0	0.0	0.0
	8:00	17.1	8.2	0.33	5.0	-0.9	0.8	0.0	0.0	0.0	0.0
	9:00	14.8	7.7	0.25	2.6	-1.5	0.5	0.0	25.9	0.0	0.0
	10:00	15.6	7.8	0.25	1.9	-1.5	0.2	20.0	0.0	0.0	0.0
	11:00	18.4	7.8	0.22	1.0	-1.5	-0.3	12.6	0.0	0.0	0.0
	12:00	17.6	7.4	0.22	1.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	13:00	15.0	7.3	0.23	1.4	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	14.2	7.0	0.23	1.6	-1.7	-0.2	0.0	0.0	0.0	0.0
	15:00	15.2	7.3	0.22	0.9	-1.6	-0.4	3.9	410.4	0.0	0.0
	16:00	16.4	7.4	0.22	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	17:00	22.7	8.3	0.24	1.3	-1.4	-0.6	13.0	0.0	0.0	0.0
	18:00	17.9	8.2	0.27	1.5	-1.5	-0.5	0.0	0.0	0.0	0.0
	19:00	19.1	8.0	0.29	1.6	-1.5	-0.2	0.0	418.0	0.0	0.0
	20:00	17.1	7.9	0.31	2.4	-1.5	0.3	0.0	644.1	0.0	0.0
	21:00	14.3	7.3	0.36	6.1	-1.3	1.2	0.0	0.0	0.0	0.0
	22:00	16.6	7.0	0.32	3.2	-1.3	-0.2	12.5	0.0	0.0	0.0
	23:00	16.1	7.1	0.30	2.2	-1.4	-0.1	0.0	115.5	0.0	0.0
	0:00	13.2	6.6	0.25	2.7	-1.3	0.4	0.1	0.0	0.0	0.0
Min		**13.2**	**6.6**	**0.2**	**0.9**	**-1.7**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**22.7**	**9.2**	**0.4**	**8.7**	**-0.7**	**1.7**	**40.5**	**1009.3**	**0.0**	**0.0**
Average		**16.5**	**7.8**	**0.3**	**2.6**	**-1.4**	**0.3**	**4.3**	**120.9**	**0.0**	**0.0**
8/23/2018	1:00	15.6	6.7	0.22	1.1	-1.4	0.1	0.0	0.3	0.0	0.0
	2:00	14.1	6.2	0.20	0.7	-1.6	-0.1	0.0	0.0	0.0	0.0
	3:00	15.3	6.3	0.20	0.5	-1.8	-0.2	0.0	0.0	0.0	0.0
	4:00	13.0	5.9	0.20	0.4	-1.8	-0.4	0.0	0.0	0.0	0.0
	5:00	11.3	5.6	0.20	0.7	-1.9	0.3	13.5	0.0	0.0	0.0
	6:00	10.9	5.4	0.22	0.9	-1.8	0.1	273.7	0.0	0.0	24.1
	7:00	11.2	5.5	0.26	1.6	-1.6	0.0	8.3	0.0	0.0	0.0
	8:00	18.6	8.5	0.57	8.0	0.2	1.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	14.8	6.4	0.28	3.9	-0.6	-0.1	0.0	0.0	0.0	0.0
	10:00	11.9	5.5	0.23	1.0	-1.6	-0.1	0.0	0.0	0.0	0.0
	11:00	11.4	5.2	0.23	1.1	-1.4	-0.4	0.0	0.0	0.0	0.0
	12:00	13.4	4.8	0.22	1.0	-1.5	-0.5	0.0	0.0	0.0	0.0
	13:00	11.6	4.7	0.22	0.9	-1.6	-0.4	0.0	0.4	0.0	0.0
	14:00	15.0	4.7	0.23	1.5	-1.7	-0.2	0.0	0.0	0.0	0.0
	15:00	13.3	4.6	0.23	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	16:00	14.7	4.8	0.24	1.5	-1.9	0.1	2.1	16.6	0.0	12.7
	17:00	14.3	4.8	0.24	1.7	-1.4	-0.6	2.9	0.0	0.0	0.0
	18:00	13.4	4.8	0.25	1.8	-1.4	-0.4	10.8	86.7	0.0	0.0
	19:00	13.4	4.9	0.29	3.0	-1.4	0.0	0.0	91.7	0.0	0.0
	20:00	12.9	4.7	0.22	1.5	-1.6	3.6	0.0	0.0	0.0	0.0
	21:00	12.8	5.0	0.29	3.7	-1.5	0.9	0.0	0.0	0.0	0.0
	22:00	12.5	4.8	0.25	2.3	-1.4	-0.1	7.5	0.0	0.0	0.0
	23:00	12.0	4.7	0.26	2.8	-1.6	0.4	0.0	0.0	0.0	0.0
	0:00	12.5	4.6	0.23	1.9	-1.6	0.2	0.0	0.0	0.0	0.0
Min		**10.9**	**4.6**	**0.2**	**0.4**	**-1.9**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**18.6**	**8.5**	**0.6**	**8.0**	**0.2**	**3.6**	**273.7**	**91.7**	**0.0**	**24.1**
Average		**13.3**	**5.4**	**0.2**	**1.9**	**-1.5**	**0.1**	**13.3**	**8.2**	**0.0**	**1.5**
24/08/2018	1:00	12.5	4.4	0.21	ZS	-1.8	-0.1	0.0	0.0	0.0	0.0
	2:00	13.2	4.5	0.21	0.6	ZS	ZS	920.8	0.0	0.0	0.0
	3:00	10.5	4.3	0.22	0.8	-1.4	0.9	0.0	0.0	0.0	0.0
	4:00	10.6	4.2	0.22	0.8	-1.7	0.7	0.0	0.0	0.0	0.0
	5:00	9.9	4.1	0.21	1.1	-1.6	1.4	0.0	0.0	0.0	0.0
	6:00	10.4	4.4	0.30	3.8	-1.4	1.6	0.0	10.0	0.0	0.0
	7:00	20.1	8.1	0.55	8.1	0.0	3.2	359.3	0.1	0.0	0.0
	8:00	14.8	6.1	0.53	7.6	0.1	0.5	0.0	0.0	0.0	0.0
	9:00	11.4	5.0	0.35	4.7	-0.8	0.2	3.3	0.0	0.0	0.0
	10:00	11.0	4.8	0.28	2.8	-1.3	1.3	10.6	312.4	0.0	0.0
	11:00	10.0	4.5	0.26	2.0	-1.4	-0.5	75.5	0.0	0.0	0.0
	12:00	11.2	4.7	0.26	1.6	-1.5	-0.3	5.2	92.1	0.0	0.0
	13:00	13.0	5.5	0.26	1.4	-1.6	-0.4	0.0	0.0	0.0	0.0
	14:00	15.3	6.1	0.29	1.9	-1.7	-0.3	0.0	0.0	0.0	0.0
	15:00	14.7	5.9	0.34	3.5	-1.5	0.1	0.0	0.0	0.0	0.0
	16:00	14.8	5.9	0.35	3.9	-1.2	-0.3	0.0	10.7	0.0	0.0
	17:00	13.1	5.9	0.38	4.8	-1.2	-0.4	0.0	436.3	0.0	0.0
	18:00	12.2	5.7	0.36	5.0	-1.3	0.1	0.0	0.0	0.0	0.0
	19:00	11.2	5.5	0.37	4.9	-1.4	0.1	0.0	0.0	0.0	0.0
	20:00	11.2	5.3	0.34	3.8	-1.2	0.2	0.0	0.0	0.0	0.0
	21:00	12.4	5.5	0.30	2.9	-1.4	0.1	0.0	0.0	0.0	0.0
	22:00	11.5	5.4	0.32	3.1	-1.4	0.2	17.4	0.1	0.0	0.0
	23:00	13.4	6.2	0.31	2.6	-1.4	0.3	0.0	0.0	0.0	0.0
	0:00	13.3	6.1	0.28	ZS	-1.5	0.4	0.0	0.0	0.0	0.0
Min		**9.9**	**4.1**	**0.2**	**0.6**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**20.1**	**8.1**	**0.5**	**8.1**	**0.1**	**3.2**	**920.8**	**436.3**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Average		**12.6**	**5.3**	**0.3**	**3.3**	**-1.3**	**0.4**	**58.0**	**35.9**	**0.0**	**0.0**
25/08/2018	1:00	15.1	6.6	0.28	1.1	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	14.9	6.2	0.26	1.0	-1.5	0.4	0.0	0.0	0.0	0.0
	3:00	14.4	6.0	0.25	0.9	-1.6	0.3	9.9	0.0	0.0	0.0
	4:00	12.7	5.7	0.26	1.0	-1.7	0.7	46.0	0.0	0.0	0.0
	5:00	12.6	5.8	0.26	2.3	-1.6	0.7	11.0	0.0	0.0	0.0
	6:00	13.1	5.9	0.30	4.2	-1.2	0.8	361.2	0.0	0.0	0.0
	7:00	12.4	6.0	0.37	5.7	-1.2	0.6	0.0	0.0	0.0	0.0
	8:00	14.2	5.9	0.36	4.7	-1.2	0.8	0.0	0.0	0.0	0.0
	9:00	12.6	5.9	0.34	4.1	-1.4	0.1	0.0	0.0	0.0	0.0
	10:00	12.9	5.8	0.31	2.9	-1.3	0.0	0.0	0.0	0.0	0.0
	11:00	13.9	6.0	0.33	2.7	-1.3	-0.3	0.0	0.0	0.0	0.0
	12:00	13.5	6.0	0.32	2.3	-1.2	-0.5	0.0	0.0	0.0	0.0
	13:00	13.2	6.0	0.30	1.8	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	13.3	6.0	0.31	2.0	-1.6	0.4	0.0	0.0	0.0	0.0
	15:00	14.9	6.0	0.34	3.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	16:00	13.1	6.0	0.34	2.9	-1.5	-0.2	0.0	0.4	0.0	0.0
	17:00	13.7	6.0	0.35	3.2	-1.5	-0.2	412.4	0.0	0.0	0.0
	18:00	13.4	6.0	0.35	4.0	-1.6	0.2	12.2	0.0	0.0	0.0
	19:00	14.1	6.2	0.38	4.0	-1.3	-0.1	0.0	0.0	0.0	0.0
	20:00	13.1	5.9	0.38	3.8	-1.4	0.0	0.0	0.0	0.0	0.0
	21:00	13.5	6.0	0.34	3.7	-1.4	-0.1	13.1	5.7	0.0	0.0
	22:00	12.4	5.8	0.35	4.5	-1.4	0.3	0.0	0.0	0.0	0.0
	23:00	11.9	5.8	0.33	3.4	-1.4	0.3	0.0	10.8	0.0	0.0
	0:00	12.5	6.1	0.33	3.2	-1.6	0.4	0.0	0.3	0.0	0.0
Min		**11.9**	**5.7**	**0.3**	**0.9**	**-1.7**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**15.1**	**6.6**	**0.4**	**5.7**	**-1.2**	**0.8**	**412.4**	**10.8**	**0.0**	**0.0**
Average		**13.4**	**6.0**	**0.3**	**3.0**	**-1.4**	**0.2**	**36.1**	**0.7**	**0.0**	**0.0**
26/08/2018	1:00	14.2	6.4	0.32	3.2	-1.4	0.3	0.0	0.0	0.0	0.0
	2:00	14.1	6.9	0.31	2.4	-1.4	0.1	0.0	0.0	0.0	0.0
	3:00	14.1	7.0	0.29	1.9	-1.6	0.4	0.0	0.0	0.0	0.0
	4:00	13.9	7.0	0.29	2.1	-1.5	0.3	0.0	1.4	0.0	0.0
	5:00	14.7	7.5	0.30	2.2	-1.4	0.3	0.0	0.0	0.0	0.0
	6:00	15.4	8.0	0.35	5.2	-1.3	1.5	0.0	288.2	0.0	0.0
	7:00	17.7	8.1	0.43	6.3	-0.6	1.2	0.0	0.0	0.0	0.0
	8:00	15.2	7.5	0.39	4.0	-0.9	0.1	0.0	0.0	0.0	0.0
	9:00	13.8	7.0	0.32	2.0	-1.3	-0.2	0.0	0.0	0.0	0.0
	10:00	13.4	6.9	0.32	1.9	-1.4	-0.4	0.0	0.0	0.0	0.0
	11:00	17.0	7.2	0.32	1.4	-1.6	0.3	0.0	0.0	0.0	0.1
	12:00	23.1	8.7	0.35	1.7	-1.4	-0.1	0.2	21.4	0.0	0.0
	13:00	15.2	6.8	0.33	1.5	-1.3	-0.3	11.7	205.3	0.0	0.0
	14:00	19.0	7.4	0.34	1.4	-1.4	-0.3	738.4	0.0	0.0	0.0
	15:00	16.6	6.7	0.31	0.9	-1.7	-0.2	12.3	10.9	0.0	0.0
	16:00	14.5	6.4	0.33	1.6	-1.7	-0.3	0.0	0.9	0.0	0.0
	17:00	17.0	6.8	0.31	1.4	-1.6	0.1	8.5	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	17.2	7.9	0.37	1.4	-1.6	-0.3	12.1	23.0	0.0	0.0
	19:00	17.2	7.4	0.37	1.6	-1.6	-0.3	3.2	0.0	0.0	0.0
	20:00	17.3	7.8	0.37	1.1	-1.5	-0.1	36.0	0.6	0.0	0.0
	21:00	17.4	7.5	0.39	1.6	-1.6	-0.1	0.0	135.0	0.0	0.0
	22:00	17.5	7.4	0.45	1.9	-1.0	-0.5	48.3	0.0	0.0	0.0
	23:00	18.1	7.4	0.45	3.4	-0.9	-0.1	0.0	0.2	0.0	0.0
	0:00	19.0	8.6	0.44	ZS	-0.7	-0.5	12.0	0.0	0.0	0.0
Min		**13.4**	**6.4**	**0.3**	**0.9**	**-1.7**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**23.1**	**8.7**	**0.5**	**6.3**	**-0.6**	**1.5**	**738.4**	**288.2**	**0.0**	**0.1**
Average		**16.3**	**7.3**	**0.4**	**2.3**	**-1.4**	**0.0**	**36.8**	**28.6**	**0.0**	**0.0**
27/08/2018	1:00	19.2	6.8	0.43	2.1	ZS	ZS	0.0	0.3	0.0	0.0
	2:00	20.8	8.0	0.33	1.5	-0.7	-0.3	13.0	0.0	0.0	0.0
	3:00	20.8	7.5	0.29	0.7	-1.5	0.4	88.5	0.0	0.0	0.0
	4:00	14.8	6.2	0.30	0.6	-1.4	1.0	0.0	0.0	0.0	0.0
	5:00	12.6	5.5	0.30	1.3	-1.3	0.9	13.1	0.0	0.0	0.0
	6:00	14.2	4.3	0.31	2.0	-1.5	1.4	110.5	0.0	0.0	0.0
	7:00	12.9	4.7	0.41	4.5	-1.1	1.0	0.0	0.3	0.0	0.0
	8:00	13.4	5.0	0.52	5.9	-0.8	0.7	0.0	0.0	0.0	0.0
	9:00	11.8	5.1	0.50	4.9	-0.6	0.3	0.0	664.6	0.0	0.0
	10:00	11.9	5.2	0.44	6.9	0.0	-0.2	0.0	0.0	0.0	0.0
	11:00	11.4	5.5	0.35	7.4	0.4	-0.1	1.4	0.0	0.0	0.0
	12:00	10.8	5.4	0.32	NT	-0.7	-0.2	0.0	0.0	0.0	0.0
	13:00	10.3	4.9	0.31	1.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	12.0	5.0	0.30	1.2	-1.4	-0.3	0.0	0.0	0.0	0.0
	15:00	14.1	5.3	0.30	1.0	-1.5	-0.2	0.0	13.6	0.0	0.0
	16:00	16.2	6.7	0.31	1.1	-1.4	-0.4	0.0	69.1	0.0	0.0
	17:00	21.1	9.1	0.42	1.8	-1.2	-0.6	0.0	0.0	0.0	0.0
	18:00	15.1	6.6	0.35	1.3	-1.3	-0.5	0.0	0.7	0.0	0.0
	19:00	31.4	19.3	0.43	1.7	-1.0	-0.5	0.1	1.3	0.0	0.0
	20:00	25.3	14.9	0.41	2.1	-0.9	-0.7	0.0	46.9	0.0	0.0
	21:00	13.0	6.9	0.30	1.6	-1.1	-0.7	0.0	0.0	0.0	0.0
	22:00	22.4	15.8	0.43	1.6	-1.0	-0.8	13.8	80.4	0.0	0.0
	23:00	15.6	8.9	0.43	2.2	-0.9	-0.6	0.0	0.0	0.0	0.0
	0:00	16.2	9.5	0.29	1.1	-1.2	-0.4	0.0	0.4	0.0	0.0
Min		**10.3**	**4.3**	**0.3**	**0.6**	**-1.5**	**-0.8**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**31.4**	**19.3**	**0.5**	**7.4**	**0.4**	**1.4**	**110.5**	**664.6**	**0.0**	**0.0**
Average		**16.1**	**7.6**	**0.4**	**2.4**	**-1.0**	**0.0**	**10.0**	**36.6**	**0.0**	**0.0**
28/08/2018	1:00	9.8	4.6	0.26	ZS	-1.8	0.1	0.0	0.1	0.0	0.0
	2:00	10.9	4.8	0.26	0.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	12.3	4.9	0.26	0.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	4:00	12.5	4.9	0.26	0.4	-1.8	-0.1	0.0	0.0	0.0	0.0
	5:00	11.5	4.9	0.25	0.4	-1.7	-0.5	0.0	0.0	0.0	0.0
	6:00	10.9	4.7	0.26	0.5	-1.7	-0.1	0.0	0.2	0.0	0.0
	7:00	15.6	6.7	0.52	3.8	-0.8	1.1	0.0	0.3	0.0	0.0
	8:00	21.6	9.1	0.69	10.0	3.6	1.8	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	16.4	7.7	0.40	6.7	0.2	-0.2	14.8	0.2	0.0	0.0
	10:00	14.6	5.5	0.28	2.0	-1.2	-0.5	27.6	0.2	0.0	0.0
	11:00	13.5	5.5	0.28	1.1	-1.5	-0.3	1.8	201.8	0.0	0.0
	12:00	12.8	5.5	0.29	0.9	-1.5	-0.5	0.0	0.0	0.0	0.0
	13:00	13.3	5.3	0.28	0.9	-1.5	-0.5	0.0	0.0	0.0	0.0
	14:00	14.4	5.6	0.28	1.2	-1.5	-0.2	0.0	0.0	0.0	0.0
	15:00	18.2	6.1	0.28	1.1	-1.6	-0.4	28.4	0.3	0.0	0.0
	16:00	17.7	6.1	0.28	1.3	-1.7	-0.3	0.0	0.0	0.0	0.0
	17:00	18.8	6.2	0.29	1.5	-1.6	-0.5	0.0	0.0	0.0	0.0
	18:00	17.9	6.3	0.32	2.6	-1.5	-0.3	0.0	0.0	0.0	0.0
	19:00	16.9	6.0	0.32	2.4	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	15.7	5.8	0.29	1.2	-1.6	-0.2	0.0	0.0	0.0	0.0
	21:00	17.2	6.0	0.31	1.6	-1.8	-0.1	0.0	23.4	0.0	0.0
	22:00	16.7	6.2	0.31	1.9	-1.3	-0.2	0.0	200.7	0.0	0.0
	23:00	17.3	6.6	0.31	2.0	-1.7	0.7	0.0	0.0	0.0	0.0
	0:00	17.6	6.9	0.31	ZS	-1.5	0.9	0.0	0.0	0.0	0.0
Min		**9.8**	**4.6**	**0.3**	**0.4**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**21.6**	**9.1**	**0.7**	**10.0**	**3.6**	**1.8**	**28.4**	**201.8**	**0.0**	**0.0**
Average		**15.2**	**5.9**	**0.3**	**2.0**	**-1.2**	**0.0**	**3.0**	**17.8**	**0.0**	**0.0**
29/08/2018	1:00	18.5	7.2	0.31	1.6	ZS	ZS	0.0	184.0	0.0	0.0
	2:00	18.8	7.3	0.30	2.1	-1.2	0.5	0.0	0.0	0.0	0.0
	3:00	16.0	6.5	0.29	1.5	-1.4	0.4	0.0	40.9	0.0	0.0
	4:00	14.9	6.1	0.29	1.6	-1.4	0.2	0.0	0.0	0.0	0.0
	5:00	16.4	6.6	0.32	4.1	-1.1	0.9	0.0	0.0	0.0	0.0
	6:00	15.8	7.2	0.40	5.1	-0.7	1.1	0.0	0.0	0.0	0.0
	7:00	19.0	7.7	0.59	7.9	-0.2	1.8	0.0	0.0	0.0	0.0
	8:00	18.1	7.7	0.67	8.0	0.1	0.6	0.0	51.6	0.0	0.0
	9:00	17.3	7.4	0.45	5.2	-0.3	0.1	0.0	0.0	0.0	0.0
	10:00	49.4	26.1	0.44	4.9	3.7	-1.0	0.1	0.0	0.0	0.0
	11:00	28.3	14.3	0.44	4.1	0.8	0.6	0.0	0.0	0.0	0.0
	12:00	19.3	10.2	0.44	2.8	0.8	-0.2	0.0	0.0	0.0	0.0
	13:00	16.7	7.3	0.41	2.8	-0.4	0.1	0.0	9.6	0.0	0.0
	14:00	15.7	6.3	0.41	3.0	-0.7	-0.4	226.8	0.0	0.0	0.0
	15:00	16.0	6.2	0.41	3.2	-1.0	-0.1	7.4	0.3	0.0	0.0
	16:00	15.6	6.3	0.41	3.8	-0.8	-0.4	0.0	306.0	0.0	0.0
	17:00	17.9	6.7	0.45	4.9	-0.9	-0.2	14.3	0.4	0.0	0.0
	18:00	19.3	6.9	0.42	4.4	-0.8	-0.1	13.9	0.2	0.0	0.0
	19:00	17.3	6.9	0.40	3.6	-1.1	-0.2	0.0	0.1	0.0	0.0
	20:00	15.8	7.0	0.34	1.4	-1.2	-0.3	0.0	0.0	0.0	0.0
	21:00	16.7	7.1	0.34	1.2	-1.2	-0.2	0.0	0.4	0.0	0.0
	22:00	15.0	6.7	0.33	1.2	-1.4	-0.1	0.0	0.0	0.0	0.0
	23:00	14.1	6.2	0.33	1.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	0:00	13.6	5.9	0.31	0.7	-1.3	-0.4	0.0	69.4	0.0	0.0
Min		**13.6**	**5.9**	**0.3**	**0.7**	**-1.4**	**-1.0**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**49.4**	**26.1**	**0.7**	**8.0**	**3.7**	**1.8**	**226.8**	**306.0**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**18.6**	**8.1**	**0.4**	**3.3**	**-0.6**	**0.1**	**10.9**	**27.6**	**0.0**	**0.0**
30/08/2018	1:00	12.6	5.9	0.32	1.4	-1.5	0.2	0.0	0.0	0.0	0.0
	2:00	11.9	5.6	0.31	1.0	-1.5	0.1	0.0	0.5	0.0	0.0
	3:00	12.4	5.6	0.32	1.6	-1.6	0.4	0.0	498.2	0.0	0.0
	4:00	12.7	5.8	0.33	2.3	-1.5	0.3	0.0	0.0	0.0	0.0
	5:00	12.1	5.7	0.33	2.5	-1.5	0.5	0.0	0.0	0.0	0.0
	6:00	12.7	5.8	0.37	3.7	-1.3	0.3	0.0	0.0	0.0	0.0
	7:00	14.2	5.9	0.44	6.0	-1.0	0.5	2.2	0.7	0.0	0.0
	8:00	13.8	5.9	0.54	7.4	-0.7	0.3	0.0	0.0	0.0	0.0
	9:00	12.5	5.6	0.45	5.2	-0.8	-0.1	0.0	0.0	0.0	0.0
	10:00	13.8	7.0	0.36	2.6	-1.3	-0.1	128.9	0.0	0.0	0.0
	11:00	13.1	5.4	0.33	1.5	-1.3	0.8	0.0	0.0	0.0	0.0
	12:00	11.7	5.1	0.36	1.8	-1.5	-0.2	0.0	0.0	0.0	0.0
	13:00	12.7	5.0	0.34	1.9	-1.6	0.0	0.0	0.0	0.0	0.0
	14:00	12.7	4.9	0.33	1.1	-1.6	-0.2	0.0	0.0	0.0	0.0
	15:00	14.3	5.0	0.34	1.3	-1.7	-0.2	3.7	0.0	0.0	0.0
	16:00	11.6	5.1	0.32	1.0	-1.7	-0.2	15.7	0.0	0.0	0.0
	17:00	13.7	5.0	0.34	1.6	-1.7	-0.2	0.0	0.0	0.0	0.0
	18:00	14.1	5.2	0.35	1.7	-1.7	-0.3	15.0	8.5	0.0	0.0
	19:00	14.6	5.1	0.35	1.3	-1.6	-0.5	0.0	0.0	0.0	0.0
	20:00	13.2	4.9	0.33	0.9	-1.6	-0.5	0.0	3.2	0.0	0.0
	21:00	11.6	4.8	0.34	1.0	-1.8	-0.2	148.8	0.0	0.0	0.0
	22:00	12.1	4.8	0.33	1.1	-1.6	-0.4	0.0	0.0	0.0	0.0
	23:00	11.2	4.6	0.34	0.8	-1.8	-0.3	9.6	0.0	0.0	0.0
	0:00	10.5	4.5	0.35	0.8	-1.8	-0.1	0.0	0.0	0.0	0.0
Min		**10.5**	**4.5**	**0.3**	**0.8**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**14.6**	**7.0**	**0.5**	**7.4**	**-0.7**	**0.8**	**148.8**	**498.2**	**0.0**	**0.0**
Average		**12.7**	**5.3**	**0.4**	**2.1**	**-1.5**	**0.0**	**13.5**	**21.3**	**0.0**	**0.0**
31/08/2018	1:00	10.7	4.8	0.38	ZS	-2.0	0.0	14.9	0.0	0.0	0.0
	2:00	11.6	4.9	0.34	0.3	ZS	ZS	0.2	0.0	0.0	0.0
	3:00	12.8	5.2	0.35	0.2	-1.4	-0.3	0.3	216.1	0.0	0.0
	4:00	15.8	5.6	0.34	0.2	-1.6	-0.4	0.0	0.1	0.0	0.0
	5:00	13.5	5.4	0.35	0.2	-1.7	-0.3	3.4	0.0	0.0	0.0
	6:00	13.7	5.4	0.35	0.2	-1.7	-0.1	0.0	0.0	0.0	0.0
	7:00	15.2	5.4	0.35	0.7	-1.4	-0.4	0.0	0.0	0.0	0.0
	8:00	16.6	5.8	0.35	0.8	-1.3	-0.7	170.1	0.0	0.0	0.0
	9:00	15.2	5.5	0.37	0.8	-1.5	-0.3	0.0	0.0	0.0	0.0
	10:00	14.7	5.7	0.35	0.7	-1.6	-0.2	IO	IO	IO	IO
	11:00	16.6	6.1	0.36	0.6	-1.6	-0.3	IO	IO	IO	IO
	12:00	13.6	5.3	0.37	1.8	-1.7	-0.2	IO	IO	IO	IO
	13:00	10.4	3.8	0.48	5.2	-0.8	0.6	IO	IO	IO	IO
	14:00	9.3	3.6	0.49	6.0	-0.8	0.3	IO	IO	IO	IO
	15:00	9.4	4.0	0.55	9.0	-0.3	0.1	IO	IO	IO	IO
	16:00	12.8	4.9	0.45	10.3	2.8	0.2	IO	IO	IO	IO
	17:00	16.3	6.6	0.42	3.6	-1.1	-0.1	IO	IO	IO	IO

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	32.9	18.3	0.61	3.7	-0.7	-0.4	IO	IO	IO	IO
	19:00	24.9	11.7	0.55	2.3	-0.8	-0.6	IO	IO	IO	IO
	20:00	21.5	9.0	0.46	2.3	-1.3	-0.1	IO	IO	IO	IO
	21:00	22.8	8.8	0.43	1.5	-1.4	-0.2	IO	IO	IO	IO
	22:00	24.5	9.7	0.37	1.5	-1.6	-0.1	IO	IO	IO	IO
	23:00	24.0	8.8	0.38	2.0	-1.4	0.4	IO	IO	IO	IO
	0:00	22.1	8.0	0.36	ZS	-1.6	-0.2	IO	IO	IO	IO
Min		**9.3**	**3.6**	**0.3**	**0.2**	**-2.0**	**-0.7**	**ID**	**ID**	**ID**	**ID**
Max		**32.9**	**18.3**	**0.6**	**10.3**	**2.8**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**16.7**	**6.8**	**0.4**	**2.4**	**-1.1**	**-0.1**	**ID**	**ID**	**ID**	**ID**
01/09/2018	1:00	21.0	7.7	0.35	0.6	ZS	ZS	IO	IO	IO	IO
	2:00	20.3	7.4	0.34	0.4	-1.5	-0.2	IO	IO	IO	IO
	3:00	21.1	7.6	0.34	0.3	-1.5	-0.3	IO	IO	IO	IO
	4:00	20.2	7.5	0.35	0.6	-1.7	0.7	IO	IO	IO	IO
	5:00	22.3	7.8	0.34	0.2	-1.7	0.0	IO	IO	IO	IO
	6:00	22.3	8.1	0.41	4.3	-1.0	0.6	IO	IO	IO	IO
	7:00	22.4	8.4	0.49	9.3	0.7	1.2	IO	IO	IO	IO
	8:00	17.8	7.2	0.58	6.5	-0.2	1.0	IO	IO	IO	IO
	9:00	18.9	7.0	0.56	6.2	-0.4	0.2	IO	IO	IO	IO
	10:00	20.0	7.5	0.45	3.3	-0.9	-0.1	IO	IO	IO	IO
	11:00	16.0	6.3	0.36	0.9	-1.4	-0.3	IO	IO	IO	IO
	12:00	16.4	6.5	0.37	1.0	-1.5	-0.4	IO	IO	IO	IO
	13:00	15.8	6.6	0.36	0.9	-1.7	-0.3	IO	IO	IO	IO
	14:00	16.7	6.5	0.37	1.0	-1.7	-0.3	IO	IO	IO	IO
	15:00	15.7	6.4	0.37	0.7	-1.7	-0.4	IO	IO	IO	IO
	16:00	15.7	6.7	0.38	1.4	-1.6	-0.5	IO	IO	IO	IO
	17:00	18.0	6.8	0.38	1.3	-1.6	-0.3	IO	IO	IO	IO
	18:00	17.1	6.6	0.38	1.1	-1.3	-0.6	IO	IO	IO	IO
	19:00	20.3	9.0	0.46	1.1	-1.4	-0.4	IO	IO	IO	IO
	20:00	16.4	6.2	0.39	0.8	-1.9	-0.2	IO	IO	IO	IO
	21:00	17.1	6.1	0.42	1.3	-1.6	-0.1	IO	IO	IO	IO
	22:00	14.8	5.8	0.45	1.4	-1.5	-0.2	IO	IO	IO	IO
	23:00	UM	UM	0.44	2.0	-1.5	0.0	IO	IO	IO	IO
	0:00	UM	UM	0.43	3.0	-1.4	1.0	IO	IO	IO	IO
Min		**14.8**	**5.8**	**0.3**	**0.2**	**-1.9**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**22.4**	**9.0**	**0.6**	**9.3**	**0.7**	**1.2**	**ID**	**ID**	**ID**	**ID**
Average		**18.5**	**7.1**	**0.4**	**2.1**	**-1.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
02/09/2018	1:00	UM	UM	0.40	3.2	-1.2	2.0	IO	IO	IO	IO
	2:00	UM	UM	0.42	3.4	-1.4	1.7	IO	IO	IO	IO
	3:00	UM	UM	0.39	2.3	-1.4	1.0	IO	IO	IO	IO
	4:00	UM	UM	0.42	3.7	-1.3	1.9	IO	IO	IO	IO
	5:00	UM	UM	0.41	2.5	-1.3	1.3	IO	IO	IO	IO
	6:00	UM	UM	0.43	4.4	-1.0	2.2	IO	IO	IO	IO
	7:00	UM	UM	0.50	7.5	1.9	2.1	IO	IO	IO	IO
	8:00	UM	UM	0.49	4.8	-0.6	1.0	IO	IO	IO	IO

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	UM	UM	0.50	3.8	-0.8	0.6	IO	IO	IO	IO
	10:00	UM	UM	0.51	4.6	-0.9	0.9	IO	IO	IO	IO
	11:00	UM	UM	0.52	4.9	-0.8	0.4	IO	IO	IO	IO
	12:00	UM	UM	0.46	3.8	-0.9	0.2	IO	IO	IO	IO
	13:00	UM	UM	0.44	2.1	-1.2	0.0	IO	IO	IO	IO
	14:00	UM	UM	0.42	1.4	-1.3	-0.6	IO	IO	IO	IO
	15:00	UM	UM	0.41	1.2	-1.2	-0.3	IO	IO	IO	IO
	16:00	UM	UM	0.44	0.9	-1.5	-0.2	IO	IO	IO	IO
	17:00	UM	UM	0.52	1.5	-1.2	-0.5	IO	IO	IO	IO
	18:00	UM	UM	0.89	3.7	-0.5	-0.8	IO	IO	IO	IO
	19:00	UM	UM	0.66	2.3	-0.4	-0.6	IO	IO	IO	IO
	20:00	UM	UM	0.60	2.3	-0.8	-0.5	IO	IO	IO	IO
	21:00	UM	UM	0.80	3.1	-0.2	-0.4	IO	IO	IO	IO
	22:00	UM	UM	1.03	5.4	0.8	0.6	IO	IO	IO	IO
	23:00	UM	UM	PO	PO	PO	PO	IO	IO	IO	IO
	0:00	21.0	9.0	PO	8.1	1.4	3.2	IO	IO	IO	
Min		**ID**	**ID**	**0.4**	**0.9**	**-1.5**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**ID**	**ID**	**1.0**	**8.1**	**1.9**	**3.2**	**ID**	**ID**	**ID**	**ID**
Average		**ID**	**ID**	**0.5**	**3.5**	**-0.7**	**0.7**	**ID**	**ID**	**ID**	**ID**
03/09/2018	1:00	15.7	6.7	PO	9.9	WP	WP	0.0	0.0	0.0	0.0
	2:00	14.1	6.3	0.58	3.4	-0.4	2.1	0.0	0.0	0.0	0.0
	3:00	14.0	6.5	0.56	1.7	-0.8	8.1	0.0	0.0	0.0	0.0
	4:00	15.0	6.1	0.53	9.4	-0.9	3.0	0.0	0.0	0.0	0.0
	5:00	17.3	7.7	0.49	5.4	-0.8	0.3	0.0	0.0	0.0	0.0
	6:00	15.7	7.0	0.48	0.8	-1.6	0.8	325.8	0.0	0.0	0.0
	7:00	12.7	5.9	0.75	8.5	-0.7	7.7	0.0	0.2	0.0	0.0
	8:00	15.9	6.9	1.10	12.5	0.5	6.0	0.0	0.5	0.0	0.0
	9:00	11.9	5.6	0.70	7.2	0.0	7.1	113.8	0.1	0.0	0.0
	10:00	11.1	5.4	0.58	5.4	-1.0	2.2	0.0	284.5	0.0	0.0
	11:00	8.7	4.0	0.49	1.9	-1.5	0.2	13.9	0.0	0.0	0.0
	12:00	10.5	4.8	0.49	2.2	-1.5	0.3	0.0	0.0	0.0	0.0
	13:00	10.1	4.7	0.48	1.1	-1.7	-0.1	272.5	0.0	0.0	0.0
	14:00	13.2	5.6	0.48	1.6	-1.7	-0.1	0.0	0.0	0.0	0.0
	15:00	12.4	5.8	0.48	1.8	-1.5	-0.5	0.0	0.0	0.0	0.0
	16:00	13.5	5.6	0.51	2.0	-1.5	-0.2	0.0	0.0	0.0	0.0
	17:00	15.1	7.7	0.54	3.5	-1.5	-0.3	221.8	0.0	0.0	0.0
	18:00	27.8	15.4	0.80	4.8	-0.7	-0.3	0.0	0.0	0.0	0.0
	19:00	28.4	15.2	0.83	2.8	-0.4	-0.8	0.0	0.0	0.0	0.0
	20:00	14.6	6.6	0.52	1.6	-1.0	-0.5	0.0	0.3	0.0	0.0
	21:00	13.0	6.4	0.51	2.4	-1.6	1.2	0.0	0.0	0.0	0.0
	22:00	13.3	6.3	0.51	2.2	-1.5	1.4	0.0	0.2	0.0	0.0
	23:00	15.3	6.6	0.57	6.3	-1.3	2.0	0.0	0.0	0.0	0.0
	0:00	24.4	9.6	0.90	13.7	0.3	3.9	185.5	139.9	0.0	0.0
Min		**8.7**	**4.0**	**0.5**	**0.8**	**-1.7**	**-0.8**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**28.4**	**15.4**	**1.1**	**13.7**	**0.5**	**8.1**	**325.8**	**284.5**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**15.1**	**7.0**	**0.6**	**4.7**	**-1.0**	**1.9**	**47.2**	**17.7**	**0.0**	**0.0**
04/09/2018	1:00	24.6	10.6	0.74	ZS	0.6	2.7	62.5	0.0	0.0	0.0
	2:00	25.9	11.7	0.71	11.2	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	20.8	8.5	0.59	9.2	2.0	1.0	0.0	0.0	0.0	0.0
	4:00	19.4	7.8	0.58	8.3	1.6	1.0	0.1	184.8	0.0	0.0
	5:00	16.8	7.2	0.57	8.7	0.7	0.8	0.0	0.0	0.0	0.0
	6:00	17.0	7.0	0.67	8.5	-0.1	1.3	0.0	0.0	0.0	0.0
	7:00	17.3	7.7	0.91	8.5	3.0	1.3	0.0	0.1	0.0	0.0
	8:00	20.8	6.8	0.76	6.7	2.9	0.3	0.0	0.0	0.0	0.0
	9:00	17.9	6.6	0.64	7.1	1.0	0.1	0.0	0.0	0.0	0.0
	10:00	17.9	6.7	0.54	7.0	0.5	0.0	268.4	0.0	0.0	0.0
	11:00	16.5	7.5	0.54	6.6	0.1	-0.2	0.0	0.0	0.0	0.0
	12:00	13.2	6.4	0.50	1.7	-1.3	-0.1	84.0	0.0	0.0	0.0
	13:00	12.7	5.7	0.50	1.3	-1.6	-0.2	0.0	0.0	0.0	0.0
	14:00	15.3	5.8	0.51	1.3	-1.4	-0.4	8.7	88.1	0.0	0.0
	15:00	13.3	5.5	0.51	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	16:00	12.5	4.9	0.51	1.3	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	12.7	5.4	0.54	1.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	18:00	13.8	6.2	0.55	1.6	-1.4	-0.3	143.7	0.3	0.0	0.0
	19:00	13.4	6.5	0.52	1.0	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	12.9	5.4	0.51	1.0	-1.6	-0.3	2.6	0.0	0.0	0.0
	21:00	15.4	5.6	0.49	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	22:00	17.2	5.8	0.49	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	23:00	20.5	6.5	0.50	1.3	-1.8	0.1	0.0	0.2	0.0	0.0
	0:00	21.3	7.7	0.50	ZS	-1.6	0.2	0.0	0.0	0.0	0.0
Min		**12.5**	**4.9**	**0.5**	**1.0**	**-1.8**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**25.9**	**11.7**	**0.9**	**11.2**	**3.0**	**2.7**	**268.4**	**184.8**	**0.0**	**0.0**
Average		**17.1**	**6.9**	**0.6**	**4.4**	**-0.3**	**0.2**	**23.7**	**11.4**	**0.0**	**0.0**
05/09/2018	1:00	23.4	8.4	0.48	0.5	ZS	ZS	131.6	0.0	0.0	0.0
	2:00	26.2	9.1	0.48	0.5	-1.7	1.1	0.0	0.0	0.0	0.0
	3:00	26.7	9.4	0.47	0.4	-1.5	1.4	181.1	0.0	0.0	0.0
	4:00	23.9	8.8	0.48	0.4	-1.6	0.2	0.0	115.0	0.0	0.0
	5:00	27.0	9.2	0.47	0.4	-1.6	0.1	0.0	0.0	0.0	0.0
	6:00	28.8	9.7	0.66	6.1	-0.5	2.8	0.0	0.0	0.0	0.0
	7:00	30.2	10.5	0.66	6.5	0.5	3.4	0.0	0.0	0.0	0.0
	8:00	22.6	8.8	0.78	7.8	-0.6	4.3	0.0	0.0	0.0	0.0
	9:00	28.1	10.9	0.66	4.2	-0.7	1.2	0.0	0.1	0.0	0.0
	10:00	20.0	7.5	0.51	1.1	-1.4	0.9	0.0	0.0	0.0	0.0
	11:00	14.9	5.6	0.64	5.7	-1.0	1.4	0.0	0.0	0.0	0.0
	12:00	10.7	4.5	0.51	1.8	-1.4	-0.5	0.0	0.0	0.0	0.0
	13:00	12.5	5.1	0.52	2.1	-1.3	-0.2	0.0	0.0	0.0	0.0
	14:00	23.3	8.8	0.52	1.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	15:00	20.7	8.2	0.53	1.3	-1.6	0.0	0.0	0.8	0.0	0.0
	16:00	15.1	5.9	0.65	4.7	-1.3	-0.2	0.0	0.0	0.0	0.0
	17:00	27.2	12.0	0.63	3.7	-1.0	-0.6	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	42.5	21.9	0.66	2.4	-0.9	-0.6	0.0	0.0	0.0	0.0
	19:00	28.0	9.8	0.62	4.2	-1.4	0.3	0.0	0.0	0.0	0.0
	20:00	35.3	11.3	1.00	11.2	1.3	1.7	0.0	0.1	0.0	0.0
	21:00	33.5	11.6	1.06	10.7	7.2	1.2	0.0	0.1	0.0	0.0
	22:00	49.0	13.9	1.35	8.4	3.5	4.4	0.1	1.4	0.0	0.1
	23:00	34.0	10.5	0.91	7.3	1.8	1.9	0.0	0.8	0.0	0.0
	0:00	34.1	11.4	0.93	8.2	2.4	2.2	0.0	0.5	0.0	0.0
Min		**10.7**	**4.5**	**0.5**	**0.4**	**-1.7**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**49.0**	**21.9**	**1.4**	**11.2**	**7.2**	**4.4**	**181.1**	**115.0**	**0.0**	**0.1**
Average		**26.6**	**9.7**	**0.7**	**4.2**	**-0.2**	**1.1**	**13.0**	**5.0**	**0.0**	**0.0**
06/09/2018	1:00	33.2	11.2	0.81	7.3	2.7	3.2	0.0	0.5	0.0	0.0
	2:00	29.1	9.4	0.63	6.6	2.7	1.4	0.0	0.0	0.0	0.0
	3:00	25.7	8.3	0.55	4.5	-0.5	0.2	0.0	0.0	0.0	0.0
	4:00	23.8	7.4	0.54	3.8	-0.8	0.4	0.0	0.0	0.0	0.0
	5:00	22.0	7.6	0.57	6.5	2.0	0.4	0.0	0.0	0.0	0.0
	6:00	23.7	7.0	0.66	5.5	0.2	2.2	16.4	0.0	0.0	0.0
	7:00	17.6	6.0	0.70	5.7	0.4	0.8	0.0	0.0	0.0	0.0
	8:00	16.4	5.5	0.84	5.1	-0.3	0.4	0.0	0.0	0.0	0.0
	9:00	26.1	8.0	0.80	8.2	2.6	1.0	0.0	0.0	0.0	0.0
	10:00	30.0	10.6	0.65	6.8	0.4	0.0	0.0	0.3	0.0	0.0
	11:00	24.5	7.9	0.56	5.3	-0.2	-0.2	121.9	1.2	0.0	0.0
	12:00	17.1	6.5	0.53	2.1	-1.2	0.1	0.0	0.0	0.0	0.0
	13:00	14.6	5.8	0.56	ZA	-1.0	-0.2	0.0	0.0	0.0	0.0
	14:00	14.6	6.0	0.55	ZA	-1.4	-0.1	0.0	0.0	0.0	0.0
	15:00	14.8	5.9	0.55	ZA	-1.3	-0.4	0.0	119.6	0.0	0.0
	16:00	15.0	6.1	0.55	ZA	-1.5	-0.3	0.0	0.0	0.0	0.0
	17:00	14.8	5.8	0.56	ZA	-1.6	-0.1	0.0	0.0	0.0	0.0
	18:00	13.1	5.5	0.56	1.6	-1.3	-0.3	0.0	0.0	0.0	0.0
	19:00	14.1	5.4	0.53	0.9	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	12.2	5.4	0.52	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	21:00	12.9	5.6	0.52	0.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	22:00	15.2	6.1	0.55	1.0	-1.5	0.3	0.0	16.2	0.0	0.0
	23:00	16.0	6.2	0.56	1.2	-1.5	0.3	0.0	0.0	0.0	0.0
	0:00	16.3	6.1	0.53	0.7	-1.7	0.5	0.0	0.0	0.0	0.0
Min		**12.2**	**5.4**	**0.5**	**0.3**	**-1.7**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**33.2**	**11.2**	**0.8**	**8.2**	**2.7**	**3.2**	**121.9**	**119.6**	**0.0**	**0.0**
Average		**19.3**	**6.9**	**0.6**	**3.9**	**-0.4**	**0.4**	**5.8**	**5.7**	**0.0**	**0.0**
07/09/2018	1:00	13.0	5.7	0.54	ZS	-1.8	0.8	0.0	0.0	0.0	0.0
	2:00	14.7	6.2	0.57	2.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	18.9	7.0	0.61	3.7	-0.2	3.0	0.8	0.0	0.0	0.0
	4:00	17.4	7.0	0.60	4.1	-0.6	3.5	0.0	0.0	0.0	0.0
	5:00	14.9	6.5	0.58	4.4	-0.5	1.5	0.0	0.0	0.0	0.0
	6:00	19.3	7.5	0.73	5.4	-0.1	6.1	0.0	613.2	0.0	0.0
	7:00	26.2	8.7	1.03	8.4	1.6	7.6	0.0	578.3	0.0	0.0
	8:00	21.4	8.0	0.92	7.6	0.9	1.8	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	14.3	6.0	0.73	4.7	-0.2	-0.4	0.0	0.0	0.0	0.0
	10:00	12.9	5.6	0.60	2.4	-1.1	0.1	0.0	0.0	0.0	0.0
	11:00	12.9	5.5	0.56	1.3	-1.3	0.0	0.0	0.0	0.0	0.1
	12:00	15.1	5.5	0.55	0.9	-1.4	-0.2	150.7	0.0	0.0	0.0
	13:00	14.1	5.3	0.57	1.1	-1.5	-0.3	0.0	0.0	0.0	0.0
	14:00	13.2	5.1	0.55	0.5	-1.6	-0.3	0.0	0.0	0.0	0.0
	15:00	14.2	5.1	0.56	0.8	-1.4	-0.5	0.0	0.0	0.0	0.0
	16:00	13.2	5.3	0.63	2.2	-1.3	-0.4	0.0	77.6	0.0	0.0
	17:00	12.4	5.1	0.63	2.5	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	12.6	5.1	0.58	1.7	-1.5	-0.2	0.1	0.0	0.0	0.0
	19:00	13.3	4.9	0.55	0.7	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	11.7	5.0	0.56	0.9	-1.6	-0.1	0.0	0.0	0.0	0.0
	21:00	11.2	4.7	0.54	0.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	22:00	10.0	4.6	0.55	0.1	-1.8	0.1	0.0	0.0	0.0	0.0
	23:00	10.9	4.5	0.56	0.4	-1.7	-0.1	0.0	0.0	0.0	0.0
	0:00	12.5	4.9	0.56	ZS	-1.7	0.1	0.0	0.0	0.0	0.0
Min		**10.0**	**4.5**	**0.5**	**0.1**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**26.2**	**8.7**	**1.0**	**8.4**	**1.6**	**7.6**	**150.7**	**613.2**	**0.0**	**0.1**
Average		**14.6**	**5.8**	**0.6**	**2.6**	**-1.0**	**0.9**	**6.3**	**52.9**	**0.0**	**0.0**
08/09/2018	1:00	13.8	5.0	0.55	0.3	ZS	ZS	16.7	0.0	0.0	0.0
	2:00	13.3	4.6	0.54	0.2	-1.3	0.4	0.0	0.0	0.0	0.0
	3:00	11.0	4.3	0.55	0.9	-1.6	0.5	0.0	0.0	0.0	0.0
	4:00	11.3	4.7	0.57	2.8	-1.2	0.7	0.0	0.0	0.0	0.0
	5:00	13.2	5.1	0.62	4.6	-1.3	3.0	0.0	0.0	0.0	0.0
	6:00	18.9	6.9	0.90	8.9	0.4	9.5	0.0	0.0	0.0	0.0
	7:00	22.4	7.5	0.90	9.9	1.2	5.4	0.0	0.2	0.0	0.0
	8:00	15.3	5.8	0.70	5.5	0.0	0.3	0.0	15.3	0.0	0.0
	9:00	12.2	4.8	0.62	2.2	-1.3	0.3	0.0	0.0	0.0	0.0
	10:00	11.9	4.8	0.61	1.9	-1.2	0.1	166.2	0.0	0.0	0.0
	11:00	12.0	4.6	0.56	0.6	-1.5	-0.3	192.1	0.0	0.0	0.0
	12:00	13.2	4.9	0.60	1.4	-1.5	-0.1	0.0	0.2	0.0	0.0
	13:00	14.0	5.4	0.61	2.2	-1.3	-0.2	0.0	0.0	0.0	0.0
	14:00	14.8	4.7	0.56	0.3	-1.5	-0.6	0.0	0.0	0.0	0.0
	15:00	15.8	4.7	0.56	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	16:00	12.9	4.7	0.57	0.2	-1.9	-0.2	0.0	0.0	0.0	0.0
	17:00	13.4	4.7	0.57	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	18:00	13.9	6.1	0.63	0.7	-1.5	-0.3	17.2	0.0	0.0	0.0
	19:00	14.1	5.9	0.63	0.6	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	15.0	6.7	0.64	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	21:00	18.8	9.3	0.76	0.9	-1.0	-0.6	0.1	0.0	0.0	0.0
	22:00	14.9	6.1	0.67	0.8	-1.4	-0.4	0.0	159.4	0.0	0.0
	23:00	12.8	5.2	0.60	0.4	-1.5	-0.6	0.0	0.0	0.0	0.0
	0:00	14.4	5.2	0.67	0.4	-1.4	-0.5	0.0	0.0	0.0	0.0
Min		**11.0**	**4.3**	**0.5**	**0.2**	**-1.9**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**22.4**	**9.3**	**0.9**	**9.9**	**1.2**	**9.5**	**192.1**	**159.4**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**14.3**	**5.5**	**0.6**	**2.0**	**-1.2**	**0.7**	**16.3**	**7.3**	**0.0**	**0.0**
09/09/2018	1:00	16.2	5.3	0.63	0.6	-1.5	-0.3	0.0	0.0	0.0	0.0
	2:00	12.8	4.7	0.60	1.2	-1.5	0.0	0.0	0.0	0.0	0.0
	3:00	15.1	4.7	0.60	0.8	-1.6	0.1	18.0	0.0	0.0	0.0
	4:00	13.1	4.6	0.58	0.8	-1.7	0.2	0.0	0.0	0.0	0.0
	5:00	13.2	4.9	0.55	0.0	-1.7	-0.3	0.0	0.0	0.0	0.0
	6:00	12.7	4.7	0.56	0.0	-1.6	-0.3	0.0	0.0	0.0	0.0
	7:00	10.9	4.5	0.57	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	8:00	11.2	4.5	0.57	0.4	-1.6	-0.4	0.7	0.0	0.0	0.0
	9:00	11.3	4.3	0.57	0.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	10:00	11.6	4.6	0.59	0.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	11:00	10.5	4.4	0.59	0.6	-1.7	-0.2	0.2	0.0	0.0	0.0
	12:00	11.6	4.8	0.63	1.5	-1.4	0.1	0.0	0.0	0.0	0.0
	13:00	12.3	4.2	0.59	0.4	-1.6	-0.6	0.0	0.0	0.0	0.0
	14:00	11.3	4.3	0.59	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	15:00	14.3	4.3	0.59	0.3	-1.8	-0.3	0.0	0.0	0.0	0.0
	16:00	12.4	4.2	0.64	0.4	-1.6	-0.3	0.0	0.1	0.0	0.0
	17:00	13.3	5.0	0.63	0.8	-1.3	-0.4	0.0	0.1	0.0	0.0
	18:00	12.8	5.2	0.76	1.6	-1.5	-0.2	0.0	0.5	0.0	0.0
	19:00	14.0	5.9	0.96	1.8	-0.2	-0.3	0.1	1.9	0.0	0.9
	20:00	14.3	5.6	1.05	2.3	0.2	-0.2	0.0	1.3	0.0	0.3
	21:00	14.9	5.2	1.08	3.5	0.8	-0.1	1.1	1.7	0.0	0.4
	22:00	13.4	5.1	1.06	5.0	0.9	0.8	0.1	1.8	0.0	0.8
	23:00	37.4	16.9	1.36	9.1	1.4	4.0	8.5	0.9	0.0	0.0
	0:00	26.6	11.6	1.16	ZS	1.4	2.9	0.1	2.0	0.0	0.0
Min		**10.5**	**4.2**	**0.6**	**0.0**	**-1.8**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**37.4**	**16.9**	**1.4**	**9.1**	**1.4**	**4.0**	**18.0**	**2.0**	**0.0**	**0.9**
Average		**14.5**	**5.6**	**0.7**	**1.4**	**-1.0**	**0.1**	**1.2**	**0.4**	**0.0**	**0.1**
10/09/2018	1:00	31.4	15.3	1.20	8.9	ZS	ZS	0.3	0.9	0.0	0.2
	2:00	29.1	14.2	1.08	8.6	0.8	4.0	0.2	0.1	0.0	0.0
	3:00	32.8	17.7	1.02	7.8	0.6	3.5	0.1	0.0	0.0	0.0
	4:00	27.7	14.5	0.91	6.3	3.3	2.2	0.1	0.0	0.0	0.0
	5:00	20.6	10.2	0.74	5.5	1.7	0.5	0.0	0.0	0.0	0.0
	6:00	23.4	9.9	0.78	4.7	0.5	1.6	0.0	0.0	0.0	0.0
	7:00	22.6	9.1	0.92	5.1	3.3	1.7	0.0	0.0	0.0	0.0
	8:00	20.9	7.3	1.04	6.1	1.7	0.3	0.0	117.0	0.0	0.0
	9:00	19.7	6.3	0.91	7.5	1.2	0.2	0.0	0.0	0.0	0.0
	10:00	20.3	6.0	0.75	7.2	0.7	-0.1	0.0	0.1	0.0	0.0
	11:00	14.9	5.7	0.70	3.2	-0.6	-0.1	13.0	109.7	0.0	0.0
	12:00	15.2	5.5	0.68	1.4	-1.0	-0.2	0.0	0.0	0.0	0.0
	13:00	16.3	5.3	0.66	1.5	-1.1	-0.5	0.0	0.0	0.0	0.0
	14:00	15.2	5.3	0.65	0.9	-1.2	-0.3	0.0	0.0	0.0	0.0
	15:00	16.3	5.5	0.65	0.5	-1.5	-0.4	120.7	0.0	0.0	0.0
	16:00	19.5	6.3	0.68	0.8	-1.7	-0.1	0.0	0.0	0.0	0.0
	17:00	19.3	6.4	0.72	0.8	-1.3	-0.5	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	18.7	6.2	0.69	0.5	-1.4	-0.7	0.0	0.0	0.0	0.0
	19:00	19.0	7.9	0.74	0.7	-1.4	-0.5	0.0	0.0	0.0	0.0
	20:00	36.4	21.2	0.88	0.9	-1.0	-0.7	0.0	0.0	0.0	0.0
	21:00	20.3	8.0	0.74	0.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	22:00	18.0	6.4	0.65	0.2	-1.6	-0.2	0.0	0.0	0.0	0.0
	23:00	18.3	6.7	0.63	0.2	-1.9	-0.1	96.2	0.0	0.0	0.0
	0:00	21.6	7.6	0.62	0.2	-1.7	-0.4	205.4	0.7	0.0	0.0
Min		**14.9**	**5.3**	**0.6**	**0.2**	**-1.9**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**36.4**	**21.2**	**1.2**	**8.9**	**3.3**	**4.0**	**205.4**	**117.0**	**0.0**	**0.2**
Average		**21.6**	**8.9**	**0.8**	**3.3**	**-0.2**	**0.4**	**18.2**	**9.5**	**0.0**	**0.0**
11/09/2018	1:00	21.1	7.3	0.64	ZS	-1.6	-0.5	0.0	0.0	0.0	0.0
	2:00	24.7	7.9	0.62	0.0	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	28.4	9.1	0.62	-0.1	-1.2	0.0	0.0	0.0	0.0	0.0
	4:00	30.4	9.8	0.63	0.1	-1.6	-0.2	0.0	0.0	0.0	0.0
	5:00	30.4	10.0	0.64	0.9	-1.7	0.3	0.0	0.0	0.0	0.0
	6:00	24.5	8.0	0.70	3.4	-1.4	0.9	26.9	0.1	0.0	0.0
	7:00	30.2	11.3	0.63	0.1	-1.5	0.2	0.0	0.0	0.0	0.0
	8:00	26.3	8.8	0.85	5.5	-1.2	0.2	0.0	0.0	0.0	0.0
	9:00	37.1	12.3	0.82	3.4	-0.9	0.0	0.0	0.0	0.0	0.0
	10:00	20.4	8.0	0.72	4.7	-0.5	0.2	0.0	0.0	0.0	0.0
	11:00	24.3	9.5	0.72	2.9	-1.2	-0.1	0.0	137.5	0.0	0.0
	12:00	17.0	7.0	NT	3.9	-1.1	1.6	0.0	114.8	0.0	0.0
	13:00	13.1	5.6	NT	5.8	-0.8	0.3	0.0	0.0	0.0	0.0
	14:00	17.9	6.6	NT	4.2	-0.9	0.3	0.0	0.0	0.0	0.0
	15:00	15.7	6.0	NT	4.0	-0.5	-0.1	0.0	0.0	0.0	0.0
	16:00	13.6	5.0	1.06	1.2	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	28.6	13.7	1.25	2.0	-1.2	-0.1	0.0	0.0	0.0	0.0
	18:00	26.8	12.3	1.26	1.8	-0.6	-0.4	0.1	0.0	0.0	0.0
	19:00	25.3	11.3	1.07	1.0	-0.7	-0.5	0.0	0.0	0.0	0.0
	20:00	25.6	11.8	0.90	0.8	-1.1	-0.5	0.0	0.0	0.0	0.0
	21:00	42.7	24.1	0.77	0.9	-0.7	-0.9	0.0	0.0	0.0	0.0
	22:00	24.0	8.6	0.47	0.5	-1.1	-0.4	0.0	0.1	0.0	0.0
	23:00	24.9	8.4	0.43	0.6	-1.7	0.0	0.0	0.0	0.0	0.0
	0:00	20.5	7.1	0.31	ZS	-1.8	-0.2	0.0	0.0	0.0	0.0
Min		**13.1**	**5.0**	**0.3**	**-0.1**	**-1.8**	**-0.9**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**42.7**	**24.1**	**1.3**	**5.8**	**-0.5**	**1.6**	**26.9**	**137.5**	**0.0**	**0.0**
Average		**24.7**	**9.6**	**0.8**	**2.2**	**-1.1**	**0.0**	**1.1**	**10.5**	**0.0**	**0.0**
12/09/2018	1:00	16.8	6.5	0.32	1.5	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	14.4	5.0	0.34	2.9	-1.1	2.6	0.0	0.0	0.0	0.0
	3:00	14.5	6.1	0.32	8.1	0.4	2.4	0.0	0.0	0.0	0.0
	4:00	11.7	4.8	0.30	7.8	0.3	0.4	0.0	0.0	0.0	0.0
	5:00	14.3	4.0	0.30	4.5	-0.8	0.1	0.0	0.0	0.0	0.0
	6:00	13.9	3.7	0.34	9.5	-0.3	1.4	0.0	0.0	0.0	0.0
	7:00	15.9	4.2	0.51	9.7	1.6	1.9	0.0	0.0	0.0	0.0
	8:00	10.3	3.1	0.54	8.3	1.7	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	13.6	4.1	0.64	11.0	1.0	0.1	20.6	0.0	0.0	0.0
	10:00	11.3	4.2	0.46	12.4	2.4	0.3	0.0	0.0	0.0	0.0
	11:00	8.8	3.3	0.34	3.7	-0.4	-0.3	0.0	0.0	0.0	0.0
	12:00	11.0	3.7	0.35	7.0	0.1	-0.1	0.0	0.0	0.0	0.0
	13:00	11.0	4.1	0.33	3.2	-0.6	-0.3	0.0	0.0	0.0	0.0
	14:00	12.2	4.3	0.31	1.0	-1.4	-0.4	0.0	0.0	0.0	0.0
	15:00	11.1	4.0	0.32	1.0	-1.4	0.1	0.0	0.0	0.0	0.0
	16:00	13.5	5.4	0.36	1.1	-1.3	-0.3	0.0	0.0	0.0	0.0
	17:00	13.2	5.5	0.37	1.3	-1.3	-0.2	0.0	0.0	0.0	0.0
	18:00	13.1	4.6	0.34	1.0	-1.5	-0.1	0.0	0.0	0.0	0.0
	19:00	15.2	4.7	0.32	0.6	-1.7	-0.1	137.3	0.0	0.0	0.0
	20:00	14.3	4.8	0.31	0.9	-1.6	0.7	0.0	0.0	0.0	0.0
	21:00	12.8	4.7	0.35	2.4	-1.3	0.6	0.0	0.0	0.0	0.0
	22:00	10.8	4.1	0.38	3.4	-1.3	0.7	0.0	0.0	0.0	0.0
	23:00	10.8	4.1	0.37	3.5	-1.5	0.9	0.0	0.0	0.0	0.0
	0:00	10.2	4.4	0.38	3.1	-1.6	0.5	125.9	0.0	0.0	0.0
Min		**8.8**	**3.1**	**0.3**	**0.6**	**-1.7**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**16.8**	**6.5**	**0.6**	**12.4**	**2.4**	**2.6**	**137.3**	**0.0**	**0.0**	**0.0**
Average		**12.7**	**4.5**	**0.4**	**4.5**	**-0.5**	**0.5**	**11.8**	**0.0**	**0.0**	**0.0**
13/09/2018	1:00	11.8	5.1	0.35	3.2	-1.4	0.5	0.0	0.0	0.0	0.0
	2:00	11.2	5.3	0.34	3.2	-1.2	0.7	0.0	0.0	0.0	0.0
	3:00	12.6	5.8	0.35	2.9	-1.1	0.7	0.8	0.0	0.0	0.0
	4:00	16.0	6.1	0.37	3.2	-0.9	1.4	0.0	0.0	0.0	0.0
	5:00	16.8	5.9	0.37	3.9	-0.9	0.9	0.7	129.5	0.0	0.0
	6:00	11.5	5.0	0.34	2.2	-1.0	2.4	0.0	0.1	0.0	0.0
	7:00	6.9	3.4	0.39	2.7	-1.3	2.1	0.0	0.0	0.0	0.0
	8:00	10.0	3.7	0.66	9.5	0.5	1.4	0.0	0.0	0.0	0.0
	9:00	13.1	5.7	0.68	10.2	-0.1	1.8	0.0	0.0	0.0	0.0
	10:00	11.1	5.0	0.51	8.9	0.2	1.1	0.1	0.1	0.0	0.0
	11:00	9.2	4.1	0.41	9.0	1.6	0.0	0.0	0.0	0.0	0.0
	12:00	9.3	3.7	0.41	7.6	2.4	-0.4	0.0	0.0	0.0	0.0
	13:00	9.4	3.9	0.38	6.9	3.8	0.1	0.0	0.0	0.0	0.0
	14:00	11.7	4.5	0.36	2.0	-1.2	-0.1	0.0	0.2	0.0	0.0
	15:00	14.5	6.7	0.40	6.9	0.8	-0.3	0.0	10.9	0.0	0.0
	16:00	48.7	31.8	0.53	3.3	-0.7	-0.4	0.0	0.0	0.0	0.0
	17:00	18.1	10.7	0.51	1.9	-1.2	-0.1	1.6	12.2	0.0	0.0
	18:00	19.3	11.4	0.48	2.3	-0.9	-0.2	1.3	0.0	0.0	0.0
	19:00	14.1	6.7	0.39	2.4	-0.9	-0.3	6.4	0.0	0.0	0.0
	20:00	12.5	5.6	0.51	1.8	-1.2	-0.2	0.0	0.0	0.0	0.0
	21:00	12.2	5.8	0.40	0.7	-1.5	-0.1	0.0	0.0	0.0	0.0
	22:00	16.7	7.9	0.41	2.3	-1.5	1.5	0.0	0.0	0.0	0.0
	23:00	23.5	9.1	0.54	9.6	0.1	1.4	0.0	0.0	0.0	0.0
	0:00	27.0	9.0	0.68	9.6	0.4	3.2	0.0	0.0	0.0	0.0
Min		**6.9**	**3.4**	**0.3**	**0.7**	**-1.5**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**48.7**	**31.8**	**0.7**	**10.2**	**3.8**	**3.2**	**6.4**	**129.5**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**15.3**	**7.2**	**0.4**	**4.8**	**-0.3**	**0.7**	**0.5**	**6.4**	**0.0**	**0.0**
14/09/2018	1:00	33.6	9.9	0.60	ZS	4.9	2.3	0.0	0.1	0.1	0.0
	2:00	22.8	7.0	0.48	9.6	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	25.5	7.6	0.47	8.1	2.4	2.7	0.0	0.0	0.0	0.0
	4:00	26.5	7.9	0.49	7.4	2.8	3.3	0.0	0.0	0.0	0.0
	5:00	24.5	8.1	0.50	6.8	3.3	5.4	0.0	0.0	0.0	0.0
	6:00	27.6	9.5	0.68	6.6	2.4	6.2	0.0	0.1	0.0	0.0
	7:00	33.5	12.7	0.94	8.7	4.3	3.7	0.0	0.4	0.0	0.0
	8:00	28.6	11.1	0.81	9.8	2.3	1.7	3.4	0.1	0.0	0.0
	9:00	29.6	11.4	0.68	7.3	0.5	0.8	0.0	0.0	0.0	0.0
	10:00	28.5	11.9	0.50	4.7	-0.2	-0.2	0.0	0.0	0.0	0.0
	11:00	24.8	11.0	0.41	3.0	-0.8	0.4	0.0	0.0	0.0	0.0
	12:00	23.8	10.1	0.41	2.8	-0.6	-0.4	0.0	0.0	0.0	0.0
	13:00	23.3	10.2	0.43	4.1	-0.7	-0.2	0.0	0.0	0.0	0.0
	14:00	22.2	9.7	0.43	3.7	-0.9	0.2	0.0	0.0	0.0	0.0
	15:00	21.8	9.1	0.43	4.4	-0.9	0.1	0.0	0.0	0.0	0.0
	16:00	20.8	8.6	0.50	5.9	-0.8	-0.1	0.0	0.0	0.0	0.0
	17:00	18.6	8.3	0.48	4.5	-0.9	-0.2	0.0	0.0	0.0	0.0
	18:00	19.0	8.2	0.50	4.5	-1.1	0.3	0.0	0.0	0.0	0.0
	19:00	18.4	8.5	0.45	3.6	-1.2	0.5	0.0	0.0	0.0	0.0
	20:00	21.2	8.5	0.36	1.5	-1.5	1.4	0.0	0.0	0.0	0.0
	21:00	20.7	8.4	0.35	1.4	-1.5	2.3	0.0	0.0	0.0	0.0
	22:00	18.5	8.2	0.37	1.7	-1.5	3.4	0.0	0.0	0.0	0.0
	23:00	20.0	8.2	0.35	0.9	-1.5	1.4	0.0	0.0	0.0	0.0
	0:00	18.6	8.1	0.33	ZS	-1.8	1.3	0.0	0.0	0.0	0.0
Min		**18.4**	**7.0**	**0.3**	**0.9**	**-1.8**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**33.6**	**12.7**	**0.9**	**9.8**	**4.9**	**6.2**	**3.4**	**0.4**	**0.1**	**0.0**
Average		**23.8**	**9.3**	**0.5**	**5.0**	**0.3**	**1.6**	**0.1**	**0.0**	**0.0**	**0.0**
15/09/2018	1:00	17.6	8.3	0.35	0.7	ZS	ZS	0.0	23.6	0.0	0.0
	2:00	18.3	8.4	0.36	1.8	-1.3	1.8	39.6	0.0	0.0	0.0
	3:00	18.6	8.6	0.34	2.3	-1.3	0.8	0.0	0.0	0.0	0.0
	4:00	17.8	8.4	0.34	1.9	-1.5	0.8	0.0	0.0	0.0	0.0
	5:00	18.1	8.3	0.34	1.3	-1.5	0.4	0.0	0.0	0.0	0.0
	6:00	17.9	8.3	0.39	2.5	-1.3	0.5	0.0	0.0	0.0	0.0
	7:00	23.5	9.5	0.55	6.6	-0.8	0.9	0.0	0.0	0.0	0.0
	8:00	20.7	8.9	0.49	4.1	-0.7	0.3	0.0	38.1	0.0	0.0
	9:00	18.7	8.0	0.45	3.8	-0.9	0.5	0.0	0.0	0.0	0.0
	10:00	17.7	7.7	0.44	2.7	-0.9	0.6	0.0	1134.6	0.0	0.0
	11:00	18.2	7.9	0.42	2.6	-1.1	0.1	0.0	0.0	0.0	0.0
	12:00	19.2	7.8	0.40	2.3	-1.3	-0.2	0.0	0.3	0.0	0.0
	13:00	17.5	7.3	0.39	1.6	-1.2	3.3	0.0	0.1	0.0	0.0
	14:00	15.0	6.8	0.38	1.2	-1.4	0.0	0.0	0.0	0.0	0.0
	15:00	15.3	6.8	0.39	1.3	-1.3	-0.3	0.0	0.0	0.0	0.0
	16:00	15.2	6.8	0.38	1.6	-1.4	-0.3	0.0	0.1	0.0	0.0
	17:00	15.7	7.1	0.38	1.4	-1.5	-0.4	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	20.0	8.0	0.40	1.2	-1.7	0.0	0.0	0.0	0.0	0.0
	19:00	20.4	7.9	0.40	0.6	-1.5	-0.5	0.0	0.0	0.0	0.0
	20:00	23.3	7.9	0.44	0.7	-1.6	-0.1	0.0	0.0	0.0	0.0
	21:00	20.6	7.5	0.43	2.1	-1.7	0.1	0.0	0.0	0.0	0.0
	22:00	19.8	8.2	0.58	7.5	-1.0	1.1	0.0	0.0	0.0	0.0
	23:00	16.5	7.4	0.47	4.1	-1.0	0.5	0.0	0.1	0.0	0.0
	0:00	15.8	7.2	0.41	1.5	-1.5	0.2	38.3	0.0	0.0	0.0
Min		**15.0**	**6.8**	**0.3**	**0.6**	**-1.7**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**23.5**	**9.5**	**0.6**	**7.5**	**-0.7**	**3.3**	**39.6**	**1134.6**	**0.0**	**0.0**
Average		**18.4**	**7.9**	**0.4**	**2.4**	**-1.3**	**0.4**	**3.2**	**49.9**	**0.0**	**0.0**
16/09/2018	1:00	15.1	6.4	0.37	0.6	-1.5	-0.2	0.0	0.0	0.0	0.0
	2:00	12.1	6.1	0.37	1.2	-1.5	0.5	126.8	0.0	0.0	0.0
	3:00	13.3	6.4	0.40	2.4	-1.4	0.4	0.0	0.0	0.0	0.0
	4:00	14.9	7.0	0.44	4.3	-1.0	1.1	0.0	0.0	0.0	0.0
	5:00	16.0	7.4	0.49	5.8	-0.5	3.6	0.0	0.0	0.0	0.0
	6:00	14.0	6.7	0.44	4.6	-0.7	1.4	0.0	0.0	0.0	0.0
	7:00	16.5	6.7	0.56	6.5	-0.4	1.9	0.0	0.1	0.0	0.0
	8:00	13.2	5.4	0.46	3.5	-0.8	-0.1	0.0	0.0	0.0	0.0
	9:00	11.3	4.3	0.39	1.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	10:00	11.3	4.0	0.39	0.9	-1.5	-0.3	0.0	0.0	0.0	0.0
	11:00	9.3	3.9	0.39	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	12:00	13.0	4.0	0.38	0.9	-1.7	-0.3	0.0	344.2	0.0	0.0
	13:00	11.1	4.1	0.38	0.7	-1.8	-0.3	0.0	0.0	0.0	0.0
	14:00	10.7	4.1	0.40	0.8	-1.6	0.8	0.0	0.0	0.0	0.0
	15:00	10.5	3.9	0.41	0.8	-1.7	0.9	0.0	0.0	0.0	0.0
	16:00	9.5	3.9	0.43	1.0	-1.6	0.2	0.0	0.0	0.0	0.0
	17:00	10.8	4.4	0.60	2.2	-0.8	-0.3	0.0	0.9	0.0	0.2
	18:00	14.7	6.7	0.45	1.3	-1.3	-0.1	0.0	0.0	0.0	0.0
	19:00	15.3	5.1	0.67	2.0	-1.0	-0.1	0.0	1.0	0.0	0.3
	20:00	14.5	4.9	0.54	1.0	-1.3	-0.4	0.9	0.2	0.0	0.0
	21:00	15.1	5.0	0.60	1.5	-1.2	-0.5	0.0	0.1	0.0	0.0
	22:00	12.9	5.0	0.50	1.5	-1.7	-0.1	0.0	0.0	0.0	0.0
	23:00	13.9	4.5	ZS	ZS	-1.5	-0.2	0.0	0.1	0.0	0.0
	0:00	12.6	4.2	0.54	ZS	-1.2	-0.3	0.0	0.0	0.0	0.0
Min		**9.3**	**3.9**	**0.4**	**0.5**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**16.5**	**7.4**	**0.7**	**6.5**	**-0.4**	**3.6**	**126.8**	**344.2**	**0.0**	**0.3**
Average		**13.0**	**5.2**	**0.5**	**2.1**	**-1.3**	**0.3**	**5.3**	**14.4**	**0.0**	**0.0**
17/09/2018	1:00	13.1	4.2	0.57	2.9	ZS	ZS	0.0	0.2	0.0	0.0
	2:00	10.1	3.4	0.33	0.4	-1.2	-0.2	0.0	0.0	0.0	0.0
	3:00	9.3	3.4	0.30	0.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	4:00	9.2	3.6	0.30	-0.2	-1.6	-0.4	0.0	0.3	0.0	0.1
	5:00	9.0	3.8	0.30	-0.1	-1.7	0.0	0.0	0.0	0.0	0.0
	6:00	11.2	4.6	0.43	4.4	-1.5	0.9	0.0	0.0	0.0	0.0
	7:00	19.5	7.1	0.60	7.3	-0.2	2.9	0.0	0.0	0.0	0.0
	8:00	20.4	6.2	0.44	4.2	-0.5	0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	21.1	6.6	0.46	6.0	-0.5	-0.3	0.0	51.9	0.0	0.0
	10:00	13.9	6.2	0.40	2.4	-1.0	0.1	0.0	0.0	0.0	0.0
	11:00	12.8	5.9	0.35	0.3	-1.4	-0.3	48.7	0.0	0.0	0.0
	12:00	14.1	6.5	0.37	1.0	-1.7	-0.2	0.0	0.0	0.0	0.0
	13:00	15.4	6.8	0.37	1.0	-1.8	0.1	0.0	0.0	0.0	0.0
	14:00	15.7	7.0	0.38	1.5	-1.5	-0.3	0.0	0.0	0.0	0.0
	15:00	15.7	6.9	0.36	0.4	-1.7	-0.3	0.0	0.0	0.0	0.0
	16:00	20.3	11.1	0.48	1.3	-1.5	-0.3	238.0	0.0	0.0	0.0
	17:00	22.5	10.8	0.43	1.1	-1.5	-0.2	0.0	0.0	0.0	0.0
	18:00	16.0	7.0	0.48	6.9	-0.3	-0.1	171.2	0.0	0.0	0.0
	19:00	14.4	6.9	0.58	13.7	3.0	0.3	0.0	0.0	0.0	0.0
	20:00	13.6	6.6	0.52	11.6	0.6	1.3	0.0	0.0	0.0	0.0
	21:00	13.0	7.1	0.64	13.1	1.0	4.0	0.0	0.0	0.0	0.0
	22:00	13.0	7.0	0.67	15.0	1.7	2.4	0.0	0.0	0.0	0.0
	23:00	20.4	10.9	0.68	13.8	1.3	3.9	0.0	0.0	0.0	0.0
	0:00	14.2	7.9	0.37	6.1	-0.3	1.9	0.0	0.0	0.0	0.0
Min		**9.0**	**3.4**	**0.3**	**-0.2**	**-1.8**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**22.5**	**11.1**	**0.7**	**15.0**	**3.0**	**4.0**	**238.0**	**51.9**	**0.0**	**0.1**
Average		**14.9**	**6.6**	**0.4**	**4.8**	**-0.6**	**0.7**	**19.1**	**2.2**	**0.0**	**0.0**
18/09/2018	1:00	13.3	7.2	0.39	ZS	-0.5	2.2	0.9	0.0	0.0	0.0
	2:00	13.6	6.7	0.38	4.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	16.3	7.4	0.42	11.4	4.5	1.6	0.0	0.0	0.0	0.0
	4:00	15.6	7.3	0.41	9.8	2.1	0.5	0.0	0.0	0.0	0.0
	5:00	15.2	6.7	0.41	6.7	1.7	0.6	0.0	0.0	0.0	0.0
	6:00	17.2	6.7	0.49	8.7	3.4	0.5	204.8	0.0	0.0	0.0
	7:00	16.2	6.6	0.54	8.1	1.9	0.1	0.0	0.0	0.0	0.0
	8:00	17.0	6.4	0.55	5.5	1.0	0.1	0.0	0.0	0.0	0.0
	9:00	17.8	6.2	0.50	2.5	-0.9	-0.2	0.2	0.0	0.0	0.0
	10:00	13.8	5.9	0.41	1.8	-1.3	-0.2	0.0	0.0	0.0	0.0
	11:00	11.8	5.4	0.40	1.0	-1.2	-0.4	0.6	0.0	0.0	0.0
	12:00	9.6	4.6	0.37	1.2	-1.5	-0.2	4.3	80.2	0.0	0.0
	13:00	8.3	4.3	0.38	1.0	-1.2	-0.5	0.0	0.0	0.0	0.0
	14:00	18.1	5.9	0.43	1.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	15:00	28.5	18.2	0.54	2.5	-0.7	-0.7	0.0	0.0	0.0	0.0
	16:00	22.6	12.8	0.48	2.1	-0.9	-0.3	0.0	0.0	0.0	0.0
	17:00	15.5	7.6	0.49	1.8	-1.1	-0.5	2.2	0.0	0.0	0.0
	18:00	11.3	4.4	0.42	1.4	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	8.9	3.6	0.41	0.4	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	8.9	3.7	0.40	0.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	21:00	8.8	3.9	0.41	0.3	-1.7	-0.1	0.0	0.0	0.0	0.0
	22:00	8.3	3.8	0.39	0.3	-1.6	-0.5	0.0	96.3	0.0	0.0
	23:00	8.4	3.9	0.39	0.4	-1.6	-0.3	0.0	0.0	0.0	0.0
	0:00	8.5	4.3	0.37	ZS	-1.7	-0.2	0.0	0.0	0.0	0.0
Min		**8.3**	**3.6**	**0.4**	**0.3**	**-1.7**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**28.5**	**18.2**	**0.6**	**11.4**	**4.5**	**2.2**	**204.8**	**96.3**	**0.0**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**13.9**	**6.4**	**0.4**	**3.3**	**-0.3**	**0.0**	**8.9**	**7.4**	**0.0**	**0.0**
19/09/2018	1:00	10.3	4.6	0.39	-0.1	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	12.1	4.7	0.29	-0.3	-1.4	0.2	0.0	0.0	0.0	0.0
	3:00	10.8	4.5	0.30	0.6	-1.4	0.3	0.0	0.0	0.0	0.0
	4:00	12.8	5.2	0.33	1.6	-1.3	0.3	1.6	0.0	0.0	0.0
	5:00	13.1	5.3	0.34	2.4	-1.4	0.7	0.0	3.3	0.0	0.0
	6:00	17.9	6.1	0.44	5.2	-0.9	1.2	0.0	0.0	0.0	0.0
	7:00	24.9	7.9	0.68	7.9	0.0	3.3	0.0	0.0	0.0	0.0
	8:00	24.8	8.1	0.75	7.8	0.5	1.1	0.0	0.0	0.0	0.0
	9:00	24.5	6.6	0.39	2.9	-0.7	-0.2	265.1	0.0	0.0	0.0
	10:00	17.6	6.0	0.32	0.7	-1.5	0.0	0.0	0.0	0.0	0.0
	11:00	15.7	5.9	0.33	0.6	-1.6	0.0	0.0	0.0	0.0	0.0
	12:00	14.9	5.4	0.35	0.7	-1.5	0.2	0.0	0.0	0.0	0.0
	13:00	14.7	5.1	0.34	0.3	-1.6	0.1	0.0	0.0	0.0	0.0
	14:00	8.5	3.8	0.38	1.8	-1.7	0.0	0.0	0.0	0.0	0.0
	15:00	10.2	4.4	0.35	0.9	-1.6	-0.2	0.0	0.0	0.0	0.0
	16:00	11.5	4.4	0.35	1.0	-1.5	-0.4	0.0	0.0	0.0	0.0
	17:00	11.3	4.6	0.42	2.9	-1.5	-0.3	8.0	0.0	0.0	0.0
	18:00	16.9	6.4	0.62	8.8	-0.8	0.1	0.0	0.0	0.0	0.0
	19:00	16.4	6.0	0.49	6.4	-0.9	0.2	1.0	0.0	0.0	0.0
	20:00	16.2	6.2	0.51	5.7	-1.1	0.5	0.2	0.0	0.0	0.0
	21:00	15.3	6.1	0.45	4.9	-1.4	0.5	0.0	0.0	0.0	0.0
	22:00	14.6	6.0	0.41	3.9	-1.4	0.5	30.5	0.0	0.0	0.0
	23:00	16.7	6.5	0.39	3.3	-1.2	0.3	0.0	0.0	0.0	0.0
	0:00	29.8	11.6	0.35	1.3	-1.7	0.4	0.0	0.0	0.0	0.0
Min		**8.5**	**3.8**	**0.3**	**-0.3**	**-1.7**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**29.8**	**11.6**	**0.7**	**8.8**	**0.5**	**3.3**	**265.1**	**3.3**	**0.0**	**0.0**
Average		**15.9**	**5.9**	**0.4**	**3.0**	**-1.2**	**0.4**	**12.8**	**0.1**	**0.0**	**0.0**
20/09/2018	1:00	31.1	12.1	0.34	1.7	-1.5	0.7	0.0	0.0	0.0	0.0
	2:00	28.4	10.9	0.33	1.0	-1.4	0.6	0.0	0.0	0.0	0.0
	3:00	28.6	11.1	0.34	1.3	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	34.8	13.1	0.36	2.3	-1.3	1.2	0.0	0.0	0.0	0.0
	5:00	31.5	11.1	0.39	6.0	-0.6	4.3	0.0	0.0	0.0	0.0
	6:00	29.6	10.7	0.50	10.5	4.4	1.9	0.0	0.0	0.0	0.0
	7:00	31.7	11.3	0.67	9.9	3.5	1.6	0.0	0.0	0.0	0.0
	8:00	33.7	12.0	0.74	8.7	2.0	1.1	0.0	0.0	0.0	0.0
	9:00	38.4	13.5	0.60	6.5	0.6	1.1	0.0	0.0	0.0	0.0
	10:00	35.4	13.0	0.49	4.1	-0.6	0.0	0.0	0.0	0.0	0.0
	11:00	33.1	12.5	0.43	3.9	-0.9	-0.3	0.0	0.0	0.0	0.0
	12:00	33.0	12.0	0.40	2.5	-1.5	-0.2	0.0	0.0	0.0	0.0
	13:00	33.9	12.5	0.41	2.2	-1.3	0.5	0.0	0.0	0.0	0.0
	14:00	31.9	11.6	0.41	1.8	-1.3	-0.1	0.0	0.0	0.0	0.0
	15:00	30.3	11.0	0.41	2.2	-1.5	-0.1	216.0	0.0	0.0	0.0
	16:00	30.0	11.0	0.45	3.3	-1.5	-0.3	0.4	0.0	0.0	0.0
	17:00	29.1	10.6	0.45	2.8	-1.6	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	29.0	10.7	0.38	1.3	-1.7	-0.1	0.0	0.0	0.0	0.0
	19:00	26.3	10.2	0.41	0.9	-1.8	0.0	0.0	0.0	0.0	0.0
	20:00	20.3	7.8	0.37	0.5	-1.4	-0.3	0.0	24.7	0.0	0.0
	21:00	21.2	8.4	0.40	0.3	-1.7	-0.2	0.3	0.0	0.0	0.0
	22:00	20.6	8.0	0.39	0.3	-1.6	-0.3	1.5	0.0	0.0	0.0
	23:00	26.6	10.3	0.37	0.1	-1.6	-0.4	0.0	0.0	0.0	0.0
	0:00	23.1	9.1	0.29	0.2	-1.6	-0.5	0.0	0.0	0.0	0.0
Min		**20.3**	**7.8**	**0.3**	**0.1**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**38.4**	**13.5**	**0.7**	**10.5**	**4.4**	**4.3**	**216.0**	**24.7**	**0.0**	**0.0**
Average		**29.6**	**11.0**	**0.4**	**3.1**	**-0.7**	**0.4**	**9.1**	**1.0**	**0.0**	**0.0**
21/09/2018	1:00	26.5	10.2	0.29	ZS	-2.0	0.1	0.0	0.0	0.0	0.0
	2:00	30.0	10.8	0.29	-0.3	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	16.8	6.2	0.29	-0.4	-1.4	-0.1	0.0	0.0	0.0	0.0
	4:00	10.3	4.1	0.30	-0.3	-1.6	0.1	206.0	0.0	0.0	0.0
	5:00	12.0	4.8	0.31	0.6	-1.7	0.1	0.0	0.0	0.0	0.0
	6:00	11.2	4.5	0.39	3.8	-1.4	0.9	0.0	0.0	0.0	0.0
	7:00	13.9	5.5	0.46	5.7	-1.1	0.6	0.0	0.0	0.0	0.0
	8:00	15.0	5.8	0.62	7.4	-1.0	0.1	0.9	0.0	0.0	0.0
	9:00	14.0	6.1	0.55	6.1	-1.0	0.3	15.3	0.0	0.0	0.0
	10:00	16.2	6.3	0.45	4.9	-1.0	0.4	0.0	0.0	0.0	0.0
	11:00	15.2	6.1	0.36	1.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	12:00	14.7	6.6	0.46	4.1	-1.2	0.2	0.0	0.0	0.0	0.0
	13:00	17.8	7.9	0.49	5.2	-0.7	0.0	0.0	0.0	0.0	0.0
	14:00	18.0	8.3	0.49	4.9	-0.8	-0.3	0.0	0.0	0.1	0.0
	15:00	19.0	8.0	0.44	3.7	-1.0	-0.3	0.0	0.0	0.0	0.0
	16:00	20.8	8.1	0.46	4.0	-1.3	-0.3	1.0	0.0	0.0	0.0
	17:00	20.7	8.8	0.53	6.2	-0.9	-0.2	0.0	0.0	0.0	0.0
	18:00	20.5	9.2	0.67	9.9	-0.7	0.2	0.0	0.0	0.0	0.0
	19:00	20.3	9.1	0.71	10.7	-0.6	0.2	0.0	0.0	0.0	0.0
	20:00	UM	UM	0.73	11.6	-0.7	0.8	1.0	0.0	0.0	0.0
	21:00	UM	UM	0.64	9.3	-0.6	0.6	0.0	0.0	0.0	0.0
	22:00	UM	UM	0.46	4.4	-1.1	0.2	0.0	0.0	0.0	0.0
	23:00	UM	UM	0.38	1.0	-1.7	-0.2	250.1	0.0	0.0	0.0
	0:00	UM	UM	0.39	ZS	-1.8	0.0	0.0	0.0	0.0	0.0
Min		**10.3**	**4.1**	**0.3**	**-0.4**	**-2.0**	**-0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**30.0**	**10.8**	**0.7**	**11.6**	**-0.6**	**0.9**	**250.1**	**0.0**	**0.1**	**0.0**
Average		**17.5**	**7.2**	**0.5**	**4.7**	**-1.2**	**0.1**	**19.8**	**0.0**	**0.0**	**0.0**
22/09/2018	1:00	UM	UM	0.40	1.7	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	UM	UM	0.33	1.5	-1.2	0.4	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.34	1.1	-1.4	0.4	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.32	1.4	-1.5	0.1	0.0	0.0	0.0	0.0
	5:00	UM	UM	0.34	3.9	-1.4	0.8	0.0	0.0	0.0	0.0
	6:00	UM	UM	0.41	3.6	-1.2	0.8	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.52	6.3	-0.6	1.0	0.0	0.0	0.0	0.0
	8:00	UM	UM	0.47	4.2	-1.0	0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	UM	UM	0.49	3.0	-0.7	-0.2	0.0	0.0	0.0	0.0
	10:00	UM	UM	0.45	3.1	-0.6	-0.1	0.0	0.0	0.0	0.0
	11:00	UM	UM	0.46	3.0	-0.8	-0.2	0.0	0.0	0.0	0.0
	12:00	UM	UM	0.42	1.5	-1.0	-0.4	15.4	0.0	0.0	0.0
	13:00	UM	UM	0.42	1.8	-1.4	-0.1	0.0	0.0	0.0	0.0
	14:00	UM	UM	0.42	2.0	-1.2	-0.5	0.0	0.0	0.0	0.0
	15:00	UM	UM	0.44	3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	16:00	UM	UM	0.41	2.3	-1.4	-0.3	0.0	0.0	0.0	0.0
	17:00	UM	UM	0.43	2.7	-1.3	-0.4	0.0	0.0	0.0	0.0
	18:00	UM	UM	0.44	3.5	-1.5	-0.1	0.0	0.0	0.0	0.0
	19:00	UM	UM	0.49	5.5	-1.2	0.3	0.0	0.0	0.0	0.0
	20:00	UM	UM	0.45	4.3	-1.4	0.3	0.0	0.0	0.0	0.0
	21:00	UM	UM	0.43	1.5	-1.7	-0.1	20.2	0.0	0.0	0.0
	22:00	UM	UM	0.42	1.7	-1.6	2.3	291.4	0.0	0.0	0.0
	23:00	UM	UM	0.40	3.1	-1.7	0.8	0.8	0.0	0.0	0.0
	0:00	UM	UM	0.35	1.6	-1.6	0.2	30.4	0.0	0.0	0.0
Min		**ID**	**ID**	**0.3**	**1.1**	**-1.7**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**ID**	**ID**	**0.5**	**6.3**	**-0.6**	**2.3**	**291.4**	**0.0**	**0.0**	**0.0**
Average		**ID**	**ID**	**0.4**	**2.8**	**-1.2**	**0.2**	**14.9**	**0.0**	**0.0**	**0.0**
23/09/2018	1:00	UM	UM	0.31	1.9	-1.4	0.5	0.0	0.0	0.0	0.0
	2:00	UM	UM	0.31	1.4	-1.5	0.3	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.31	1.6	-1.4	0.1	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.30	1.0	-1.7	0.1	1.0	0.0	0.0	0.0
	5:00	UM	UM	0.29	1.2	-1.9	0.2	15.1	0.0	0.0	0.0
	6:00	UM	UM	0.31	2.3	-1.7	0.6	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.38	3.8	-1.3	0.4	0.0	0.0	0.0	0.0
	8:00	UM	UM	0.36	2.6	-1.5	0.0	36.3	0.0	0.0	0.0
	9:00	UM	UM	0.34	1.9	-1.8	0.0	0.0	0.0	0.0	0.0
	10:00	UM	UM	0.34	1.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	11:00	UM	UM	0.31	1.1	-1.6	-0.3	0.0	0.2	0.0	0.0
	12:00	UM	UM	0.30	0.7	-1.8	-0.1	0.0	0.0	0.0	0.0
	13:00	UM	UM	0.31	0.6	-1.8	-0.5	0.0	0.0	0.0	0.0
	14:00	UM	UM	0.32	0.7	-1.8	-0.3	0.8	0.0	0.0	0.0
	15:00	UM	UM	0.32	0.6	-1.9	-0.4	0.8	0.0	0.0	0.0
	16:00	UM	UM	0.34	1.2	-1.7	-0.3	0.0	0.0	0.0	0.0
	17:00	UM	UM	0.38	1.3	-1.4	-0.5	0.0	0.0	0.0	0.0
	18:00	UM	UM	0.45	1.6	-1.4	-0.1	0.0	0.2	0.0	0.0
	19:00	UM	UM	0.70	1.8	-0.1	-0.3	11.1	1.4	0.0	0.3
	20:00	UM	UM	0.66	3.6	0.2	-0.1	0.0	0.9	0.0	0.2
	21:00	UM	UM	0.51	3.9	-0.8	0.4	0.0	0.3	0.0	0.0
	22:00	UM	UM	0.58	3.5	-0.6	0.2	306.3	0.8	0.0	0.2
	23:00	UM	UM	0.47	3.6	-0.9	0.4	0.0	0.1	0.0	0.0
	0:00	UM	UM	0.46	ZS	-1.1	0.3	0.0	0.0	0.0	0.0
Min		**ID**	**ID**	**0.3**	**0.6**	**-1.9**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**ID**	**ID**	**0.7**	**3.9**	**0.2**	**0.6**	**306.3**	**1.4**	**0.0**	**0.3**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Average		**ID**	**ID**	**0.4**	**1.9**	**-1.3**	**0.0**	**15.5**	**0.2**	**0.0**	**0.0**
24/09/2018	1:00	UM	UM	0.42	3.1	ZS	ZS	82.5	0.1	0.0	0.0
	2:00	UM	UM	0.33	1.6	-1.2	0.4	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.31	1.0	-1.5	0.4	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.32	0.8	-1.6	0.2	257.1	0.0	0.0	0.0
	5:00	UM	UM	0.32	1.4	-1.2	0.1	0.0	0.0	0.0	0.0
	6:00	UM	UM	0.43	7.4	-1.0	1.8	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.62	10.3	-0.1	1.5	0.0	0.0	0.0	0.0
	8:00	UM	UM	0.52	5.4	-0.7	0.2	0.0	0.0	0.0	0.0
	9:00	UM	UM	0.50	4.8	-0.9	0.2	0.0	0.0	0.0	0.0
	10:00	UM	UM	0.47	3.6	-1.2	0.1	0.0	0.4	0.0	0.0
	11:00	15.9	6.5	0.41	2.6	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	16.7	6.1	0.37	1.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	13:00	16.5	5.9	0.35	0.6	-1.6	-0.2	0.0	0.0	0.0	0.0
	14:00	UM	UM	0.36	0.9	-1.5	-0.4	0.0	0.0	0.0	0.0
	15:00	UM	UM	0.33	0.5	-1.6	-0.4	0.0	0.0	0.0	0.0
	16:00	UM	UM	0.36	1.2	-1.6	-0.4	1.0	0.0	0.0	7.5
	17:00	UM	UM	0.36	0.4	-1.6	-0.5	0.0	0.0	0.0	0.0
	18:00	UM	UM	0.38	0.9	-1.7	-0.5	0.0	0.0	0.0	0.0
	19:00	UM	UM	0.35	0.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	20:00	UM	UM	0.34	0.1	-1.8	-0.3	0.0	0.0	0.0	0.0
	21:00	UM	UM	0.34	0.2	-1.6	-0.6	0.0	0.0	0.0	17.0
	22:00	UM	UM	0.33	0.1	-2.0	0.2	0.0	0.0	0.0	0.0
	23:00	UM	UM	ZS	0.2	-1.5	-0.3	0.0	0.0	0.0	0.0
	0:00	UM	UM	0.34	0.1	-1.8	-0.3	0.0	0.0	0.0	0.0
Min		**ID**	**ID**	**0.3**	**0.1**	**-2.0**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**ID**	**ID**	**0.6**	**10.3**	**-0.1**	**1.8**	**257.1**	**0.4**	**0.0**	**17.0**
Average		**ID**	**ID**	**0.4**	**2.0**	**-1.4**	**0.0**	**14.2**	**0.0**	**0.0**	**1.0**
25/09/2018	1:00	UM	UM	0.36	ZS	-1.8	-0.4	0.0	0.0	0.0	7.7
	2:00	UM	UM	0.36	0.1	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	UM	UM	0.35	0.0	-1.5	-0.1	0.0	0.0	0.0	0.0
	4:00	UM	UM	0.35	0.1	-1.7	-0.2	0.0	0.0	0.0	0.0
	5:00	UM	UM	0.31	-0.3	-1.8	0.0	0.0	0.0	0.0	0.1
	6:00	UM	UM	0.31	-0.2	-1.7	-0.1	0.0	0.0	0.0	0.0
	7:00	UM	UM	0.45	5.0	-0.8	0.3	0.0	0.1	0.0	0.0
	8:00	UM	UM	0.66	9.3	1.7	0.5	0.0	0.0	0.0	0.0
	9:00	UM	UM	0.48	3.8	-0.8	-0.1	0.0	0.0	0.0	0.0
	10:00	14.7	5.5	0.38	0.7	-1.4	-0.3	0.0	0.0	0.0	0.0
	11:00	12.3	4.2	0.38	0.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	12:00	8.1	2.5	0.39	0.4	-1.7	-0.3	0.0	0.0	0.0	0.0
	13:00	6.3	2.2	0.38	0.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	14:00	8.4	2.4	0.38	0.4	-1.5	-0.4	23.6	0.0	0.0	0.0
	15:00	20.7	9.3	0.44	0.9	-1.2	-0.6	0.0	0.0	0.0	0.0
	16:00	16.7	5.2	0.43	1.2	-1.1	-0.4	54.2	0.0	0.0	0.0
	17:00	16.3	7.3	0.45	1.9	-1.3	-0.5	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	11.0	3.4	0.41	1.6	-1.5	-0.4	0.0	0.0	0.0	0.0
	19:00	9.2	3.0	0.38	1.0	-1.4	-0.4	0.0	0.0	0.0	0.0
	20:00	8.8	3.2	0.43	1.9	-1.5	0.0	0.0	0.1	0.1	0.1
	21:00	7.7	3.1	0.53	5.3	-1.2	0.7	0.0	0.0	0.0	0.1
	22:00	7.7	2.8	0.40	1.9	-1.3	-0.2	0.0	0.0	0.0	0.0
	23:00	7.2	2.6	0.41	1.2	-1.6	0.4	12.4	0.0	0.0	0.0
	0:00	6.4	2.4	0.41	ZS	-1.4	0.4	0.0	0.0	0.0	0.0
Min		**ID**	**ID**	**0.3**	**-0.3**	**-1.8**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**ID**	**ID**	**0.7**	**9.3**	**1.7**	**0.7**	**54.2**	**0.1**	**0.1**	**7.7**
Average		**ID**	**ID**	**0.4**	**1.7**	**-1.3**	**-0.1**	**3.8**	**0.0**	**0.0**	**0.3**
26/09/2018	1:00	6.6	2.5	0.37	0.2	ZS	ZS	262.0	0.0	0.0	0.0
	2:00	10.2	4.3	0.37	2.2	-1.2	1.6	0.0	0.0	0.0	0.0
	3:00	15.8	6.6	0.40	3.6	-1.0	1.7	0.1	0.0	0.0	0.0
	4:00	13.7	6.3	0.39	5.0	-0.5	9.5	0.0	0.0	0.0	2.4
	5:00	14.9	6.7	0.43	7.4	0.0	7.2	0.0	0.0	0.0	0.0
	6:00	14.7	5.4	0.45	6.0	1.4	0.7	0.2	0.0	0.0	0.0
	7:00	18.7	7.3	0.64	6.6	5.5	1.1	0.0	0.0	0.0	0.0
	8:00	11.8	4.8	0.68	8.9	2.5	0.5	0.0	0.0	0.0	0.0
	9:00	16.2	5.4	0.66	11.7	3.3	0.0	0.0	0.0	0.0	0.0
	10:00	13.9	4.9	0.42	10.9	2.9	0.1	0.0	0.0	0.0	0.0
	11:00	16.2	5.7	0.50	8.7	1.8	-0.3	0.0	0.0	0.0	0.0
	12:00	15.9	5.9	0.39	3.1	-0.4	-0.2	0.0	0.0	0.0	0.0
	13:00	16.5	6.1	0.36	3.6	-0.3	-0.4	0.0	0.0	0.0	0.0
	14:00	19.1	6.9	0.34	1.6	-1.0	-0.7	0.0	0.0	0.0	0.0
	15:00	23.0	5.5	0.33	0.8	-1.5	-0.6	0.0	0.0	0.0	0.0
	16:00	18.7	5.7	0.34	0.8	-1.4	-0.4	0.0	0.0	0.0	0.0
	17:00	17.8	5.6	0.34	0.9	-1.7	-0.3	0.0	0.0	0.0	0.0
	18:00	16.7	5.4	0.34	0.9	-1.6	-0.2	311.4	0.0	0.0	0.0
	19:00	14.2	4.9	0.33	0.5	-1.5	-0.3	0.0	0.0	0.0	0.0
	20:00	14.8	5.2	0.35	0.4	-1.6	-0.4	0.0	0.0	0.0	0.0
	21:00	11.0	4.1	0.34	0.7	-1.6	-0.4	0.0	0.0	0.0	0.0
	22:00	9.4	3.6	0.39	4.1	-1.4	0.7	318.4	0.0	0.0	0.0
	23:00	11.3	4.1	0.44	6.1	-0.9	1.3	0.0	0.0	0.0	0.0
	0:00	10.0	3.9	0.37	3.2	-1.3	0.6	0.0	0.0	0.0	0.0
Min		**6.6**	**2.5**	**0.3**	**0.2**	**-1.7**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**23.0**	**7.3**	**0.7**	**11.7**	**5.5**	**9.5**	**318.4**	**0.0**	**0.0**	**2.4**
Average		**14.6**	**5.3**	**0.4**	**4.1**	**-0.1**	**0.9**	**37.2**	**0.0**	**0.0**	**0.1**
27/09/2018	1:00	9.1	4.5	0.34	1.0	-1.5	0.5	0.0	0.0	0.0	0.0
	2:00	8.9	4.3	0.34	1.5	-1.5	0.4	171.9	0.0	0.0	0.0
	3:00	10.1	4.4	0.33	1.1	-1.6	0.2	0.0	0.0	0.0	0.0
	4:00	12.8	5.3	0.34	1.3	-1.6	0.2	0.0	0.0	0.0	0.0
	5:00	13.5	5.9	0.36	2.1	-1.5	0.2	0.0	0.0	0.0	0.0
	6:00	17.6	7.3	0.38	3.3	-1.4	0.4	0.0	0.0	0.0	0.0
	7:00	22.5	9.7	0.49	4.0	-1.1	0.7	68.4	0.0	0.0	0.0
	8:00	28.7	10.9	0.54	5.0	-0.8	0.1	10.8	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	30.3	11.2	0.49	4.6	-1.1	0.5	0.0	0.0	0.0	0.0
	10:00	27.7	10.8	0.43	3.1	-1.0	-0.2	0.0	0.0	0.0	0.0
	11:00	25.2	10.2	0.40	3.1	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	24.0	10.5	0.42	2.9	-1.1	-0.2	0.0	0.0	0.0	0.0
	13:00	24.7	11.0	0.46	3.6	-1.0	-0.1	0.0	0.0	0.0	0.0
	14:00	24.4	9.9	0.46	3.6	-1.1	-0.1	0.0	0.0	0.0	0.0
	15:00	21.9	9.8	0.45	3.7	-1.2	-0.3	0.0	0.0	0.0	0.0
	16:00	19.6	9.6	0.51	5.3	-1.1	-0.3	0.0	0.0	0.0	0.0
	17:00	20.7	9.8	0.59	6.9	-0.9	-0.1	0.0	0.0	0.0	0.7
	18:00	20.8	9.8	0.61	7.8	-1.0	0.1	0.0	0.0	0.0	0.0
	19:00	19.9	9.7	0.55	5.6	-0.9	0.0	312.5	0.0	0.0	0.0
	20:00	21.2	10.2	0.51	5.2	-1.0	0.1	0.0	0.0	0.0	0.0
	21:00	21.4	10.3	0.49	4.8	-1.3	0.5	0.0	0.0	0.0	0.0
	22:00	24.4	10.2	0.44	3.4	-1.2	0.2	2.0	0.0	0.0	0.0
	23:00	18.3	9.8	0.42	2.3	-1.6	0.5	0.0	0.0	0.0	0.0
	0:00	18.4	9.7	0.33	1.6	-1.7	0.4	0.0	0.0	0.0	0.0
Min		**8.9**	**4.3**	**0.3**	**1.0**	**-1.7**	**-0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**30.3**	**11.2**	**0.6**	**7.8**	**-0.8**	**0.7**	**312.5**	**0.0**	**0.0**	**0.7**
Average		**20.3**	**8.9**	**0.4**	**3.6**	**-1.2**	**0.2**	**23.6**	**0.0**	**0.0**	**0.0**
28/09/2018	1:00	17.5	9.3	0.33	ZS	-1.7	0.3	14.5	0.0	0.0	0.0
	2:00	17.9	9.1	0.33	0.8	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	17.6	8.9	0.34	0.8	-1.3	0.3	0.0	0.0	0.0	0.0
	4:00	17.8	9.1	0.32	0.6	-1.6	0.1	0.1	0.0	0.0	0.0
	5:00	18.1	8.6	0.33	0.9	-1.8	0.3	0.0	0.0	0.0	0.0
	6:00	21.6	9.0	0.37	2.5	-1.3	0.2	0.0	0.0	0.0	0.0
	7:00	25.6	9.1	0.51	5.3	-1.0	0.6	0.0	0.0	0.0	0.0
	8:00	23.6	8.8	0.58	6.5	-0.6	0.3	0.0	0.0	0.0	0.0
	9:00	22.4	8.6	0.53	5.1	-1.0	0.1	0.0	0.0	0.0	0.0
	10:00	21.4	8.1	0.44	3.5	-1.1	-0.3	0.0	0.0	0.0	0.0
	11:00	19.3	7.6	0.41	2.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	12:00	20.3	7.6	0.40	1.8	-1.4	-0.3	0.0	0.0	0.0	0.0
	13:00	20.2	7.6	0.43	2.4	-1.5	-0.2	0.0	0.0	0.0	0.0
	14:00	21.9	7.8	0.43	2.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	15:00	21.5	7.6	0.45	2.9	-1.1	-0.5	0.0	0.0	0.0	0.0
	16:00	21.0	8.0	0.48	3.5	-1.2	-0.2	0.0	0.0	0.0	0.0
	17:00	20.8	8.0	0.49	4.2	-1.1	-0.3	0.9	0.0	0.1	0.0
	18:00	23.2	8.2	0.54	5.3	-1.1	0.1	0.0	0.0	0.0	0.0
	19:00	20.7	7.9	0.45	3.7	-1.2	0.1	0.0	0.0	0.0	0.0
	20:00	22.2	8.1	0.36	1.2	-1.5	-0.2	0.0	0.0	0.0	0.0
	21:00	21.9	8.2	0.35	1.0	-1.7	-0.1	0.0	0.0	0.0	0.0
	22:00	22.7	8.0	0.36	1.3	-1.5	1.2	0.0	0.0	0.0	0.0
	23:00	19.8	7.7	0.37	1.5	-1.6	0.2	0.0	0.0	0.0	0.0
	0:00	19.7	8.0	0.38	ZS	-1.5	0.0	0.0	0.0	0.0	0.0
Min		**17.5**	**7.6**	**0.3**	**0.6**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**25.6**	**9.3**	**0.6**	**6.5**	**-0.6**	**1.2**	**14.5**	**0.0**	**0.1**	**0.0**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**20.8**	**8.3**	**0.4**	**2.7**	**-1.3**	**0.1**	**0.6**	**0.0**	**0.0**	**0.0**
29/09/2018	1:00	18.9	7.8	0.36	0.8	ZS	ZS	0.0	0.1	0.0	0.0
	2:00	19.5	7.9	0.29	0.8	-1.6	0.3	0.0	0.1	0.0	0.2
	3:00	19.6	7.8	0.28	0.2	-1.8	0.2	0.0	0.1	0.2	0.2
	4:00	20.9	8.2	0.31	1.6	-1.8	0.2	0.0	0.7	0.0	0.0
	5:00	19.6	7.9	0.30	1.2	-1.6	0.0	0.0	0.0	0.1	0.0
	6:00	19.0	7.5	0.36	3.4	-1.6	0.4	0.1	0.1	0.0	0.1
	7:00	18.1	7.2	0.41	4.9	-1.3	0.3	0.0	0.1	0.0	0.2
	8:00	15.7	6.5	0.41	3.7	-1.2	-0.3	0.0	6.9	0.0	0.3
	9:00	16.0	6.0	0.38	2.9	-1.5	-0.1	0.0	0.1	0.0	0.0
	10:00	17.6	6.3	0.41	3.6	-1.2	-0.1	0.0	0.0	0.0	0.0
	11:00	18.5	6.8	0.42	3.9	-1.4	0.2	0.0	0.0	0.0	0.0
	12:00	16.7	7.1	0.39	2.4	-1.5	0.0	0.0	0.0	0.0	0.0
	13:00	16.9	7.1	0.37	1.8	-1.7	-0.1	0.0	7.3	0.0	0.0
	14:00	17.7	7.6	0.40	2.3	-1.6	-0.1	0.0	0.0	0.0	0.0
	15:00	17.6	7.7	0.41	2.4	-1.4	-0.4	0.0	0.0	0.0	0.0
	16:00	18.5	8.0	0.41	2.9	-1.6	-0.1	0.0	0.0	0.0	0.0
	17:00	17.9	7.8	0.41	3.8	-1.2	-0.1	0.0	0.0	0.0	0.0
	18:00	21.5	8.9	0.41	2.8	-1.3	-0.1	0.0	0.0	0.0	0.0
	19:00	24.6	9.3	0.40	2.0	-1.3	-0.1	0.0	0.0	0.0	0.0
	20:00	21.4	8.7	0.38	2.3	-1.4	-0.1	0.0	0.0	0.0	0.0
	21:00	21.0	8.3	0.35	1.5	-1.6	0.1	0.0	0.0	0.0	0.1
	22:00	18.2	8.3	0.37	1.7	-1.6	0.2	0.0	0.5	0.0	0.0
	23:00	17.7	8.1	0.41	1.8	-1.7	0.3	0.1	0.1	0.0	0.5
	0:00	17.2	7.9	0.36	2.0	-1.4	-0.1	23.5	0.0	0.0	0.0
Min		**15.7**	**6.0**	**0.3**	**0.2**	**-1.8**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.6**	**9.3**	**0.4**	**4.9**	**-1.2**	**0.4**	**23.5**	**7.3**	**0.2**	**0.5**
Average		**18.8**	**7.7**	**0.4**	**2.4**	**-1.5**	**0.0**	**1.0**	**0.7**	**0.0**	**0.1**
30/09/2018	1:00	17.3	8.0	0.36	2.3	-1.3	0.1	0.0	0.0	0.0	0.0
	2:00	16.6	8.0	0.33	1.0	-1.6	0.1	0.0	0.0	0.0	0.0
	3:00	16.8	7.8	0.34	1.1	-1.6	0.1	0.0	0.0	0.0	0.0
	4:00	16.1	7.9	0.34	1.7	-1.6	0.1	0.0	0.0	0.1	0.0
	5:00	17.4	8.0	0.34	1.3	-1.5	0.1	0.0	0.1	0.0	0.0
	6:00	18.7	8.5	0.37	2.0	-1.4	0.2	0.0	0.0	0.0	0.0
	7:00	23.2	9.6	0.41	3.5	-1.1	0.0	0.0	0.0	0.0	0.0
	8:00	22.5	8.9	0.41	3.4	-1.3	0.0	0.0	0.0	0.0	0.0
	9:00	20.0	8.2	0.39	2.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	10:00	18.1	7.7	0.36	1.3	-1.5	-0.3	0.0	0.0	0.0	0.0
	11:00	17.7	7.4	0.35	0.8	-1.6	-0.1	0.0	0.0	0.0	0.0
	12:00	17.0	6.8	0.35	0.9	-1.6	-0.5	0.0	0.0	0.0	0.0
	13:00	15.3	6.6	0.36	1.0	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	16.8	7.0	0.37	1.0	-1.6	0.2	293.6	0.0	0.0	0.0
	15:00	18.2	7.0	0.37	1.2	-1.8	0.0	0.0	0.0	0.0	0.0
	16:00	16.9	6.6	0.38	1.5	-1.5	-0.2	1.2	0.0	0.0	0.0
	17:00	15.7	7.0	0.40	2.1	-1.7	0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	16.6	6.7	0.44	2.8	-1.4	-0.2	0.0	0.0	0.0	0.0
	19:00	16.1	7.1	0.54	4.7	-1.1	0.1	0.0	0.0	0.0	0.0
	20:00	15.6	6.7	0.55	4.3	-1.0	0.2	0.0	0.0	0.0	0.0
	21:00	14.0	6.4	0.61	2.6	-0.8	0.2	0.0	9.2	0.0	0.0
	22:00	16.1	7.5	0.64	2.7	-0.7	0.2	0.1	0.7	0.0	0.0
	23:00	14.4	6.5	0.83	2.8	-0.1	-0.1	0.1	1.6	0.0	0.4
	0:00	19.7	8.3	0.87	ZS	1.0	-0.5	0.3	2.0	0.0	0.7
Min		**14.0**	**6.4**	**0.3**	**0.8**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**23.2**	**9.6**	**0.9**	**4.7**	**1.0**	**0.2**	**293.6**	**9.2**	**0.1**	**0.7**
Average		**17.4**	**7.5**	**0.4**	**2.1**	**-1.2**	**0.0**	**12.3**	**0.6**	**0.0**	**0.0**
01/10/2018	1:00	17.7	6.4	0.84	2.6	ZS	ZS	0.1	1.0	11.1	0.6
	2:00	14.7	6.0	0.40	0.4	-1.0	0.0	0.0	0.0	0.0	0.0
	3:00	12.7	5.8	0.31	0.5	-1.3	0.4	0.0	0.0	0.0	0.0
	4:00	12.8	6.1	0.30	1.4	-1.2	0.4	0.0	0.0	0.0	0.0
	5:00	12.8	6.0	0.31	1.6	-1.3	0.5	0.0	0.0	0.0	0.0
	6:00	13.4	6.0	0.40	5.0	-1.1	0.5	10.8	0.0	0.0	0.0
	7:00	15.8	6.8	0.54	7.7	-0.6	0.2	0.0	0.0	0.0	0.0
	8:00	15.0	6.2	0.57	7.3	-0.6	0.0	0.0	0.0	0.0	0.0
	9:00	15.7	6.2	0.47	5.1	-0.9	-0.4	0.0	0.0	0.0	0.0
	10:00	16.1	5.9	0.33	1.4	-1.4	-0.2	0.0	0.0	0.0	0.0
	11:00	14.4	5.8	0.33	1.2	-1.4	-0.6	0.0	0.0	0.0	0.0
	12:00	12.9	5.7	0.33	0.9	-1.6	-0.3	0.0	0.0	0.0	0.0
	13:00	12.3	5.6	0.35	1.4	-1.6	-0.2	0.0	0.0	0.0	0.0
	14:00	14.1	5.6	0.36	1.5	-1.4	0.3	0.0	0.0	0.0	0.0
	15:00	13.5	5.6	0.39	2.1	-1.5	-0.3	0.0	0.0	0.0	0.0
	16:00	13.0	5.5	0.41	2.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	13.4	5.6	0.39	2.2	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	14.0	5.6	0.42	3.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	12.7	5.6	0.36	1.4	-1.6	-0.3	0.0	0.0	0.0	0.0
	20:00	11.8	5.4	0.32	0.3	-1.8	0.0	0.0	0.0	0.0	0.0
	21:00	12.3	5.1	0.33	0.6	-1.7	-0.4	0.0	0.0	0.0	0.0
	22:00	11.9	5.0	0.34	0.9	-1.7	-0.5	0.0	0.0	0.0	0.0
	23:00	11.8	5.1	0.34	0.7	-1.9	0.0	0.0	0.0	0.0	0.0
	0:00	10.3	5.0	0.34	0.4	-1.8	0.0	38.4	0.0	0.0	0.0
Min		**10.3**	**5.0**	**0.3**	**0.3**	**-1.9**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**17.7**	**6.8**	**0.8**	**7.7**	**-0.6**	**0.5**	**38.4**	**1.0**	**11.1**	**0.6**
Average		**13.5**	**5.7**	**0.4**	**2.2**	**-1.4**	**-0.1**	**2.1**	**0.0**	**0.5**	**0.0**
02/10/2018	1:00	9.8	4.8	0.32	ZS	-1.6	-0.3	0.0	0.0	0.0	0.0
	2:00	10.7	5.2	0.33	0.7	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	10.3	4.9	0.34	1.3	-1.5	0.6	0.0	0.1	0.0	0.0
	4:00	10.0	4.8	0.34	1.6	-1.7	0.5	0.0	0.0	0.0	0.0
	5:00	12.1	5.8	0.39	4.6	-1.4	1.3	0.0	0.0	0.0	0.0
	6:00	20.6	9.7	0.57	9.1	-0.4	3.9	0.0	0.0	0.0	0.0
	7:00	20.0	8.0	0.74	9.2	0.3	3.0	0.0	0.0	0.0	0.0
	8:00	20.5	7.1	0.59	7.0	-0.5	0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	22.5	6.3	0.42	2.7	-1.3	-0.2	0.0	0.0	0.0	0.0
	10:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	11:00	13.8	5.6	0.59	0.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	12:00	15.7	5.8	0.55	NT	-1.2	-0.3	0.0	0.0	0.0	0.0
	13:00	15.4	5.3	0.50	NT	-0.8	-0.1	0.0	0.0	0.0	0.0
	14:00	21.9	5.7	0.48	0.6	NT	NT	0.0	0.0	0.0	0.0
	15:00	18.6	6.3	0.47	0.4	NT	NT	0.0	0.0	0.0	0.0
	16:00	21.9	6.7	NT	0.3	-1.2	0.0	0.0	0.0	0.0	0.0
	17:00	NT	NT	0.44	0.8	-1.3	0.0	0.0	0.0	0.0	0.0
	18:00	20.8	6.6	0.42	0.5	-1.3	0.0	0.0	0.0	0.0	0.0
	19:00	17.8	6.4	0.42	0.6	-1.3	0.0	0.0	0.0	0.0	0.0
	20:00	18.7	6.8	0.45	1.7	-1.3	0.2	0.0	0.0	0.0	0.0
	21:00	20.9	7.5	0.44	1.4	-1.2	0.3	7.0	0.0	0.0	0.0
	22:00	17.7	6.9	0.40	0.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	23:00	18.3	6.7	0.39	0.1	-1.4	0.2	0.0	0.0	0.0	0.0
	0:00	17.0	6.9	0.38	ZS	-1.3	0.1	250.7	0.0	0.0	0.0
Min		**9.8**	**4.8**	**0.3**	**0.1**	**-1.7**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**22.5**	**9.7**	**0.7**	**9.2**	**0.3**	**3.9**	**250.7**	**0.1**	**0.0**	**0.0**
Average		**17.0**	**6.3**	**0.5**	**2.3**	**-1.2**	**0.4**	**10.7**	**0.0**	**0.0**	**0.0**
03/10/2018	1:00	17.4	7.2	0.38	0.3	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	17.4	7.0	0.27	-0.2	-1.2	0.4	0.0	0.0	0.0	0.0
	3:00	17.3	6.9	0.28	0.1	-1.4	0.3	0.0	0.0	0.0	0.0
	4:00	16.2	7.0	0.30	1.0	-1.6	0.5	245.6	0.0	0.0	0.0
	5:00	16.0	7.0	0.30	1.5	-1.3	0.3	0.0	0.0	0.0	0.0
	6:00	17.4	7.7	0.35	3.2	-1.4	0.7	0.0	0.0	0.0	0.0
	7:00	21.9	8.5	0.46	4.9	-1.1	0.3	0.0	0.0	0.0	0.0
	8:00	23.7	8.8	0.54	5.7	-0.7	0.2	0.9	0.0	0.0	0.0
	9:00	24.1	8.9	0.53	4.8	-0.7	0.0	48.7	44.6	31.6	137.1
	10:00	23.3	8.7	0.45	4.3	-0.9	0.0	22.8	14.6	15.2	53.0
	11:00	21.2	9.1	0.39	3.2	-1.1	0.1	5.2	4.6	4.6	15.8
	12:00	18.9	8.3	0.35	1.6	-1.3	-0.2	0.9	0.8	0.8	2.9
	13:00	20.1	8.1	0.37	2.1	-1.4	0.1	0.0	0.0	0.0	0.0
	14:00	21.1	8.3	0.37	2.6	-1.2	-0.1	0.0	0.0	0.0	0.0
	15:00	21.3	8.7	0.39	2.7	-1.1	0.1	0.0	0.0	0.0	0.0
	16:00	23.2	10.1	0.46	4.3	-0.8	0.1	0.0	0.0	0.0	0.0
	17:00	21.7	11.0	0.51	6.3	-0.5	-0.1	0.0	0.0	0.0	0.0
	18:00	19.8	9.1	0.55	8.5	-0.8	0.4	0.0	0.0	0.0	0.0
	19:00	19.0	9.1	0.52	8.1	-0.8	0.4	0.0	0.0	0.0	0.0
	20:00	20.5	9.1	0.48	7.6	-0.6	0.5	0.0	0.0	0.0	0.0
	21:00	18.0	8.7	0.42	4.5	-0.8	0.4	0.0	0.0	0.0	0.0
	22:00	17.9	8.6	0.35	2.5	-1.1	0.4	0.0	0.0	0.0	0.0
	23:00	18.5	8.8	0.33	1.8	-1.3	0.4	0.0	0.0	0.0	0.0
	0:00	18.8	8.9	0.31	0.7	-1.4	0.4	0.0	0.0	0.0	0.0
Min		**16.0**	**6.9**	**0.3**	**-0.2**	**-1.6**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.1**	**11.0**	**0.5**	**8.5**	**-0.5**	**0.7**	**245.6**	**44.6**	**31.6**	**137.1**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Average		**19.8**	**8.5**	**0.4**	**3.4**	**-1.0**	**0.2**	**13.5**	**2.7**	**2.2**	**8.7**
Carifesta (Second Deployment)											
11/12/2018	1:00	16.8	6.5	0.275	ZS	-0.2	0.1	ID	ID	ID	ID
	2:00	17.9	7.0	0.276	-0.8	ZS	ZS	ID	ID	ID	ID
	3:00	19.5	7.7	0.278	-1.1	-0.2	0.5	ID	ID	ID	ID
	4:00	20.4	7.9	0.279	-0.6	-0.3	0.5	ID	ID	ID	ID
	5:00	19.9	7.7	0.276	-1.0	-0.4	0.7	ID	ID	ID	ID
	6:00	21.3	8.2	0.319	1.9	-0.1	0.7	ID	ID	ID	ID
	7:00	22.6	8.4	0.454	5.4	0.2	2.9	ID	ID	ID	ID
	8:00	23.5	8.9	0.547	7.7	0.4	0.6	ID	ID	ID	ID
	9:00	24.3	8.4	0.400	3.2	0.3	0.4	ID	ID	ID	ID
	10:00	23.1	8.3	0.310	-0.6	0.4	-0.1	ID	ID	ID	ID
	11:00	29.1	12.4	0.337	0.0	0.5	0.2	ID	ID	ID	ID
	12:00	21.1	7.3	0.286	-1.2	0.1	0.0	ID	ID	ID	ID
	13:00	20.9	7.1	0.283	-1.4	-0.2	0.1	ID	ID	ID	ID
	14:00	18.7	6.8	0.321	-0.3	-0.1	-0.2	ID	ID	ID	ID
	15:00	14.3	5.4	0.313	-0.8	-0.1	2.6	ID	ID	ID	ID
	16:00	12.5	5.0	0.298	-1.1	-0.2	7.8	ID	ID	ID	ID
	17:00	14.9	5.8	0.370	1.1	-0.1	1.6	ID	ID	ID	ID
	18:00	21.6	7.0	0.298	-1.1	-0.2	2.6	ID	ID	ID	ID
	19:00	24.6	7.1	0.296	-1.4	-0.1	1.7	ID	ID	ID	ID
	20:00	22.7	7.2	0.316	-1.1	-0.4	0.1	ID	ID	ID	ID
	21:00	26.5	8.8	0.276	-2.0	-0.4	0.1	ID	ID	ID	ID
	22:00	28.9	10.3	0.286	-2.0	-0.3	0.2	ID	ID	ID	ID
	23:00	27.0	9.9	0.271	-2.0	-0.4	0.1	ID	ID	ID	ID
	0:00	25.0	9.6	0.266	ZS	-0.3	0.3	ID	ID	ID	ID
Min		**12.5**	**5.0**	**0.266**	**-2.0**	**-0.4**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**29.1**	**12.4**	**0.547**	**7.7**	**0.5**	**7.8**	**ID**	**ID**	**ID**	**ID**
Average		**21.6**	**7.9**	**0.318**	**0.0**	**-0.1**	**1.0**	**ID**	**ID**	**ID**	**ID**
12/12/2018	1:00	22.9	9.2	0.266	-1.6	ZS	ZS	ID	ID	ID	ID
	2:00	23.1	9.2	0.277	-1.5	-0.1	0.5	ID	ID	ID	ID
	3:00	23.4	9.2	0.266	-1.8	-0.3	0.6	ID	ID	ID	ID
	4:00	26.8	10.3	0.262	-1.9	-0.3	0.5	ID	ID	ID	ID
	5:00	39.4	12.6	0.261	-2.2	-0.4	0.2	ID	ID	ID	ID
	6:00	37.7	12.0	0.259	-2.1	-0.4	3.4	ID	ID	ID	ID
	7:00	45.9	13.5	0.262	-2.0	0.0	13.8	ID	ID	ID	ID
	8:00	40.9	12.6	0.305	-0.7	-0.3	0.2	ID	ID	ID	ID
	9:00	37.8	12.1	0.304	-0.5	-0.1	-0.2	ID	ID	ID	ID
	10:00	29.6	10.5	0.284	-1.1	-0.4	0.1	ID	ID	ID	ID
	11:00	18.5	7.3	0.295	-1.5	-0.2	-0.1	ID	ID	ID	ID
	12:00	21.1	8.3	0.285	-1.6	-0.3	0.0	ID	ID	ID	ID
	13:00	13.9	5.5	0.291	-1.3	-0.2	-0.1	ID	ID	ID	ID
	14:00	26.2	10.2	0.285	-1.3	-0.3	0.7	ID	ID	ID	ID
	15:00	25.5	9.5	0.298	-1.6	-0.3	0.1	ID	ID	ID	ID
	16:00	29.9	10.4	0.298	-1.0	-0.3	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	32.6	11.5	0.301	-1.5	-0.2	-0.3	ID	ID	ID	ID
	18:00	41.2	12.6	0.310	-1.2	-0.3	0.0	ID	ID	ID	ID
	19:00	37.4	11.7	0.285	-1.8	-0.2	-0.1	ID	ID	ID	ID
	20:00	36.8	11.7	0.288	-1.9	-0.3	0.1	ID	ID	ID	ID
	21:00	31.8	10.8	0.287	-1.9	-0.3	0.0	ID	ID	ID	ID
	22:00	28.7	10.8	0.294	-1.9	-0.4	0.1	ID	ID	ID	ID
	23:00	30.3	11.6	0.295	-1.9	-0.5	0.2	ID	ID	ID	ID
	0:00	29.1	11.6	0.299	-2.0	ZS	ZS	ID	ID	ID	ID
Min		**13.9**	**5.5**	**0.259**	**-2.2**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**45.9**	**13.5**	**0.310**	**-0.5**	**0.0**	**13.8**	**ID**	**ID**	**ID**	**ID**
Average		**30.4**	**10.6**	**0.286**	**-1.6**	**-0.3**	**0.9**	**ID**	**ID**	**ID**	**ID**
13/12/2018	1:00	33.6	12.7	0.304	-2.0	-0.3	0.1	ID	ID	ID	ID
	2:00	33.6	13.7	0.302	ZS	-0.3	-0.1	ID	ID	ID	ID
	3:00	35.3	14.2	0.309	-1.5	-0.3	0.1	ID	ID	ID	ID
	4:00	36.9	14.3	0.313	-1.9	-0.3	-0.1	ID	ID	ID	ID
	5:00	35.3	13.7	0.300	-2.1	-0.4	0.0	ID	ID	ID	ID
	6:00	36.1	14.2	0.306	-2.1	-0.3	0.3	ID	ID	ID	ID
	7:00	43.9	15.8	0.314	-2.0	-0.3	1.5	ID	ID	ID	ID
	8:00	43.3	16.1	0.342	-1.2	-0.2	1.5	ID	ID	ID	ID
	9:00	43.7	17.0	0.359	-0.7	-0.2	0.0	ID	ID	ID	ID
	10:00	46.3	17.4	0.344	-1.0	-0.2	-0.1	ID	ID	ID	ID
	11:00	44.9	17.2	0.326	-1.5	-0.2	-0.2	ID	ID	ID	ID
	12:00	43.1	16.9	0.330	-1.5	-0.4	0.3	ID	ID	ID	ID
	13:00	39.3	15.7	0.328	-1.5	-0.4	0.1	ID	ID	ID	ID
	14:00	41.3	15.4	0.328	-1.5	-0.2	0.9	ID	ID	ID	ID
	15:00	41.1	15.5	0.322	-1.5	-0.2	-0.2	ID	ID	ID	ID
	16:00	41.4	15.8	0.327	-1.1	-0.2	0.0	ID	ID	ID	ID
	17:00	42.7	16.4	0.350	0.0	-0.2	-0.1	ID	ID	ID	ID
	18:00	44.1	17.0	0.362	0.7	-0.4	-0.1	ID	ID	ID	ID
	19:00	45.3	17.0	0.335	-1.3	-0.3	0.0	ID	ID	ID	ID
	20:00	46.6	17.2	0.327	-1.9	-0.3	0.1	ID	ID	ID	ID
	21:00	39.1	15.7	0.322	-1.4	-0.3	0.2	ID	ID	ID	ID
	22:00	39.6	15.7	0.331	-1.1	-0.5	0.2	ID	ID	ID	ID
	23:00	36.2	14.8	0.328	-1.0	-0.2	-0.1	ID	ID	ID	ID
	0:00	35.4	14.2	0.314	-1.8	-0.3	0.1	ID	ID	ID	ID
Min		**33.6**	**12.7**	**0.300**	**-2.1**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**46.6**	**17.4**	**0.362**	**0.7**	**-0.2**	**1.5**	**ID**	**ID**	**ID**	**ID**
Average		**40.3**	**15.6**	**0.326**	**-1.3**	**-0.3**	**0.2**	**ID**	**ID**	**ID**	**ID**
14/12/2018	1:00	32.6	13.0	0.301	ZS	-0.4	0.2	ID	ID	ID	ID
	2:00	21.8	9.5	0.290	-1.6	ZS	ZS	ID	ID	ID	ID
	3:00	28.9	12.2	0.292	-1.6	-0.2	1.0	ID	ID	ID	ID
	4:00	30.7	12.8	0.278	-2.0	-0.2	0.9	ID	ID	ID	ID
	5:00	31.6	12.6	0.286	-1.7	-0.2	1.1	ID	ID	ID	ID
	6:00	31.1	12.4	0.286	-1.7	-0.2	2.9	ID	ID	ID	ID
	7:00	35.4	13.3	0.280	-1.9	-0.2	6.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	35.5	13.0	0.305	-1.3	-0.1	3.8	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	-0.4	0.1	ID	ID	ID	ID
	10:00	36.5	13.4	PO	-1.4	-0.1	-0.2	ID	ID	ID	ID
	11:00	34.1	12.4	0.532	-1.4	-0.1	-0.1	ID	ID	ID	ID
	12:00	32.9	11.5	0.341	-1.8	-0.3	0.1	ID	ID	ID	ID
	13:00	31.0	10.9	0.334	-1.6	-0.3	0.1	ID	ID	ID	ID
	14:00	30.4	10.8	0.336	-1.6	-0.1	2.9	ID	ID	ID	ID
	15:00	28.1	10.4	0.333	-1.7	-0.2	0.5	ID	ID	ID	ID
	16:00	26.9	10.2	0.316	-1.6	-0.4	0.2	ID	ID	ID	ID
	17:00	27.4	9.6	0.321	-1.0	-0.5	0.3	ID	ID	ID	ID
	18:00	28.5	9.7	0.323	-0.7	-0.2	-0.2	ID	ID	ID	ID
	19:00	39.3	13.1	0.370	-1.6	-0.2	-0.1	ID	ID	ID	ID
	20:00	33.6	10.6	0.362	-1.4	0.0	-0.2	ID	ID	ID	ID
	21:00	30.4	9.7	0.318	-1.3	-0.1	-0.1	ID	ID	ID	ID
	22:00	29.2	9.5	0.311	-1.6	-0.2	-0.1	ID	ID	ID	ID
	23:00	29.6	9.1	0.307	-1.6	-0.3	0.1	ID	ID	ID	ID
	0:00	25.4	8.8	0.302	ZS	-0.4	0.2	ID	ID	ID	ID
Min		**21.8**	**8.8**	**0.278**	**-2.0**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**39.3**	**13.4**	**0.532**	**-0.7**	**0.0**	**6.4**	**ID**	**ID**	**ID**	**ID**
Average		**30.9**	**11.2**	**0.324**	**-1.5**	**-0.2**	**0.9**	**ID**	**ID**	**ID**	**ID**
15/12/2018	1:00	22.9	8.4	0.301	-1.0	ZS	ZS	ID	ID	ID	ID
	2:00	21.4	8.1	0.289	-1.1	-0.2	0.1	ID	ID	ID	ID
	3:00	20.2	7.8	0.322	0.7	-0.1	0.5	ID	ID	ID	ID
	4:00	19.2	7.6	0.287	-0.4	-0.4	0.9	ID	ID	ID	ID
	5:00	19.2	7.6	0.281	-1.4	-0.3	0.4	ID	ID	ID	ID
	6:00	19.3	7.6	0.263	-2.2	-0.4	0.1	ID	ID	ID	ID
	7:00	21.6	7.9	0.261	-2.1	-0.5	-0.1	ID	ID	ID	ID
	8:00	24.7	8.1	0.265	-2.1	-0.5	0.2	ID	ID	ID	ID
	9:00	30.4	9.0	0.266	-1.7	-0.3	-0.2	ID	ID	ID	ID
	10:00	30.4	8.8	0.274	-1.6	-0.2	-0.1	ID	ID	ID	ID
	11:00	26.7	8.3	0.270	-1.4	-0.5	0.0	ID	ID	ID	ID
	12:00	27.1	10.2	0.291	-1.4	-0.4	-0.1	ID	ID	ID	ID
	13:00	24.7	8.0	0.281	-1.2	-0.3	-0.1	ID	ID	ID	ID
	14:00	24.0	8.2	0.291	-0.8	-0.3	-0.2	ID	ID	ID	ID
	15:00	27.4	8.5	0.283	-1.0	-0.3	-0.1	ID	ID	ID	ID
	16:00	19.4	7.2	0.279	-1.2	-0.5	0.1	ID	ID	ID	ID
	17:00	20.5	7.4	0.282	-1.4	-0.5	0.2	ID	ID	ID	ID
	18:00	21.7	8.1	0.340	-0.3	-0.4	-0.1	ID	ID	ID	ID
	19:00	26.9	10.4	0.366	-0.6	-0.3	0.1	ID	ID	ID	ID
	20:00	24.3	9.1	0.356	-0.5	-0.3	0.0	ID	ID	ID	ID
	21:00	22.3	7.7	0.349	-1.3	-0.3	0.1	ID	ID	ID	ID
	22:00	21.8	7.4	0.335	-0.7	-0.3	2.4	ID	ID	ID	ID
	23:00	24.0	8.4	0.330	0.0	-0.3	3.1	ID	ID	ID	ID
	0:00	15.2	6.4	0.343	1.6	ZS	ZS	ID	ID	ID	ID
Min		**15.2**	**6.4**	**0.261**	**-2.2**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**30.4**	**10.4**	**0.366**	**1.6**	**-0.1**	**3.1**	**ID**	**ID**	**ID**	**ID**
Average		**23.1**	**8.2**	**0.300**	**-1.0**	**-0.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
16/12/2018	1:00	17.2	7.1	0.378	4.5	0.0	1.4	ID	ID	ID	ID
	2:00	16.9	6.9	0.367	ZS	-0.1	2.0	ID	ID	ID	ID
	3:00	18.0	7.4	0.413	3.3	0.1	1.9	ID	ID	ID	ID
	4:00	20.1	8.1	0.321	-0.3	-0.1	0.5	ID	ID	ID	ID
	5:00	15.7	6.4	0.290	-1.9	-0.4	1.3	ID	ID	ID	ID
	6:00	16.1	7.0	0.293	-1.1	-0.3	1.2	ID	ID	ID	ID
	7:00	22.0	8.0	0.430	3.8	0.1	2.5	ID	ID	ID	ID
	8:00	22.1	8.3	0.497	4.6	0.2	1.9	ID	ID	ID	ID
	9:00	25.0	9.6	0.378	1.6	0.1	0.4	ID	ID	ID	ID
	10:00	25.5	9.6	0.303	-1.2	-0.2	0.1	ID	ID	ID	ID
	11:00	24.7	9.0	0.302	-1.5	-0.3	0.0	ID	ID	ID	ID
	12:00	24.7	9.1	0.291	-1.9	-0.4	-0.1	ID	ID	ID	ID
	13:00	22.5	8.7	0.302	-1.7	-0.4	-0.1	ID	ID	ID	ID
	14:00	21.8	8.3	0.322	-0.4	-0.3	0.0	ID	ID	ID	ID
	15:00	24.3	8.4	0.316	-0.5	-0.4	0.1	ID	ID	ID	ID
	16:00	22.7	8.4	0.325	0.2	-0.4	0.2	ID	ID	ID	ID
	17:00	22.8	8.4	0.384	1.7	-0.5	0.5	ID	ID	ID	ID
	18:00	22.0	8.2	0.393	3.9	-0.4	0.6	ID	ID	ID	ID
	19:00	22.3	8.4	0.397	2.4	-0.2	0.4	ID	ID	ID	ID
	20:00	26.7	10.3	0.404	-0.1	-0.4	0.1	ID	ID	ID	ID
	21:00	27.0	10.4	0.402	-0.3	-0.2	0.1	ID	ID	ID	ID
	22:00	30.4	11.4	0.427	0.4	-0.2	0.0	ID	ID	ID	ID
	23:00	28.8	9.5	0.442	1.6	-0.2	0.2	ID	ID	ID	ID
	0:00	27.4	10.1	0.393	ZS	-0.2	0.1	ID	ID	ID	ID
Min		**15.7**	**6.4**	**0.290**	**-1.9**	**-0.5**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**30.4**	**11.4**	**0.497**	**4.6**	**0.2**	**2.5**	**ID**	**ID**	**ID**	**ID**
Average		**22.8**	**8.6**	**0.365**	**0.8**	**-0.2**	**0.6**	**ID**	**ID**	**ID**	**ID**
17/12/2018	1:00	29.3	9.6	0.508	1.3	ZS	ZS	ID	ID	ID	ID
	2:00	23.9	8.2	0.299	0.7	-0.1	0.4	ID	ID	ID	ID
	3:00	20.4	8.0	0.306	-0.2	-0.2	0.5	ID	ID	ID	ID
	4:00	20.9	8.3	0.298	0.2	-0.2	0.8	ID	ID	ID	ID
	5:00	20.7	8.2	0.313	0.4	-0.2	3.1	ID	ID	ID	ID
	6:00	16.9	6.7	0.343	2.1	-0.3	3.1	ID	ID	ID	ID
	7:00	19.2	7.6	0.483	7.9	0.1	1.8	ID	ID	ID	ID
	8:00	26.8	9.0	0.684	12.5	0.6	1.1	ID	ID	ID	ID
	9:00	32.2	9.7	0.403	2.5	-0.1	0.4	ID	ID	ID	ID
	10:00	34.3	10.0	0.310	-0.9	-0.2	-0.1	ID	ID	ID	ID
	11:00	32.8	10.1	0.301	-1.5	-0.1	0.1	ID	ID	ID	ID
	12:00	32.7	9.8	0.294	-1.4	-0.2	-0.1	ID	ID	ID	ID
	13:00	27.9	8.9	0.319	-1.2	-0.2	-0.1	ID	ID	ID	ID
	14:00	26.7	8.9	0.317	-0.7	-0.2	0.0	ID	ID	ID	ID
	15:00	24.4	8.3	0.325	-0.7	-0.2	-0.1	ID	ID	ID	ID
	16:00	26.8	8.7	0.328	-0.8	-0.3	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	23.8	8.3	0.324	-1.1	-0.2	-0.2	ID	ID	ID	ID
	18:00	23.3	8.1	0.348	-0.6	-0.4	0.3	ID	ID	ID	ID
	19:00	21.7	8.1	0.320	-1.0	-0.3	0.1	ID	ID	ID	ID
	20:00	21.9	8.4	0.312	-1.5	-0.3	0.2	ID	ID	ID	ID
	21:00	24.4	8.8	0.310	-1.7	-0.4	0.1	ID	ID	ID	ID
	22:00	27.9	9.5	0.310	-1.8	-0.3	0.4	ID	ID	ID	ID
	23:00	26.0	9.4	0.323	-1.9	-0.3	1.7	ID	ID	ID	ID
	0:00	29.9	9.6	0.306	-1.8	-0.5	0.3	ID	ID	ID	ID
Min		**16.9**	**6.7**	**0.294**	**-1.9**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**34.3**	**10.1**	**0.684**	**12.5**	**0.6**	**3.1**	**ID**	**ID**	**ID**	**ID**
Average		**25.6**	**8.8**	**0.349**	**0.4**	**-0.2**	**0.6**	**ID**	**ID**	**ID**	**ID**
18/12/2018	1:00	29.5	10.4	0.303	ZS	-0.4	0.1	ID	ID	ID	ID
	2:00	14.6	6.1	0.298	-1.9	ZS	ZS	ID	ID	ID	ID
	3:00	14.8	5.2	0.293	-2.1	-0.2	-0.1	ID	ID	ID	ID
	4:00	13.1	5.3	0.324	-1.1	-0.1	-0.2	ID	ID	ID	ID
	5:00	11.6	4.9	0.305	-1.7	0.0	20.0	ID	ID	ID	ID
	6:00	15.3	6.3	0.312	-1.4	-0.1	2.1	ID	ID	ID	ID
	7:00	18.2	7.6	0.367	0.4	-0.2	1.2	ID	ID	ID	ID
	8:00	16.2	6.6	0.555	5.4	0.1	0.6	ID	ID	ID	ID
	9:00	16.0	5.8	0.525	4.1	0.1	0.5	ID	ID	ID	ID
	10:00	13.7	5.1	0.365	-0.2	0.1	0.1	ID	ID	ID	ID
	11:00	20.0	6.1	0.338	-1.2	-0.1	-0.1	ID	ID	ID	ID
	12:00	15.8	5.5	0.397	0.9	0.1	0.1	ID	ID	ID	ID
	13:00	17.8	5.4	0.337	-1.3	0.0	-0.1	ID	ID	ID	ID
	14:00	17.9	5.9	0.322	-1.4	-0.1	0.1	ID	ID	ID	ID
	15:00	18.3	6.5	0.337	-1.0	0.0	0.1	ID	ID	ID	ID
	16:00	19.3	6.8	0.352	-0.7	-0.2	0.0	ID	ID	ID	ID
	17:00	18.3	7.1	0.345	-1.3	-0.1	-0.2	ID	ID	ID	ID
	18:00	18.4	7.0	0.354	-0.9	-0.4	0.2	ID	ID	ID	ID
	19:00	17.8	6.8	0.418	1.5	-0.2	0.4	ID	ID	ID	ID
	20:00	21.0	8.2	0.457	2.6	0.2	0.4	ID	ID	ID	ID
	21:00	20.8	8.5	0.376	-0.6	0.0	0.3	ID	ID	ID	ID
	22:00	23.2	8.8	0.344	-1.4	0.0	0.9	ID	ID	ID	ID
	23:00	25.1	9.1	0.326	-1.4	-0.2	2.8	ID	ID	ID	ID
	0:00	23.8	9.1	0.323	ZS	-0.2	0.7	ID	ID	ID	ID
Min		**11.6**	**4.9**	**0.293**	**-2.1**	**-0.4**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**29.5**	**10.4**	**0.555**	**5.4**	**0.2**	**20.0**	**ID**	**ID**	**ID**	**ID**
Average		**18.4**	**6.8**	**0.361**	**-0.2**	**-0.1**	**1.3**	**ID**	**ID**	**ID**	**ID**
19/12/2018	1:00	25.7	9.4	0.319	-1.7	ZS	ZS	ID	ID	ID	ID
	2:00	26.8	9.7	0.322	-2.0	-0.1	0.0	ID	ID	ID	ID
	3:00	27.5	10.0	0.323	-1.9	-0.3	1.0	ID	ID	ID	ID
	4:00	27.5	10.0	0.331	-1.8	-0.1	0.8	ID	ID	ID	ID
	5:00	27.5	10.0	0.333	-1.8	-0.2	2.9	ID	ID	ID	ID
	6:00	27.5	10.0	0.398	1.3	0.0	2.2	ID	ID	ID	ID
	7:00	27.5	10.0	0.530	5.2	0.2	1.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	27.5	10.0	0.691	7.0	0.4	1.4	ID	ID	ID	ID
	9:00	27.5	10.0	0.555	3.6	0.4	0.6	ID	ID	ID	ID
	10:00	27.5	10.0	0.496	2.7	0.1	1.1	ID	ID	ID	ID
	11:00	27.5	10.0	0.437	0.3	-0.1	0.3	ID	ID	ID	ID
	12:00	27.5	10.0	0.423	0.0	0.0	0.0	ID	ID	ID	ID
	13:00	27.4	10.2	0.434	-0.1	-0.2	0.3	ID	ID	ID	ID
	14:00	26.2	10.5	0.459	0.7	0.0	0.1	ID	ID	ID	ID
	15:00	29.7	11.3	0.384	-1.3	0.0	0.0	ID	ID	ID	ID
	16:00	24.9	9.7	0.378	-1.2	-0.2	-0.1	ID	ID	ID	ID
	17:00	25.3	10.0	0.391	-0.8	-0.2	0.1	ID	ID	ID	ID
	18:00	28.8	11.5	0.397	-0.6	-0.1	0.0	ID	ID	ID	ID
	19:00	28.9	12.1	0.403	-0.4	0.0	0.1	ID	ID	ID	ID
	20:00	28.6	12.0	0.351	-1.8	0.0	0.1	ID	ID	ID	ID
	21:00	28.7	11.8	0.362	-1.5	-0.1	0.1	ID	ID	ID	ID
	22:00	34.7	13.8	0.381	-1.1	-0.1	0.4	ID	ID	ID	ID
	23:00	39.7	16.0	0.398	-0.6	0.0	7.7	ID	ID	ID	ID
	0:00	46.1	18.1	0.383	-1.3	ZS	ZS	ID	ID	ID	ID
Min		**24.9**	**9.4**	**0.319**	**-2.0**	**-0.3**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**46.1**	**18.1**	**0.691**	**7.0**	**0.4**	**7.7**	**ID**	**ID**	**ID**	**ID**
Average		**29.0**	**11.1**	**0.412**	**0.0**	**0.0**	**0.9**	**ID**	**ID**	**ID**	**ID**
20/12/2018	1:00	45.2	18.0	0.376	-1.3	-0.4	1.4	ID	ID	ID	ID
	2:00	45.5	18.9	0.387	ZS	-0.3	1.2	ID	ID	ID	ID
	3:00	48.1	18.8	0.392	-0.7	-0.2	1.1	ID	ID	ID	ID
	4:00	45.4	18.5	0.388	-0.9	-0.2	0.8	ID	ID	ID	ID
	5:00	44.9	18.3	0.378	-1.1	-0.1	3.8	ID	ID	ID	ID
	6:00	44.8	18.1	0.375	-1.6	-0.2	0.5	ID	ID	ID	ID
	7:00	43.4	18.0	0.393	-0.3	-0.2	0.6	ID	ID	ID	ID
	8:00	43.2	17.7	0.398	-0.4	-0.1	0.1	ID	ID	ID	ID
	9:00	44.3	17.9	0.389	-1.2	-0.1	0.0	ID	ID	ID	ID
	10:00	45.6	17.7	0.379	-1.4	-0.3	0.0	ID	ID	ID	ID
	11:00	50.8	18.0	0.371	-1.2	-0.3	0.1	ID	ID	ID	ID
	12:00	54.6	18.3	0.377	-1.5	-0.2	0.0	ID	ID	ID	ID
	13:00	58.2	19.0	0.377	-1.4	-0.2	0.0	ID	ID	ID	ID
	14:00	62.1	19.5	0.391	-1.3	-0.4	0.1	ID	ID	ID	ID
	15:00	56.4	18.8	0.384	-1.2	-0.4	0.1	ID	ID	ID	ID
	16:00	52.0	18.4	0.380	-1.5	-0.3	0.0	ID	ID	ID	ID
	17:00	46.8	17.8	0.388	-1.3	-0.3	-0.1	ID	ID	ID	ID
	18:00	42.5	17.1	0.394	-1.1	-0.2	-0.3	ID	ID	ID	ID
	19:00	39.1	16.7	0.413	-1.2	-0.3	0.2	ID	ID	ID	ID
	20:00	39.6	16.6	0.444	-1.8	-0.3	0.0	ID	ID	ID	ID
	21:00	39.4	16.5	0.375	-1.7	-0.3	0.1	ID	ID	ID	ID
	22:00	39.4	16.3	0.378	-1.8	-0.3	0.0	ID	ID	ID	ID
	23:00	39.8	16.1	0.379	-1.8	-0.3	1.2	ID	ID	ID	ID
	0:00	40.9	16.9	0.377	-1.8	-0.1	-0.1	ID	ID	ID	ID
Min		**39.1**	**16.1**	**0.371**	**-1.8**	**-0.4**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**62.1**	**19.5**	**0.444**	**-0.3**	**-0.1**	**3.8**	**ID**	**ID**	**ID**	**ID**
Average		**46.3**	**17.8**	**0.387**	**-1.3**	**-0.2**	**0.4**	**ID**	**ID**	**ID**	**ID**
21/12/2018	1:00	41.1	16.4	0.370	ZS	-0.3	0.1	ID	ID	ID	ID
	2:00	45.3	17.3	0.365	-1.7	ZS	ZS	ID	ID	ID	ID
	3:00	41.8	16.1	0.367	-1.9	-0.2	0.0	ID	ID	ID	ID
	4:00	42.6	16.3	0.360	-2.0	-0.2	0.2	ID	ID	ID	ID
	5:00	38.5	15.7	0.361	-1.8	-0.3	1.6	ID	ID	ID	ID
	6:00	35.9	15.2	0.364	-1.7	-0.2	1.9	ID	ID	ID	ID
	7:00	33.5	14.5	0.419	0.5	-0.2	0.7	ID	ID	ID	ID
	8:00	33.9	14.7	0.430	1.3	0.1	0.0	ID	ID	ID	ID
	9:00	36.7	15.3	0.391	-0.9	0.1	-0.1	ID	ID	ID	ID
	10:00	35.4	14.8	0.377	-1.6	-0.2	-0.1	ID	ID	ID	ID
	11:00	33.8	13.8	0.373	-1.5	-0.2	0.0	ID	ID	ID	ID
	12:00	35.3	13.9	0.388	-0.5	-0.3	0.0	ID	ID	ID	ID
	13:00	37.5	14.7	0.416	0.0	-0.1	-0.1	ID	ID	ID	ID
	14:00	41.0	14.7	0.432	0.8	0.1	0.1	ID	ID	ID	ID
	15:00	43.2	14.6	0.384	-1.0	-0.3	0.4	ID	ID	ID	ID
	16:00	40.1	13.4	0.387	-0.5	-0.2	0.0	ID	ID	ID	ID
	17:00	34.1	13.2	0.420	0.6	0.0	0.2	ID	ID	ID	ID
	18:00	31.5	12.8	0.433	0.7	-0.1	-0.1	ID	ID	ID	ID
	19:00	29.7	11.9	0.471	3.2	-0.2	0.5	ID	ID	ID	ID
	20:00	28.9	11.6	0.479	2.5	0.1	0.6	ID	ID	ID	ID
	21:00	26.2	10.9	0.420	-1.3	-0.2	0.0	ID	ID	ID	ID
	22:00	24.8	9.9	0.400	-1.4	-0.2	0.3	ID	ID	ID	ID
	23:00	25.1	9.6	0.370	-1.8	-0.1	2.3	ID	ID	ID	ID
	0:00	24.1	9.1	0.372	ZS	-0.3	0.7	ID	ID	ID	ID
Min		**24.1**	**9.1**	**0.360**	**-2.0**	**-0.3**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**45.3**	**17.3**	**0.479**	**3.2**	**0.1**	**2.3**	**ID**	**ID**	**ID**	**ID**
Average		**35.0**	**13.8**	**0.398**	**-0.4**	**-0.2**	**0.4**	**ID**	**ID**	**ID**	**ID**
22/12/2018	1:00	25.7	8.9	0.338	-1.5	ZS	ZS	ID	ID	ID	ID
	2:00	30.7	9.8	0.333	-1.8	-0.4	0.2	ID	ID	ID	ID
	3:00	30.1	9.2	0.321	-2.1	-0.5	0.0	ID	ID	ID	ID
	4:00	29.2	9.3	0.316	-2.1	-0.5	-0.1	ID	ID	ID	ID
	5:00	34.9	9.6	0.317	-2.1	-0.4	-0.1	ID	ID	ID	ID
	6:00	27.3	8.7	0.323	-1.7	-0.5	0.5	ID	ID	ID	ID
	7:00	22.6	7.6	0.328	-1.7	-0.4	0.1	ID	ID	ID	ID
	8:00	19.5	7.1	0.329	-1.6	-0.5	0.2	ID	ID	ID	ID
	9:00	17.2	6.5	0.319	-2.0	-0.4	-0.1	ID	ID	ID	ID
	10:00	18.4	6.3	0.324	-1.5	-0.7	0.1	ID	ID	ID	ID
	11:00	18.4	6.5	0.325	-1.6	-0.6	0.1	ID	ID	ID	ID
	12:00	19.9	6.8	0.329	-1.5	-0.5	-0.1	ID	ID	ID	ID
	13:00	24.8	7.1	0.336	-1.3	-0.4	-0.3	ID	ID	ID	ID
	14:00	28.6	7.8	0.340	-1.5	-0.5	0.0	ID	ID	ID	ID
	15:00	33.9	9.8	0.355	-1.1	-0.4	-0.1	ID	ID	ID	ID
	16:00	29.3	7.5	0.328	-1.4	-0.4	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	31.1	8.0	0.336	-1.2	-0.3	-0.2	ID	ID	ID	ID
	18:00	27.0	10.2	0.418	-1.2	-0.4	0.2	ID	ID	ID	ID
	19:00	22.4	9.1	0.366	-1.5	-0.3	-0.1	ID	ID	ID	ID
	20:00	15.5	6.0	0.346	-1.6	-0.3	-0.1	ID	ID	ID	ID
	21:00	15.6	6.2	0.339	-1.5	-0.5	-0.2	ID	ID	ID	ID
	22:00	15.6	5.9	0.341	-1.6	-0.4	0.0	ID	ID	ID	ID
	23:00	14.7	5.6	0.345	-1.5	-0.5	-0.1	ID	ID	ID	ID
	0:00	14.8	5.6	0.316	-1.4	ZS	ZS	ID	ID	ID	ID
Min		**14.7**	**5.6**	**0.316**	**-2.1**	**-0.7**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**34.9**	**10.2**	**0.418**	**-1.1**	**-0.3**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**23.6**	**7.7**	**0.336**	**-1.6**	**-0.4**	**0.0**	**ID**	**ID**	**ID**	**ID**
23/12/2018	1:00	16.9	6.4	0.372	-1.7	-0.2	0.2	ID	ID	ID	ID
	2:00	22.7	7.7	0.358	ZS	-0.3	-0.1	ID	ID	ID	ID
	3:00	23.4	8.5	0.360	-1.8	-0.3	-0.1	ID	ID	ID	ID
	4:00	27.8	9.2	0.347	-2.0	-0.4	0.2	ID	ID	ID	ID
	5:00	26.4	9.0	0.341	-2.2	-0.3	0.0	ID	ID	ID	ID
	6:00	25.2	8.6	0.341	-2.2	-0.3	0.0	ID	ID	ID	ID
	7:00	20.0	7.7	0.343	-2.0	-0.4	0.0	ID	ID	ID	ID
	8:00	17.4	7.5	0.354	-1.8	-0.3	0.0	ID	ID	ID	ID
	9:00	13.0	6.2	0.358	-1.9	-0.3	0.1	ID	ID	ID	ID
	10:00	19.0	8.2	0.361	-1.8	-0.2	-0.1	ID	ID	ID	ID
	11:00	21.5	8.9	0.362	-1.9	-0.3	0.2	ID	ID	ID	ID
	12:00	24.6	9.7	0.360	-2.0	-0.2	-0.2	ID	ID	ID	ID
	13:00	26.8	9.9	0.364	-1.9	-0.2	-0.2	ID	ID	ID	ID
	14:00	26.8	9.9	0.362	-1.8	-0.2	0.4	ID	ID	ID	ID
	15:00	26.8	9.9	0.364	-1.7	-0.2	0.0	ID	ID	ID	ID
	16:00	26.8	9.9	0.367	-1.8	-0.2	-0.1	ID	ID	ID	ID
	17:00	26.8	9.9	0.414	0.6	0.0	-0.1	ID	ID	ID	ID
	18:00	26.8	9.9	0.439	1.7	-0.1	0.0	ID	ID	ID	ID
	19:00	26.8	9.9	0.442	1.0	-0.1	0.3	ID	ID	ID	ID
	20:00	26.8	9.9	0.495	-0.3	0.0	-0.2	ID	ID	ID	ID
	21:00	26.8	9.9	0.470	-1.5	-0.1	0.1	ID	ID	ID	ID
	22:00	26.8	9.9	0.480	-0.8	-0.2	0.3	ID	ID	ID	ID
	23:00	26.8	9.9	0.511	0.3	-0.1	0.1	ID	ID	ID	ID
	0:00	26.8	9.9	0.527	ZS	0.1	0.2	ID	ID	ID	ID
Min		**13.0**	**6.2**	**0.341**	**-2.2**	**-0.4**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**27.8**	**9.9**	**0.527**	**1.7**	**0.1**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**24.1**	**9.0**	**0.395**	**-1.3**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
24/12/2018	1:00	26.8	9.9	0.498	0.7	ZS	ZS	ID	ID	ID	ID
	2:00	26.8	9.9	0.498	0.9	0.1	0.5	ID	ID	ID	ID
	3:00	26.8	9.9	0.406	-0.7	-0.3	0.4	ID	ID	ID	ID
	4:00	26.8	9.9	0.358	-1.4	-0.4	0.4	ID	ID	ID	ID
	5:00	26.8	9.9	0.357	-1.8	-0.1	0.0	ID	ID	ID	ID
	6:00	26.8	9.9	0.354	-1.8	-0.2	-0.2	ID	ID	ID	ID
	7:00	26.8	9.9	0.356	-1.9	-0.2	-0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	26.8	9.9	0.368	-1.6	-0.7	0.3	ID	ID	ID	ID
	9:00	26.8	9.9	0.392	-0.8	-0.5	0.0	ID	ID	ID	ID
	10:00	31.0	12.3	0.417	-0.8	0.0	0.2	ID	ID	ID	ID
	11:00	31.4	12.5	0.376	-1.5	-0.6	-0.1	ID	ID	ID	ID
	12:00	32.8	12.0	0.392	-0.6	-0.6	0.0	ID	ID	ID	ID
	13:00	31.1	12.0	0.419	0.2	-0.4	-0.1	ID	ID	ID	ID
	14:00	34.0	12.4	0.394	-0.8	-0.4	-0.2	ID	ID	ID	ID
	15:00	33.0	11.8	0.415	0.6	-0.5	1.5	ID	ID	ID	ID
	16:00	48.6	13.8	0.381	-1.1	-0.7	0.2	ID	ID	ID	ID
	17:00	46.6	14.2	0.379	-1.4	-0.7	0.1	ID	ID	ID	ID
	18:00	39.2	13.6	0.392	-1.3	-0.7	0.1	ID	ID	ID	ID
	19:00	37.9	14.4	0.418	-1.1	-0.6	0.0	ID	ID	ID	ID
	20:00	37.4	14.7	0.444	-1.5	-0.5	-0.1	ID	ID	ID	ID
	21:00	32.5	12.9	0.405	-1.6	-0.7	0.1	ID	ID	ID	ID
	22:00	29.4	12.1	0.402	-1.8	-0.4	-0.1	ID	ID	ID	ID
	23:00	27.7	12.2	0.410	-1.7	-0.2	-0.2	ID	ID	ID	ID
	0:00	29.1	12.5	0.354	-1.4	-0.3	0.1	ID	ID	ID	ID
Min		**26.8**	**9.9**	**0.354**	**-1.9**	**-0.7**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**48.6**	**14.7**	**0.498**	**0.9**	**0.1**	**1.5**	**ID**	**ID**	**ID**	**ID**
Average		**31.8**	**11.8**	**0.399**	**-1.0**	**-0.4**	**0.1**	**ID**	**ID**	**ID**	**ID**
25/12/2018	1:00	28.7	12.8	0.413	ZS	-0.2	-0.3	ID	ID	ID	ID
	2:00	29.2	12.3	0.404	-1.0	ZS	ZS	ID	ID	ID	ID
	3:00	32.3	12.7	0.383	-1.6	-0.3	-0.1	ID	ID	ID	ID
	4:00	32.9	12.7	0.368	-1.7	-0.3	-0.1	ID	ID	ID	ID
	5:00	34.4	12.8	0.364	-1.8	-0.4	0.0	ID	ID	ID	ID
	6:00	38.8	13.3	0.356	-2.1	-0.5	0.3	ID	ID	ID	ID
	7:00	36.3	12.8	0.372	-1.8	-0.4	0.3	ID	ID	ID	ID
	8:00	34.0	12.5	0.365	-2.0	-0.3	-0.1	ID	ID	ID	ID
	9:00	27.4	10.7	0.385	-0.8	-0.2	0.1	ID	ID	ID	ID
	10:00	18.8	7.6	0.389	-0.3	-0.2	0.3	ID	ID	ID	ID
	11:00	14.5	6.4	0.374	-0.7	-0.1	-0.1	ID	ID	ID	ID
	12:00	14.5	6.9	0.387	-0.9	-0.1	0.0	ID	ID	ID	ID
	13:00	18.6	8.7	0.371	-2.0	-0.1	-0.4	ID	ID	ID	ID
	14:00	25.4	10.5	0.375	-2.1	-0.3	0.0	ID	ID	ID	ID
	15:00	30.7	12.7	0.378	-2.1	-0.2	0.2	ID	ID	ID	ID
	16:00	36.4	14.4	0.391	-1.7	-0.3	0.1	ID	ID	ID	ID
	17:00	39.3	15.1	0.391	-1.8	-0.2	-0.2	ID	ID	ID	ID
	18:00	34.7	14.1	0.387	-2.0	-0.4	0.0	ID	ID	ID	ID
	19:00	36.7	14.1	0.400	-1.5	-0.5	-0.4	ID	ID	ID	ID
	20:00	37.0	14.0	0.396	-1.8	-1.0	0.3	ID	ID	ID	ID
	21:00	36.4	13.9	0.393	-1.9	-0.6	0.0	ID	ID	ID	ID
	22:00	36.6	14.1	0.406	-1.7	-0.6	0.0	ID	ID	ID	ID
	23:00	35.2	14.1	0.404	-1.6	-0.3	0.1	ID	ID	ID	ID
	0:00	34.6	14.9	0.392	ZS	ZS	ZS	ID	ID	ID	ID
Min		**14.5**	**6.4**	**0.356**	**-2.1**	**-1.0**	**-0.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**39.3**	**15.1**	**0.413**	**-0.3**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**31.0**	**12.3**	**0.385**	**-1.6**	**-0.4**	**0.0**	**ID**	**ID**	**ID**	**ID**
26/12/2018	1:00	36.5	15.6	0.388	-1.8	ZS	ZS	ID	ID	ID	ID
	2:00	38.0	16.2	0.381	-2.0	-0.3	-0.1	ID	ID	ID	ID
	3:00	38.5	16.5	0.386	-1.9	-0.3	0.2	ID	ID	ID	ID
	4:00	41.8	17.9	0.389	-2.0	-0.5	0.5	ID	ID	ID	ID
	5:00	49.9	19.6	0.392	-2.2	-0.4	0.0	ID	ID	ID	ID
	6:00	50.2	20.1	0.389	-2.2	-0.4	0.3	ID	ID	ID	ID
	7:00	49.8	20.2	0.397	-2.0	-0.2	-0.2	ID	ID	ID	ID
	8:00	49.2	19.1	0.399	-1.6	-0.3	0.2	ID	ID	ID	ID
	9:00	50.1	19.1	0.393	-2.0	-0.2	-0.1	ID	ID	ID	ID
	10:00	47.6	18.2	0.389	-2.1	-0.4	0.1	ID	ID	ID	ID
	11:00	45.8	17.3	0.386	-2.0	-0.5	0.1	ID	ID	ID	ID
	12:00	39.9	15.8	0.385	-2.1	-0.3	-0.2	ID	ID	ID	ID
	13:00	82.3	40.6	0.439	-1.2	0.6	-0.1	ID	ID	ID	ID
	14:00	37.2	15.8	0.390	-2.1	-0.2	0.3	ID	ID	ID	ID
	15:00	39.6	15.5	0.394	-2.1	-0.4	0.1	ID	ID	ID	ID
	16:00	43.9	16.0	0.389	-2.0	-0.4	0.0	ID	ID	ID	ID
	17:00	46.4	15.9	0.389	-2.0	-0.5	0.1	ID	ID	ID	ID
	18:00	48.1	16.0	0.450	-1.7	-0.1	-0.1	ID	ID	ID	ID
	19:00	47.9	16.3	0.427	-1.8	-0.1	-0.2	ID	ID	ID	ID
	20:00	45.4	16.2	0.418	-1.9	-0.3	0.0	ID	ID	ID	ID
	21:00	44.1	15.2	0.398	-2.0	-0.4	0.0	ID	ID	ID	ID
	22:00	40.9	15.3	0.402	-1.9	-0.3	-0.1	ID	ID	ID	ID
	23:00	36.5	14.4	0.399	-1.9	-0.2	-0.1	ID	ID	ID	ID
	0:00	37.6	14.9	0.394	-2.1	ZS	ZS	ID	ID	ID	ID
Min		**36.5**	**14.4**	**0.381**	**-2.2**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**82.3**	**40.6**	**0.450**	**-1.2**	**0.6**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**45.3**	**17.8**	**0.399**	**-1.9**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
27/12/2018	1:00	37.5	15.3	0.385	-2.1	-0.3	-0.1	ID	ID	ID	ID
	2:00	37.5	16.1	0.387	ZS	-0.5	0.3	ID	ID	ID	ID
	3:00	39.0	16.2	0.378	-1.8	-0.3	0.1	ID	ID	ID	ID
	4:00	43.2	17.2	0.374	-2.1	-0.4	0.0	ID	ID	ID	ID
	5:00	48.9	17.9	0.379	-2.1	-0.3	0.1	ID	ID	ID	ID
	6:00	48.2	17.8	0.391	-2.0	-0.4	0.1	ID	ID	ID	ID
	7:00	52.0	19.2	0.394	-2.1	-0.3	0.1	ID	ID	ID	ID
	8:00	56.3	19.6	0.388	-1.9	-0.1	-0.1	ID	ID	ID	ID
	9:00	51.4	18.4	0.394	-1.9	-0.1	0.0	ID	ID	ID	ID
	10:00	55.4	20.3	0.397	-1.7	-0.3	0.1	ID	ID	ID	ID
	11:00	44.3	16.4	0.389	-1.7	-0.2	-0.1	ID	ID	ID	ID
	12:00	41.5	15.3	0.390	-1.6	-0.2	-0.1	ID	ID	ID	ID
	13:00	40.3	15.4	0.398	-1.6	-0.5	0.0	ID	ID	ID	ID
	14:00	37.8	15.0	0.398	-1.8	-0.3	-0.2	ID	ID	ID	ID
	15:00	42.4	17.5	0.398	-1.6	-0.3	0.1	ID	ID	ID	ID
	16:00	43.9	17.0	0.407	-1.6	-0.4	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	49.5	17.6	0.416	-1.4	-0.3	0.0	ID	ID	ID	ID
	18:00	48.6	17.2	0.403	-0.9	-0.1	-0.2	ID	ID	ID	ID
	19:00	50.0	17.0	0.397	-1.4	-0.3	-0.1	ID	ID	ID	ID
	20:00	46.5	16.3	0.394	-1.9	-0.4	0.1	ID	ID	ID	ID
	21:00	42.5	15.4	0.378	-1.9	-0.1	-0.3	ID	ID	ID	ID
	22:00	38.6	15.0	0.389	-1.5	-0.2	0.0	ID	ID	ID	ID
	23:00	37.3	14.4	0.381	-2.0	-0.2	-0.1	ID	ID	ID	ID
	0:00	35.0	13.6	0.371	-2.2	-0.2	0.0	ID	ID	ID	ID
Min		**35.0**	**13.6**	**0.371**	**-2.2**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**56.3**	**20.3**	**0.416**	**-0.9**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**44.5**	**16.7**	**0.391**	**-1.8**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
28/12/2018	1:00	32.0	13.0	0.370	ZS	-0.2	0.1	ID	ID	ID	ID
	2:00	30.0	12.2	0.365	-1.9	ZS	ZS	ID	ID	ID	ID
	3:00	28.4	11.5	0.359	-2.1	-0.4	0.3	ID	ID	ID	ID
	4:00	27.9	11.7	0.367	-2.2	-0.3	0.1	ID	ID	ID	ID
	5:00	32.5	12.6	0.367	-2.2	-0.4	0.3	ID	ID	ID	ID
	6:00	35.3	13.5	0.382	-1.6	-0.3	0.3	ID	ID	ID	ID
	7:00	32.1	12.4	0.393	-1.3	-0.3	0.3	ID	ID	ID	ID
	8:00	37.8	14.2	0.387	-1.8	-0.4	0.1	ID	ID	ID	ID
	9:00	34.5	13.1	0.394	-1.5	-0.4	0.1	ID	ID	ID	ID
	10:00	37.6	13.5	0.389	-1.2	-0.4	0.1	ID	ID	ID	ID
	11:00	37.2	13.2	0.377	-1.8	-0.3	-0.1	ID	ID	ID	ID
	12:00	34.1	12.0	0.375	-1.5	-0.5	0.3	ID	ID	ID	ID
	13:00	30.4	11.2	0.391	-1.5	-0.3	0.1	ID	ID	ID	ID
	14:00	26.0	10.3	0.386	-1.5	-0.3	-0.2	ID	ID	ID	ID
	15:00	25.2	10.1	0.395	-1.2	-0.2	-0.2	ID	ID	ID	ID
	16:00	26.3	11.0	0.414	-1.1	-0.4	0.1	ID	ID	ID	ID
	17:00	25.6	10.8	0.459	0.8	-0.3	0.2	ID	ID	ID	ID
	18:00	31.0	11.3	0.402	-1.5	-0.2	-0.1	ID	ID	ID	ID
	19:00	35.1	12.0	0.402	-1.8	-0.2	-0.1	ID	ID	ID	ID
	20:00	33.1	11.8	0.389	-2.0	-0.3	-0.1	ID	ID	ID	ID
	21:00	30.1	10.6	0.384	-1.9	-0.1	-0.2	ID	ID	ID	ID
	22:00	29.6	10.0	0.389	-1.9	-0.3	0.0	ID	ID	ID	ID
	23:00	25.3	8.9	0.383	-2.0	-0.3	-0.1	ID	ID	ID	ID
	0:00	22.7	8.4	0.388	ZS	ZS	ZS	ID	ID	ID	ID
Min		**22.7**	**8.4**	**0.359**	**-2.2**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**37.8**	**14.2**	**0.459**	**0.8**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**30.8**	**11.6**	**0.388**	**-1.6**	**-0.3**	**0.1**	**ID**	**ID**	**ID**	**ID**
29/12/2018	1:00	20.4	8.0	0.382	-1.3	ZS	ZS	ID	ID	ID	ID
	2:00	19.3	7.5	0.364	-1.7	-0.4	0.2	ID	ID	ID	ID
	3:00	19.2	7.5	0.364	-2.0	-0.4	-0.1	ID	ID	ID	ID
	4:00	19.2	7.7	0.361	-2.1	-0.3	0.1	ID	ID	ID	ID
	5:00	19.7	7.7	0.359	-2.2	-0.3	0.1	ID	ID	ID	ID
	6:00	20.7	7.9	0.358	-2.2	-0.4	0.1	ID	ID	ID	ID
	7:00	20.7	7.6	0.358	-2.2	-0.3	0.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	22.1	8.1	0.435	0.9	-0.1	0.2	ID	ID	ID	ID
	9:00	20.7	8.1	0.477	3.2	0.0	0.5	ID	ID	ID	ID
	10:00	22.0	7.5	0.379	-1.7	-0.3	0.2	ID	ID	ID	ID
	11:00	24.9	8.5	0.383	-1.1	-0.2	-0.3	ID	ID	ID	ID
	12:00	23.2	8.5	0.372	-1.7	-0.1	-0.3	ID	ID	ID	ID
	13:00	23.4	8.5	0.371	-1.6	-0.1	-0.1	ID	ID	ID	ID
	14:00	23.7	8.4	0.372	-1.9	-0.4	0.0	ID	ID	ID	ID
	15:00	22.1	7.5	0.368	-1.7	-0.4	-0.1	ID	ID	ID	ID
	16:00	21.3	7.3	0.370	-1.6	-0.5	-0.1	ID	ID	ID	ID
	17:00	18.2	7.0	0.381	-1.6	-0.5	0.2	ID	ID	ID	ID
	18:00	19.4	7.6	0.391	-1.5	-0.3	-0.3	ID	ID	ID	ID
	19:00	20.5	7.4	0.395	-1.7	-0.2	-0.1	ID	ID	ID	ID
	20:00	18.8	7.0	0.435	-1.5	-0.3	-0.1	ID	ID	ID	ID
	21:00	20.6	6.8	0.416	-0.8	-0.3	0.0	ID	ID	ID	ID
	22:00	18.3	6.4	0.461	0.7	-0.2	0.2	ID	ID	ID	ID
	23:00	20.7	8.1	0.609	0.9	0.0	0.1	ID	ID	ID	ID
	0:00	14.8	6.5	0.529	2.5	ZS	ZS	ID	ID	ID	ID
Min		**14.8**	**6.4**	**0.358**	**-2.2**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**24.9**	**8.5**	**0.609**	**3.2**	**0.0**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**20.6**	**7.6**	**0.404**	**-1.0**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
30/12/2018	1:00	10.3	4.5	0.522	5.5	-0.1	1.4	ID	ID	ID	ID
	2:00	12.9	4.8	0.388	ZS	-0.5	0.0	ID	ID	ID	ID
	3:00	8.9	3.7	0.384	-1.3	-0.5	0.0	ID	ID	ID	ID
	4:00	9.3	3.5	0.403	-0.3	-0.3	1.7	ID	ID	ID	ID
	5:00	10.0	3.8	0.436	1.6	0.0	3.6	ID	ID	ID	ID
	6:00	11.2	4.5	0.463	2.1	0.3	3.7	ID	ID	ID	ID
	7:00	9.2	3.9	0.400	-0.1	0.2	4.9	ID	ID	ID	ID
	8:00	7.7	3.2	0.435	0.6	0.0	0.6	ID	ID	ID	ID
	9:00	8.9	3.5	0.442	1.1	-0.2	1.0	ID	ID	ID	ID
	10:00	13.0	4.9	0.419	0.0	-0.1	0.7	ID	ID	ID	ID
	11:00	19.2	7.1	0.379	-1.6	-0.1	0.4	ID	ID	ID	ID
	12:00	18.2	6.7	0.371	-2.1	-0.3	-0.1	ID	ID	ID	ID
	13:00	20.8	7.9	0.374	-1.9	-0.3	0.6	ID	ID	ID	ID
	14:00	22.3	7.7	0.369	-2.1	-0.2	0.0	ID	ID	ID	ID
	15:00	21.1	7.6	0.367	-1.5	-0.3	0.3	ID	ID	ID	ID
	16:00	20.5	7.2	0.367	-1.2	-0.3	0.2	ID	ID	ID	ID
	17:00	19.2	7.1	0.376	-1.4	-0.3	0.2	ID	ID	ID	ID
	18:00	21.1	8.0	0.409	-0.1	-0.2	0.2	ID	ID	ID	ID
	19:00	20.7	7.7	0.590	1.6	0.0	0.3	ID	ID	ID	ID
	20:00	22.8	8.2	0.633	-0.5	0.4	-0.1	ID	ID	ID	ID
	21:00	24.9	8.8	0.637	-0.6	0.1	0.2	ID	ID	ID	ID
	22:00	24.4	8.4	0.657	-0.4	0.2	0.3	ID	ID	ID	ID
	23:00	25.2	9.4	0.762	0.9	0.5	0.1	ID	ID	ID	ID
	0:00	22.4	8.9	0.678	ZS	0.6	0.0	ID	ID	ID	ID
Min		**7.7**	**3.2**	**0.367**	**-2.1**	**-0.5**	**-0.1**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**25.2**	**9.4**	**0.762**	**5.5**	**0.6**	**4.9**	**ID**	**ID**	**ID**	**ID**
Average		**16.8**	**6.3**	**0.469**	**-0.1**	**-0.1**	**0.8**	**ID**	**ID**	**ID**	**ID**
31/12/2018	1:00	20.9	8.7	0.528	1.7	ZS	ZS	ID	ID	ID	ID
	2:00	20.0	6.7	0.418	-1.3	-0.2	0.1	ID	ID	ID	ID
	3:00	18.9	6.6	0.377	-1.8	-0.1	-0.2	ID	ID	ID	ID
	4:00	16.2	6.2	0.370	-1.7	-0.2	-0.1	ID	ID	ID	ID
	5:00	16.5	6.2	0.369	-2.1	-0.4	-0.1	ID	ID	ID	ID
	6:00	16.1	6.0	0.368	-2.2	-0.5	-0.1	ID	ID	ID	ID
	7:00	17.5	6.3	0.374	-2.1	-0.5	0.1	ID	ID	ID	ID
	8:00	20.5	5.9	0.379	-1.9	-0.4	-0.2	ID	ID	ID	ID
	9:00	22.9	6.7	0.396	-0.8	-0.5	0.5	ID	ID	ID	ID
	10:00	22.0	6.8	0.382	-1.7	-0.4	0.0	ID	ID	ID	ID
	11:00	30.8	13.3	0.410	-1.1	0.0	0.1	ID	ID	ID	ID
	12:00	28.1	9.1	0.408	-1.5	-0.3	-0.1	ID	ID	ID	ID
	13:00	23.8	9.0	0.444	0.2	-0.1	0.0	ID	ID	ID	ID
	14:00	29.7	10.7	0.393	-1.6	-0.2	0.0	ID	ID	ID	ID
	15:00	28.4	10.3	0.401	-1.3	-0.1	-0.1	ID	ID	ID	ID
	16:00	33.4	12.0	0.388	-1.5	-0.3	0.0	ID	ID	ID	ID
	17:00	39.8	13.8	0.389	-1.6	-0.1	0.0	ID	ID	ID	ID
	18:00	39.0	14.4	0.399	-1.4	-0.2	-0.1	ID	ID	ID	ID
	19:00	40.7	15.1	0.400	-1.7	-0.1	0.0	ID	ID	ID	ID
	20:00	37.5	13.9	0.411	-1.6	-0.2	0.0	ID	ID	ID	ID
	21:00	36.1	13.6	0.412	-1.6	-0.1	0.0	ID	ID	ID	ID
	22:00	26.5	9.9	0.415	-1.4	-0.3	0.0	ID	ID	ID	ID
	23:00	25.3	9.3	0.441	-1.0	-0.3	0.1	ID	ID	ID	ID
	0:00	32.6	12.0	0.453	-0.8	0.0	0.1	ID	ID	ID	ID
Min		**16.1**	**5.9**	**0.368**	**-2.2**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**40.7**	**15.1**	**0.528**	**1.7**	**0.0**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**26.8**	**9.7**	**0.405**	**-1.3**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
01/01/2019	1:00	37.4	15.3	0.486	ZS	ZS	ZS	ID	ID	ID	ID
	2:00	31.9	13.3	0.486	-1.2	ZS	ZS	ID	ID	ID	ID
	3:00	23.2	9.6	0.429	-1.3	-0.2	0.1	ID	ID	ID	ID
	4:00	18.9	7.2	0.401	-1.8	-0.3	0.2	ID	ID	ID	ID
	5:00	20.0	7.2	0.382	-2.1	-0.2	-0.2	ID	ID	ID	ID
	6:00	17.8	6.4	0.382	-2.2	-0.4	0.0	ID	ID	ID	ID
	7:00	22.2	8.0	0.379	-1.9	-0.4	0.3	ID	ID	ID	ID
	8:00	20.2	7.5	0.438	0.4	-0.1	0.5	ID	ID	ID	ID
	9:00	20.4	8.1	0.414	-0.7	-0.2	0.1	ID	ID	ID	ID
	10:00	25.4	9.1	0.370	-2.2	-0.4	0.5	ID	ID	ID	ID
	11:00	29.1	9.5	0.369	-2.1	-0.2	0.1	ID	ID	ID	ID
	12:00	29.0	9.0	0.366	-2.2	-0.2	0.0	ID	ID	ID	ID
	13:00	25.3	8.3	0.365	-2.1	-0.3	0.1	ID	ID	ID	ID
	14:00	22.7	7.9	0.364	-2.1	-0.3	0.2	ID	ID	ID	ID
	15:00	24.4	7.7	0.370	-1.8	-0.3	0.0	ID	ID	ID	ID
	16:00	23.8	7.5	0.371	-2.0	-0.2	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	22.1	7.9	0.372	-1.9	-0.2	0.1	ID	ID	ID	ID
	18:00	29.4	14.2	0.457	-1.0	0.0	-0.1	ID	ID	ID	ID
	19:00	17.2	6.4	0.501	-1.1	0.0	-0.4	ID	ID	ID	ID
	20:00	15.0	6.3	0.540	-0.9	-0.1	-0.2	ID	ID	ID	ID
	21:00	19.1	7.1	0.575	-1.0	0.0	-0.4	ID	ID	ID	ID
	22:00	22.4	9.0	0.643	-0.6	-0.1	-0.1	ID	ID	ID	ID
	23:00	17.8	6.3	0.505	-1.3	0.0	-0.1	ID	ID	ID	ID
	0:00	21.1	7.0	0.427	ZS	-0.2	0.3	ID	ID	ID	ID
Min		**15.0**	**6.3**	**0.364**	**-2.2**	**-0.4**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**37.4**	**15.3**	**0.643**	**0.4**	**0.0**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**23.2**	**8.6**	**0.433**	**-1.5**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
02/01/2019	1:00	18.9	6.5	0.417	-1.7	ZS	ZS	ID	ID	ID	ID
	2:00	17.7	6.5	0.386	-2.1	-0.4	0.1	ID	ID	ID	ID
	3:00	17.1	6.0	0.381	-2.1	-0.3	0.1	ID	ID	ID	ID
	4:00	14.5	5.5	0.382	-2.1	-0.3	0.2	ID	ID	ID	ID
	5:00	16.0	6.1	0.385	-1.9	-0.4	0.5	ID	ID	ID	ID
	6:00	15.7	5.8	0.381	-2.2	-0.2	0.2	ID	ID	ID	ID
	7:00	16.2	5.9	0.389	-2.0	-0.2	-0.1	ID	ID	ID	ID
	8:00	20.5	6.1	0.404	-1.9	-0.4	0.5	ID	ID	ID	ID
	9:00	19.9	6.4	0.405	-1.6	-0.4	0.2	ID	ID	ID	ID
	10:00	17.5	6.6	0.434	-1.2	0.1	-0.1	ID	ID	ID	ID
	11:00	20.6	7.0	0.448	-1.8	0.0	-0.1	ID	ID	ID	ID
	12:00	27.6	8.1	0.446	-1.8	-0.1	0.3	ID	ID	ID	ID
	13:00	24.3	7.9	0.414	-1.5	-0.1	0.0	ID	ID	ID	ID
	14:00	21.7	7.2	0.401	-1.5	-0.1	-0.1	ID	ID	ID	ID
	15:00	20.9	6.7	0.403	-1.7	-0.1	-0.2	ID	ID	ID	ID
	16:00	21.1	6.6	0.403	-1.6	-0.4	0.1	ID	ID	ID	ID
	17:00	20.5	8.7	0.458	-1.3	-0.2	-0.2	ID	ID	ID	ID
	18:00	15.6	5.9	0.415	-1.7	-0.2	-0.3	ID	ID	ID	ID
	19:00	15.2	5.9	0.410	-1.8	-0.3	0.1	ID	ID	ID	ID
	20:00	16.1	5.9	0.409	-2.0	-0.3	-0.2	ID	ID	ID	ID
	21:00	14.9	6.0	0.421	-2.0	-0.3	0.0	ID	ID	ID	ID
	22:00	16.1	6.1	0.412	-1.7	-0.3	0.0	ID	ID	ID	ID
	23:00	16.2	6.5	0.407	-2.0	-0.3	-0.1	ID	ID	ID	ID
	0:00	20.8	7.1	0.396	-2.2	ZS	ZS	ID	ID	ID	ID
Min		**14.5**	**5.5**	**0.381**	**-2.2**	**-0.4**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**27.6**	**8.7**	**0.458**	**-1.2**	**0.1**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**18.6**	**6.5**	**0.409**	**-1.8**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
03/01/2019	1:00	20.0	7.3	0.393	-2.2	-0.3	0.1	ID	ID	ID	ID
	2:00	20.6	7.2	0.395	ZS	-0.4	0.1	ID	ID	ID	ID
	3:00	18.9	6.8	0.392	-1.9	-0.2	0.0	ID	ID	ID	ID
	4:00	18.6	6.6	0.395	-2.2	-0.3	0.1	ID	ID	ID	ID
	5:00	18.5	6.6	0.392	-2.2	-0.3	-0.1	ID	ID	ID	ID
	6:00	18.9	6.8	0.395	-2.2	-0.4	0.2	ID	ID	ID	ID
	7:00	18.2	6.8	0.398	-2.1	-0.5	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	18.1	6.4	0.429	-1.1	-0.3	0.1	ID	ID	ID	ID
	9:00	18.6	6.4	0.441	-0.6	-0.1	0.0	ID	ID	ID	ID
	10:00	18.4	6.5	0.416	-1.7	-0.4	0.1	ID	ID	ID	ID
	11:00	18.9	6.8	0.407	-1.8	-0.2	0.0	ID	ID	ID	ID
	12:00	21.6	7.0	0.411	-1.8	-0.2	0.1	ID	ID	ID	ID
	13:00	20.3	7.1	0.414	-1.9	-0.4	-0.3	ID	ID	ID	ID
	14:00	20.9	7.2	0.421	-1.7	-0.3	-0.1	ID	ID	ID	ID
	15:00	20.5	7.1	0.418	-1.8	-0.2	0.0	ID	ID	ID	ID
	16:00	19.1	6.8	0.428	-1.7	-0.3	0.0	ID	ID	ID	ID
	17:00	18.3	6.7	0.433	-1.7	-0.2	-0.2	ID	ID	ID	ID
	18:00	17.6	6.5	0.416	-1.9	-0.2	-0.1	ID	ID	ID	ID
	19:00	16.7	6.4	0.423	-2.0	-0.1	-0.1	ID	ID	ID	ID
	20:00	17.1	6.5	0.412	-2.1	-0.2	0.1	ID	ID	ID	ID
	21:00	16.6	6.4	0.420	-2.0	-0.3	0.1	ID	ID	ID	ID
	22:00	15.8	6.2	0.420	-2.0	-0.2	-0.3	ID	ID	ID	ID
	23:00	17.6	6.6	0.424	-2.1	-0.2	-0.1	ID	ID	ID	ID
	0:00	19.1	6.9	0.433	-2.0	-0.4	0.3	ID	ID	ID	ID
Min		**15.8**	**6.2**	**0.392**	**-2.2**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**21.6**	**7.3**	**0.441**	**-0.6**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**18.7**	**6.7**	**0.414**	**-1.9**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
04/01/2019	1:00	19.0	7.2	0.405	ZS	-0.1	-0.1	ID	ID	ID	ID
	2:00	19.8	7.4	0.403	-2.0	ZS	ZS	ID	ID	ID	ID
	3:00	21.0	7.7	0.405	-2.2	-0.4	0.2	ID	ID	ID	ID
	4:00	20.8	7.6	0.406	-2.3	-0.3	-0.1	ID	ID	ID	ID
	5:00	20.5	8.0	0.410	-2.3	-0.1	0.2	ID	ID	ID	ID
	6:00	18.1	7.3	0.411	-2.3	-0.3	0.0	ID	ID	ID	ID
	7:00	18.3	7.0	0.416	-2.1	-0.2	-0.1	ID	ID	ID	ID
	8:00	19.8	7.5	0.429	-2.0	-0.3	0.0	ID	ID	ID	ID
	9:00	19.8	7.3	0.428	-1.9	-0.1	-0.2	ID	ID	ID	ID
	10:00	19.1	7.0	0.422	-1.9	-0.2	0.0	ID	ID	ID	ID
	11:00	19.0	7.0	0.427	-1.7	-0.2	0.0	ID	ID	ID	ID
	12:00	19.9	7.3	0.428	-1.8	-0.2	0.1	ID	ID	ID	ID
	13:00	21.9	7.5	0.428	-1.9	-0.1	-0.2	ID	ID	ID	ID
	14:00	21.5	7.3	0.430	-1.9	-0.3	0.1	ID	ID	ID	ID
	15:00	21.8	7.8	0.428	-1.8	-0.3	0.0	ID	ID	ID	ID
	16:00	21.9	7.8	0.432	-1.9	0.0	-0.4	ID	ID	ID	ID
	17:00	23.8	8.1	0.450	-1.5	-0.3	0.0	ID	ID	ID	ID
	18:00	19.5	6.9	0.439	-1.7	-0.3	0.1	ID	ID	ID	ID
	19:00	18.4	6.6	0.432	-1.8	-0.3	-0.3	ID	ID	ID	ID
	20:00	16.2	6.0	0.420	-1.9	-0.5	0.0	ID	ID	ID	ID
	21:00	15.0	5.8	0.474	-1.9	-0.4	-0.1	ID	ID	ID	ID
	22:00	16.0	6.2	0.419	-2.1	-0.4	0.1	ID	ID	ID	ID
	23:00	16.7	6.5	0.426	-2.1	-0.3	0.0	ID	ID	ID	ID
	0:00	19.6	7.1	0.432	ZS	-0.3	0.1	ID	ID	ID	ID
Min		**15.0**	**5.8**	**0.403**	**-2.3**	**-0.5**	**-0.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**23.8**	**8.1**	**0.474**	**-1.5**	**0.0**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**19.5**	**7.2**	**0.425**	**-1.9**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
05/01/2019	1:00	20.6	7.5	0.421	-1.9	ZS	ZS	ID	ID	ID	ID
	2:00	20.3	7.5	0.414	-2.1	-0.3	0.0	ID	ID	ID	ID
	3:00	20.4	7.6	0.413	-2.2	-0.4	0.1	ID	ID	ID	ID
	4:00	22.4	8.2	0.411	-2.2	-0.4	0.0	ID	ID	ID	ID
	5:00	24.8	8.9	0.417	-2.2	-0.4	0.0	ID	ID	ID	ID
	6:00	24.1	8.7	0.422	-2.0	-0.5	0.3	ID	ID	ID	ID
	7:00	24.6	8.9	0.419	-2.0	-0.4	0.3	ID	ID	ID	ID
	8:00	23.7	8.6	0.422	-2.1	-0.3	-0.1	ID	ID	ID	ID
	9:00	22.5	8.4	0.420	-2.0	-0.5	-0.1	ID	ID	ID	ID
	10:00	24.5	8.7	0.434	-2.0	-0.4	-0.1	ID	ID	ID	ID
	11:00	24.2	9.0	0.427	-1.9	-0.6	-0.1	ID	ID	ID	ID
	12:00	26.9	9.6	0.433	-1.9	-0.6	0.1	ID	ID	ID	ID
	13:00	28.7	9.5	0.443	-1.7	-0.4	0.1	ID	ID	ID	ID
	14:00	27.5	10.0	0.445	-1.8	-0.5	0.0	ID	ID	ID	ID
	15:00	30.3	10.5	0.437	-1.6	-0.4	-0.4	ID	ID	ID	ID
	16:00	30.2	10.9	0.443	-1.6	-0.4	0.0	ID	ID	ID	ID
	17:00	31.1	11.1	0.448	-1.9	-0.1	-0.3	ID	ID	ID	ID
	18:00	31.7	12.0	0.460	-1.8	-0.3	0.0	ID	ID	ID	ID
	19:00	30.6	11.1	0.453	-1.7	-0.5	0.0	ID	ID	ID	ID
	20:00	30.4	11.3	0.461	-1.7	-0.6	0.0	ID	ID	ID	ID
	21:00	30.4	11.6	0.473	-1.6	-0.5	0.0	ID	ID	ID	ID
	22:00	37.8	13.4	0.462	-1.9	-0.5	0.0	ID	ID	ID	ID
	23:00	43.8	15.6	0.469	-2.0	-0.2	0.0	ID	ID	ID	ID
	0:00	42.9	16.1	0.487	-1.8	ZS	ZS	ID	ID	ID	ID
Min		**20.3**	**7.5**	**0.411**	**-2.2**	**-0.6**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**43.8**	**16.1**	**0.487**	**-1.6**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**28.1**	**10.2**	**0.439**	**-1.9**	**-0.4**	**0.0**	**ID**	**ID**	**ID**	**ID**
06/01/2019	1:00	47.5	16.2	ZS	ZS	-0.4	0.1	ID	ID	ID	ID
	2:00	39.8	14.8	0.464	ZS	-0.3	0.5	ID	ID	ID	ID
	3:00	30.7	12.9	0.514	0.3	0.0	0.5	ID	ID	ID	ID
	4:00	41.8	15.4	0.465	-2.2	-0.1	-0.1	ID	ID	ID	ID
	5:00	48.7	17.2	0.465	-1.7	-0.3	0.2	ID	ID	ID	ID
	6:00	51.6	18.4	0.485	-0.8	-0.2	0.2	ID	ID	ID	ID
	7:00	56.8	19.5	0.501	-0.7	-0.4	0.6	ID	ID	ID	ID
	8:00	60.3	21.1	0.518	0.0	-0.2	0.2	ID	ID	ID	ID
	9:00	66.5	22.4	0.512	-0.6	-0.1	0.1	ID	ID	ID	ID
	10:00	65.7	22.4	0.487	-1.8	-0.1	-0.2	ID	ID	ID	ID
	11:00	62.0	21.8	0.479	-2.0	-0.1	-0.3	ID	ID	ID	ID
	12:00	62.0	21.5	0.474	-2.2	-0.4	0.1	ID	ID	ID	ID
	13:00	62.9	21.6	0.481	-1.9	-0.7	0.0	ID	ID	ID	ID
	14:00	62.7	21.1	0.494	-1.8	-0.4	-0.3	ID	ID	ID	ID
	15:00	62.2	23.4	0.496	-1.5	-0.2	-0.3	ID	ID	ID	ID
	16:00	69.1	25.4	0.493	-1.5	-0.1	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	70.2	28.0	0.528	-1.8	0.0	-0.3	ID	ID	ID	ID
	18:00	106.1	56.2	0.777	0.6	0.6	-0.3	ID	ID	ID	ID
	19:00	64.9	23.9	0.648	-0.9	0.4	-0.5	ID	ID	ID	ID
	20:00	62.2	21.5	0.606	-1.2	0.1	-0.2	ID	ID	ID	ID
	21:00	57.9	20.8	0.600	-0.3	-0.2	-0.1	ID	ID	ID	ID
	22:00	55.5	20.2	0.593	-1.0	0.0	-0.1	ID	ID	ID	ID
	23:00	51.9	18.6	ZS	-0.3	0.1	-0.3	ID	ID	ID	ID
	0:00	51.0	18.2	0.662	ZS	-0.4	0.1	ID	ID	ID	ID
Min		**30.7**	**12.9**	**0.464**	**-2.2**	**-0.7**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**106.1**	**56.2**	**0.777**	**0.6**	**0.6**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**58.8**	**21.8**	**0.534**	**-1.1**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
07/01/2019	1:00	47.5	18.3	0.611	0.9	ZS	ZS	ID	ID	ID	ID
	2:00	46.0	17.3	0.483	-1.9	-0.5	0.3	ID	ID	ID	ID
	3:00	48.2	17.6	0.476	-2.0	-0.1	-0.3	ID	ID	ID	ID
	4:00	48.8	18.3	0.484	-1.6	-0.3	0.0	ID	ID	ID	ID
	5:00	50.4	19.2	0.482	-1.9	-0.2	-0.1	ID	ID	ID	ID
	6:00	49.2	19.0	0.485	-2.1	-0.1	-0.1	ID	ID	ID	ID
	7:00	47.4	18.5	0.487	-2.1	-0.2	-0.1	ID	ID	ID	ID
	8:00	96.7	48.4	0.576	0.7	0.4	-0.4	ID	ID	ID	ID
	9:00	59.4	23.4	0.548	-0.7	0.1	-0.1	ID	ID	ID	ID
	10:00	49.6	18.5	0.518	-1.1	-0.2	0.0	ID	ID	ID	ID
	11:00	45.5	18.1	0.514	-1.1	-0.2	0.1	ID	ID	ID	ID
	12:00	81.1	39.6	0.554	-1.1	0.3	-0.4	ID	ID	ID	ID
	13:00	56.3	22.8	0.522	-1.4	0.2	0.0	ID	ID	ID	ID
	14:00	46.7	19.3	0.520	-1.1	0.0	0.3	ID	ID	ID	ID
	15:00	40.5	17.1	0.516	-1.2	-0.2	-0.2	ID	ID	ID	ID
	16:00	40.5	17.1	0.545	-0.9	0.1	-0.3	ID	ID	ID	ID
	17:00	40.5	17.1	0.557	-1.1	0.1	0.0	ID	ID	ID	ID
	18:00	40.5	17.1	0.560	-1.3	-0.1	0.2	ID	ID	ID	ID
	19:00	40.5	17.1	0.507	-1.6	0.1	-0.1	ID	ID	ID	ID
	20:00	40.5	17.1	0.512	-1.7	-0.1	0.0	ID	ID	ID	ID
	21:00	40.5	17.1	0.502	-1.8	-0.2	0.1	ID	ID	ID	ID
	22:00	40.5	17.1	0.496	-2.0	-0.3	-0.1	ID	ID	ID	ID
	23:00	40.5	17.1	ZS	-2.1	-0.3	0.1	ID	ID	ID	ID
	0:00	40.5	17.1	0.485	-2.1	-0.2	0.0	ID	ID	ID	ID
Min		**40.5**	**17.1**	**0.476**	**-2.1**	**-0.5**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**96.7**	**48.4**	**0.611**	**0.9**	**0.4**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**49.1**	**20.4**	**0.519**	**-1.4**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
08/01/2019	1:00	40.5	17.1	0.495	ZS	-0.2	-0.2	ID	ID	ID	ID
	2:00	40.5	17.1	0.480	-1.9	ZS	ZS	ID	ID	ID	ID
	3:00	40.5	17.1	0.475	-2.2	-0.3	-0.2	ID	ID	ID	ID
	4:00	40.5	17.1	0.467	-2.2	-0.1	-0.3	ID	ID	ID	ID
	5:00	40.5	17.1	0.466	-2.2	-0.3	0.0	ID	ID	ID	ID
	6:00	40.5	17.1	0.465	-2.1	-0.1	-0.1	ID	ID	ID	ID
	7:00	40.5	17.1	0.473	-1.5	-0.4	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	40.5	17.1	0.554	0.8	-0.2	0.1	ID	ID	ID	ID
	9:00	40.5	17.1	0.572	1.8	0.1	0.0	ID	ID	ID	ID
	10:00	40.5	17.1	0.491	-0.6	-0.1	0.1	ID	ID	ID	ID
	11:00	40.5	17.1	0.469	-1.2	-0.6	0.1	ID	ID	ID	ID
	12:00	40.5	17.1	0.469	-1.4	-0.6	0.1	ID	ID	ID	ID
	13:00	40.5	17.1	0.481	-1.2	-0.4	-0.2	ID	ID	ID	ID
	14:00	40.5	17.1	0.472	-1.5	-0.5	0.4	ID	ID	ID	ID
	15:00	40.5	17.1	0.464	-1.5	-0.2	0.0	ID	ID	ID	ID
	16:00	40.5	17.1	0.554	2.4	0.0	0.2	ID	ID	ID	ID
	17:00	40.5	17.1	0.487	-0.8	-0.1	-0.2	ID	ID	ID	ID
	18:00	40.5	17.1	0.468	-0.8	-0.4	-0.2	ID	ID	ID	ID
	19:00	40.5	17.1	0.501	0.7	-0.2	0.1	ID	ID	ID	ID
	20:00	40.5	17.1	0.456	-1.6	-0.1	-0.1	ID	ID	ID	ID
	21:00	40.5	17.1	0.467	-1.7	-0.4	0.3	ID	ID	ID	ID
	22:00	40.5	17.1	0.446	-2.0	-0.1	-0.1	ID	ID	ID	ID
	23:00	40.5	17.1	0.448	-2.1	-0.4	0.1	ID	ID	ID	ID
	0:00	40.5	17.1	0.437	ZS	-0.1	-0.1	ID	ID	ID	ID
Min		**40.5**	**17.1**	**0.437**	**-2.2**	**-0.6**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**40.5**	**17.1**	**0.572**	**2.4**	**0.1**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**40.5**	**17.1**	**0.482**	**-1.0**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
09/01/2019	1:00	40.5	17.1	0.439	-1.8	ZS	ZS	ID	ID	ID	ID
	2:00	40.5	17.1	0.430	-2.1	-0.1	-0.1	ID	ID	ID	ID
	3:00	40.5	17.1	0.432	-2.2	-0.4	0.2	ID	ID	ID	ID
	4:00	40.5	17.1	0.435	-2.2	-0.4	0.1	ID	ID	ID	ID
	5:00	40.5	17.1	0.437	-2.1	-0.2	-0.3	ID	ID	ID	ID
	6:00	40.5	17.1	0.455	-0.9	-0.3	0.2	ID	ID	ID	ID
	7:00	40.5	17.1	0.440	-2.1	-0.4	0.0	ID	ID	ID	ID
	8:00	40.5	17.1	0.471	-1.2	-0.2	-0.2	ID	ID	ID	ID
	9:00	40.5	17.1	0.494	-0.2	-0.3	-0.3	ID	ID	ID	ID
	10:00	39.8	16.8	0.463	-1.0	-0.3	-0.2	ID	ID	ID	ID
	11:00	29.8	11.9	0.471	-1.2	-0.2	0.1	ID	ID	ID	ID
	12:00	30.5	11.9	0.473	-1.3	-0.1	-0.3	ID	ID	ID	ID
	13:00	32.8	12.3	0.482	-1.0	-0.2	-0.2	ID	ID	ID	ID
	14:00	40.8	17.0	0.593	-0.3	-0.1	-0.1	ID	ID	ID	ID
	15:00	35.9	16.0	0.529	-1.3	-0.1	0.0	ID	ID	ID	ID
	16:00	41.3	20.1	0.558	-0.8	-0.2	-0.1	ID	ID	ID	ID
	17:00	33.1	13.4	0.537	-0.7	-0.2	-0.2	ID	ID	ID	ID
	18:00	32.8	13.1	0.515	-0.8	-0.2	0.0	ID	ID	ID	ID
	19:00	35.5	16.1	0.623	-1.0	0.1	0.0	ID	ID	ID	ID
	20:00	28.7	11.8	0.495	-1.6	-0.1	0.0	ID	ID	ID	ID
	21:00	29.8	12.4	0.472	-1.8	-0.3	-0.1	ID	ID	ID	ID
	22:00	29.7	11.9	0.463	-1.1	-0.1	-0.3	ID	ID	ID	ID
	23:00	30.1	12.1	0.484	-1.4	-0.2	0.0	ID	ID	ID	ID
	0:00	29.9	12.2	0.463	-1.9	ZS	ZS	ID	ID	ID	ID
Min		**28.7**	**11.8**	**0.430**	**-2.2**	**-0.4**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**41.3**	**20.1**	**0.623**	**-0.2**	**0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**36.0**	**15.1**	**0.486**	**-1.3**	**-0.2**	**-0.1**	**ID**	**ID**	**ID**	**ID**
10/01/2019	1:00	29.7	12.3	0.457	-2.0	-0.3	-0.2	ID	ID	ID	ID
	2:00	30.1	12.1	0.457	ZS	-0.3	-0.3	ID	ID	ID	ID
	3:00	30.4	12.5	0.453	-1.8	-0.5	0.0	ID	ID	ID	ID
	4:00	32.3	12.9	0.460	-2.0	-0.3	-0.2	ID	ID	ID	ID
	5:00	31.7	13.3	0.465	-2.1	-0.4	0.0	ID	ID	ID	ID
	6:00	32.9	13.8	0.463	-2.2	-0.5	0.2	ID	ID	ID	ID
	7:00	35.7	14.1	0.475	-2.1	-0.3	0.0	ID	ID	ID	ID
	8:00	39.4	14.8	0.521	-0.5	-0.2	0.0	ID	ID	ID	ID
	9:00	41.5	15.5	0.564	0.8	0.0	-0.1	ID	ID	ID	ID
	10:00	40.6	16.0	0.538	0.5	-0.1	0.0	ID	ID	ID	ID
	11:00	44.0	16.1	0.509	-0.1	0.0	0.0	ID	ID	ID	ID
	12:00	40.7	16.1	0.495	-1.5	-0.2	0.1	ID	ID	ID	ID
	13:00	42.5	16.1	0.509	-1.0	-0.1	0.0	ID	ID	ID	ID
	14:00	42.7	16.1	0.500	-1.4	-0.2	0.2	ID	ID	ID	ID
	15:00	41.0	16.1	0.505	-1.2	-0.3	-0.1	ID	ID	ID	ID
	16:00	42.6	16.4	0.538	-0.1	-0.1	-0.1	ID	ID	ID	ID
	17:00	42.2	16.7	0.544	0.2	-0.3	0.1	ID	ID	ID	ID
	18:00	43.5	16.8	0.542	-0.3	-0.2	-0.2	ID	ID	ID	ID
	19:00	43.5	16.8	0.516	-0.8	-0.1	-0.2	ID	ID	ID	ID
	20:00	42.2	16.4	0.500	-1.4	-0.2	0.0	ID	ID	ID	ID
	21:00	44.4	17.2	0.495	-1.6	-0.4	0.3	ID	ID	ID	ID
	22:00	42.7	16.8	0.502	-1.4	-0.5	-0.1	ID	ID	ID	ID
	23:00	43.3	17.2	0.502	-1.9	-0.3	0.3	ID	ID	ID	ID
	0:00	42.7	16.9	0.491	-1.7	-0.4	0.2	ID	ID	ID	ID
Min		**29.7**	**12.1**	**0.453**	**-2.2**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**44.4**	**17.2**	**0.564**	**0.8**	**0.0**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**39.3**	**15.4**	**0.500**	**-1.1**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
11/01/2019	1:00	45.8	17.7	0.494	ZS	-0.2	0.0	ID	ID	ID	ID
	2:00	44.4	17.9	0.487	-1.6	ZS	ZS	ID	ID	ID	ID
	3:00	46.4	18.2	0.490	-1.5	-0.1	0.2	ID	ID	ID	ID
	4:00	46.4	18.4	0.499	-1.6	-0.2	0.2	ID	ID	ID	ID
	5:00	46.2	18.4	0.490	-1.5	-0.2	0.0	ID	ID	ID	ID
	6:00	47.0	18.4	0.504	-0.8	-0.3	0.3	ID	ID	ID	ID
	7:00	45.7	18.5	0.601	2.6	0.1	0.3	ID	ID	ID	ID
	8:00	45.4	17.4	0.587	2.0	-0.1	0.3	ID	ID	ID	ID
	9:00	46.2	17.6	0.611	2.4	0.0	0.0	ID	ID	ID	ID
	10:00	44.2	16.9	0.567	1.3	-0.2	0.2	ID	ID	ID	ID
	11:00	43.1	16.7	0.510	-0.6	-0.1	0.0	ID	ID	ID	ID
	12:00	42.3	16.0	0.501	-1.3	-0.2	-0.1	ID	ID	ID	ID
	13:00	41.6	15.7	0.495	-1.5	-0.5	0.1	ID	ID	ID	ID
	14:00	41.1	15.6	0.514	-0.6	-0.1	-0.1	ID	ID	ID	ID
	15:00	40.5	15.3	0.507	-0.8	0.0	-0.4	ID	ID	ID	ID
	16:00	41.6	15.2	0.520	-0.2	-0.2	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	38.5	14.7	0.525	-0.5	-0.3	0.0	ID	ID	ID	ID
	18:00	39.6	15.1	0.535	0.1	-0.3	0.0	ID	ID	ID	ID
	19:00	37.2	14.7	0.510	-0.9	-0.3	0.1	ID	ID	ID	ID
	20:00	36.1	14.2	0.521	-0.5	-0.2	0.0	ID	ID	ID	ID
	21:00	36.3	14.5	0.512	-1.0	0.0	-0.1	ID	ID	ID	ID
	22:00	33.8	13.6	0.516	-0.7	-0.2	0.2	ID	ID	ID	ID
	23:00	34.3	13.6	0.495	-1.0	0.0	-0.3	ID	ID	ID	ID
	0:00	31.0	12.7	0.489	ZS	-0.2	0.0	ID	ID	ID	ID
Min		**31.0**	**12.7**	**0.487**	**-1.6**	**-0.5**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**47.0**	**18.5**	**0.611**	**2.6**	**0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**41.4**	**16.1**	**0.520**	**-0.4**	**-0.2**	**0.1**	**ID**	**ID**	**ID**	**ID**
12/01/2019	1:00	28.6	11.9	0.480	-1.2	ZS	ZS	ID	ID	ID	ID
	2:00	28.6	11.3	0.461	-2.0	-0.4	0.0	ID	ID	ID	ID
	3:00	27.0	11.1	0.457	-2.1	-0.4	0.0	ID	ID	ID	ID
	4:00	25.6	10.2	0.449	-2.2	-0.3	-0.1	ID	ID	ID	ID
	5:00	26.3	10.1	0.453	-2.2	-0.3	-0.2	ID	ID	ID	ID
	6:00	25.6	9.8	0.445	-2.2	-0.5	0.2	ID	ID	ID	ID
	7:00	24.0	9.2	0.445	-2.0	-0.4	-0.2	ID	ID	ID	ID
	8:00	23.6	8.9	0.456	-1.4	-0.2	-0.2	ID	ID	ID	ID
	9:00	22.2	8.4	0.486	-0.4	0.1	-0.5	ID	ID	ID	ID
	10:00	22.1	8.5	0.467	-1.5	-0.2	-0.3	ID	ID	ID	ID
	11:00	25.9	8.4	0.464	-1.6	-0.2	-0.3	ID	ID	ID	ID
	12:00	22.3	7.9	0.457	-1.8	-0.2	0.0	ID	ID	ID	ID
	13:00	20.4	7.8	0.459	-1.6	-0.3	-0.1	ID	ID	ID	ID
	14:00	20.0	7.6	0.477	-1.5	-0.6	0.0	ID	ID	ID	ID
	15:00	22.2	7.5	0.455	-1.5	-0.7	-0.1	ID	ID	ID	ID
	16:00	21.6	7.8	0.473	-1.5	-0.6	0.0	ID	ID	ID	ID
	17:00	21.3	7.8	0.469	-1.7	-0.6	0.2	ID	ID	ID	ID
	18:00	21.9	8.7	0.537	-1.4	-0.7	0.0	ID	ID	ID	ID
	19:00	23.6	8.5	0.633	-0.6	-0.5	-0.2	ID	ID	ID	ID
	20:00	24.7	8.4	0.599	-0.8	-0.5	0.0	ID	ID	ID	ID
	21:00	24.9	9.3	0.576	-0.9	-0.2	-0.2	ID	ID	ID	ID
	22:00	22.2	9.7	0.523	-1.4	-0.2	-0.3	ID	ID	ID	ID
	23:00	19.2	7.2	0.490	-1.3	-0.5	-0.2	ID	ID	ID	ID
	0:00	18.1	7.0	0.487	-1.7	ZS	ZS	ID	ID	ID	ID
Min		**18.1**	**7.0**	**0.445**	**-2.2**	**-0.7**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**28.6**	**11.9**	**0.633**	**-0.4**	**0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**23.4**	**8.9**	**0.487**	**-1.5**	**-0.4**	**-0.1**	**ID**	**ID**	**ID**	**ID**
13/01/2019	1:00	17.9	7.0	0.488	-1.8	-0.5	-0.2	ID	ID	ID	ID
	2:00	20.8	9.0	0.560	ZS	-0.6	0.2	ID	ID	ID	ID
	3:00	20.2	8.8	0.547	-1.5	-0.6	-0.2	ID	ID	ID	ID
	4:00	17.5	7.5	0.504	-2.0	-0.6	0.1	ID	ID	ID	ID
	5:00	18.7	7.8	0.488	-1.8	-0.7	0.1	ID	ID	ID	ID
	6:00	21.6	8.8	0.464	-2.0	-0.8	0.3	ID	ID	ID	ID
	7:00	15.2	6.5	0.469	-2.1	-0.5	-0.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	18.9	7.3	0.465	-1.9	-0.6	-0.1	ID	ID	ID	ID
	9:00	19.8	7.4	0.462	-1.9	-0.7	-0.1	ID	ID	ID	ID
	10:00	19.0	7.2	0.462	-1.9	-0.8	0.2	ID	ID	ID	ID
	11:00	18.2	7.0	0.458	-1.9	-0.5	-0.1	ID	ID	ID	ID
	12:00	17.6	7.0	0.454	-2.0	-0.4	0.0	ID	ID	ID	ID
	13:00	16.9	6.6	0.471	-1.5	-0.4	-0.1	ID	ID	ID	ID
	14:00	35.1	18.9	0.525	-1.5	-0.2	-0.1	ID	ID	ID	ID
	15:00	22.1	10.2	0.500	-1.8	-0.4	0.0	ID	ID	ID	ID
	16:00	27.0	14.3	0.587	-0.7	-0.2	-0.3	ID	ID	ID	ID
	17:00	33.3	20.8	0.631	-1.1	-0.3	0.0	ID	ID	ID	ID
	18:00	61.0	40.5	0.878	1.1	0.3	-0.1	ID	ID	ID	ID
	19:00	55.1	36.2	1.063	1.4	0.8	-0.5	ID	ID	ID	ID
	20:00	58.8	37.1	1.035	0.8	1.3	-0.4	ID	ID	ID	ID
	21:00	41.1	26.1	0.966	1.0	0.7	-0.1	ID	ID	ID	ID
	22:00	19.0	8.4	0.746	-0.7	0.4	-0.2	ID	ID	ID	ID
	23:00	25.5	12.2	0.754	-0.4	0.4	-0.1	ID	ID	ID	ID
	0:00	19.9	8.0	0.661	ZS	0.4	0.1	ID	ID	ID	ID
Min		**15.2**	**6.5**	**0.454**	**-2.1**	**-0.8**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**61.0**	**40.5**	**1.063**	**1.4**	**1.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**26.7**	**13.8**	**0.610**	**-1.1**	**-0.2**	**-0.1**	**ID**	**ID**	**ID**	**ID**
14/01/2019	1:00	25.8	11.4	0.765	0.0	ZS	ZS	ID	ID	ID	ID
	2:00	20.7	8.0	0.559	-1.2	0.4	-0.4	ID	ID	ID	ID
	3:00	27.6	13.2	0.541	-1.6	-0.1	0.0	ID	ID	ID	ID
	4:00	28.3	13.1	0.497	-1.5	0.0	-0.1	ID	ID	ID	ID
	5:00	30.5	14.5	0.482	-1.9	-0.1	-0.1	ID	ID	ID	ID
	6:00	24.3	10.8	0.465	-2.1	-0.3	0.1	ID	ID	ID	ID
	7:00	36.3	19.0	0.488	-1.6	-0.2	0.0	ID	ID	ID	ID
	8:00	27.6	10.7	0.528	-0.6	0.0	0.0	ID	ID	ID	ID
	9:00	30.4	9.7	0.559	0.4	0.2	0.0	ID	ID	ID	ID
	10:00	28.2	9.8	0.509	-0.6	0.4	-0.1	ID	ID	ID	ID
	11:00	28.0	10.1	0.488	-0.8	-0.2	0.1	ID	ID	ID	ID
	12:00	22.7	8.8	0.551	1.0	0.0	0.0	ID	ID	ID	ID
	13:00	20.1	8.0	0.524	0.1	-0.3	0.3	ID	ID	ID	ID
	14:00	29.2	8.7	0.526	0.4	0.0	-0.1	ID	ID	ID	ID
	15:00	22.7	9.0	0.501	-1.1	-0.3	0.0	ID	ID	ID	ID
	16:00	21.9	8.1	0.528	0.3	-0.1	-0.2	ID	ID	ID	ID
	17:00	29.7	11.0	0.530	-0.5	-0.2	-0.1	ID	ID	ID	ID
	18:00	36.1	13.2	0.526	-0.9	-0.1	0.1	ID	ID	ID	ID
	19:00	37.1	14.7	0.514	-1.5	-0.1	-0.2	ID	ID	ID	ID
	20:00	35.4	14.2	0.490	-1.7	0.0	-0.3	ID	ID	ID	ID
	21:00	35.8	14.0	0.489	-1.9	-0.3	-0.1	ID	ID	ID	ID
	22:00	33.8	13.4	0.482	-2.1	-0.2	0.1	ID	ID	ID	ID
	23:00	34.4	13.2	0.481	-2.0	-0.3	0.0	ID	ID	ID	ID
	0:00	34.3	13.4	0.474	-2.1	-0.3	0.3	ID	ID	ID	ID
Min		**20.1**	**8.0**	**0.465**	**-2.1**	**-0.3**	**-0.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**37.1**	**19.0**	**0.765**	**1.0**	**0.4**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**29.2**	**11.7**	**0.521**	**-1.0**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
15/01/2019	1:00	33.3	13.1	0.475	ZS	ZS	ZS	ID	ID	ID	ID
	2:00	31.3	12.7	0.476	-1.7	ZS	ZS	ID	ID	ID	ID
	3:00	22.1	8.9	0.484	-2.0	-0.3	0.2	ID	ID	ID	ID
	4:00	20.2	8.2	0.487	-1.9	-0.2	-0.1	ID	ID	ID	ID
	5:00	16.4	7.1	0.516	-0.2	-0.1	0.6	ID	ID	ID	ID
	6:00	17.7	7.3	0.604	4.0	0.0	0.8	ID	ID	ID	ID
	7:00	26.7	10.3	0.906	11.6	0.7	1.8	ID	ID	ID	ID
	8:00	33.0	12.7	0.990	10.9	1.3	0.5	ID	ID	ID	ID
	9:00	27.7	10.8	0.664	4.1	0.5	-0.2	ID	ID	ID	ID
	10:00	28.1	11.3	0.607	2.5	0.2	-0.1	ID	ID	ID	ID
	11:00	29.7	12.0	0.563	0.9	0.1	-0.2	ID	ID	ID	ID
	12:00	29.1	12.2	0.544	0.1	-0.1	0.1	ID	ID	ID	ID
	13:00	30.2	12.2	0.564	0.5	-0.1	0.1	ID	ID	ID	ID
	14:00	29.3	12.1	0.561	0.5	-0.4	0.7	ID	ID	ID	ID
	15:00	30.4	12.4	0.548	-0.4	-0.4	0.2	ID	ID	ID	ID
	16:00	33.3	12.6	0.557	-0.2	-0.4	0.2	ID	ID	ID	ID
	17:00	32.2	12.8	0.551	-0.9	-0.5	0.3	ID	ID	ID	ID
	18:00	33.0	13.0	0.549	-0.3	-0.3	-0.2	ID	ID	ID	ID
	19:00	32.4	13.4	0.542	-0.9	-0.2	-0.1	ID	ID	ID	ID
	20:00	34.4	14.7	0.527	-1.8	-0.4	0.0	ID	ID	ID	ID
	21:00	32.5	13.6	0.527	-1.8	-0.2	-0.3	ID	ID	ID	ID
	22:00	32.2	13.4	0.529	-1.6	-0.3	0.1	ID	ID	ID	ID
	23:00	34.2	13.6	0.525	-1.8	-0.4	-0.1	ID	ID	ID	ID
	0:00	32.0	13.2	0.518	ZS	-0.7	-0.1	ID	ID	ID	ID
Min		**16.4**	**7.1**	**0.475**	**-2.0**	**-0.7**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**34.4**	**14.7**	**0.990**	**11.6**	**1.3**	**1.8**	**ID**	**ID**	**ID**	**ID**
Average		**29.2**	**11.8**	**0.576**	**0.9**	**-0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
16/01/2019	1:00	32.2	13.3	0.509	-1.9	ZS	ZS	ID	ID	ID	ID
	2:00	31.6	13.2	0.509	-2.2	-0.3	0.1	ID	ID	ID	ID
	3:00	32.2	13.4	0.511	-2.2	-0.3	0.1	ID	ID	ID	ID
	4:00	31.2	13.1	0.511	-2.2	-0.3	-0.2	ID	ID	ID	ID
	5:00	30.0	12.8	0.509	-2.3	-0.8	0.1	ID	ID	ID	ID
	6:00	30.5	12.9	0.511	-2.2	-0.3	-0.1	ID	ID	ID	ID
	7:00	29.2	12.2	0.516	-2.1	-0.3	0.1	ID	ID	ID	ID
	8:00	27.1	11.6	0.556	-0.8	-0.2	0.0	ID	ID	ID	ID
	9:00	27.1	11.6	0.583	-0.1	-0.1	0.0	ID	ID	ID	ID
	10:00	27.1	11.6	0.530	-1.4	-0.4	0.2	ID	ID	ID	ID
	11:00	27.1	11.6	0.525	-1.7	-0.4	-0.2	ID	ID	ID	ID
	12:00	28.1	10.9	0.518	-1.8	-0.3	0.1	ID	ID	ID	ID
	13:00	28.6	10.1	0.526	-1.8	-0.5	-0.2	ID	ID	ID	ID
	14:00	25.7	10.1	0.533	-1.9	-0.5	-0.2	ID	ID	ID	ID
	15:00	25.3	9.9	0.522	-1.7	-0.4	-0.1	ID	ID	ID	ID
	16:00	24.2	9.7	0.527	-1.4	-0.2	-0.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	23.9	9.8	0.530	-1.6	-0.7	0.2	ID	ID	ID	ID
	18:00	24.5	10.1	0.531	-1.7	-0.5	0.0	ID	ID	ID	ID
	19:00	24.9	10.1	0.515	-1.9	-0.4	0.0	ID	ID	ID	ID
	20:00	23.8	9.9	0.519	-2.1	-0.3	0.1	ID	ID	ID	ID
	21:00	23.8	9.9	0.517	-1.8	-0.5	0.0	ID	ID	ID	ID
	22:00	25.1	10.1	0.515	-1.9	-0.4	-0.1	ID	ID	ID	ID
	23:00	25.2	10.6	0.524	-2.0	-0.5	0.3	ID	ID	ID	ID
	0:00	26.7	10.8	0.511	-2.2	ZS	ZS	ID	ID	ID	ID
Min		**23.8**	**9.7**	**0.509**	**-2.3**	**-0.8**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**32.2**	**13.4**	**0.583**	**-0.1**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**27.3**	**11.2**	**0.523**	**-1.8**	**-0.4**	**0.0**	**ID**	**ID**	**ID**	**ID**
17/01/2019	1:00	25.6	10.9	0.513	-2.1	-0.5	0.0	ID	ID	ID	ID
	2:00	27.9	11.6	0.520	ZS	-0.5	0.0	ID	ID	ID	ID
	3:00	28.5	12.0	0.526	-1.9	-0.1	-0.2	ID	ID	ID	ID
	4:00	29.9	13.0	0.528	-2.1	-0.1	-0.2	ID	ID	ID	ID
	5:00	28.6	12.5	0.530	-2.2	0.0	-0.2	ID	ID	ID	ID
	6:00	28.7	12.5	0.541	-1.5	0.0	-0.1	ID	ID	ID	ID
	7:00	29.7	12.6	0.566	-0.2	-0.2	1.1	ID	ID	ID	ID
	8:00	31.4	12.8	0.599	0.0	-0.3	0.3	ID	ID	ID	ID
	9:00	31.1	12.8	0.615	0.5	-0.1	0.1	ID	ID	ID	ID
	10:00	30.5	12.5	0.543	-1.7	-0.7	-0.1	ID	ID	ID	ID
	11:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	12:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	13:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	14:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	15:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	16:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	17:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	18:00	30.4	12.5	0.541	-1.8	-0.7	-0.2	ID	ID	ID	ID
	19:00	26.3	11.2	1.027	-0.2	0.7	0.0	ID	ID	ID	ID
	20:00	23.7	10.3	1.002	-0.1	0.5	0.3	ID	ID	ID	ID
	21:00	27.6	11.8	0.891	-1.7	0.4	-0.2	ID	ID	ID	ID
	22:00	27.5	11.5	0.847	-1.8	0.2	0.2	ID	ID	ID	ID
	23:00	26.6	11.2	0.813	-1.9	0.0	-0.1	ID	ID	ID	ID
	0:00	26.5	10.9	0.785	-2.0	0.1	-0.1	ID	ID	ID	ID
Min		**23.7**	**10.3**	**0.513**	**-2.2**	**-0.7**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**31.4**	**13.0**	**1.027**	**0.5**	**0.7**	**1.1**	**ID**	**ID**	**ID**	**ID**
Average		**28.9**	**12.1**	**0.632**	**-1.4**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
18/01/2019	1:00	26.8	10.5	0.752	ZS	0.0	-0.1	ID	ID	ID	ID
	2:00	23.9	9.5	0.735	-2.1	ZS	ZS	ID	ID	ID	ID
	3:00	21.7	8.9	0.718	-2.1	-0.1	0.0	ID	ID	ID	ID
	4:00	21.2	9.0	0.718	-2.1	-0.2	-0.1	ID	ID	ID	ID
	5:00	20.7	8.9	0.712	-2.2	-0.2	-0.1	ID	ID	ID	ID
	6:00	17.5	7.6	0.708	-1.9	-0.2	0.0	ID	ID	ID	ID
	7:00	16.8	7.6	0.699	-1.9	-0.4	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	15.9	7.1	0.717	-1.5	-0.3	0.0	ID	ID	ID	ID
	9:00	17.5	7.8	0.754	-0.1	-0.2	0.0	ID	ID	ID	ID
	10:00	22.7	9.9	0.718	-1.0	-0.1	0.0	ID	ID	ID	ID
	11:00	26.7	10.9	0.713	-1.4	-0.2	0.1	ID	ID	ID	ID
	12:00	26.2	10.3	0.703	-1.2	-0.1	-0.1	ID	ID	ID	ID
	13:00	27.9	10.8	0.706	-1.0	-0.2	0.1	ID	ID	ID	ID
	14:00	28.9	10.9	0.690	-1.2	0.0	0.0	ID	ID	ID	ID
	15:00	27.9	10.2	0.687	-1.1	0.0	-0.1	ID	ID	ID	ID
	16:00	26.2	9.7	0.701	-0.4	-0.2	0.0	ID	ID	ID	ID
	17:00	23.6	10.4	0.844	5.3	0.0	0.3	ID	ID	ID	ID
	18:00	22.1	9.4	0.778	2.4	0.1	0.1	ID	ID	ID	ID
	19:00	24.4	10.4	0.694	-1.0	-0.2	0.1	ID	ID	ID	ID
	20:00	27.8	11.0	0.674	-1.5	-0.1	0.2	ID	ID	ID	ID
	21:00	28.1	11.5	0.685	-1.8	-0.4	0.1	ID	ID	ID	ID
	22:00	30.0	12.2	0.683	-1.9	-0.3	0.1	ID	ID	ID	ID
	23:00	29.2	11.8	0.669	-1.7	-0.1	-0.1	ID	ID	ID	ID
	0:00	29.2	12.0	0.677	ZS	-0.1	-0.1	ID	ID	ID	ID
Min		**15.9**	**7.1**	**0.669**	**-2.2**	**-0.4**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**30.0**	**12.2**	**0.844**	**5.3**	**0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**24.3**	**9.9**	**0.714**	**-1.0**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
19/01/2019	1:00	32.1	12.7	0.665	-1.8	ZS	ZS	ID	ID	ID	ID
	2:00	34.7	13.7	0.652	-1.9	-0.3	0.3	ID	ID	ID	ID
	3:00	34.9	13.6	0.641	-2.1	-0.3	-0.1	ID	ID	ID	ID
	4:00	35.9	13.9	0.644	-2.2	-0.3	0.1	ID	ID	ID	ID
	5:00	36.2	14.2	0.647	-2.0	-0.3	0.1	ID	ID	ID	ID
	6:00	34.4	13.8	0.641	-2.2	-0.3	-0.1	ID	ID	ID	ID
	7:00	30.6	12.4	0.655	-1.4	-0.3	0.3	ID	ID	ID	ID
	8:00	28.7	11.7	0.667	-1.0	-0.2	0.4	ID	ID	ID	ID
	9:00	28.9	11.8	0.650	-1.2	0.0	-0.2	ID	ID	ID	ID
	10:00	31.5	12.2	0.654	-1.6	-0.1	-0.1	ID	ID	ID	ID
	11:00	30.8	12.1	0.652	-1.5	-0.1	-0.2	ID	ID	ID	ID
	12:00	31.9	12.4	0.652	-1.6	-0.2	-0.2	ID	ID	ID	ID
	13:00	33.9	12.7	0.651	-1.7	-0.2	-0.2	ID	ID	ID	ID
	14:00	35.7	12.8	0.658	-1.6	-0.2	-0.3	ID	ID	ID	ID
	15:00	32.3	12.2	0.654	-1.6	-0.2	0.1	ID	ID	ID	ID
	16:00	29.5	11.3	0.647	-1.8	-0.3	-0.2	ID	ID	ID	ID
	17:00	27.6	11.0	0.650	-1.6	-0.3	-0.2	ID	ID	ID	ID
	18:00	26.1	10.9	0.661	-1.3	-0.3	-0.2	ID	ID	ID	ID
	19:00	25.7	10.5	0.671	-1.5	-0.3	-0.2	ID	ID	ID	ID
	20:00	25.6	10.6	0.857	-1.5	-0.2	0.0	ID	ID	ID	ID
	21:00	23.2	10.0	0.675	-1.5	-0.3	0.2	ID	ID	ID	ID
	22:00	21.9	9.8	0.685	-1.4	-0.1	-0.1	ID	ID	ID	ID
	23:00	21.5	9.4	0.682	-1.2	-0.2	0.1	ID	ID	ID	ID
	0:00	23.2	9.6	0.652	-1.7	ZS	ZS	ID	ID	ID	ID
Min		**21.5**	**9.4**	**0.641**	**-2.2**	**-0.3**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**36.2**	**14.2**	**0.857**	**-1.0**	**0.0**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**29.9**	**11.9**	**0.665**	**-1.6**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
20/01/2019	1:00	29.0	11.0	0.661	-1.8	0.0	-0.1	ID	ID	ID	ID
	2:00	19.7	8.4	0.645	ZS	-0.1	0.0	ID	ID	ID	ID
	3:00	29.5	11.4	0.625	-1.9	-0.2	0.0	ID	ID	ID	ID
	4:00	27.2	10.9	0.624	-1.9	-0.3	0.4	ID	ID	ID	ID
	5:00	24.7	10.3	0.636	-1.8	-0.1	-0.1	ID	ID	ID	ID
	6:00	24.3	10.1	0.632	-1.8	-0.2	0.2	ID	ID	ID	ID
	7:00	24.2	10.1	0.652	-1.5	-0.3	0.2	ID	ID	ID	ID
	8:00	22.9	9.6	0.636	-2.0	0.0	-0.3	ID	ID	ID	ID
	9:00	23.8	10.1	0.634	-2.0	-0.2	-0.1	ID	ID	ID	ID
	10:00	24.6	10.4	0.630	-1.9	-0.1	-0.3	ID	ID	ID	ID
	11:00	24.2	10.0	0.633	-2.0	-0.5	0.0	ID	ID	ID	ID
	12:00	26.2	10.6	0.637	-2.0	-0.3	-0.1	ID	ID	ID	ID
	13:00	26.9	10.6	0.643	-2.1	-0.4	0.2	ID	ID	ID	ID
	14:00	26.1	11.7	0.657	-1.8	-0.4	0.1	ID	ID	ID	ID
	15:00	24.9	9.9	0.641	-2.1	-0.4	0.1	ID	ID	ID	ID
	16:00	28.2	11.5	0.654	-1.3	-0.3	0.0	ID	ID	ID	ID
	17:00	22.7	9.8	0.700	0.7	-0.3	0.1	ID	ID	ID	ID
	18:00	32.1	13.3	0.712	-1.2	-0.1	-0.1	ID	ID	ID	ID
	19:00	31.9	13.0	0.856	-0.8	0.2	0.1	ID	ID	ID	ID
	20:00	35.7	13.4	0.701	-1.6	0.1	-0.2	ID	ID	ID	ID
	21:00	33.7	13.3	0.764	-0.8	0.2	-0.3	ID	ID	ID	ID
	22:00	34.8	14.2	0.782	-0.7	0.3	0.0	ID	ID	ID	ID
	23:00	37.0	14.9	0.800	-0.3	0.4	0.2	ID	ID	ID	ID
	0:00	36.5	15.0	0.873	ZS	0.3	0.3	ID	ID	ID	ID
Min		**19.7**	**8.4**	**0.624**	**-2.1**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**37.0**	**15.0**	**0.873**	**0.7**	**0.4**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**28.0**	**11.4**	**0.685**	**-1.5**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
21/01/2019	1:00	36.8	15.3	0.904	1.2	ZS	ZS	ID	ID	ID	ID
	2:00	39.4	15.2	0.681	-0.3	0.0	0.2	ID	ID	ID	ID
	3:00	40.2	15.4	0.633	-1.8	-0.3	0.3	ID	ID	ID	ID
	4:00	40.5	15.6	0.629	-1.8	-0.3	0.1	ID	ID	ID	ID
	5:00	40.5	15.9	0.626	-1.8	-0.6	0.4	ID	ID	ID	ID
	6:00	42.0	16.5	0.632	-1.3	-0.4	0.3	ID	ID	ID	ID
	7:00	39.0	15.9	0.684	0.9	0.0	-0.1	ID	ID	ID	ID
	8:00	42.2	16.4	0.769	4.0	0.1	0.2	ID	ID	ID	ID
	9:00	44.1	16.7	0.787	4.3	0.0	0.0	ID	ID	ID	ID
	10:00	42.1	16.2	0.711	0.7	0.0	0.0	ID	ID	ID	ID
	11:00	44.7	16.8	0.708	0.7	0.1	0.0	ID	ID	ID	ID
	12:00	43.7	16.6	0.694	0.8	0.0	-0.1	ID	ID	ID	ID
	13:00	51.4	19.0	0.706	-1.0	0.0	0.1	ID	ID	ID	ID
	14:00	45.4	17.3	0.687	-0.1	0.0	0.1	ID	ID	ID	ID
	15:00	59.4	18.8	0.721	1.3	0.1	-0.1	ID	ID	ID	ID
	16:00	46.8	17.4	0.707	1.0	-0.1	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	45.6	17.1	0.670	-0.2	-0.3	0.0	ID	ID	ID	ID
	18:00	43.9	17.0	0.665	-0.8	-0.2	0.0	ID	ID	ID	ID
	19:00	41.5	16.3	0.652	-1.5	-0.3	-0.1	ID	ID	ID	ID
	20:00	39.6	16.2	0.646	-1.7	-0.2	-0.2	ID	ID	ID	ID
	21:00	38.7	15.3	0.640	-1.9	-0.3	-0.2	ID	ID	ID	ID
	22:00	34.7	14.5	0.646	-1.7	-0.4	0.1	ID	ID	ID	ID
	23:00	34.5	14.3	0.633	-2.0	-0.1	0.0	ID	ID	ID	ID
	0:00	34.6	14.4	0.624	-2.0	-0.2	-0.1	ID	ID	ID	ID
Min		**34.5**	**14.3**	**0.624**	**-2.0**	**-0.6**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**59.4**	**19.0**	**0.904**	**4.3**	**0.1**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**42.1**	**16.3**	**0.686**	**-0.2**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
22/01/2019	1:00	34.4	14.1	0.643	ZS	-0.5	0.0	ID	ID	ID	ID
	2:00	35.3	14.9	0.621	-1.9	ZS	ZS	ID	ID	ID	ID
	3:00	36.4	14.7	0.614	-2.0	-0.3	0.1	ID	ID	ID	ID
	4:00	39.1	15.2	0.615	-2.1	-0.4	0.1	ID	ID	ID	ID
	5:00	37.2	14.3	0.612	-2.2	-0.5	0.3	ID	ID	ID	ID
	6:00	37.0	13.8	0.618	-1.7	-0.3	0.0	ID	ID	ID	ID
	7:00	34.8	13.9	0.658	0.0	-0.2	0.3	ID	ID	ID	ID
	8:00	35.4	13.8	0.695	0.7	-0.1	0.0	ID	ID	ID	ID
	9:00	37.9	13.8	0.675	0.0	-0.1	0.1	ID	ID	ID	ID
	10:00	30.6	12.2	0.627	-1.6	-0.4	0.2	ID	ID	ID	ID
	11:00	31.3	12.2	0.632	-1.5	-0.3	0.0	ID	ID	ID	ID
	12:00	33.9	13.2	0.626	-1.6	-0.2	-0.1	ID	ID	ID	ID
	13:00	30.2	12.1	0.648	-0.9	-0.1	-0.1	ID	ID	ID	ID
	14:00	29.2	11.7	0.634	-0.9	-0.2	-0.3	ID	ID	ID	ID
	15:00	32.4	11.8	0.642	-0.7	-0.3	0.0	ID	ID	ID	ID
	16:00	31.9	11.6	0.700	1.3	-0.2	-0.2	ID	ID	ID	ID
	17:00	30.5	11.3	0.725	2.5	-0.1	0.1	ID	ID	ID	ID
	18:00	28.3	10.9	0.693	1.5	-0.2	0.0	ID	ID	ID	ID
	19:00	29.1	12.5	0.640	-0.9	0.2	-0.4	ID	ID	ID	ID
	20:00	25.0	10.1	0.640	-1.7	-0.3	0.0	ID	ID	ID	ID
	21:00	23.3	9.7	0.623	-1.8	-0.3	0.2	ID	ID	ID	ID
	22:00	22.7	9.9	0.628	-1.8	-0.3	-0.1	ID	ID	ID	ID
	23:00	22.8	9.3	0.610	-1.9	-0.5	0.1	ID	ID	ID	ID
	0:00	22.3	9.3	0.605	ZS	-0.4	0.0	ID	ID	ID	ID
Min		**22.3**	**9.3**	**0.605**	**-2.2**	**-0.5**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**39.1**	**15.2**	**0.725**	**2.5**	**0.2**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**31.3**	**12.3**	**0.643**	**-0.9**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
23/01/2019	1:00	22.9	9.8	0.602	-1.6	ZS	ZS	ID	ID	ID	ID
	2:00	22.4	9.4	0.592	-2.0	-0.3	0.2	ID	ID	ID	ID
	3:00	25.1	10.0	0.603	-2.0	-0.5	0.1	ID	ID	ID	ID
	4:00	25.2	10.5	0.609	-1.8	-0.2	0.0	ID	ID	ID	ID
	5:00	25.9	10.0	0.601	-1.8	-0.3	0.5	ID	ID	ID	ID
	6:00	24.7	9.8	0.603	-1.4	-0.3	0.2	ID	ID	ID	ID
	7:00	28.1	10.5	0.607	-2.0	-0.4	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	23.6	9.8	0.664	-0.9	-0.2	-0.3	ID	ID	ID	ID
	9:00	23.3	9.2	0.675	0.2	-0.3	0.3	ID	ID	ID	ID
	10:00	17.8	7.8	0.627	-1.4	-0.1	0.0	ID	ID	ID	ID
	11:00	17.3	7.3	0.617	-1.2	-0.2	0.0	ID	ID	ID	ID
	12:00	18.0	7.9	0.627	-1.5	-0.2	-0.3	ID	ID	ID	ID
	13:00	21.6	8.8	0.631	-1.1	-0.3	0.0	ID	ID	ID	ID
	14:00	21.3	8.9	0.639	-1.2	-0.1	-0.3	ID	ID	ID	ID
	15:00	22.4	9.1	0.642	-0.9	-0.5	0.1	ID	ID	ID	ID
	16:00	22.8	9.5	0.663	-0.8	-0.3	0.0	ID	ID	ID	ID
	17:00	21.0	8.5	0.643	-1.4	-0.5	0.4	ID	ID	ID	ID
	18:00	17.4	7.3	0.636	-1.3	-0.3	0.2	ID	ID	ID	ID
	19:00	17.9	7.3	0.672	0.5	-0.2	0.1	ID	ID	ID	ID
	20:00	17.4	6.9	0.618	-1.6	-0.4	0.1	ID	ID	ID	ID
	21:00	16.1	6.6	0.612	-1.9	-0.1	-0.4	ID	ID	ID	ID
	22:00	17.2	7.1	0.617	-1.9	-0.3	0.0	ID	ID	ID	ID
	23:00	16.7	7.3	0.623	-1.8	-0.3	0.1	ID	ID	ID	ID
	0:00	16.2	6.7	0.598	-2.1	ZS	ZS	ID	ID	ID	ID
Min		**16.1**	**6.6**	**0.592**	**-2.1**	**-0.5**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**28.1**	**10.5**	**0.675**	**0.5**	**-0.1**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**20.9**	**8.6**	**0.626**	**-1.4**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
24/01/2019	1:00	17.5	6.9	0.598	-2.1	-0.5	0.3	ID	ID	ID	ID
	2:00	16.8	7.2	0.591	ZS	-0.4	0.2	ID	ID	ID	ID
	3:00	19.3	7.6	0.585	-1.5	-0.3	0.0	ID	ID	ID	ID
	4:00	22.1	8.1	0.594	-1.8	-0.3	0.1	ID	ID	ID	ID
	5:00	22.2	7.9	0.588	-2.1	-0.5	0.0	ID	ID	ID	ID
	6:00	20.9	7.8	0.591	-2.1	-0.4	0.0	ID	ID	ID	ID
	7:00	21.4	7.7	0.588	-2.1	-0.4	0.0	ID	ID	ID	ID
	8:00	21.6	7.4	0.612	-1.4	-0.3	-0.1	ID	ID	ID	ID
	9:00	21.8	7.3	0.637	-0.7	-0.1	-0.2	ID	ID	ID	ID
	10:00	20.4	7.2	0.606	-1.5	-0.3	-0.1	ID	ID	ID	ID
	11:00	18.6	6.8	0.593	-1.6	-0.3	-0.2	ID	ID	ID	ID
	12:00	16.8	6.2	0.593	-1.7	-0.4	-0.1	ID	ID	ID	ID
	13:00	18.9	6.3	0.610	-1.7	-0.4	0.0	ID	ID	ID	ID
	14:00	15.6	5.4	0.594	-1.6	-0.3	0.1	ID	ID	ID	ID
	15:00	18.5	6.5	0.610	-1.3	-0.3	0.0	ID	ID	ID	ID
	16:00	24.0	7.2	0.626	-0.7	-0.4	0.0	ID	ID	ID	ID
	17:00	20.6	7.1	0.629	-0.8	-0.2	0.1	ID	ID	ID	ID
	18:00	20.3	7.1	0.610	-1.2	-0.5	0.0	ID	ID	ID	ID
	19:00	20.6	7.2	0.638	-0.7	-0.5	0.2	ID	ID	ID	ID
	20:00	17.4	6.5	0.626	-0.5	-0.2	-0.2	ID	ID	ID	ID
	21:00	18.5	6.7	0.609	-1.7	-0.2	0.0	ID	ID	ID	ID
	22:00	16.7	6.3	0.608	-1.8	-0.2	-0.2	ID	ID	ID	ID
	23:00	16.6	6.1	0.613	-1.7	-0.6	0.1	ID	ID	ID	ID
	0:00	15.1	5.8	ZS	ZS	-0.4	0.3	ID	ID	ID	ID
Min		**15.1**	**5.4**	**0.585**	**-2.1**	**-0.6**	**-0.2**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**24.0**	**8.1**	**0.638**	**-0.5**	**-0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**19.3**	**6.9**	**0.607**	**-1.5**	**-0.4**	**0.0**	**ID**	**ID**	**ID**	**ID**
25/01/2019	1:00	15.0	5.6	0.586	ZS	-0.2	-0.1	ID	ID	ID	ID
	2:00	15.5	5.7	0.579	-1.7	ZS	ZS	ID	ID	ID	ID
	3:00	15.7	5.7	0.586	-2.0	-0.2	0.0	ID	ID	ID	ID
	4:00	15.4	5.5	0.578	-2.0	-0.4	0.2	ID	ID	ID	ID
	5:00	16.4	5.7	0.571	-2.2	-0.2	0.0	ID	ID	ID	ID
	6:00	15.9	5.7	0.571	-2.2	-0.2	-0.2	ID	ID	ID	ID
	7:00	16.1	5.9	0.585	-2.0	-0.4	0.2	ID	ID	ID	ID
	8:00	16.3	5.6	0.638	-0.7	-0.2	-0.1	ID	ID	ID	ID
	9:00	14.5	5.7	0.900	10.1	0.2	0.2	ID	ID	ID	ID
	10:00	15.3	5.6	0.700	2.1	0.2	0.1	ID	ID	ID	ID
	11:00	16.5	5.5	0.608	-1.2	-0.2	-0.1	ID	ID	ID	ID
	12:00	14.2	5.3	0.614	-0.8	-0.2	0.0	ID	ID	ID	ID
	13:00	14.5	5.3	0.619	-1.0	-0.3	-0.1	ID	ID	ID	ID
	14:00	14.0	5.3	0.623	-1.1	-0.2	-0.2	ID	ID	ID	ID
	15:00	15.6	5.8	0.630	-0.6	-0.1	-0.2	ID	ID	ID	ID
	16:00	17.4	7.4	0.672	0.4	-0.1	-0.1	ID	ID	ID	ID
	17:00	15.6	5.7	0.643	0.0	0.0	-0.2	ID	ID	ID	ID
	18:00	16.1	5.6	0.630	-0.4	-0.2	-0.1	ID	ID	ID	ID
	19:00	15.1	5.8	0.635	-0.4	-0.2	-0.1	ID	ID	ID	ID
	20:00	15.6	6.1	0.641	-1.2	-0.2	0.0	ID	ID	ID	ID
	21:00	15.0	5.8	0.651	-1.3	-0.3	0.1	ID	ID	ID	ID
	22:00	33.8	21.2	0.863	-0.8	0.0	0.1	ID	ID	ID	ID
	23:00	15.9	6.7	0.867	-0.5	-0.2	-0.1	ID	ID	ID	ID
	0:00	13.7	5.3	0.661	ZS	-0.1	-0.3	ID	ID	ID	ID
Min		**13.7**	**5.3**	**0.571**	**-2.2**	**-0.4**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**33.8**	**21.2**	**0.900**	**10.1**	**0.2**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**16.2**	**6.4**	**0.652**	**-0.4**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
26/01/2019	1:00	13.9	5.4	0.642	-1.4	ZS	ZS	ID	ID	ID	ID
	2:00	13.7	5.2	0.588	-1.8	-0.2	0.0	ID	ID	ID	ID
	3:00	13.4	5.2	0.583	-2.0	-0.2	-0.2	ID	ID	ID	ID
	4:00	13.2	5.1	0.578	-2.0	-0.2	0.0	ID	ID	ID	ID
	5:00	13.4	5.0	0.578	-2.1	-0.3	-0.1	ID	ID	ID	ID
	6:00	12.4	4.8	0.574	-1.7	-0.4	0.2	ID	ID	ID	ID
	7:00	13.2	4.9	0.577	-1.5	-0.3	0.1	ID	ID	ID	ID
	8:00	13.2	4.7	0.582	-1.4	-0.1	-0.2	ID	ID	ID	ID
	9:00	12.3	4.6	0.587	-1.5	-0.2	0.0	ID	ID	ID	ID
	10:00	12.3	4.4	0.590	-1.6	-0.3	0.1	ID	ID	ID	ID
	11:00	16.6	4.8	0.588	-1.4	-0.4	0.0	ID	ID	ID	ID
	12:00	12.7	4.9	0.616	-1.3	-0.1	-0.1	ID	ID	ID	ID
	13:00	12.0	4.9	0.615	-1.8	0.1	-0.9	ID	ID	ID	ID
	14:00	11.1	4.4	0.721	-2.0	0.0	-0.5	ID	ID	ID	ID
	15:00	10.7	4.1	0.795	-1.5	-0.1	-0.1	ID	ID	ID	ID
	16:00	11.0	4.2	0.771	-1.7	-0.4	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	10.7	4.0	0.759	-1.3	-0.2	0.0	ID	ID	ID	ID
	18:00	13.8	5.3	0.769	-1.5	-0.2	-0.1	ID	ID	ID	ID
	19:00	14.1	5.7	0.781	-1.3	-0.1	-0.1	ID	ID	ID	ID
	20:00	15.7	5.8	0.763	-1.4	-0.3	0.0	ID	ID	ID	ID
	21:00	14.6	5.7	0.778	-0.6	-0.2	-0.2	ID	ID	ID	ID
	22:00	15.0	5.7	0.785	0.0	0.1	0.0	ID	ID	ID	ID
	23:00	14.7	5.5	0.788	0.0	-0.1	0.3	ID	ID	ID	ID
	0:00	13.0	5.1	ZS	0.0	ZS	ZS	ID	ID	ID	ID
Min		**10.7**	**4.0**	**0.574**	**-2.1**	**-0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**16.6**	**5.8**	**0.795**	**0.0**	**0.1**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**13.2**	**5.0**	**0.670**	**-1.4**	**-0.2**	**-0.1**	**ID**	**ID**	**ID**	**ID**
27/01/2019	1:00	8.6	3.8	0.730	1.0	0.0	0.9	ID	ID	ID	ID
	2:00	8.2	3.4	0.730	ZS	-0.2	0.8	ID	ID	ID	ID
	3:00	7.3	3.3	0.718	0.2	-0.1	0.9	ID	ID	ID	ID
	4:00	8.1	3.6	0.693	-1.7	-0.1	-0.2	ID	ID	ID	ID
	5:00	9.1	4.0	0.705	-0.5	-0.4	0.1	ID	ID	ID	ID
	6:00	14.2	5.5	0.680	-1.9	-0.2	0.2	ID	ID	ID	ID
	7:00	14.4	5.5	0.725	0.2	-0.2	0.6	ID	ID	ID	ID
	8:00	14.2	5.4	0.757	1.2	0.0	0.5	ID	ID	ID	ID
	9:00	10.0	4.0	0.764	1.2	0.0	0.3	ID	ID	ID	ID
	10:00	6.8	2.8	0.689	-1.4	-0.2	0.0	ID	ID	ID	ID
	11:00	6.4	2.0	0.661	-1.8	-0.3	0.1	ID	ID	ID	ID
	12:00	7.1	2.9	0.656	-1.8	-0.2	-0.1	ID	ID	ID	ID
	13:00	7.7	2.9	0.669	-1.9	-0.4	0.8	ID	ID	ID	ID
	14:00	5.9	2.1	0.670	-2.0	-0.3	0.0	ID	ID	ID	ID
	15:00	6.7	3.1	0.688	-2.0	-0.1	-0.5	ID	ID	ID	ID
	16:00	6.7	2.9	0.688	-1.4	-0.2	-0.1	ID	ID	ID	ID
	17:00	9.3	3.6	0.712	-1.2	0.0	-0.3	ID	ID	ID	ID
	18:00	9.2	3.5	0.769	0.0	-0.3	0.3	ID	ID	ID	ID
	19:00	10.0	4.1	0.791	0.8	0.0	0.1	ID	ID	ID	ID
	20:00	11.6	4.2	0.712	-0.5	0.0	-0.1	ID	ID	ID	ID
	21:00	11.6	4.2	0.729	0.5	0.1	0.1	ID	ID	ID	ID
	22:00	13.8	5.1	0.722	-0.3	0.0	0.0	ID	ID	ID	ID
	23:00	15.7	6.4	0.782	-0.4	0.1	-0.2	ID	ID	ID	ID
	0:00	15.0	5.8	0.772	ZS	0.1	0.0	ID	ID	ID	ID
Min		**5.9**	**2.0**	**0.656**	**-2.0**	**-0.4**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**15.7**	**6.4**	**0.791**	**1.2**	**0.1**	**0.9**	**ID**	**ID**	**ID**	**ID**
Average		**9.9**	**3.9**	**0.717**	**-0.6**	**-0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
28/01/2019	1:00	16.4	6.6	0.882	0.2	ZS	ZS	ID	ID	ID	ID
	2:00	17.3	6.0	0.682	-1.4	0.0	0.2	ID	ID	ID	ID
	3:00	14.5	5.5	0.661	-1.9	-0.1	0.4	ID	ID	ID	ID
	4:00	15.0	5.9	0.668	-1.6	-0.2	0.3	ID	ID	ID	ID
	5:00	13.4	5.6	0.665	-2.0	-0.2	0.2	ID	ID	ID	ID
	6:00	14.0	5.5	0.673	-1.5	0.0	0.3	ID	ID	ID	ID
	7:00	15.2	5.7	0.716	0.4	0.0	0.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	17.0	6.0	0.878	4.5	0.0	0.4	ID	ID	ID	ID
	9:00	18.6	6.4	0.953	6.6	0.5	0.2	ID	ID	ID	ID
	10:00	16.7	6.6	0.794	2.3	0.2	0.1	ID	ID	ID	ID
	11:00	16.9	6.0	0.696	-1.2	0.1	-0.2	ID	ID	ID	ID
	12:00	15.8	6.4	0.699	-1.5	-0.1	0.1	ID	ID	ID	ID
	13:00	17.0	6.2	0.700	-1.7	-0.1	0.0	ID	ID	ID	ID
	14:00	17.2	6.3	0.694	-1.6	-0.2	0.0	ID	ID	ID	ID
	15:00	16.8	6.0	0.681	-1.8	-0.3	0.2	ID	ID	ID	ID
	16:00	17.2	6.2	0.708	-1.2	-0.3	0.0	ID	ID	ID	ID
	17:00	17.4	6.3	0.711	-1.4	-0.3	-0.1	ID	ID	ID	ID
	18:00	16.1	5.9	0.715	-0.7	-0.2	-0.3	ID	ID	ID	ID
	19:00	15.1	5.7	0.695	-1.7	-0.1	-0.3	ID	ID	ID	ID
	20:00	17.4	5.9	0.687	-1.6	-0.3	0.2	ID	ID	ID	ID
	21:00	18.9	6.3	0.688	-1.8	-0.2	-0.1	ID	ID	ID	ID
	22:00	17.3	6.2	0.680	-1.9	-0.2	-0.1	ID	ID	ID	ID
	23:00	17.5	6.1	0.682	-1.9	-0.1	-0.1	ID	ID	ID	ID
	0:00	16.4	5.7	0.671	-2.1	-0.5	-0.2	ID	ID	ID	ID
Min		**13.4**	**5.5**	**0.661**	**-2.1**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**18.9**	**6.6**	**0.953**	**6.6**	**0.5**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**16.5**	**6.0**	**0.720**	**-0.7**	**-0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
29/01/2019	1:00	14.9	5.5	0.676	ZS	-0.2	0.0	ID	ID	ID	ID
	2:00	14.1	5.5	0.669	-1.9	ZS	ZS	ID	ID	ID	ID
	3:00	13.5	5.3	0.664	-2.1	-0.2	0.1	ID	ID	ID	ID
	4:00	13.1	5.0	0.664	-2.2	-0.2	0.2	ID	ID	ID	ID
	5:00	12.0	4.7	0.665	-2.0	-0.1	0.0	ID	ID	ID	ID
	6:00	13.8	5.1	0.677	-1.5	-0.1	0.2	ID	ID	ID	ID
	7:00	14.1	5.3	0.673	-2.0	-0.2	0.0	ID	ID	ID	ID
	7:00	15.9	5.7	0.706	-1.1	-0.6	0.3	ID	ID	ID	ID
	9:00	16.2	5.4	0.725	-0.4	-0.4	0.1	ID	ID	ID	ID
	10:00	16.0	5.6	0.697	-1.2	-0.4	0.1	ID	ID	ID	ID
	11:00	16.2	5.4	0.685	-1.2	-0.4	0.0	ID	ID	ID	ID
	12:00	16.7	5.7	0.693	-1.4	-0.2	0.0	ID	ID	ID	ID
	13:00	16.7	5.5	0.696	-1.3	0.0	-0.1	ID	ID	ID	ID
	14:00	15.0	5.3	0.704	-1.4	-0.1	0.0	ID	ID	ID	ID
	15:00	15.1	5.1	0.697	-1.4	-0.1	-0.1	ID	ID	ID	ID
	16:00	14.5	4.9	0.724	-0.7	-0.3	-0.1	ID	ID	ID	ID
	17:00	11.9	4.3	0.719	-0.9	-0.3	0.0	ID	ID	ID	ID
	18:00	11.8	4.2	0.701	-1.1	-0.5	0.2	ID	ID	ID	ID
	19:00	11.5	4.2	0.695	-1.3	-0.4	0.1	ID	ID	ID	ID
	20:00	11.7	4.1	0.686	-1.7	-0.3	0.2	ID	ID	ID	ID
	21:00	11.6	4.4	0.689	-1.8	-0.2	-0.2	ID	ID	ID	ID
	22:00	13.7	4.9	0.706	-1.7	-0.3	0.1	ID	ID	ID	ID
	23:00	12.9	4.7	0.685	-2.0	-0.5	0.0	ID	ID	ID	ID
	0:00	12.5	4.7	0.682	ZS	-0.1	-0.2	ID	ID	ID	ID
Min		**11.5**	**4.1**	**0.664**	**-2.2**	**-0.6**	**-0.2**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**16.7**	**5.7**	**0.725**	**-0.4**	**0.0**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**14.0**	**5.0**	**0.691**	**-1.5**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
30/01/2019	1:00	12.6	4.8	0.681	-1.7	ZS	ZS	ID	ID	ID	ID
	2:00	12.2	4.7	0.669	-2.1	-0.5	0.0	ID	ID	ID	ID
	3:00	13.4	5.0	0.675	-2.2	-0.5	0.2	ID	ID	ID	ID
	4:00	13.8	5.0	0.680	-2.2	-0.3	-0.1	ID	ID	ID	ID
	5:00	12.6	5.1	0.679	-2.3	-0.4	0.0	ID	ID	ID	ID
	6:00	13.2	5.0	0.673	-2.3	-0.6	0.2	ID	ID	ID	ID
	7:00	12.3	4.8	0.677	-2.2	-0.2	-0.1	ID	ID	ID	ID
	8:00	14.2	5.0	0.706	-1.2	-0.4	0.1	ID	ID	ID	ID
	9:00	14.3	5.2	0.753	-0.7	-0.1	-0.3	ID	ID	ID	ID
	10:00	15.0	5.1	0.703	-1.2	-0.4	0.0	ID	ID	ID	ID
	11:00	15.5	5.2	0.696	-1.2	-0.1	-0.2	ID	ID	ID	ID
	12:00	15.2	5.3	0.699	-1.1	-0.3	-0.2	ID	ID	ID	ID
	13:00	15.8	5.3	0.712	-1.2	-0.3	0.0	ID	ID	ID	ID
	14:00	14.8	5.1	0.708	-1.4	-0.5	0.3	ID	ID	ID	ID
	15:00	14.8	5.0	0.706	-1.4	-0.4	0.1	ID	ID	ID	ID
	16:00	13.2	5.1	0.736	-1.3	-0.2	-0.1	ID	ID	ID	ID
	17:00	19.6	8.7	0.746	-0.1	0.2	-0.2	ID	ID	ID	ID
	18:00	14.6	5.7	0.738	-0.4	0.0	0.0	ID	ID	ID	ID
	19:00	13.4	5.2	0.728	-1.6	-0.1	-0.2	ID	ID	ID	ID
	20:00	13.1	5.0	0.696	-1.8	-0.4	0.2	ID	ID	ID	ID
	21:00	12.4	4.5	0.700	-1.9	-0.2	0.1	ID	ID	ID	ID
	22:00	12.2	4.6	0.693	-1.9	-0.4	0.1	ID	ID	ID	ID
	23:00	14.0	5.1	0.695	-2.1	-0.1	-0.2	ID	ID	ID	ID
	0:00	14.1	4.9	ZS	-2.3	ZS	ZS	ID	ID	ID	ID
Min		**12.2**	**4.5**	**0.669**	**-2.3**	**-0.6**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**19.6**	**8.7**	**0.753**	**-0.1**	**0.2**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**14.0**	**5.2**	**0.702**	**-1.6**	**-0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
31/01/2019	1:00	13.6	4.7	0.676	-2.3	-0.2	0.1	ID	ID	ID	ID
	2:00	12.9	4.7	0.679	ZS	-0.1	-0.3	ID	ID	ID	ID
	3:00	12.3	4.7	0.674	-2.1	-0.3	-0.1	ID	ID	ID	ID
	4:00	14.3	5.2	0.680	-2.2	-0.4	0.1	ID	ID	ID	ID
	5:00	13.7	4.9	0.674	-2.2	-0.2	0.0	ID	ID	ID	ID
	6:00	11.8	4.6	0.669	-2.2	-0.2	0.0	ID	ID	ID	ID
	7:00	12.8	4.6	0.674	-2.0	-0.2	-0.1	ID	ID	ID	ID
	8:00	12.5	4.6	0.687	-1.4	-0.2	0.0	ID	ID	ID	ID
	9:00	24.5	13.5	0.756	-0.5	-0.1	0.1	ID	ID	ID	ID
	10:00	13.6	5.1	0.712	-1.3	0.1	0.0	ID	ID	ID	ID
	11:00	15.7	5.6	0.728	-1.5	0.1	-0.2	ID	ID	ID	ID
	12:00	15.3	5.4	0.700	-1.4	-0.2	-0.1	ID	ID	ID	ID
	13:00	18.9	7.4	0.709	-1.2	-0.2	-0.1	ID	ID	ID	ID
	14:00	18.0	7.4	0.716	-1.2	-0.2	0.0	ID	ID	ID	ID
	15:00	15.9	6.5	0.718	-1.0	-0.2	0.1	ID	ID	ID	ID
	16:00	16.4	6.4	0.719	-1.0	-0.1	0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	13.4	4.8	0.717	-0.9	-0.2	-0.1	ID	ID	ID	ID
	18:00	15.6	6.5	0.759	-1.0	0.1	0.0	ID	ID	ID	ID
	19:00	15.1	6.4	0.725	-1.4	-0.1	0.1	ID	ID	ID	ID
	20:00	18.7	9.0	0.705	-1.9	-0.1	-0.3	ID	ID	ID	ID
	21:00	13.5	5.8	0.697	-1.9	-0.3	0.1	ID	ID	ID	ID
	22:00	15.0	6.3	0.709	-1.9	-0.3	0.1	ID	ID	ID	ID
	23:00	16.1	6.2	0.690	-2.0	-0.3	0.0	ID	ID	ID	ID
	0:00	20.9	9.8	0.690	-2.1	0.0	-0.4	ID	ID	ID	ID
Min		**11.8**	**4.6**	**0.669**	**-2.3**	**-0.4**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**24.5**	**13.5**	**0.759**	**-0.5**	**0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
Average		**15.4**	**6.3**	**0.703**	**-1.6**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
01/02/2019	1:00	17.7	7.2	0.682	ZS	-0.2	0.1	ID	ID	ID	ID
	2:00	18.1	7.7	0.684	-1.7	ZS	ZS	ID	ID	ID	ID
	3:00	23.2	10.4	0.686	-2.0	0.0	-0.2	ID	ID	ID	ID
	4:00	21.6	9.2	0.678	-2.1	-0.1	-0.4	ID	ID	ID	ID
	5:00	15.1	6.1	0.673	-2.2	-0.2	0.1	ID	ID	ID	ID
	6:00	19.0	8.0	0.673	-2.2	-0.1	0.1	ID	ID	ID	ID
	7:00	16.5	6.9	0.680	-2.1	-0.2	0.0	ID	ID	ID	ID
	8:00	17.1	6.9	0.736	-0.9	-0.3	-0.1	ID	ID	ID	ID
	9:00	16.7	6.8	0.749	0.1	-0.1	0.2	ID	ID	ID	ID
	10:00	UM	UM	0.695	-1.3	0.0	-0.1	ID	ID	ID	ID
	11:00	UM	UM	0.685	-1.8	-0.2	0.2	ID	ID	ID	ID
	12:00	UM	UM	0.676	-1.6	-0.1	-0.2	ID	ID	ID	ID
	13:00	UM	UM	0.724	0.4	0.0	-0.1	ID	ID	ID	ID
	14:00	13.7	5.3	0.714	-0.7	0.0	0.2	ID	ID	ID	ID
	15:00	16.9	8.4	0.817	-0.8	0.1	-0.4	ID	ID	ID	ID
	16:00	33.2	22.8	0.814	-0.9	0.2	0.0	ID	ID	ID	ID
	17:00	18.1	9.4	0.771	-1.1	0.0	0.0	ID	ID	ID	ID
	18:00	13.1	4.6	0.717	-1.0	0.0	-0.1	ID	ID	ID	ID
	19:00	12.6	4.3	0.687	-1.5	0.0	-0.2	ID	ID	ID	ID
	20:00	12.1	4.2	0.690	-1.6	-0.2	-0.2	ID	ID	ID	ID
	21:00	12.6	4.3	0.693	-1.4	0.0	-0.1	ID	ID	ID	ID
	22:00	12.6	4.5	0.682	-1.7	-0.1	-0.1	ID	ID	ID	ID
	23:00	11.4	4.3	0.679	ZS	-0.3	-0.1	ID	ID	ID	ID
	0:00	12.3	4.3	0.693	ZS	0.0	-0.2	ID	ID	ID	ID
Min		**11.4**	**4.2**	**0.673**	**-2.2**	**-0.3**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**33.2**	**22.8**	**0.817**	**0.4**	**0.2**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**16.7**	**7.3**	**0.707**	**-1.3**	**-0.1**	**-0.1**	**ID**	**ID**	**ID**	**ID**
02/02/2019	1:00	11.7	4.3	0.680	-1.4	ZS	ZS	ID	ID	ID	ID
	2:00	12.6	4.6	0.673	-1.7	0.0	0.0	ID	ID	ID	ID
	3:00	12.3	4.8	0.673	-2.1	0.0	-0.2	ID	ID	ID	ID
	4:00	10.1	4.1	0.676	-1.6	-0.2	-0.1	ID	ID	ID	ID
	5:00	7.8	3.1	0.661	-1.5	-0.1	0.2	ID	ID	ID	ID
	6:00	9.5	4.0	0.680	-2.1	0.0	-0.1	ID	ID	ID	ID
	7:00	8.7	3.6	0.778	2.5	0.1	1.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	10.6	4.1	0.926	6.4	0.6	0.5	ID	ID	ID	ID
	9:00	10.1	4.3	0.976	9.9	1.1	0.7	ID	ID	ID	ID
	10:00	9.3	4.0	0.751	1.5	0.6	0.1	ID	ID	ID	ID
	11:00	8.8	4.1	0.691	-1.8	0.1	-0.1	ID	ID	ID	ID
	12:00	7.8	3.3	0.689	-2.0	0.1	0.0	ID	ID	ID	ID
	13:00	7.8	3.2	0.687	-1.6	0.0	0.0	ID	ID	ID	ID
	14:00	8.0	3.4	0.692	-1.5	0.2	-0.2	ID	ID	ID	ID
	15:00	8.2	3.2	0.694	0.1	0.2	-0.1	ID	ID	ID	ID
	16:00	9.2	4.8	0.700	-0.1	0.2	0.0	ID	ID	ID	ID
	17:00	6.6	2.8	0.708	-0.1	0.1	-0.2	ID	ID	ID	ID
	18:00	15.8	9.3	0.754	2.5	0.4	0.0	ID	ID	ID	ID
	19:00	9.7	3.7	0.705	-1.2	0.2	0.0	ID	ID	ID	ID
	20:00	10.7	4.6	0.740	-1.0	0.0	0.3	ID	ID	ID	ID
	21:00	10.1	3.8	0.719	-1.1	0.2	-0.1	ID	ID	ID	ID
	22:00	10.3	4.0	0.744	-0.9	0.2	-0.1	ID	ID	ID	ID
	23:00	10.7	4.5	0.773	-0.8	0.2	-0.1	ID	ID	ID	ID
	0:00	9.6	3.7	0.729	-1.4	ZS	ZS	ID	ID	ID	ID
Min		**6.6**	**2.8**	**0.661**	**-2.1**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**15.8**	**9.3**	**0.976**	**9.9**	**1.1**	**1.0**	**ID**	**ID**	**ID**	**ID**
Average		**9.8**	**4.1**	**0.729**	**0.0**	**0.2**	**0.1**	**ID**	**ID**	**ID**	**ID**
03/02/2019	1:00	10.7	3.8	0.698	-1.5	0.1	0.0	ID	ID	ID	ID
	2:00	9.7	3.8	0.678	ZS	0.0	0.0	ID	ID	ID	ID
	3:00	10.8	4.0	0.678	-2.0	0.0	-0.2	ID	ID	ID	ID
	4:00	10.2	3.8	0.676	-2.1	0.0	-0.1	ID	ID	ID	ID
	5:00	9.3	3.7	0.672	-2.0	0.0	-0.2	ID	ID	ID	ID
	6:00	9.1	3.6	0.674	-2.1	0.0	-0.1	ID	ID	ID	ID
	7:00	10.7	3.9	0.728	0.3	0.0	0.5	ID	ID	ID	ID
	8:00	11.7	4.0	0.779	3.1	0.3	0.8	ID	ID	ID	ID
	9:00	9.5	3.4	0.681	-1.8	0.1	-0.1	ID	ID	ID	ID
	10:00	10.0	3.5	0.690	-1.8	-0.1	0.1	ID	ID	ID	ID
	11:00	11.0	3.5	0.686	-1.9	-0.1	0.0	ID	ID	ID	ID
	12:00	12.0	3.6	0.677	-1.8	0.0	0.0	ID	ID	ID	ID
	13:00	11.7	4.1	0.702	-1.6	0.0	-0.2	ID	ID	ID	ID
	14:00	11.9	4.0	0.694	-1.9	0.1	-0.2	ID	ID	ID	ID
	15:00	11.3	4.2	0.694	-1.9	-0.2	0.1	ID	ID	ID	ID
	16:00	12.6	5.1	0.693	-1.6	0.1	-0.1	ID	ID	ID	ID
	17:00	12.0	4.0	0.706	-1.4	0.0	-0.3	ID	ID	ID	ID
	18:00	12.8	4.2	0.741	-1.2	0.1	-0.1	ID	ID	ID	ID
	19:00	12.2	4.5	0.744	-1.2	0.1	-0.1	ID	ID	ID	ID
	20:00	13.1	4.8	0.778	-1.2	0.2	-0.1	ID	ID	ID	ID
	21:00	12.1	4.9	0.960	0.2	0.4	-0.1	ID	ID	ID	ID
	22:00	13.0	5.2	0.992	1.1	0.6	0.0	ID	ID	ID	ID
	23:00	14.2	5.6	0.941	0.8	0.7	0.0	ID	ID	ID	ID
	0:00	12.0	5.2	0.929	ZS	0.8	-0.2	ID	ID	ID	ID
Min		**9.1**	**3.4**	**0.672**	**-2.1**	**-0.2**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**14.2**	**5.6**	**0.992**	**3.1**	**0.8**	**0.8**	**ID**	**ID**	**ID**	**ID**
Average		**11.4**	**4.2**	**0.745**	**-1.1**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
04/02/2019	1:00	14.9	5.7	1.046	1.6	ZS	ZS	ID	ID	ID	ID
	2:00	11.8	4.9	0.713	-1.4	0.1	0.1	ID	ID	ID	ID
	3:00	15.3	6.2	0.687	-1.9	0.2	-0.2	ID	ID	ID	ID
	4:00	14.3	5.9	0.685	-1.9	0.0	-0.1	ID	ID	ID	ID
	5:00	18.0	7.3	0.689	-1.6	0.0	0.0	ID	ID	ID	ID
	6:00	18.0	7.8	0.702	-1.1	0.0	0.1	ID	ID	ID	ID
	7:00	19.4	8.6	0.730	-0.9	0.0	0.0	ID	ID	ID	ID
	8:00	19.3	8.0	0.916	3.9	0.3	0.2	ID	ID	ID	ID
	9:00	21.5	8.1	0.855	2.1	0.5	0.0	ID	ID	ID	ID
	10:00	20.7	7.6	0.741	-0.5	0.2	0.0	ID	ID	ID	ID
	11:00	21.0	7.7	0.727	-0.8	0.2	0.0	ID	ID	ID	ID
	12:00	19.3	7.5	0.759	-0.2	0.2	-0.2	ID	ID	ID	ID
	13:00	17.6	6.7	0.713	-1.5	0.0	0.1	ID	ID	ID	ID
	14:00	18.8	7.4	0.740	-0.6	-0.2	0.3	ID	ID	ID	ID
	15:00	20.3	7.9	0.745	-0.5	0.0	0.1	ID	ID	ID	ID
	16:00	19.2	7.5	0.734	-1.3	0.0	-0.1	ID	ID	ID	ID
	17:00	18.5	7.3	0.764	-0.2	-0.1	0.1	ID	ID	ID	ID
	18:00	19.5	7.2	0.857	1.9	0.2	-0.1	ID	ID	ID	ID
	19:00	18.2	7.0	0.789	1.0	0.2	0.1	ID	ID	ID	ID
	20:00	19.8	7.2	0.715	-1.5	0.1	0.1	ID	ID	ID	ID
	21:00	18.0	7.0	0.723	-1.6	0.1	-0.1	ID	ID	ID	ID
	22:00	16.0	6.8	ZS	-1.7	0.0	-0.1	ID	ID	ID	ID
	23:00	17.5	7.2	ZS	-1.7	0.1	-0.1	ID	ID	ID	ID
	0:00	17.6	7.1	0.253	-2.0	0.0	0.0	ID	ID	ID	ID
Min		**11.8**	**4.9**	**0.253**	**-2.0**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**21.5**	**8.6**	**1.046**	**3.9**	**0.5**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**18.1**	**7.1**	**0.740**	**-0.5**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
05/02/2019	1:00	17.8	7.4	0.254	ZS	0.0	-0.1	ID	ID	ID	ID
	2:00	19.0	7.6	0.251	-1.9	ZS	ZS	ID	ID	ID	ID
	3:00	19.1	7.7	0.253	-2.1	0.0	0.0	ID	ID	ID	ID
	4:00	19.3	8.0	0.254	-2.2	-0.1	-0.1	ID	ID	ID	ID
	5:00	19.9	8.1	0.259	-2.3	-0.1	0.0	ID	ID	ID	ID
	6:00	19.2	7.8	0.251	-2.3	0.0	-0.1	ID	ID	ID	ID
	7:00	16.1	6.8	0.258	-2.1	-0.2	0.2	ID	ID	ID	ID
	8:00	14.7	6.1	0.293	-1.3	0.1	-0.2	ID	ID	ID	ID
	9:00	17.0	6.6	0.326	0.1	0.0	0.1	ID	ID	ID	ID
	10:00	18.4	7.6	0.337	0.7	0.2	-0.2	ID	ID	ID	ID
	11:00	17.8	7.1	0.319	-0.4	0.1	0.2	ID	ID	ID	ID
	12:00	18.1	7.6	0.285	-1.5	0.2	-0.2	ID	ID	ID	ID
	13:00	20.9	7.8	0.337	0.2	0.2	-0.1	ID	ID	ID	ID
	14:00	20.0	7.6	0.322	-0.2	0.1	0.1	ID	ID	ID	ID
	15:00	19.1	7.1	0.361	0.6	0.2	0.2	ID	ID	ID	ID
	16:00	20.3	7.4	0.389	1.4	0.3	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	21.8	8.8	0.387	2.1	0.4	-0.1	ID	ID	ID	ID
	18:00	20.4	7.3	0.498	5.0	0.5	-0.1	ID	ID	ID	ID
	19:00	19.0	6.8	0.388	2.5	0.4	0.1	ID	ID	ID	ID
	20:00	17.6	6.6	0.317	-0.1	-0.1	0.3	ID	ID	ID	ID
	21:00	16.5	6.4	0.284	-0.9	0.2	-0.1	ID	ID	ID	ID
	22:00	17.5	6.7	0.283	-1.5	0.1	-0.1	ID	ID	ID	ID
	23:00	16.7	6.9	0.293	ZS	0.0	-0.2	ID	ID	ID	ID
	0:00	17.2	7.2	0.271	ZS	0.0	-0.2	ID	ID	ID	ID
Min		**14.7**	**6.1**	**0.251**	**-2.3**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**21.8**	**8.8**	**0.498**	**5.0**	**0.5**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**18.5**	**7.3**	**0.311**	**-0.3**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
06/02/2019	1:00	19.1	7.7	ZS	-1.4	ZS	ZS	ID	ID	ID	ID
	2:00	18.9	7.6	0.273	-1.4	0.0	0.2	ID	ID	ID	ID
	3:00	19.8	7.9	0.251	-1.8	-0.1	0.1	ID	ID	ID	ID
	4:00	21.9	8.1	0.245	-2.1	-0.1	0.0	ID	ID	ID	ID
	5:00	22.3	8.2	0.247	-2.2	0.0	-0.2	ID	ID	ID	ID
	6:00	22.3	8.1	0.247	-2.2	0.1	-0.3	ID	ID	ID	ID
	7:00	18.8	6.8	0.247	-2.1	0.0	-0.1	ID	ID	ID	ID
	8:00	23.5	6.8	0.289	-0.4	0.0	-0.1	ID	ID	ID	ID
	9:00	23.3	6.8	0.292	-0.5	0.1	0.0	ID	ID	ID	ID
	10:00	19.4	6.5	0.257	-1.5	0.0	-0.1	ID	ID	ID	ID
	11:00	17.2	6.3	0.268	-1.3	0.1	-0.1	ID	ID	ID	ID
	12:00	18.1	6.5	0.264	-1.1	0.1	0.0	ID	ID	ID	ID
	13:00	18.0	6.3	0.271	-1.2	0.1	-0.4	ID	ID	ID	ID
	14:00	17.3	6.5	0.286	-1.3	-0.1	-0.1	ID	ID	ID	ID
	15:00	17.8	6.8	0.271	-1.2	0.0	-0.2	ID	ID	ID	ID
	16:00	20.1	7.2	0.307	-1.0	-0.1	0.0	ID	ID	ID	ID
	17:00	21.4	8.3	0.331	-0.4	0.1	-0.1	ID	ID	ID	ID
	18:00	21.2	8.1	0.319	-0.9	0.1	0.1	ID	ID	ID	ID
	19:00	21.8	8.4	0.310	-1.5	0.2	-0.5	ID	ID	ID	ID
	20:00	24.0	11.5	0.344	-1.5	0.0	0.0	ID	ID	ID	ID
	21:00	19.7	7.8	0.276	-1.7	0.0	-0.1	ID	ID	ID	ID
	22:00	18.9	7.8	0.281	-1.7	-0.1	0.2	ID	ID	ID	ID
	23:00	17.4	7.7	ZS	-1.9	-0.1	0.2	ID	ID	ID	ID
	0:00	17.9	7.9	0.265	-2.1	ZS	ZS	ID	ID	ID	ID
Min		**17.2**	**6.3**	**0.245**	**-2.2**	**-0.1**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**24.0**	**11.5**	**0.344**	**-0.4**	**0.2**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**20.0**	**7.6**	**0.279**	**-1.4**	**0.0**	**-0.1**	**ID**	**ID**	**ID**	**ID**
07/02/2019	1:00	19.1	8.3	0.261	-2.3	0.0	-0.2	ID	ID	ID	ID
	2:00	20.7	8.8	0.270	ZS	-0.2	0.0	ID	ID	ID	ID
	3:00	22.7	9.2	0.269	-2.0	-0.1	0.2	ID	ID	ID	ID
	4:00	24.2	9.5	0.271	-2.1	-0.1	0.0	ID	ID	ID	ID
	5:00	20.4	8.4	0.270	-2.2	-0.1	-0.1	ID	ID	ID	ID
	6:00	15.1	6.4	0.273	-2.2	-0.2	0.2	ID	ID	ID	ID
	7:00	16.0	6.8	0.272	-1.9	0.0	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	19.8	7.7	0.321	-0.7	0.1	-0.1	ID	ID	ID	ID
	9:00	21.3	9.0	0.332	-0.5	0.2	-0.2	ID	ID	ID	ID
	10:00	21.6	8.4	0.294	-1.6	0.0	-0.1	ID	ID	ID	ID
	11:00	20.4	8.8	0.361	1.2	0.1	0.4	ID	ID	ID	ID
	12:00	18.0	7.9	0.383	2.3	0.3	0.1	ID	ID	ID	ID
	13:00	18.4	8.2	0.296	-1.4	0.2	-0.1	ID	ID	ID	ID
	14:00	22.5	9.2	0.314	-0.8	0.0	0.0	ID	ID	ID	ID
	15:00	23.9	9.7	0.296	-1.3	0.2	-0.1	ID	ID	ID	ID
	16:00	25.9	9.9	0.322	-0.2	0.2	-0.3	ID	ID	ID	ID
	17:00	25.1	9.8	0.331	-0.4	0.0	-0.1	ID	ID	ID	ID
	18:00	24.4	9.7	0.306	-0.7	-0.1	-0.2	ID	ID	ID	ID
	19:00	23.8	9.3	0.288	-1.8	-0.3	0.3	ID	ID	ID	ID
	20:00	23.3	8.9	0.282	-1.9	-0.1	-0.1	ID	ID	ID	ID
	21:00	20.7	8.3	0.282	-1.9	0.0	-0.2	ID	ID	ID	ID
	22:00	21.3	8.4	0.285	-2.0	-0.1	-0.2	ID	ID	ID	ID
	23:00	20.0	8.2	ZS	-2.0	-0.1	0.1	ID	ID	ID	ID
	0:00	21.3	8.5	0.273	-2.0	0.0	-0.1	ID	ID	ID	ID
Min		**15.1**	**6.4**	**0.261**	**-2.3**	**-0.3**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**25.9**	**9.9**	**0.383**	**2.3**	**0.3**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**21.3**	**8.6**	**0.298**	**-1.2**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
08/02/2019	1:00	18.3	8.2	0.269	ZS	-0.1	-0.1	ID	ID	ID	ID
	2:00	17.8	7.7	0.269	-2.0	ZS	ZS	ID	ID	ID	ID
	3:00	23.1	9.3	0.264	-1.8	-0.1	0.1	ID	ID	ID	ID
	4:00	26.6	9.9	0.263	-2.2	-0.4	0.1	ID	ID	ID	ID
	5:00	26.9	10.1	0.256	-2.3	-0.1	-0.1	ID	ID	ID	ID
	6:00	26.9	10.0	0.258	-2.3	-0.1	-0.2	ID	ID	ID	ID
	7:00	25.0	9.3	0.265	-2.0	0.0	0.0	ID	ID	ID	ID
	8:00	24.5	8.9	0.295	-1.5	0.0	-0.1	ID	ID	ID	ID
	9:00	22.5	8.6	0.313	-0.8	0.2	-0.2	ID	ID	ID	ID
	10:00	22.0	8.4	0.279	-1.5	-0.1	-0.1	ID	ID	ID	ID
	11:00	20.4	7.7	0.276	-1.6	0.1	-0.1	ID	ID	ID	ID
	12:00	20.5	7.6	0.292	-1.4	0.1	-0.2	ID	ID	ID	ID
	13:00	20.0	7.7	0.303	-1.2	-0.1	0.1	ID	ID	ID	ID
	14:00	18.8	7.3	0.291	-1.4	0.0	-0.3	ID	ID	ID	ID
	15:00	20.0	7.6	0.282	-1.2	-0.2	0.0	ID	ID	ID	ID
	16:00	22.7	8.1	0.307	-0.8	-0.1	-0.2	ID	ID	ID	ID
	17:00	22.3	8.3	0.308	-0.7	-0.2	0.0	ID	ID	ID	ID
	18:00	22.6	8.5	0.366	-0.6	0.2	-0.4	ID	ID	ID	ID
	19:00	21.5	7.9	0.329	-1.1	0.1	-0.2	ID	ID	ID	ID
	20:00	20.7	7.7	0.310	-1.7	0.0	-0.1	ID	ID	ID	ID
	21:00	18.8	7.4	0.295	-1.7	-0.1	0.0	ID	ID	ID	ID
	22:00	18.7	7.3	0.288	-1.7	-0.3	0.1	ID	ID	ID	ID
	23:00	17.9	7.0	0.286	-1.8	-0.2	0.0	ID	ID	ID	ID
	0:00	17.6	7.6	0.379	ZS	-0.2	-0.1	ID	ID	ID	ID
Min		**17.6**	**7.0**	**0.256**	**-2.3**	**-0.4**	**-0.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**26.9**	**10.1**	**0.379**	**-0.6**	**0.2**	**0.1**	**ID**	**ID**	**ID**	**ID**
Average		**21.5**	**8.3**	**0.294**	**-1.5**	**-0.1**	**-0.1**	**ID**	**ID**	**ID**	**ID**
09/02/2019	1:00	24.8	13.0	0.348	-1.0	ZS	ZS	ID	ID	ID	ID
	2:00	15.6	6.8	0.298	-1.8	-0.2	0.0	ID	ID	ID	ID
	3:00	14.7	6.4	0.288	-1.2	-0.4	0.5	ID	ID	ID	ID
	4:00	17.2	7.1	0.289	-1.0	-0.1	0.1	ID	ID	ID	ID
	5:00	20.8	7.9	0.271	-2.1	-0.3	-0.1	ID	ID	ID	ID
	6:00	20.9	8.0	0.262	-2.2	-0.1	-0.1	ID	ID	ID	ID
	7:00	20.1	7.6	0.264	-2.0	-0.3	0.1	ID	ID	ID	ID
	8:00	20.2	7.4	0.264	-1.9	-0.4	0.1	ID	ID	ID	ID
	9:00	20.4	7.3	0.280	-1.7	0.2	-0.2	ID	ID	ID	ID
	10:00	18.2	7.3	0.280	-1.7	-0.1	0.0	ID	ID	ID	ID
	11:00	18.9	7.4	0.292	-1.7	0.0	0.1	ID	ID	ID	ID
	12:00	18.9	7.3	0.287	-1.8	0.0	-0.2	ID	ID	ID	ID
	13:00	17.8	6.8	0.295	-1.8	-0.2	0.2	ID	ID	ID	ID
	14:00	60.3	42.0	0.418	-0.6	0.0	0.3	ID	ID	ID	ID
	15:00	32.7	17.5	0.340	-1.2	0.4	-0.5	ID	ID	ID	ID
	16:00	19.0	8.3	0.306	-1.7	-0.3	0.1	ID	ID	ID	ID
	17:00	20.3	9.5	0.331	-1.5	0.0	0.0	ID	ID	ID	ID
	18:00	28.7	15.5	0.487	-0.5	0.0	0.0	ID	ID	ID	ID
	19:00	37.7	22.3	0.622	0.2	1.0	-0.2	ID	ID	ID	ID
	20:00	17.1	7.1	0.327	-1.8	0.3	-0.1	ID	ID	ID	ID
	21:00	18.7	9.1	0.364	-1.4	0.1	-0.2	ID	ID	ID	ID
	22:00	14.1	5.6	0.315	-1.7	-0.1	-0.1	ID	ID	ID	ID
	23:00	12.5	5.1	0.324	-1.5	-0.1	-0.2	ID	ID	ID	ID
	0:00	10.4	4.3	ZS	-1.6	ZS	ZS	ID	ID	ID	ID
Min		**10.4**	**4.3**	**0.262**	**-2.2**	**-0.4**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**60.3**	**42.0**	**0.622**	**0.2**	**1.0**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**21.7**	**10.3**	**0.328**	**-1.5**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
10/02/2019	1:00	9.8	4.1	0.307	-1.9	-0.2	-0.1	ID	ID	ID	ID
	2:00	11.7	4.9	0.293	ZS	-0.4	0.1	ID	ID	ID	ID
	3:00	13.5	5.4	0.293	-1.9	-0.5	0.0	ID	ID	ID	ID
	4:00	7.1	3.4	0.282	-2.1	-0.3	-0.1	ID	ID	ID	ID
	5:00	8.3	3.8	0.280	-2.2	-0.3	-0.3	ID	ID	ID	ID
	6:00	12.4	6.7	0.298	-1.5	-0.2	0.2	ID	ID	ID	ID
	7:00	13.0	7.2	0.308	-1.6	0.1	-0.2	ID	ID	ID	ID
	8:00	7.9	3.6	0.297	-1.5	0.0	0.1	ID	ID	ID	ID
	9:00	10.8	4.7	0.295	-1.8	0.2	0.1	ID	ID	ID	ID
	10:00	12.3	5.0	0.296	-1.9	-0.1	0.2	ID	ID	ID	ID
	11:00	12.0	4.8	0.292	-2.0	-0.1	0.2	ID	ID	ID	ID
	12:00	12.1	4.7	0.286	-2.1	-0.2	-0.1	ID	ID	ID	ID
	13:00	9.4	3.9	0.288	-2.1	-0.3	0.0	ID	ID	ID	ID
	14:00	13.5	5.2	0.301	-2.1	0.0	-0.2	ID	ID	ID	ID
	15:00	13.6	5.6	0.287	-2.1	-0.2	0.0	ID	ID	ID	ID
	16:00	20.5	10.0	0.382	-1.4	-0.1	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	20.0	10.4	0.403	-1.4	0.1	0.1	ID	ID	ID	ID
	18:00	20.9	9.3	0.389	-0.9	0.1	-0.1	ID	ID	ID	ID
	19:00	29.8	12.2	0.345	-1.3	0.1	0.1	ID	ID	ID	ID
	20:00	30.7	13.0	0.384	-1.6	0.2	-0.1	ID	ID	ID	ID
	21:00	30.6	12.3	0.446	-1.4	0.4	-0.3	ID	ID	ID	ID
	22:00	29.6	12.1	0.514	-0.1	0.2	0.2	ID	ID	ID	ID
	23:00	30.9	12.1	0.412	-0.4	0.3	0.0	ID	ID	ID	ID
	0:00	32.9	13.0	0.428	ZS	0.2	0.1	ID	ID	ID	ID
Min		**7.1**	**3.4**	**0.280**	**-2.2**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**32.9**	**13.0**	**0.514**	**-0.1**	**0.4**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**17.2**	**7.4**	**0.338**	**-1.6**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
11/02/2019	1:00	33.8	13.5	0.534	1.6	ZS	ZS	ID	ID	ID	ID
	2:00	33.9	14.0	0.309	-1.4	0.4	-0.1	ID	ID	ID	ID
	3:00	37.8	15.5	0.303	-2.0	0.0	0.0	ID	ID	ID	ID
	4:00	41.3	16.3	0.289	-1.9	0.0	0.2	ID	ID	ID	ID
	5:00	43.6	16.7	0.281	-2.1	0.0	0.1	ID	ID	ID	ID
	6:00	46.2	17.5	0.279	-2.2	0.0	-0.2	ID	ID	ID	ID
	7:00	53.6	19.8	0.286	-2.1	-0.1	-0.2	ID	ID	ID	ID
	8:00	55.8	20.3	0.306	-1.3	0.1	-0.1	ID	ID	ID	ID
	9:00	58.7	20.2	0.330	-0.7	0.1	0.1	ID	ID	ID	ID
	10:00	57.7	21.0	0.321	-1.1	0.2	0.0	ID	ID	ID	ID
	11:00	61.2	21.7	0.332	-0.6	0.3	0.0	ID	ID	ID	ID
	12:00	67.6	22.3	0.329	-0.6	0.2	0.1	ID	ID	ID	ID
	13:00	UM	UM	0.312	-1.0	0.0	0.2	ID	ID	ID	ID
	14:00	UM	UM	0.345	-0.7	0.2	0.0	ID	ID	ID	ID
	15:00	65.3	23.6	0.320	-0.9	0.1	0.0	ID	ID	ID	ID
	16:00	72.9	27.7	0.347	-1.0	0.1	0.3	ID	ID	ID	ID
	17:00	80.3	33.9	0.354	-0.8	0.3	-0.2	ID	ID	ID	ID
	18:00	56.9	25.7	0.397	1.2	0.4	-0.2	ID	ID	ID	ID
	19:00	59.2	23.3	0.328	0.4	0.2	-0.1	ID	ID	ID	ID
	20:00	46.2	18.3	0.352	1.0	-0.2	0.2	ID	ID	ID	ID
	21:00	55.7	21.3	0.364	1.8	0.0	0.2	ID	ID	ID	ID
	22:00	66.5	24.6	0.295	-1.8	0.0	-0.1	ID	ID	ID	ID
	23:00	76.2	28.4	ZS	-1.8	0.0	0.0	ID	ID	ID	ID
	0:00	77.7	28.9	ZS	ZS	-0.1	0.0	ID	ID	ID	ID
Min		**33.8**	**13.5**	**0.279**	**-2.2**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**80.3**	**33.9**	**0.534**	**1.8**	**0.4**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**56.7**	**21.6**	**0.332**	**-0.8**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
12/02/2019	1:00	79.4	29.7	0.280	ZS	-0.1	-0.1	ID	ID	ID	ID
	2:00	82.1	30.6	0.273	-2.1	ZS	ZS	ID	ID	ID	ID
	3:00	77.2	29.2	0.277	-2.1	-0.2	0.3	ID	ID	ID	ID
	4:00	60.3	23.3	0.288	-2.1	0.1	-0.1	ID	ID	ID	ID
	5:00	46.1	17.6	0.297	-1.4	-0.1	0.3	ID	ID	ID	ID
	6:00	40.5	15.5	0.286	-2.0	0.0	-0.1	ID	ID	ID	ID
	7:00	39.9	15.1	0.346	-0.4	0.1	-0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	30.1	12.0	0.569	6.4	0.6	0.4	ID	ID	ID	ID
	9:00	25.0	10.0	0.469	4.1	0.3	0.5	ID	ID	ID	ID
	10:00	27.9	10.4	0.390	2.1	0.5	0.0	ID	ID	ID	ID
	11:00	30.1	11.4	0.310	-0.6	0.1	0.1	ID	ID	ID	ID
	12:00	35.5	13.1	0.314	-0.9	0.1	0.2	ID	ID	ID	ID
	13:00	35.6	13.8	0.335	-0.4	0.1	0.1	ID	ID	ID	ID
	14:00	37.2	13.1	0.325	-0.5	0.2	0.1	ID	ID	ID	ID
	15:00	35.7	12.3	0.330	-0.4	0.0	0.1	ID	ID	ID	ID
	16:00	38.0	12.5	0.390	0.7	0.2	0.0	ID	ID	ID	ID
	17:00	33.5	12.1	0.356	0.0	0.1	-0.2	ID	ID	ID	ID
	18:00	34.0	12.4	0.315	-0.9	-0.1	0.1	ID	ID	ID	ID
	19:00	34.1	12.8	0.307	-1.6	0.0	0.0	ID	ID	ID	ID
	20:00	32.8	12.2	0.304	-1.7	-0.1	0.1	ID	ID	ID	ID
	21:00	32.0	12.1	0.300	-1.9	-0.1	0.1	ID	ID	ID	ID
	22:00	32.2	12.0	0.295	-1.9	-0.1	0.0	ID	ID	ID	ID
	23:00	29.4	11.3	0.297	ZS	0.0	0.0	ID	ID	ID	ID
	0:00	30.7	11.8	0.304	ZS	ZS	ZS	ID	ID	ID	ID
Min		**25.0**	**10.0**	**0.273**	**-2.1**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**82.1**	**30.6**	**0.569**	**6.4**	**0.6**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**40.8**	**15.3**	**0.332**	**-0.4**	**0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
13/02/2019	1:00	30.5	11.9	0.284	-1.9	ZS	ZS	ID	ID	ID	ID
	2:00	35.8	13.6	0.290	-2.0	-0.4	-0.1	ID	ID	ID	ID
	3:00	36.0	14.1	0.294	-2.2	-0.6	0.0	ID	ID	ID	ID
	4:00	35.3	13.9	0.292	-2.2	-0.3	-0.3	ID	ID	ID	ID
	5:00	34.7	14.1	0.304	-2.1	-0.3	0.2	ID	ID	ID	ID
	6:00	37.1	15.2	0.319	-1.9	-0.2	0.0	ID	ID	ID	ID
	7:00	30.9	12.5	0.342	0.2	-0.2	0.4	ID	ID	ID	ID
	8:00	28.2	11.1	0.618	5.8	0.4	0.7	ID	ID	ID	ID
	9:00	33.2	13.0	0.698	8.2	0.7	1.1	ID	ID	ID	ID
	10:00	33.4	13.2	0.457	2.6	0.1	0.8	ID	ID	ID	ID
	11:00	34.2	13.6	0.361	0.1	0.0	0.3	ID	ID	ID	ID
	12:00	33.3	12.7	0.333	-1.3	-0.4	-0.1	ID	ID	ID	ID
	13:00	29.2	11.5	0.338	-1.4	-0.4	0.1	ID	ID	ID	ID
	14:00	28.1	11.1	0.333	-1.5	-0.5	0.0	ID	ID	ID	ID
	15:00	27.2	10.9	0.326	-1.5	-0.5	0.1	ID	ID	ID	ID
	16:00	25.4	10.3	0.329	-1.5	-0.1	-0.4	ID	ID	ID	ID
	17:00	25.8	10.2	0.353	-1.3	-0.1	0.0	ID	ID	ID	ID
	18:00	25.7	10.4	0.341	-1.5	-0.4	-0.1	ID	ID	ID	ID
	19:00	26.6	10.6	0.335	-1.8	-0.1	0.1	ID	ID	ID	ID
	20:00	26.8	10.7	0.320	-1.9	-0.1	-0.1	ID	ID	ID	ID
	21:00	27.3	10.8	0.314	-2.1	-0.1	0.1	ID	ID	ID	ID
	22:00	27.4	11.0	0.318	-1.6	0.0	0.1	ID	ID	ID	ID
	23:00	26.5	10.8	0.311	-2.1	0.1	-0.1	ID	ID	ID	ID
	0:00	25.4	10.4	0.304	-2.1	ZS	ZS	ID	ID	ID	ID
Min		**25.4**	**10.2**	**0.284**	**-2.2**	**-0.6**	**-0.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**37.1**	**15.2**	**0.698**	**8.2**	**0.7**	**1.1**	**ID**	**ID**	**ID**	**ID**
Average		**30.2**	**12.0**	**0.355**	**-0.7**	**-0.2**	**0.1**	**ID**	**ID**	**ID**	**ID**
14/02/2019	1:00	26.0	10.2	0.294	-2.1	0.0	0.2	ID	ID	ID	ID
	2:00	23.7	9.7	0.291	ZS	0.0	0.1	ID	ID	ID	ID
	3:00	23.5	9.6	0.301	-1.6	0.1	0.3	ID	ID	ID	ID
	4:00	27.7	10.9	0.297	-2.1	0.1	-0.2	ID	ID	ID	ID
	5:00	19.8	8.4	0.313	-1.5	-0.3	0.4	ID	ID	ID	ID
	6:00	23.8	9.8	0.300	-1.9	0.0	0.0	ID	ID	ID	ID
	7:00	21.7	8.9	0.304	-2.1	-0.1	0.1	ID	ID	ID	ID
	8:00	24.2	9.7	0.353	-0.8	-0.1	0.1	ID	ID	ID	ID
	9:00	26.6	9.9	0.441	1.8	0.1	0.1	ID	ID	ID	ID
	10:00	26.3	10.3	0.332	-1.4	-0.2	0.2	ID	ID	ID	ID
	11:00	30.6	11.8	0.328	-1.6	-0.2	0.0	ID	ID	ID	ID
	12:00	31.6	12.3	0.323	-1.6	-0.4	0.1	ID	ID	ID	ID
	13:00	34.6	13.2	0.338	-1.5	-0.3	0.0	ID	ID	ID	ID
	14:00	29.1	11.5	0.398	0.2	-0.2	0.1	ID	ID	ID	ID
	15:00	33.9	11.9	0.379	-0.2	0.1	0.0	ID	ID	ID	ID
	16:00	33.9	12.3	0.390	-0.3	-0.1	0.0	ID	ID	ID	ID
	17:00	35.9	13.3	0.432	0.8	0.2	0.0	ID	ID	ID	ID
	18:00	34.7	13.4	0.480	1.1	0.3	-0.1	ID	ID	ID	ID
	19:00	33.8	13.8	0.520	1.5	0.5	-0.2	ID	ID	ID	ID
	20:00	37.2	14.8	0.421	-0.9	0.1	0.0	ID	ID	ID	ID
	21:00	34.6	14.1	0.412	-1.2	0.1	0.1	ID	ID	ID	ID
	22:00	33.4	13.3	0.422	-1.4	0.1	0.0	ID	ID	ID	ID
	23:00	34.3	13.7	0.396	-1.4	0.2	0.1	ID	ID	ID	ID
	0:00	33.7	12.8	0.367	-1.7	-0.2	0.0	ID	ID	ID	ID
Min		**19.8**	**8.4**	**0.291**	**-2.1**	**-0.4**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**37.2**	**14.8**	**0.520**	**1.8**	**0.5**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**29.8**	**11.6**	**0.368**	**-0.9**	**0.0**	**0.1**	**ID**	**ID**	**ID**	**ID**
15/02/2019	1:00	29.6	12.1	0.347	ZS	0.2	-0.1	ID	ID	ID	ID
	2:00	31.0	12.3	0.323	-1.5	ZS	ZS	ID	ID	ID	ID
	3:00	31.6	12.4	0.316	-1.9	0.2	-0.1	ID	ID	ID	ID
	4:00	33.3	12.9	0.323	-2.1	-0.1	0.1	ID	ID	ID	ID
	5:00	32.6	13.3	0.323	-2.2	-0.2	0.0	ID	ID	ID	ID
	6:00	34.2	13.8	0.330	-2.0	-0.3	0.2	ID	ID	ID	ID
	7:00	37.5	14.8	0.439	1.6	-0.1	0.3	ID	ID	ID	ID
	8:00	41.1	16.4	0.616	5.7	0.3	0.1	ID	ID	ID	ID
	9:00	42.8	16.8	0.598	5.7	0.3	0.0	ID	ID	ID	ID
	10:00	44.2	17.4	0.426	1.6	0.1	0.1	ID	ID	ID	ID
	11:00	43.8	17.6	0.473	2.6	-0.1	0.0	ID	ID	ID	ID
	12:00	41.4	17.3	0.392	0.0	-0.3	-0.2	ID	ID	ID	ID
	13:00	45.8	18.5	0.406	-0.2	-0.2	0.2	ID	ID	ID	ID
	14:00	53.5	21.1	0.441	0.7	0.1	-0.1	ID	ID	ID	ID
	15:00	58.1	22.6	0.477	2.1	0.2	0.0	ID	ID	ID	ID
	16:00	66.7	24.6	0.503	3.1	0.2	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	66.7	25.4	0.507	4.0	-0.1	0.1	ID	ID	ID	ID
	18:00	71.7	26.8	0.475	3.2	-0.4	0.3	ID	ID	ID	ID
	19:00	70.0	26.8	0.477	3.9	0.0	0.1	ID	ID	ID	ID
	20:00	69.4	26.1	0.433	1.8	-0.2	0.0	ID	ID	ID	ID
	21:00	69.2	26.1	0.419	1.7	-0.2	0.2	ID	ID	ID	ID
	22:00	68.9	25.9	0.391	0.6	-0.1	0.1	ID	ID	ID	ID
	23:00	69.1	25.9	0.375	0.0	-0.1	0.2	ID	ID	ID	ID
	0:00	68.1	25.5	0.379	ZS	0.1	0.1	ID	ID	ID	ID
Min		**29.6**	**12.1**	**0.316**	**-2.2**	**-0.4**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**71.7**	**26.8**	**0.616**	**5.7**	**0.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**50.9**	**19.7**	**0.425**	**1.3**	**0.0**	**0.1**	**ID**	**ID**	**ID**	**ID**
16/02/2019	1:00	66.0	25.4	0.343	-1.0	ZS	ZS	ID	ID	ID	ID
	2:00	66.3	24.9	0.343	-1.3	0.0	0.5	ID	ID	ID	ID
	3:00	64.4	24.7	0.332	-1.5	0.2	0.1	ID	ID	ID	ID
	4:00	63.5	24.6	0.328	-1.8	0.0	0.3	ID	ID	ID	ID
	5:00	62.9	24.0	0.333	-1.5	0.1	0.2	ID	ID	ID	ID
	6:00	62.1	24.4	0.354	-0.6	0.0	0.3	ID	ID	ID	ID
	7:00	60.9	23.6	0.431	3.1	0.2	0.2	ID	ID	ID	ID
	8:00	61.1	23.9	0.391	0.8	0.0	0.4	ID	ID	ID	ID
	9:00	57.8	22.5	0.396	0.5	0.1	0.2	ID	ID	ID	ID
	10:00	57.6	21.9	0.371	-0.8	0.1	0.1	ID	ID	ID	ID
	11:00	55.1	21.4	0.382	0.1	0.3	-0.2	ID	ID	ID	ID
	12:00	56.6	21.6	0.396	0.5	0.2	0.0	ID	ID	ID	ID
	13:00	55.3	21.1	0.375	-0.3	-0.1	0.2	ID	ID	ID	ID
	14:00	56.0	21.1	0.356	-1.2	0.0	0.1	ID	ID	ID	ID
	15:00	52.6	20.1	0.368	-0.3	0.0	-0.1	ID	ID	ID	ID
	16:00	50.1	19.4	0.417	1.2	0.1	-0.1	ID	ID	ID	ID
	17:00	48.6	18.9	0.433	1.8	0.2	0.1	ID	ID	ID	ID
	18:00	47.2	18.7	0.436	1.8	0.4	-0.1	ID	ID	ID	ID
	19:00	49.3	19.1	0.431	0.9	0.3	0.1	ID	ID	ID	ID
	20:00	46.7	18.9	0.382	-0.7	0.0	0.3	ID	ID	ID	ID
	21:00	46.6	18.5	0.383	-1.3	0.0	0.1	ID	ID	ID	ID
	22:00	45.7	18.3	0.396	-1.2	-0.1	0.3	ID	ID	ID	ID
	23:00	46.4	18.5	0.391	-1.2	0.0	-0.1	ID	ID	ID	ID
	0:00	44.4	17.6	0.367	-1.3	ZS	ZS	ID	ID	ID	ID
Min		**44.4**	**17.6**	**0.328**	**-1.8**	**-0.1**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**66.3**	**25.4**	**0.436**	**3.1**	**0.4**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**55.1**	**21.4**	**0.381**	**-0.2**	**0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
17/02/2019	1:00	45.6	17.6	0.345	-1.7	0.1	0.1	ID	ID	ID	ID
	2:00	46.6	17.7	0.348	ZS	0.0	-0.1	ID	ID	ID	ID
	3:00	44.6	16.9	0.340	-1.5	0.0	-0.1	ID	ID	ID	ID
	4:00	43.1	16.5	0.321	-1.9	0.1	-0.2	ID	ID	ID	ID
	5:00	38.2	15.2	0.310	-2.0	-0.3	0.0	ID	ID	ID	ID
	6:00	36.9	14.7	0.312	-2.0	-0.4	0.0	ID	ID	ID	ID
	7:00	33.1	13.9	0.326	-1.6	-0.4	-0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	33.6	13.7	0.336	-1.3	-0.5	-0.2	ID	ID	ID	ID
	9:00	33.3	13.4	0.331	-1.8	-0.3	0.0	ID	ID	ID	ID
	10:00	31.9	12.7	0.328	-1.9	-0.4	-0.1	ID	ID	ID	ID
	11:00	33.5	13.1	0.332	-1.7	-0.5	-0.1	ID	ID	ID	ID
	12:00	35.7	13.4	0.331	-1.9	-0.2	-0.2	ID	ID	ID	ID
	13:00	35.9	13.3	0.345	-1.1	-0.2	-0.1	ID	ID	ID	ID
	14:00	34.0	12.5	0.336	-1.5	0.0	-0.2	ID	ID	ID	ID
	15:00	33.7	12.6	0.330	-1.2	-0.2	0.0	ID	ID	ID	ID
	16:00	37.0	12.5	0.323	-1.4	-0.2	0.0	ID	ID	ID	ID
	17:00	33.8	12.5	0.339	-1.5	-0.2	0.1	ID	ID	ID	ID
	18:00	34.2	13.2	0.405	-0.7	-0.1	0.1	ID	ID	ID	ID
	19:00	34.1	13.4	0.447	0.1	0.1	-0.2	ID	ID	ID	ID
	20:00	34.5	13.6	0.418	-0.4	0.2	-0.2	ID	ID	ID	ID
	21:00	33.7	13.5	0.390	-0.7	-0.1	0.3	ID	ID	ID	ID
	22:00	35.3	13.6	0.431	1.1	0.1	0.1	ID	ID	ID	ID
	23:00	36.9	13.6	0.486	0.3	0.2	0.2	ID	ID	ID	ID
	0:00	35.5	14.6	0.452	ZS	0.3	-0.2	ID	ID	ID	ID
Min		**31.9**	**12.5**	**0.310**	**-2.0**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**46.6**	**17.7**	**0.486**	**1.1**	**0.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**36.4**	**14.1**	**0.361**	**-1.2**	**-0.1**	**-0.1**	**ID**	**ID**	**ID**	**ID**
18/02/2019	1:00	37.9	14.5	0.445	0.6	ZS	ZS	ID	ID	ID	ID
	2:00	39.6	14.1	0.341	-1.2	-0.2	-0.2	ID	ID	ID	ID
	3:00	36.4	13.4	0.312	-2.0	-0.5	-0.2	ID	ID	ID	ID
	4:00	36.0	13.6	0.316	-1.6	-0.5	0.1	ID	ID	ID	ID
	5:00	33.0	12.9	0.312	-1.8	-0.6	0.3	ID	ID	ID	ID
	6:00	32.6	12.8	0.317	-2.0	-0.6	0.0	ID	ID	ID	ID
	7:00	33.2	12.8	0.316	-1.9	-0.6	0.2	ID	ID	ID	ID
	8:00	39.4	12.9	0.375	-0.2	-0.4	0.1	ID	ID	ID	ID
	9:00	43.3	13.9	0.388	0.4	-0.2	-0.2	ID	ID	ID	ID
	10:00	38.7	15.7	0.355	-1.2	-0.5	0.3	ID	ID	ID	ID
	11:00	34.7	13.6	0.339	-1.3	-0.4	0.1	ID	ID	ID	ID
	12:00	106.8	61.2	0.521	1.0	0.4	0.1	ID	ID	ID	ID
	13:00	50.9	21.5	0.403	-0.8	0.3	-0.2	ID	ID	ID	ID
	14:00	66.5	30.8	0.411	0.2	0.6	-0.1	ID	ID	ID	ID
	15:00	49.0	15.6	0.375	-0.8	0.2	-0.1	ID	ID	ID	ID
	16:00	41.1	14.5	0.378	-0.7	0.0	-0.3	ID	ID	ID	ID
	17:00	39.7	14.8	0.402	-0.2	-0.2	0.2	ID	ID	ID	ID
	18:00	38.3	14.2	0.389	UM	0.1	-0.1	ID	ID	ID	ID
	19:00	37.0	14.4	0.370	UM	0.0	0.0	ID	ID	ID	ID
	20:00	41.3	17.4	0.364	UM	0.0	0.2	ID	ID	ID	ID
	21:00	35.8	13.7	0.357	UM	0.0	-0.1	ID	ID	ID	ID
	22:00	32.0	12.4	0.342	UM	-0.2	-0.2	ID	ID	ID	ID
	23:00	29.3	11.7	0.338	UM	-0.3	-0.1	ID	ID	ID	ID
	0:00	30.8	12.2	0.336	-0.7	-0.2	-0.1	ID	ID	ID	ID
Min		**29.3**	**11.7**	**0.312**	**-2.0**	**-0.6**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**106.8**	**61.2**	**0.521**	**1.0**	**0.6**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**41.8**	**16.9**	**0.367**	**-0.8**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
19/02/2019	1:00	30.6	12.0	0.326	ZS	-0.3	-0.1	ID	ID	ID	ID
	2:00	32.2	12.7	0.325	-1.2	ZS	ZS	ID	ID	ID	ID
	3:00	33.4	12.7	0.325	-1.5	-0.2	0.0	ID	ID	ID	ID
	4:00	34.6	12.4	0.318	-1.5	0.1	-0.3	ID	ID	ID	ID
	5:00	34.0	12.1	0.326	-1.6	0.0	-0.2	ID	ID	ID	ID
	6:00	29.9	11.7	0.331	-1.6	-0.1	-0.2	ID	ID	ID	ID
	7:00	29.2	11.2	0.332	-1.5	0.0	0.0	ID	ID	ID	ID
	8:00	28.4	10.9	0.370	-0.7	0.0	0.0	ID	ID	ID	ID
	9:00	27.9	10.4	0.387	-0.2	0.2	-0.2	ID	ID	ID	ID
	10:00	27.0	10.5	0.354	-0.7	0.1	-0.1	ID	ID	ID	ID
	11:00	24.4	10.1	0.371	-0.8	0.1	-0.1	ID	ID	ID	ID
	12:00	27.0	10.9	0.392	-0.8	0.0	-0.1	ID	ID	ID	ID
	13:00	31.1	11.7	0.422	-0.9	0.2	-0.1	ID	ID	ID	ID
	14:00	29.7	10.4	0.384	-0.9	0.1	0.0	ID	ID	ID	ID
	15:00	35.0	10.8	0.380	-0.5	-0.1	0.1	ID	ID	ID	ID
	16:00	30.7	9.8	0.398	0.2	0.1	-0.2	ID	ID	ID	ID
	17:00	29.3	9.9	0.412	-0.1	0.0	-0.1	ID	ID	ID	ID
	18:00	UM	UM	0.406	-0.4	0.2	0.0	ID	ID	ID	ID
	19:00	UM	UM	0.395	-0.8	-0.1	0.2	ID	ID	ID	ID
	20:00	UM	UM	0.391	-1.2	0.1	-0.3	ID	ID	ID	ID
	21:00	UM	UM	0.393	-1.3	0.1	-0.3	ID	ID	ID	ID
	22:00	UM	UM	0.393	-1.2	0.0	0.2	ID	ID	ID	ID
	23:00	UM	UM	0.387	-1.3	0.0	0.0	ID	ID	ID	ID
	0:00	UM	UM	0.439	ZS	0.1	-0.3	ID	ID	ID	ID
Min		**24.4**	**9.8**	**0.318**	**-1.6**	**-0.3**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**35.0**	**12.7**	**0.439**	**0.2**	**0.2**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**30.3**	**11.2**	**0.373**	**-0.9**	**0.0**	**-0.1**	**ID**	**ID**	**ID**	**ID**
20/02/2019	1:00	UM	UM	0.438	-1.3	ZS	ZS	ID	ID	ID	ID
	2:00	UM	UM	0.401	-1.6	0.0	0.0	ID	ID	ID	ID
	3:00	UM	UM	0.384	-1.6	-0.3	0.1	ID	ID	ID	ID
	4:00	UM	UM	0.390	-1.7	-0.2	0.2	ID	ID	ID	ID
	5:00	UM	UM	PO	PO	PO	PO	ID	ID	ID	ID
	6:00	26.2	9.8	0.579	-1.7	0.0	-0.2	ID	ID	ID	ID
	7:00	27.1	9.9	0.557	-0.9	0.0	0.2	ID	ID	ID	ID
	8:00	26.9	9.5	0.570	-0.8	-0.1	-0.1	ID	ID	ID	ID
	9:00	21.7	8.7	0.580	-0.2	-0.1	0.0	ID	ID	ID	ID
	10:00	21.2	8.5	0.550	-0.2	-0.1	0.0	ID	ID	ID	ID
	11:00	21.1	8.1	0.535	-0.7	-0.1	0.1	ID	ID	ID	ID
	12:00	23.2	8.9	0.542	-0.5	0.0	0.0	ID	ID	ID	ID
	13:00	19.8	7.6	0.555	0.3	-0.2	0.2	ID	ID	ID	ID
	14:00	27.0	9.6	0.529	-1.0	-0.1	-0.1	ID	ID	ID	ID
	15:00	30.4	11.1	0.514	-0.9	-0.1	-0.1	ID	ID	ID	ID
	16:00	35.4	11.2	0.558	-0.1	-0.1	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	35.7	12.0	0.553	-0.3	-0.2	-0.1	ID	ID	ID	ID
	18:00	35.3	12.5	0.535	-0.3	0.0	0.0	ID	ID	ID	ID
	19:00	37.4	12.8	0.517	-1.0	-0.1	0.0	ID	ID	ID	ID
	20:00	34.3	12.2	0.507	-1.3	0.0	-0.1	ID	ID	ID	ID
	21:00	32.2	11.3	0.497	-1.4	-0.1	-0.1	ID	ID	ID	ID
	22:00	28.1	10.2	0.488	-1.2	-0.1	0.0	ID	ID	ID	ID
	23:00	27.1	10.4	0.483	-1.5	-0.3	0.0	ID	ID	ID	ID
	0:00	30.2	11.8	0.482	-1.6	ZS	ZS	ID	ID	ID	ID
Min		**19.8**	**7.6**	**0.384**	**-1.7**	**-0.3**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**37.4**	**12.8**	**0.580**	**0.3**	**0.0**	**0.2**	**ID**	**ID**	**ID**	**ID**
Average		**28.4**	**10.3**	**0.511**	**-0.9**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
21/02/2019	1:00	32.7	12.2	0.478	-1.6	0.0	0.1	ID	ID	ID	ID
	2:00	32.0	11.5	0.461	ZS	-0.2	0.2	ID	ID	ID	ID
	3:00	33.1	11.7	0.455	-1.5	0.0	-0.2	ID	ID	ID	ID
	4:00	33.6	12.0	0.455	-1.6	-0.1	0.0	ID	ID	ID	ID
	5:00	37.2	12.8	0.450	-1.6	-0.2	-0.2	ID	ID	ID	ID
	6:00	35.2	12.3	0.447	-1.7	-0.4	0.0	ID	ID	ID	ID
	7:00	34.3	12.0	0.446	-1.7	-0.3	-0.1	ID	ID	ID	ID
	8:00	35.1	12.3	0.473	-0.9	-0.3	0.1	ID	ID	ID	ID
	9:00	32.7	12.1	0.480	-0.4	0.1	-0.4	ID	ID	ID	ID
	10:00	29.4	11.1	0.468	-1.0	-0.1	0.3	ID	ID	ID	ID
	11:00	27.3	10.3	0.469	-1.1	0.0	-0.3	ID	ID	ID	ID
	12:00	26.8	10.3	0.450	-1.0	-0.1	0.0	ID	ID	ID	ID
	13:00	25.9	9.9	0.454	-1.1	-0.2	0.0	ID	ID	ID	ID
	14:00	26.4	9.8	0.451	-0.9	0.0	-0.4	ID	ID	ID	ID
	15:00	28.4	9.3	0.449	-1.0	-0.1	0.0	ID	ID	ID	ID
	16:00	34.6	10.3	0.454	-0.6	-0.3	0.2	ID	ID	ID	ID
	17:00	32.2	9.3	0.474	0.0	-0.1	0.0	ID	ID	ID	ID
	18:00	25.9	8.3	0.452	-0.4	-0.1	-0.2	ID	ID	ID	ID
	19:00	24.9	7.1	0.435	-0.8	-0.1	0.1	ID	ID	ID	ID
	20:00	19.6	6.2	0.427	-1.1	0.0	-0.3	ID	ID	ID	ID
	21:00	17.2	5.5	0.428	-1.3	-0.4	-0.1	ID	ID	ID	ID
	22:00	14.7	5.3	0.424	-1.2	-0.4	0.4	ID	ID	ID	ID
	23:00	13.2	5.2	0.426	-1.3	-0.2	0.0	ID	ID	ID	ID
	0:00	14.9	5.9	ZS	ZS	-0.4	0.2	ID	ID	ID	ID
Min		**13.2**	**5.2**	**0.424**	**-1.7**	**-0.4**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**37.2**	**12.8**	**0.480**	**0.0**	**0.1**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**27.8**	**9.7**	**0.452**	**-1.1**	**-0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
22/02/2019	1:00	15.0	5.6	0.412	ZS	0.0	-0.1	ID	ID	ID	ID
	2:00	17.1	6.0	0.413	-1.2	ZS	ZS	ID	ID	ID	ID
	3:00	17.7	6.3	0.420	-1.5	-0.3	0.3	ID	ID	ID	ID
	4:00	21.5	6.8	0.417	-1.7	-0.5	0.6	ID	ID	ID	ID
	5:00	21.5	6.8	0.412	-1.7	-0.4	-0.2	ID	ID	ID	ID
	6:00	21.7	6.7	0.411	-1.7	-0.3	-0.1	ID	ID	ID	ID
	7:00	18.6	6.1	0.411	-1.6	-0.3	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	17.0	5.8	0.443	-0.4	-0.3	0.0	ID	ID	ID	ID
	9:00	17.4	5.7	0.465	0.5	0.0	0.2	ID	ID	ID	ID
	10:00	16.0	5.4	0.430	-0.5	0.0	0.0	ID	ID	ID	ID
	11:00	15.3	5.1	0.433	-0.8	-0.2	0.1	ID	ID	ID	ID
	12:00	13.6	4.9	0.422	-0.7	0.0	-0.3	ID	ID	ID	ID
	13:00	13.7	4.7	0.422	-0.8	-0.2	0.1	ID	ID	ID	ID
	14:00	14.5	4.8	0.426	-0.9	-0.2	0.1	ID	ID	ID	ID
	15:00	14.1	4.9	0.420	-0.4	-0.2	-0.1	ID	ID	ID	ID
	16:00	20.1	5.5	0.425	-0.4	-0.2	-0.1	ID	ID	ID	ID
	17:00	17.4	5.2	0.435	-0.3	-0.1	0.0	ID	ID	ID	ID
	18:00	16.0	4.9	0.446	0.4	-0.1	-0.2	ID	ID	ID	ID
	19:00	17.1	5.1	0.490	2.0	0.0	0.2	ID	ID	ID	ID
	20:00	14.7	4.8	0.441	-0.2	0.0	0.0	ID	ID	ID	ID
	21:00	16.0	4.9	0.467	0.2	0.0	-0.1	ID	ID	ID	ID
	22:00	14.7	4.8	0.436	-1.2	0.0	0.2	ID	ID	ID	ID
	23:00	13.6	5.0	0.442	-1.2	-0.1	0.2	ID	ID	ID	ID
	0:00	12.0	4.6	0.440	ZS	ZS	ZS	ID	ID	ID	ID
Min		**12.0**	**4.6**	**0.411**	**-1.7**	**-0.5**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**21.7**	**6.8**	**0.490**	**2.0**	**0.0**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**16.5**	**5.4**	**0.432**	**-0.6**	**-0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
23/02/2019	1:00	12.7	4.8	0.439	-1.1	ZS	ZS	ID	ID	ID	ID
	2:00	12.9	5.0	0.428	-1.3	-0.1	0.0	ID	ID	ID	ID
	3:00	14.5	5.6	0.426	-1.4	-0.2	0.0	ID	ID	ID	ID
	4:00	16.4	6.1	0.428	-1.5	-0.1	0.0	ID	ID	ID	ID
	5:00	17.0	5.8	0.420	-1.6	-0.2	0.1	ID	ID	ID	ID
	6:00	18.0	6.2	0.434	-1.5	-0.3	0.0	ID	ID	ID	ID
	7:00	18.3	6.4	0.443	-1.2	0.0	0.0	ID	ID	ID	ID
	8:00	17.9	6.2	0.469	-0.8	-0.1	-0.1	ID	ID	ID	ID
	9:00	18.8	6.2	0.530	0.7	-0.1	0.0	ID	ID	ID	ID
	10:00	19.0	5.9	0.533	0.9	0.1	0.0	ID	ID	ID	ID
	11:00	19.6	6.0	0.524	0.5	0.2	-0.2	ID	ID	ID	ID
	12:00	17.2	5.3	0.556	1.0	0.1	0.0	ID	ID	ID	ID
	13:00	17.2	4.9	0.607	1.3	0.1	-0.1	ID	ID	ID	ID
	14:00	25.7	9.4	0.700	1.1	0.4	-0.2	ID	ID	ID	ID
	15:00	46.4	22.9	0.903	2.0	0.5	-0.1	ID	ID	ID	ID
	16:00	19.3	5.6	0.933	1.9	0.4	-0.2	ID	ID	ID	ID
	17:00	28.8	11.4	0.998	2.7	0.6	-0.2	ID	ID	ID	ID
	18:00	27.9	10.9	0.934	1.4	0.7	0.0	ID	ID	ID	ID
	19:00	49.0	30.9	0.952	0.7	1.2	-0.5	ID	ID	ID	ID
	20:00	38.3	21.9	0.958	0.4	1.1	-0.3	ID	ID	ID	ID
	21:00	30.1	13.7	0.967	0.5	0.4	0.1	ID	ID	ID	ID
	22:00	37.5	19.8	1.106	0.9	0.6	-0.1	ID	ID	ID	ID
	23:00	26.9	10.1	0.924	0.7	0.5	0.1	ID	ID	ID	ID
	0:00	21.9	9.3	0.868	1.6	ZS	ZS	ID	ID	ID	ID
Min		**12.7**	**4.8**	**0.420**	**-1.6**	**-0.3**	**-0.5**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**49.0**	**30.9**	**1.106**	**2.7**	**1.2**	**0.1**	**ID**	**ID**	**ID**	**ID**
Average		**23.8**	**10.0**	**0.687**	**0.3**	**0.3**	**-0.1**	**ID**	**ID**	**ID**	**ID**
24/02/2019	1:00	20.7	8.6	0.696	-0.2	0.2	0.0	ID	ID	ID	ID
	2:00	16.7	6.1	0.516	ZS	0.1	-0.2	ID	ID	ID	ID
	3:00	16.6	6.1	0.471	-1.3	-0.1	0.1	ID	ID	ID	ID
	4:00	20.6	7.0	0.457	-1.5	0.0	0.1	ID	ID	ID	ID
	5:00	18.8	6.0	0.439	-1.5	-0.2	0.0	ID	ID	ID	ID
	6:00	19.0	6.5	0.443	-1.6	0.0	-0.3	ID	ID	ID	ID
	7:00	19.7	5.9	0.422	-1.6	-0.2	0.1	ID	ID	ID	ID
	8:00	40.0	18.9	0.489	-0.5	0.2	-0.1	ID	ID	ID	ID
	9:00	27.2	10.0	0.468	-1.3	-0.1	-0.1	ID	ID	ID	ID
	10:00	63.8	36.3	0.491	-0.6	0.5	-0.3	ID	ID	ID	ID
	11:00	47.3	24.2	0.444	-1.2	0.2	-0.2	ID	ID	ID	ID
	12:00	18.6	6.9	0.437	-1.5	-0.2	-0.1	ID	ID	ID	ID
	13:00	17.0	6.4	0.431	-1.5	-0.2	0.0	ID	ID	ID	ID
	14:00	13.8	4.9	0.427	-1.4	-0.1	0.1	ID	ID	ID	ID
	15:00	34.8	5.5	0.425	-1.3	-0.3	0.3	ID	ID	ID	ID
	16:00	50.5	33.9	0.665	1.8	2.9	0.0	ID	ID	ID	ID
	17:00	21.2	8.4	0.448	-0.7	0.5	0.1	ID	ID	ID	ID
	18:00	15.0	5.0	0.444	-1.2	-0.1	0.2	ID	ID	ID	ID
	19:00	20.9	7.6	0.556	-0.4	0.0	-0.1	ID	ID	ID	ID
	20:00	20.2	7.6	0.598	0.4	0.0	-0.1	ID	ID	ID	ID
	21:00	19.9	7.3	0.616	0.8	0.3	-0.1	ID	ID	ID	ID
	22:00	18.4	7.5	0.752	2.0	0.4	0.5	ID	ID	ID	ID
	23:00	20.3	7.3	ZS	0.7	0.3	0.2	ID	ID	ID	ID
	0:00	18.4	7.6	0.599	ZS	0.3	-0.2	ID	ID	ID	ID
Min		**13.8**	**4.9**	**0.422**	**-1.6**	**-0.3**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**63.8**	**36.3**	**0.752**	**2.0**	**2.9**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**25.0**	**10.5**	**0.510**	**-0.6**	**0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
25/02/2019	1:00	20.9	5.9	0.571	1.7	ZS	ZS	ID	ID	ID	ID
	2:00	17.6	5.6	0.451	-0.4	0.1	0.0	ID	ID	ID	ID
	3:00	14.1	4.6	0.440	-1.1	-0.1	0.5	ID	ID	ID	ID
	4:00	14.8	4.7	0.414	-1.2	-0.1	0.0	ID	ID	ID	ID
	5:00	14.7	5.1	0.416	-1.5	-0.1	0.0	ID	ID	ID	ID
	6:00	15.1	5.1	0.415	-1.6	-0.1	-0.2	ID	ID	ID	ID
	7:00	16.5	5.5	0.434	-1.1	-0.1	0.1	ID	ID	ID	ID
	8:00	22.0	6.2	0.474	-0.1	-0.1	0.3	ID	ID	ID	ID
	9:00	31.2	7.4	0.515	1.0	0.0	0.1	ID	ID	ID	ID
	10:00	28.9	10.5	0.507	0.6	0.1	0.2	ID	ID	ID	ID
	11:00	42.7	21.7	0.526	0.8	0.7	-0.1	ID	ID	ID	ID
	12:00	83.0	43.9	0.546	1.4	1.0	-0.2	ID	ID	ID	ID
	13:00	46.5	21.5	0.530	0.0	0.8	-0.2	ID	ID	ID	ID
	14:00	63.9	39.5	0.665	3.9	1.7	-0.3	ID	ID	ID	ID
	15:00	48.8	29.3	0.690	0.1	1.2	-0.3	ID	ID	ID	ID
	16:00	23.9	8.1	0.519	-0.4	0.4	-0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	21.5	7.2	0.523	-0.6	0.1	0.1	ID	ID	ID	ID
	18:00	21.2	7.2	0.495	-0.7	-0.1	0.1	ID	ID	ID	ID
	19:00	20.0	7.3	0.491	-1.1	-0.2	0.2	ID	ID	ID	ID
	20:00	20.8	8.4	0.490	-1.2	-0.2	0.0	ID	ID	ID	ID
	21:00	20.8	7.5	0.462	-1.4	-0.1	-0.2	ID	ID	ID	ID
	22:00	21.5	7.2	0.465	-1.4	-0.1	0.0	ID	ID	ID	ID
	23:00	20.2	7.3	0.470	-1.4	0.1	-0.4	ID	ID	ID	ID
	0:00	19.8	7.4	0.466	-1.2	0.0	-0.1	ID	ID	ID	ID
Min		**14.1**	**4.6**	**0.414**	**-1.6**	**-0.2**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**83.0**	**43.9**	**0.690**	**3.9**	**1.7**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**27.9**	**11.8**	**0.499**	**-0.3**	**0.2**	**0.0**	**ID**	**ID**	**ID**	**ID**
26/02/2019	1:00	18.2	6.9	0.464	ZS	-0.1	0.1	ID	ID	ID	ID
	2:00	18.6	6.9	0.457	-1.4	ZS	ZS	ID	ID	ID	ID
	3:00	17.8	7.0	0.463	-1.6	-0.1	0.0	ID	ID	ID	ID
	4:00	18.8	7.2	0.467	-1.5	-0.1	0.0	ID	ID	ID	ID
	5:00	19.5	7.5	0.468	-1.7	0.0	0.0	ID	ID	ID	ID
	6:00	23.1	8.9	0.470	-1.6	-0.3	0.1	ID	ID	ID	ID
	7:00	19.9	8.0	0.472	-1.7	0.0	0.0	ID	ID	ID	ID
	8:00	22.8	9.0	0.508	-1.1	-0.2	0.2	ID	ID	ID	ID
	9:00	25.2	9.4	0.504	-0.4	0.1	-0.2	ID	ID	ID	ID
	10:00	25.7	9.2	0.495	-0.7	0.0	0.2	ID	ID	ID	ID
	11:00	26.3	9.7	0.486	-1.4	0.0	-0.1	ID	ID	ID	ID
	12:00	27.1	9.9	0.501	-1.0	0.1	-0.2	ID	ID	ID	ID
	13:00	26.5	10.1	0.498	-1.0	-0.1	0.2	ID	ID	ID	ID
	14:00	27.8	10.1	0.531	-0.8	0.1	0.3	ID	ID	ID	ID
	15:00	30.4	11.1	0.542	-0.9	0.2	0.0	ID	ID	ID	ID
	16:00	28.6	10.1	0.510	-0.9	0.2	0.2	ID	ID	ID	ID
	17:00	25.6	9.7	0.521	-1.1	0.2	-0.2	ID	ID	ID	ID
	18:00	26.3	9.8	0.500	-1.0	-0.1	0.0	ID	ID	ID	ID
	19:00	25.3	9.8	0.496	-1.4	-0.1	-0.1	ID	ID	ID	ID
	20:00	27.0	10.1	0.489	-1.5	-0.1	-0.1	ID	ID	ID	ID
	21:00	28.6	10.1	0.490	-1.4	0.0	0.1	ID	ID	ID	ID
	22:00	31.0	11.1	0.488	-1.4	-0.1	0.2	ID	ID	ID	ID
	23:00	33.6	12.0	0.494	-1.3	0.0	-0.2	ID	ID	ID	ID
	0:00	33.5	12.4	ZS	ZS	0.0	-0.1	ID	ID	ID	ID
Min		**17.8**	**6.9**	**0.457**	**-1.7**	**-0.3**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**33.6**	**12.4**	**0.542**	**-0.4**	**0.2**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**25.3**	**9.4**	**0.492**	**-1.2**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
27/02/2019	1:00	32.9	12.9	0.480	-1.5	ZS	ZS	ID	ID	ID	ID
	2:00	34.2	13.1	0.498	-1.6	0.2	-0.4	ID	ID	ID	ID
	3:00	36.9	13.8	0.489	-1.7	0.0	-0.1	ID	ID	ID	ID
	4:00	37.0	14.4	0.494	-1.7	-0.2	0.2	ID	ID	ID	ID
	5:00	40.6	15.4	0.492	-1.6	-0.1	0.4	ID	ID	ID	ID
	6:00	42.4	16.3	0.494	-1.6	-0.2	0.2	ID	ID	ID	ID
	7:00	44.6	16.9	0.498	-1.5	-0.2	0.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	49.4	18.3	0.569	1.0	0.1	0.4	ID	ID	ID	ID
	9:00	53.0	19.2	0.564	0.7	0.0	0.2	ID	ID	ID	ID
	10:00	51.5	18.8	0.515	-1.0	-0.2	0.2	ID	ID	ID	ID
	11:00	49.3	18.7	0.509	-0.9	0.0	-0.1	ID	ID	ID	ID
	12:00	50.9	19.2	0.507	-1.3	-0.3	0.2	ID	ID	ID	ID
	13:00	55.5	20.8	0.517	-1.0	-0.1	0.1	ID	ID	ID	ID
	14:00	56.4	20.1	0.514	-1.0	0.0	0.3	ID	ID	ID	ID
	15:00	55.5	21.2	0.515	-1.2	0.0	0.2	ID	ID	ID	ID
	16:00	56.3	21.4	0.526	-0.6	0.0	-0.2	ID	ID	ID	ID
	17:00	51.6	20.0	0.537	-1.0	0.2	-0.2	ID	ID	ID	ID
	18:00	55.8	21.1	0.531	-0.7	-0.1	-0.2	ID	ID	ID	ID
	19:00	58.4	21.9	0.509	-1.1	-0.2	0.2	ID	ID	ID	ID
	20:00	62.1	23.3	0.517	-1.0	0.0	0.0	ID	ID	ID	ID
	21:00	63.3	23.8	0.515	-1.3	0.0	-0.3	ID	ID	ID	ID
	22:00	60.3	22.8	0.523	-1.4	-0.2	0.0	ID	ID	ID	ID
	23:00	61.1	23.2	0.509	-1.5	-0.2	-0.1	ID	ID	ID	ID
	0:00	60.6	22.7	0.517	-1.4	ZS	ZS	ID	ID	ID	ID
Min		**32.9**	**12.9**	**0.480**	**-1.7**	**-0.3**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**63.3**	**23.8**	**0.569**	**1.0**	**0.2**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**50.8**	**19.1**	**0.514**	**-1.1**	**-0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
28/02/2019	1:00	59.4	22.5	0.498	-1.7	-0.1	0.0	ID	ID	ID	ID
	2:00	59.0	22.2	0.494	ZS	-0.1	-0.3	ID	ID	ID	ID
	3:00	57.8	22.3	0.493	-1.3	-0.1	0.1	ID	ID	ID	ID
	4:00	56.8	21.8	0.490	-1.5	-0.3	0.5	ID	ID	ID	ID
	5:00	55.4	21.3	0.489	-1.5	-0.1	0.2	ID	ID	ID	ID
	6:00	52.4	20.6	0.486	-1.6	-0.1	0.0	ID	ID	ID	ID
	7:00	50.5	19.9	0.497	-1.6	-0.1	0.1	ID	ID	ID	ID
	8:00	50.7	19.7	0.527	-0.5	0.0	0.3	ID	ID	ID	ID
	9:00	53.7	19.6	0.548	0.6	0.1	0.1	ID	ID	ID	ID
	10:00	51.5	18.9	0.512	-1.0	0.1	0.0	ID	ID	ID	ID
	11:00	47.8	17.7	0.506	-0.9	-0.1	0.0	ID	ID	ID	ID
	12:00	43.9	17.2	0.506	-0.9	-0.1	0.2	ID	ID	ID	ID
	13:00	45.3	16.4	0.505	-0.7	0.2	-0.3	ID	ID	ID	ID
	14:00	44.4	16.0	0.533	0.5	0.2	0.7	ID	ID	ID	ID
	15:00	38.8	15.4	0.555	0.7	0.1	0.2	ID	ID	ID	ID
	16:00	39.1	14.3	0.513	-0.3	0.1	0.1	ID	ID	ID	ID
	17:00	41.8	14.8	0.554	0.8	0.0	0.0	ID	ID	ID	ID
	18:00	40.8	14.0	0.599	2.7	-0.1	0.5	ID	ID	ID	ID
	19:00	38.3	14.8	0.579	2.1	0.3	0.1	ID	ID	ID	ID
	20:00	34.4	13.3	0.508	-0.4	0.1	0.0	ID	ID	ID	ID
	21:00	38.1	14.2	0.493	-1.0	-0.2	0.2	ID	ID	ID	ID
	22:00	41.7	15.6	0.491	-1.3	0.0	0.0	ID	ID	ID	ID
	23:00	43.8	16.1	0.497	-1.3	0.1	-0.2	ID	ID	ID	ID
	0:00	41.0	15.4	0.480	-1.5	-0.1	0.0	ID	ID	ID	ID
Min		**34.4**	**13.3**	**0.480**	**-1.7**	**-0.3**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**59.4**	**22.5**	**0.599**	**2.7**	**0.3**	**0.7**	**ID**	**ID**	**ID**	**ID**
Average		**46.9**	**17.7**	**0.515**	**-0.5**	**0.0**	**0.1**	**ID**	**ID**	**ID**	**ID**
01/03/2019	1:00	41.0	14.7	0.474	ZS	-0.1	0.1	ID	ID	ID	ID
	2:00	36.3	14.0	0.472	-1.2	ZS	ZS	ID	ID	ID	ID
	3:00	35.8	13.7	0.474	-1.3	-0.1	0.6	ID	ID	ID	ID
	4:00	37.6	13.9	0.483	-1.1	0.0	0.7	ID	ID	ID	ID
	5:00	37.1	14.3	0.493	-0.6	-0.3	1.2	ID	ID	ID	ID
	6:00	42.1	15.9	0.493	0.9	0.0	0.8	ID	ID	ID	ID
	7:00	44.9	17.0	0.542	1.2	0.1	1.8	ID	ID	ID	ID
	8:00	47.7	18.0	0.567	1.0	0.0	0.5	ID	ID	ID	ID
	9:00	56.8	19.8	0.547	0.6	0.0	-0.2	ID	ID	ID	ID
	10:00	56.0	20.2	0.528	-0.6	-0.1	0.1	ID	ID	ID	ID
	11:00	48.9	18.0	0.533	-0.4	0.0	0.3	ID	ID	ID	ID
	12:00	42.2	15.8	0.515	-0.8	0.0	0.1	ID	ID	ID	ID
	13:00	34.4	12.8	0.520	-0.6	0.2	-0.4	ID	ID	ID	ID
	14:00	39.2	14.3	0.523	-0.6	0.0	-0.1	ID	ID	ID	ID
	15:00	47.2	17.2	0.513	-0.4	0.0	0.0	ID	ID	ID	ID
	16:00	52.3	18.7	0.572	0.7	0.2	-0.1	ID	ID	ID	ID
	17:00	53.1	19.7	0.573	0.8	0.1	-0.3	ID	ID	ID	ID
	18:00	54.6	20.5	0.541	0.1	0.1	-0.2	ID	ID	ID	ID
	19:00	49.4	19.3	0.532	-0.7	0.0	0.1	ID	ID	ID	ID
	20:00	53.3	20.2	0.515	-0.8	-0.1	-0.2	ID	ID	ID	ID
	21:00	54.5	20.5	0.515	-1.1	-0.1	-0.2	ID	ID	ID	ID
	22:00	60.1	22.0	0.519	-1.3	-0.1	-0.1	ID	ID	ID	ID
	23:00	62.4	23.1	0.519	-0.6	-0.2	0.4	ID	ID	ID	ID
	0:00	68.5	24.9	0.532	ZS	-0.2	0.1	ID	ID	ID	ID
Min		**34.4**	**12.8**	**0.472**	**-1.3**	**-0.3**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**68.5**	**24.9**	**0.573**	**1.2**	**0.2**	**1.8**	**ID**	**ID**	**ID**	**ID**
Average		**48.1**	**17.9**	**0.521**	**-0.3**	**0.0**	**0.2**	**ID**	**ID**	**ID**	**ID**
02/03/2019	1:00	68.1	25.1	0.511	-1.0	ZS	ZS	ID	ID	ID	ID
	2:00	64.4	23.5	0.497	-1.4	0.0	0.0	ID	ID	ID	ID
	3:00	58.1	21.8	0.505	-1.1	0.0	0.2	ID	ID	ID	ID
	4:00	51.9	19.8	0.500	-1.1	-0.2	0.3	ID	ID	ID	ID
	5:00	52.7	20.0	0.508	-1.1	0.0	0.2	ID	ID	ID	ID
	6:00	55.8	20.9	0.492	-1.5	-0.2	0.2	ID	ID	ID	ID
	7:00	54.1	20.5	0.525	-0.2	-0.2	0.4	ID	ID	ID	ID
	8:00	53.6	20.0	0.565	1.2	0.1	0.8	ID	ID	ID	ID
	9:00	56.9	20.9	0.581	0.7	0.1	0.2	ID	ID	ID	ID
	10:00	56.8	20.0	0.571	-0.2	0.2	0.1	ID	ID	ID	ID
	11:00	69.9	20.7	0.590	-0.6	0.2	0.1	ID	ID	ID	ID
	12:00	83.0	21.1	0.591	-0.5	0.4	-0.2	ID	ID	ID	ID
	13:00	51.8	18.0	0.510	-1.0	0.0	0.6	ID	ID	ID	ID
	14:00	54.9	18.1	0.504	-1.1	-0.1	0.0	ID	ID	ID	ID
	15:00	48.3	17.3	0.508	-0.6	-0.2	0.1	ID	ID	ID	ID
	16:00	43.1	15.7	0.513	-0.7	0.0	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	32.8	13.0	0.606	3.4	0.0	0.1	ID	ID	ID	ID
	18:00	38.9	14.9	0.596	1.9	0.2	-0.1	ID	ID	ID	ID
	19:00	36.6	15.4	0.671	4.3	0.3	0.2	ID	ID	ID	ID
	20:00	40.3	15.2	0.557	-0.7	0.1	-0.1	ID	ID	ID	ID
	21:00	50.0	18.6	0.568	-0.4	0.0	0.0	ID	ID	ID	ID
	22:00	52.0	19.8	0.552	-1.0	0.0	-0.2	ID	ID	ID	ID
	23:00	50.0	19.5	0.567	-0.9	0.0	0.0	ID	ID	ID	ID
	0:00	54.5	20.6	0.552	-1.0	ZS	ZS	ID	ID	ID	ID
Min		**32.8**	**13.0**	**0.492**	**-1.5**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**83.0**	**25.1**	**0.671**	**4.3**	**0.4**	**0.8**	**ID**	**ID**	**ID**	**ID**
Average		**53.3**	**19.2**	**0.547**	**-0.2**	**0.0**	**0.1**	**ID**	**ID**	**ID**	**ID**
03/03/2019	1:00	58.4	21.7	0.548	-1.2	0.0	0.3	ID	ID	ID	ID
	2:00	59.7	22.4	0.510	ZS	0.0	0.4	ID	ID	ID	ID
	3:00	60.0	22.9	0.498	-1.0	0.1	0.3	ID	ID	ID	ID
	4:00	62.7	23.7	0.499	-0.9	0.0	0.6	ID	ID	ID	ID
	5:00	68.0	25.7	0.511	-0.9	0.0	0.5	ID	ID	ID	ID
	6:00	65.5	25.3	0.532	0.5	-0.1	0.4	ID	ID	ID	ID
	7:00	64.4	24.9	0.581	2.7	0.1	0.5	ID	ID	ID	ID
	8:00	61.9	23.7	0.563	1.2	0.1	0.3	ID	ID	ID	ID
	9:00	62.9	24.4	0.516	-1.0	0.1	0.0	ID	ID	ID	ID
	10:00	57.1	22.1	0.510	-1.4	-0.2	0.4	ID	ID	ID	ID
	11:00	86.4	47.1	0.647	0.7	0.5	0.4	ID	ID	ID	ID
	12:00	68.7	26.1	0.521	-1.2	0.1	0.1	ID	ID	ID	ID
	13:00	59.6	22.8	0.530	-0.4	0.1	-0.1	ID	ID	ID	ID
	14:00	64.5	24.5	0.530	-0.6	0.0	-0.3	ID	ID	ID	ID
	15:00	66.0	24.5	0.539	-0.4	0.2	0.0	ID	ID	ID	ID
	16:00	62.3	23.7	0.537	-0.3	0.0	0.0	ID	ID	ID	ID
	17:00	57.0	21.8	0.568	0.3	0.0	-0.1	ID	ID	ID	ID
	18:00	55.2	21.3	0.604	0.7	0.0	0.0	ID	ID	ID	ID
	19:00	52.3	20.3	0.692	1.4	0.3	-0.1	ID	ID	ID	ID
	20:00	52.9	20.8	0.703	0.5	0.3	-0.1	ID	ID	ID	ID
	21:00	51.2	19.9	0.647	0.1	0.1	0.3	ID	ID	ID	ID
	22:00	55.9	21.3	0.640	-0.5	0.1	-0.1	ID	ID	ID	ID
	23:00	51.8	19.7	0.643	-0.7	0.2	-0.1	ID	ID	ID	ID
	0:00	50.2	18.2	0.701	ZS	ZS	ZS	ID	ID	ID	ID
Min		**50.2**	**18.2**	**0.498**	**-1.4**	**-0.2**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**86.4**	**47.1**	**0.703**	**2.7**	**0.5**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**60.6**	**23.7**	**0.574**	**-0.1**	**0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
04/03/2019	1:00	54.1	19.6	0.741	0.0	ZS	ZS	ID	ID	ID	ID
	2:00	56.3	19.8	0.521	-1.2	-0.1	0.2	ID	ID	ID	ID
	3:00	53.9	19.0	0.514	-1.2	-0.1	0.0	ID	ID	ID	ID
	4:00	57.7	23.3	0.523	-0.5	-0.2	0.2	ID	ID	ID	ID
	5:00	49.8	19.3	0.516	-1.4	-0.1	0.3	ID	ID	ID	ID
	6:00	45.9	17.3	0.516	-1.3	-0.3	0.9	ID	ID	ID	ID
	7:00	43.0	16.5	0.558	0.7	0.0	0.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	46.2	18.0	0.701	5.2	0.3	0.4	ID	ID	ID	ID
	9:00	37.8	15.2	0.636	2.5	0.1	1.4	ID	ID	ID	ID
	10:00	35.5	14.0	0.542	-0.5	0.1	0.0	ID	ID	ID	ID
	11:00	36.4	14.1	0.562	0.0	0.1	0.0	ID	ID	ID	ID
	12:00	37.3	14.4	0.603	2.1	0.1	0.2	ID	ID	ID	ID
	13:00	36.5	14.7	0.590	1.3	0.3	-0.2	ID	ID	ID	ID
	14:00	39.3	15.1	0.611	2.0	0.0	0.4	ID	ID	ID	ID
	15:00	46.0	17.6	0.625	2.9	0.1	0.2	ID	ID	ID	ID
	16:00	56.8	20.4	0.662	3.9	0.2	0.1	ID	ID	ID	ID
	17:00	62.9	21.7	0.706	5.1	0.4	-0.2	ID	ID	ID	ID
	18:00	66.8	22.8	0.745	6.9	0.2	0.3	ID	ID	ID	ID
	19:00	66.8	23.4	0.626	3.6	0.3	0.0	ID	ID	ID	ID
	20:00	67.2	24.0	0.586	0.9	0.1	0.3	ID	ID	ID	ID
	21:00	66.9	24.0	0.556	-0.1	-0.1	0.2	ID	ID	ID	ID
	22:00	59.3	21.7	0.551	-0.9	-0.1	0.0	ID	ID	ID	ID
	23:00	58.0	21.4	0.542	-1.3	-0.1	0.2	ID	ID	ID	ID
	0:00	55.6	20.7	0.560	-1.2	0.0	0.1	ID	ID	ID	ID
Min		**35.5**	**14.0**	**0.514**	**-1.4**	**-0.3**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**67.2**	**24.0**	**0.745**	**6.9**	**0.4**	**1.4**	**ID**	**ID**	**ID**	**ID**
Average		**51.5**	**19.1**	**0.596**	**1.1**	**0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
05/03/2019	1:00	57.5	20.8	0.525	ZS	0.2	0.0	ID	ID	ID	ID
	2:00	61.6	21.8	0.519	-1.1	ZS	ZS	ID	ID	ID	ID
	3:00	65.5	23.8	0.518	-1.3	0.0	0.3	ID	ID	ID	ID
	4:00	63.3	22.7	0.520	-1.0	-0.1	0.2	ID	ID	ID	ID
	5:00	62.8	22.7	0.534	0.4	-0.1	0.5	ID	ID	ID	ID
	6:00	60.2	22.4	0.579	1.6	0.0	0.3	ID	ID	ID	ID
	7:00	61.8	22.5	0.675	5.1	0.2	0.6	ID	ID	ID	ID
	8:00	58.8	21.0	0.856	9.3	0.3	0.5	ID	ID	ID	ID
	9:00	49.2	18.4	0.745	5.9	0.5	0.1	ID	ID	ID	ID
	10:00	49.1	17.9	0.647	3.4	0.3	-0.1	ID	ID	ID	ID
	11:00	50.2	18.5	0.586	1.5	0.2	-0.1	ID	ID	ID	ID
	12:00	51.1	18.3	0.577	1.3	-0.1	0.3	ID	ID	ID	ID
	13:00	45.7	16.8	0.577	0.9	0.2	0.0	ID	ID	ID	ID
	14:00	43.4	16.3	0.553	-0.2	0.0	-0.1	ID	ID	ID	ID
	15:00	47.2	16.7	0.597	1.1	0.1	0.1	ID	ID	ID	ID
	16:00	43.5	16.0	0.573	0.8	-0.1	0.1	ID	ID	ID	ID
	17:00	41.7	15.6	0.627	2.6	0.2	0.0	ID	ID	ID	ID
	18:00	40.3	14.8	0.693	5.2	0.3	0.3	ID	ID	ID	ID
	19:00	38.9	14.6	0.585	1.6	0.1	0.0	ID	ID	ID	ID
	20:00	38.6	14.7	0.541	-0.7	0.1	-0.4	ID	ID	ID	ID
	21:00	39.5	15.4	0.529	-1.2	0.1	-0.3	ID	ID	ID	ID
	22:00	41.7	16.2	0.525	-1.3	-0.1	0.1	ID	ID	ID	ID
	23:00	42.1	16.2	0.546	-0.4	0.0	-0.1	ID	ID	ID	ID
	0:00	44.2	17.0	0.537	ZS	-0.1	0.1	ID	ID	ID	ID
Min		**38.6**	**14.6**	**0.518**	**-1.3**	**-0.1**	**-0.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**65.5**	**23.8**	**0.856**	**9.3**	**0.5**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**49.9**	**18.4**	**0.590**	**1.5**	**0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
06/03/2019	1:00	48.5	18.6	0.534	-0.8	ZS	ZS	ID	ID	ID	ID
	2:00	50.0	19.0	0.522	-1.2	-0.1	0.2	ID	ID	ID	ID
	3:00	49.1	18.6	0.517	-1.5	0.0	-0.1	ID	ID	ID	ID
	4:00	50.3	18.9	0.518	-1.6	0.0	-0.1	ID	ID	ID	ID
	5:00	48.5	18.2	0.518	-1.6	-0.2	0.1	ID	ID	ID	ID
	6:00	45.9	17.6	0.526	-1.2	-0.2	-0.1	ID	ID	ID	ID
	7:00	47.3	18.6	0.558	0.3	-0.1	0.1	ID	ID	ID	ID
	8:00	50.8	19.4	0.641	2.7	0.0	1.0	ID	ID	ID	ID
	9:00	54.5	20.3	0.595	1.1	0.1	-0.1	ID	ID	ID	ID
	10:00	54.3	20.7	0.564	-0.1	0.0	0.2	ID	ID	ID	ID
	11:00	55.1	21.0	0.545	-0.9	0.0	-0.1	ID	ID	ID	ID
	12:00	61.4	23.0	0.546	-1.0	0.0	-0.1	ID	ID	ID	ID
	13:00	65.5	25.0	0.546	-1.1	0.0	0.0	ID	ID	ID	ID
	14:00	73.7	27.0	0.552	-1.1	-0.1	0.1	ID	ID	ID	ID
	15:00	82.5	28.9	0.556	-0.8	-0.1	0.3	ID	ID	ID	ID
	16:00	76.9	27.4	0.563	-0.7	0.1	-0.4	ID	ID	ID	ID
	17:00	74.8	26.8	0.579	-0.8	0.0	0.0	ID	ID	ID	ID
	18:00	72.4	26.9	0.576	-1.1	0.0	-0.3	ID	ID	ID	ID
	19:00	67.9	26.0	0.567	-1.2	0.0	-0.1	ID	ID	ID	ID
	20:00	67.0	25.6	0.565	-1.3	0.0	-0.1	ID	ID	ID	ID
	21:00	66.8	24.9	0.568	-1.2	0.0	0.0	ID	ID	ID	ID
	22:00	64.9	24.6	0.566	-1.4	0.0	-0.2	ID	ID	ID	ID
	23:00	64.8	24.7	0.593	-0.4	0.0	0.0	ID	ID	ID	ID
	0:00	61.4	23.9	ZS	-0.6	ZS	ZS	ID	ID	ID	ID
Min		**45.9**	**17.6**	**0.517**	**-1.6**	**-0.2**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**82.5**	**28.9**	**0.641**	**2.7**	**0.1**	**1.0**	**ID**	**ID**	**ID**	**ID**
Average		**60.6**	**22.7**	**0.557**	**-0.7**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
07/03/2019	1:00	56.9	22.8	0.553	-1.3	-0.1	0.4	ID	ID	ID	ID
	2:00	57.5	22.4	0.554	ZS	-0.1	0.2	ID	ID	ID	ID
	3:00	58.3	22.5	0.550	-1.1	-0.1	0.4	ID	ID	ID	ID
	4:00	58.4	22.4	0.548	-1.2	0.0	0.2	ID	ID	ID	ID
	5:00	59.4	22.7	0.547	-1.4	-0.2	0.2	ID	ID	ID	ID
	6:00	60.1	23.1	0.562	-0.8	-0.3	1.0	ID	ID	ID	ID
	7:00	58.1	22.7	0.633	2.2	0.1	0.2	ID	ID	ID	ID
	8:00	60.2	23.3	0.775	5.7	0.3	0.2	ID	ID	ID	ID
	9:00	54.4	20.7	0.725	4.1	0.2	0.0	ID	ID	ID	ID
	10:00	50.6	19.3	0.648	2.4	-0.2	0.2	ID	ID	ID	ID
	11:00	49.0	18.4	0.614	1.4	-0.5	0.4	ID	ID	ID	ID
	12:00	45.3	17.4	0.603	0.5	-0.4	0.2	ID	ID	ID	ID
	13:00	44.8	17.4	0.626	1.3	-0.5	0.5	ID	ID	ID	ID
	14:00	45.5	17.1	0.605	0.4	-0.4	0.5	ID	ID	ID	ID
	15:00	44.4	16.5	0.615	0.7	-0.3	0.0	ID	ID	ID	ID
	16:00	42.1	16.3	0.640	1.6	-0.3	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	39.9	16.0	0.714	2.9	-0.1	-0.1	ID	ID	ID	ID
	18:00	42.0	16.7	0.749	3.9	-0.1	0.2	ID	ID	ID	ID
	19:00	38.6	15.4	0.701	3.2	-0.1	0.1	ID	ID	ID	ID
	20:00	37.7	15.0	0.621	0.6	-0.1	0.3	ID	ID	ID	ID
	21:00	36.5	14.6	0.624	0.2	-0.2	0.1	ID	ID	ID	ID
	22:00	37.0	14.7	0.600	-0.2	0.0	0.0	ID	ID	ID	ID
	23:00	35.8	14.9	ZS	-0.3	-0.1	0.4	ID	ID	ID	ID
	0:00	35.6	14.5	0.583	-0.2	-0.1	0.3	ID	ID	ID	ID
Min		**35.6**	**14.5**	**0.547**	**-1.4**	**-0.5**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**60.2**	**23.3**	**0.775**	**5.7**	**0.3**	**1.0**	**ID**	**ID**	**ID**	**ID**
Average		**47.8**	**18.6**	**0.626**	**1.1**	**-0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
08/03/2019	1:00	35.9	14.3	0.574	ZS	0.1	0.2	ID	ID	ID	ID
	2:00	35.6	14.5	0.568	-0.1	ZS	ZS	ID	ID	ID	ID
	3:00	34.4	14.0	0.567	-0.4	-0.1	0.4	ID	ID	ID	ID
	4:00	35.3	13.9	0.568	-0.6	-0.1	0.5	ID	ID	ID	ID
	5:00	34.1	13.8	0.566	-0.3	-0.1	0.2	ID	ID	ID	ID
	6:00	34.8	13.7	0.604	1.0	-0.2	0.4	ID	ID	ID	ID
	7:00	34.1	13.6	0.733	4.6	0.0	0.5	ID	ID	ID	ID
	8:00	33.0	13.4	0.892	7.0	0.3	0.3	ID	ID	ID	ID
	9:00	33.9	13.2	0.796	4.4	0.4	-0.1	ID	ID	ID	ID
	10:00	33.6	13.0	0.676	2.1	0.1	-0.1	ID	ID	ID	ID
	11:00	35.1	13.2	0.639	1.0	-0.2	-0.1	ID	ID	ID	ID
	12:00	32.7	12.5	0.615	0.4	-0.4	0.2	ID	ID	ID	ID
	13:00	30.7	12.2	0.615	0.3	-0.1	0.0	ID	ID	ID	ID
	14:00	30.5	12.7	0.601	-0.3	-0.2	0.2	ID	ID	ID	ID
	15:00	34.0	13.8	0.589	-0.3	-0.1	0.0	ID	ID	ID	ID
	16:00	32.6	12.3	0.654	1.9	0.1	0.1	ID	ID	ID	ID
	17:00	31.6	12.2	0.679	1.6	0.2	-0.2	ID	ID	ID	ID
	18:00	27.5	11.2	0.664	1.2	-0.1	0.1	ID	ID	ID	ID
	19:00	27.4	10.3	0.597	-0.6	-0.2	0.2	ID	ID	ID	ID
	20:00	29.6	11.3	0.578	-1.3	-0.1	0.1	ID	ID	ID	ID
	21:00	28.5	11.0	0.578	-1.1	0.0	-0.2	ID	ID	ID	ID
	22:00	27.6	10.9	0.562	-1.3	-0.1	0.1	ID	ID	ID	ID
	23:00	26.3	10.2	0.573	ZS	-0.1	0.2	ID	ID	ID	ID
	0:00	24.5	10.2	0.566	ZS	-0.1	0.1	ID	ID	ID	ID
Min		**24.5**	**10.2**	**0.562**	**-1.3**	**-0.4**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**35.9**	**14.5**	**0.892**	**7.0**	**0.4**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**31.8**	**12.5**	**0.627**	**0.9**	**-0.1**	**0.1**	**ID**	**ID**	**ID**	**ID**
09/03/2019	1:00	24.0	10.1	0.575	-0.4	ZS	ZS	ID	ID	ID	ID
	2:00	24.6	10.1	0.563	-0.7	-0.1	0.1	ID	ID	ID	ID
	3:00	23.3	9.8	0.560	-1.0	0.0	0.1	ID	ID	ID	ID
	4:00	24.1	10.0	0.560	-0.8	0.1	-0.1	ID	ID	ID	ID
	5:00	25.4	10.2	0.561	-1.0	0.0	0.1	ID	ID	ID	ID
	6:00	25.4	10.1	0.581	-0.5	-0.2	0.3	ID	ID	ID	ID
	7:00	24.1	10.1	0.645	1.4	0.0	0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	8:00	25.1	10.1	0.656	1.4	-0.1	0.2	ID	ID	ID	ID
	9:00	26.5	9.9	0.655	1.3	0.0	0.2	ID	ID	ID	ID
	10:00	23.9	9.5	0.587	0.1	0.0	-0.2	ID	ID	ID	ID
	11:00	24.3	9.4	0.614	0.1	0.1	0.0	ID	ID	ID	ID
	12:00	24.4	9.3	0.586	-0.2	0.0	-0.1	ID	ID	ID	ID
	13:00	26.4	9.1	0.589	-0.1	0.2	-0.2	ID	ID	ID	ID
	14:00	26.4	9.1	0.611	0.0	-0.1	0.1	ID	ID	ID	ID
	15:00	26.4	9.1	0.591	-0.4	0.1	-0.1	ID	ID	ID	ID
	16:00	26.4	9.1	0.600	0.1	0.0	0.0	ID	ID	ID	ID
	17:00	26.4	9.1	0.587	-0.6	0.0	0.1	ID	ID	ID	ID
	18:00	26.4	9.1	0.608	-1.1	0.0	0.0	ID	ID	ID	ID
	19:00	26.4	9.1	0.631	-0.9	-0.1	0.0	ID	ID	ID	ID
	20:00	26.4	9.1	0.615	-1.2	0.1	-0.1	ID	ID	ID	ID
	21:00	26.4	9.1	0.625	-1.0	0.2	-0.2	ID	ID	ID	ID
	22:00	26.4	9.1	0.639	-0.9	0.0	0.5	ID	ID	ID	ID
	23:00	26.4	9.1	0.600	-1.2	-0.1	0.2	ID	ID	ID	ID
	0:00	26.4	9.1	0.624	-1.2	ZS	ZS	ID	ID	ID	ID
Min		**23.3**	**9.1**	**0.560**	**-1.2**	**-0.2**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**26.5**	**10.2**	**0.656**	**1.4**	**0.2**	**0.5**	**ID**	**ID**	**ID**	**ID**
Average		**25.5**	**9.5**	**0.603**	**-0.4**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
10/03/2019	1:00	26.4	9.1	0.574	-1.5	-0.1	-0.1	ID	ID	ID	ID
	2:00	26.4	9.1	0.555	ZS	-0.1	0.0	ID	ID	ID	ID
	3:00	26.4	9.1	0.548	-1.0	-0.1	0.0	ID	ID	ID	ID
	4:00	26.4	9.1	0.543	-1.2	-0.2	-0.2	ID	ID	ID	ID
	5:00	26.4	9.1	0.545	-1.5	-0.3	0.0	ID	ID	ID	ID
	6:00	26.4	9.1	0.550	-1.2	-0.2	0.3	ID	ID	ID	ID
	7:00	26.4	9.1	0.561	-1.2	-0.2	-0.1	ID	ID	ID	ID
	8:00	26.4	9.1	0.565	-0.6	0.1	-0.3	ID	ID	ID	ID
	9:00	26.4	9.1	0.571	-0.6	0.1	-0.2	ID	ID	ID	ID
	10:00	26.4	9.1	0.547	-1.0	0.0	0.2	ID	ID	ID	ID
	11:00	26.4	9.1	0.543	-1.3	0.0	-0.1	ID	ID	ID	ID
	12:00	26.4	9.1	0.548	-1.3	0.1	0.1	ID	ID	ID	ID
	13:00	26.4	9.1	0.703	0.3	0.6	-0.1	ID	ID	ID	ID
	14:00	26.4	9.1	0.564	-1.3	0.3	-0.3	ID	ID	ID	ID
	15:00	26.4	9.1	0.553	-1.3	0.0	0.0	ID	ID	ID	ID
	16:00	26.4	9.1	0.587	-1.2	0.1	-0.2	ID	ID	ID	ID
	17:00	26.4	9.1	0.857	-1.1	0.2	0.0	ID	ID	ID	ID
	18:00	26.4	9.1	1.010	-0.6	0.3	-0.3	ID	ID	ID	ID
	19:00	26.4	9.1	1.244	-0.6	0.4	-0.2	ID	ID	ID	ID
	20:00	26.4	9.1	1.450	-0.7	0.3	-0.1	ID	ID	ID	ID
	21:00	26.4	9.1	1.261	-0.8	0.3	-0.1	ID	ID	ID	ID
	22:00	26.4	9.1	1.340	-0.5	0.3	0.0	ID	ID	ID	ID
	23:00	26.4	9.1	1.095	-0.8	0.5	0.1	ID	ID	ID	ID
	0:00	26.4	9.1	0.939	ZS	0.5	0.0	ID	ID	ID	ID
Min		**26.4**	**9.1**	**0.543**	**-1.5**	**-0.3**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**26.4**	**9.1**	**1.450**	**0.3**	**0.6**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**26.4**	**9.1**	**0.761**	**-0.9**	**0.1**	**-0.1**	**ID**	**ID**	**ID**	**ID**
11/03/2019	1:00	26.4	9.1	0.663	-0.3	ZS	ZS	ID	ID	ID	ID
	2:00	26.4	9.1	0.561	-0.7	0.3	-0.1	ID	ID	ID	ID
	3:00	26.4	9.1	0.554	-1.4	-0.1	0.3	ID	ID	ID	ID
	4:00	26.4	9.1	0.551	-1.2	0.2	-0.2	ID	ID	ID	ID
	5:00	26.4	9.1	0.550	-1.4	0.0	-0.1	ID	ID	ID	ID
	6:00	26.4	9.1	0.560	-1.5	-0.1	0.2	ID	ID	ID	ID
	7:00	26.4	9.1	0.580	-0.9	0.0	0.0	ID	ID	ID	ID
	8:00	26.4	9.1	0.633	0.2	0.2	-0.1	ID	ID	ID	ID
	9:00	26.4	9.1	0.688	1.2	0.2	0.2	ID	ID	ID	ID
	10:00	26.4	9.1	0.616	0.2	0.2	0.9	ID	ID	ID	ID
	11:00	26.4	9.1	0.578	-0.6	0.2	-0.2	ID	ID	ID	ID
	12:00	26.5	9.9	0.586	-0.9	0.2	0.0	ID	ID	ID	ID
	13:00	26.4	10.8	0.583	-1.1	0.1	-0.2	ID	ID	ID	ID
	14:00	28.2	10.3	0.574	-1.1	0.0	0.0	ID	ID	ID	ID
	15:00	28.4	10.4	0.572	-0.8	0.3	-0.1	ID	ID	ID	ID
	16:00	30.1	11.0	0.589	-0.7	0.1	-0.1	ID	ID	ID	ID
	17:00	28.8	10.7	0.601	-0.7	0.0	-0.2	ID	ID	ID	ID
	18:00	32.9	11.3	0.618	0.0	0.1	-0.2	ID	ID	ID	ID
	19:00	32.1	11.6	0.596	-0.8	0.0	0.1	ID	ID	ID	ID
	20:00	34.7	12.5	0.600	-0.5	0.2	-0.1	ID	ID	ID	ID
	21:00	32.6	12.3	0.595	-1.2	0.0	0.0	ID	ID	ID	ID
	22:00	29.6	11.8	0.595	-1.0	0.1	0.0	ID	ID	ID	ID
	23:00	28.8	11.4	0.589	-0.5	0.0	0.2	ID	ID	ID	ID
	0:00	23.3	9.7	ZS	ZS	0.0	0.2	ID	ID	ID	ID
Min		**23.3**	**9.1**	**0.550**	**-1.5**	**-0.1**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**34.7**	**12.5**	**0.688**	**1.2**	**0.3**	**0.9**	**ID**	**ID**	**ID**	**ID**
Average		**28.0**	**10.2**	**0.593**	**-0.7**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
12/03/2019	1:00	25.0	10.3	0.579	ZS	0.3	-0.1	ID	ID	ID	ID
	2:00	28.0	11.5	0.581	-1.0	ZS	ZS	ID	ID	ID	ID
	3:00	26.1	10.9	0.568	-1.3	-0.1	0.1	ID	ID	ID	ID
	4:00	27.7	11.1	0.579	-1.2	0.0	0.3	ID	ID	ID	ID
	5:00	30.7	12.0	0.578	-1.4	-0.2	0.1	ID	ID	ID	ID
	6:00	33.6	13.4	0.598	-0.6	-0.2	0.1	ID	ID	ID	ID
	7:00	31.4	13.1	0.698	1.8	-0.1	0.1	ID	ID	ID	ID
	8:00	27.9	12.2	0.886	8.5	0.3	0.4	ID	ID	ID	ID
	9:00	33.0	13.7	0.923	7.5	0.5	0.0	ID	ID	ID	ID
	10:00	37.6	14.6	0.765	4.8	0.2	0.5	ID	ID	ID	ID
	11:00	29.5	11.0	0.722	4.0	0.4	0.2	ID	ID	ID	ID
	12:00	30.0	10.1	0.671	1.9	0.1	0.3	ID	ID	ID	ID
	13:00	26.3	9.4	0.692	2.2	0.3	0.0	ID	ID	ID	ID
	14:00	27.2	9.0	0.652	1.1	0.3	0.0	ID	ID	ID	ID
	15:00	24.6	9.0	0.667	2.1	0.2	0.2	ID	ID	ID	ID
	16:00	26.5	9.9	0.727	3.0	0.3	0.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	27.4	10.1	0.830	5.2	0.2	0.7	ID	ID	ID	ID
	18:00	27.7	10.4	0.819	5.6	0.6	0.3	ID	ID	ID	ID
	19:00	27.6	10.6	0.742	4.5	0.4	0.2	ID	ID	ID	ID
	20:00	27.9	10.5	0.678	2.3	0.0	0.5	ID	ID	ID	ID
	21:00	26.4	10.4	0.602	-0.7	-0.1	0.0	ID	ID	ID	ID
	22:00	29.2	10.7	0.590	-1.3	-0.4	0.3	ID	ID	ID	ID
	23:00	28.7	10.6	0.583	-1.5	0.0	-0.1	ID	ID	ID	ID
	0:00	26.8	10.1	0.583	ZS	-0.2	-0.3	ID	ID	ID	ID
Min		**24.6**	**9.0**	**0.568**	**-1.5**	**-0.4**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**37.6**	**14.6**	**0.923**	**8.5**	**0.6**	**0.7**	**ID**	**ID**	**ID**	**ID**
Average		**28.6**	**11.0**	**0.680**	**2.1**	**0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
13/03/2019	1:00	27.5	10.8	0.581	-1.3	ZS	ZS	ID	ID	ID	ID
	2:00	27.6	10.9	0.585	-1.5	-0.3	-0.1	ID	ID	ID	ID
	3:00	24.6	10.1	0.581	-1.6	-0.5	-0.1	ID	ID	ID	ID
	4:00	21.9	8.7	0.585	-1.5	-0.4	0.2	ID	ID	ID	ID
	5:00	23.5	9.7	0.587	-1.3	-0.2	-0.2	ID	ID	ID	ID
	6:00	23.9	9.6	0.628	0.9	-0.4	0.3	ID	ID	ID	ID
	7:00	24.7	9.6	0.726	3.6	-0.2	0.5	ID	ID	ID	ID
	8:00	23.8	9.3	0.878	6.3	0.1	0.6	ID	ID	ID	ID
	9:00	26.2	9.6	0.839	5.6	0.4	0.2	ID	ID	ID	ID
	10:00	25.9	9.9	0.721	2.1	0.3	-0.2	ID	ID	ID	ID
	11:00	24.4	9.6	0.644	1.0	0.1	0.0	ID	ID	ID	ID
	12:00	24.4	9.2	0.612	-0.2	0.0	-0.1	ID	ID	ID	ID
	13:00	23.6	9.0	0.605	-0.7	0.0	-0.2	ID	ID	ID	ID
	14:00	24.2	10.1	0.615	-0.3	-0.1	0.1	ID	ID	ID	ID
	15:00	28.4	12.8	0.647	0.4	0.1	0.0	ID	ID	ID	ID
	16:00	23.3	8.6	0.668	1.1	0.3	-0.2	ID	ID	ID	ID
	17:00	22.0	8.8	0.720	2.5	0.2	0.0	ID	ID	ID	ID
	18:00	23.1	8.9	0.733	3.1	0.3	-0.2	ID	ID	ID	ID
	19:00	21.8	8.8	0.731	3.2	0.4	-0.1	ID	ID	ID	ID
	20:00	21.5	8.2	0.677	1.8	0.1	0.1	ID	ID	ID	ID
	21:00	22.5	8.5	0.624	-0.3	0.0	0.0	ID	ID	ID	ID
	22:00	21.8	7.8	0.584	-1.5	0.0	0.1	ID	ID	ID	ID
	23:00	19.3	6.8	0.578	-1.5	-0.3	0.2	ID	ID	ID	ID
	0:00	18.3	6.4	0.572	-1.5	ZS	ZS	ID	ID	ID	ID
Min		**18.3**	**6.4**	**0.572**	**-1.6**	**-0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**28.4**	**12.8**	**0.878**	**6.3**	**0.4**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**23.7**	**9.2**	**0.655**	**0.8**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
14/03/2019	1:00	17.2	6.2	0.564	-1.6	-0.4	0.0	ID	ID	ID	ID
	2:00	17.2	6.3	0.561	ZS	-0.3	0.3	ID	ID	ID	ID
	3:00	15.9	6.1	0.561	-1.3	-0.1	-0.1	ID	ID	ID	ID
	4:00	14.8	6.1	0.568	-1.1	-0.2	0.4	ID	ID	ID	ID
	5:00	14.8	5.9	0.576	-0.3	-0.3	0.4	ID	ID	ID	ID
	6:00	16.7	6.3	0.620	2.3	-0.2	0.6	ID	ID	ID	ID
	7:00	19.7	6.9	0.694	4.9	0.1	0.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	7:00	21.6	7.7	0.920	8.9	0.6	0.2	ID	ID	ID	ID
	9:00	21.8	8.1	0.892	7.3	0.4	0.3	ID	ID	ID	ID
	10:00	24.6	8.7	0.699	3.2	0.1	0.5	ID	ID	ID	ID
	11:00	23.9	8.5	0.616	0.7	0.0	0.2	ID	ID	ID	ID
	12:00	23.1	8.5	0.595	0.1	-0.1	0.2	ID	ID	ID	ID
	13:00	22.6	8.3	0.586	-0.8	0.1	-0.2	ID	ID	ID	ID
	14:00	21.0	7.9	0.573	-1.0	-0.1	-0.2	ID	ID	ID	ID
	15:00	23.8	7.7	0.573	-0.5	-0.1	-0.2	ID	ID	ID	ID
	16:00	20.5	7.7	0.596	-0.4	-0.2	-0.4	ID	ID	ID	ID
	17:00	21.9	8.2	0.604	-0.8	-0.4	0.1	ID	ID	ID	ID
	18:00	22.7	8.5	0.591	-0.8	-0.2	-0.4	ID	ID	ID	ID
	19:00	25.6	9.2	0.592	-1.2	-0.5	0.0	ID	ID	ID	ID
	20:00	29.6	9.9	0.609	-1.1	-0.6	0.2	ID	ID	ID	ID
	21:00	29.9	10.9	0.599	-1.3	-0.5	0.0	ID	ID	ID	ID
	22:00	32.6	11.6	0.599	-1.2	-0.3	-0.1	ID	ID	ID	ID
	23:00	33.0	12.2	0.599	-1.4	-0.1	0.0	ID	ID	ID	ID
	0:00	35.7	12.7	0.603	-1.5	-0.2	0.1	ID	ID	ID	ID
Min		**14.8**	**5.9**	**0.561**	**-1.6**	**-0.6**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**35.7**	**12.7**	**0.920**	**8.9**	**0.6**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**22.9**	**8.3**	**0.625**	**0.5**	**-0.2**	**0.1**	**ID**	**ID**	**ID**	**ID**
15/03/2019	1:00	33.4	12.6	ZS	ZS	-0.2	-0.1	ID	ID	ID	ID
	2:00	31.8	12.5	0.592	-1.2	ZS	ZS	ID	ID	ID	ID
	3:00	30.5	12.2	0.603	-1.2	-0.2	0.0	ID	ID	ID	ID
	4:00	17.3	7.0	0.607	-1.6	-0.4	0.1	ID	ID	ID	ID
	5:00	20.7	8.8	0.617	-1.5	0.0	-0.3	ID	ID	ID	ID
	6:00	19.7	8.3	0.609	-1.6	-0.2	-0.1	ID	ID	ID	ID
	7:00	21.4	8.8	0.613	-1.5	-0.4	0.1	ID	ID	ID	ID
	8:00	23.8	9.5	0.657	-1.0	-0.1	-0.1	ID	ID	ID	ID
	9:00	29.5	11.6	0.676	-0.4	-0.1	-0.2	ID	ID	ID	ID
	10:00	44.3	16.3	0.658	-0.5	-0.2	-0.1	ID	ID	ID	ID
	11:00	46.9	16.5	0.656	-0.5	-0.1	0.0	ID	ID	ID	ID
	12:00	44.4	16.0	0.674	-0.1	0.1	0.2	ID	ID	ID	ID
	13:00	46.0	16.9	0.686	0.4	0.0	0.0	ID	ID	ID	ID
	14:00	51.5	19.1	0.708	1.4	0.1	-0.1	ID	ID	ID	ID
	15:00	58.1	20.5	0.708	2.0	0.1	0.1	ID	ID	ID	ID
	16:00	59.8	20.7	0.781	4.2	0.1	0.2	ID	ID	ID	ID
	17:00	57.7	20.7	0.680	0.6	-0.1	0.1	ID	ID	ID	ID
	18:00	59.8	21.2	0.700	1.0	0.1	0.0	ID	ID	ID	ID
	19:00	65.0	22.6	0.701	0.9	0.1	0.0	ID	ID	ID	ID
	20:00	72.0	25.3	0.686	0.1	0.3	-0.3	ID	ID	ID	ID
	21:00	78.4	27.6	0.680	-0.3	0.0	-0.1	ID	ID	ID	ID
	22:00	85.0	29.0	0.669	-0.1	-0.2	0.6	ID	ID	ID	ID
	23:00	87.3	29.6	0.665	-0.6	0.2	-0.2	ID	ID	ID	ID
	0:00	85.3	29.1	0.638	ZS	0.2	-0.3	ID	ID	ID	ID
Min		**17.3**	**7.0**	**0.592**	**-1.6**	**-0.4**	**-0.3**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Max		**87.3**	**29.6**	**0.781**	**4.2**	**0.3**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**48.7**	**17.6**	**0.664**	**-0.1**	**0.0**	**0.0**	**ID**	**ID**	**ID**	**ID**
16/03/2019	1:00	85.4	28.4	0.615	-1.2	ZS	ZS	ID	ID	ID	ID
	2:00	77.0	27.1	0.606	-1.3	0.0	-0.2	ID	ID	ID	ID
	3:00	76.1	26.8	0.604	-1.5	-0.1	-0.1	ID	ID	ID	ID
	4:00	72.0	25.9	0.604	-1.6	0.0	0.1	ID	ID	ID	ID
	5:00	68.0	25.0	0.608	-1.6	0.1	-0.3	ID	ID	ID	ID
	6:00	69.5	25.5	0.606	-1.4	0.0	-0.1	ID	ID	ID	ID
	7:00	70.9	26.0	0.663	1.2	-0.1	0.3	ID	ID	ID	ID
	7:00	75.6	27.3	0.679	2.2	0.2	0.2	ID	ID	ID	ID
	9:00	86.1	31.6	0.725	3.2	0.3	0.0	ID	ID	ID	ID
	10:00	101.9	41.0	0.715	1.8	0.2	0.2	ID	ID	ID	ID
	11:00	114.7	45.3	0.694	1.0	0.2	0.0	ID	ID	ID	ID
	12:00	125.8	49.0	0.662	-0.6	0.3	0.0	ID	ID	ID	ID
	13:00	124.6	45.2	0.638	-1.0	0.2	-0.1	ID	ID	ID	ID
	14:00	140.1	50.7	0.631	-1.1	0.1	0.1	ID	ID	ID	ID
	15:00	159.1	61.6	0.670	-0.9	0.1	0.1	ID	ID	ID	ID
	16:00	163.8	60.5	0.671	-1.2	0.1	0.0	ID	ID	ID	ID
	17:00	169.4	61.5	0.640	-1.1	-0.1	0.1	ID	ID	ID	ID
	18:00	184.6	65.6	0.644	-1.2	0.0	0.0	ID	ID	ID	ID
	19:00	194.0	69.3	0.648	-1.2	0.0	-0.1	ID	ID	ID	ID
	20:00	213.3	76.5	PO	-1.0	0.1	0.1	ID	ID	ID	ID
	21:00	228.2	80.8	PO	-1.1	0.1	-0.4	ID	ID	ID	ID
	22:00	249.9	87.1	PO	-1.1	0.1	0.0	ID	ID	ID	ID
	23:00	266.7	92.7	0.654	-1.0	0.1	0.0	ID	ID	ID	ID
	0:00	252.6	87.9	0.651	-1.2	ZS	ZS	ID	ID	ID	ID
Min		**68.0**	**25.0**	**0.604**	**-1.6**	**-0.1**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**266.7**	**92.7**	**0.725**	**3.2**	**0.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
Average		**140.4**	**50.8**	**0.649**	**-0.5**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
17/03/2019	1:00	226.8	79.5	0.680	-0.9	0.1	0.1	ID	ID	ID	ID
	2:00	203.9	71.8	0.646	ZS	0.2	-0.2	ID	ID	ID	ID
	3:00	178.6	63.1	0.628	-1.4	0.0	-0.1	ID	ID	ID	ID
	4:00	172.3	60.5	0.626	-1.5	0.2	0.0	ID	ID	ID	ID
	5:00	163.3	57.4	0.620	-1.6	-0.3	0.3	ID	ID	ID	ID
	6:00	157.2	55.5	0.629	-1.6	0.0	0.0	ID	ID	ID	ID
	7:00	152.5	53.7	0.641	-1.0	0.0	0.3	ID	ID	ID	ID
	8:00	142.2	50.4	0.632	-0.9	0.2	-0.2	ID	ID	ID	ID
	9:00	145.3	50.4	0.622	-1.2	0.2	-0.3	ID	ID	ID	ID
	10:00	147.4	50.6	0.620	-1.5	0.0	-0.1	ID	ID	ID	ID
	11:00	155.8	51.7	0.616	-1.4	0.1	-0.2	ID	ID	ID	ID
	12:00	158.8	53.4	0.633	-1.4	0.0	0.1	ID	ID	ID	ID
	13:00	163.5	53.9	0.631	-1.4	-0.2	0.2	ID	ID	ID	ID
	14:00	141.9	49.9	0.657	-1.1	0.0	-0.4	ID	ID	ID	ID
	15:00	128.9	47.3	0.743	-1.1	0.1	-0.2	ID	ID	ID	ID
	16:00	138.0	49.1	PO	-0.4	0.0	-0.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	17:00	154.3	52.0	0.766	-0.8	-0.1	0.0	ID	ID	ID	ID
	18:00	162.0	52.8	0.847	-0.3	0.0	0.0	ID	ID	ID	ID
	19:00	145.8	48.2	1.122	0.5	0.0	0.0	ID	ID	ID	ID
	20:00	146.1	48.1	0.786	1.3	0.3	-0.1	ID	ID	ID	ID
	21:00	149.2	50.3	0.944	0.4	0.3	-0.3	ID	ID	ID	ID
	22:00	137.4	45.6	1.350	-0.3	0.3	-0.1	ID	ID	ID	ID
	23:00	111.5	38.7	0.706	0.4	0.0	0.4	ID	ID	ID	ID
	0:00	119.3	40.5	0.746	ZS	0.3	-0.2	ID	ID	ID	ID
Min		**111.5**	**38.7**	**0.616**	**-1.6**	**-0.3**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**226.8**	**79.5**	**1.350**	**1.3**	**0.3**	**0.4**	**ID**	**ID**	**ID**	**ID**
Average		**154.2**	**53.1**	**0.734**	**-0.8**	**0.1**	**0.0**	**ID**	**ID**	**ID**	**ID**
18/03/2019	1:00	111.3	39.3	0.745	1.2	ZS	ZS	ID	ID	ID	ID
	2:00	104.7	36.8	0.620	-0.6	0.0	0.1	ID	ID	ID	ID
	3:00	92.3	32.3	0.605	-1.1	-0.1	0.4	ID	ID	ID	ID
	4:00	85.4	30.5	0.604	-0.6	-0.1	0.5	ID	ID	ID	ID
	5:00	85.0	30.1	0.605	-0.9	0.1	0.0	ID	ID	ID	ID
	6:00	92.7	32.6	0.662	2.5	0.2	0.6	ID	ID	ID	ID
	7:00	111.9	38.7	0.726	3.9	0.2	0.4	ID	ID	ID	ID
	7:00	109.0	37.3	0.791	4.9	0.2	0.0	ID	ID	ID	ID
	9:00	110.4	37.1	0.685	2.2	0.2	-0.1	ID	ID	ID	ID
	10:00	118.5	39.1	0.613	-0.1	-0.1	0.4	ID	ID	ID	ID
	11:00	109.5	38.1	MM	-0.5	0.1	-0.3	ID	ID	ID	ID
	12:00	MM	MM	MM	MM	MM	MM	ID	ID	ID	ID
	13:00	MM	MM	0.581	MM	MM	MM	ID	ID	ID	ID
	14:00	MM	MM	0.589	2.2	MM	MM	ID	ID	ID	ID
	15:00	MM	MM	0.577	1.6	MM	MM	ID	ID	ID	ID
	16:00	MM	MM	0.620	2.1	0.1	0.4	ID	ID	ID	ID
	17:00	MM	MM	0.632	2.6	0.1	0.2	ID	ID	ID	ID
	18:00	MM	MM	0.673	3.9	0.2	0.1	ID	ID	ID	ID
	19:00	MM	MM	0.625	1.1	0.3	0.1	ID	ID	ID	ID
	20:00	MM	MM	0.602	0.3	0.2	-0.1	ID	ID	ID	ID
	21:00	MM	MM	0.594	0.4	0.1	0.1	ID	ID	ID	ID
	22:00	MM	MM	0.599	0.4	0.0	0.2	ID	ID	ID	ID
	23:00	MM	MM	0.588	-0.2	0.1	0.1	ID	ID	ID	ID
	0:00	MM	MM	0.584	-0.5	0.2	0.0	ID	ID	ID	ID
Min		**85.0**	**30.1**	**0.577**	**-1.1**	**-0.1**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**118.5**	**39.3**	**0.791**	**4.9**	**0.3**	**0.6**	**ID**	**ID**	**ID**	**ID**
Average		**102.8**	**35.6**	**0.633**	**1.1**	**0.1**	**0.2**	**ID**	**ID**	**ID**	**ID**
19/03/2019	1:00	MM	MM	0.575	ZS	0.3	0.0	ID	ID	ID	ID
	2:00	MM	MM	0.574	-0.5	ZS	ZS	ID	ID	ID	ID
	3:00	MM	MM	0.576	-0.8	0.0	0.3	ID	ID	ID	ID
	4:00	MM	MM	0.575	-0.9	0.1	0.1	ID	ID	ID	ID
	5:00	MM	MM	0.577	-0.9	0.2	0.0	ID	ID	ID	ID
	6:00	MM	MM	0.577	-0.9	0.2	-0.1	ID	ID	ID	ID
	7:00	MM	MM	0.578	-0.7	0.2	0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	MM	MM	0.613	MM	0.4	0.0	ID	ID	ID	ID
	9:00	MM	MM	0.644	MM	0.3	0.4	ID	ID	ID	ID
	10:00	MM	MM	0.617	MM	0.3	0.2	ID	ID	ID	ID
	11:00	MM	MM	0.587	MM	0.3	0.1	ID	ID	ID	ID
	12:00	MM	MM	0.580	1.6	0.0	0.5	ID	ID	ID	ID
	13:00	MM	MM	0.591	1.6	0.2	1.0	ID	ID	ID	ID
	14:00	MM	MM	0.595	1.3	0.2	0.8	ID	ID	ID	ID
	15:00	92.1	40.1	0.679	1.2	0.7	0.3	ID	ID	ID	ID
	16:00	88.2	28.2	0.631	2.9	0.5	0.3	ID	ID	ID	ID
	17:00	81.7	26.6	0.647	1.6	0.3	0.0	ID	ID	ID	ID
	18:00	82.1	26.5	0.660	2.5	0.4	0.2	ID	ID	ID	ID
	19:00	85.2	30.1	PO	1.2	0.5	0.1	ID	ID	ID	ID
	20:00	89.5	30.5	1.047	1.1	0.6	0.1	ID	ID	ID	ID
	21:00	89.4	30.8	0.820	0.3	0.4	0.3	ID	ID	ID	ID
	22:00	86.2	28.5	0.667	-0.3	0.4	0.2	ID	ID	ID	ID
	23:00	84.1	28.4	0.633	-0.5	0.3	0.0	ID	ID	ID	ID
	0:00	82.5	27.9	0.634	ZS	0.5	0.0	ID	ID	ID	ID
Min		**81.7**	**26.5**	**0.574**	**-0.9**	**0.0**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**92.1**	**40.1**	**1.047**	**2.9**	**0.7**	**1.0**	**ID**	**ID**	**ID**	**ID**
Average		**86.1**	**29.7**	**0.638**	**0.6**	**0.3**	**0.2**	**ID**	**ID**	**ID**	**ID**

µg/m³ = microgram per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = insufficient data; IO = Instrument offline; MM = maintenance mode; NO_2 = nitrogen dioxide; PF = pump failure; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); PO = power outage; ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide; UM = unknown malfunction; ZS = nightly zero and span

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

Attachment B-2 New Amsterdam Data Record

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
15/10/2018	1:00	18.7	8.5	0.46	0.7	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	14.3	7.3	0.44	0.4	-0.7	0.2	0.0	0.0	0.0	0.0
	3:00	13.3	5.6	0.36	-0.2	-1.0	0.4	0.0	0.0	0.0	0.0
	4:00	11.9	5.6	0.35	0.6	-1.2	0.2	0.0	0.0	0.0	0.0
	5:00	20.2	10.8	0.41	1.4	-0.9	0.4	0.0	0.0	0.0	0.0
	6:00	21.5	9.7	0.41	2.3	-0.7	0.5	0.0	0.0	0.0	0.0
	7:00	19.8	8.3	0.36	0.7	-0.6	0.0	0.0	0.0	0.0	0.0
	8:00	22.7	11.6	0.41	0.6	-0.7	0.1	0.0	0.0	0.0	0.0
	9:00	19.7	8.2	0.40	0.9	-0.6	-0.1	0.0	0.0	0.0	0.0
	10:00	16.5	5.0	0.36	-0.5	-0.9	-0.1	0.0	0.0	0.0	0.0
	11:00	9.8	2.3	0.30	-0.3	-1.1	-0.2	0.0	0.0	0.0	0.0
	12:00	7.5	2.5	0.32	-0.7	-1.1	-0.4	0.0	0.0	0.0	0.0
	13:00	11.8	3.9	0.33	-0.6	-0.9	-0.4	0.0	0.0	0.0	0.0
	14:00	12.4	3.6	0.33	-0.8	-0.9	-0.4	0.0	0.0	0.0	0.0
	15:00	12.1	3.2	0.33	-0.7	-1.2	-0.2	0.0	0.0	0.0	0.0
	16:00	9.7	2.3	0.32	-1.2	-1.0	-0.4	0.0	0.0	0.0	0.0
	17:00	10.6	2.4	0.33	-1.3	-1.0	-0.5	0.0	0.0	0.0	0.0
	18:00	11.9	4.3	0.38	-0.4	-1.3	0.0	0.0	0.0	0.0	0.0
	19:00	12.9	6.0	0.41	0.1	-1.2	0.0	0.0	0.0	0.0	0.0
	20:00	14.9	7.6	0.42	0.2	-1.0	0.2	0.0	0.0	0.0	0.0
	21:00	15.0	6.7	0.41	0.6	-1.1	0.0	0.0	0.0	0.0	0.0
	22:00	17.3	6.2	0.41	1.5	-1.0	0.2	0.0	0.0	0.0	0.0
	23:00	11.4	3.9	0.40	0.5	-1.1	0.7	0.0	0.0	0.0	0.0
	0:00	9.8	3.1	0.35	-0.1	-1.1	0.6	0.0	0.0	0.0	0.0
Min		**7.5**	**2.3**	**0.3**	**-1.3**	**-1.3**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**22.7**	**11.6**	**0.5**	**2.3**	**-0.6**	**0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**14.4**	**5.8**	**0.4**	**0.2**	**-1.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
16/10/2018	1:00	14.9	7.7	0.45	ZS	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	17.0	8.0	0.46	-0.9	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	20.2	11.4	0.51	-1.1	-0.6	1.7	0.0	0.0	0.0	0.0
	4:00	18.1	8.2	0.45	-1.0	-0.9	1.1	0.0	0.0	0.0	0.0
	5:00	24.4	11.1	0.53	-1.3	-0.6	1.0	0.0	0.0	0.0	0.0
	6:00	26.4	10.6	0.54	-0.8	-0.3	1.0	0.0	0.0	0.0	0.0
	7:00	20.3	8.7	0.46	-1.2	-0.6	1.7	0.0	0.0	0.0	0.0
	8:00	18.8	3.8	0.43	-3.3	-0.6	0.1	0.0	0.0	0.0	0.0
	9:00	14.8	2.9	0.40	-2.8	-0.9	-0.2	0.0	0.0	0.0	0.0
	10:00	12.8	2.6	0.36	-3.1	-0.9	-0.4	0.0	0.0	0.0	0.0
	11:00	9.6	2.2	0.35	-3.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	12:00	11.4	2.4	0.33	-3.2	-1.2	-0.3	0.0	0.0	0.0	0.0
	13:00	12.8	4.5	0.34	-3.0	-1.2	-0.4	0.0	0.0	0.0	0.0
	14:00	14.3	4.5	0.35	-3.0	-1.1	-0.2	0.0	0.0	0.0	0.0
	15:00	14.0	3.2	0.34	-3.1	-1.0	-0.5	0.0	0.0	0.0	0.0
	16:00	22.7	5.1	0.35	-3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	17:00	11.4	3.1	0.36	-3.5	-1.3	-0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	18:00	11.6	3.3	0.37	-3.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	19:00	8.5	2.8	0.37	-3.0	-1.2	-0.5	0.0	0.0	0.0	0.0
	20:00	7.5	2.6	0.36	-3.5	-1.4	-0.2	0.0	0.0	0.0	0.0
	21:00	7.2	2.4	0.36	-3.3	-1.3	0.0	0.0	0.0	0.0	0.0
	22:00	7.4	2.3	0.35	-3.5	-1.2	-0.4	0.0	0.0	0.0	0.0
	23:00	7.1	2.5	0.35	-3.2	-1.5	-0.3	0.0	0.0	0.0	0.0
	0:00	8.9	3.0	0.35	ZS	ZS	ZS	0.0	0.0	0.0	0.0
Min		**7.1**	**2.2**	**0.3**	**-3.6**	**-1.5**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**26.4**	**11.4**	**0.5**	**-0.8**	**-0.3**	**1.7**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**14.3**	**4.9**	**0.4**	**-2.6**	**-1.0**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**
17/10/2018	1:00	10.3	3.4	0.34	-2.6	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	9.2	3.9	0.35	-2.8	-1.1	0.1	0.0	0.0	0.0	0.0
	3:00	12.3	5.0	0.40	-2.2	-1.1	0.5	0.0	0.0	0.0	0.0
	4:00	12.8	4.8	0.36	-3.0	-1.1	0.4	0.0	0.0	0.0	0.0
	5:00	23.1	5.5	0.36	-1.2	-1.4	0.6	0.0	0.0	0.0	0.0
	6:00	33.4	6.9	0.42	-0.1	-1.0	0.2	0.0	0.0	0.0	0.0
	7:00	15.2	6.4	0.42	-1.9	-1.0	0.5	0.0	0.0	0.0	0.0
	8:00	29.7	7.2	0.44	-1.9	-0.8	-0.2	0.0	0.0	0.0	0.0
	9:00	40.1	6.8	0.42	-2.6	-1.1	0.0	0.0	0.0	0.0	0.0
	10:00	54.9	6.7	0.36	-3.5	-1.0	-0.1	0.0	0.0	0.0	0.0
	11:00	89.7	9.1	0.36	-3.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	12:00	48.3	8.0	0.37	-3.4	-1.0	-0.2	0.0	0.0	0.0	0.0
	13:00	43.7	8.4	0.38	-2.5	-0.9	-0.5	0.0	0.0	0.0	0.0
	14:00	54.6	6.7	0.37	-3.1	-1.2	0.0	0.0	0.0	0.0	0.0
	15:00	28.2	6.2	0.38	-3.2	-1.1	-0.2	0.0	0.0	0.0	0.0
	16:00	41.1	6.1	0.37	-3.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	17:00	17.8	4.2	0.37	-3.2	-1.2	-0.4	0.0	0.0	0.0	0.0
	18:00	14.6	4.2	0.38	-2.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	15.0	5.1	0.39	-3.6	-1.5	0.0	0.0	0.0	0.0	0.0
	20:00	16.0	5.1	0.39	-3.2	-1.4	-0.3	0.0	0.0	0.0	0.0
	21:00	16.4	5.0	0.38	-3.1	-1.2	-0.3	0.0	0.0	0.0	0.0
	22:00	13.8	5.1	0.37	-3.0	-1.5	-0.1	0.0	0.0	0.0	0.0
	23:00	14.3	5.0	0.37	-3.3	-1.7	0.1	0.0	0.0	0.0	0.0
	0:00	14.1	5.1	0.37	-3.2	-1.3	-0.2	0.0	0.0	0.0	0.0
Min		**9.2**	**3.4**	**0.3**	**-3.6**	**-1.7**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**89.7**	**9.1**	**0.4**	**-0.1**	**-0.8**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**27.9**	**5.8**	**0.4**	**-2.8**	**-1.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
18/10/2018	1:00	13.2	5.4	0.37	-3.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	2:00	15.3	5.8	0.41	-2.2	-1.0	0.0	0.0	0.0	0.0	0.0
	3:00	12.7	5.6	0.38	-3.2	-1.6	0.2	0.0	0.0	0.0	0.0
	4:00	13.8	5.8	0.37	-3.1	-1.5	-0.1	0.0	0.0	0.0	0.0
	5:00	14.4	5.7	0.37	-3.2	-1.5	0.0	0.0	0.0	0.0	0.0
	6:00	28.6	7.0	0.42	-1.5	-1.2	-0.1	0.0	0.0	0.0	0.0
	7:00	32.3	7.4	0.44	-2.5	-1.3	0.1	0.0	0.0	0.0	0.0
	8:00	39.3	7.4	0.44	-3.0	-1.4	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	9:00	49.7	7.7	0.44	-2.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	10:00	57.0	8.4	0.42	-3.5	-1.0	-0.4	0.0	0.0	0.0	0.0
	11:00	PO	PO	0.46	PO	PO	PO	PO	PO	PO	PO
	12:00	110.7	12.3	1.04	-3.3	-1.4	-0.1	0.0	0.0	0.0	0.0
	13:00	73.2	10.4	1.05	-3.3	-1.2	-0.5	0.0	0.0	0.0	0.0
	14:00	45.7	7.8	0.80	-3.3	-1.2	-0.2	0.0	0.0	0.0	0.0
	15:00	28.5	6.7	0.58	-3.6	-1.3	-0.4	0.0	0.0	0.0	0.0
	16:00	22.8	6.3	0.45	-3.6	-1.5	0.0	0.0	0.0	0.0	0.0
	17:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	18:00	14.7	5.9	0.56	-3.4	-1.1	-0.5	0.0	0.0	0.0	0.0
	19:00	14.4	5.0	0.54	-3.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	20:00	13.1	4.8	0.49	-3.3	-1.3	-0.4	0.0	0.0	0.0	0.0
	21:00	13.9	5.1	0.50	-3.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	22:00	15.3	4.5	0.47	-3.6	-1.5	-0.1	0.0	0.0	0.0	0.0
	23:00	17.0	4.4	ZS	-2.8	-1.4	-0.2	0.0	0.0	0.0	0.0
	0:00	17.2	4.3	ZS	-2.3	-1.4	-0.2	0.0	0.0	0.0	0.0
Min		**12.7**	**4.3**	**0.4**	**-3.6**	**-1.6**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**110.7**	**12.3**	**1.0**	**-1.5**	**-1.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**30.1**	**6.5**	**0.5**	**-3.1**	**-1.3**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
19/10/2018	1:00	18.5	4.6	0.45	ZS	-1.5	0.1	0.0	0.0	0.0	0.0
	2:00	11.6	4.6	0.45	-2.1	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	12.9	5.1	0.48	-2.5	-1.1	0.4	0.0	0.0	0.0	0.0
	4:00	14.0	5.5	0.48	-2.3	-1.1	0.3	0.0	0.0	0.0	0.0
	5:00	15.3	5.7	0.43	-2.9	-1.7	0.1	0.0	0.0	0.0	0.0
	6:00	19.7	6.6	0.46	-2.3	-1.6	0.1	0.0	0.0	0.0	0.0
	7:00	21.0	6.7	0.46	-3.1	-1.6	0.2	0.0	0.0	0.0	0.0
	8:00	37.8	7.6	0.47	-2.8	-1.6	-0.3	0.0	0.0	0.0	0.0
	9:00	34.2	7.9	0.47	-3.5	-1.5	-0.2	0.0	0.0	0.0	0.0
	10:00	46.9	8.6	0.44	-3.8	-1.7	0.0	0.0	0.0	0.0	0.0
	11:00	35.2	12.0	0.50	-2.5	-1.4	-0.2	0.0	0.0	0.0	0.0
	12:00	26.4	10.6	0.49	-3.2	-1.0	-0.3	0.0	0.0	0.0	0.0
	13:00	24.6	9.8	0.42	-3.0	-1.4	0.1	0.0	0.3	0.0	0.0
	14:00	19.1	8.5	0.44	-1.6	-1.2	-0.3	0.0	0.3	0.0	0.0
	15:00	23.6	10.7	0.47	-0.9	-1.1	-0.1	0.0	0.0	0.0	0.0
	16:00	19.6	8.9	0.38	-2.9	-1.4	0.1	0.0	0.9	0.0	0.0
	17:00	20.2	8.9	0.40	-2.3	-1.3	-0.2	0.0	1.8	0.0	0.0
	18:00	20.5	8.9	0.43	-1.2	-1.1	-0.2	0.0	1.9	0.0	0.0
	19:00	18.1	7.7	0.42	-2.0	-1.4	0.0	0.0	1.5	0.0	0.0
	20:00	17.4	7.1	0.37	-2.6	-1.3	-0.2	0.0	2.3	0.0	0.0
	21:00	17.6	7.3	0.36	-2.6	-1.5	0.1	0.0	1.8	0.0	0.0
	22:00	16.5	7.1	0.34	-2.5	-1.4	-0.1	0.0	2.0	0.0	0.0
	23:00	16.5	7.1	0.35	-1.9	-1.3	-0.4	0.0	0.6	0.0	0.0
	0:00	16.6	7.0	0.35	ZS	-1.6	0.0	0.0	1.7	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**11.6**	**4.6**	**0.3**	**-3.8**	**-1.7**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**46.9**	**12.0**	**0.5**	**-0.9**	**-1.0**	**0.4**	**0.0**	**2.3**	**0.0**	**0.0**
Average		**21.8**	**7.7**	**0.4**	**-2.5**	**-1.4**	**-0.1**	**0.0**	**0.6**	**0.0**	**0.0**
20/10/2018	1:00	16.4	6.9	0.36	-1.2	ZS	ZS	0.0	1.6	0.0	0.0
	2:00	16.5	7.0	0.35	-1.0	-1.3	0.0	0.0	1.5	0.0	0.0
	3:00	15.7	6.6	0.35	-0.7	-1.4	0.5	0.0	1.9	0.0	0.0
	4:00	16.2	6.7	0.34	0.1	-1.6	0.9	0.0	2.4	0.0	0.0
	5:00	17.2	6.5	0.34	0.5	-1.4	0.6	0.0	1.4	0.0	0.0
	6:00	19.8	6.7	0.35	0.5	-1.3	0.5	0.0	2.1	0.0	0.0
	7:00	20.0	7.4	0.39	-0.8	-1.2	0.1	0.0	2.2	0.0	0.0
	8:00	18.4	6.9	0.37	-2.0	-1.2	0.1	0.0	1.7	0.0	0.0
	9:00	19.0	7.2	0.38	-1.7	-1.2	0.1	0.0	1.1	0.0	0.0
	10:00	18.3	6.6	0.36	-2.8	-1.1	-0.2	0.0	1.4	0.0	0.0
	11:00	17.1	6.1	0.34	-3.2	-1.3	0.0	0.0	0.6	0.0	0.0
	12:00	14.7	6.3	0.34	-2.6	-1.1	-0.4	0.0	0.8	0.0	0.0
	13:00	21.7	8.3	0.37	-3.0	-1.1	-0.2	0.0	1.5	0.0	0.0
	14:00	18.7	8.0	0.35	-2.9	-1.0	-0.3	0.0	1.7	0.0	0.0
	15:00	18.3	8.5	0.36	-2.5	-1.2	0.1	0.0	0.8	0.0	0.0
	16:00	14.3	5.7	0.36	-2.0	-1.4	-0.2	0.0	1.1	0.0	0.0
	17:00	19.5	7.3	0.38	-1.1	-1.3	-0.3	0.0	1.5	0.0	0.0
	18:00	30.1	16.9	0.48	-0.3	-1.1	0.0	0.0	2.0	0.0	0.0
	19:00	47.7	28.2	0.53	1.2	-1.0	0.3	0.0	1.9	0.0	0.0
	20:00	33.9	18.4	0.50	0.7	-1.0	0.5	0.0	1.7	0.0	0.0
	21:00	38.7	19.6	0.51	0.9	-0.8	1.1	0.0	1.4	0.0	0.0
	22:00	25.7	13.1	0.49	-0.4	-0.8	0.5	0.0	1.9	0.0	0.0
	23:00	23.5	10.8	0.47	0.0	-0.9	0.2	0.0	1.9	0.0	0.0
	0:00	23.7	11.0	0.45	0.4	-0.7	0.4	0.0	1.4	0.0	0.0
Min		**14.3**	**5.7**	**0.3**	**-3.2**	**-1.6**	**-0.4**	**0.0**	**0.6**	**0.0**	**0.0**
Max		**47.7**	**28.2**	**0.5**	**1.2**	**-0.7**	**1.1**	**0.0**	**2.4**	**0.0**	**0.0**
Average		**21.9**	**9.8**	**0.4**	**-1.0**	**-1.1**	**0.2**	**0.0**	**1.6**	**0.0**	**0.0**
21/10/2018	1:00	24.1	9.3	0.43	-0.1	-0.9	1.2	0.0	1.1	0.0	0.0
	2:00	24.5	9.1	0.42	0.0	-0.8	1.0	0.0	1.5	0.0	0.0
	3:00	22.0	9.0	0.39	-0.1	-1.0	1.2	0.0	1.9	0.0	0.0
	4:00	23.4	8.8	0.44	-0.3	-1.0	0.9	0.0	1.4	0.0	0.0
	5:00	23.4	10.8	0.61	0.3	-0.9	0.9	0.0	1.9	0.0	0.0
	6:00	22.9	11.7	0.67	0.1	-0.6	0.8	0.0	1.1	0.0	0.0
	7:00	19.8	9.2	0.56	-1.2	-0.7	0.6	0.0	1.1	0.0	0.0
	8:00	19.8	9.0	0.48	-1.4	-0.8	0.5	0.0	1.7	0.0	0.0
	9:00	21.1	7.6	0.37	-3.3	-1.1	0.2	0.0	1.4	0.0	0.0
	10:00	20.4	7.8	0.36	-3.1	-1.2	0.2	0.0	1.6	0.0	0.0
	11:00	20.1	8.6	0.37	-3.5	-1.1	0.1	0.0	1.1	0.0	0.0
	12:00	20.2	8.4	0.37	-3.4	-1.0	-0.1	0.0	0.5	0.0	0.0
	13:00	20.2	8.4	0.36	-3.4	-1.1	-0.3	0.0	0.2	0.0	0.0
	14:00	20.2	8.5	0.36	-3.4	-1.1	-0.3	0.0	1.4	0.0	0.0
	15:00	19.0	8.1	0.34	-3.6	-1.2	-0.1	0.0	0.6	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	18.0	7.4	0.34	-3.8	-1.2	-0.5	0.0	0.3	0.0	0.0
	17:00	16.9	7.0	0.35	-3.6	-1.1	-0.3	0.0	0.0	0.0	0.0
	18:00	20.1	7.5	0.35	-3.0	-1.3	-0.4	0.0	0.0	0.0	0.0
	19:00	18.8	7.9	0.37	-3.7	-1.3	-0.3	0.0	0.0	0.0	1.8
	20:00	19.2	8.1	0.36	-3.5	-1.5	-0.1	0.0	0.0	0.0	5.6
	21:00	19.3	7.5	0.35	-2.8	-1.4	-0.1	0.0	2.1	0.0	0.0
	22:00	17.1	7.3	0.34	-3.3	-1.5	-0.2	0.0	3.1	0.0	0.0
	23:00	16.6	7.5	0.34	-3.3	-1.6	0.0	0.0	3.0	0.0	0.0
	0:00	16.8	7.3	0.33	ZS	-1.6	-0.2	0.0	3.2	0.0	0.0
Min		**16.6**	**7.0**	**0.3**	**-3.8**	**-1.6**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.5**	**11.7**	**0.7**	**0.3**	**-0.6**	**1.2**	**0.0**	**3.2**	**0.0**	**5.6**
Average		**20.2**	**8.4**	**0.4**	**-2.3**	**-1.1**	**0.2**	**0.0**	**1.3**	**0.0**	**0.3**
22/10/2018	1:00	15.9	7.0	0.33	-0.7	ZS	ZS	0.0	3.2	0.0	0.0
	2:00	14.8	6.5	0.33	-0.7	-1.2	0.2	0.0	3.3	0.0	0.0
	3:00	17.3	6.9	0.34	0.0	-1.3	-0.2	0.0	3.1	0.0	0.0
	4:00	15.2	6.4	0.33	-0.5	-1.3	-0.1	0.0	3.3	0.0	0.0
	5:00	16.1	6.2	0.33	-0.5	-1.4	0.0	0.0	3.2	0.0	0.0
	6:00	16.0	6.6	0.35	-0.2	-1.4	-0.2	0.0	3.3	0.0	0.0
	7:00	16.2	6.2	0.36	-0.7	-1.3	-0.2	0.0	3.4	0.0	0.0
	8:00	19.8	6.4	0.39	-0.7	-1.2	-0.4	0.0	3.4	0.0	0.0
	9:00	14.4	6.1	0.45	-0.4	-1.0	-0.2	0.0	3.5	0.0	0.0
	10:00	14.9	6.3	0.37	-0.7	-1.3	0.1	0.0	3.4	0.0	0.0
	11:00	16.5	6.4	0.36	-0.7	-1.1	-0.3	0.0	3.6	0.0	0.0
	12:00	15.0	6.1	0.36	-1.0	-1.3	-0.1	0.0	3.7	0.0	0.0
	13:00	15.3	6.0	0.37	-0.7	-1.2	0.0	0.0	3.9	0.0	0.0
	14:00	15.4	5.9	0.36	-0.6	-1.3	0.0	0.0	3.8	0.0	0.0
	15:00	15.6	5.7	0.36	-0.8	-1.3	-0.4	0.0	4.0	0.0	0.0
	16:00	15.3	5.9	0.36	-1.2	-1.3	-0.4	0.0	4.0	0.0	0.0
	17:00	15.6	5.6	0.36	-0.2	-1.4	-0.4	0.0	4.1	0.0	0.0
	18:00	14.6	5.3	0.37	-0.3	-1.3	-0.4	0.0	4.2	0.0	0.0
	19:00	16.7	5.9	0.42	1.3	-1.1	-0.2	0.0	4.3	0.0	0.0
	20:00	32.6	16.2	0.47	2.2	-0.9	0.1	0.0	4.2	0.0	0.0
	21:00	14.1	5.3	0.40	-0.2	-1.1	0.1	0.0	4.5	0.0	0.0
	22:00	11.8	5.1	0.35	-0.1	-1.1	-0.1	0.0	4.5	0.0	0.0
	23:00	12.6	5.5	0.35	-0.4	-1.4	0.0	0.0	4.8	0.0	0.0
	0:00	11.4	5.0	0.34	-0.4	-1.3	0.1	0.0	4.5	0.0	0.5
Min		**11.4**	**5.0**	**0.3**	**-1.2**	**-1.4**	**-0.4**	**0.0**	**3.1**	**0.0**	**0.0**
Max		**32.6**	**16.2**	**0.5**	**2.2**	**-0.9**	**0.2**	**0.0**	**4.8**	**0.0**	**0.5**
Average		**16.0**	**6.4**	**0.4**	**-0.3**	**-1.2**	**-0.1**	**0.0**	**3.8**	**0.0**	**0.0**
23/10/2018	1:00	10.6	4.7	0.34	ZS	-1.4	-0.1	0.0	4.6	0.0	2.3
	2:00	11.3	4.7	0.34	-1.9	ZS	ZS	0.0	4.7	0.0	4.2
	3:00	12.3	4.7	0.34	-1.7	-1.0	-0.1	0.0	4.7	0.0	2.3
	4:00	11.5	4.7	0.34	-1.3	-1.5	0.2	0.0	4.7	0.0	1.7
	5:00	14.4	5.7	0.38	1.4	-1.2	0.4	0.0	4.8	0.0	1.1
	6:00	14.7	5.9	0.42	1.8	-1.1	0.8	0.0	4.8	0.0	0.5

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	14.3	5.2	0.39	-1.0	-1.3	0.6	0.0	4.9	0.0	1.7
	8:00	16.8	5.1	0.36	-2.9	-1.1	-0.4	0.0	4.8	0.0	0.6
	9:00	19.6	5.2	0.38	-2.9	-1.1	-0.5	0.0	4.8	0.0	0.0
	10:00	19.9	5.4	0.37	-2.3	-1.3	-0.2	0.0	4.6	0.0	1.7
	11:00	20.3	5.6	0.36	-2.8	-1.3	-0.3	0.0	4.4	0.0	0.6
	12:00	17.6	6.4	0.37	-2.3	-1.1	-0.4	0.0	4.5	0.0	0.0
	13:00	16.4	5.8	0.36	-2.2	-1.3	-0.3	0.0	4.4	0.0	0.0
	14:00	16.6	5.3	0.36	-2.6	-1.3	-0.3	0.0	4.5	0.0	0.0
	15:00	14.1	5.2	0.34	-2.3	-1.6	-0.2	0.0	4.7	0.0	0.0
	16:00	13.0	4.9	0.36	-2.6	-1.3	-0.4	0.0	4.3	0.0	0.0
	17:00	13.0	4.5	0.36	-2.5	-1.3	-0.4	0.0	4.8	0.0	0.0
	18:00	13.9	4.7	0.37	-2.8	-1.4	-0.3	0.0	4.8	0.0	0.0
	19:00	12.2	4.9	0.39	-2.2	-1.3	-0.2	0.0	4.9	0.0	0.0
	20:00	12.2	4.9	0.43	-2.3	-1.1	-0.2	0.0	5.0	0.0	0.0
	21:00	12.1	4.9	0.39	-1.8	-1.5	0.1	0.0	5.0	0.0	0.0
	22:00	11.4	4.8	0.37	-2.6	-1.4	-0.1	0.0	5.0	0.0	0.0
	23:00	12.0	4.8	0.39	-2.3	-1.5	-0.3	0.0	5.1	0.0	0.0
	0:00	12.1	5.2	0.39	ZS	-1.6	-0.1	0.0	5.1	0.0	0.0
Min		**10.6**	**4.5**	**0.3**	**-2.9**	**-1.6**	**-0.5**	**0.0**	**4.3**	**0.0**	**0.0**
Max		**20.3**	**6.4**	**0.4**	**1.8**	**-1.0**	**0.8**	**0.0**	**5.1**	**0.0**	**4.2**
Average		**14.3**	**5.1**	**0.4**	**-1.9**	**-1.3**	**-0.1**	**0.0**	**4.7**	**0.0**	**0.7**
24/10/2018	1:00	11.4	4.8	0.36	-2.1	ZS	ZS	0.0	5.2	0.0	0.0
	2:00	11.5	4.9	0.35	-2.2	-1.2	0.0	0.0	5.3	0.0	0.0
	3:00	12.4	4.8	0.35	-2.0	-1.5	-0.2	0.0	5.2	0.0	0.0
	4:00	12.2	4.9	0.35	-1.7	-1.5	-0.1	0.0	5.1	0.0	0.0
	5:00	13.3	4.9	0.35	-1.9	-1.4	0.0	0.0	5.1	0.0	0.0
	6:00	17.4	6.2	0.41	0.6	-1.2	0.4	0.0	5.1	0.0	0.0
	7:00	18.2	6.1	0.45	-1.2	-0.9	0.3	0.0	4.9	0.0	0.0
	8:00	22.0	5.2	0.39	-2.1	-1.0	-0.3	0.0	4.9	0.0	0.0
	9:00	24.3	5.3	0.38	-2.8	-1.2	-0.3	0.0	5.1	0.0	0.0
	10:00	21.3	5.5	0.38	-2.5	-1.1	-0.3	0.0	5.0	0.0	0.0
	11:00	35.1	6.5	0.38	-2.4	-1.2	-0.2	0.0	5.1	0.0	0.0
	12:00	22.4	6.4	0.37	-2.8	-1.2	-0.3	0.0	4.9	0.0	0.0
	13:00	20.3	6.2	0.39	-2.9	-1.1	-0.1	0.0	5.1	0.0	0.0
	14:00	21.4	6.2	0.37	-2.7	-1.1	-0.1	0.0	5.3	0.0	0.0
	15:00	17.2	5.5	0.36	-2.4	-1.2	-0.5	0.0	5.2	0.0	0.0
	16:00	16.4	6.6	0.38	-2.7	-1.3	-0.2	0.0	5.1	0.0	0.0
	17:00	18.0	7.9	0.40	-1.5	-1.1	-0.3	0.0	5.3	0.0	0.0
	18:00	18.2	9.1	0.42	-2.1	-1.2	-0.1	0.0	5.4	0.0	0.0
	19:00	15.5	6.3	0.43	-2.5	-1.2	-0.2	0.0	5.3	0.0	0.0
	20:00	12.8	5.4	0.41	-2.3	-1.3	-0.5	0.0	5.4	0.0	0.0
	21:00	14.2	5.7	0.39	-1.8	-1.5	0.0	0.0	5.3	0.0	0.0
	22:00	13.0	5.8	0.40	-2.0	-1.6	0.0	0.0	5.2	0.0	0.0
	23:00	13.9	5.8	0.40	-2.4	-1.3	-0.4	0.0	5.5	0.0	0.0
	0:00	13.1	5.7	0.38	-2.4	-1.4	-0.4	0.0	5.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**11.4**	**4.8**	**0.3**	**-2.9**	**-1.6**	**-0.5**	**0.0**	**4.9**	**0.0**	**0.0**
Max		**35.1**	**9.1**	**0.5**	**0.6**	**-0.9**	**0.4**	**0.0**	**5.5**	**0.0**	**0.0**
Average		**17.3**	**5.9**	**0.4**	**-2.1**	**-1.3**	**-0.2**	**0.0**	**5.2**	**0.0**	**0.0**
25/10/2018	1:00	12.6	5.7	0.37	-1.8	-1.5	0.0	0.0	5.4	0.0	0.0
	2:00	12.8	5.6	0.37	-2.3	-1.5	-0.1	0.0	5.4	0.0	0.0
	3:00	12.9	5.9	0.39	-2.0	-1.4	-0.1	0.0	5.4	0.0	0.0
	4:00	17.3	7.4	0.48	-1.3	-1.0	0.0	0.0	5.2	0.0	0.0
	5:00	15.9	6.7	0.39	-1.4	-1.3	0.1	0.0	5.4	0.0	0.0
	6:00	14.2	6.4	0.40	-1.3	-1.5	0.1	0.0	5.4	0.0	0.0
	7:00	17.6	6.8	0.42	-1.8	-1.3	0.0	0.0	5.5	0.0	0.0
	8:00	31.6	7.3	0.42	-2.2	-1.1	-0.3	0.0	5.6	0.0	0.0
	9:00	36.9	8.1	0.42	-1.8	-1.3	-0.2	0.0	5.3	0.0	0.0
	10:00	32.4	9.0	0.42	-1.6	-1.2	-0.3	0.0	5.3	0.0	0.0
	11:00	38.0	8.8	0.40	-2.5	-1.1	-0.4	0.0	5.2	0.0	0.0
	12:00	35.2	7.4	0.40	-2.4	-1.3	-0.3	0.0	5.2	0.0	0.0
	13:00	29.6	7.3	0.39	-2.4	-1.2	-0.3	0.0	5.1	0.0	0.0
	14:00	26.9	6.4	0.38	-2.7	-1.4	-0.5	0.0	5.2	0.0	0.0
	15:00	22.1	6.0	0.39	-2.3	-1.5	-0.3	0.0	5.5	0.0	0.0
	16:00	18.6	5.3	0.38	-2.7	-1.5	-0.3	0.0	5.5	0.0	0.0
	17:00	12.9	5.1	0.39	-2.6	-1.4	-0.3	0.0	5.4	0.0	0.0
	18:00	11.8	4.7	0.43	-2.4	-1.4	-0.4	0.0	5.3	0.0	0.0
	19:00	14.9	5.3	0.48	-2.2	-1.1	-0.3	0.0	5.4	0.0	0.0
	20:00	10.0	4.6	0.42	-2.0	-1.6	0.1	0.0	5.4	0.0	0.0
	21:00	10.7	4.7	0.41	-2.2	-1.5	0.0	0.0	5.4	0.0	0.0
	22:00	10.0	4.7	0.41	-2.6	-1.5	-0.1	0.0	5.4	0.0	0.0
	23:00	9.7	4.4	0.40	-2.9	-1.6	-0.1	0.0	5.2	0.0	0.0
	0:00	9.4	4.4	0.39	-2.7	-1.4	-0.3	0.0	5.3	0.0	0.0
Min		**9.4**	**4.4**	**0.4**	**-2.9**	**-1.6**	**-0.5**	**0.0**	**5.1**	**0.0**	**0.0**
Max		**38.0**	**9.0**	**0.5**	**-1.3**	**-1.0**	**0.1**	**0.0**	**5.6**	**0.0**	**0.0**
Average		**19.3**	**6.2**	**0.4**	**-2.2**	**-1.4**	**-0.2**	**0.0**	**5.3**	**0.0**	**0.0**
26/10/2018	1:00	9.3	4.1	0.39	ZS	-1.2	-0.3	0.0	5.3	0.0	0.0
	2:00	9.9	4.2	0.39	-0.6	ZS	ZS	0.0	5.3	0.0	0.0
	3:00	9.5	4.1	0.39	-0.8	-1.2	-0.2	0.0	5.2	0.0	0.0
	4:00	9.4	4.0	0.38	-1.0	-1.3	-0.3	0.0	5.5	0.0	0.0
	5:00	9.6	3.9	0.38	-1.0	-1.4	-0.2	0.0	5.4	0.0	0.0
	6:00	12.2	4.0	0.40	-0.4	-1.2	-0.1	0.0	5.4	0.0	0.0
	7:00	10.2	3.7	0.41	-0.6	-1.4	-0.3	0.0	5.6	0.0	0.0
	8:00	13.6	3.6	0.41	-1.1	-1.5	0.0	0.0	5.6	0.0	0.0
	9:00	13.4	3.5	0.41	-0.8	-1.3	-0.4	0.0	5.6	0.0	0.0
	10:00	12.2	3.3	0.40	-1.0	-1.2	-0.6	0.0	5.4	0.0	0.0
	11:00	13.1	3.4	0.41	-0.6	-1.2	-0.3	0.0	5.6	0.0	0.0
	12:00	16.8	3.5	0.39	-0.8	-1.5	-0.2	0.0	5.5	0.0	0.0
	13:00	14.0	3.3	0.40	-1.2	-1.3	-0.2	0.0	5.4	0.0	0.0
	14:00	25.0	4.1	0.40	-1.1	-1.4	-0.5	0.0	5.4	0.0	0.0
	15:00	29.1	4.2	0.41	-1.1	-1.4	-0.4	0.0	5.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	24.9	4.4	0.39	-1.3	-1.5	-0.2	0.0	5.3	0.0	0.0
	17:00	12.1	3.5	0.39	-1.0	-1.5	-0.3	0.0	5.3	0.0	0.0
	18:00	11.8	3.8	0.42	0.0	-1.5	-0.3	0.0	5.4	0.0	0.0
	19:00	9.9	3.9	0.44	0.1	-1.5	-0.3	0.0	5.6	0.0	0.0
	20:00	10.6	4.1	0.41	-0.7	-1.4	-0.1	0.0	5.7	0.0	0.0
	21:00	10.4	4.1	0.41	-0.9	-1.4	-0.2	0.0	5.5	0.0	0.0
	22:00	12.1	4.5	0.40	-0.9	-1.5	-0.1	0.0	5.3	0.0	0.0
	23:00	11.3	4.2	0.39	-0.9	-1.4	-0.1	0.0	5.3	0.0	0.0
	0:00	11.9	4.0	0.39	ZS	-1.8	-0.2	0.0	5.2	0.0	0.0
Min		**9.3**	**3.3**	**0.4**	**-1.3**	**-1.8**	**-0.6**	**0.0**	**5.2**	**0.0**	**0.0**
Max		**29.1**	**4.5**	**0.4**	**0.1**	**-1.2**	**0.0**	**0.0**	**5.7**	**0.0**	**0.0**
Average		**13.4**	**3.9**	**0.4**	**-0.8**	**-1.4**	**-0.2**	**0.0**	**5.4**	**0.0**	**0.0**
27/10/2018	1:00	12.9	5.2	0.43	BO	ZS	ZS	0.0	5.2	0.0	0.0
	2:00	16.0	7.0	0.57	BO	-1.7	0.6	0.0	5.2	0.0	0.0
	3:00	16.6	7.9	0.70	BO	-1.6	0.6	0.0	5.4	0.0	0.0
	4:00	15.3	5.8	0.49	BO	-1.7	0.3	0.0	5.5	0.0	0.0
	5:00	10.7	3.6	0.40	BO	-1.6	0.1	0.0	5.5	0.0	0.0
	6:00	12.0	3.9	0.42	BO	-1.8	0.2	0.0	5.5	0.0	0.0
	7:00	16.5	4.3	0.43	BO	-1.7	-0.1	0.0	5.4	0.0	0.0
	8:00	13.2	4.1	0.41	BO	-1.7	-0.3	0.0	5.6	0.0	0.0
	9:00	17.2	4.0	0.40	BO	-1.6	-0.3	0.0	5.5	0.0	0.0
	10:00	14.2	4.2	0.39	BO	-1.5	-0.5	0.0	5.5	0.0	0.0
	11:00	16.9	4.0	0.40	BO	-1.6	-0.3	0.0	5.2	0.0	0.0
	12:00	16.5	4.6	0.39	BO	-1.5	-0.4	0.0	5.1	0.0	0.0
	13:00	13.5	4.1	0.39	BO	-1.7	-0.3	0.0	5.1	0.0	0.0
	14:00	13.1	4.4	0.39	BO	-1.6	-0.3	0.0	5.1	0.0	0.0
	15:00	11.3	3.9	0.39	BO	-1.5	-0.3	0.0	5.5	0.0	0.0
	16:00	10.3	3.7	0.39	BO	-1.5	-0.3	0.0	5.3	0.0	0.0
	17:00	11.3	3.6	0.39	BO	-1.6	-0.5	0.0	5.4	0.0	0.0
	18:00	12.5	4.1	0.44	BO	-1.5	-0.3	0.0	5.2	0.0	0.0
	19:00	12.1	4.7	0.47	BO	-1.5	-0.2	0.0	5.3	0.0	0.0
	20:00	11.3	4.4	0.46	BO	-1.3	-0.1	0.0	5.3	0.0	0.0
	21:00	11.8	4.3	0.45	BO	-1.3	-0.4	0.0	5.2	0.0	0.0
	22:00	10.4	4.1	0.42	BO	-1.5	0.0	0.0	5.3	0.0	0.0
	23:00	10.6	4.0	0.43	BO	-1.5	-0.2	0.0	5.1	0.0	0.0
	0:00	9.8	3.9	0.42	BO	-1.5	-0.2	0.0	5.2	0.0	0.0
Min		**9.8**	**3.6**	**0.4**	**ID**	**-1.8**	**-0.5**	**0.0**	**5.1**	**0.0**	**0.0**
Max		**17.2**	**7.9**	**0.7**	**ID**	**-1.3**	**0.6**	**0.0**	**5.6**	**0.0**	**0.0**
Average		**13.2**	**4.5**	**0.4**	**ID**	**-1.6**	**-0.1**	**0.0**	**5.3**	**0.0**	**0.0**
28/10/2018	1:00	9.2	3.6	0.42	BO	-1.5	-0.3	0.0	5.2	0.0	0.0
	2:00	8.4	3.6	0.41	4.1	-1.6	0.0	0.0	5.1	0.0	0.0
	3:00	9.5	3.7	0.40	4.0	-1.6	-0.2	0.0	5.0	0.0	0.0
	4:00	10.2	3.7	0.41	3.7	-1.5	-0.4	0.0	5.3	0.0	0.0
	5:00	10.0	3.9	0.41	3.4	-1.6	0.2	0.0	5.3	0.0	0.0
	6:00	10.6	3.9	0.43	3.5	-1.7	-0.1	0.0	5.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	12.5	4.0	0.44	3.6	-1.5	-0.3	0.0	5.3	0.0	0.0
	8:00	10.4	3.7	0.41	2.9	-1.6	-0.4	0.0	5.2	0.0	0.0
	9:00	10.8	3.6	0.40	2.8	-1.5	-0.4	0.0	5.2	0.0	0.0
	10:00	12.4	3.7	0.40	2.7	-1.7	-0.1	0.0	5.5	0.0	0.0
	11:00	10.3	3.6	0.40	2.2	-1.7	-0.2	0.0	5.5	0.0	0.0
	12:00	8.9	3.4	0.39	2.1	-1.6	-0.3	0.0	5.7	0.0	0.0
	13:00	14.4	7.2	0.44	2.6	-0.8	-0.6	0.0	5.3	0.0	0.0
	14:00	19.3	10.7	0.46	2.7	-0.7	-0.4	0.0	5.5	0.0	0.0
	15:00	11.8	5.6	0.42	2.3	-1.2	0.0	0.0	5.3	0.0	0.0
	16:00	9.9	4.1	0.42	2.1	-1.4	-0.2	0.0	5.3	0.0	0.0
	17:00	11.1	3.7	0.43	1.7	-1.5	-0.4	0.0	5.4	0.0	0.0
	18:00	12.2	4.2	0.45	2.5	-1.5	-0.2	0.0	5.3	0.0	0.0
	19:00	9.6	3.8	0.47	2.0	-1.6	-0.2	0.0	5.5	0.0	0.0
	20:00	10.2	3.7	0.46	2.2	-1.5	-0.1	0.0	5.3	0.0	0.0
	21:00	8.4	3.4	0.44	2.2	-1.3	0.0	0.0	5.3	0.0	0.0
	22:00	8.4	3.2	0.42	1.6	-1.6	-0.1	0.0	5.5	0.0	0.0
	23:00	7.9	2.8	0.42	1.6	-1.6	-0.1	0.0	5.3	0.0	0.0
	0:00	6.3	2.6	0.42	ZS	-1.7	0.0	0.0	5.3	0.0	0.0
Min		**6.3**	**2.6**	**0.4**	**1.6**	**-1.7**	**-0.6**	**0.0**	**5.0**	**0.0**	**0.0**
Max		**19.3**	**10.7**	**0.5**	**4.1**	**-0.7**	**0.2**	**0.0**	**5.7**	**0.0**	**0.0**
Average		**10.5**	**4.1**	**0.4**	**2.7**	**-1.5**	**-0.2**	**0.0**	**5.3**	**0.0**	**0.0**
29/10/2018	1:00	6.3	2.2	0.43	BO	ZS	ZS	0.0	5.4	0.0	0.0
	2:00	6.6	2.2	0.44	BO	-1.6	0.4	0.0	5.1	0.0	0.0
	3:00	8.1	2.1	0.43	BO	-1.8	0.9	0.0	5.3	0.0	0.0
	4:00	10.4	3.6	0.51	BO	-1.5	0.6	0.0	5.1	0.0	0.0
	5:00	12.4	4.9	0.52	BO	-1.3	1.1	0.0	5.1	0.0	0.0
	6:00	15.6	6.5	0.48	BO	-1.4	0.6	0.0	5.0	0.0	0.0
	7:00	18.5	6.2	0.48	BO	-1.6	0.7	0.0	5.2	0.0	0.0
	8:00	20.9	6.9	0.57	BO	-1.4	0.3	0.0	4.9	0.0	0.0
	9:00	18.5	4.4	0.49	BO	-1.4	-0.3	0.0	5.2	0.0	0.0
	10:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	11:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	12:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	13:00	13.2	3.8	PO	PO	PO	PO	PO	PO	PO	PO
	14:00	23.4	4.6	0.64	BO	-1.4	-0.4	0.0	6.7	0.0	1.1
	15:00	15.6	3.2	0.64	BO	-1.6	0.0	0.0	6.1	0.0	0.0
	16:00	15.7	3.5	0.59	BO	-1.6	-0.5	0.0	6.0	0.0	0.0
	17:00	11.5	3.6	0.59	BO	-1.8	-0.3	0.0	5.5	0.0	0.0
	18:00	10.9	3.6	0.58	BO	-1.7	-0.2	0.0	5.6	0.0	0.0
	19:00	11.9	3.6	0.61	BO	-1.6	0.1	0.0	5.3	0.0	0.0
	20:00	33.1	14.6	0.61	BO	-1.6	0.3	0.0	5.3	0.0	0.0
	21:00	14.3	5.4	0.57	BO	-1.4	-0.1	0.0	5.2	0.0	0.0
	22:00	11.6	3.6	0.53	BO	-1.7	-0.1	0.0	5.2	0.0	0.0
	23:00	10.0	3.7	0.54	BO	-1.6	0.0	0.0	5.0	0.0	0.0
	0:00	10.2	3.8	0.52	BO	-1.6	0.0	0.0	4.9	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**6.3**	**2.1**	**0.4**	**ID**	**-1.8**	**-0.5**	**0.0**	**4.9**	**0.0**	**0.0**
Max		**33.1**	**14.6**	**0.6**	**ID**	**-1.3**	**1.1**	**0.0**	**6.7**	**0.0**	**1.1**
Average		**14.2**	**4.6**	**0.5**	**ID**	**-1.5**	**0.2**	**0.0**	**5.4**	**0.0**	**0.1**
30/10/2018	1:00	10.0	3.9	0.51	BO	-1.6	0.4	0.0	4.8	0.0	0.0
	2:00	11.0	3.9	0.51	BO	-1.4	0.0	0.0	4.9	0.0	0.0
	3:00	13.6	4.1	0.50	BO	-1.7	0.5	0.0	4.8	0.0	0.0
	4:00	11.9	3.8	0.48	BO	-1.7	0.4	0.0	4.7	0.0	0.0
	5:00	14.5	4.6	0.53	BO	-1.7	0.7	0.0	4.6	0.0	0.0
	6:00	16.2	4.6	0.57	BO	-1.5	0.5	0.0	4.7	0.0	0.0
	7:00	32.6	6.1	0.59	BO	-1.2	0.1	0.0	4.7	0.0	0.0
	8:00	29.1	5.2	0.50	2.5	-1.4	-0.2	0.0	4.7	0.0	0.0
	9:00	32.0	5.4	0.50	2.9	-1.5	-0.3	0.0	4.7	0.0	0.0
	10:00	41.5	5.8	0.51	2.6	-1.5	-0.2	0.0	4.7	0.0	0.0
	11:00	34.7	5.5	0.51	2.9	-1.4	-0.3	0.0	4.6	0.0	0.0
	12:00	48.4	5.6	0.48	1.8	-1.7	0.0	0.0	4.6	0.0	0.0
	13:00	65.3	6.9	0.48	2.7	-1.5	-0.4	0.0	4.5	0.0	0.0
	14:00	21.8	4.9	0.50	1.9	-1.6	-0.1	0.0	4.5	0.0	0.0
	15:00	26.3	4.5	0.48	1.2	-1.6	-0.2	0.0	4.5	0.0	0.0
	16:00	13.6	3.9	0.49	1.5	-1.6	-0.4	0.0	5.6	0.0	0.0
	17:00	14.5	4.2	0.50	1.1	-1.8	-0.2	0.0	4.4	0.0	0.0
	18:00	15.7	4.2	0.51	1.8	-1.7	-0.3	0.0	4.4	0.0	0.0
	19:00	28.8	20.2	0.60	1.9	-0.7	-0.3	0.0	4.3	0.0	0.0
	20:00	48.6	38.3	0.68	2.6	-0.3	0.1	0.0	4.4	0.0	0.0
	21:00	25.4	15.6	0.56	2.0	-1.0	0.0	0.0	4.2	0.0	0.0
	22:00	10.8	4.0	0.48	1.2	-1.6	-0.3	0.0	4.3	0.0	0.0
	23:00	10.2	4.1	0.48	1.2	-1.9	-0.1	0.0	4.4	0.0	0.0
	0:00	10.5	4.2	0.48	ZS	-1.9	-0.2	0.0	4.4	0.0	0.0
Min		**10.0**	**3.8**	**0.5**	**ID**	**-1.9**	**-0.4**	**0.0**	**4.2**	**0.0**	**0.0**
Max		**65.3**	**38.3**	**0.7**	**ID**	**-0.3**	**0.7**	**0.0**	**5.6**	**0.0**	**0.0**
Average		**24.5**	**7.2**	**0.5**	**ID**	**-1.5**	**0.0**	**0.0**	**4.6**	**0.0**	**0.0**
31/10/2018	1:00	11.2	4.2	0.27	1.9	ZS	ZS	0.0	4.5	0.0	0.0
	2:00	10.9	4.3	0.27	1.5	-1.5	-0.2	0.0	4.4	0.0	0.0
	3:00	11.8	4.5	0.27	1.5	-1.6	-0.3	0.0	4.3	0.0	0.0
	4:00	11.9	4.8	0.27	1.6	-1.5	-0.3	0.0	4.3	0.0	0.0
	5:00	13.6	5.2	0.30	2.5	-1.5	-0.1	0.0	4.3	0.0	0.0
	6:00	18.4	5.8	0.37	3.8	-1.1	0.0	0.0	4.2	0.0	0.0
	7:00	18.7	5.9	0.33	1.7	-1.3	-0.3	0.0	4.1	0.0	0.0
	8:00	36.1	7.0	0.32	1.4	-1.3	-0.3	0.0	4.2	0.0	0.0
	9:00	50.3	8.4	0.31	1.1	-1.2	-0.4	0.0	4.0	0.0	0.0
	10:00	96.8	10.8	0.28	1.2	-1.7	-0.1	0.0	4.4	0.0	0.0
	11:00	70.3	9.8	0.28	0.9	-1.6	-0.3	0.0	4.3	0.0	0.0
	12:00	49.7	9.4	0.29	1.3	-1.5	-0.3	0.0	4.2	0.0	0.0
	13:00	27.8	7.5	0.28	0.7	-1.7	-0.4	0.0	4.4	0.0	0.0
	14:00	40.0	8.2	0.28	0.4	-1.7	-0.2	0.0	4.0	0.0	0.0
	15:00	37.3	9.0	0.29	0.7	-1.7	-0.4	0.0	3.8	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	21.9	7.5	0.27	0.5	-1.7	-0.6	0.0	3.9	0.0	0.0
	17:00	25.4	7.9	0.29	0.3	-1.7	-0.1	0.0	4.0	0.0	0.0
	18:00	23.3	7.9	0.31	0.8	-1.8	-0.1	0.0	3.7	0.0	0.0
	19:00	20.5	7.7	0.31	1.2	-1.7	-0.3	0.0	3.7	0.0	0.0
	20:00	18.3	7.2	0.30	0.5	-1.8	0.2	0.0	3.6	0.0	0.0
	21:00	18.9	7.2	0.29	0.5	-1.5	-0.3	0.0	3.7	0.0	0.0
	22:00	17.5	7.0	0.28	0.2	-1.7	-0.4	0.0	3.5	0.0	0.0
	23:00	17.3	7.1	0.29	0.5	-2.0	0.0	0.0	1.2	0.0	0.0
	0:00	20.1	7.8	0.28	0.6	-2.0	-0.4	0.0	1.3	0.0	0.0
Min		**10.9**	**4.2**	**0.3**	**0.2**	**-2.0**	**-0.6**	**0.0**	**1.2**	**0.0**	**0.0**
Max		**96.8**	**10.8**	**0.4**	**3.8**	**-1.1**	**0.2**	**0.0**	**4.5**	**0.0**	**0.0**
Average		**28.7**	**7.2**	**0.3**	**1.1**	**-1.6**	**-0.2**	**0.0**	**3.8**	**0.0**	**0.0**
01/11/2018	1:00	21.2	8.3	0.29	0.2	-2.0	-0.3	0.0	1.3	0.0	0.0
	2:00	23.2	9.0	0.29	0.5	-2.0	-0.2	0.0	1.7	0.0	0.0
	3:00	21.1	8.5	0.29	0.5	-2.1	-0.4	0.0	2.0	0.0	0.0
	4:00	20.0	7.9	0.29	1.3	-2.0	0.0	0.0	1.5	0.0	0.0
	5:00	21.7	8.3	0.32	1.7	-1.7	0.0	0.0	2.6	0.0	0.0
	6:00	28.2	9.6	0.33	1.6	-1.7	0.4	0.0	1.7	0.0	0.0
	7:00	30.8	10.3	0.36	1.9	-1.4	-0.1	0.0	2.7	0.0	0.0
	8:00	29.0	10.1	0.38	3.0	-1.2	-0.1	0.0	2.4	0.0	0.0
	9:00	24.9	9.2	0.32	3.8	-0.9	0.0	0.0	2.7	0.0	0.0
	10:00	21.6	7.8	0.31	0.4	-1.6	-0.1	0.0	2.6	0.0	0.0
	11:00	22.6	7.5	0.31	0.7	-1.4	-0.3	0.0	2.6	0.0	0.0
	12:00	23.9	7.6	0.29	0.9	-1.6	-0.2	0.0	2.3	0.0	0.0
	13:00	29.8	7.4	0.28	0.3	-1.3	-0.4	0.0	2.5	0.0	0.0
	14:00	22.2	9.2	0.29	0.2	-1.6	-0.3	0.0	2.6	0.0	0.0
	15:00	28.4	14.6	0.34	0.4	-1.3	-0.6	0.0	2.9	0.0	0.0
	16:00	22.2	11.9	0.33	0.7	-1.1	-0.7	0.0	2.9	0.0	0.0
	17:00	18.4	7.7	0.33	-0.1	-1.4	-0.4	0.0	2.9	0.0	0.0
	18:00	14.0	5.9	0.32	1.2	-1.8	-0.2	0.0	3.0	0.0	0.0
	19:00	18.7	8.1	0.41	2.9	-1.5	0.8	0.0	2.6	0.0	0.0
	20:00	16.4	4.8	0.40	3.6	-1.4	0.2	0.0	2.7	0.0	0.0
	21:00	14.9	4.6	0.40	2.2	-1.5	0.3	0.0	2.9	0.0	0.0
	22:00	13.4	4.2	0.29	0.3	-1.6	0.1	0.0	2.5	0.0	0.0
	23:00	13.0	4.2	0.30	1.1	-1.8	0.1	0.0	3.0	0.0	0.0
	0:00	12.1	4.0	0.27	0.5	-2.1	0.3	0.0	3.1	0.0	0.0
Min		**12.1**	**4.0**	**0.3**	**-0.1**	**-2.1**	**-0.7**	**0.0**	**1.3**	**0.0**	**0.0**
Max		**30.8**	**14.6**	**0.4**	**3.8**	**-0.9**	**0.8**	**0.0**	**3.1**	**0.0**	**0.0**
Average		**21.3**	**7.9**	**0.3**	**1.2**	**-1.6**	**-0.1**	**0.0**	**2.5**	**0.0**	**0.0**
02/11/2018	1:00	11.5	3.6	0.27	ZS	-1.8	0.1	0.0	2.4	0.0	0.0
	2:00	11.9	4.0	0.28	-1.0	ZS	ZS	0.0	2.8	0.0	0.0
	3:00	12.7	4.0	0.27	-2.0	-1.6	0.5	0.0	2.8	0.0	0.0
	4:00	9.9	3.3	0.26	-2.9	-1.7	0.1	0.0	2.8	0.0	0.0
	5:00	12.0	3.7	0.26	-3.2	-1.6	0.4	0.0	2.6	0.0	0.0
	6:00	10.3	3.3	0.28	-2.6	-1.5	0.4	0.0	2.8	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	11.9	4.7	0.32	-1.3	-1.7	0.4	0.0	2.9	0.0	0.0
	8:00	12.6	4.7	0.39	-1.7	-1.3	0.2	0.0	2.9	0.0	0.0
	9:00	20.1	4.2	0.36	-3.0	-1.3	-0.1	0.0	2.8	0.0	0.0
	10:00	21.3	4.2	0.30	-3.7	-1.4	-0.5	0.0	2.4	0.0	0.0
	11:00	24.3	4.3	0.29	-3.3	-1.4	-0.3	0.0	2.7	0.0	0.0
	12:00	16.7	4.0	0.30	0.3	-1.5	-0.3	0.0	2.2	0.0	0.0
	13:00	19.5	3.5	0.26	-3.1	-1.6	-0.5	0.0	0.6	0.0	0.0
	14:00	19.5	3.5	0.26	-3.6	-1.4	-0.6	0.0	1.1	0.0	0.0
	15:00	19.5	3.5	0.27	-3.8	-1.5	-0.4	0.0	1.9	0.0	0.0
	16:00	19.5	3.5	0.28	-3.6	-1.5	-0.5	0.0	0.8	0.0	0.0
	17:00	19.5	3.5	0.30	-3.3	-1.6	-0.4	0.0	1.4	0.0	0.0
	18:00	19.5	3.5	0.32	-2.8	-1.7	-0.1	0.0	0.8	0.0	0.0
	19:00	19.5	3.5	0.32	-2.8	-1.7	0.3	0.0	1.6	0.0	0.0
	20:00	19.5	3.5	0.33	-2.0	-1.7	0.3	0.0	0.8	0.0	0.0
	21:00	19.5	3.5	0.31	-3.2	-1.6	0.1	0.0	1.4	0.0	0.0
	22:00	19.5	3.5	0.28	-3.0	-1.5	-0.2	0.0	0.3	0.0	0.0
	23:00	19.5	3.5	0.29	-2.3	-1.5	-0.2	0.0	0.9	0.0	0.0
	0:00	19.5	3.5	0.29	ZS	-1.8	0.2	0.0	0.9	0.0	0.0
Min		**9.9**	**3.3**	**0.3**	**-3.8**	**-1.8**	**-0.6**	**0.0**	**0.3**	**0.0**	**0.0**
Max		**24.3**	**4.7**	**0.4**	**0.3**	**-1.3**	**0.5**	**0.0**	**2.9**	**0.0**	**0.0**
Average		**17.0**	**3.7**	**0.3**	**-2.6**	**-1.6**	**0.0**	**0.0**	**1.9**	**0.0**	**0.0**
03/11/2018	1:00	19.5	3.5	0.29	-1.9	ZS	ZS	0.0	0.6	0.0	0.0
	2:00	19.5	3.5	0.28	-0.9	-1.4	0.5	0.0	0.2	0.0	0.0
	3:00	19.5	3.5	0.29	-1.5	-1.3	0.3	0.0	0.0	0.0	0.0
	4:00	19.5	3.5	0.28	-0.8	-1.6	0.7	0.0	0.0	0.0	0.0
	5:00	19.5	3.5	0.27	-1.8	-1.5	0.4	0.0	0.6	0.0	0.0
	6:00	19.5	3.5	0.32	0.7	-1.3	0.4	0.0	0.8	0.0	0.0
	7:00	19.5	3.5	0.32	-3.8	-1.4	0.1	0.0	0.3	0.0	0.0
	8:00	19.5	3.5	0.29	-3.6	-1.5	-0.4	0.0	0.0	0.0	0.0
	9:00	19.5	3.5	0.27	-3.8	-1.6	-0.2	0.0	0.0	0.0	0.0
	10:00	19.5	3.5	0.27	-4.1	-1.6	-0.3	0.0	0.5	0.0	0.0
	11:00	19.5	3.5	0.26	-4.0	-1.7	-0.2	0.0	0.6	0.0	0.0
	12:00	19.5	3.5	0.26	-3.5	-1.7	-0.5	0.0	0.8	0.0	0.0
	13:00	19.5	3.5	0.25	-3.7	-1.9	-0.2	0.0	0.5	0.0	0.0
	14:00	19.5	3.5	0.26	-3.8	-1.8	-0.4	0.2	2.4	0.4	2.3
	15:00	19.5	3.5	0.27	-3.8	-1.6	-0.4	1.2	1.2	0.6	14.4
	16:00	19.5	3.5	0.26	-4.0	-1.8	-0.3	0.9	1.6	0.4	4.6
	17:00	19.5	3.5	0.31	-2.8	-1.6	-0.5	0.0	1.0	0.0	0.0
	18:00	19.5	3.5	0.35	-2.3	-1.5	-0.2	0.0	0.3	0.0	0.0
	19:00	19.5	3.5	0.33	-2.4	-1.5	-0.4	0.0	0.5	0.0	0.1
	20:00	19.5	3.5	0.34	-2.8	-1.6	-0.1	0.0	0.3	0.0	0.0
	21:00	19.5	3.5	0.33	-2.3	-1.5	-0.1	0.0	0.6	0.0	0.0
	22:00	19.5	3.5	0.29	-3.3	-1.7	-0.1	0.0	0.3	0.0	0.0
	23:00	19.5	3.5	0.31	-2.4	-1.5	0.0	0.0	0.2	0.0	0.0
	0:00	19.5	3.5	0.31	-1.6	-1.5	0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**19.5**	**3.5**	**0.3**	**-4.1**	**-1.9**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**19.5**	**3.5**	**0.3**	**0.7**	**-1.3**	**0.7**	**1.2**	**2.4**	**0.6**	**14.4**
Average		**19.5**	**3.5**	**0.3**	**-2.7**	**-1.6**	**-0.1**	**0.1**	**0.6**	**0.1**	**0.9**
04/11/2018	1:00	19.5	3.5	0.36	-0.5	-1.6	0.2	0.0	0.5	0.0	0.0
	2:00	19.5	3.5	0.33	0.4	-1.2	0.3	0.0	0.3	0.0	0.0
	3:00	19.5	3.5	0.30	-0.6	-1.2	0.4	0.0	0.0	0.0	0.0
	4:00	19.5	3.5	0.30	-1.1	-1.2	0.8	0.0	0.3	0.0	0.0
	5:00	19.5	3.5	0.30	-1.2	-1.1	0.9	0.0	0.2	0.0	0.0
	6:00	19.5	3.5	0.34	-1.8	-1.1	0.1	0.0	0.2	0.0	0.0
	7:00	19.5	3.5	0.33	-2.0	-1.1	0.3	0.0	0.0	0.0	0.0
	8:00	19.5	3.5	0.30	-0.8	-0.9	0.2	0.0	0.4	0.0	0.0
	9:00	19.5	3.5	0.30	2.3	-0.1	0.1	0.0	0.8	0.0	0.0
	10:00	19.5	3.5	0.33	0.3	-0.3	-0.2	0.0	0.6	0.0	0.0
	11:00	19.5	3.5	0.32	-2.1	-0.9	-0.5	0.0	0.8	0.0	0.0
	12:00	19.5	3.5	0.31	-2.9	-1.1	-0.5	0.0	1.6	0.0	0.0
	13:00	19.5	3.5	0.30	-3.7	-1.6	-0.2	0.0	1.2	0.0	0.0
	14:00	19.5	3.5	0.31	-3.6	-1.5	-0.2	0.0	0.6	0.0	0.0
	15:00	19.5	3.5	0.30	-4.0	-1.6	-0.4	0.0	0.9	0.0	0.0
	16:00	19.5	3.5	0.30	-3.4	-1.6	-0.4	0.0	0.6	0.0	0.0
	17:00	19.5	3.5	0.32	-3.8	-1.4	-0.2	0.0	1.4	0.0	0.0
	18:00	19.5	3.5	0.32	-3.0	-1.7	-0.1	0.0	0.7	0.0	0.0
	19:00	19.5	3.5	0.37	-2.3	-1.3	-0.1	0.0	0.6	0.0	0.0
	20:00	19.5	3.5	0.43	-1.0	-1.4	0.0	0.0	0.3	0.0	0.0
	21:00	19.5	3.5	0.59	1.8	-0.9	0.4	0.0	0.3	0.0	0.0
	22:00	19.5	3.5	0.51	2.4	-0.9	0.5	0.0	0.3	0.0	0.0
	23:00	19.5	3.5	0.56	4.2	-0.4	2.5	0.0	0.3	0.0	0.0
	0:00	19.5	3.5	0.43	ZS	-0.6	5.7	0.0	0.0	0.0	0.0
Min		**19.5**	**3.5**	**0.3**	**-4.0**	**-1.7**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**19.5**	**3.5**	**0.6**	**4.2**	**-0.1**	**5.7**	**0.0**	**1.6**	**0.0**	**0.0**
Average		**19.5**	**3.5**	**0.4**	**-1.1**	**-1.1**	**0.4**	**0.0**	**0.5**	**0.0**	**0.0**
05/11/2018	1:00	19.5	3.5	0.37	2.3	ZS	ZS	0.0	0.3	0.0	0.0
	2:00	19.5	3.5	0.37	2.7	-0.7	1.8	0.0	0.6	0.0	0.0
	3:00	19.5	3.5	0.32	1.2	-1.0	0.5	0.0	0.0	0.0	0.0
	4:00	19.5	3.5	0.29	1.4	-1.1	0.7	0.0	0.3	0.0	0.0
	5:00	19.5	3.5	0.29	1.4	-1.1	0.9	0.0	0.3	0.0	0.0
	6:00	19.5	3.5	0.32	0.7	-0.8	1.2	0.0	0.3	0.0	0.0
	7:00	19.5	3.5	0.31	-1.4	-1.0	5.1	0.0	0.3	0.0	0.0
	8:00	19.5	3.5	0.37	-1.6	-0.8	1.1	0.0	0.6	0.0	0.0
	9:00	18.2	3.6	0.29	-3.4	-1.3	-0.4	0.0	0.8	0.0	0.0
	10:00	11.1	3.6	0.28	-2.8	-1.2	-0.4	0.0	0.8	0.0	0.0
	11:00	10.5	3.6	0.29	-2.1	-1.3	-0.2	0.0	0.3	0.0	0.0
	12:00	12.6	3.7	0.28	-3.0	-1.3	-0.5	0.0	1.3	0.0	0.0
	13:00	10.1	3.7	0.27	-2.8	-1.7	0.0	0.0	0.0	0.0	0.0
	14:00	10.9	3.7	0.26	-2.6	-1.4	-0.4	0.0	0.0	0.0	0.0
	15:00	11.6	3.6	0.26	-2.7	-1.4	-0.4	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	10.8	3.3	0.29	-1.8	-1.4	-0.2	0.0	0.3	0.0	0.0
	17:00	11.0	4.2	0.28	-2.6	-1.2	-0.6	7.9	0.3	0.0	0.0
	18:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	19:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	20:00	14.1	5.1	0.49	-1.8	-1.3	-0.1	0.0	0.0	0.0	0.0
	21:00	10.2	3.4	0.43	-2.4	-1.5	0.1	0.0	0.0	0.0	0.0
	22:00	12.3	4.9	0.43	-2.0	-1.4	0.0	0.0	0.0	0.0	0.0
	23:00	10.2	4.6	0.39	-1.9	-1.3	0.1	0.0	0.0	0.0	0.0
	0:00	19.8	13.2	0.45	-1.8	-1.1	0.3	0.0	0.0	0.0	0.0
Min		**10.1**	**3.3**	**0.3**	**-3.4**	**-1.7**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**19.8**	**13.2**	**0.5**	**2.7**	**-0.7**	**5.1**	**7.9**	**1.3**	**0.0**	**0.0**
Average		**15.0**	**4.2**	**0.3**	**-1.2**	**-1.2**	**0.4**	**0.4**	**0.3**	**0.0**	**0.0**
06/11/2018	1:00	16.9	10.3	0.41	ZS	-0.9	0.8	0.0	0.0	0.0	0.0
	2:00	8.1	3.1	0.35	-1.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	8.3	2.8	0.34	-1.5	-1.1	0.1	0.0	0.0	0.0	0.0
	4:00	9.3	3.4	0.33	-1.5	-1.7	0.7	0.0	0.0	0.0	0.0
	5:00	13.8	3.7	0.33	-1.1	-1.5	0.4	0.0	0.0	0.0	0.0
	6:00	14.3	5.7	0.41	0.1	-1.2	2.9	0.0	0.0	0.0	0.0
	7:00	12.1	4.5	0.36	-1.3	-1.2	1.5	0.0	0.0	0.0	0.0
	8:00	17.7	4.7	0.36	-1.9	-1.2	0.1	0.0	0.0	0.0	0.0
	9:00	13.3	4.6	0.34	-2.2	-1.1	-0.4	0.0	0.0	0.0	0.0
	10:00	15.9	5.4	0.37	-2.1	-1.3	-0.3	0.0	0.0	0.0	0.0
	11:00	16.1	6.8	0.37	-2.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	12:00	15.7	7.5	0.37	-1.6	-1.1	-0.2	0.0	0.0	0.0	0.0
	13:00	23.6	11.1	0.39	-2.1	-0.8	-0.3	0.0	0.0	0.0	0.0
	14:00	17.3	9.2	0.36	-2.1	-1.0	-0.4	0.0	0.0	0.0	0.0
	15:00	13.7	6.2	0.34	-2.4	-1.1	-0.3	0.0	0.0	0.0	0.0
	16:00	20.5	11.0	0.39	-2.0	-0.3	-0.2	0.0	0.0	0.0	0.0
	17:00	11.3	3.9	0.34	-2.4	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	10.9	4.1	0.34	-2.4	-1.6	-0.3	0.0	0.0	0.0	0.0
	19:00	11.2	4.3	0.34	-2.3	-1.6	-0.1	0.0	0.0	0.0	0.0
	20:00	11.8	4.4	0.38	-1.6	-1.8	0.0	0.0	0.0	0.0	0.0
	21:00	14.0	5.5	0.42	-2.0	-1.3	-0.3	0.0	0.0	0.0	0.0
	22:00	13.8	5.0	0.36	-1.3	-1.6	0.0	0.0	0.0	0.0	0.0
	23:00	14.3	5.8	0.34	-2.0	-1.4	-0.1	0.0	0.0	0.0	0.0
	0:00	11.0	4.6	0.31	ZS	-1.5	-0.1	0.0	0.0	0.0	0.0
Min		**8.1**	**2.8**	**0.3**	**-2.4**	**-1.8**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**23.6**	**11.1**	**0.4**	**0.1**	**-0.3**	**2.9**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**13.9**	**5.7**	**0.4**	**-1.8**	**-1.2**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**
07/11/2018	1:00	11.7	4.6	0.31	-1.9	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	11.1	4.6	0.27	-2.0	-1.8	-0.1	0.0	0.0	0.0	0.0
	3:00	10.5	4.4	0.27	-2.0	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	11.6	4.5	0.28	-1.5	-1.5	0.1	0.0	0.0	0.0	0.0
	5:00	20.9	5.8	0.31	-0.2	-1.5	1.1	0.0	0.0	0.0	0.0
	6:00	18.9	6.0	0.36	-0.6	-1.5	1.2	0.0	0.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	25.1	6.8	0.36	-0.3	-1.4	1.1	0.0	0.0	0.0	0.0
	8:00	27.7	5.7	0.32	-0.7	-1.4	0.0	0.1	0.4	0.0	0.0
	9:00	24.3	5.2	0.31	-1.9	-1.6	0.2	0.0	0.0	0.0	0.0
	10:00	27.3	5.1	0.36	-2.2	-1.4	-0.4	0.0	0.3	0.0	0.0
	11:00	25.2	4.9	0.30	-1.7	-1.2	-0.4	0.0	0.0	0.0	0.0
	12:00	28.5	5.1	0.29	-1.9	-1.5	-0.1	0.0	0.3	0.0	0.0
	13:00	20.9	5.3	0.31	-1.5	-1.3	-0.2	0.0	0.0	0.0	0.0
	14:00	27.8	5.2	0.32	-2.0	-1.5	-0.2	0.0	0.0	0.0	0.0
	15:00	22.4	5.9	0.31	-2.3	-1.3	-0.5	0.0	0.0	0.0	0.0
	16:00	14.8	5.5	0.30	-2.2	-1.6	-0.2	0.0	0.4	0.0	0.0
	17:00	11.3	3.6	0.30	-2.2	-1.5	-0.2	0.0	0.7	0.0	0.0
	18:00	10.7	3.4	0.31	-1.9	-1.7	-0.1	0.0	0.7	0.0	0.0
	19:00	9.8	3.5	0.29	-2.0	-1.7	-0.3	0.0	0.0	0.0	0.0
	20:00	9.5	3.5	0.29	-1.8	-1.5	-0.1	0.0	0.0	0.0	0.0
	21:00	13.1	3.8	0.29	-1.8	-1.5	-0.1	0.0	0.0	0.0	0.0
	22:00	9.7	3.6	0.26	-2.2	-1.4	-0.4	0.0	0.3	0.0	0.0
	23:00	10.5	3.9	0.30	-2.2	-1.6	-0.1	0.0	0.0	0.0	0.0
	0:00	11.2	4.0	0.29	-2.3	-1.6	0.0	0.0	0.0	0.0	0.0
Min		**9.5**	**3.4**	**0.3**	**-2.3**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**28.5**	**6.8**	**0.4**	**-0.2**	**-1.2**	**1.2**	**0.1**	**0.7**	**0.0**	**0.0**
Average		**17.3**	**4.7**	**0.3**	**-1.7**	**-1.5**	**0.0**	**0.0**	**0.1**	**0.0**	**0.0**
08/11/2018	1:00	10.0	4.0	0.29	-1.8	-1.8	0.6	0.0	0.0	0.0	0.0
	2:00	9.9	4.3	0.29	-1.9	-1.6	0.1	0.0	0.0	0.0	0.0
	3:00	10.7	4.8	0.33	-1.8	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	13.4	5.7	0.36	-1.4	-1.4	0.5	0.0	0.0	0.0	0.0
	5:00	12.9	5.0	0.33	-1.8	-1.5	0.6	0.0	0.0	0.0	0.0
	6:00	20.2	6.4	0.39	0.3	-1.2	0.6	0.0	0.0	0.0	0.0
	7:00	20.8	5.3	0.36	-1.1	-1.2	0.0	0.0	0.0	0.0	0.0
	8:00	24.9	5.5	0.33	-2.2	-1.3	-0.4	0.0	0.0	0.0	0.0
	9:00	29.8	5.6	0.33	-1.7	-1.4	-0.2	0.0	0.0	0.0	0.0
	10:00	27.2	5.5	0.33	-2.2	-1.2	-0.6	0.0	0.0	0.0	0.0
	11:00	25.6	5.6	0.33	-2.2	-1.5	-0.3	0.0	0.0	0.0	0.0
	12:00	23.2	5.1	0.29	-2.3	-1.3	-0.3	0.0	0.0	0.0	0.0
	13:00	29.5	7.2	0.29	-2.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	14:00	19.2	5.3	0.30	-1.6	-1.4	-0.4	0.0	0.0	0.0	0.0
	15:00	16.2	4.8	0.29	-2.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	16:00	15.0	5.0	0.29	-2.5	-1.5	-0.4	0.0	0.0	0.0	0.0
	17:00	14.7	4.9	0.30	-2.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	18:00	13.8	5.1	0.31	-2.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	19:00	14.1	5.3	0.31	-1.7	-1.6	-0.2	0.0	0.0	0.0	0.0
	20:00	13.7	5.4	0.30	-2.2	-1.6	-0.3	0.0	0.0	0.0	0.0
	21:00	14.4	5.5	0.29	-2.4	-1.7	0.0	0.0	0.0	0.0	0.0
	22:00	14.6	5.7	0.29	-2.0	-1.6	-0.3	0.0	0.0	0.0	0.0
	23:00	13.2	5.7	0.29	-2.2	-1.7	0.1	0.0	0.0	0.0	0.0
	0:00	13.2	5.5	0.24	ZS	-1.8	-0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**9.9**	**4.0**	**0.2**	**-2.6**	**-1.8**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**29.8**	**7.2**	**0.4**	**0.3**	**-1.2**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**17.5**	**5.3**	**0.3**	**-1.9**	**-1.5**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
09/11/2018	1:00	14.0	5.8	0.25	ZS	-1.9	0.2	0.0	0.0	0.0	0.0
	2:00	16.3	6.8	0.28	-0.5	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	13.6	5.8	0.25	-1.8	-1.3	0.2	0.0	0.0	0.0	0.0
	4:00	13.1	5.7	0.24	-2.0	-1.6	-0.2	0.0	0.0	0.0	0.0
	5:00	13.1	5.5	0.24	-1.9	-1.6	-0.1	0.0	0.0	0.0	0.0
	6:00	14.0	5.7	0.27	-1.3	-1.8	0.0	0.0	0.0	0.0	0.0
	7:00	19.2	6.0	0.30	-2.3	-1.7	0.3	0.0	0.0	0.0	0.0
	8:00	23.3	6.3	0.30	-2.5	-1.3	-0.3	0.0	0.0	0.0	0.0
	9:00	32.4	7.3	0.30	-2.0	-1.4	-0.2	0.0	0.0	0.0	0.0
	10:00	50.2	7.7	0.28	-2.3	-1.5	-0.1	0.0	0.0	0.0	0.0
	11:00	34.0	6.6	0.28	-2.4	-1.5	-0.4	0.0	0.0	0.0	0.0
	12:00	42.2	8.9	0.30	-0.9	-1.3	-0.2	0.0	0.0	0.0	0.0
	13:00	32.7	8.6	0.32	-2.0	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	27.3	8.2	0.30	-2.3	-1.2	-0.4	0.0	0.0	0.0	0.0
	15:00	18.5	6.5	0.31	-1.9	-1.5	-0.3	0.0	0.0	0.0	0.0
	16:00	16.7	5.5	0.30	-2.2	-1.4	-0.6	0.0	0.0	0.0	0.0
	17:00	15.5	4.8	0.28	-2.4	-1.5	-0.3	0.0	0.0	0.0	0.0
	18:00	11.2	4.6	0.29	-2.3	-1.6	-0.4	0.0	0.0	0.0	0.0
	19:00	12.5	4.3	0.29	-2.5	-1.6	-0.3	0.0	0.0	0.0	0.0
	20:00	13.3	4.2	0.27	-2.6	-1.6	-0.1	0.0	0.0	0.0	0.0
	21:00	12.4	4.1	0.27	-2.3	-1.6	-0.2	0.0	0.0	0.0	0.0
	22:00	11.3	4.2	0.26	-2.4	-1.6	-0.1	0.0	0.0	0.0	0.0
	23:00	11.5	4.3	0.27	-2.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	0:00	10.9	4.4	0.27	ZS	-1.7	-0.3	0.0	0.0	0.0	0.0
Min		**10.9**	**4.1**	**0.2**	**-2.6**	**-1.9**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**50.2**	**8.9**	**0.3**	**-0.5**	**-1.2**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**20.0**	**5.9**	**0.3**	**-2.0**	**-1.5**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
10/11/2018	1:00	10.6	4.3	0.26	BO	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	9.2	4.1	0.25	BO	-1.7	0.0	0.0	0.0	0.0	0.0
	3:00	9.7	4.1	0.25	BO	-1.7	-0.4	0.0	0.0	0.0	0.0
	4:00	10.4	4.4	0.25	BO	-2.0	0.1	0.0	0.0	0.0	0.0
	5:00	12.9	4.8	0.27	BO	-1.9	0.0	0.0	0.0	0.0	0.0
	6:00	17.2	6.6	0.33	BO	-1.9	0.2	0.0	0.0	0.0	0.0
	7:00	21.9	6.7	0.35	BO	-1.2	-0.1	0.0	0.0	0.0	0.0
	8:00	25.9	6.0	0.27	BO	-1.7	0.1	0.0	0.0	0.0	0.0
	9:00	37.0	7.1	0.26	BO	-1.6	-0.2	0.0	0.0	0.0	0.0
	10:00	39.1	7.4	0.25	BO	-1.5	-0.5	0.0	1.4	0.2	0.9
	11:00	28.7	7.7	0.27	BO	-2.0	-0.1	0.2	0.0	0.0	0.0
	12:00	26.7	8.0	0.26	BO	-1.5	-0.5	0.1	0.8	0.0	0.1
	13:00	35.5	9.1	0.26	BO	-1.7	-0.2	0.0	0.3	0.3	0.0
	14:00	23.3	7.4	0.26	BO	-1.6	-0.3	0.0	0.9	0.2	0.3
	15:00	18.9	6.6	0.25	BO	-1.7	-0.3	0.0	0.3	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	18.4	6.6	0.27	BO	-1.6	-0.5	0.0	0.3	0.0	0.0
	17:00	18.1	6.8	0.28	BO	-1.8	-0.3	0.0	0.0	0.0	0.1
	18:00	19.3	7.1	0.31	BO	-1.8	-0.5	0.0	0.2	0.0	0.0
	19:00	18.9	7.6	0.36	BO	-1.8	-0.2	0.0	0.1	0.0	0.0
	20:00	16.2	7.2	0.30	BO	-2.0	-0.1	0.0	0.5	0.0	0.0
	21:00	16.2	6.4	0.28	BO	-1.6	-0.1	0.1	0.1	0.0	0.0
	22:00	15.4	6.5	0.28	BO	-1.8	-0.1	0.1	0.2	0.0	0.1
	23:00	15.8	6.4	0.29	BO	-1.8	-0.1	0.0	0.3	0.0	0.0
	0:00	15.7	6.0	0.27	BO	-1.6	-0.1	0.0	0.7	0.2	0.1
Min		**9.2**	**4.1**	**0.2**	**ID**	**-2.0**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**39.1**	**9.1**	**0.4**	**ID**	**-1.2**	**0.2**	**0.2**	**1.4**	**0.3**	**0.9**
Average		**20.0**	**6.4**	**0.3**	**ID**	**-1.7**	**-0.2**	**0.0**	**0.2**	**0.0**	**0.1**
11/11/2018	1:00	14.6	5.9	0.26	2.9	-1.8	0.0	0.0	0.0	0.0	0.2
	2:00	14.1	6.0	0.26	2.7	-1.8	-0.2	0.0	0.3	0.0	0.0
	3:00	15.5	6.0	0.27	2.5	-1.7	-0.1	0.0	0.0	0.0	0.0
	4:00	15.2	6.4	0.28	2.6	-1.7	0.4	0.0	0.4	0.0	0.0
	5:00	23.3	12.5	0.40	2.1	-1.6	0.7	0.0	0.0	0.0	0.0
	6:00	29.2	13.6	0.40	2.1	-1.6	1.4	0.0	0.0	0.0	0.0
	7:00	27.7	10.3	0.36	2.1	-1.3	0.5	0.0	0.2	0.0	0.0
	8:00	26.2	8.6	0.32	0.5	-1.5	-0.3	0.0	0.2	0.0	0.0
	9:00	22.0	7.2	0.30	0.3	-1.6	-0.2	0.0	0.2	0.0	0.0
	10:00	24.6	7.6	0.31	-0.1	-1.6	-0.5	0.0	0.2	0.0	0.0
	11:00	19.7	7.3	0.28	-0.2	-1.5	-0.4	0.0	0.5	0.0	0.1
	12:00	21.4	7.0	0.29	-0.4	-1.7	-0.2	0.0	0.0	0.0	0.0
	13:00	23.4	7.4	0.28	-0.1	-1.6	-0.4	0.0	0.3	0.0	0.0
	14:00	22.1	9.7	0.29	-0.5	-1.2	-0.5	0.0	0.0	0.1	0.0
	15:00	17.9	6.9	0.27	-1.0	-1.6	-0.3	0.0	0.0	0.0	0.0
	16:00	16.6	5.9	0.27	-1.1	-1.7	-0.2	0.0	0.3	0.0	0.0
	17:00	17.8	5.9	0.29	-0.9	-1.7	-0.3	0.0	0.2	0.0	0.0
	18:00	16.7	6.1	0.29	-0.3	-1.6	-0.3	0.0	0.0	0.0	0.0
	19:00	13.7	5.8	0.31	-1.1	-1.6	-0.3	0.0	0.5	0.0	0.0
	20:00	13.9	5.9	0.30	-0.3	-1.8	-0.1	0.0	0.2	0.0	0.1
	21:00	18.3	6.8	0.39	0.2	-1.7	0.2	0.0	0.3	0.0	0.0
	22:00	19.2	8.4	0.48	-0.4	-1.6	0.1	0.0	0.0	0.0	0.0
	23:00	12.5	5.5	0.30	-1.6	-1.6	-0.1	0.2	0.3	0.0	0.1
	0:00	13.7	5.4	0.35	ZS	-1.7	0.1	0.0	0.0	0.0	0.1
Min		**12.5**	**5.4**	**0.3**	**-1.6**	**-1.8**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**29.2**	**13.6**	**0.5**	**2.9**	**-1.2**	**1.4**	**0.2**	**0.5**	**0.1**	**0.2**
Average		**19.1**	**7.4**	**0.3**	**0.4**	**-1.6**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**
12/11/2018	1:00	14.4	5.4	0.37	2.5	ZS	ZS	0.0	0.0	0.0	0.1
	2:00	16.4	7.0	0.33	3.7	-1.4	0.5	0.0	0.2	0.2	0.0
	3:00	14.3	6.5	0.32	2.8	-1.6	0.8	0.2	0.1	0.1	2.3
	4:00	18.0	7.5	0.40	21.7	-1.9	0.4	0.0	0.1	0.0	0.3
	5:00	19.4	7.9	0.52	15.1	-1.2	1.1	0.0	0.0	0.0	0.0
	6:00	31.6	11.3	0.56	13.6	-0.8	0.6	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	25.1	9.2	0.51	9.6	-0.6	2.4	0.0	0.0	0.0	0.0
	8:00	28.8	6.6	0.43	5.9	-0.7	0.1	0.0	0.0	0.0	0.0
	9:00	20.3	4.6	0.32	4.2	-1.1	-0.5	0.0	0.0	0.0	0.0
	10:00	18.1	5.2	0.30	3.7	-1.7	-0.1	0.0	0.0	0.0	0.0
	11:00	16.5	5.0	0.31	3.1	-1.6	-0.2	0.0	0.3	0.0	0.0
	12:00	15.4	4.7	0.29	2.6	-1.8	-0.2	0.0	0.0	0.0	0.0
	13:00	17.9	6.3	0.30	2.8	-1.6	-0.5	0.0	0.0	0.0	0.0
	14:00	23.0	3.8	0.30	2.4	-1.9	-0.2	0.0	0.0	0.0	0.0
	15:00	19.7	3.7	0.31	3.8	-1.7	-0.4	0.0	0.0	0.0	0.0
	16:00	11.5	3.5	0.30	2.3	-1.5	-0.4	0.0	0.0	0.0	0.0
	17:00	11.2	2.8	0.30	2.2	-1.7	-0.4	0.0	0.0	0.0	0.0
	18:00	8.7	3.0	0.32	1.3	-1.7	-0.1	0.0	0.0	0.0	0.0
	19:00	9.1	3.2	0.32	1.4	-1.5	-0.5	0.0	0.0	0.0	0.3
	20:00	8.7	3.2	0.30	1.2	-1.9	0.0	0.0	0.0	0.0	0.0
	21:00	12.3	4.2	0.28	1.1	-1.6	-0.6	0.0	0.0	0.0	0.0
	22:00	12.0	4.2	0.28	1.1	-1.9	-0.1	0.0	0.5	0.0	0.0
	23:00	10.8	3.9	0.29	0.9	-1.7	-0.4	0.0	0.4	0.0	0.0
	0:00	11.6	3.8	0.28	0.8	-1.7	-0.2	0.0	0.0	0.3	0.0
Min		**8.7**	**2.8**	**0.3**	**0.8**	**-1.9**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**31.6**	**11.3**	**0.6**	**21.7**	**-0.6**	**2.4**	**0.2**	**0.5**	**0.3**	**2.3**
Average		**16.4**	**5.3**	**0.3**	**4.6**	**-1.5**	**0.1**	**0.0**	**0.1**	**0.0**	**0.1**
13/11/2018	1:00	11.0	3.9	0.29	ZS	-1.9	-0.4	0.0	0.0	0.0	0.0
	2:00	11.0	4.0	0.28	BO	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	10.1	3.9	0.28	BO	-1.6	0.0	0.0	0.0	0.0	0.0
	4:00	10.9	4.1	0.28	BO	-1.6	-0.2	0.0	0.0	0.0	0.0
	5:00	12.0	4.1	0.28	BO	-1.7	-0.1	0.0	0.0	0.0	0.0
	6:00	14.9	4.5	0.31	BO	-1.6	-0.2	0.0	0.0	0.0	0.0
	7:00	19.7	4.6	0.33	BO	-1.6	-0.1	0.0	0.0	0.0	0.0
	8:00	26.2	4.9	0.32	BO	-1.7	-0.3	0.0	0.0	0.0	0.0
	9:00	37.6	5.8	0.35	BO	-1.4	-0.3	0.0	0.0	0.0	0.0
	10:00	41.2	6.1	0.33	BO	-1.6	-0.1	0.0	0.0	0.0	0.0
	11:00	31.2	4.7	0.30	3.2	-1.7	-0.3	0.0	0.0	0.0	0.0
	12:00	39.2	5.3	0.32	2.7	-1.6	-0.2	0.0	0.0	0.0	0.0
	13:00	24.3	4.3	0.29	2.6	-1.7	-0.1	0.0	0.0	0.0	0.0
	14:00	46.3	5.0	0.30	1.8	-1.7	-0.5	0.0	0.0	0.0	0.0
	15:00	25.2	4.9	0.31	1.7	-1.6	-0.4	0.0	0.4	0.0	0.0
	16:00	19.3	4.7	0.31	1.9	-1.7	-0.2	0.0	0.0	0.0	0.1
	17:00	11.9	3.7	0.31	1.4	-1.8	-0.2	0.0	0.0	0.0	0.0
	18:00	11.6	3.8	0.32	1.2	-1.7	-0.4	0.0	0.2	0.0	0.0
	19:00	12.6	4.1	0.33	1.4	-1.9	-0.1	0.0	0.0	0.0	0.0
	20:00	13.8	6.8	0.35	1.2	-1.4	-0.5	0.1	0.2	0.0	0.0
	21:00	47.1	36.1	0.48	1.8	-0.4	0.0	0.2	0.0	0.0	0.0
	22:00	43.7	34.4	0.50	1.7	-0.2	0.2	0.0	0.0	0.0	0.0
	23:00	32.2	23.3	0.45	1.5	-0.4	-0.1	0.0	0.0	0.0	0.0
	0:00	43.6	33.8	0.51	ZS	-0.1	0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**10.1**	**3.7**	**0.3**	**ID**	**-1.9**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**47.1**	**36.1**	**0.5**	**ID**	**-0.1**	**0.2**	**0.2**	**0.4**	**0.0**	**0.1**
Average		**24.8**	**9.2**	**0.3**	**ID**	**-1.4**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
14/11/2018	1:00	13.3	6.7	0.33	1.1	ZS	ZS	0.0	0.2	0.0	0.0
	2:00	12.7	6.2	0.28	1.0	-1.3	0.1	0.0	0.0	0.0	0.0
	3:00	15.1	8.4	0.29	1.3	-1.4	0.2	0.0	0.2	0.0	0.0
	4:00	10.1	3.8	0.26	0.8	-1.6	0.1	0.0	0.0	0.0	0.0
	5:00	13.8	4.5	0.30	1.6	-1.5	0.0	0.0	0.0	0.0	0.0
	6:00	18.1	5.2	0.29	1.9	-1.5	0.3	0.0	0.0	0.1	0.0
	7:00	14.1	4.5	0.29	0.1	-1.7	0.0	0.0	0.0	0.0	0.0
	8:00	22.1	5.0	0.33	0.2	-1.4	-0.3	0.1	0.3	0.0	0.0
	9:00	27.4	4.7	0.29	0.4	-1.4	-0.2	0.0	0.2	0.0	0.0
	10:00	37.2	5.5	0.28	0.1	-1.4	-0.7	0.0	0.2	0.0	0.0
	11:00	32.4	5.0	0.29	-0.3	-1.4	-0.4	0.0	0.0	0.0	0.1
	12:00	36.8	6.0	0.27	0.0	-1.4	-0.6	0.0	0.0	0.0	0.0
	13:00	33.4	5.0	0.26	-0.6	-1.6	-0.3	0.0	0.2	0.0	0.0
	14:00	36.2	4.7	0.27	-0.1	-1.6	-0.3	0.0	0.1	0.0	0.0
	15:00	24.6	4.7	0.27	-0.5	-1.3	-0.4	0.0	0.0	0.0	0.0
	16:00	32.5	8.0	0.32	0.7	-1.0	-0.1	0.0	0.0	0.0	0.0
	17:00	29.7	4.7	0.28	-0.5	-1.5	-0.2	0.0	0.0	0.0	0.0
	18:00	25.1	5.6	0.34	-0.5	-1.3	-0.3	0.0	0.0	0.0	0.0
	19:00	22.4	8.1	0.33	-0.4	-1.1	-0.2	0.0	0.0	0.0	0.0
	20:00	25.1	10.7	0.32	-0.3	-1.4	-0.2	0.0	0.0	0.0	0.0
	21:00	19.6	8.0	0.30	-0.9	-1.5	-0.2	0.0	0.0	0.0	0.0
	22:00	18.0	7.7	0.29	-0.9	-1.4	-0.2	0.0	0.0	0.0	0.0
	23:00	17.5	7.2	0.29	-1.2	-1.7	0.0	0.0	0.0	0.0	0.0
	0:00	17.7	7.5	0.30	-1.0	-1.6	-0.2	0.0	0.0	0.0	0.0
Min		**10.1**	**3.8**	**0.3**	**-1.2**	**-1.7**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**37.2**	**10.7**	**0.3**	**1.9**	**-1.0**	**0.3**	**0.1**	**0.3**	**0.1**	**0.1**
Average		**23.1**	**6.1**	**0.3**	**0.1**	**-1.4**	**-0.2**	**0.0**	**0.1**	**0.0**	**0.0**
15/11/2018	1:00	17.1	7.3	0.28	-1.4	-1.5	-0.3	0.0	0.4	0.0	0.0
	2:00	12.5	5.2	0.28	-1.4	-1.4	-0.3	0.0	0.0	0.0	0.0
	3:00	12.5	5.7	0.29	-1.2	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	17.1	7.8	0.31	-1.3	-1.4	-0.1	0.0	0.0	0.0	0.0
	5:00	22.3	9.0	0.33	-0.7	-1.3	-0.2	0.0	0.2	0.0	0.0
	6:00	34.5	12.2	0.35	0.5	-1.3	0.2	0.0	0.0	0.0	0.0
	7:00	28.7	15.1	0.41	-0.5	-1.1	0.0	0.0	0.2	0.0	0.0
	8:00	33.2	16.6	0.42	0.1	-1.0	0.3	0.0	0.0	0.0	0.0
	9:00	47.6	15.9	0.46	0.0	-0.9	0.6	0.0	0.0	0.0	0.0
	10:00	40.9	12.6	0.36	-0.1	-0.9	0.0	0.0	0.0	0.0	0.0
	11:00	58.7	12.7	0.34	-0.6	-0.8	-0.3	0.0	0.0	0.0	0.0
	12:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	13:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	14:00	77.5	11.3	0.46	-1.3	-1.1	-0.3	0.0	0.0	0.0	0.1
	15:00	27.6	8.7	0.45	-1.5	-1.3	-0.2	0.0	0.0	0.0	0.1

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	24.5	7.9	0.43	-2.2	-1.4	-0.2	0.0	0.0	0.0	0.2
	17:00	21.8	7.8	0.41	-2.0	-1.6	-0.2	0.0	0.0	0.0	0.2
	18:00	26.1	9.0	0.40	-1.8	-1.7	0.0	0.0	0.0	0.0	0.0
	19:00	28.0	10.6	0.39	-1.7	-1.5	-0.2	0.0	0.0	0.0	0.0
	20:00	29.4	11.5	0.37	-1.5	-1.5	0.0	0.0	0.0	0.0	0.0
	21:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	22:00	33.7	12.0	0.86	PO	PO	PO	0.0	0.0	0.0	0.0
	23:00	31.0	11.3	1.00	-1.4	-1.1	0.0	0.0	0.1	0.0	0.6
	0:00	22.1	8.9	0.96	-1.7	-1.4	0.1	0.0	0.0	0.0	0.5
Min		**12.5**	**5.2**	**0.3**	**-2.2**	**-1.7**	**-0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**77.5**	**16.6**	**1.0**	**0.5**	**-0.8**	**0.6**	**0.0**	**0.4**	**0.0**	**0.6**
Average		**30.8**	**10.4**	**0.5**	**-1.1**	**-1.3**	**0.0**	**0.0**	**0.0**	**0.0**	**0.1**
16/11/2018	1:00	19.9	7.3	0.90	ZS	-1.4	-0.1	0.0	0.0	0.0	0.0
	2:00	18.8	6.4	0.85	1.0	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	17.8	6.6	0.68	-0.1	-1.2	0.5	0.0	0.0	0.2	0.0
	4:00	15.6	5.5	0.46	-0.4	-1.5	0.2	0.0	0.0	0.0	0.0
	5:00	15.6	5.1	0.38	0.2	-1.3	-0.1	0.0	0.0	0.0	0.0
	6:00	16.6	6.2	0.37	0.3	-1.4	0.1	0.0	0.0	0.0	0.1
	7:00	19.2	6.2	0.39	-1.1	-1.1	-0.1	0.0	0.2	0.0	0.0
	8:00	18.8	6.4	0.40	-1.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	9:00	20.5	6.9	0.37	-2.2	-1.2	0.0	0.0	0.0	0.0	0.4
	10:00	21.2	7.1	0.34	-1.9	-1.2	-0.2	0.0	0.0	0.0	0.1
	11:00	22.0	7.4	0.34	-1.7	-1.3	-0.1	0.0	0.0	0.0	0.0
	12:00	22.6	7.6	0.33	-2.0	-1.1	-0.5	0.0	0.0	0.0	0.0
	13:00	21.7	7.7	0.32	-2.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	14:00	29.7	13.1	0.38	-0.9	-0.8	-0.5	0.0	0.0	0.0	0.0
	15:00	23.0	8.2	0.33	-1.9	-1.2	-0.4	0.0	0.0	0.0	0.0
	16:00	PO	PO	PO	PO	PO	PO	PO	PO	PO	PO
	17:00	23.1	8.3	0.46	PO	PO	PO	PO	PO	PO	PO
	18:00	24.1	8.1	0.44	-1.9	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	25.1	8.3	0.43	-1.6	-1.5	-0.1	0.0	0.0	0.0	0.0
	20:00	21.0	7.7	0.42	-1.0	-1.4	0.2	0.0	0.0	0.0	0.0
	21:00	19.8	7.5	0.39	-1.7	-1.3	-0.2	0.0	0.0	0.0	0.0
	22:00	19.7	7.7	0.37	-1.6	-1.4	-0.2	0.0	0.0	0.0	0.0
	23:00	21.8	8.2	0.38	-1.9	-1.2	0.2	0.0	0.0	0.0	0.0
	0:00	21.0	8.4	0.37	ZS	-1.6	0.1	0.0	0.0	0.0	0.0
Min		**15.6**	**5.1**	**0.3**	**-2.2**	**-1.6**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**29.7**	**13.1**	**0.9**	**1.0**	**-0.8**	**0.5**	**0.0**	**0.2**	**0.2**	**0.4**
Average		**20.8**	**7.5**	**0.4**	**-1.2**	**-1.3**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
17/11/2018	1:00	21.2	8.3	0.36	-1.0	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	20.1	8.0	0.26	-1.0	-1.1	0.0	0.0	0.0	0.0	0.0
	3:00	16.5	6.8	0.26	-0.9	-1.5	0.1	0.0	0.0	0.0	0.0
	4:00	17.0	6.7	0.27	0.9	-1.4	0.6	0.0	0.0	0.0	0.0
	5:00	16.3	6.4	0.26	-0.3	-1.4	0.2	0.0	0.0	0.0	0.0
	6:00	19.4	6.9	0.30	0.9	-1.2	0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	21.0	7.9	0.39	0.0	-0.9	0.2	0.0	0.0	0.0	0.0
	8:00	20.6	6.6	0.29	-1.9	-0.9	-0.1	0.0	0.0	0.0	0.0
	9:00	20.8	6.7	0.26	-2.8	-1.3	-0.2	0.0	0.0	0.0	0.0
	10:00	20.2	6.3	0.25	-2.1	-1.3	-0.2	0.0	0.0	0.0	0.0
	11:00	17.8	5.9	0.25	-2.2	-1.2	-0.1	0.0	0.0	0.0	0.0
	12:00	18.0	5.9	0.24	-2.0	-1.2	-0.1	0.0	0.0	0.0	0.0
	13:00	18.6	6.1	0.24	-2.1	-1.4	-0.5	0.0	0.0	0.0	0.0
	14:00	16.6	6.1	0.24	-2.3	-1.2	-0.4	0.0	0.0	0.0	0.0
	15:00	15.6	6.0	0.24	-2.0	-1.3	-0.5	0.0	0.0	0.0	0.0
	16:00	17.0	6.1	0.24	-2.5	-1.3	-0.5	0.0	0.0	0.0	0.0
	17:00	16.5	6.0	0.24	-2.3	-1.3	-0.2	0.0	0.0	0.0	0.0
	18:00	14.6	5.9	0.25	-2.6	-1.4	-0.4	0.0	0.0	0.0	0.0
	19:00	14.7	5.7	0.26	-2.4	-1.2	-0.4	0.0	0.0	0.0	0.0
	20:00	14.1	5.6	0.25	-2.4	-1.3	-0.3	0.0	0.0	0.0	0.0
	21:00	14.6	5.3	0.24	-2.3	-1.3	-0.5	0.0	0.0	0.0	0.0
	22:00	14.2	5.5	0.24	-2.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	23:00	15.9	6.5	0.23	-2.1	-1.6	-0.1	0.0	0.0	0.0	0.0
	0:00	15.5	6.3	0.23	-1.9	-1.3	-0.4	0.0	0.0	0.0	0.0
Min		**14.1**	**5.3**	**0.2**	**-2.8**	**-1.6**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**21.2**	**8.3**	**0.4**	**0.9**	**-0.9**	**0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**17.4**	**6.4**	**0.3**	**-1.6**	**-1.3**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
18/11/2018	1:00	15.1	6.3	0.23	-1.9	-1.3	-0.3	0.0	0.3	0.2	0.1
	2:00	14.4	6.1	0.23	-1.9	-1.5	-0.2	0.0	0.1	0.0	0.0
	3:00	15.6	6.4	0.23	-1.8	-1.5	-0.1	0.0	0.2	0.0	0.0
	4:00	14.7	6.1	0.23	-1.9	-1.5	-0.3	0.0	0.3	0.1	0.2
	5:00	14.5	6.2	0.24	-0.8	-1.4	0.1	0.0	0.0	0.0	0.0
	6:00	16.1	5.9	0.24	-1.3	-1.3	0.0	0.0	0.0	0.0	0.1
	7:00	20.3	6.5	0.29	-0.3	-1.2	0.1	0.0	0.0	0.0	0.0
	8:00	18.4	6.4	0.27	-1.9	-1.2	-0.2	0.0	0.1	0.0	0.0
	9:00	16.4	5.3	0.27	-1.8	-1.1	-0.2	0.0	0.0	0.0	0.2
	10:00	17.2	5.0	0.26	-1.5	-1.2	0.0	0.0	0.0	0.0	0.0
	11:00	14.1	4.9	0.26	-1.9	-1.3	-0.3	0.0	0.0	0.0	0.0
	12:00	14.2	4.9	0.26	-2.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	13:00	15.1	5.2	0.25	-2.0	-1.2	-0.2	0.0	0.1	0.0	0.1
	14:00	17.3	8.1	0.28	-1.5	-0.7	-0.7	0.0	0.0	0.0	0.0
	15:00	11.7	4.2	0.24	-2.0	-1.4	-0.3	0.0	0.0	0.0	0.0
	16:00	12.4	4.2	0.24	-2.1	-1.4	-0.2	0.0	0.2	0.1	0.0
	17:00	12.6	4.3	0.25	-2.0	-1.4	-0.1	0.0	0.2	0.0	0.0
	18:00	12.6	4.6	0.26	-1.7	-1.2	-0.5	0.0	0.0	0.0	0.0
	19:00	15.6	6.5	0.27	-2.2	-1.5	-0.1	0.0	0.0	0.0	0.1
	20:00	12.9	4.9	0.25	-2.7	-1.3	-0.2	0.0	0.1	0.0	0.0
	21:00	13.7	5.3	0.24	-2.4	-1.1	-0.6	0.0	0.0	0.1	0.1
	22:00	15.1	5.7	0.25	-2.1	-1.4	-0.3	0.0	0.6	0.0	0.3
	23:00	16.9	6.7	0.26	-2.0	-1.6	-0.1	0.0	0.0	0.0	0.0
	0:00	16.6	6.6	0.25	ZS	-1.3	-0.4	0.1	0.2	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**11.7**	**4.2**	**0.2**	**-2.7**	**-1.6**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**20.3**	**8.1**	**0.3**	**-0.3**	**-0.7**	**0.1**	**0.1**	**0.6**	**0.2**	**0.3**
Average		**15.1**	**5.7**	**0.3**	**-1.8**	**-1.3**	**-0.2**	**0.0**	**0.1**	**0.0**	**0.0**
19/11/2018	1:00	17.0	6.9	0.26	-2.6	ZS	ZS	0.0	0.4	0.0	0.0
	2:00	17.5	6.9	0.26	-2.6	-1.2	0.3	0.0	0.0	0.2	0.0
	3:00	17.1	6.8	0.27	-2.2	-1.3	0.5	0.0	0.0	0.0	0.2
	4:00	11.6	4.5	0.26	-2.3	-1.2	0.2	0.0	0.5	0.0	0.0
	5:00	11.8	4.5	0.27	-1.8	-1.2	0.0	0.0	0.0	0.0	0.1
	6:00	15.1	4.6	0.31	-1.1	-1.1	0.0	0.0	0.0	0.0	0.0
	7:00	18.9	5.8	0.40	-1.5	-1.0	0.2	0.0	0.2	0.0	0.0
	8:00	21.8	6.5	0.35	-2.7	-1.0	-0.3	0.0	0.0	0.0	0.0
	9:00	24.4	7.4	0.30	-4.0	-1.0	-0.3	0.0	0.2	0.0	0.1
	10:00	23.6	8.4	0.28	-3.8	-1.2	-0.3	0.0	0.6	0.2	0.0
	11:00	24.9	9.8	0.30	-3.4	-1.0	-0.1	0.0	0.2	0.0	0.0
	12:00	22.9	9.1	0.29	-3.6	-1.0	-0.5	0.0	0.2	0.0	0.0
	13:00	24.8	8.1	0.26	-4.0	-1.0	-0.6	0.0	0.0	0.0	0.0
	14:00	17.9	6.5	0.28	-3.5	-1.2	-0.4	0.0	0.0	0.0	0.0
	15:00	21.8	8.1	0.28	-4.4	-1.4	-0.3	0.0	0.0	0.0	0.0
	16:00	22.6	7.7	0.27	-3.8	-1.3	-0.3	0.0	0.0	0.0	0.0
	17:00	18.0	6.8	0.29	-3.5	-1.3	-0.2	0.0	0.0	0.0	0.0
	18:00	16.9	6.6	0.46	-4.0	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	18.1	7.0	0.70	-1.8	-1.2	-0.1	0.0	0.0	0.0	0.0
	20:00	14.0	5.8	0.39	-2.2	-1.1	0.0	0.2	0.6	0.2	4.6
	21:00	14.4	5.7	0.38	-2.3	-1.0	0.1	0.1	0.2	0.1	7.9
	22:00	21.2	7.5	0.31	-3.9	-1.3	-0.2	0.0	0.0	0.0	0.0
	23:00	20.0	7.5	0.31	-4.0	-1.3	0.2	0.0	0.0	0.0	0.0
	0:00	14.9	5.8	ZS	ZS	-1.3	-0.1	0.0	0.0	0.0	0.1
Min		**11.6**	**4.5**	**0.3**	**-4.4**	**-1.4**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.9**	**9.8**	**0.7**	**-1.1**	**-1.0**	**0.5**	**0.2**	**0.6**	**0.2**	**7.9**
Average		**18.8**	**6.8**	**0.3**	**-3.0**	**-1.2**	**-0.1**	**0.0**	**0.1**	**0.0**	**0.5**
20/11/2018	1:00	15.0	4.8	0.30	ZS	-1.2	-0.4	0.0	0.0	0.0	0.0
	2:00	16.9	5.4	0.29	-2.8	ZS	ZS	0.0	0.3	0.0	0.4
	3:00	16.9	5.5	0.29	-3.7	-1.1	0.3	0.0	0.4	0.0	0.0
	4:00	17.2	6.0	0.29	-3.8	-1.1	-0.1	0.0	0.0	0.0	0.0
	5:00	18.9	6.7	0.29	-3.9	-1.2	-0.2	0.0	0.0	0.0	0.0
	6:00	20.1	7.7	0.31	-3.5	-1.5	0.1	0.0	0.0	0.0	0.0
	7:00	22.2	7.4	0.31	-3.5	-1.2	-0.1	0.0	0.0	0.0	0.0
	8:00	17.9	6.3	0.29	-4.3	-1.1	-0.4	0.0	0.0	0.0	0.0
	9:00	13.7	5.2	0.30	-4.1	-1.1	-0.3	0.0	0.0	0.0	0.0
	10:00	17.1	5.5	0.28	-4.3	-1.0	-0.5	0.0	0.0	0.0	0.0
	11:00	18.9	6.7	PO	-4.2	-1.4	-0.5	0.0	0.0	0.0	0.0
	12:00	19.7	7.1	0.38	-4.3	-1.3	-0.4	0.0	0.0	0.0	0.0
	13:00	19.5	6.9	0.36	-4.5	-1.3	-0.4	0.0	0.0	0.0	0.0
	14:00	20.7	7.5	0.35	-4.4	-1.2	-0.5	0.0	0.0	0.0	0.0
	15:00	23.0	7.2	0.34	-4.2	-1.3	-0.2	0.0	0.4	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	18.4	7.0	0.32	-4.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	17:00	19.9	7.2	0.32	-4.4	-1.4	-0.1	0.0	0.0	0.0	0.0
	18:00	19.5	7.4	0.33	-4.2	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	20.4	7.6	0.33	-4.2	-1.4	-0.1	0.0	0.0	0.0	0.0
	20:00	21.0	7.5	0.33	-4.2	-1.3	-0.1	0.0	0.0	0.0	0.0
	21:00	20.5	7.5	0.31	-4.3	-1.1	-0.4	0.0	0.0	0.0	0.0
	22:00	20.1	7.6	0.31	-4.2	-1.3	-0.1	0.0	0.0	0.0	0.0
	23:00	19.0	7.4	0.30	-4.0	-1.3	-0.2	0.0	0.0	0.0	0.0
	0:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
Min		**13.7**	**4.8**	**0.3**	**-4.5**	**-1.5**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**23.0**	**7.7**	**0.4**	**-2.8**	**-1.0**	**0.3**	**0.0**	**0.4**	**0.0**	**0.4**
Average		**19.0**	**6.7**	**0.3**	**-4.0**	**-1.3**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
21/11/2018	1:00	19.1	7.4	PO	-2.5	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	18.4	7.2	0.33	-3.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	3:00	17.5	7.0	0.31	-3.4	-1.3	-0.3	0.0	0.0	0.0	0.0
	4:00	15.6	6.4	0.30	-3.8	-1.2	-0.1	0.0	0.0	0.0	0.0
	5:00	16.2	6.2	0.29	-3.6	-1.3	-0.1	0.0	0.0	0.0	0.0
	6:00	18.4	6.4	0.31	-1.9	-1.1	-0.4	0.0	0.0	0.0	0.0
	7:00	19.0	6.4	0.33	-3.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	8:00	21.9	6.5	0.32	-4.0	-1.1	-0.5	0.0	0.0	0.0	0.0
	9:00	23.8	6.4	0.33	-2.1	-0.9	-0.3	0.0	0.0	0.0	0.0
	10:00	22.8	7.0	0.30	-3.2	-1.1	-0.2	0.0	0.0	0.0	0.0
	11:00	23.0	6.4	0.28	-4.0	-1.2	-0.2	0.0	0.0	0.0	0.0
	12:00	20.4	6.8	0.28	-4.0	-1.4	-0.2	0.0	0.0	0.0	0.0
	13:00	21.7	7.2	0.28	-4.0	-1.1	-0.4	0.0	0.0	0.0	0.0
	14:00	28.1	7.1	0.28	-3.8	-1.3	-0.5	0.0	0.0	0.0	0.0
	15:00	21.5	7.0	0.28	-4.1	-1.3	-0.3	0.0	0.0	0.0	0.0
	16:00	22.8	7.1	0.28	-4.1	-1.3	-0.5	0.0	0.0	0.0	0.0
	17:00	27.0	7.3	0.28	-4.2	-1.4	-0.2	0.0	0.0	0.0	0.0
	18:00	18.1	6.8	0.28	-4.1	-1.2	-0.5	0.0	0.0	0.0	0.0
	19:00	19.1	6.8	0.28	-3.7	-1.4	-0.1	0.0	0.0	0.0	0.0
	20:00	18.5	6.5	0.27	-4.2	-1.2	-0.1	0.0	0.0	0.0	0.0
	21:00	17.5	6.6	0.27	-4.3	-1.3	-0.3	0.0	0.0	0.0	0.0
	22:00	16.1	6.3	0.26	-4.1	-1.3	-0.2	0.0	0.0	0.0	0.0
	23:00	16.2	6.2	0.26	-4.0	-1.4	-0.2	0.0	0.0	0.0	0.0
	0:00	17.1	6.4	0.26	-4.0	-1.3	-0.1	0.0	0.0	0.0	0.0
Min		**15.6**	**6.2**	**0.3**	**-4.3**	**-1.4**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**28.1**	**7.4**	**0.3**	**-1.9**	**-0.9**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**20.0**	**6.7**	**0.3**	**-3.7**	**-1.2**	**-0.3**	**0.0**	**0.0**	**0.0**	**0.0**
22/11/2018	1:00	15.7	6.2	0.25	-3.8	-1.4	-0.1	0.0	0.0	0.0	0.0
	2:00	14.8	5.7	0.26	-3.5	-1.2	-0.2	0.0	0.0	0.0	0.0
	3:00	14.9	5.7	0.26	-3.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	4:00	15.9	5.7	0.25	-3.6	-1.4	0.2	0.0	0.0	0.0	0.0
	5:00	18.3	5.8	0.27	-3.5	-1.4	0.3	0.0	0.0	0.0	0.0
	6:00	17.4	5.9	0.28	-3.1	-1.1	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	16.7	5.7	0.28	-3.9	-1.4	0.1	0.0	0.0	0.0	0.0
	8:00	18.0	6.0	0.29	-3.3	-1.5	0.0	0.0	0.0	0.0	0.0
	9:00	17.2	5.8	0.28	-3.6	-1.2	-0.3	0.0	0.0	0.0	0.0
	10:00	16.4	5.5	0.26	-4.0	-1.2	-0.3	0.0	0.0	0.0	0.0
	11:00	16.1	5.3	0.26	-3.6	-1.3	-0.3	0.0	0.0	0.0	0.0
	12:00	16.2	5.4	0.26	-3.6	-1.2	-0.5	0.0	0.0	0.0	0.0
	13:00	18.5	5.8	0.27	-3.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	14:00	17.5	6.1	0.26	-3.2	-0.9	-0.5	0.0	0.0	0.0	0.0
	15:00	17.2	5.7	0.26	-3.6	-1.2	-0.4	0.0	0.0	0.0	0.0
	16:00	17.0	6.1	0.27	-3.8	-1.3	-0.4	0.0	0.0	0.0	0.0
	17:00	17.1	6.1	0.27	-3.5	-1.2	-0.3	0.0	0.0	0.0	0.0
	18:00	17.5	6.2	0.29	-3.5	-1.2	-0.4	0.0	0.0	0.0	0.0
	19:00	17.3	6.0	0.29	-3.7	-1.3	-0.1	0.0	0.0	0.0	0.0
	20:00	15.4	5.8	0.29	-3.4	-1.0	-0.2	0.0	0.0	0.0	0.0
	21:00	14.5	5.8	0.28	-3.1	-1.4	0.1	0.0	0.0	0.0	0.0
	22:00	13.8	5.6	0.27	-3.5	-1.2	-0.3	0.0	0.0	0.0	0.0
	23:00	14.7	5.7	0.28	-3.7	-1.2	-0.4	0.0	0.0	0.0	0.0
	0:00	15.7	5.6	0.24	-3.3	-1.3	-0.3	0.0	0.0	0.0	0.0
Min		**13.8**	**5.3**	**0.2**	**-4.0**	**-1.5**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**18.5**	**6.2**	**0.3**	**-3.1**	**-0.9**	**0.3**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**16.4**	**5.8**	**0.3**	**-3.5**	**-1.2**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
23/11/2018	1:00	14.5	5.6	0.25	ZS	-1.3	-0.1	0.0	0.0	0.0	0.0
	2:00	14.7	5.6	0.25	-1.0	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	14.0	5.3	0.24	-1.5	-0.8	-0.2	0.0	0.0	0.0	0.0
	4:00	14.1	5.2	0.24	-2.2	-1.4	0.2	0.0	0.0	0.0	0.0
	5:00	14.5	5.4	0.24	-2.4	-1.2	0.0	0.0	0.0	0.0	0.0
	6:00	16.0	5.3	0.27	-1.1	-1.1	0.0	0.0	0.0	0.0	0.0
	7:00	22.3	7.0	0.31	0.2	-0.9	0.0	0.0	0.0	0.0	0.0
	8:00	22.7	5.8	0.28	-2.5	-0.9	-0.2	0.0	0.0	0.0	0.0
	9:00	21.2	5.8	0.27	-2.9	-1.1	-0.2	0.0	0.0	0.0	0.0
	10:00	20.5	5.5	0.24	-2.9	-1.2	-0.4	0.0	0.0	0.0	0.0
	11:00	23.3	7.6	0.27	-2.9	-1.0	-0.2	0.0	0.5	0.0	0.0
	12:00	22.3	6.9	0.25	-2.5	-0.9	-0.4	0.0	0.0	0.0	0.0
	13:00	25.8	6.0	0.25	-2.5	-1.0	-0.3	0.0	0.2	0.0	0.1
	14:00	22.4	5.9	0.25	-3.2	-1.1	-0.4	0.0	0.1	0.0	0.0
	15:00	19.9	5.5	0.26	-2.6	-1.1	-0.3	0.1	0.0	0.0	0.2
	16:00	25.0	6.4	0.26	-2.5	-1.0	-0.3	0.0	0.0	0.0	0.2
	17:00	19.1	5.5	0.26	-2.9	-1.2	-0.3	0.0	0.0	0.0	0.0
	18:00	19.7	7.6	0.31	-2.6	-0.8	-0.4	0.0	0.0	0.0	0.0
	19:00	16.0	5.9	0.32	-2.8	-0.9	-0.2	0.0	0.2	0.0	0.0
	20:00	15.6	5.5	0.30	-2.8	-1.0	-0.2	0.0	0.0	0.0	0.1
	21:00	15.1	5.3	0.28	-2.6	-1.0	-0.1	0.0	0.0	0.0	0.1
	22:00	14.3	5.1	0.27	-2.3	-1.2	0.1	0.0	0.2	0.0	0.0
	23:00	13.2	5.2	0.27	-2.3	-1.2	0.2	0.0	0.4	0.0	0.0
	0:00	13.9	5.4	0.26	ZS	-1.1	-0.2	0.0	0.1	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**13.2**	**5.1**	**0.2**	**-3.2**	**-1.4**	**-0.4**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**25.8**	**7.6**	**0.3**	**0.2**	**-0.8**	**0.2**	**0.1**	**0.5**	**0.0**	**0.2**
Average		**18.3**	**5.8**	**0.3**	**-2.3**	**-1.1**	**-0.2**	**0.0**	**0.1**	**0.0**	**0.0**
24/11/2018	1:00	12.9	4.9	0.26	-1.9	ZS	ZS	0.1	0.0	0.0	0.0
	2:00	13.7	5.1	0.27	-2.1	-1.0	0.0	0.0	0.0	0.0	0.0
	3:00	13.8	5.1	0.25	-2.4	-1.2	-0.2	0.1	0.0	0.0	0.0
	4:00	13.1	5.1	0.25	-2.6	-1.1	-0.4	0.1	0.1	0.0	0.0
	5:00	14.8	5.2	0.26	-2.7	-1.3	0.5	0.0	0.0	0.0	0.3
	6:00	17.5	5.5	0.30	-1.1	-1.0	0.1	0.1	0.1	0.0	0.2
	7:00	24.0	6.7	0.47	0.3	-0.6	0.2	0.0	0.0	0.0	0.0
	8:00	18.2	5.6	0.33	-2.3	-0.9	-0.2	0.0	0.1	0.0	0.0
	9:00	16.5	5.0	0.29	-2.7	-0.8	-0.7	0.0	0.2	0.0	0.0
	10:00	14.4	4.8	0.27	-3.0	-1.1	-0.4	0.0	0.1	0.0	0.0
	11:00	14.7	4.6	0.27	-2.7	-1.1	-0.4	0.0	0.0	0.0	0.0
	12:00	13.2	4.2	0.27	-3.0	-1.0	-0.5	0.0	0.0	0.0	0.0
	13:00	15.1	4.0	0.27	-2.7	-1.2	-0.4	0.0	0.0	0.0	0.0
	14:00	15.0	6.9	0.30	-3.1	-1.1	-0.4	0.0	0.0	0.0	0.0
	15:00	11.1	3.8	0.28	-3.5	-1.3	-0.4	0.0	0.0	0.0	0.1
	16:00	12.1	4.2	0.29	-2.9	-1.2	-0.5	0.0	0.0	0.0	0.0
	17:00	12.3	5.3	0.31	-2.7	-1.1	-0.3	0.0	0.1	0.0	0.1
	18:00	11.9	3.9	0.31	-2.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	9.1	3.1	0.32	-2.9	-1.1	-0.3	0.0	0.2	0.0	0.0
	20:00	9.9	3.6	0.30	-3.0	-1.5	0.1	0.0	0.0	0.0	0.0
	21:00	10.3	3.6	0.28	-3.1	-1.4	0.0	0.0	0.0	0.0	0.0
	22:00	11.6	4.3	0.29	-3.0	-1.3	-0.1	0.0	0.2	0.0	0.1
	23:00	12.4	4.7	0.29	-3.4	-1.3	-0.2	0.0	0.0	0.0	0.0
	0:00	14.5	5.3	0.32	-2.4	-1.2	0.1	0.0	0.1	0.0	0.1
Min		**9.1**	**3.1**	**0.2**	**-3.5**	**-1.5**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.0**	**6.9**	**0.5**	**0.3**	**-0.6**	**0.5**	**0.1**	**0.2**	**0.0**	**0.3**
Average		**13.8**	**4.8**	**0.3**	**-2.6**	**-1.1**	**-0.2**	**0.0**	**0.1**	**0.0**	**0.0**
25/11/2018	1:00	13.7	5.1	0.30	-2.8	-1.0	0.2	0.0	0.2	0.0	0.2
	2:00	14.1	5.5	0.28	-2.3	-1.1	-0.3	0.0	0.0	0.0	0.0
	3:00	14.1	5.7	0.28	-3.1	-1.2	-0.4	0.0	0.0	0.0	0.0
	4:00	14.4	5.8	0.28	-3.1	-1.4	-0.2	0.0	0.0	0.0	0.0
	5:00	13.4	5.3	0.28	-3.0	-1.2	-0.2	0.0	0.0	0.0	0.0
	6:00	12.5	4.8	0.31	-1.9	-1.2	0.1	0.0	0.0	0.0	0.0
	7:00	19.0	5.9	0.33	-2.6	-1.4	0.2	0.0	0.0	0.0	0.0
	8:00	12.1	4.4	0.32	-3.4	-1.1	-0.1	0.0	0.0	0.0	0.0
	9:00	12.4	4.5	0.32	-3.5	-1.0	-0.3	0.0	0.0	0.0	0.0
	10:00	15.4	5.4	0.32	-3.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	11:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	12:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0
	13:00	19.3	7.2	0.46	-3.5	-1.0	-0.5	0.0	0.0	0.0	0.0
	14:00	19.0	7.0	0.44	-3.7	-1.1	-0.3	0.0	0.0	0.0	0.0
	15:00	12.5	4.7	0.43	-3.5	-1.5	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	27.0	9.4	0.40	-3.4	-1.5	-0.1	0.0	0.0	0.0	0.0
	17:00	27.9	10.1	0.39	-3.8	-1.2	-0.4	0.0	0.0	0.0	0.0
	18:00	29.3	10.2	0.37	-3.6	-1.3	-0.1	0.0	0.0	0.0	0.0
	19:00	29.2	10.2	0.36	-3.4	-1.2	-0.1	0.0	0.0	0.0	0.0
	20:00	27.0	10.0	0.36	-3.6	-1.2	-0.2	0.0	0.0	0.0	0.0
	21:00	25.6	9.4	0.36	-3.5	-1.2	-0.3	0.0	0.0	0.0	0.0
	22:00	24.0	9.0	0.35	-3.5	-1.6	0.0	0.0	0.0	0.0	0.0
	23:00	23.2	8.8	0.34	-3.6	-1.4	-0.1	0.0	0.0	0.0	0.0
	0:00	22.9	8.7	0.34	ZS	-1.3	-0.1	0.0	0.0	0.0	0.0
Min		**12.1**	**4.4**	**0.3**	**-3.8**	**-1.6**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**29.3**	**10.2**	**0.5**	**-1.9**	**-1.0**	**0.2**	**0.0**	**0.2**	**0.0**	**0.2**
Average		**19.4**	**7.1**	**0.3**	**-3.2**	**-1.2**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
26/11/2018	1:00	24.1	8.9	0.34	-0.8	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	24.2	8.9	0.34	-1.4	-1.2	-0.1	0.0	0.0	0.0	0.0
	3:00	23.2	9.0	0.34	-1.6	-1.3	0.0	0.0	0.0	0.0	0.0
	4:00	23.5	9.3	0.33	-0.9	-1.2	0.0	0.0	0.0	0.0	0.0
	5:00	24.4	9.3	0.33	-1.2	-1.1	0.0	0.0	0.0	0.0	0.0
	6:00	25.4	9.3	0.37	-0.2	-1.1	0.0	0.0	0.0	0.0	0.0
	7:00	24.1	9.3	0.38	-1.3	-1.2	-0.1	0.0	0.0	0.0	0.0
	8:00	27.7	10.0	0.38	-1.4	-1.0	-0.3	0.0	0.0	0.0	0.0
	9:00	30.5	10.5	0.38	-1.8	-1.2	-0.2	0.0	0.0	0.0	0.0
	10:00	29.2	10.3	0.35	-1.5	-1.1	-0.2	0.0	0.0	0.0	0.0
	11:00	30.8	10.4	0.34	-1.8	-1.3	-0.2	0.0	0.0	0.0	0.0
	12:00	28.7	9.8	0.34	-1.7	-1.3	-0.1	0.0	0.0	0.0	0.0
	13:00	29.0	10.8	0.35	-1.6	-1.0	-0.4	0.0	0.0	0.0	0.0
	14:00	31.1	13.1	0.38	-1.1	-0.7	-0.7	0.0	0.0	0.0	0.0
	15:00	23.0	8.9	0.35	-1.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	16:00	24.2	10.7	0.37	-1.2	-0.9	-0.4	0.0	0.0	0.0	0.0
	17:00	21.5	8.6	0.36	-1.8	-1.1	-0.5	0.0	0.0	0.0	0.0
	18:00	19.3	7.0	0.37	-1.7	-1.4	0.0	0.0	0.0	0.0	0.0
	19:00	19.6	7.4	0.37	-1.8	-1.1	-0.4	0.0	0.0	0.0	0.0
	20:00	21.3	8.7	0.37	-1.9	-1.3	0.0	0.0	0.0	0.0	0.0
	21:00	22.2	9.1	0.36	-2.1	-1.2	-0.2	0.0	0.0	0.0	0.0
	22:00	21.5	9.0	0.36	-1.8	-0.9	-0.4	0.0	0.0	0.0	0.0
	23:00	20.7	8.0	0.36	-1.7	-1.2	0.0	0.0	0.0	0.0	0.0
	0:00	19.8	8.0	0.36	-1.9	-1.3	0.0	0.0	0.0	0.0	0.0
Min		**19.3**	**7.0**	**0.3**	**-2.1**	**-1.4**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**31.1**	**13.1**	**0.4**	**-0.2**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**24.5**	**9.3**	**0.4**	**-1.5**	**-1.1**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
27/11/2018	1:00	18.8	7.4	0.36	ZS	-1.1	-0.3	0.0	0.0	0.0	0.0
	2:00	19.3	7.4	0.36	-1.1	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	17.4	6.7	0.35	-1.4	-1.0	0.0	0.0	0.0	0.0	0.0
	4:00	15.7	5.3	0.35	-0.9	-1.0	0.7	0.0	0.0	0.0	0.0
	5:00	21.1	6.6	0.38	0.7	-1.1	1.5	0.0	0.0	0.0	0.0
	6:00	PO	PO	PO	PO	PO	PO	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	21.1	6.5	0.52	-0.5	-1.0	0.2	0.0	0.0	0.0	0.0
	8:00	19.4	7.5	0.56	0.7	-0.8	0.0	0.0	0.0	0.0	0.0
	9:00	28.4	9.5	0.54	-0.9	-0.7	0.2	0.0	0.0	0.0	0.0
	10:00	21.9	9.2	0.48	-1.7	-1.1	-0.1	0.0	0.0	0.0	0.0
	11:00	14.8	5.4	0.44	-2.3	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	19.2	6.6	0.44	-2.3	-1.1	-0.4	0.0	0.0	0.0	0.0
	13:00	15.2	5.3	0.43	-2.1	-1.1	-0.5	0.0	0.0	0.0	0.0
	14:00	10.1	3.3	0.42	-1.9	-1.1	-0.2	0.0	0.0	0.0	0.0
	15:00	11.6	4.0	0.41	-2.0	-1.2	-0.1	0.0	0.0	0.0	0.0
	16:00	13.2	4.5	0.44	-1.4	-1.2	0.0	0.0	0.0	0.0	0.0
	17:00	15.0	5.6	0.42	-1.8	-1.2	-0.2	0.0	0.0	0.0	0.0
	18:00	20.0	7.0	0.43	-1.0	-1.1	-0.3	0.0	0.0	0.0	0.0
	19:00	20.0	7.0	0.42	-1.5	-1.2	-0.1	0.0	0.0	0.0	0.0
	20:00	23.0	7.9	0.40	-1.8	-1.2	-0.3	0.0	0.0	0.0	0.0
	21:00	25.0	9.5	0.38	-2.2	-1.1	-0.3	0.0	0.0	0.0	0.0
	22:00	30.5	12.4	0.42	-1.3	-0.9	-0.1	0.0	0.0	0.0	0.0
	23:00	35.4	14.0	0.39	-2.1	-1.1	-0.3	0.0	0.0	0.0	0.0
	0:00	37.2	14.9	0.39	ZS	-1.3	0.0	0.0	0.0	0.0	0.0
Min		**10.1**	**3.3**	**0.4**	**-2.3**	**-1.3**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**37.2**	**14.9**	**0.6**	**0.7**	**-0.7**	**1.5**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**20.6**	**7.5**	**0.4**	**-1.4**	**-1.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
28/11/2018	1:00	30.8	11.7	0.37	-1.0	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	26.9	10.0	0.28	-1.2	-1.1	0.5	0.0	0.0	0.0	0.0
	3:00	26.1	9.5	0.29	-1.5	-1.2	0.1	0.0	0.0	0.0	0.0
	4:00	26.6	8.9	0.29	-1.7	-1.1	0.1	0.0	0.0	0.0	0.0
	5:00	18.5	5.7	0.30	-0.2	-1.1	-0.1	0.0	0.0	0.0	0.0
	6:00	21.7	6.1	0.32	0.5	-1.1	0.1	0.0	0.0	0.0	0.0
	7:00	20.2	6.0	0.38	0.6	-0.8	0.2	0.0	0.0	0.0	0.0
	8:00	15.1	5.0	0.38	-0.4	-0.7	0.0	0.0	0.0	0.0	0.0
	9:00	18.7	4.9	0.34	-1.1	-0.8	-0.2	0.0	0.0	0.0	0.0
	10:00	25.2	7.2	0.32	-1.5	-1.0	-0.1	0.0	0.0	0.0	0.0
	11:00	28.4	8.8	0.30	-2.3	-1.1	-0.1	0.0	0.0	0.0	0.0
	12:00	22.5	7.8	0.29	-2.5	-1.1	-0.2	0.0	0.0	0.0	0.0
	13:00	28.7	10.1	0.30	-2.3	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	25.9	9.3	0.29	-2.1	-1.1	-0.2	0.0	0.0	0.0	0.0
	15:00	31.1	10.7	0.30	-2.3	-1.1	-0.6	0.0	0.0	0.0	0.0
	16:00	30.2	9.9	0.30	-2.2	-1.1	-0.3	0.0	0.0	0.0	0.0
	17:00	33.7	12.1	0.30	-1.7	-1.1	-0.5	0.0	0.0	0.0	0.0
	18:00	35.9	13.1	0.31	-1.7	-1.1	-0.2	0.0	0.0	0.0	0.0
	19:00	41.2	14.7	0.31	-2.1	-1.0	-0.4	0.0	0.0	0.0	0.0
	20:00	40.0	15.2	0.31	-2.2	-1.0	-0.3	0.0	0.0	0.0	0.0
	21:00	41.0	15.5	0.30	-2.4	-1.1	-0.5	0.0	0.0	0.0	0.0
	22:00	44.4	16.6	0.29	-2.2	-1.1	-0.2	0.0	0.0	0.0	0.0
	23:00	46.2	17.3	0.30	-2.2	-1.3	0.0	0.0	0.0	0.0	0.0
	0:00	45.3	17.3	0.29	-2.3	-1.3	-0.1	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
Min		**15.1**	**4.9**	**0.3**	**-2.5**	**-1.3**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**46.2**	**17.3**	**0.4**	**0.6**	**-0.7**	**0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**30.2**	**10.6**	**0.3**	**-1.6**	**-1.1**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
29/11/2018	1:00	44.2	16.8	0.29	-2.3	-1.2	-0.1	0.0	0.0	0.0	0.0
	2:00	39.7	15.6	0.28	-2.4	-1.3	0.0	0.0	0.0	0.0	0.0
	3:00	39.5	15.7	0.28	-2.4	-1.2	0.1	0.0	0.0	0.0	0.0
	4:00	39.4	15.7	0.28	-2.3	-1.1	0.1	0.0	0.0	0.0	0.0
	5:00	40.5	15.8	0.28	-2.0	-1.2	0.2	0.0	0.0	0.0	0.0
	6:00	39.7	15.8	0.30	-1.9	-1.0	0.0	0.0	0.0	0.0	0.0
	7:00	39.2	15.2	0.30	-1.6	-1.1	-0.2	0.0	0.0	0.0	0.0
	8:00	38.1	13.9	0.30	-1.8	-1.0	-0.4	0.0	0.0	0.0	0.0
	9:00	41.7	14.4	0.30	PF	-1.1	-0.4	0.0	0.0	0.0	0.0
	10:00	41.3	13.9	0.28	PF	-1.0	-0.5	0.0	0.0	0.0	0.0
	11:00	44.2	13.1	0.28	PF	-0.9	-0.6	0.0	0.0	0.0	0.0
	12:00	45.2	12.9	0.28	PF	-1.3	-0.2	0.0	0.0	0.0	0.0
	13:00	40.8	12.2	0.27	PF	-1.2	0.0	0.0	0.0	0.0	0.0
	14:00	42.5	12.3	0.27	PF	-1.2	-0.2	0.0	0.0	0.0	0.0
	15:00	37.0	11.6	0.27	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	16:00	36.6	11.4	0.27	PF	-1.3	0.0	0.0	0.0	0.0	0.0
	17:00	35.3	11.7	0.28	PF	-1.0	-0.6	0.0	0.0	0.0	0.0
	18:00	36.0	12.0	0.29	PF	-1.2	-0.3	0.0	0.0	0.0	0.0
	19:00	33.3	12.0	0.29	PF	-1.0	-0.6	0.0	0.0	0.0	0.0
	20:00	31.8	11.8	0.29	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
	21:00	36.5	12.2	0.28	PF	-1.4	-0.1	0.0	0.0	0.0	0.0
	22:00	34.1	12.6	0.28	PF	-1.4	0.1	0.0	0.0	0.0	0.0
	23:00	35.3	13.0	0.28	PF	-1.2	0.0	0.0	0.0	0.0	0.0
	0:00	33.7	12.7	0.27	PF	-1.2	0.0	0.0	0.0	0.0	0.0
Min		**31.8**	**11.4**	**0.3**	**ID**	**-1.4**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**45.2**	**16.8**	**0.3**	**ID**	**-0.9**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**
Average		**38.6**	**13.5**	**0.3**	**ID**	**-1.1**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**
30/11/2018	1:00	33.0	12.8	0.27	PF	-1.0	-0.2	0.0	0.0	0.0	0.0
	2:00	32.4	12.5	0.27	PF	ZS	ZS	0.0	0.0	0.0	0.0
	3:00	32.7	12.7	0.27	PF	-0.8	0.1	0.0	0.0	0.0	0.0
	4:00	33.6	13.1	0.28	PF	-1.2	0.5	0.0	0.0	0.0	0.0
	5:00	36.6	14.0	0.28	PF	-1.0	0.4	0.0	0.0	0.0	0.0
	6:00	40.1	14.5	0.30	PF	-1.0	0.4	0.0	0.0	0.0	0.0
	7:00	44.0	15.9	0.32	PF	-1.0	0.2	0.0	0.0	0.0	0.0
	8:00	49.8	15.5	0.30	PF	-1.1	0.3	0.0	0.0	0.0	0.0
	9:00	52.7	14.5	0.30	PF	-1.0	0.1	0.0	0.0	0.0	0.0
	10:00	51.4	13.0	0.28	PF	-1.2	0.1	0.0	0.0	0.0	0.0
	11:00	67.5	12.0	0.26	PF	-1.0	0.0	0.0	0.0	0.0	0.0
	12:00	48.6	11.4	0.25	PF	-1.2	0.2	0.0	2.3	0.2	0.1
	13:00	42.5	11.9	0.27	PF	-1.0	-0.1	0.0	0.2	0.0	0.0
	14:00	44.9	12.2	0.27	PF	-1.0	-0.5	0.0	0.0	0.0	0.0
	15:00	44.2	12.7	0.27	PF	-1.0	-0.2	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	16:00	45.6	13.8	0.28	PF	-1.0	-0.1	0.0	0.0	0.0	0.0
	17:00	40.3	12.7	0.28	PF	-1.1	0.2	0.0	0.2	0.0	0.0
	18:00	35.6	12.6	0.28	PF	-1.1	0.0	0.0	0.0	0.0	0.0
	19:00	34.5	12.8	0.28	PF	-1.2	-0.1	0.1	0.0	0.0	0.0
	20:00	32.1	12.1	0.28	PF	-1.0	-0.2	0.0	0.2	0.0	0.0
	21:00	30.4	11.7	0.27	PF	-1.4	0.3	0.0	0.0	0.0	0.0
	22:00	27.2	11.2	0.26	PF	-1.2	0.2	0.0	0.0	0.0	0.0
	23:00	29.1	11.4	0.26	PF	-1.2	-0.1	0.0	0.1	0.0	0.0
	0:00	27.2	11.1	0.26	PF	-1.3	0.0	0.0	0.2	0.0	0.0
Min		**27.2**	**11.1**	**0.3**	**ID**	**-1.4**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**67.5**	**15.9**	**0.3**	**ID**	**-0.8**	**0.5**	**0.1**	**2.3**	**0.2**	**0.1**
Average		**39.8**	**12.8**	**0.3**	**ID**	**-1.1**	**0.1**	**0.0**	**0.1**	**0.0**	**0.0**
01/12/2018	1:00	26.8	11.0	0.26	PF	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	25.7	10.6	0.24	PF	-1.1	0.0	0.0	0.0	0.0	0.0
	3:00	27.4	10.6	0.24	PF	-1.1	0.1	0.0	0.0	0.0	0.0
	4:00	26.1	10.5	0.24	PF	-1.2	0.2	0.0	0.0	0.0	0.0
	5:00	26.1	10.4	0.24	PF	-1.3	0.2	0.0	0.0	0.0	0.0
	6:00	25.7	10.2	0.24	PF	-1.3	0.2	0.0	0.0	0.0	0.0
	7:00	27.2	10.1	0.25	PF	-1.2	0.1	0.0	0.0	0.0	0.0
	8:00	39.9	10.5	0.25	PF	-1.2	0.3	0.0	0.0	0.0	0.0
	9:00	37.3	10.2	0.24	PF	-1.0	0.2	0.0	0.2	0.0	0.0
	10:00	38.1	10.1	0.24	PF	-1.2	-0.1	0.0	0.1	0.0	0.0
	11:00	29.6	9.8	0.30	PF	-1.2	0.0	0.0	0.0	0.0	0.0
	12:00	34.6	9.9	0.25	PF	-1.1	-0.4	0.0	0.0	0.0	0.1
	13:00	31.1	9.7	0.24	PF	-1.4	-0.1	0.0	0.0	0.0	0.0
	14:00	28.7	9.2	0.25	PF	-1.1	-0.2	0.0	0.0	0.0	0.1
	15:00	28.4	9.1	0.24	PF	-1.1	-0.4	0.1	0.0	0.0	0.1
	16:00	26.2	9.2	0.24	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
	17:00	34.0	15.1	0.26	PF	-1.1	0.0	0.0	0.2	0.0	0.0
	18:00	29.7	12.6	0.28	PF	-0.9	-0.4	0.0	0.0	0.1	0.0
	19:00	28.8	13.7	0.29	PF	-1.0	-0.1	0.0	0.0	0.0	0.0
	20:00	21.9	8.8	0.26	PF	-0.9	-0.6	0.0	0.0	0.0	0.1
	21:00	21.5	8.0	0.25	PF	-1.2	-0.2	0.0	0.0	0.1	0.0
	22:00	19.8	7.3	0.25	PF	-1.3	0.1	0.0	0.0	0.0	0.0
	23:00	20.9	8.2	0.24	PF	-1.4	0.0	0.0	0.2	0.0	0.0
	0:00	21.9	8.1	0.24	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
Min		**19.8**	**7.3**	**0.2**	**ID**	**-1.4**	**-0.6**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**39.9**	**15.1**	**0.3**	**ID**	**-0.9**	**0.3**	**0.1**	**0.2**	**0.1**	**0.1**
Average		**28.2**	**10.1**	**0.3**	**ID**	**-1.1**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
02/12/2018	1:00	19.4	7.7	0.24	PF	-1.1	0.0	0.0	0.0	0.0	0.0
	2:00	19.0	7.6	0.24	PF	-1.3	-0.1	0.0	0.0	0.0	0.0
	3:00	19.6	7.6	0.24	PF	-1.5	0.3	0.0	0.0	0.0	0.0
	4:00	19.4	7.7	0.24	PF	-1.5	0.1	0.0	0.0	0.0	0.0
	5:00	19.3	7.5	0.23	PF	-1.3	0.2	0.0	0.2	0.0	0.0
	6:00	18.5	7.2	0.25	PF	-1.4	0.3	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10} µg/m³	$PM_{2.5}$ µg/m³	CO ppm	NO_2 [a] ppb	SO_2 [a] ppb	H_2S [a] ppb	Benzene ppb	Toluene ppb	Ethylbenzene ppb	Xylene ppb
	7:00	20.2	7.5	0.26	PF	-1.3	0.3	0.0	0.0	0.0	0.0
	8:00	21.2	7.3	0.24	PF	-1.3	-0.1	0.0	0.0	0.0	0.0
	9:00	22.1	7.4	0.24	PF	-1.4	0.0	0.0	0.0	0.0	0.0
	10:00	24.5	7.5	0.24	PF	-1.3	-0.3	0.0	0.0	0.0	0.0
	11:00	22.6	7.4	0.24	PF	-1.2	-0.2	0.0	0.3	0.0	0.0
	12:00	23.7	7.6	0.23	PF	-1.3	-0.2	0.0	0.0	0.0	0.0
	13:00	22.1	7.8	0.25	PF	-1.2	-0.3	0.0	0.0	0.0	0.0
	14:00	21.7	7.2	0.24	PF	-1.2	-0.4	0.0	0.0	0.1	0.0
	15:00	21.1	7.0	0.23	PF	-1.5	-0.2	0.0	0.0	0.0	0.0
	16:00	18.3	6.7	0.23	PF	-1.5	-0.1	0.0	0.0	0.0	0.0
	17:00	21.4	7.4	0.25	PF	-1.4	-0.3	0.0	0.0	0.0	0.0
	18:00	21.3	7.4	0.25	PF	-0.9	-0.7	0.0	0.0	0.0	0.0
	19:00	21.0	7.5	0.27	PF	-1.0	-0.4	0.0	0.0	0.0	0.0
	20:00	20.1	7.5	0.27	PF	-1.1	-0.2	0.0	0.0	0.0	0.0
	21:00	18.9	7.2	0.25	PF	-1.2	-0.3	0.0	0.2	0.0	0.0
	22:00	21.0	7.2	0.25	PF	-1.2	-0.2	0.0	0.0	0.0	0.0
	23:00	18.4	7.2	0.22	PF	-1.3	-0.1	0.1	0.0	0.0	0.0
	0:00	19.3	7.2	0.22	PF	-1.3	-0.3	0.0	0.2	0.0	0.0
Min		**18.3**	**6.7**	**0.2**	**ID**	**-1.5**	**-0.7**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**24.5**	**7.8**	**0.3**	**ID**	**-0.9**	**0.3**	**0.1**	**0.3**	**0.1**	**0.0**
Average		**20.6**	**7.4**	**0.2**	**ID**	**-1.3**	**-0.1**	**0.0**	**0.0**	**0.0**	**0.0**
03/12/2018	1:00	19.4	7.2	0.23	PF	ZS	ZS	0.0	0.0	0.0	0.0
	2:00	18.8	7.2	0.29	PF	-0.8	-0.1	0.0	0.0	0.0	0.0
	3:00	18.1	7.2	0.23	PF	-1.1	-0.4	0.0	0.0	0.0	0.0
	4:00	20.0	7.7	0.22	PF	-1.2	-0.3	0.0	0.2	0.0	0.1
	5:00	21.0	8.0	0.21	PF	-1.1	-0.2	0.0	0.0	0.0	0.2
	6:00	24.2	8.3	0.21	PF	-1.2	-0.2	0.1	0.0	0.0	0.2
	7:00	25.2	8.9	0.23	PF	-1.1	-0.4	0.0	0.2	0.0	0.0
	8:00	32.7	9.5	0.24	PF	-1.3	-0.2	0.0	0.0	0.0	0.0
	9:00	34.2	9.7	0.25	PF	-1.0	-0.4	0.1	0.1	0.0	0.0
	10:00	30.4	9.4	0.24	PF	-1.4	-0.1	0.0	0.1	0.0	0.0
	11:00	34.4	9.6	0.24	PF	-1.3	-0.1	0.0	0.2	0.0	0.0
	12:00	35.0	10.1	0.26	PF	MM	MM	0.0	0.0	0.0	0.0
	13:00	43.1	11.6	MM	PF	MM	MM	0.0	0.0	0.0	0.0
	14:00	40.2	11.0	MM	PF	-1.1	-0.3	0.0	0.0	0.0	0.1
	15:00	36.3	10.8	0.25	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	16:00	41.8	11.4	0.25	PF	-0.7	-0.5	0.0	0.0	0.0	0.0
	17:00	41.6	12.2	0.27	PF	-0.8	-0.4	0.0	0.0	0.0	0.0
	18:00	43.3	14.5	0.30	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	19:00	47.5	15.1	0.34	PF	-0.9	-0.1	0.0	0.0	0.0	0.0
	20:00	42.4	13.6	0.29	PF	-1.0	0.4	0.0	0.0	0.0	0.0
	21:00	35.0	16.4	0.33	PF	-0.9	0.1	0.0	0.0	0.0	0.0
	22:00	35.5	13.5	0.30	PF	-1.1	-0.3	0.0	0.0	0.0	0.0
	23:00	26.9	10.6	0.29	PF	-1.1	-0.1	0.0	0.0	0.0	0.0
	0:00	30.9	11.8	0.28	PF	-1.2	0.0	0.0	0.0	0.0	0.0

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Min		**18.1**	**7.2**	**0.2**	**ID**	**-1.4**	**-0.5**	**0.0**	**0.0**	**0.0**	**0.0**
Max		**47.5**	**16.4**	**0.3**	**ID**	**-0.7**	**0.4**	**0.1**	**0.2**	**0.0**	**0.2**
Average		**32.4**	**10.6**	**0.3**	**ID**	**-1.1**	**-0.2**	**0.0**	**0.0**	**0.0**	**0.0**

µg/m³ = microgram per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = insufficient data; IO = Instrument offline; MM = maintenance mode; NO_2 = nitrogen dioxide; PF = pump failure; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); PO = power outage; ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide; UM = unknown malfunction; ZS = nightly zero and span

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

Attachment B-3 New Guyana School Data Record

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
12/04/2019	1:00	19.8	7.6	0.083	ZS	0.9	7.1	ID	ID	ID	ID
	2:00	19.0	7.2	0.073	0.3	ZS	ZS	ID	ID	ID	ID
	3:00	18.4	6.9	0.070	0.5	0.3	3.1	ID	ID	ID	ID
	4:00	18.9	7.1	0.076	0.5	0.6	3.7	ID	ID	ID	ID
	5:00	21.5	8.1	0.080	1.0	0.7	0.9	ID	ID	ID	ID
	6:00	21.4	8.4	0.087	0.8	0.6	1.3	ID	ID	ID	ID
	7:00	25.4	9.0	0.104	1.6	0.9	1.9	ID	ID	ID	ID
	8:00	28.8	11.2	0.119	1.4	0.8	5.1	ID	ID	ID	ID
	9:00	24.3	8.7	0.085	0.4	0.7	4.2	ID	ID	ID	ID
	10:00	25.9	9.1	0.089	0.7	0.6	4.7	ID	ID	ID	ID
	11:00	23.1	7.8	0.074	0.4	0.9	4.9	ID	ID	ID	ID
	12:00	25.3	9.9	0.085	0.7	0.9	4.7	ID	ID	ID	ID
	13:00	28.8	10.1	0.090	0.9	1.0	7.0	ID	ID	ID	ID
	14:00	31.1	12.6	0.096	0.8	1.1	8.3	ID	ID	ID	ID
	15:00	29.3	11.3	0.082	0.5	1.0	7.7	ID	ID	ID	ID
	16:00	25.4	7.6	0.080	0.6	0.7	5.4	ID	ID	ID	ID
	17:00	28.2	8.3	0.090	1.2	0.6	5.4	ID	ID	ID	ID
	18:00	34.0	12.3	0.119	2.2	1.1	2.3	ID	ID	ID	ID
	19:00	35.3	12.3	0.120	2.8	1.0	5.0	ID	ID	ID	ID
	20:00	36.9	14.0	0.128	2.6	1.2	6.7	ID	ID	ID	ID
	21:00	32.2	11.0	0.106	1.9	1.0	6.9	ID	ID	ID	ID
	22:00	33.7	10.8	0.090	1.6	0.9	7.9	ID	ID	ID	ID
	23:00	36.6	12.0	0.082	1.3	0.9	7.2	ID	ID	ID	ID
	0:00	42.3	13.5	0.078	ZS	0.7	7.0	ID	ID	ID	ID
Min		**18.4**	**6.9**	**0.070**	**0.3**	**0.3**	**0.9**	**ID**	**ID**	**ID**	**ID**
Max		**42.3**	**14.0**	**0.128**	**2.8**	**1.2**	**8.3**	**ID**	**ID**	**ID**	**ID**
Average		**27.7**	**9.9**	**0.091**	**1.1**	**0.8**	**5.2**	**ID**	**ID**	**ID**	**ID**
13/04/2019	1:00	44.7	14.7	ZS	1.5	ZS	ZS	ID	ID	ID	ID
	2:00	50.8	16.2	0.087	0.9	0.7	3.8	ID	ID	ID	ID
	3:00	49.9	15.9	0.069	0.3	0.8	8.1	ID	ID	ID	ID
	4:00	48.6	16.1	0.067	0.6	0.7	7.6	ID	ID	ID	ID
	5:00	49.6	16.7	0.076	0.9	0.7	6.5	ID	ID	ID	ID
	6:00	49.0	17.1	0.083	0.9	0.9	8.4	ID	ID	ID	ID
	7:00	55.4	18.2	0.124	2.5	0.9	6.5	ID	ID	ID	ID
	8:00	50.2	16.9	0.085	0.5	1.1	5.2	ID	ID	ID	ID
	9:00	55.3	17.7	0.092	0.9	0.6	7.3	ID	ID	ID	ID
	10:00	54.1	16.9	0.079	0.6	0.8	7.1	ID	ID	ID	ID
	11:00	49.6	15.3	0.076	0.4	0.9	8.5	ID	ID	ID	ID
	12:00	43.8	14.4	0.077	0.5	1.0	8.0	ID	ID	ID	ID
	13:00	43.5	14.2	0.075	0.5	0.9	7.5	ID	ID	ID	ID
	14:00	39.6	12.3	0.069	0.5	1.0	9.9	ID	ID	ID	ID
	15:00	35.3	11.6	0.068	0.4	0.9	8.9	ID	ID	ID	ID
	16:00	37.0	13.0	0.076	0.8	1.1	10.8	ID	ID	ID	ID
	17:00	38.0	13.0	0.081	0.7	1.2	12.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	18:00	38.0	13.6	0.107	1.4	1.0	10.7	ID	ID	ID	ID
	19:00	43.6	16.1	0.121	2.3	1.1	14.5	ID	ID	ID	ID
	20:00	41.6	15.7	0.135	3.5	1.6	11.6	ID	ID	ID	ID
	21:00	46.0	16.8	0.116	2.1	1.0	14.6	ID	ID	ID	ID
	22:00	42.4	15.8	0.080	1.0	1.2	13.3	ID	ID	ID	ID
	23:00	45.4	16.9	ZS	0.9	0.9	12.0	ID	ID	ID	ID
	0:00	43.9	15.7	0.067	0.5	ZS	ZS	ID	ID	ID	ID
Min		**35.3**	**11.6**	**0.067**	**0.3**	**0.6**	**3.8**	**ID**	**ID**	**ID**	**ID**
Max		**55.4**	**18.2**	**0.135**	**3.5**	**1.6**	**14.6**	**ID**	**ID**	**ID**	**ID**
Average		**45.6**	**15.5**	**0.087**	**1.0**	**1.0**	**9.2**	**ID**	**ID**	**ID**	**ID**
14/04/2019	1:00	41.1	15.3	0.052	0.1	0.8	13.5	ID	ID	ID	ID
	2:00	40.1	15.0	0.051	ZS	0.7	10.8	ID	ID	ID	ID
	3:00	41.6	15.2	0.053	0.5	0.9	7.6	ID	ID	ID	ID
	4:00	44.4	16.1	0.055	0.3	0.8	7.5	ID	ID	ID	ID
	5:00	47.2	16.2	0.055	0.6	0.8	6.2	ID	ID	ID	ID
	6:00	45.7	16.0	0.066	0.8	0.8	2.8	ID	ID	ID	ID
	7:00	50.7	17.0	0.088	1.5	0.8	1.9	ID	ID	ID	ID
	8:00	51.4	17.9	0.077	0.7	0.7	1.8	ID	ID	ID	ID
	9:00	47.6	15.9	0.061	0.2	0.6	2.2	ID	ID	ID	ID
	10:00	47.9	15.9	0.061	0.5	0.6	4.0	ID	ID	ID	ID
	11:00	49.8	15.3	0.056	0.2	0.8	4.9	ID	ID	ID	ID
	12:00	52.3	15.8	0.050	0.2	0.8	4.2	ID	ID	ID	ID
	13:00	48.1	15.1	0.047	0.1	0.7	6.0	ID	ID	ID	ID
	14:00	46.8	14.8	0.045	0.2	0.9	5.8	ID	ID	ID	ID
	15:00	45.0	14.4	0.039	0.2	0.8	7.2	ID	ID	ID	ID
	16:00	39.8	13.4	0.031	0.1	1.0	6.4	ID	ID	ID	ID
	17:00	44.1	13.7	0.040	0.3	0.7	8.4	ID	ID	ID	ID
	18:00	43.1	13.9	0.049	0.9	1.0	6.2	ID	ID	ID	ID
	19:00	44.6	17.5	0.084	1.9	1.0	7.2	ID	ID	ID	ID
	20:00	41.6	17.3	0.082	2.2	1.0	6.5	ID	ID	ID	ID
	21:00	42.9	17.6	0.088	1.7	0.9	6.3	ID	ID	ID	ID
	22:00	42.3	17.9	0.070	1.2	0.9	9.7	ID	ID	ID	ID
	23:00	35.4	13.1	ZS	1.1	0.6	4.6	ID	ID	ID	ID
	0:00	33.9	12.4	0.028	ZS	0.6	3.6	ID	ID	ID	ID
Min		**33.9**	**12.4**	**0.028**	**0.1**	**0.6**	**1.8**	**ID**	**ID**	**ID**	**ID**
Max		**52.3**	**17.9**	**0.088**	**2.2**	**1.0**	**13.5**	**ID**	**ID**	**ID**	**ID**
Average		**44.5**	**15.5**	**0.058**	**0.7**	**0.8**	**6.1**	**ID**	**ID**	**ID**	**ID**
15/04/2019	1:00	35.8	13.0	0.026	0.5	ZS	ZS	ID	ID	ID	ID
	2:00	35.8	12.3	0.014	0.3	0.8	2.2	ID	ID	ID	ID
	3:00	31.9	11.3	0.002	0.3	0.6	1.6	ID	ID	ID	ID
	4:00	31.4	11.7	0.009	0.8	0.6	1.6	ID	ID	ID	ID
	5:00	34.1	12.6	0.015	0.5	0.4	2.1	ID	ID	ID	ID
	6:00	32.7	11.8	0.015	0.8	0.6	2.0	ID	ID	ID	ID
	7:00	36.0	12.8	0.067	2.7	0.8	1.5	ID	ID	ID	ID
	8:00	36.3	13.0	0.055	1.6	0.7	1.1	ID	ID	ID	ID
	9:00	35.5	12.8	0.073	1.6	0.8	0.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	10:00	38.4	12.6	0.047	1.1	0.7	0.2	ID	ID	ID	ID
	11:00	37.8	12.6	0.039	0.9	0.7	-0.4	ID	ID	ID	ID
	12:00	38.4	13.3	0.048	0.9	0.5	-0.7	ID	ID	ID	ID
	13:00	36.8	12.5	0.049	0.8	0.7	-0.8	ID	ID	ID	ID
	14:00	35.0	11.9	0.033	0.5	0.7	-0.9	ID	ID	ID	ID
	15:00	34.4	12.1	0.059	1.0	0.6	-0.7	ID	ID	ID	ID
	16:00	35.2	11.8	0.036	1.0	0.5	-0.6	ID	ID	ID	ID
	17:00	36.6	13.1	0.032	1.2	0.7	-0.8	ID	ID	ID	ID
	18:00	40.9	14.9	0.062	3.2	1.2	-0.6	ID	ID	ID	ID
	19:00	44.2	15.3	0.080	3.4	0.8	-0.2	ID	ID	ID	ID
	20:00	43.6	16.5	0.091	3.5	0.7	0.2	ID	ID	ID	ID
	21:00	44.5	16.7	0.083	2.9	1.0	0.1	ID	ID	ID	ID
	22:00	48.4	19.4	0.075	2.2	0.8	0.6	ID	ID	ID	ID
	23:00	48.3	16.6	0.053	1.4	0.8	0.6	ID	ID	ID	ID
	0:00	47.4	16.2	0.043	1.3	0.8	0.5	ID	ID	ID	ID
Min		**31.4**	**11.3**	**0.002**	**0.3**	**0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**48.4**	**19.4**	**0.091**	**3.5**	**1.2**	**2.2**	**ID**	**ID**	**ID**	**ID**
Average		**38.3**	**13.6**	**0.046**	**1.4**	**0.7**	**0.4**	**ID**	**ID**	**ID**	**ID**
16/04/2019	1:00	43.7	15.8	0.028	ZS	0.7	0.5	ID	ID	ID	ID
	2:00	41.5	14.3	0.023	0.6	ZS	ZS	ID	ID	ID	ID
	3:00	39.9	14.2	0.025	0.5	0.7	0.9	ID	ID	ID	ID
	4:00	39.7	14.4	0.027	0.7	0.5	0.4	ID	ID	ID	ID
	5:00	37.5	13.8	0.017	0.6	0.6	0.7	ID	ID	ID	ID
	6:00	44.8	17.5	0.037	2.0	1.0	1.1	ID	ID	ID	ID
	7:00	84.9	39.8	0.147	4.8	3.6	0.6	ID	ID	ID	ID
	8:00	49.6	18.8	0.071	1.3	1.6	1.4	ID	ID	ID	ID
	9:00	41.3	14.2	0.026	0.4	0.8	2.1	ID	ID	ID	ID
	10:00	41.4	13.9	0.023	0.4	1.1	8.7	ID	ID	ID	ID
	11:00	42.5	14.0	0.025	0.5	1.2	10.6	ID	ID	ID	ID
	12:00	46.1	15.3	0.029	0.6	1.2	10.4	ID	ID	ID	ID
	13:00	42.5	13.8	0.036	0.7	1.2	11.4	ID	ID	ID	ID
	14:00	41.2	13.4	0.020	0.4	0.8	13.3	ID	ID	ID	ID
	15:00	41.9	13.3	0.024	0.6	0.9	12.6	ID	ID	ID	ID
	16:00	51.2	13.4	0.022	0.5	0.9	12.1	ID	ID	ID	ID
	17:00	74.7	15.7	0.037	1.1	1.0	12.1	ID	ID	ID	ID
	18:00	55.4	16.2	0.063	1.5	1.0	11.2	ID	ID	ID	ID
	19:00	54.7	19.3	0.081	2.5	1.1	11.6	ID	ID	ID	ID
	20:00	46.5	16.9	0.085	2.4	1.2	10.0	ID	ID	ID	ID
	21:00	47.7	17.7	0.082	2.7	1.0	6.7	ID	ID	ID	ID
	22:00	47.9	17.3	0.067	2.2	0.8	3.9	ID	ID	ID	ID
	23:00	43.3	16.0	0.050	1.8	1.1	1.4	ID	ID	ID	ID
	0:00	43.7	14.9	0.033	ZS	0.9	3.7	ID	ID	ID	ID
Min		**37.5**	**13.3**	**0.017**	**0.4**	**0.5**	**0.4**	**ID**	**ID**	**ID**	**ID**
Max		**84.9**	**39.8**	**0.147**	**4.8**	**3.6**	**13.3**	**ID**	**ID**	**ID**	**ID**
Average		**47.6**	**16.4**	**0.045**	**1.3**	**1.1**	**6.4**	**ID**	**ID**	**ID**	**ID**
17/04/2019	1:00	41.1	13.9	0.013	0.3	ZS	ZS	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	2:00	42.0	14.5	-0.001	0.0	0.7	6.3	ID	ID	ID	ID
	3:00	40.0	13.7	-0.004	0.0	0.6	5.6	ID	ID	ID	ID
	4:00	38.7	13.4	0.001	0.3	0.8	3.9	ID	ID	ID	ID
	5:00	37.8	14.1	0.024	1.7	0.6	1.4	ID	ID	ID	ID
	6:00	38.6	13.9	0.040	2.3	0.6	0.7	ID	ID	ID	ID
	7:00	62.2	27.1	0.178	5.5	0.9	0.2	ID	ID	ID	ID
	8:00	45.2	16.8	0.070	1.8	0.9	0.0	ID	ID	ID	ID
	9:00	39.5	13.6	0.028	0.9	0.8	1.9	ID	ID	ID	ID
	10:00	37.7	12.7	0.017	0.5	0.9	8.6	ID	ID	ID	ID
	11:00	37.4	12.1	0.010	0.3	0.9	12.0	ID	ID	ID	ID
	12:00	37.0	11.7	0.005	0.2	0.9	11.6	ID	ID	ID	ID
	13:00	37.5	11.9	0.011	0.3	1.1	13.9	ID	ID	ID	ID
	14:00	35.4	11.9	0.022	0.3	1.2	14.6	ID	ID	ID	ID
	15:00	35.9	11.8	0.018	0.2	1.0	13.7	ID	ID	ID	ID
	16:00	37.6	13.5	0.034	1.1	1.3	17.5	ID	ID	ID	ID
	17:00	43.1	17.4	0.054	0.8	1.1	16.5	ID	ID	ID	ID
	18:00	43.4	17.0	0.083	1.9	1.5	16.5	ID	ID	ID	ID
	19:00	56.6	27.6	0.156	2.5	1.8	16.7	ID	ID	ID	ID
	20:00	37.7	14.6	0.076	1.9	1.5	21.5	ID	ID	ID	ID
	21:00	33.4	13.3	0.052	1.1	1.2	18.0	ID	ID	ID	ID
	22:00	24.4	9.6	0.040	1.1	1.0	9.0	ID	ID	ID	ID
	23:00	28.0	10.7	0.046	1.5	0.9	2.2	ID	ID	ID	ID
	0:00	31.5	14.8	0.085	2.0	ZS	ZS	ID	ID	ID	ID
Min		**24.4**	**9.6**	**-0.004**	**0.0**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**62.2**	**27.6**	**0.178**	**5.5**	**1.8**	**21.5**	**ID**	**ID**	**ID**	**ID**
Average		**39.2**	**14.6**	**0.044**	**1.2**	**1.0**	**9.7**	**ID**	**ID**	**ID**	**ID**
18/04/2019	1:00	27.0	11.4	0.037	0.8	0.9	8.7	ID	ID	ID	ID
	2:00	23.7	9.8	0.025	ZS	1.1	11.5	ID	ID	ID	ID
	3:00	22.2	9.5	0.006	0.5	0.6	3.6	ID	ID	ID	ID
	4:00	18.2	7.7	-0.001	0.6	0.6	-0.5	ID	ID	ID	ID
	5:00	26.4	10.7	0.001	0.2	0.8	9.5	ID	ID	ID	ID
	6:00	28.3	11.0	0.012	0.5	0.8	6.5	ID	ID	ID	ID
	7:00	36.0	13.0	0.046	2.0	0.8	8.5	ID	ID	ID	ID
	8:00	25.9	11.4	0.087	2.1	0.8	5.7	ID	ID	ID	ID
	9:00	31.2	12.6	0.042	1.4	0.9	6.6	ID	ID	ID	ID
	10:00	31.7	12.3	0.025	0.5	1.0	14.3	ID	ID	ID	ID
	11:00	30.3	12.4	0.029	0.6	1.0	18.2	ID	ID	ID	ID
	12:00	40.8	18.1	0.045	0.4	1.3	12.6	ID	ID	ID	ID
	13:00	35.5	12.3	0.020	0.3	1.4	20.9	ID	ID	ID	ID
	14:00	35.1	12.3	0.018	0.1	1.2	24.0	ID	ID	ID	ID
	15:00	37.3	12.7	0.017	0.3	1.3	23.2	ID	ID	ID	ID
	16:00	39.2	13.0	0.025	0.6	1.3	25.6	ID	ID	ID	ID
	17:00	37.8	13.0	0.035	1.2	1.1	24.7	ID	ID	ID	ID
	18:00	42.7	15.3	0.066	2.2	1.4	22.6	ID	ID	ID	ID
	19:00	48.3	20.4	0.097	2.6	1.8	23.4	ID	ID	ID	ID
	20:00	42.3	16.8	0.076	2.4	1.7	29.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	21:00	38.3	14.4	0.059	1.9	1.5	21.2	ID	ID	ID	ID
	22:00	38.0	16.0	0.065	2.2	1.2	20.0	ID	ID	ID	ID
	23:00	37.9	15.1	0.051	1.7	1.0	4.4	ID	ID	ID	ID
	0:00	37.3	14.0	0.032	1.4	0.7	2.8	ID	ID	ID	ID
Min		**18.2**	**7.7**	**-0.001**	**0.1**	**0.6**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**48.3**	**20.4**	**0.097**	**2.6**	**1.8**	**29.7**	**ID**	**ID**	**ID**	**ID**
Average		**33.8**	**13.1**	**0.038**	**1.2**	**1.1**	**14.5**	**ID**	**ID**	**ID**	**ID**
19/04/2019	1:00	36.3	13.3	0.023	ZS	0.8	1.7	ID	ID	ID	ID
	2:00	43.4	20.7	0.040	0.6	ZS	ZS	ID	ID	ID	ID
	3:00	39.7	17.7	0.063	1.2	0.7	2.5	ID	ID	ID	ID
	4:00	51.8	25.1	0.102	1.0	1.0	1.4	ID	ID	ID	ID
	5:00	48.5	22.7	0.094	0.6	1.1	4.2	ID	ID	ID	ID
	6:00	39.1	15.3	0.056	0.7	0.8	3.6	ID	ID	ID	ID
	7:00	38.4	13.9	0.039	1.1	0.6	1.4	ID	ID	ID	ID
	8:00	36.0	13.2	0.029	0.5	0.9	11.9	ID	ID	ID	ID
	9:00	34.0	12.5	0.014	-0.2	1.0	12.6	ID	ID	ID	ID
	10:00	36.1	12.6	0.011	-0.1	0.9	15.5	ID	ID	ID	ID
	11:00	33.7	12.2	0.002	-0.2	1.0	14.3	ID	ID	ID	ID
	12:00	32.8	12.1	0.004	-0.3	1.0	16.7	ID	ID	ID	ID
	13:00	33.5	12.7	0.004	-0.2	1.0	15.7	ID	ID	ID	ID
	14:00	32.9	12.7	0.004	-0.3	1.0	19.8	ID	ID	ID	ID
	15:00	34.3	13.1	0.014	-0.1	0.9	17.8	ID	ID	ID	ID
	16:00	32.9	12.2	0.008	-0.1	1.1	17.5	ID	ID	ID	ID
	17:00	32.7	12.6	0.017	0.0	1.0	16.0	ID	ID	ID	ID
	18:00	36.6	14.3	0.042	0.5	1.1	15.3	ID	ID	ID	ID
	19:00	42.2	18.9	0.076	1.2	1.0	16.5	ID	ID	ID	ID
	20:00	36.3	15.4	0.056	1.1	1.4	19.1	ID	ID	ID	ID
	21:00	33.7	13.7	0.045	1.1	1.4	25.0	ID	ID	ID	ID
	22:00	37.5	14.7	0.043	0.8	1.3	18.7	ID	ID	ID	ID
	23:00	35.4	14.7	0.037	0.6	1.0	8.1	ID	ID	ID	ID
	0:00	34.6	15.2	0.028	ZS	0.9	4.4	ID	ID	ID	ID
Min		**32.7**	**12.1**	**0.002**	**-0.3**	**0.6**	**1.4**	**ID**	**ID**	**ID**	**ID**
Max		**51.8**	**25.1**	**0.102**	**1.2**	**1.4**	**25.0**	**ID**	**ID**	**ID**	**ID**
Average		**37.2**	**15.1**	**0.035**	**0.4**	**1.0**	**12.2**	**ID**	**ID**	**ID**	**ID**
20/04/2019	1:00	33.2	14.6	0.025	0.5	ZS	ZS	ID	ID	ID	ID
	2:00	30.2	13.1	0.015	0.3	0.7	1.5	ID	ID	ID	ID
	3:00	31.6	13.8	0.031	0.5	0.5	0.3	ID	ID	ID	ID
	4:00	31.0	12.9	0.013	0.4	0.5	0.2	ID	ID	ID	ID
	5:00	29.5	12.7	0.019	0.4	0.7	2.1	ID	ID	ID	ID
	6:00	30.4	12.2	0.021	0.6	0.6	2.8	ID	ID	ID	ID
	7:00	33.9	14.3	0.045	1.6	0.7	3.1	ID	ID	ID	ID
	8:00	32.8	13.5	0.037	0.9	0.9	13.2	ID	ID	ID	ID
	9:00	33.5	13.2	0.037	0.8	0.8	9.5	ID	ID	ID	ID
	10:00	35.7	12.7	0.027	0.6	0.9	14.6	ID	ID	ID	ID
	11:00	31.6	11.7	0.013	0.3	1.3	21.3	ID	ID	ID	ID
	12:00	32.8	12.3	0.023	0.4	1.2	18.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	13:00	32.0	11.6	0.011	0.2	1.0	16.1	ID	ID	ID	ID
	14:00	30.6	12.1	0.022	0.2	1.0	13.8	ID	ID	ID	ID
	15:00	28.5	11.4	0.014	0.0	1.1	12.2	ID	ID	ID	ID
	16:00	32.8	11.5	0.016	0.3	1.1	14.1	ID	ID	ID	ID
	17:00	32.1	12.1	0.030	0.8	1.5	20.8	ID	ID	ID	ID
	18:00	35.1	12.3	0.034	1.3	1.4	21.1	ID	ID	ID	ID
	19:00	39.3	16.3	0.064	2.3	1.8	24.4	ID	ID	ID	ID
	20:00	30.7	12.3	0.047	1.7	1.5	21.0	ID	ID	ID	ID
	21:00	31.9	12.0	0.052	2.0	1.4	20.4	ID	ID	ID	ID
	22:00	31.9	12.2	0.039	1.7	1.3	17.0	ID	ID	ID	ID
	23:00	29.7	11.4	0.045	2.1	1.1	14.7	ID	ID	ID	ID
	0:00	29.6	11.4	ZS	1.8	ZS	ZS	ID	ID	ID	ID
Min		**28.5**	**11.4**	**0.011**	**0.0**	**0.5**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**39.3**	**16.3**	**0.064**	**2.3**	**1.8**	**24.4**	**ID**	**ID**	**ID**	**ID**
Average		**32.1**	**12.6**	**0.030**	**0.9**	**1.0**	**12.8**	**ID**	**ID**	**ID**	**ID**
21/04/2019	1:00	30.4	11.6	0.035	1.3	0.8	5.8	ID	ID	ID	ID
	2:00	29.3	11.9	0.029	ZS	0.9	6.0	ID	ID	ID	ID
	3:00	30.7	12.3	0.022	1.1	1.1	20.1	ID	ID	ID	ID
	4:00	31.5	12.4	0.027	1.3	1.0	6.1	ID	ID	ID	ID
	5:00	34.2	13.5	0.039	1.4	0.8	4.2	ID	ID	ID	ID
	6:00	35.3	13.2	0.017	1.1	0.7	0.6	ID	ID	ID	ID
	7:00	35.8	13.5	0.015	0.6	0.6	3.8	ID	ID	ID	ID
	8:00	37.3	14.7	0.023	0.4	0.6	3.2	ID	ID	ID	ID
	9:00	36.8	14.5	0.020	0.4	0.8	3.8	ID	ID	ID	ID
	10:00	35.0	12.6	0.012	0.2	0.7	7.8	ID	ID	ID	ID
	11:00	31.6	11.2	0.008	0.0	0.9	9.9	ID	ID	ID	ID
	12:00	32.9	13.2	0.008	0.1	1.0	9.8	ID	ID	ID	ID
	13:00	26.0	9.9	0.001	-0.1	1.1	12.3	ID	ID	ID	ID
	14:00	30.3	11.0	0.007	0.0	1.0	14.4	ID	ID	ID	ID
	15:00	34.1	11.6	0.005	0.0	1.0	14.7	ID	ID	ID	ID
	16:00	33.6	11.5	0.000	-0.1	1.1	14.4	ID	ID	ID	ID
	17:00	35.7	12.4	0.006	-0.1	0.9	12.9	ID	ID	ID	ID
	18:00	36.4	12.9	0.018	0.6	0.7	11.7	ID	ID	ID	ID
	19:00	41.1	15.9	0.058	1.8	1.2	12.1	ID	ID	ID	ID
	20:00	40.0	14.7	0.061	1.5	1.2	14.8	ID	ID	ID	ID
	21:00	37.0	13.7	0.048	1.6	1.2	15.2	ID	ID	ID	ID
	22:00	38.7	14.4	0.042	1.7	1.1	15.4	ID	ID	ID	ID
	23:00	35.6	13.6	0.040	1.4	1.0	7.0	ID	ID	ID	ID
	0:00	36.3	13.4	0.024	ZS	0.9	8.7	ID	ID	ID	ID
Min		**26.0**	**9.9**	**0.000**	**-0.1**	**0.6**	**0.6**	**ID**	**ID**	**ID**	**ID**
Max		**41.1**	**15.9**	**0.061**	**1.8**	**1.2**	**20.1**	**ID**	**ID**	**ID**	**ID**
Average		**34.4**	**12.9**	**0.023**	**0.7**	**0.9**	**9.8**	**ID**	**ID**	**ID**	**ID**
22/04/2019	1:00	36.5	14.0	0.030	1.3	ZS	ZS	ID	ID	ID	ID
	2:00	37.7	15.5	0.019	1.0	0.9	2.6	ID	ID	ID	ID
	3:00	38.5	13.7	0.015	0.7	1.0	12.0	ID	ID	ID	ID
	4:00	35.5	13.3	0.021	1.5	1.1	15.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	5:00	36.4	12.7	0.014	1.4	0.8	1.2	ID	ID	ID	ID
	6:00	38.9	14.6	0.012	0.5	0.6	1.7	ID	ID	ID	ID
	7:00	41.1	16.6	0.038	1.2	0.9	1.1	ID	ID	ID	ID
	8:00	34.7	13.0	0.002	0.1	0.7	0.4	ID	ID	ID	ID
	9:00	35.9	12.7	0.003	0.3	0.6	0.4	ID	ID	ID	ID
	10:00	36.0	12.4	-0.001	0.3	0.8	-0.4	ID	ID	ID	ID
	11:00	37.8	12.7	0.008	0.3	0.6	-0.3	ID	ID	ID	ID
	12:00	36.6	12.5	0.009	0.3	0.6	-0.5	ID	ID	ID	ID
	13:00	36.6	12.1	0.008	0.0	0.8	4.3	ID	ID	ID	ID
	14:00	34.5	12.0	0.007	-0.1	1.0	7.1	ID	ID	ID	ID
	15:00	35.9	11.6	0.005	0.0	0.9	7.1	ID	ID	ID	ID
	16:00	34.8	12.4	0.008	-0.1	0.9	6.5	ID	ID	ID	ID
	17:00	35.4	12.0	0.015	0.2	1.0	6.9	ID	ID	ID	ID
	18:00	39.9	17.7	0.078	1.8	1.5	9.2	ID	ID	ID	ID
	19:00	40.0	16.7	0.081	3.4	2.3	6.6	ID	ID	ID	ID
	20:00	37.4	14.1	0.094	2.8	1.3	3.3	ID	ID	ID	ID
	21:00	37.9	13.5	0.076	2.5	1.1	3.8	ID	ID	ID	ID
	22:00	35.3	12.7	0.058	2.0	1.0	3.7	ID	ID	ID	ID
	23:00	37.6	12.9	0.058	2.4	1.0	3.6	ID	ID	ID	ID
	0:00	35.6	12.4	0.049	2.1	0.8	0.7	ID	ID	ID	ID
Min		**34.5**	**11.6**	**-0.001**	**-0.1**	**0.6**	**-0.5**	**ID**	**ID**	**ID**	**ID**
Max		**41.1**	**17.7**	**0.094**	**3.4**	**2.3**	**15.0**	**ID**	**ID**	**ID**	**ID**
Average		**36.9**	**13.5**	**0.030**	**1.1**	**1.0**	**4.2**	**ID**	**ID**	**ID**	**ID**
23/04/2019	1:00	36.7	12.2	0.034	ZS	0.7	0.4	ID	ID	ID	ID
	2:00	34.9	13.1	0.039	1.9	ZS	ZS	ID	ID	ID	ID
	3:00	36.5	12.6	0.041	2.0	1.0	-0.3	ID	ID	ID	ID
	4:00	30.9	11.9	0.028	1.7	0.9	-0.4	ID	ID	ID	ID
	5:00	33.0	11.9	0.032	2.0	0.7	0.0	ID	ID	ID	ID
	6:00	30.4	11.4	0.039	2.5	1.0	-0.1	ID	ID	ID	ID
	7:00	36.4	13.1	0.096	4.0	1.2	0.4	ID	ID	ID	ID
	8:00	32.2	11.5	0.047	1.6	1.1	-0.8	ID	ID	ID	ID
	9:00	29.2	10.7	0.021	1.0	0.8	-0.7	ID	ID	ID	ID
	10:00	29.6	9.9	0.006	0.6	0.5	-0.8	ID	ID	ID	ID
	11:00	30.1	9.8	0.011	0.4	0.7	-0.2	ID	ID	ID	ID
	12:00	31.5	10.2	0.020	0.4	0.7	3.1	ID	ID	ID	ID
	13:00	31.7	10.6	0.017	0.4	0.8	3.3	ID	ID	ID	ID
	14:00	29.9	9.6	0.011	0.2	0.9	7.1	ID	ID	ID	ID
	15:00	26.8	9.6	0.017	0.2	0.8	4.1	ID	ID	ID	ID
	16:00	24.8	8.8	0.015	0.5	0.8	2.5	ID	ID	ID	ID
	17:00	29.5	9.7	0.024	0.7	0.9	3.3	ID	ID	ID	ID
	18:00	33.6	12.2	0.050	1.6	0.8	3.8	ID	ID	ID	ID
	19:00	38.2	16.1	0.082	1.5	1.1	6.0	ID	ID	ID	ID
	20:00	32.1	13.4	0.062	0.8	1.1	6.1	ID	ID	ID	ID
	21:00	30.5	12.2	0.052	0.4	0.9	7.7	ID	ID	ID	ID
	22:00	30.1	12.3	0.055	0.4	1.1	8.7	ID	ID	ID	ID
	23:00	30.9	12.2	0.032	0.0	0.9	9.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	0:00	32.3	12.9	0.037	ZS	1.0	9.0	ID	ID	ID	ID
Min		**24.8**	**8.8**	**0.006**	**0.0**	**0.5**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**38.2**	**16.1**	**0.096**	**4.0**	**1.2**	**9.1**	**ID**	**ID**	**ID**	**ID**
Average		**31.7**	**11.6**	**0.036**	**1.1**	**0.9**	**3.1**	**ID**	**ID**	**ID**	**ID**
24/04/2019	1:00	28.2	11.4	0.032	0.0	ZS	ZS	ID	ID	ID	ID
	2:00	11.8	5.5	0.003	-0.1	0.7	1.8	ID	ID	ID	ID
	3:00	10.6	4.8	0.022	1.0	0.9	3.9	ID	ID	ID	ID
	4:00	11.8	5.2	0.026	0.5	0.4	-0.2	ID	ID	ID	ID
	5:00	25.0	14.4	0.202	0.7	0.6	-0.3	ID	ID	ID	ID
	6:00	44.9	27.8	0.424	1.1	1.1	-0.4	ID	ID	ID	ID
	7:00	71.4	45.8	0.761	1.1	1.5	-0.4	ID	ID	ID	ID
	8:00	57.8	36.7	0.540	0.5	1.5	-0.5	ID	ID	ID	ID
	9:00	13.9	6.5	0.044	0.3	0.7	-0.6	ID	ID	ID	ID
	10:00	17.8	7.9	0.033	0.5	0.7	1.4	ID	ID	ID	ID
	11:00	21.9	7.8	0.020	0.2	0.5	3.1	ID	ID	ID	ID
	12:00	19.9	7.7	0.015	0.0	0.6	3.3	ID	ID	ID	ID
	13:00	17.7	7.3	0.025	0.1	0.7	3.9	ID	ID	ID	ID
	14:00	20.5	7.4	0.024	0.2	0.6	3.1	ID	ID	ID	ID
	15:00	21.1	7.4	0.024	0.1	0.7	4.8	ID	ID	ID	ID
	16:00	22.5	7.4	0.029	0.5	0.9	4.1	ID	ID	ID	ID
	17:00	17.3	6.2	0.031	0.5	0.6	3.4	ID	ID	ID	ID
	18:00	17.9	7.5	0.044	0.8	0.8	4.6	ID	ID	ID	ID
	19:00	19.4	8.2	0.056	1.3	1.0	5.3	ID	ID	ID	ID
	20:00	23.3	9.5	0.086	2.1	0.8	4.9	ID	ID	ID	ID
	21:00	24.0	9.6	0.104	2.7	1.1	2.1	ID	ID	ID	ID
	22:00	19.7	8.1	0.056	2.5	1.5	1.7	ID	ID	ID	ID
	23:00	15.5	6.3	0.044	1.0	ZS	ZS	ID	ID	ID	ID
	0:00	12.3	4.7	0.034	0.8	ZS	ZS	ID	ID	ID	ID
Min		**10.6**	**4.7**	**0.003**	**-0.1**	**0.4**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**71.4**	**45.8**	**0.761**	**2.7**	**1.5**	**5.3**	**ID**	**ID**	**ID**	**ID**
Average		**23.6**	**11.3**	**0.112**	**0.8**	**0.8**	**2.3**	**ID**	**ID**	**ID**	**ID**
25/04/2019	1:00	13.7	5.9	0.021	0.4	0.6	3.6	ID	ID	ID	ID
	2:00	19.4	8.1	0.023	ZS	0.6	2.2	ID	ID	ID	ID
	3:00	19.2	7.1	0.021	0.2	2.3	57.9	ID	ID	ID	ID
	4:00	9.1	4.2	0.016	0.2	2.5	71.8	ID	ID	ID	ID
	5:00	9.4	4.2	0.031	1.6	1.1	14.0	ID	ID	ID	ID
	6:00	14.3	6.4	0.035	1.6	0.9	3.4	ID	ID	ID	ID
	7:00	16.6	7.9	0.065	3.3	0.6	5.8	ID	ID	ID	ID
	8:00	14.6	6.5	0.038	1.4	0.8	0.4	ID	ID	ID	ID
	9:00	22.7	10.0	0.124	5.1	0.8	0.0	ID	ID	ID	ID
	10:00	18.1	7.9	0.059	3.2	0.7	0.2	ID	ID	ID	ID
	11:00	12.5	4.4	0.064	7.7	1.6	0.6	ID	ID	ID	ID
	12:00	7.8	3.3	0.052	4.6	2.3	2.4	ID	ID	ID	ID
	13:00	13.2	5.7	0.056	1.2	0.7	0.9	ID	ID	ID	ID
	14:00	18.3	7.8	0.030	0.3	0.8	2.6	ID	ID	ID	ID
	15:00	22.0	9.4	0.046	0.7	1.0	7.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	16:00	25.9	9.6	0.049	0.8	0.9	7.6	ID	ID	ID	ID
	17:00	31.4	11.4	0.048	0.8	1.0	6.2	ID	ID	ID	ID
	18:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	19:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	20:00	40.2	15.0	PO	PO	1.1	3.0	ID	ID	ID	ID
	21:00	44.2	18.4	0.278	1.4	1.0	3.7	ID	ID	ID	ID
	22:00	42.3	17.0	0.252	0.9	0.8	2.8	ID	ID	ID	ID
	23:00	45.9	18.2	0.233	0.8	0.9	2.4	ID	ID	ID	ID
	0:00	46.0	18.2	0.218	0.6	0.8	1.5	ID	ID	ID	ID
Min		**7.8**	**3.3**	**0.016**	**0.2**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**46.0**	**18.4**	**0.278**	**7.7**	**2.5**	**71.8**	**ID**	**ID**	**ID**	**ID**
Average		**23.0**	**9.4**	**0.084**	**1.8**	**1.1**	**9.1**	**ID**	**ID**	**ID**	**ID**
26/04/2019	1:00	38.8	15.8	0.193	ZS	0.7	0.7	ID	ID	ID	ID
	2:00	38.6	15.5	0.179	0.7	ZS	ZS	ID	ID	ID	ID
	3:00	37.4	14.7	0.170	0.8	0.6	0.5	ID	ID	ID	ID
	4:00	35.7	14.3	0.159	0.9	0.8	-0.1	ID	ID	ID	ID
	5:00	35.3	13.9	0.145	0.9	0.5	0.4	ID	ID	ID	ID
	6:00	37.0	14.2	0.157	2.2	0.6	0.2	ID	ID	ID	ID
	7:00	38.8	15.0	0.163	1.8	0.9	0.0	ID	ID	ID	ID
	8:00	43.5	16.0	0.172	1.0	0.7	0.0	ID	ID	ID	ID
	9:00	44.5	16.3	0.164	1.2	0.6	0.3	ID	ID	ID	ID
	10:00	45.5	16.6	0.170	1.1	0.7	0.6	ID	ID	ID	ID
	11:00	47.3	16.2	0.145	0.9	0.7	0.8	ID	ID	ID	ID
	12:00	44.9	15.2	0.126	0.7	0.7	1.3	ID	ID	ID	ID
	13:00	47.3	15.9	0.132	0.9	0.7	1.6	ID	ID	ID	ID
	14:00	47.6	18.2	0.123	1.0	1.0	2.7	ID	ID	ID	ID
	15:00	49.2	15.6	0.117	0.8	1.0	3.0	ID	ID	ID	ID
	16:00	42.1	13.9	0.108	0.8	0.7	4.4	ID	ID	ID	ID
	17:00	40.0	13.1	0.118	1.5	0.9	8.9	ID	ID	ID	ID
	18:00	38.0	13.0	0.140	2.8	1.0	8.9	ID	ID	ID	ID
	19:00	37.7	12.6	0.142	2.8	1.1	7.8	ID	ID	ID	ID
	20:00	33.9	11.9	0.142	3.0	0.9	6.6	ID	ID	ID	ID
	21:00	31.1	10.7	0.122	2.8	1.3	5.5	ID	ID	ID	ID
	22:00	27.7	9.4	0.105	1.9	0.8	6.3	ID	ID	ID	ID
	23:00	23.1	8.8	0.095	1.3	1.1	6.8	ID	ID	ID	ID
	0:00	23.5	8.7	0.086	ZS	0.9	5.9	ID	ID	ID	ID
Min		**23.1**	**8.7**	**0.086**	**0.7**	**0.5**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**49.2**	**18.2**	**0.193**	**3.0**	**1.3**	**8.9**	**ID**	**ID**	**ID**	**ID**
Average		**38.7**	**14.0**	**0.140**	**1.5**	**0.8**	**3.2**	**ID**	**ID**	**ID**	**ID**
27/04/2019	1:00	22.4	8.6	0.078	1.6	ZS	ZS	ID	ID	ID	ID
	2:00	21.9	9.0	0.071	1.7	0.9	7.2	ID	ID	ID	ID
	3:00	20.5	8.0	0.066	1.2	0.9	7.6	ID	ID	ID	ID
	4:00	21.5	7.8	0.070	1.6	0.8	6.8	ID	ID	ID	ID
	5:00	19.2	7.5	0.067	1.8	0.9	5.1	ID	ID	ID	ID
	6:00	19.9	7.4	0.069	1.8	0.8	2.5	ID	ID	ID	ID
	7:00	27.1	8.2	0.096	3.3	0.8	0.2	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	26.2	8.5	0.081	1.0	0.8	0.4	ID	ID	ID	ID
	9:00	25.0	8.5	0.075	0.9	0.9	2.3	ID	ID	ID	ID
	10:00	24.1	8.0	MM	0.4	0.9	4.9	ID	ID	ID	ID
	11:00	23.5	7.8	MM	0.6	0.9	3.6	ID	ID	ID	ID
	12:00	24.3	7.8	0.267	0.6	0.8	3.4	ID	ID	ID	ID
	13:00	25.8	7.8	0.248	0.5	0.9	4.2	ID	ID	ID	ID
	14:00	26.0	8.0	0.262	0.5	0.7	3.7	ID	ID	ID	ID
	15:00	30.9	9.0	0.270	0.6	0.8	3.3	ID	ID	ID	ID
	16:00	24.6	8.2	0.274	0.6	0.8	3.3	ID	ID	ID	ID
	17:00	25.6	8.8	0.280	0.8	1.0	3.7	ID	ID	ID	ID
	18:00	28.7	9.3	0.302	2.3	1.2	2.9	ID	ID	ID	ID
	19:00	30.4	10.8	0.339	5.7	2.3	3.1	ID	ID	ID	ID
	20:00	27.8	9.9	0.326	2.8	1.2	1.8	ID	ID	ID	ID
	21:00	26.3	9.6	0.321	3.1	1.0	0.8	ID	ID	ID	ID
	22:00	24.7	9.3	0.311	4.4	2.0	1.0	ID	ID	ID	ID
	23:00	24.1	9.0	0.313	2.6	1.1	1.3	ID	ID	ID	ID
	0:00	22.6	9.2	0.308	2.2	ZS	ZS	ID	ID	ID	ID
Min		**19.2**	**7.4**	**0.066**	**0.4**	**0.7**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**30.9**	**10.8**	**0.339**	**5.7**	**2.3**	**7.6**	**ID**	**ID**	**ID**	**ID**
Average		**24.7**	**8.6**	**0.204**	**1.8**	**1.0**	**3.3**	**ID**	**ID**	**ID**	**ID**
28/04/2019	1:00	21.4	8.2	0.286	1.9	0.8	0.7	ID	ID	ID	ID
	2:00	21.3	8.5	0.289	ZS	0.8	1.2	ID	ID	ID	ID
	3:00	22.4	8.9	0.292	2.3	1.0	0.5	ID	ID	ID	ID
	4:00	19.8	8.0	0.280	1.4	0.8	0.5	ID	ID	ID	ID
	5:00	22.3	8.5	0.278	1.0	0.9	0.7	ID	ID	ID	ID
	6:00	23.7	8.7	0.278	1.0	0.6	0.6	ID	ID	ID	ID
	7:00	24.1	9.0	0.291	1.1	0.5	1.2	ID	ID	ID	ID
	8:00	28.7	9.2	0.289	0.9	0.7	0.6	ID	ID	ID	ID
	9:00	26.8	9.4	0.283	0.7	0.7	0.6	ID	ID	ID	ID
	10:00	29.9	9.1	0.283	0.7	0.9	0.4	ID	ID	ID	ID
	11:00	30.4	9.1	0.264	0.6	0.9	0.4	ID	ID	ID	ID
	12:00	27.7	8.9	0.249	0.6	0.9	0.3	ID	ID	ID	ID
	13:00	25.9	8.6	0.247	0.6	0.9	0.2	ID	ID	ID	ID
	14:00	24.7	8.2	0.242	0.6	0.8	0.1	ID	ID	ID	ID
	15:00	24.0	8.3	0.254	0.6	0.8	-0.2	ID	ID	ID	ID
	16:00	25.6	9.2	0.275	0.7	0.7	-0.3	ID	ID	ID	ID
	17:00	23.2	9.0	0.288	0.9	0.7	-0.6	ID	ID	ID	ID
	18:00	26.5	9.6	0.294	2.1	1.3	-0.5	ID	ID	ID	ID
	19:00	26.4	10.4	0.319	3.7	1.7	-0.3	ID	ID	ID	ID
	20:00	27.3	10.9	0.342	5.7	2.5	0.5	ID	ID	ID	ID
	21:00	24.0	9.0	0.326	4.7	2.0	0.8	ID	ID	ID	ID
	22:00	22.6	9.4	0.332	2.6	0.9	0.9	ID	ID	ID	ID
	23:00	23.2	9.1	0.306	1.8	0.7	0.2	ID	ID	ID	ID
	0:00	21.9	8.4	0.292	ZS	ZS	ZS	ID	ID	ID	ID
Min		**19.8**	**8.0**	**0.242**	**0.6**	**0.5**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**30.4**	**10.9**	**0.342**	**5.7**	**2.5**	**1.2**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Average		**24.7**	**9.0**	**0.287**	**1.7**	**1.0**	**0.4**	**ID**	**ID**	**ID**	**ID**
29/04/2019	1:00	21.4	8.4	0.285	1.2	ZS	ZS	ID	ID	ID	ID
	2:00	22.7	9.1	0.274	1.0	0.4	1.0	ID	ID	ID	ID
	3:00	21.8	8.6	0.271	0.8	0.6	0.7	ID	ID	ID	ID
	4:00	22.2	8.6	0.275	1.5	0.6	0.7	ID	ID	ID	ID
	5:00	21.9	8.6	0.262	1.1	0.4	0.5	ID	ID	ID	ID
	6:00	22.1	9.0	0.269	1.4	0.8	0.9	ID	ID	ID	ID
	7:00	22.0	8.9	0.290	2.1	0.5	1.5	ID	ID	ID	ID
	8:00	25.0	9.1	0.377	1.4	0.7	1.1	ID	ID	ID	ID
	9:00	27.4	9.5	0.342	1.1	0.5	0.6	ID	ID	ID	ID
	10:00	26.3	10.2	0.290	0.7	0.7	0.2	ID	ID	ID	ID
	11:00	25.0	9.2	0.279	0.4	0.7	0.1	ID	ID	ID	ID
	12:00	25.6	9.4	0.300	0.7	0.7	0.1	ID	ID	ID	ID
	13:00	28.4	9.8	0.361	1.6	1.1	-0.9	ID	ID	ID	ID
	14:00	28.1	9.9	0.361	1.0	1.0	-0.5	ID	ID	ID	ID
	15:00	26.4	10.2	0.287	0.6	0.7	-0.5	ID	ID	ID	ID
	16:00	20.5	8.5	0.434	2.7	1.0	1.6	ID	ID	ID	ID
	17:00	26.3	10.0	0.419	2.7	1.1	0.1	ID	ID	ID	ID
	18:00	26.5	9.8	0.333	2.8	1.2	0.6	ID	ID	ID	ID
	19:00	28.3	10.4	0.363	4.9	1.4	1.0	ID	ID	ID	ID
	20:00	25.9	9.7	0.345	6.0	2.5	0.0	ID	ID	ID	ID
	21:00	23.2	8.7	0.322	4.3	2.1	0.2	ID	ID	ID	ID
	22:00	19.8	7.8	0.303	4.3	2.5	0.0	ID	ID	ID	ID
	23:00	20.3	7.3	0.288	1.3	1.0	0.7	ID	ID	ID	ID
	0:00	19.8	7.4	0.283	1.5	0.7	0.3	ID	ID	ID	ID
Min		**19.8**	**7.3**	**0.262**	**0.4**	**0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**28.4**	**10.4**	**0.434**	**6.0**	**2.5**	**1.6**	**ID**	**ID**	**ID**	**ID**
Average		**24.0**	**9.1**	**0.317**	**2.0**	**1.0**	**0.4**	**ID**	**ID**	**ID**	**ID**
30/04/2019	1:00	21.0	8.0	0.278	ZS	0.7	0.3	ID	ID	ID	ID
	2:00	20.4	8.1	0.266	0.8	ZS	ZS	ID	ID	ID	ID
	3:00	22.1	8.3	0.269	1.3	0.7	1.1	ID	ID	ID	ID
	4:00	21.9	8.5	0.275	1.8	0.8	1.3	ID	ID	ID	ID
	5:00	19.8	8.3	0.269	0.3	0.9	3.4	ID	ID	ID	ID
	6:00	9.6	3.9	0.275	0.6	0.6	2.3	ID	ID	ID	ID
	7:00	10.1	4.2	0.323	1.6	0.6	5.2	ID	ID	ID	ID
	8:00	14.8	5.8	0.408	2.6	0.8	0.6	ID	ID	ID	ID
	9:00	18.3	7.2	0.427	1.8	0.9	0.5	ID	ID	ID	ID
	10:00	24.1	8.1	0.292	0.8	0.7	0.2	ID	ID	ID	ID
	11:00	22.5	8.0	0.288	0.7	0.7	0.4	ID	ID	ID	ID
	12:00	20.8	7.0	0.295	0.9	0.7	1.0	ID	ID	ID	ID
	13:00	18.6	6.1	0.357	2.4	0.8	1.0	ID	ID	ID	ID
	14:00	19.8	5.9	0.369	1.8	1.0	1.3	ID	ID	ID	ID
	15:00	18.9	7.1	0.305	0.7	1.0	2.1	ID	ID	ID	ID
	16:00	19.2	6.0	0.349	1.9	0.9	2.3	ID	ID	ID	ID
	17:00	23.0	7.2	0.380	2.2	1.1	2.3	ID	ID	ID	ID
	18:00	22.9	7.8	0.324	2.2	0.8	1.1	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	19:00	25.9	10.0	0.358	5.2	1.5	1.2	ID	ID	ID	ID
	20:00	24.2	9.2	0.325	2.6	1.2	0.3	ID	ID	ID	ID
	21:00	28.7	10.2	0.322	4.4	2.1	0.0	ID	ID	ID	ID
	22:00	28.5	10.6	0.316	2.2	1.2	1.1	ID	ID	ID	ID
	23:00	27.2	11.0	0.318	ZS	1.4	0.5	ID	ID	ID	ID
	0:00	27.3	11.2	0.306	ZS	1.1	0.5	ID	ID	ID	ID
Min		**9.6**	**3.9**	**0.266**	**0.3**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**28.7**	**11.2**	**0.427**	**5.2**	**2.1**	**5.2**	**ID**	**ID**	**ID**	**ID**
Average		**21.2**	**7.8**	**0.321**	**1.9**	**1.0**	**1.3**	**ID**	**ID**	**ID**	**ID**
01/05/2019	1:00	26.1	10.6	0.296	1.5	ZS	ZS	ID	ID	ID	ID
	2:00	25.9	10.8	0.299	1.6	0.7	1.7	ID	ID	ID	ID
	3:00	24.6	10.4	0.296	0.6	0.7	2.2	ID	ID	ID	ID
	4:00	26.4	11.6	0.302	0.3	0.8	2.7	ID	ID	ID	ID
	5:00	29.7	12.3	0.301	0.5	0.7	2.3	ID	ID	ID	ID
	6:00	29.5	12.2	0.301	0.8	0.7	1.2	ID	ID	ID	ID
	7:00	30.6	12.9	0.327	1.2	0.6	2.2	ID	ID	ID	ID
	8:00	26.5	11.5	0.338	1.2	1.0	2.7	ID	ID	ID	ID
	9:00	27.1	10.9	0.321	0.9	0.9	11.6	ID	ID	ID	ID
	10:00	24.7	10.4	0.340	0.9	0.6	2.7	ID	ID	ID	ID
	11:00	25.1	10.4	0.324	0.7	0.8	3.0	ID	ID	ID	ID
	12:00	24.3	9.5	0.314	0.2	0.7	3.0	ID	ID	ID	ID
	13:00	20.5	8.0	0.311	0.6	1.0	3.4	ID	ID	ID	ID
	14:00	21.1	8.3	0.302	0.3	0.7	4.2	ID	ID	ID	ID
	15:00	24.8	9.9	0.322	0.9	1.0	4.6	ID	ID	ID	ID
	16:00	27.6	10.7	0.318	1.0	1.2	5.6	ID	ID	ID	ID
	17:00	31.3	12.0	0.321	0.9	1.0	5.2	ID	ID	ID	ID
	18:00	32.2	12.7	0.327	0.9	0.8	4.7	ID	ID	ID	ID
	19:00	29.4	11.5	0.334	1.1	1.0	4.4	ID	ID	ID	ID
	20:00	30.6	12.2	0.329	1.9	0.8	1.6	ID	ID	ID	ID
	21:00	29.3	11.9	0.320	1.2	0.9	1.1	ID	ID	ID	ID
	22:00	30.1	11.6	0.309	0.7	0.7	1.4	ID	ID	ID	ID
	23:00	30.4	12.1	0.299	0.6	ZS	ZS	ID	ID	ID	ID
	0:00	32.2	12.4	0.300	0.3	ZS	ZS	ID	ID	ID	ID
Min		**20.5**	**8.0**	**0.296**	**0.2**	**0.6**	**1.1**	**ID**	**ID**	**ID**	**ID**
Max		**32.2**	**12.9**	**0.340**	**1.9**	**1.2**	**11.6**	**ID**	**ID**	**ID**	**ID**
Average		**27.5**	**11.1**	**0.315**	**0.9**	**0.8**	**3.4**	**ID**	**ID**	**ID**	**ID**
02/05/2019	1:00	31.5	12.1	0.293	0.3	0.5	2.0	ID	ID	ID	ID
	2:00	32.9	12.7	0.291	ZS	0.6	1.3	ID	ID	ID	ID
	3:00	31.1	12.3	0.295	0.2	0.5	1.5	ID	ID	ID	ID
	4:00	35.3	13.6	0.287	0.0	0.5	2.0	ID	ID	ID	ID
	5:00	35.0	12.5	0.285	0.2	0.5	2.2	ID	ID	ID	ID
	6:00	34.4	12.6	0.291	0.5	0.6	2.3	ID	ID	ID	ID
	7:00	31.4	13.0	0.329	1.5	0.8	5.8	ID	ID	ID	ID
	8:00	38.2	14.1	0.445	2.6	0.6	1.2	ID	ID	ID	ID
	9:00	40.7	14.8	0.387	2.0	0.9	0.5	ID	ID	ID	ID
	10:00	41.4	14.9	0.316	1.1	0.8	1.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	11:00	43.2	14.9	0.315	0.8	1.0	2.9	ID	ID	ID	ID
	12:00	40.9	13.9	0.322	0.7	0.7	4.3	ID	ID	ID	ID
	13:00	35.1	12.6	0.430	1.7	1.0	7.9	ID	ID	ID	ID
	14:00	29.2	11.7	0.442	1.2	1.0	3.7	ID	ID	ID	ID
	15:00	21.5	9.5	0.336	0.3	0.7	7.6	ID	ID	ID	ID
	16:00	25.5	10.7	0.468	4.5	1.1	2.2	ID	ID	ID	ID
	17:00	30.1	12.5	0.583	5.8	1.5	3.5	ID	ID	ID	ID
	18:00	36.0	13.7	0.379	4.0	1.7	2.6	ID	ID	ID	ID
	19:00	35.1	12.9	0.347	4.3	1.9	1.3	ID	ID	ID	ID
	20:00	36.7	13.4	0.347	4.1	2.0	1.5	ID	ID	ID	ID
	21:00	35.7	13.5	0.349	1.9	1.3	2.4	ID	ID	ID	ID
	22:00	24.3	10.5	0.344	0.9	0.8	1.9	ID	ID	ID	ID
	23:00	24.0	10.9	0.332	0.7	0.8	0.8	ID	ID	ID	ID
	0:00	22.5	10.5	0.325	1.2	0.9	1.2	ID	ID	ID	ID
Min		**21.5**	**9.5**	**0.285**	**0.0**	**0.5**	**0.5**	**ID**	**ID**	**ID**	**ID**
Max		**43.2**	**14.9**	**0.583**	**5.8**	**2.0**	**7.9**	**ID**	**ID**	**ID**	**ID**
Average		**33.0**	**12.7**	**0.356**	**1.8**	**0.9**	**2.7**	**ID**	**ID**	**ID**	**ID**
03/05/2019	1:00	29.6	12.4	0.317	ZS	0.7	5.1	ID	ID	ID	ID
	2:00	35.0	14.3	0.311	0.6	ZS	ZS	ID	ID	ID	ID
	3:00	26.7	11.9	0.306	-0.1	0.4	2.9	ID	ID	ID	ID
	4:00	32.5	12.9	0.306	0.1	0.6	1.5	ID	ID	ID	ID
	5:00	33.3	12.7	0.309	0.2	0.5	2.4	ID	ID	ID	ID
	6:00	32.5	12.8	0.323	1.0	0.7	1.2	ID	ID	ID	ID
	7:00	37.5	14.6	0.361	1.8	0.6	1.0	ID	ID	ID	ID
	8:00	42.4	15.6	0.427	2.7	0.9	0.2	ID	ID	ID	ID
	9:00	46.3	15.5	0.422	1.6	0.8	0.1	ID	ID	ID	ID
	10:00	44.6	15.4	0.358	2.8	1.1	6.6	ID	ID	ID	ID
	11:00	40.3	14.8	0.343	1.1	1.0	6.1	ID	ID	ID	ID
	12:00	38.8	13.7	0.323	1.0	0.9	6.0	ID	ID	ID	ID
	13:00	44.7	14.2	0.383	0.6	1.1	7.0	ID	ID	ID	ID
	14:00	26.0	10.2	0.368	1.7	1.1	9.9	ID	ID	ID	ID
	15:00	27.7	11.1	0.354	1.2	1.1	5.3	ID	ID	ID	ID
	16:00	40.7	14.2	0.446	1.8	0.9	3.2	ID	ID	ID	ID
	17:00	40.7	14.7	0.467	3.2	1.2	3.2	ID	ID	ID	ID
	18:00	41.8	14.2	0.364	2.8	1.0	4.5	ID	ID	ID	ID
	19:00	40.9	14.4	0.361	2.6	0.9	5.1	ID	ID	ID	ID
	20:00	41.7	14.5	0.357	2.5	1.2	3.7	ID	ID	ID	ID
	21:00	39.8	14.1	0.351	1.7	1.0	2.3	ID	ID	ID	ID
	22:00	37.7	13.8	0.333	1.0	0.7	1.9	ID	ID	ID	ID
	23:00	40.2	14.0	0.332	0.6	0.7	2.6	ID	ID	ID	ID
	0:00	42.5	14.1	0.318	ZS	0.8	4.1	ID	ID	ID	ID
Min		**26.0**	**10.2**	**0.306**	**-0.1**	**0.4**	**0.1**	**ID**	**ID**	**ID**	**ID**
Max		**46.3**	**15.6**	**0.467**	**3.2**	**1.2**	**9.9**	**ID**	**ID**	**ID**	**ID**
Average		**37.7**	**13.8**	**0.356**	**1.5**	**0.9**	**3.7**	**ID**	**ID**	**ID**	**ID**
04/05/2019	1:00	37.7	13.5	0.313	0.3	ZS	ZS	ID	ID	ID	ID
	2:00	37.9	13.3	0.308	-0.1	0.9	4.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	3:00	37.2	13.2	0.309	0.0	0.8	3.9	ID	ID	ID	ID
	4:00	31.3	12.0	0.313	-0.1	0.7	4.2	ID	ID	ID	ID
	5:00	36.1	13.2	0.306	0.1	0.5	2.2	ID	ID	ID	ID
	6:00	38.4	13.4	0.315	0.6	0.6	1.7	ID	ID	ID	ID
	7:00	38.2	14.1	0.343	1.6	0.6	1.6	ID	ID	ID	ID
	8:00	32.0	12.5	0.366	1.4	0.7	1.2	ID	ID	ID	ID
	9:00	30.8	12.7	0.376	2.1	0.7	1.5	ID	ID	ID	ID
	10:00	32.5	12.5	0.333	0.7	0.8	1.5	ID	ID	ID	ID
	11:00	34.8	12.4	0.340	0.7	1.2	7.3	ID	ID	ID	ID
	12:00	35.6	11.8	0.343	0.6	0.9	8.3	ID	ID	ID	ID
	13:00	35.2	11.7	0.332	0.5	0.9	7.3	ID	ID	ID	ID
	14:00	26.5	10.1	0.349	1.0	1.2	9.0	ID	ID	ID	ID
	15:00	27.2	10.3	0.342	0.4	1.1	5.4	ID	ID	ID	ID
	16:00	29.6	11.1	0.337	0.5	0.8	5.8	ID	ID	ID	ID
	17:00	34.3	12.3	0.357	1.3	1.0	5.8	ID	ID	ID	ID
	18:00	35.0	12.8	0.373	2.0	1.1	5.9	ID	ID	ID	ID
	19:00	23.4	9.5	0.358	1.9	1.2	8.9	ID	ID	ID	ID
	20:00	22.5	9.2	0.349	1.6	1.3	11.0	ID	ID	ID	ID
	21:00	21.4	9.0	0.341	1.0	0.8	9.1	ID	ID	ID	ID
	22:00	19.4	7.9	0.371	4.5	1.8	11.7	ID	ID	ID	ID
	23:00	25.4	9.8	0.347	1.6	1.2	6.8	ID	ID	ID	ID
	0:00	28.3	10.2	0.330	0.8	ZS	ZS	ID	ID	ID	ID
Min		**19.4**	**7.9**	**0.306**	**-0.1**	**0.5**	**1.2**	**ID**	**ID**	**ID**	**ID**
Max		**38.4**	**14.1**	**0.376**	**4.5**	**1.8**	**11.7**	**ID**	**ID**	**ID**	**ID**
Average		**31.3**	**11.6**	**0.340**	**1.0**	**0.9**	**5.7**	**ID**	**ID**	**ID**	**ID**
05/05/2019	1:00	18.7	7.6	0.303	-0.3	0.8	7.8	ID	ID	ID	ID
	2:00	15.2	5.8	0.307	ZS	0.9	9.5	ID	ID	ID	ID
	3:00	17.8	6.5	0.303	0.0	0.9	10.6	ID	ID	ID	ID
	4:00	17.0	6.5	0.299	0.1	0.6	12.1	ID	ID	ID	ID
	5:00	23.5	8.8	0.300	0.0	0.7	11.0	ID	ID	ID	ID
	6:00	22.7	9.3	0.295	-0.4	0.5	10.5	ID	ID	ID	ID
	7:00	22.5	8.5	0.315	0.0	0.4	10.4	ID	ID	ID	ID
	8:00	26.2	9.5	0.332	0.2	0.6	7.0	ID	ID	ID	ID
	9:00	29.2	9.6	0.323	0.4	0.8	7.7	ID	ID	ID	ID
	10:00	18.3	6.7	0.312	0.0	0.7	9.5	ID	ID	ID	ID
	11:00	17.9	6.8	0.308	-0.3	0.5	9.3	ID	ID	ID	ID
	12:00	13.1	5.5	0.331	0.2	0.9	13.7	ID	ID	ID	ID
	13:00	21.8	7.4	0.317	-0.2	0.9	14.2	ID	ID	ID	ID
	14:00	19.4	6.7	0.317	-0.2	1.0	14.1	ID	ID	ID	ID
	15:00	20.1	7.2	0.323	0.1	0.8	11.4	ID	ID	ID	ID
	16:00	13.0	5.3	0.336	0.3	0.7	14.2	ID	ID	ID	ID
	17:00	14.7	5.8	0.341	0.3	0.9	13.4	ID	ID	ID	ID
	18:00	12.5	4.9	0.328	0.4	1.1	18.9	ID	ID	ID	ID
	19:00	12.0	4.8	0.391	3.6	1.8	17.2	ID	ID	ID	ID
	20:00	12.2	5.3	0.395	3.3	1.3	14.4	ID	ID	ID	ID
	21:00	17.2	7.1	0.386	5.9	2.5	12.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	22:00	20.2	7.5	0.319	0.0	3.0	69.6	ID	ID	ID	ID
	23:00	18.8	7.7	0.332	0.5	2.1	49.9	ID	ID	ID	ID
	0:00	20.6	7.9	0.316	ZS	ZS	ZS	ID	ID	ID	ID
Min		**12.0**	**4.8**	**0.295**	**-0.4**	**0.4**	**7.0**	**ID**	**ID**	**ID**	**ID**
Max		**29.2**	**9.6**	**0.395**	**5.9**	**3.0**	**69.6**	**ID**	**ID**	**ID**	**ID**
Average		**18.5**	**7.0**	**0.326**	**0.6**	**1.1**	**16.0**	**ID**	**ID**	**ID**	**ID**
06/05/2019	1:00	22.7	9.0	ZS	0.4	ZS	ZS	ID	ID	ID	ID
	2:00	31.1	11.5	0.313	0.0	0.9	5.9	ID	ID	ID	ID
	3:00	23.7	9.0	0.299	-0.4	0.8	8.8	ID	ID	ID	ID
	4:00	17.7	7.1	0.294	-0.4	1.8	38.4	ID	ID	ID	ID
	5:00	17.7	7.4	0.305	0.0	0.8	3.5	ID	ID	ID	ID
	6:00	17.8	7.4	0.323	0.9	1.2	9.1	ID	ID	ID	ID
	7:00	21.3	8.5	0.336	0.7	0.8	3.8	ID	ID	ID	ID
	7:00	20.5	8.6	0.332	0.4	0.8	2.7	ID	ID	ID	ID
	9:00	23.5	9.0	0.332	0.2	0.6	2.2	ID	ID	ID	ID
	10:00	26.2	9.4	0.321	-0.1	0.9	2.3	ID	ID	ID	ID
	11:00	18.4	7.2	0.320	-0.3	0.9	9.9	ID	ID	ID	ID
	12:00	13.4	5.6	0.320	-0.3	0.9	11.5	ID	ID	ID	ID
	13:00	15.9	6.2	0.317	-0.4	1.2	11.9	ID	ID	ID	ID
	14:00	15.1	6.0	0.323	-0.2	1.0	9.7	ID	ID	ID	ID
	15:00	16.6	6.6	0.325	-0.1	0.8	7.7	ID	ID	ID	ID
	16:00	15.9	6.4	0.330	-0.1	0.7	8.2	ID	ID	ID	ID
	17:00	17.0	6.3	0.335	0.0	0.8	10.1	ID	ID	ID	ID
	18:00	11.5	4.6	0.350	0.7	1.0	11.9	ID	ID	ID	ID
	19:00	19.6	9.5	0.388	1.8	1.2	15.1	ID	ID	ID	ID
	20:00	23.3	9.1	0.385	2.2	1.2	16.4	ID	ID	ID	ID
	21:00	19.9	7.7	0.385	1.7	1.0	13.5	ID	ID	ID	ID
	22:00	24.6	9.4	0.359	1.2	1.0	10.7	ID	ID	ID	ID
	23:00	31.9	10.9	ZS	0.6	1.0	10.6	ID	ID	ID	ID
	0:00	32.7	11.7	0.330	0.0	1.0	13.2	ID	ID	ID	ID
Min		**11.5**	**4.6**	**0.294**	**-0.4**	**0.6**	**2.2**	**ID**	**ID**	**ID**	**ID**
Max		**32.7**	**11.7**	**0.388**	**2.2**	**1.8**	**38.4**	**ID**	**ID**	**ID**	**ID**
Average		**20.7**	**8.1**	**0.333**	**0.4**	**1.0**	**10.3**	**ID**	**ID**	**ID**	**ID**
07/05/2019	1:00	37.2	12.5	0.319	ZS	0.7	4.4	ID	ID	ID	ID
	2:00	37.2	12.5	0.314	-0.1	ZS	ZS	ID	ID	ID	ID
	3:00	30.7	11.3	0.311	-0.4	0.6	8.2	ID	ID	ID	ID
	4:00	17.4	6.9	0.309	-0.6	0.9	18.4	ID	ID	ID	ID
	5:00	17.2	7.3	0.317	0.1	1.3	30.9	ID	ID	ID	ID
	6:00	19.2	7.1	0.321	0.5	0.7	5.9	ID	ID	ID	ID
	7:00	22.4	8.6	0.374	2.8	1.2	13.2	ID	ID	ID	ID
	8:00	20.3	8.0	0.406	1.2	0.9	9.0	ID	ID	ID	ID
	9:00	17.9	7.3	0.374	0.5	0.8	10.1	ID	ID	ID	ID
	10:00	20.4	8.2	0.349	0.7	0.7	6.8	ID	ID	ID	ID
	11:00	24.9	9.1	0.327	-0.1	0.9	8.8	ID	ID	ID	ID
	12:00	27.6	9.8	0.333	0.2	0.6	8.6	ID	ID	ID	ID
	13:00	27.4	9.2	0.492	0.8	0.9	8.9	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	14:00	30.0	10.1	0.441	0.6	0.9	6.9	ID	ID	ID	ID
	15:00	34.2	11.9	0.348	0.6	0.5	5.9	ID	ID	ID	ID
	16:00	37.0	12.7	0.440	1.1	0.6	5.4	ID	ID	ID	ID
	17:00	37.0	12.3	0.485	3.0	1.1	5.7	ID	ID	ID	ID
	18:00	38.7	13.1	0.397	2.6	1.0	5.8	ID	ID	ID	ID
	19:00	38.2	13.2	0.403	3.6	0.9	8.1	ID	ID	ID	ID
	20:00	35.0	13.0	0.383	2.5	1.0	7.3	ID	ID	ID	ID
	21:00	27.9	10.7	0.365	2.0	1.0	6.5	ID	ID	ID	ID
	22:00	36.7	13.6	0.359	1.5	0.8	6.5	ID	ID	ID	ID
	23:00	38.3	14.2	ZS	ZS	0.6	3.6	ID	ID	ID	ID
	0:00	35.1	13.5	0.335	ZS	0.5	8.0	ID	ID	ID	ID
Min		**17.2**	**6.9**	**0.309**	**-0.6**	**0.5**	**3.6**	**ID**	**ID**	**ID**	**ID**
Max		**38.7**	**14.2**	**0.492**	**3.6**	**1.3**	**30.9**	**ID**	**ID**	**ID**	**ID**
Average		**29.5**	**10.7**	**0.370**	**1.1**	**0.8**	**8.8**	**ID**	**ID**	**ID**	**ID**
08/05/2019	1:00	38.8	14.2	ZS	-0.2	ZS	ZS	ID	ID	ID	ID
	2:00	24.0	9.6	0.309	-0.3	0.5	5.0	ID	ID	ID	ID
	3:00	35.6	13.0	0.315	-0.3	0.3	5.7	ID	ID	ID	ID
	4:00	40.1	14.6	0.314	-0.2	0.7	6.3	ID	ID	ID	ID
	5:00	37.0	13.9	0.315	-0.1	0.3	7.9	ID	ID	ID	ID
	6:00	37.2	13.4	0.325	0.3	0.6	8.6	ID	ID	ID	ID
	7:00	38.4	14.0	0.343	0.9	0.6	6.3	ID	ID	ID	ID
	7:00	40.5	14.1	0.437	0.7	0.5	5.4	ID	ID	ID	ID
	9:00	40.9	13.9	0.435	1.2	0.6	7.5	ID	ID	ID	ID
	10:00	33.0	12.2	0.340	0.1	0.6	4.4	ID	ID	ID	ID
	11:00	29.0	10.7	0.341	-0.2	0.4	4.8	ID	ID	ID	ID
	12:00	25.3	9.5	0.348	0.0	0.6	9.7	ID	ID	ID	ID
	13:00	16.2	6.6	0.407	2.6	0.6	6.4	ID	ID	ID	ID
	14:00	15.0	6.3	0.421	1.9	0.7	7.6	ID	ID	ID	ID
	15:00	20.4	8.1	0.354	0.6	0.5	5.1	ID	ID	ID	ID
	16:00	27.3	10.3	0.509	1.8	0.7	10.5	ID	ID	ID	ID
	17:00	23.7	9.2	0.474	1.8	0.8	4.7	ID	ID	ID	ID
	18:00	29.3	11.6	0.395	2.1	0.7	5.6	ID	ID	ID	ID
	19:00	31.0	11.9	0.386	2.5	0.7	7.5	ID	ID	ID	ID
	20:00	32.2	12.2	0.395	2.5	0.8	5.4	ID	ID	ID	ID
	21:00	31.7	12.0	0.375	1.9	0.7	5.6	ID	ID	ID	ID
	22:00	31.5	11.5	0.360	1.6	0.5	5.5	ID	ID	ID	ID
	23:00	29.5	11.5	0.342	0.6	ZS	ZS	ID	ID	ID	ID
	0:00	30.1	11.9	0.348	1.1	ZS	ZS	ID	ID	ID	ID
Min		**15.0**	**6.3**	**0.309**	**-0.3**	**0.3**	**4.4**	**ID**	**ID**	**ID**	**ID**
Max		**40.9**	**14.6**	**0.509**	**2.6**	**0.8**	**10.5**	**ID**	**ID**	**ID**	**ID**
Average		**30.8**	**11.5**	**0.373**	**1.0**	**0.6**	**6.5**	**ID**	**ID**	**ID**	**ID**
09/05/2019	1:00	31.9	11.9	0.335	0.5	0.5	4.1	ID	ID	ID	ID
	2:00	30.2	11.9	0.331	ZS	0.6	3.2	ID	ID	ID	ID
	3:00	31.6	12.3	0.330	0.2	0.6	3.0	ID	ID	ID	ID
	4:00	31.6	12.3	0.331	0.4	0.3	2.1	ID	ID	ID	ID
	5:00	32.1	12.6	0.337	0.8	0.3	0.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	6:00	32.4	13.0	0.350	1.5	0.1	0.0	ID	ID	ID	ID
	7:00	33.0	13.1	0.388	2.3	0.5	0.3	ID	ID	ID	ID
	8:00	35.0	13.8	0.522	2.1	0.6	-0.4	ID	ID	ID	ID
	9:00	40.6	14.5	0.432	1.2	0.8	-0.2	ID	ID	ID	ID
	10:00	37.1	14.2	0.364	0.4	0.5	0.5	ID	ID	ID	ID
	11:00	37.3	13.8	0.360	0.4	0.5	0.3	ID	ID	ID	ID
	12:00	38.0	13.3	0.375	1.6	0.4	0.6	ID	ID	ID	ID
	13:00	42.2	13.5	0.444	2.7	0.4	0.7	ID	ID	ID	ID
	14:00	52.9	14.8	0.469	2.1	0.7	4.3	ID	ID	ID	ID
	15:00	43.9	15.6	0.411	0.7	0.7	5.5	ID	ID	ID	ID
	16:00	42.7	14.7	0.440	1.5	0.8	3.5	ID	ID	ID	ID
	17:00	54.5	15.8	0.502	2.4	0.8	4.3	ID	ID	ID	ID
	18:00	43.2	14.1	0.397	1.7	0.7	4.3	ID	ID	ID	ID
	19:00	44.8	15.6	0.402	2.0	0.5	5.4	ID	ID	ID	ID
	20:00	41.9	14.1	0.396	1.8	0.4	5.0	ID	ID	ID	ID
	21:00	41.4	14.0	0.408	1.9	0.5	4.5	ID	ID	ID	ID
	22:00	43.9	14.7	0.396	1.9	0.4	5.5	ID	ID	ID	ID
	23:00	26.9	11.1	0.415	2.9	0.8	14.8	ID	ID	ID	ID
	0:00	24.0	10.2	0.353	1.8	0.9	10.4	ID	ID	ID	ID
Min		**24.0**	**10.2**	**0.330**	**0.2**	**0.1**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**54.5**	**15.8**	**0.522**	**2.9**	**0.9**	**14.8**	**ID**	**ID**	**ID**	**ID**
Average		**38.0**	**13.5**	**0.395**	**1.5**	**0.6**	**3.4**	**ID**	**ID**	**ID**	**ID**
10/05/2019	1:00	23.9	9.1	0.338	ZS	1.0	22.7	ID	ID	ID	ID
	2:00	21.9	7.9	0.338	-0.1	ZS	ZS	ID	ID	ID	ID
	3:00	18.3	6.3	0.327	-0.4	0.1	7.5	ID	ID	ID	ID
	4:00	22.3	7.2	0.331	-0.3	0.2	2.8	ID	ID	ID	ID
	5:00	20.3	6.1	0.336	-0.2	0.3	1.9	ID	ID	ID	ID
	6:00	15.8	4.7	0.341	-0.2	0.1	0.7	ID	ID	ID	ID
	7:00	20.8	7.6	0.341	-0.2	0.1	-0.3	ID	ID	ID	ID
	7:00	17.7	6.8	0.371	-0.3	0.1	1.7	ID	ID	ID	ID
	9:00	20.6	8.0	0.502	2.1	0.4	0.0	ID	ID	ID	ID
	10:00	44.1	16.6	0.371	0.4	0.1	0.0	ID	ID	ID	ID
	11:00	44.8	17.0	0.373	0.4	0.3	0.7	ID	ID	ID	ID
	12:00	44.9	16.1	0.376	0.5	0.2	1.5	ID	ID	ID	ID
	13:00	49.4	18.1	0.450	1.2	0.4	1.7	ID	ID	ID	ID
	14:00	50.5	17.7	0.485	1.5	0.8	1.3	ID	ID	ID	ID
	15:00	44.5	17.0	0.384	0.8	0.7	7.7	ID	ID	ID	ID
	16:00	51.0	18.7	0.522	1.7	0.7	7.7	ID	ID	ID	ID
	17:00	53.8	18.4	0.556	2.2	0.8	5.7	ID	ID	ID	ID
	18:00	52.7	19.3	0.438	2.9	0.9	6.9	ID	ID	ID	ID
	19:00	51.2	18.4	0.436	3.2	1.0	6.7	ID	ID	ID	ID
	20:00	47.2	18.3	0.420	2.1	0.9	7.7	ID	ID	ID	ID
	21:00	48.1	18.2	0.409	1.4	0.8	6.7	ID	ID	ID	ID
	22:00	47.6	17.8	0.413	1.6	0.7	4.7	ID	ID	ID	ID
	23:00	42.9	16.6	0.394	1.1	0.7	5.0	ID	ID	ID	ID
	0:00	41.4	15.8	0.377	ZS	0.8	6.8	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Min		**15.8**	**4.7**	**0.327**	**-0.4**	**0.1**	**-0.3**	**ID**	**ID**	**ID**	**ID**
Max		**53.8**	**19.3**	**0.556**	**3.2**	**1.0**	**22.7**	**ID**	**ID**	**ID**	**ID**
Average		**37.3**	**13.7**	**0.401**	**1.0**	**0.5**	**4.7**	**ID**	**ID**	**ID**	**ID**
11/05/2019	1:00	39.1	15.4	0.378	0.7	ZS	ZS	ID	ID	ID	ID
	2:00	41.5	15.5	0.376	0.4	0.7	6.6	ID	ID	ID	ID
	3:00	39.1	15.0	0.380	0.4	0.5	3.1	ID	ID	ID	ID
	4:00	39.9	15.3	0.379	0.2	0.5	4.3	ID	ID	ID	ID
	5:00	39.9	15.0	0.377	0.2	0.5	2.3	ID	ID	ID	ID
	6:00	37.9	14.9	0.385	0.9	0.5	2.4	ID	ID	ID	ID
	7:00	31.6	13.8	0.414	1.7	0.6	2.4	ID	ID	ID	ID
	8:00	35.8	14.6	0.407	1.4	0.5	0.7	ID	ID	ID	ID
	9:00	40.5	14.8	0.382	0.4	0.6	3.0	ID	ID	ID	ID
	10:00	40.8	14.3	0.376	0.3	0.4	5.5	ID	ID	ID	ID
	11:00	45.2	14.5	0.369	0.2	0.6	6.4	ID	ID	ID	ID
	12:00	43.0	14.3	0.363	0.2	0.7	6.4	ID	ID	ID	ID
	13:00	44.4	14.2	0.364	0.2	0.7	6.1	ID	ID	ID	ID
	14:00	44.7	14.4	0.374	0.5	0.7	5.7	ID	ID	ID	ID
	15:00	46.2	16.6	0.394	1.0	0.6	5.5	ID	ID	ID	ID
	16:00	44.6	14.4	0.376	0.4	0.7	4.2	ID	ID	ID	ID
	17:00	45.4	14.9	0.416	1.6	0.7	3.3	ID	ID	ID	ID
	18:00	46.3	15.9	0.421	3.8	1.0	3.7	ID	ID	ID	ID
	19:00	50.7	16.8	0.416	4.3	1.2	2.6	ID	ID	ID	ID
	20:00	46.1	15.7	0.425	3.6	1.1	3.0	ID	ID	ID	ID
	21:00	46.1	14.7	0.402	2.7	0.9	4.3	ID	ID	ID	ID
	22:00	47.9	15.1	0.392	2.9	0.9	3.5	ID	ID	ID	ID
	23:00	44.7	14.5	0.382	1.4	0.4	5.0	ID	ID	ID	ID
	0:00	38.5	13.3	0.360	0.7	ZS	ZS	ID	ID	ID	ID
Min		**31.6**	**13.3**	**0.360**	**0.2**	**0.4**	**0.7**	**ID**	**ID**	**ID**	**ID**
Max		**50.7**	**16.8**	**0.425**	**4.3**	**1.2**	**6.6**	**ID**	**ID**	**ID**	**ID**
Average		**42.5**	**14.9**	**0.388**	**1.3**	**0.7**	**4.1**	**ID**	**ID**	**ID**	**ID**
12/05/2019	1:00	34.3	12.4	0.348	0.4	0.2	8.1	ID	ID	ID	ID
	2:00	33.1	12.3	0.339	ZS	0.5	5.8	ID	ID	ID	ID
	3:00	32.5	11.8	0.342	0.5	0.3	3.0	ID	ID	ID	ID
	4:00	30.0	11.6	0.340	0.3	0.3	2.3	ID	ID	ID	ID
	5:00	28.2	11.0	0.347	0.7	0.5	0.7	ID	ID	ID	ID
	6:00	29.5	11.8	0.348	0.4	0.5	1.5	ID	ID	ID	ID
	7:00	33.5	12.7	0.358	0.5	0.7	1.1	ID	ID	ID	ID
	7:00	33.6	13.1	0.375	0.4	0.5	0.4	ID	ID	ID	ID
	9:00	35.4	13.2	0.374	0.2	0.5	3.6	ID	ID	ID	ID
	10:00	38.6	13.5	0.378	0.2	0.5	4.6	ID	ID	ID	ID
	11:00	35.2	12.9	0.373	0.4	0.5	3.9	ID	ID	ID	ID
	12:00	34.7	12.4	0.374	0.5	0.9	6.6	ID	ID	ID	ID
	13:00	34.7	11.9	0.364	0.1	0.7	7.5	ID	ID	ID	ID
	14:00	32.4	11.6	0.363	0.0	0.6	5.7	ID	ID	ID	ID
	15:00	32.8	12.1	0.364	0.1	0.8	5.8	ID	ID	ID	ID
	16:00	29.8	10.9	0.363	0.1	0.8	5.3	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	17:00	30.9	11.4	0.369	0.4	0.9	3.0	ID	ID	ID	ID
	18:00	33.2	12.3	0.403	1.1	0.8	2.0	ID	ID	ID	ID
	19:00	37.6	13.9	0.403	1.8	0.8	1.4	ID	ID	ID	ID
	20:00	36.3	13.9	0.419	2.0	0.8	1.2	ID	ID	ID	ID
	21:00	36.0	13.4	0.393	1.4	0.8	0.9	ID	ID	ID	ID
	22:00	34.4	12.6	0.388	1.2	0.8	0.6	ID	ID	ID	ID
	23:00	35.9	13.1	0.383	1.0	0.8	0.8	ID	ID	ID	ID
	0:00	33.1	12.8	0.370	ZS	0.7	0.8	ID	ID	ID	ID
Min		**28.2**	**10.9**	**0.339**	**0.0**	**0.2**	**0.4**	**ID**	**ID**	**ID**	**ID**
Max		**38.6**	**13.9**	**0.419**	**2.0**	**0.9**	**8.1**	**ID**	**ID**	**ID**	**ID**
Average		**33.6**	**12.4**	**0.370**	**0.6**	**0.6**	**3.2**	**ID**	**ID**	**ID**	**ID**
13/05/2019	1:00	34.8	13.0	0.371	0.7	ZS	ZS	ID	ID	ID	ID
	2:00	26.8	11.1	0.353	0.0	0.5	2.7	ID	ID	ID	ID
	3:00	25.1	10.6	0.356	0.5	0.8	2.3	ID	ID	ID	ID
	4:00	25.5	10.1	0.357	0.8	0.6	2.1	ID	ID	ID	ID
	5:00	29.7	12.0	0.360	0.9	0.7	0.8	ID	ID	ID	ID
	6:00	31.5	12.5	0.364	1.3	0.8	0.7	ID	ID	ID	ID
	7:00	35.3	13.0	0.419	2.4	0.9	0.7	ID	ID	ID	ID
	8:00	41.4	13.2	0.482	3.3	0.9	0.8	ID	ID	ID	ID
	9:00	42.2	13.4	0.453	1.6	0.8	0.5	ID	ID	ID	ID
	10:00	37.4	13.5	0.383	1.0	0.7	0.2	ID	ID	ID	ID
	11:00	36.9	13.3	0.375	0.8	0.6	0.7	ID	ID	ID	ID
	12:00	33.8	12.8	0.367	0.6	0.4	0.3	ID	ID	ID	ID
	13:00	36.3	12.7	0.443	2.6	0.5	0.5	ID	ID	ID	ID
	14:00	36.1	12.1	0.413	1.9	0.6	0.6	ID	ID	ID	ID
	15:00	37.2	12.6	0.380	0.7	0.8	1.4	ID	ID	ID	ID
	16:00	40.1	12.4	0.466	2.2	1.0	1.6	ID	ID	ID	ID
	17:00	49.4	13.3	0.516	2.9	1.1	1.8	ID	ID	ID	ID
	18:00	44.5	13.7	0.421	3.1	1.0	2.4	ID	ID	ID	ID
	19:00	48.3	18.6	0.461	4.1	1.1	1.4	ID	ID	ID	ID
	20:00	41.3	14.9	0.435	4.2	1.3	0.5	ID	ID	ID	ID
	21:00	36.0	13.1	0.404	3.9	1.8	0.6	ID	ID	ID	ID
	22:00	34.5	13.1	0.385	1.7	0.9	0.9	ID	ID	ID	ID
	23:00	33.8	12.9	0.372	1.1	0.9	1.0	ID	ID	ID	ID
	0:00	32.1	12.2	0.354	0.2	0.7	1.2	ID	ID	ID	ID
Min		**25.1**	**10.1**	**0.353**	**0.0**	**0.4**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**49.4**	**18.6**	**0.516**	**4.2**	**1.8**	**2.7**	**ID**	**ID**	**ID**	**ID**
Average		**36.3**	**12.9**	**0.404**	**1.8**	**0.8**	**1.1**	**ID**	**ID**	**ID**	**ID**
14/05/2019	1:00	30.8	12.0	0.350	ZS	ZS	ZS	ID	ID	ID	ID
	2:00	28.2	11.3	0.351	0.2	ZS	ZS	ID	ID	ID	ID
	3:00	29.4	11.8	0.348	0.1	0.7	3.7	ID	ID	ID	ID
	4:00	28.2	11.4	0.345	-0.1	0.6	4.5	ID	ID	ID	ID
	5:00	28.7	11.2	0.343	-0.1	0.7	5.6	ID	ID	ID	ID
	6:00	31.4	12.1	0.369	1.0	0.8	5.6	ID	ID	ID	ID
	7:00	34.6	13.0	0.402	2.1	0.8	3.9	ID	ID	ID	ID
	7:00	38.7	13.8	0.503	1.7	0.9	3.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	9:00	41.5	12.7	0.468	1.4	1.0	4.3	ID	ID	ID	ID
	10:00	34.8	12.5	0.375	0.6	0.8	4.8	ID	ID	ID	ID
	11:00	35.0	12.2	0.370	0.4	0.8	4.8	ID	ID	ID	ID
	12:00	32.9	12.1	0.369	0.5	0.7	4.7	ID	ID	ID	ID
	13:00	34.6	11.1	0.487	2.3	0.9	3.2	ID	ID	ID	ID
	14:00	36.3	11.0	0.452	0.7	1.2	5.3	ID	ID	ID	ID
	15:00	32.7	10.7	0.366	0.5	1.0	6.1	ID	ID	ID	ID
	16:00	36.3	11.7	0.546	1.7	1.1	5.3	ID	ID	ID	ID
	17:00	40.8	11.8	0.518	2.0	1.1	5.6	ID	ID	ID	ID
	18:00	36.5	12.4	0.463	2.4	1.0	4.6	ID	ID	ID	ID
	19:00	33.9	11.6	0.394	3.9	1.6	6.1	ID	ID	ID	ID
	20:00	33.2	13.3	0.405	4.1	2.1	7.1	ID	ID	ID	ID
	21:00	32.5	11.6	0.396	2.8	1.4	6.4	ID	ID	ID	ID
	22:00	33.2	11.9	0.390	1.7	0.8	5.6	ID	ID	ID	ID
	23:00	32.8	12.0	0.383	1.6	1.0	2.7	ID	ID	ID	ID
	0:00	31.5	11.7	0.358	ZS	0.9	1.6	ID	ID	ID	ID
Min		**28.2**	**10.7**	**0.343**	**-0.1**	**0.6**	**1.6**	**ID**	**ID**	**ID**	**ID**
Max		**41.5**	**13.8**	**0.546**	**4.1**	**2.1**	**7.1**	**ID**	**ID**	**ID**	**ID**
Average		**33.7**	**12.0**	**0.406**	**1.4**	**1.0**	**4.8**	**ID**	**ID**	**ID**	**ID**
15/05/2019	1:00	29.7	11.2	ZS	1.0	ZS	ZS	ID	ID	ID	ID
	2:00	28.9	10.8	0.341	0.7	0.7	0.6	ID	ID	ID	ID
	3:00	29.8	10.8	0.349	0.9	0.7	0.1	ID	ID	ID	ID
	4:00	26.1	10.6	0.353	0.9	0.8	0.1	ID	ID	ID	ID
	5:00	28.7	10.9	0.354	1.5	0.9	0.2	ID	ID	ID	ID
	6:00	32.4	12.2	0.377	2.9	0.7	0.3	ID	ID	ID	ID
	7:00	31.8	12.3	0.425	3.2	1.1	0.4	ID	ID	ID	ID
	8:00	38.6	13.0	0.492	3.6	1.0	3.3	ID	ID	ID	ID
	9:00	35.9	11.4	0.473	1.9	1.0	6.7	ID	ID	ID	ID
	10:00	32.3	10.9	0.379	0.6	0.8	6.3	ID	ID	ID	ID
	11:00	30.6	10.9	0.386	0.8	1.0	4.2	ID	ID	ID	ID
	12:00	27.4	11.7	0.415	1.5	1.2	15.4	ID	ID	ID	ID
	13:00	34.3	12.4	0.482	3.9	1.4	9.0	ID	ID	ID	ID
	14:00	35.4	12.4	0.477	1.8	1.3	8.3	ID	ID	ID	ID
	15:00	32.8	12.0	0.407	0.7	1.2	10.1	ID	ID	ID	ID
	16:00	36.5	12.2	0.501	1.4	1.2	9.2	ID	ID	ID	ID
	17:00	40.2	13.3	0.518	2.3	1.1	5.7	ID	ID	ID	ID
	18:00	36.9	12.7	0.426	2.0	1.1	7.5	ID	ID	ID	ID
	19:00	37.9	13.3	0.413	2.8	1.2	8.9	ID	ID	ID	ID
	20:00	36.1	13.0	0.404	3.5	1.8	7.8	ID	ID	ID	ID
	21:00	35.0	12.5	0.405	3.4	1.7	4.7	ID	ID	ID	ID
	22:00	33.1	12.7	0.404	4.1	1.7	5.2	ID	ID	ID	ID
	23:00	32.4	12.7	0.385	2.2	ZS	ZS	ID	ID	ID	ID
	0:00	33.2	12.9	0.377	0.9	ZS	ZS	ID	ID	ID	ID
Min		**26.1**	**10.6**	**0.341**	**0.6**	**0.7**	**0.1**	**ID**	**ID**	**ID**	**ID**
Max		**40.2**	**13.3**	**0.518**	**4.1**	**1.8**	**15.4**	**ID**	**ID**	**ID**	**ID**
Average		**33.2**	**12.0**	**0.415**	**2.0**	**1.1**	**5.4**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
16/05/2019	1:00	31.0	11.6	0.361	0.5	0.9	-0.2	ID	ID	ID	ID
	2:00	24.6	10.2	0.367	ZS	0.7	0.4	ID	ID	ID	ID
	3:00	25.7	10.4	0.355	0.4	0.6	0.0	ID	ID	ID	ID
	4:00	24.9	9.7	0.344	0.0	0.7	1.5	ID	ID	ID	ID
	5:00	23.9	9.3	0.359	1.1	0.7	3.0	ID	ID	ID	ID
	6:00	25.0	10.0	0.379	2.7	0.8	0.7	ID	ID	ID	ID
	7:00	26.1	9.9	0.464	2.5	1.0	0.5	ID	ID	ID	ID
	7:00	26.1	10.3	0.524	4.0	1.0	0.3	ID	ID	ID	ID
	9:00	22.6	10.0	0.580	4.4	1.4	8.2	ID	ID	ID	ID
	10:00	26.5	9.8	0.370	0.5	1.2	9.9	ID	ID	ID	ID
	11:00	27.2	9.9	0.365	0.4	1.0	7.9	ID	ID	ID	ID
	12:00	27.8	10.1	0.369	0.8	1.0	8.7	ID	ID	ID	ID
	13:00	32.5	10.1	0.456	2.4	1.4	11.4	ID	ID	ID	ID
	14:00	29.5	9.7	0.474	0.2	1.4	9.2	ID	ID	ID	ID
	15:00	26.9	9.6	0.375	0.4	1.1	10.6	ID	ID	ID	ID
	16:00	31.6	12.0	0.450	0.5	1.2	8.7	ID	ID	ID	ID
	17:00	40.2	13.7	0.504	1.6	1.3	7.2	ID	ID	ID	ID
	18:00	33.9	13.8	0.447	2.1	1.3	6.5	ID	ID	ID	ID
	19:00	28.9	11.6	0.438	3.4	2.1	35.2	ID	ID	ID	ID
	20:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	21:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	22:00	30.2	11.5	PO	PO	PO	PO	ID	ID	ID	ID
	23:00	28.8	10.7	0.600	2.1	0.9	1.2	ID	ID	ID	ID
	0:00	27.5	10.2	0.541	1.0	0.8	1.4	ID	ID	ID	ID
Min		**22.6**	**9.3**	**0.344**	**0.0**	**0.6**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**40.2**	**13.8**	**0.600**	**4.4**	**2.1**	**35.2**	**ID**	**ID**	**ID**	**ID**
Average		**28.2**	**10.6**	**0.434**	**1.6**	**1.1**	**6.3**	**ID**	**ID**	**ID**	**ID**
17/05/2019	1:00	25.8	9.3	0.518	0.1	0.9	4.0	ID	ID	ID	ID
	2:00	24.5	9.5	0.509	0.0	0.9	11.0	ID	ID	ID	ID
	3:00	25.9	9.7	0.493	0.0	1.0	9.9	ID	ID	ID	ID
	4:00	24.9	9.5	0.481	0.0	0.8	7.8	ID	ID	ID	ID
	5:00	26.2	10.0	0.480	0.2	0.9	6.7	ID	ID	ID	ID
	6:00	27.7	10.5	0.496	1.0	0.8	6.8	ID	ID	ID	ID
	7:00	27.4	10.8	0.523	2.1	0.9	5.0	ID	ID	ID	ID
	8:00	30.0	12.2	0.589	2.7	1.3	11.9	ID	ID	ID	ID
	9:00	31.8	12.5	0.552	0.9	1.3	5.7	ID	ID	ID	ID
	10:00	33.6	12.8	0.473	0.1	0.9	8.5	ID	ID	ID	ID
	11:00	35.8	12.7	0.479	0.3	1.0	8.4	ID	ID	ID	ID
	12:00	38.6	13.6	0.477	1.0	0.9	4.5	ID	ID	ID	ID
	13:00	41.3	13.5	0.510	3.1	1.1	4.3	ID	ID	ID	ID
	14:00	42.3	13.5	0.537	1.8	1.2	5.1	ID	ID	ID	ID
	15:00	39.4	13.1	0.445	0.3	1.0	5.8	ID	ID	ID	ID
	16:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	17:00	42.7	12.9	0.715	1.9	1.3	5.1	ID	ID	ID	ID
	18:00	36.8	12.7	0.585	1.3	0.9	3.4	ID	ID	ID	ID
	19:00	36.9	13.4	0.584	2.2	1.0	2.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	20:00	36.5	12.8	0.581	2.0	0.9	2.6	ID	ID	ID	ID
	21:00	33.7	12.2	0.570	2.0	0.9	1.6	ID	ID	ID	ID
	22:00	33.5	12.0	0.555	2.0	0.8	1.1	ID	ID	ID	ID
	23:00	35.8	13.2	0.537	1.8	0.8	0.6	ID	ID	ID	ID
	0:00	38.4	12.8	0.529	1.7	0.9	0.3	ID	ID	ID	ID
Min		**24.5**	**9.3**	**0.445**	**0.0**	**0.8**	**0.3**	**ID**	**ID**	**ID**	**ID**
Max		**42.7**	**13.6**	**0.715**	**3.1**	**1.3**	**11.9**	**ID**	**ID**	**ID**	**ID**
Average		**33.5**	**12.0**	**0.531**	**1.3**	**1.0**	**5.3**	**ID**	**ID**	**ID**	**ID**
18/05/2019	1:00	35.5	11.7	0.523	2.2	0.7	0.5	ID	ID	ID	ID
	2:00	33.8	11.8	0.487	1.0	0.8	0.2	ID	ID	ID	ID
	3:00	34.7	12.6	0.476	0.4	0.7	0.2	ID	ID	ID	ID
	4:00	32.1	11.8	0.471	0.7	0.7	0.4	ID	ID	ID	ID
	5:00	32.7	11.3	0.466	1.1	0.7	0.9	ID	ID	ID	ID
	6:00	28.0	10.3	0.462	0.9	0.7	0.9	ID	ID	ID	ID
	7:00	29.9	10.5	0.488	0.7	0.7	6.2	ID	ID	ID	ID
	7:00	27.6	10.3	0.494	0.4	1.1	1.1	ID	ID	ID	ID
	9:00	27.9	10.3	0.473	-0.1	0.8	2.3	ID	ID	ID	ID
	10:00	27.7	9.8	0.472	0.0	0.9	3.0	ID	ID	ID	ID
	11:00	25.4	9.0	0.477	0.2	0.8	3.7	ID	ID	ID	ID
	12:00	23.9	8.1	0.467	0.1	0.8	2.7	ID	ID	ID	ID
	13:00	23.4	8.1	0.476	0.5	0.8	1.1	ID	ID	ID	ID
	14:00	24.9	8.1	0.475	0.3	0.8	1.7	ID	ID	ID	ID
	15:00	23.7	8.0	0.469	0.1	0.9	2.7	ID	ID	ID	ID
	16:00	22.5	8.1	0.464	0.1	0.9	2.8	ID	ID	ID	ID
	17:00	24.5	8.3	0.461	0.2	0.8	2.6	ID	ID	ID	ID
	18:00	25.6	9.3	0.471	1.0	0.5	2.1	ID	ID	ID	ID
	19:00	33.2	11.5	0.524	2.7	0.7	0.7	ID	ID	ID	ID
	20:00	39.7	14.5	0.540	3.3	0.9	0.1	ID	ID	ID	ID
	21:00	34.5	12.3	0.503	1.9	0.9	0.8	ID	ID	ID	ID
	22:00	29.1	10.3	0.477	1.7	0.7	1.1	ID	ID	ID	ID
	23:00	31.0	9.9	0.476	1.5	0.9	0.6	ID	ID	ID	ID
	0:00	31.0	10.5	0.465	1.1	0.7	0.0	ID	ID	ID	ID
Min		**22.5**	**8.0**	**0.461**	**-0.1**	**0.5**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**39.7**	**14.5**	**0.540**	**3.3**	**1.1**	**6.2**	**ID**	**ID**	**ID**	**ID**
Average		**29.3**	**10.3**	**0.482**	**0.9**	**0.8**	**1.6**	**ID**	**ID**	**ID**	**ID**
19/05/2019	1:00	29.1	10.0	0.444	0.4	0.7	0.9	ID	ID	ID	ID
	2:00	25.2	8.9	0.439	0.2	0.8	1.1	ID	ID	ID	ID
	3:00	24.2	8.7	0.435	0.1	0.8	1.1	ID	ID	ID	ID
	4:00	26.5	9.0	0.437	0.4	0.5	1.7	ID	ID	ID	ID
	5:00	26.5	9.2	0.430	0.6	0.6	2.1	ID	ID	ID	ID
	6:00	31.5	9.9	UM	1.8	0.8	1.6	ID	ID	ID	ID
	7:00	32.8	11.6	0.603	2.3	1.1	-0.1	ID	ID	ID	ID
	8:00	27.5	10.8	0.577	0.9	0.8	-0.4	ID	ID	ID	ID
	9:00	30.1	11.4	0.574	0.9	0.6	-0.6	ID	ID	ID	ID
	10:00	33.8	11.2	0.546	0.6	0.8	-0.3	ID	ID	ID	ID
	11:00	35.2	11.7	0.541	0.4	0.8	1.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	12:00	34.0	11.4	0.522	0.4	0.8	1.1	ID	ID	ID	ID
	13:00	33.0	11.1	0.523	0.1	0.7	1.1	ID	ID	ID	ID
	14:00	31.3	10.8	0.536	0.1	0.8	2.3	ID	ID	ID	ID
	15:00	32.3	11.2	0.519	0.3	0.6	1.1	ID	ID	ID	ID
	16:00	34.2	11.8	0.520	0.3	0.5	1.2	ID	ID	ID	ID
	17:00	36.1	12.5	0.525	0.4	0.7	1.9	ID	ID	ID	ID
	18:00	35.3	12.8	0.540	1.1	0.8	3.5	ID	ID	ID	ID
	19:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	20:00	33.3	13.0	0.656	2.1	1.0	0.5	ID	ID	ID	ID
	21:00	33.0	12.0	0.614	1.9	0.9	2.3	ID	ID	ID	ID
	22:00	36.4	12.5	0.617	4.1	1.4	1.5	ID	ID	ID	ID
	23:00	33.4	12.3	0.594	2.7	1.2	0.2	ID	ID	ID	ID
	0:00	33.7	12.0	0.572	1.8	0.7	0.2	ID	ID	ID	ID
Min		**24.2**	**8.7**	**0.430**	**0.1**	**0.5**	**-0.6**	**ID**	**ID**	**ID**	**ID**
Max		**36.4**	**13.0**	**0.656**	**4.1**	**1.4**	**3.5**	**ID**	**ID**	**ID**	**ID**
Average		**31.7**	**11.1**	**0.535**	**1.0**	**0.8**	**1.1**	**ID**	**ID**	**ID**	**ID**
20/05/2019	1:00	26.5	10.2	0.545	0.5	1.2	12.6	ID	ID	ID	ID
	2:00	19.3	8.1	0.535	0.1	1.6	23.6	ID	ID	ID	ID
	3:00	18.4	8.1	0.533	0.4	1.8	37.4	ID	ID	ID	ID
	4:00	13.2	5.6	0.544	0.9	1.0	7.1	ID	ID	ID	ID
	5:00	11.3	4.6	0.510	-0.2	2.2	47.1	ID	ID	ID	ID
	6:00	11.3	4.6	0.493	-0.2	2.0	45.7	ID	ID	ID	ID
	7:00	10.5	4.4	0.526	2.2	1.8	28.2	ID	ID	ID	ID
	7:00	11.8	5.2	0.630	3.1	1.6	19.2	ID	ID	ID	ID
	9:00	10.1	4.5	0.611	2.8	1.8	18.2	ID	ID	ID	ID
	10:00	12.4	5.4	0.591	5.5	1.3	9.6	ID	ID	ID	ID
	11:00	11.0	4.3	0.531	1.8	1.1	7.3	ID	ID	ID	ID
	12:00	11.3	4.4	0.522	1.0	0.9	4.4	ID	ID	ID	ID
	13:00	14.8	5.6	0.610	2.6	1.1	2.2	ID	ID	ID	ID
	14:00	15.4	5.3	0.667	1.3	1.2	2.4	ID	ID	ID	ID
	15:00	12.5	4.4	0.515	1.0	1.0	1.7	ID	ID	ID	ID
	16:00	13.5	4.9	0.622	2.0	1.0	2.3	ID	ID	ID	ID
	17:00	12.8	3.4	0.609	2.8	1.1	1.9	ID	ID	ID	ID
	18:00	12.1	3.4	0.576	5.0	1.0	1.6	ID	ID	ID	ID
	19:00	9.8	3.3	0.558	5.1	1.1	0.2	ID	ID	ID	ID
	20:00	9.4	3.2	0.528	2.6	0.7	0.2	ID	ID	ID	ID
	21:00	9.6	3.2	0.546	4.5	1.1	0.4	ID	ID	ID	ID
	22:00	12.1	3.5	0.584	8.0	1.6	1.6	ID	ID	ID	ID
	23:00	13.0	4.0	0.568	4.7	1.4	1.4	ID	ID	ID	ID
	0:00	11.9	3.9	0.475	1.0	0.7	1.5	ID	ID	ID	ID
Min		**9.4**	**3.2**	**0.475**	**-0.2**	**0.7**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**26.5**	**10.2**	**0.667**	**8.0**	**2.2**	**47.1**	**ID**	**ID**	**ID**	**ID**
Average		**13.1**	**4.9**	**0.560**	**2.4**	**1.3**	**11.6**	**ID**	**ID**	**ID**	**ID**
21/05/2019	1:00	11.1	3.6	0.486	1.3	0.7	2.8	ID	ID	ID	ID
	2:00	13.7	4.1	0.502	1.2	1.0	1.3	ID	ID	ID	ID
	3:00	12.8	3.9	0.473	0.4	0.9	5.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	4:00	12.3	3.7	0.461	0.5	1.0	2.6	ID	ID	ID	ID
	5:00	12.3	4.2	0.465	0.5	1.4	22.0	ID	ID	ID	ID
	6:00	9.6	3.5	0.440	0.0	0.9	4.0	ID	ID	ID	ID
	7:00	9.0	3.0	0.429	-0.2	0.6	0.2	ID	ID	ID	ID
	8:00	6.4	2.6	0.486	0.3	1.2	18.9	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	10:00	7.0	3.3	PO	PO	PO	PO	ID	ID	ID	ID
	11:00	9.6	4.5	0.669	4.8	2.2	1.7	ID	ID	ID	ID
	12:00	10.4	4.4	0.621	0.4	1.2	2.8	ID	ID	ID	ID
	13:00	11.6	4.4	0.699	0.2	0.7	3.1	ID	ID	ID	ID
	14:00	13.8	5.2	0.696	-0.2	0.9	1.9	ID	ID	ID	ID
	15:00	14.2	5.3	0.574	0.3	0.8	1.2	ID	ID	ID	ID
	16:00	18.1	5.8	0.733	1.3	0.9	0.9	ID	ID	ID	ID
	17:00	19.3	5.7	0.697	1.9	1.0	1.3	ID	ID	ID	ID
	18:00	19.9	7.0	0.607	2.3	0.9	2.9	ID	ID	ID	ID
	19:00	21.0	8.7	0.597	2.5	0.9	2.6	ID	ID	ID	ID
	20:00	22.3	8.5	0.579	2.1	1.0	2.1	ID	ID	ID	ID
	21:00	22.1	9.0	0.575	1.6	0.8	2.1	ID	ID	ID	ID
	22:00	20.4	8.2	0.559	2.0	0.9	1.6	ID	ID	ID	ID
	23:00	20.2	7.9	0.555	1.4	0.9	1.5	ID	ID	ID	ID
	0:00	18.4	7.5	0.522	0.6	1.2	11.3	ID	ID	ID	ID
Min		**6.4**	**2.6**	**0.429**	**-0.2**	**0.6**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**22.3**	**9.0**	**0.733**	**4.8**	**2.2**	**22.0**	**ID**	**ID**	**ID**	**ID**
Average		**14.6**	**5.4**	**0.565**	**1.2**	**1.0**	**4.3**	**ID**	**ID**	**ID**	**ID**
22/05/2019	1:00	17.1	6.9	0.530	1.0	0.8	5.9	ID	ID	ID	ID
	2:00	21.7	8.4	0.556	1.4	1.0	5.7	ID	ID	ID	ID
	3:00	21.3	8.3	0.520	1.4	0.9	4.4	ID	ID	ID	ID
	4:00	21.9	8.7	0.527	1.4	1.1	2.6	ID	ID	ID	ID
	5:00	22.4	8.9	0.508	1.4	0.8	0.7	ID	ID	ID	ID
	6:00	24.2	9.2	0.513	2.0	0.9	0.5	ID	ID	ID	ID
	7:00	23.6	9.3	0.545	2.1	1.2	0.1	ID	ID	ID	ID
	7:00	23.3	9.3	0.625	1.8	1.1	0.5	ID	ID	ID	ID
	9:00	27.5	10.1	0.615	2.4	0.8	0.5	ID	ID	ID	ID
	10:00	26.4	10.1	0.524	1.2	0.8	0.1	ID	ID	ID	ID
	11:00	26.0	10.0	0.512	1.0	0.7	0.5	ID	ID	ID	ID
	12:00	23.6	9.3	0.540	2.2	0.8	1.2	ID	ID	ID	ID
	13:00	29.5	10.1	0.588	1.0	1.0	1.1	ID	ID	ID	ID
	14:00	28.9	9.4	0.573	1.3	1.0	1.4	ID	ID	ID	ID
	15:00	26.1	9.4	0.485	0.3	1.0	1.4	ID	ID	ID	ID
	16:00	31.2	9.9	0.606	1.3	1.0	1.8	ID	ID	ID	ID
	17:00	34.9	10.0	0.595	1.7	0.7	2.0	ID	ID	ID	ID
	18:00	35.2	11.6	0.562	2.0	0.7	1.7	ID	ID	ID	ID
	19:00	27.9	10.8	0.552	2.4	0.9	1.8	ID	ID	ID	ID
	20:00	25.8	9.7	0.541	2.2	0.5	2.0	ID	ID	ID	ID
	21:00	18.0	7.2	0.527	1.6	0.8	1.5	ID	ID	ID	ID
	22:00	16.4	6.5	0.537	1.9	0.7	1.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	23:00	17.2	6.5	0.503	1.1	0.7	1.6	ID	ID	ID	ID
	0:00	18.9	6.9	0.522	1.7	0.8	1.3	ID	ID	ID	ID
Min		**16.4**	**6.5**	**0.485**	**0.3**	**0.5**	**0.1**	**ID**	**ID**	**ID**	**ID**
Max		**35.2**	**11.6**	**0.625**	**2.4**	**1.2**	**5.9**	**ID**	**ID**	**ID**	**ID**
Average		**24.5**	**9.0**	**0.546**	**1.6**	**0.9**	**1.7**	**ID**	**ID**	**ID**	**ID**
23/05/2019	1:00	17.3	6.6	0.504	1.2	0.7	0.6	ID	ID	ID	ID
	2:00	16.8	7.0	0.487	0.9	0.6	0.6	ID	ID	ID	ID
	3:00	13.8	5.8	0.479	0.4	0.3	0.6	ID	ID	ID	ID
	4:00	14.4	5.7	0.512	1.3	0.4	0.6	ID	ID	ID	ID
	5:00	14.3	5.3	0.466	-0.4	0.6	6.5	ID	ID	ID	ID
	6:00	16.4	5.3	0.474	0.3	0.3	2.8	ID	ID	ID	ID
	7:00	12.9	4.5	0.490	-0.2	0.5	0.8	ID	ID	ID	ID
	8:00	11.9	4.5	0.499	-0.1	0.4	-0.7	ID	ID	ID	ID
	9:00	12.3	4.8	0.504	-0.3	0.4	-0.8	ID	ID	ID	ID
	10:00	11.3	4.4	0.482	-0.4	0.3	-0.7	ID	ID	ID	ID
	11:00	10.5	4.3	0.489	0.0	0.5	-0.3	ID	ID	ID	ID
	12:00	9.8	3.8	0.505	0.8	0.6	-0.2	ID	ID	ID	ID
	13:00	12.8	3.9	0.634	1.7	1.1	2.1	ID	ID	ID	ID
	14:00	18.4	4.7	0.686	0.9	0.9	3.2	ID	ID	ID	ID
	15:00	14.7	4.4	0.512	0.4	0.8	1.4	ID	ID	ID	ID
	16:00	16.2	4.3	0.552	1.4	0.9	0.8	ID	ID	ID	ID
	17:00	25.8	5.4	0.759	1.8	1.1	0.8	ID	ID	ID	ID
	18:00	18.8	6.2	0.562	2.3	0.8	2.3	ID	ID	ID	ID
	19:00	20.5	7.1	0.586	3.6	1.0	2.2	ID	ID	ID	ID
	20:00	17.4	5.7	0.582	3.2	1.0	2.5	ID	ID	ID	ID
	21:00	16.5	5.4	0.553	2.0	0.9	2.7	ID	ID	ID	ID
	22:00	15.3	5.5	0.538	1.6	0.8	2.4	ID	ID	ID	ID
	23:00	14.6	5.2	0.523	1.2	0.9	1.4	ID	ID	ID	ID
	0:00	12.7	4.6	0.489	2.1	0.5	1.5	ID	ID	ID	ID
Min		**9.8**	**3.8**	**0.466**	**-0.4**	**0.3**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**25.8**	**7.1**	**0.759**	**3.6**	**1.1**	**6.5**	**ID**	**ID**	**ID**	**ID**
Average		**15.2**	**5.2**	**0.536**	**1.1**	**0.7**	**1.4**	**ID**	**ID**	**ID**	**ID**
24/05/2019	1:00	11.9	4.4	0.496	2.7	0.7	0.6	ID	ID	ID	ID
	2:00	9.7	3.6	0.474	1.3	0.8	-0.2	ID	ID	ID	ID
	3:00	10.4	4.2	0.505	1.2	0.6	0.0	ID	ID	ID	ID
	4:00	9.9	4.1	0.509	0.9	1.0	12.3	ID	ID	ID	ID
	5:00	8.2	3.1	0.511	1.0	0.8	5.2	ID	ID	ID	ID
	6:00	7.3	2.8	0.552	3.3	1.1	6.8	ID	ID	ID	ID
	7:00	12.1	4.6	0.642	4.0	1.2	2.9	ID	ID	ID	ID
	7:00	9.5	4.0	0.640	3.0	1.3	2.9	ID	ID	ID	ID
	9:00	9.6	3.5	0.592	1.2	1.0	3.4	ID	ID	ID	ID
	10:00	6.5	2.7	0.524	0.6	0.7	0.8	ID	ID	ID	ID
	11:00	8.9	3.6	0.533	1.5	1.1	1.5	ID	ID	ID	ID
	12:00	11.3	4.2	0.549	3.9	2.0	39.1	ID	ID	ID	ID
	13:00	8.6	3.5	0.565	5.9	2.0	1.5	ID	ID	ID	ID
	14:00	6.6	2.4	0.558	6.8	1.5	11.7	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	15:00	11.9	6.4	0.694	12.2	11.7	17.4	ID	ID	ID	ID
	16:00	9.3	4.4	1.198	11.4	4.0	6.1	ID	ID	ID	ID
	17:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	18:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	19:00	9.4	3.5	0.772	6.6	1.4	1.0	ID	ID	ID	ID
	20:00	11.0	3.6	0.676	2.6	0.9	-0.4	ID	ID	ID	ID
	21:00	12.1	4.0	0.697	3.7	1.1	0.0	ID	ID	ID	ID
	22:00	12.2	3.6	0.636	1.2	0.9	1.0	ID	ID	ID	ID
	23:00	12.0	3.7	0.626	3.4	1.0	1.0	ID	ID	ID	ID
	0:00	10.5	3.5	ZS	ZS	1.0	0.9	ID	ID	ID	ID
Min		**6.5**	**2.4**	**0.474**	**0.6**	**0.6**	**-0.4**	**ID**	**ID**	**ID**	**ID**
Max		**12.2**	**6.4**	**1.198**	**12.2**	**11.7**	**39.1**	**ID**	**ID**	**ID**	**ID**
Average		**9.9**	**3.8**	**0.617**	**3.7**	**1.7**	**5.2**	**ID**	**ID**	**ID**	**ID**
25/05/2019	1:00	14.4	4.1	0.639	4.5	ZS	ZS	ID	ID	ID	ID
	2:00	13.4	3.9	0.607	4.2	1.0	1.3	ID	ID	ID	ID
	3:00	15.5	4.3	0.590	6.2	1.3	0.5	ID	ID	ID	ID
	4:00	14.8	4.2	0.578	3.5	1.0	0.3	ID	ID	ID	ID
	5:00	14.7	4.5	0.590	3.7	0.8	0.5	ID	ID	ID	ID
	6:00	14.6	4.1	0.592	5.6	0.9	0.1	ID	ID	ID	ID
	7:00	13.0	3.8	0.608	4.7	1.2	-0.5	ID	ID	ID	ID
	8:00	12.2	4.3	0.628	4.5	1.2	-0.7	ID	ID	ID	ID
	9:00	10.7	4.0	0.592	1.8	0.9	-0.5	ID	ID	ID	ID
	10:00	10.3	4.0	0.562	0.6	0.9	-0.4	ID	ID	ID	ID
	11:00	5.8	2.1	0.553	-0.1	0.6	-0.3	ID	ID	ID	ID
	12:00	9.6	3.8	0.553	0.0	0.6	-0.2	ID	ID	ID	ID
	13:00	11.3	4.6	0.557	0.1	0.5	0.1	ID	ID	ID	ID
	14:00	13.7	5.2	0.559	0.2	0.5	0.4	ID	ID	ID	ID
	15:00	15.5	5.4	0.559	0.2	0.5	1.6	ID	ID	ID	ID
	16:00	17.2	6.9	0.572	0.6	0.9	1.0	ID	ID	ID	ID
	17:00	20.1	7.8	0.571	0.7	0.8	0.7	ID	ID	ID	ID
	18:00	21.8	8.3	0.582	1.1	0.7	0.9	ID	ID	ID	ID
	19:00	24.2	9.2	0.588	1.9	0.5	1.5	ID	ID	ID	ID
	20:00	25.6	10.2	0.591	2.1	0.8	0.8	ID	ID	ID	ID
	21:00	25.3	10.3	0.566	1.4	0.7	1.1	ID	ID	ID	ID
	22:00	24.1	10.0	0.567	1.6	0.8	1.3	ID	ID	ID	ID
	23:00	24.7	9.9	0.558	1.3	0.8	1.3	ID	ID	ID	ID
	0:00	23.9	9.6	0.543	1.1	ZS	ZS	ID	ID	ID	ID
Min		**5.8**	**2.1**	**0.543**	**-0.1**	**0.5**	**-0.7**	**ID**	**ID**	**ID**	**ID**
Max		**25.6**	**10.3**	**0.639**	**6.2**	**1.3**	**1.6**	**ID**	**ID**	**ID**	**ID**
Average		**16.5**	**6.0**	**0.579**	**2.1**	**0.8**	**0.5**	**ID**	**ID**	**ID**	**ID**
26/05/2019	1:00	23.1	9.3	0.529	0.7	0.8	0.7	ID	ID	ID	ID
	2:00	23.0	9.2	0.521	ZS	0.4	0.6	ID	ID	ID	ID
	3:00	23.2	9.4	0.518	0.7	0.5	0.8	ID	ID	ID	ID
	4:00	24.0	9.2	0.533	1.3	0.5	0.7	ID	ID	ID	ID
	5:00	23.4	9.2	0.532	1.1	0.6	0.3	ID	ID	ID	ID
	6:00	22.1	9.1	0.522	0.7	0.6	0.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	7:00	21.4	8.4	0.529	0.8	0.7	0.7	ID	ID	ID	ID
	7:00	16.5	6.4	0.535	0.4	0.6	0.2	ID	ID	ID	ID
	9:00	14.3	5.8	0.534	0.2	0.8	-0.1	ID	ID	ID	ID
	10:00	15.3	5.9	0.530	0.2	0.6	-0.1	ID	ID	ID	ID
	11:00	15.5	5.7	0.535	0.1	0.6	-0.2	ID	ID	ID	ID
	12:00	11.0	4.3	0.531	0.0	0.4	-0.7	ID	ID	ID	ID
	13:00	11.0	3.7	0.543	0.2	0.4	-0.5	ID	ID	ID	ID
	14:00	12.2	4.6	0.545	0.2	0.3	-0.4	ID	ID	ID	ID
	15:00	11.4	4.5	0.541	0.2	0.4	-0.5	ID	ID	ID	ID
	16:00	11.1	4.4	0.556	0.5	0.2	0.0	ID	ID	ID	ID
	17:00	12.2	4.8	0.555	0.6	0.5	-0.3	ID	ID	ID	ID
	18:00	13.2	4.9	0.570	1.1	0.4	0.2	ID	ID	ID	ID
	19:00	15.6	5.9	0.604	2.4	0.6	0.4	ID	ID	ID	ID
	20:00	30.0	13.4	0.635	3.8	1.2	0.7	ID	ID	ID	ID
	21:00	18.6	6.7	0.611	2.4	1.1	0.3	ID	ID	ID	ID
	22:00	15.0	5.3	0.580	2.0	0.8	0.7	ID	ID	ID	ID
	23:00	12.8	5.0	0.550	1.3	0.6	1.0	ID	ID	ID	ID
	0:00	13.7	5.0	ZS	ZS	0.3	1.2	ID	ID	ID	ID
Min		**11.0**	**3.7**	**0.518**	**0.0**	**0.2**	**-0.7**	**ID**	**ID**	**ID**	**ID**
Max		**30.0**	**13.4**	**0.635**	**3.8**	**1.2**	**1.2**	**ID**	**ID**	**ID**	**ID**
Average		**17.1**	**6.7**	**0.549**	**1.0**	**0.6**	**0.3**	**ID**	**ID**	**ID**	**ID**
27/05/2019	1:00	13.8	4.7	0.535	0.8	ZS	ZS	ID	ID	ID	ID
	2:00	13.8	5.6	0.537	0.9	0.4	1.6	ID	ID	ID	ID
	3:00	14.7	5.7	0.528	0.5	0.6	2.5	ID	ID	ID	ID
	4:00	14.6	5.6	0.528	0.9	0.4	3.0	ID	ID	ID	ID
	5:00	15.9	5.7	0.529	1.0	0.5	2.4	ID	ID	ID	ID
	6:00	14.0	5.2	0.517	0.1	0.2	3.8	ID	ID	ID	ID
	7:00	14.6	5.3	0.527	0.2	0.3	2.4	ID	ID	ID	ID
	8:00	10.7	4.3	0.516	-0.4	0.2	0.5	ID	ID	ID	ID
	9:00	11.4	4.5	0.515	-0.4	0.3	-0.8	ID	ID	ID	ID
	10:00	9.6	3.9	0.504	-0.4	0.1	-0.3	ID	ID	ID	ID
	11:00	9.4	3.8	0.508	-0.4	0.2	-0.2	ID	ID	ID	ID
	12:00	9.9	3.7	0.507	-0.3	0.1	0.2	ID	ID	ID	ID
	13:00	11.6	4.4	0.532	0.0	0.2	0.4	ID	ID	ID	ID
	14:00	9.7	4.2	0.524	0.0	0.5	0.7	ID	ID	ID	ID
	15:00	9.7	4.1	PO	PO	PO	PO	ID	ID	ID	ID
	16:00	12.1	4.2	0.664	0.2	0.4	1.2	ID	ID	ID	ID
	17:00	12.9	4.5	0.654	0.8	0.7	1.2	ID	ID	ID	ID
	18:00	13.7	5.4	0.670	2.5	1.1	1.2	ID	ID	ID	ID
	19:00	21.1	8.4	0.714	3.3	1.1	1.6	ID	ID	ID	ID
	20:00	21.1	7.2	0.698	2.7	0.9	1.0	ID	ID	ID	ID
	21:00	21.2	7.3	0.690	2.8	1.0	0.6	ID	ID	ID	ID
	22:00	19.4	6.6	0.666	2.0	0.9	0.2	ID	ID	ID	ID
	23:00	15.9	6.4	0.626	1.5	0.8	0.2	ID	ID	ID	ID
	0:00	15.6	5.8	0.618	1.1	0.7	0.4	ID	ID	ID	ID
Min		**9.4**	**3.7**	**0.504**	**-0.4**	**0.1**	**-0.8**	**ID**	**ID**	**ID**	**ID**

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Max		**21.2**	**8.4**	**0.714**	**3.3**	**1.1**	**3.8**	**ID**	**ID**	**ID**	**ID**
Average		**14.0**	**5.3**	**0.579**	**0.9**	**0.5**	**1.1**	**ID**	**ID**	**ID**	**ID**
28/05/2019	1:00	13.6	5.1	0.607	0.8	0.8	0.2	ID	ID	ID	ID
	2:00	13.6	5.5	0.590	0.2	0.5	0.5	ID	ID	ID	ID
	3:00	12.3	4.8	0.576	-0.3	0.5	1.2	ID	ID	ID	ID
	4:00	14.1	5.5	0.567	-0.3	0.4	0.6	ID	ID	ID	ID
	5:00	16.5	4.5	0.557	-0.6	0.5	3.2	ID	ID	ID	ID
	6:00	19.8	5.8	0.563	-0.6	0.4	5.3	ID	ID	ID	ID
	7:00	19.3	7.2	0.583	-0.5	0.7	2.3	ID	ID	ID	ID
	7:00	19.3	7.6	0.603	0.2	0.5	0.9	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	10:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	11:00	PO	PO	PO	PO	PO	PO	ID	ID	ID	ID
	12:00	21.5	8.7	0.691	-0.1	0.4	0.7	ID	ID	ID	ID
	13:00	36.3	12.1	0.699	-0.2	0.2	-0.2	ID	ID	ID	ID
	14:00	42.7	13.0	0.701	0.1	0.8	0.2	ID	ID	ID	ID
	15:00	42.1	13.4	0.677	0.7	0.8	-0.4	ID	ID	ID	ID
	16:00	44.7	14.1	0.735	2.0	0.9	-0.8	ID	ID	ID	ID
	17:00	47.9	15.2	0.837	4.1	1.1	-0.7	ID	ID	ID	ID
	18:00	54.8	17.3	0.720	3.4	0.9	-0.3	ID	ID	ID	ID
	19:00	52.6	17.5	0.732	4.0	0.9	0.1	ID	ID	ID	ID
	20:00	45.2	16.2	0.684	2.0	1.0	-0.4	ID	ID	ID	ID
	21:00	48.6	16.3	0.690	2.6	0.8	0.2	ID	ID	ID	ID
	22:00	49.4	16.9	0.669	1.8	0.9	0.4	ID	ID	ID	ID
	23:00	41.9	15.7	0.643	0.6	0.5	1.6	ID	ID	ID	ID
	0:00	43.8	16.2	0.620	0.4	0.7	1.3	ID	ID	ID	ID
Min		**12.3**	**4.5**	**0.557**	**-0.6**	**0.2**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**54.8**	**17.5**	**0.837**	**4.1**	**1.1**	**5.3**	**ID**	**ID**	**ID**	**ID**
Average		**33.3**	**11.4**	**0.655**	**1.0**	**0.7**	**0.8**	**ID**	**ID**	**ID**	**ID**
29/05/2019	1:00	43.4	15.6	0.618	-0.1	0.9	2.2	ID	ID	ID	ID
	2:00	43.7	15.6	0.588	-0.1	0.8	0.9	ID	ID	ID	ID
	3:00	41.2	14.7	0.578	-0.1	0.8	0.5	ID	ID	ID	ID
	4:00	39.4	14.0	0.590	0.5	0.7	1.0	ID	ID	ID	ID
	5:00	36.9	13.3	0.578	0.0	0.6	1.0	ID	ID	ID	ID
	6:00	39.3	13.7	0.592	-0.1	0.7	4.3	ID	ID	ID	ID
	7:00	39.6	14.1	0.592	0.2	0.7	3.0	ID	ID	ID	ID
	8:00	39.9	15.0	0.729	3.1	1.0	1.8	ID	ID	ID	ID
	9:00	37.7	14.2	0.682	2.2	1.0	0.8	ID	ID	ID	ID
	10:00	38.4	14.1	0.598	0.4	0.7	1.4	ID	ID	ID	ID
	11:00	35.0	12.8	0.583	0.2	0.9	2.4	ID	ID	ID	ID
	12:00	23.7	9.4	0.546	0.0	0.8	0.1	ID	ID	ID	ID
	13:00	30.7	12.4	0.602	0.7	0.9	1.1	ID	ID	ID	ID
	14:00	33.3	13.1	0.924	2.1	1.2	1.6	ID	ID	ID	ID
	15:00	35.6	13.5	0.768	2.0	1.5	1.2	ID	ID	ID	ID
	16:00	35.2	13.4	0.709	1.9	1.2	0.0	ID	ID	ID	ID
	17:00	37.7	13.6	0.659	2.3	0.9	0.6	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	18:00	32.9	12.6	0.612	2.2	1.1	1.5	ID	ID	ID	ID
	19:00	31.6	12.4	0.613	2.7	0.9	3.0	ID	ID	ID	ID
	20:00	32.8	12.6	0.609	2.4	1.0	2.2	ID	ID	ID	ID
	21:00	32.4	11.9	0.582	1.4	1.1	3.7	ID	ID	ID	ID
	22:00	28.3	10.8	0.559	0.4	0.8	4.9	ID	ID	ID	ID
	23:00	27.6	10.5	0.550	0.2	0.6	3.8	ID	ID	ID	ID
	0:00	31.1	11.4	0.550	0.0	0.7	4.0	ID	ID	ID	ID
Min		**23.7**	**9.4**	**0.546**	**-0.1**	**0.6**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**43.7**	**15.6**	**0.924**	**3.1**	**1.5**	**4.9**	**ID**	**ID**	**ID**	**ID**
Average		**35.3**	**13.1**	**0.625**	**1.0**	**0.9**	**2.0**	**ID**	**ID**	**ID**	**ID**
30/05/2019	1:00	32.1	12.7	0.553	-0.2	0.7	7.8	ID	ID	ID	ID
	2:00	34.7	13.1	0.556	-0.2	0.8	7.9	ID	ID	ID	ID
	3:00	34.0	13.1	0.553	0.0	0.9	7.8	ID	ID	ID	ID
	4:00	28.9	10.9	0.539	-0.5	0.7	8.0	ID	ID	ID	ID
	5:00	33.7	13.0	0.547	-0.2	0.9	9.2	ID	ID	ID	ID
	6:00	35.6	13.1	0.555	0.2	0.9	10.5	ID	ID	ID	ID
	7:00	35.7	13.5	0.611	2.2	0.8	5.7	ID	ID	ID	ID
	7:00	35.5	13.5	0.686	2.0	1.2	5.2	ID	ID	ID	ID
	9:00	32.7	12.1	0.635	0.9	1.2	6.5	ID	ID	ID	ID
	10:00	35.3	12.9	0.575	0.9	1.0	4.1	ID	ID	ID	ID
	11:00	28.8	11.4	0.591	1.1	1.1	5.0	ID	ID	ID	ID
	12:00	25.3	11.7	0.594	2.6	1.1	11.1	ID	ID	ID	ID
	13:00	25.0	10.5	0.703	1.9	1.1	1.5	ID	ID	ID	ID
	14:00	27.8	10.4	0.689	0.1	0.7	1.4	ID	ID	ID	ID
	15:00	27.1	9.7	0.549	1.0	0.6	1.3	ID	ID	ID	ID
	16:00	29.9	10.4	0.671	2.1	0.6	2.5	ID	ID	ID	ID
	17:00	30.5	10.5	0.730	2.0	0.7	2.6	ID	ID	ID	ID
	18:00	23.7	8.9	0.580	2.1	0.9	2.3	ID	ID	ID	ID
	19:00	27.6	10.8	0.621	4.3	0.8	2.6	ID	ID	ID	ID
	20:00	29.8	11.3	0.631	3.2	1.1	2.0	ID	ID	ID	ID
	21:00	31.1	11.6	0.590	2.1	0.9	2.1	ID	ID	ID	ID
	22:00	29.1	11.5	0.556	1.3	1.0	2.8	ID	ID	ID	ID
	23:00	27.1	10.5	0.556	1.5	0.6	2.4	ID	ID	ID	ID
	0:00	27.1	10.3	ZS	0.8	0.6	1.7	ID	ID	ID	ID
Min		**23.7**	**8.9**	**0.539**	**-0.5**	**0.6**	**1.3**	**ID**	**ID**	**ID**	**ID**
Max		**35.7**	**13.5**	**0.730**	**4.3**	**1.2**	**11.1**	**ID**	**ID**	**ID**	**ID**
Average		**30.3**	**11.6**	**0.603**	**1.3**	**0.9**	**4.7**	**ID**	**ID**	**ID**	**ID**
31/05/2019	1:00	24.6	9.2	0.543	0.6	0.4	1.3	ID	ID	ID	ID
	2:00	23.4	8.7	0.517	0.1	0.8	0.5	ID	ID	ID	ID
	3:00	21.2	8.3	0.515	-0.2	0.9	3.1	ID	ID	ID	ID
	4:00	15.2	6.0	0.533	-0.6	1.0	10.0	ID	ID	ID	ID
	5:00	15.3	6.0	0.508	-0.6	1.1	7.7	ID	ID	ID	ID
	6:00	15.3	6.0	0.518	1.1	0.7	3.6	ID	ID	ID	ID
	7:00	17.8	7.2	0.659	5.3	1.2	3.9	ID	ID	ID	ID
	8:00	19.9	7.6	0.695	2.6	1.3	2.5	ID	ID	ID	ID
	9:00	20.7	8.0	0.588	0.3	1.1	2.5	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	10:00	21.6	8.3	0.552	0.5	0.9	1.7	ID	ID	ID	ID
	11:00	20.5	8.0	0.549	0.7	1.0	1.1	ID	ID	ID	ID
	12:00	21.1	8.0	0.556	0.6	1.0	1.3	ID	ID	ID	ID
	13:00	22.6	7.7	0.622	1.5	0.7	1.4	ID	ID	ID	ID
	14:00	24.1	7.3	0.697	0.9	0.8	1.6	ID	ID	ID	ID
	15:00	20.4	6.9	0.562	0.5	0.9	0.7	ID	ID	ID	ID
	16:00	23.8	7.1	0.680	1.9	0.9	1.4	ID	ID	ID	ID
	17:00	34.9	8.1	0.715	3.4	1.3	2.3	ID	ID	ID	ID
	18:00	23.8	7.6	0.592	2.2	1.2	3.6	ID	ID	ID	ID
	19:00	21.6	8.6	0.661	5.1	1.2	4.0	ID	ID	ID	ID
	20:00	23.0	9.0	0.646	5.0	1.3	1.3	ID	ID	ID	ID
	21:00	19.9	7.3	0.582	2.9	1.1	1.3	ID	ID	ID	ID
	22:00	20.4	7.5	0.612	3.2	1.0	2.1	ID	ID	ID	ID
	23:00	17.1	6.8	0.558	1.3	0.9	3.4	ID	ID	ID	ID
	0:00	15.7	5.1	0.513	-0.4	0.9	3.8	ID	ID	ID	ID
Min		**15.2**	**5.1**	**0.508**	**-0.6**	**0.4**	**0.5**	**ID**	**ID**	**ID**	**ID**
Max		**34.9**	**9.2**	**0.715**	**5.3**	**1.3**	**10.0**	**ID**	**ID**	**ID**	**ID**
Average		**21.0**	**7.5**	**0.591**	**1.6**	**1.0**	**2.8**	**ID**	**ID**	**ID**	**ID**
01/06/2019	1:00	16.8	5.2	0.523	-0.4	0.8	5.2	ID	ID	ID	ID
	2:00	14.2	4.5	0.530	0.1	1.0	5.8	ID	ID	ID	ID
	3:00	17.6	4.7	0.535	-0.3	0.9	9.0	ID	ID	ID	ID
	4:00	16.9	5.2	0.535	-0.1	1.2	10.3	ID	ID	ID	ID
	5:00	17.7	5.9	0.541	0.2	1.0	6.0	ID	ID	ID	ID
	6:00	17.8	5.3	0.541	0.8	0.8	6.1	ID	ID	ID	ID
	7:00	14.0	5.4	0.576	1.1	1.0	3.4	ID	ID	ID	ID
	7:00	13.5	5.5	0.554	0.2	0.9	1.0	ID	ID	ID	ID
	9:00	12.2	4.7	0.540	0.3	0.7	1.1	ID	ID	ID	ID
	10:00	9.5	3.7	0.534	0.0	0.7	2.4	ID	ID	ID	ID
	11:00	10.2	3.7	0.548	0.3	0.8	2.9	ID	ID	ID	ID
	12:00	12.3	3.8	0.542	0.1	0.7	3.4	ID	ID	ID	ID
	13:00	9.7	3.5	0.549	0.0	0.9	2.8	ID	ID	ID	ID
	14:00	11.5	4.3	0.571	0.4	0.7	3.1	ID	ID	ID	ID
	15:00	11.2	4.6	0.564	0.5	0.8	2.5	ID	ID	ID	ID
	16:00	12.1	4.1	0.564	0.6	0.8	2.3	ID	ID	ID	ID
	17:00	16.2	6.2	0.577	1.0	0.8	2.4	ID	ID	ID	ID
	18:00	12.9	4.5	0.596	1.5	0.8	1.9	ID	ID	ID	ID
	19:00	13.1	5.0	0.598	1.9	1.1	2.2	ID	ID	ID	ID
	20:00	14.8	5.2	0.631	2.9	0.7	2.3	ID	ID	ID	ID
	21:00	14.0	4.4	0.632	2.7	0.9	0.4	ID	ID	ID	ID
	22:00	11.4	4.2	0.591	2.1	1.1	1.0	ID	ID	ID	ID
	23:00	12.1	3.9	0.558	1.0	0.8	0.4	ID	ID	ID	ID
	0:00	11.5	4.2	0.553	0.6	0.7	0.5	ID	ID	ID	ID
Min		**9.5**	**3.5**	**0.523**	**-0.4**	**0.7**	**0.4**	**ID**	**ID**	**ID**	**ID**
Max		**17.8**	**6.2**	**0.632**	**2.9**	**1.2**	**10.3**	**ID**	**ID**	**ID**	**ID**
Average		**13.5**	**4.7**	**0.562**	**0.7**	**0.9**	**3.3**	**ID**	**ID**	**ID**	**ID**
02/06/2019	1:00	11.3	4.1	0.542	0.3	0.8	0.4	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	2:00	11.6	4.2	0.537	0.3	0.9	-0.2	ID	ID	ID	ID
	3:00	12.0	4.3	0.536	0.0	0.7	0.0	ID	ID	ID	ID
	4:00	11.5	4.1	0.539	0.1	0.8	-0.1	ID	ID	ID	ID
	5:00	11.1	4.3	0.531	0.2	0.7	0.1	ID	ID	ID	ID
	6:00	12.0	4.2	0.542	0.4	0.9	0.6	ID	ID	ID	ID
	7:00	14.3	5.2	0.555	0.3	0.7	0.0	ID	ID	ID	ID
	8:00	18.6	7.0	0.545	-0.1	0.7	0.4	ID	ID	ID	ID
	9:00	18.6	6.8	0.537	-0.3	0.5	1.5	ID	ID	ID	ID
	10:00	14.4	5.0	0.539	-0.3	0.8	1.3	ID	ID	ID	ID
	11:00	14.0	5.4	0.534	-0.3	0.6	1.6	ID	ID	ID	ID
	12:00	14.0	6.3	0.546	-0.2	0.5	0.8	ID	ID	ID	ID
	13:00	9.5	4.0	0.533	0.0	0.7	0.6	ID	ID	ID	ID
	14:00	23.2	8.8	0.555	0.2	0.8	1.9	ID	ID	ID	ID
	15:00	27.6	9.8	0.554	-0.2	0.7	2.6	ID	ID	ID	ID
	16:00	26.0	10.1	0.554	-0.1	0.5	2.1	ID	ID	ID	ID
	17:00	27.6	10.6	0.570	0.2	0.9	1.9	ID	ID	ID	ID
	18:00	29.2	11.3	0.585	0.8	0.5	2.1	ID	ID	ID	ID
	19:00	32.2	12.3	0.633	2.4	0.7	1.6	ID	ID	ID	ID
	20:00	30.5	12.0	0.641	4.1	1.2	0.3	ID	ID	ID	ID
	21:00	25.8	9.3	0.633	3.5	1.2	-0.2	ID	ID	ID	ID
	22:00	28.0	9.9	0.639	3.0	0.8	0.4	ID	ID	ID	ID
	23:00	28.2	9.9	0.626	2.9	1.0	0.3	ID	ID	ID	ID
	0:00	24.1	9.3	0.608	2.3	1.0	0.3	ID	ID	ID	ID
Min		**9.5**	**4.0**	**0.531**	**-0.3**	**0.5**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**32.2**	**12.3**	**0.641**	**4.1**	**1.2**	**2.6**	**ID**	**ID**	**ID**	**ID**
Average		**19.8**	**7.4**	**0.567**	**0.8**	**0.8**	**0.8**	**ID**	**ID**	**ID**	**ID**
03/06/2019	1:00	22.5	8.3	0.592	1.7	0.9	0.0	ID	ID	ID	ID
	2:00	17.6	7.3	0.576	0.9	0.6	0.2	ID	ID	ID	ID
	3:00	15.1	5.9	0.560	0.2	0.7	0.6	ID	ID	ID	ID
	4:00	15.6	5.2	0.561	0.1	0.9	5.4	ID	ID	ID	ID
	5:00	15.4	5.5	0.584	1.3	1.0	4.8	ID	ID	ID	ID
	6:00	14.5	5.5	0.576	0.8	0.9	2.1	ID	ID	ID	ID
	7:00	13.2	4.6	0.572	0.0	0.9	4.2	ID	ID	ID	ID
	7:00	21.7	5.5	0.703	1.9	0.8	-0.2	ID	ID	ID	ID
	9:00	19.6	5.3	0.659	0.8	0.8	3.3	ID	ID	ID	ID
	10:00	11.1	4.2	0.555	-0.4	0.4	2.9	ID	ID	ID	ID
	11:00	14.1	4.8	0.559	-0.3	0.5	2.6	ID	ID	ID	ID
	12:00	15.2	5.1	0.580	-0.3	0.3	1.9	ID	ID	ID	ID
	13:00	16.9	5.7	0.667	-0.1	0.4	1.3	ID	ID	ID	ID
	14:00	24.1	8.2	0.623	0.1	0.4	2.8	ID	ID	ID	ID
	15:00	24.8	9.5	0.585	-0.1	0.4	2.2	ID	ID	ID	ID
	16:00	25.6	9.2	0.645	0.4	0.6	2.0	ID	ID	ID	ID
	17:00	31.2	11.3	0.621	MM	0.6	2.3	ID	ID	ID	ID
	18:00	35.5	13.0	MM	MM	0.6	1.5	ID	ID	ID	ID
	19:00	42.1	15.7	MM	2.6	0.4	1.5	ID	ID	ID	ID
	20:00	40.5	16.3	0.663	3.0	0.7	0.8	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	21:00	36.2	13.9	0.625	1.4	0.4	0.1	ID	ID	ID	ID
	22:00	36.3	13.9	0.631	2.5	0.6	0.4	ID	ID	ID	ID
	23:00	33.6	12.6	0.583	0.3	0.6	1.2	ID	ID	ID	ID
	0:00	34.5	12.6	0.582	0.2	0.6	0.2	ID	ID	ID	ID
Min		**11.1**	**4.2**	**0.555**	**-0.4**	**0.3**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**42.1**	**16.3**	**0.703**	**3.0**	**1.0**	**5.4**	**ID**	**ID**	**ID**	**ID**
Average		**24.0**	**8.7**	**0.605**	**0.8**	**0.6**	**1.8**	**ID**	**ID**	**ID**	**ID**
04/06/2019	1:00	26.8	10.4	0.571	ZS	0.6	0.5	ID	ID	ID	ID
	2:00	19.2	7.7	0.561	0.2	ZS	ZS	ID	ID	ID	ID
	3:00	16.2	6.3	0.563	-0.1	0.5	-0.1	ID	ID	ID	ID
	4:00	18.9	6.9	0.557	0.0	0.4	0.0	ID	ID	ID	ID
	5:00	22.6	7.8	0.553	-0.1	0.5	-0.1	ID	ID	ID	ID
	6:00	21.7	7.7	0.559	-0.1	0.3	0.0	ID	ID	ID	ID
	7:00	22.0	7.7	0.566	0.0	0.5	-0.1	ID	ID	ID	ID
	8:00	30.7	9.0	0.659	1.2	0.3	0.2	ID	ID	ID	ID
	9:00	26.1	7.9	0.615	0.1	0.5	1.8	ID	ID	ID	ID
	10:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	11:00	19.0	6.3	0.697	-0.2	0.5	1.3	ID	ID	ID	ID
	12:00	18.1	6.0	0.683	0.2	0.5	2.5	ID	ID	ID	ID
	13:00	17.7	5.9	0.702	0.4	0.4	1.1	ID	ID	ID	ID
	14:00	25.1	7.2	0.747	0.7	0.7	1.4	ID	ID	ID	ID
	15:00	22.4	7.4	0.694	0.2	0.5	1.6	ID	ID	ID	ID
	16:00	26.7	7.6	0.733	1.1	0.5	2.0	ID	ID	ID	ID
	17:00	27.0	8.4	0.758	1.0	0.8	2.1	ID	ID	ID	ID
	18:00	25.8	8.6	0.714	1.4	0.6	2.2	ID	ID	ID	ID
	19:00	29.1	10.4	0.677	1.5	0.5	1.4	ID	ID	ID	ID
	20:00	25.6	10.1	0.669	1.0	0.5	2.8	ID	ID	ID	ID
	21:00	23.5	8.7	0.673	1.1	0.7	2.0	ID	ID	ID	ID
	22:00	21.8	8.2	0.651	0.5	0.7	1.5	ID	ID	ID	ID
	23:00	23.6	8.5	0.629	0.0	0.6	2.5	ID	ID	ID	ID
	0:00	23.8	8.8	0.629	0.1	0.5	1.1	ID	ID	ID	ID
Min		**16.2**	**5.9**	**0.553**	**-0.2**	**0.3**	**-0.1**	**ID**	**ID**	**ID**	**ID**
Max		**30.7**	**10.4**	**0.758**	**1.5**	**0.8**	**2.8**	**ID**	**ID**	**ID**	**ID**
Average		**23.2**	**8.0**	**0.646**	**0.5**	**0.5**	**1.3**	**ID**	**ID**	**ID**	**ID**
05/06/2019	1:00	23.9	8.5	0.614	0.1	0.4	0.8	ID	ID	ID	ID
	2:00	27.0	9.0	0.614	-0.2	0.5	0.8	ID	ID	ID	ID
	3:00	28.0	9.8	0.609	-0.1	0.7	0.4	ID	ID	ID	ID
	4:00	31.0	10.1	0.606	-0.2	0.5	0.2	ID	ID	ID	ID
	5:00	30.3	9.9	0.603	0.0	0.5	1.4	ID	ID	ID	ID
	6:00	29.1	9.7	0.607	0.4	0.8	2.2	ID	ID	ID	ID
	7:00	33.8	11.3	0.641	1.2	0.9	2.1	ID	ID	ID	ID
	7:00	36.9	11.4	0.733	0.9	0.9	2.3	ID	ID	ID	ID
	9:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	10:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	11:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	12:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	13:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	14:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	15:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	16:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	17:00	PO	PO	PO	PO	P	P	ID	ID	ID	ID
	18:00	27.3	8.5	0.950	2.7	1.5	1.0	ID	ID	ID	ID
	19:00	25.9	8.5	0.864	3.4	1.3	1.4	ID	ID	ID	ID
	20:00	31.3	10.8	0.855	4.0	1.4	1.2	ID	ID	ID	ID
	21:00	36.4	12.9	0.816	3.2	1.3	0.7	ID	ID	ID	ID
	22:00	34.3	12.2	0.783	2.1	1.2	2.2	ID	ID	ID	ID
	23:00	29.6	10.6	0.758	1.4	1.1	3.6	ID	ID	ID	ID
	0:00	30.7	10.3	0.732	1.1	1.0	2.8	ID	ID	ID	ID
Min		**23.9**	**8.5**	**0.603**	**-0.2**	**0.4**	**0.2**	**ID**	**ID**	**ID**	**ID**
Max		**36.9**	**12.9**	**0.950**	**4.0**	**1.5**	**3.6**	**ID**	**ID**	**ID**	**ID**
Average		**30.4**	**10.2**	**0.719**	**1.3**	**0.9**	**1.5**	**ID**	**ID**	**ID**	**ID**
06/06/2019	1:00	29.0	10.0	ZS	1.3	1.1	1.3	ID	ID	ID	ID
	2:00	30.6	9.8	0.700	1.3	1.2	0.5	ID	ID	ID	ID
	3:00	30.7	10.1	0.687	1.0	1.1	0.3	ID	ID	ID	ID
	4:00	31.7	10.5	0.674	1.0	0.9	0.3	ID	ID	ID	ID
	5:00	33.7	11.3	0.677	2.0	1.1	0.3	ID	ID	ID	ID
	6:00	32.1	10.9	0.670	0.7	1.0	5.9	ID	ID	ID	ID
	7:00	30.6	10.5	0.670	0.2	0.8	4.6	ID	ID	ID	ID
	8:00	37.1	11.5	0.852	5.2	1.1	6.2	ID	ID	ID	ID
	9:00	20.2	8.6	0.908	2.6	1.2	6.9	ID	ID	ID	ID
	10:00	23.9	8.6	0.667	1.0	0.6	4.4	ID	ID	ID	ID
	11:00	32.9	10.7	0.661	0.7	0.3	6.0	ID	ID	ID	ID
	12:00	35.1	11.0	0.659	1.3	0.9	6.6	ID	ID	ID	ID
	13:00	37.2	10.6	0.699	1.4	1.1	4.6	ID	ID	ID	ID
	14:00	33.1	9.7	0.708	1.2	1.0	4.5	ID	ID	ID	ID
	15:00	26.6	9.0	0.672	0.3	0.6	2.2	ID	ID	ID	ID
	16:00	25.4	8.1	0.759	1.2	0.8	2.7	ID	ID	ID	ID
	17:00	33.5	9.3	0.783	2.0	1.2	4.2	ID	ID	ID	ID
	18:00	29.8	9.2	0.788	3.4	1.3	5.5	ID	ID	ID	ID
	19:00	20.1	8.0	0.702	2.7	1.3	6.0	ID	ID	ID	ID
	20:00	17.1	6.3	0.675	1.8	0.9	5.7	ID	ID	ID	ID
	21:00	20.6	7.3	0.653	1.8	0.7	5.5	ID	ID	ID	ID
	22:00	26.6	9.1	0.639	1.6	0.9	4.9	ID	ID	ID	ID
	23:00	21.4	7.9	ZS	0.9	0.6	4.0	ID	ID	ID	ID
	0:00	13.6	5.2	0.611	0.6	0.7	3.4	ID	ID	ID	ID
Min		**13.6**	**5.2**	**0.611**	**0.2**	**0.3**	**0.3**	**ID**	**ID**	**ID**	**ID**
Max		**37.2**	**11.5**	**0.908**	**5.2**	**1.3**	**6.9**	**ID**	**ID**	**ID**	**ID**
Average		**28.0**	**9.3**	**0.705**	**1.6**	**0.9**	**4.0**	**ID**	**ID**	**ID**	**ID**
07/06/2019	1:00	17.9	6.8	0.616	0.5	0.8	15.1	ID	ID	ID	ID
	2:00	18.2	7.0	0.606	0.1	1.5	25.1	ID	ID	ID	ID
	3:00	16.6	6.7	0.607	0.4	1.3	8.5	ID	ID	ID	ID
	4:00	14.8	5.9	0.598	-0.1	1.0	9.9	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	5:00	10.6	3.6	0.597	0.2	0.8	9.4	ID	ID	ID	ID
	6:00	12.7	4.0	0.591	-0.2	0.9	6.3	ID	ID	ID	ID
	7:00	12.1	4.4	0.598	0.2	0.7	1.8	ID	ID	ID	ID
	7:00	11.4	4.0	0.653	0.0	0.6	-0.2	ID	ID	ID	ID
	9:00	11.4	4.3	0.647	-0.1	0.6	3.5	ID	ID	ID	ID
	10:00	10.3	4.0	0.582	-0.4	0.1	1.9	ID	ID	ID	ID
	11:00	6.7	2.1	0.583	-0.3	0.0	1.2	ID	ID	ID	ID
	12:00	13.0	3.7	0.599	-0.1	0.3	14.3	ID	ID	ID	ID
	13:00	11.6	4.1	0.665	0.4	0.6	7.3	ID	ID	ID	ID
	14:00	11.6	4.3	0.626	0.1	0.7	12.1	ID	ID	ID	ID
	15:00	12.1	4.6	0.583	0.1	0.9	8.4	ID	ID	ID	ID
	16:00	15.8	4.7	0.699	1.2	1.2	5.5	ID	ID	ID	ID
	17:00	15.9	4.8	0.677	0.8	1.2	6.3	ID	ID	ID	ID
	18:00	14.7	5.3	0.609	0.9	1.0	6.2	ID	ID	ID	ID
	19:00	18.5	6.5	0.656	3.6	0.9	6.6	ID	ID	ID	ID
	20:00	17.9	6.8	0.601	1.9	1.1	16.6	ID	ID	ID	ID
	21:00	13.3	5.2	0.632	1.1	1.0	13.0	ID	ID	ID	ID
	22:00	11.7	4.7	0.622	0.5	1.0	11.1	ID	ID	ID	ID
	23:00	13.7	4.9	ZS	0.4	0.8	11.2	ID	ID	ID	ID
	0:00	14.0	5.4	0.585	0.2	0.8	11.0	ID	ID	ID	ID
Min		**6.7**	**2.1**	**0.582**	**-0.4**	**0.0**	**-0.2**	**ID**	**ID**	**ID**	**ID**
Max		**18.5**	**7.0**	**0.699**	**3.6**	**1.5**	**25.1**	**ID**	**ID**	**ID**	**ID**
Average		**13.6**	**4.9**	**0.619**	**0.5**	**0.8**	**8.8**	**ID**	**ID**	**ID**	**ID**
08/06/2019	1:00	15.4	6.1	0.600	0.0	0.7	14.6	ID	ID	ID	ID
	2:00	17.3	6.6	0.583	-0.2	0.6	5.6	ID	ID	ID	ID
	3:00	19.7	6.9	0.574	-0.1	0.4	3.2	ID	ID	ID	ID
	4:00	11.7	4.1	0.549	-0.5	0.6	7.2	ID	ID	ID	ID
	5:00	14.6	5.0	0.561	-0.4	0.5	11.4	ID	ID	ID	ID
	6:00	14.4	5.0	0.579	-0.6	1.3	27.8	ID	ID	ID	ID
	7:00	8.5	2.6	0.576	-0.7	0.5	2.5	ID	ID	ID	ID
	8:00	6.1	2.1	0.566	-0.6	0.4	5.2	ID	ID	ID	ID
	9:00	7.2	2.8	0.594	0.4	1.1	28.3	ID	ID	ID	ID
	10:00	7.2	2.6	0.627	1.5	0.8	12.7	ID	ID	ID	ID
	11:00	7.9	2.6	0.619	0.8	0.3	2.0	ID	ID	ID	ID
	12:00	8.2	3.3	0.616	1.1	0.3	0.5	ID	ID	ID	ID
	13:00	9.2	3.8	0.642	1.5	0.7	9.0	ID	ID	ID	ID
	14:00	12.7	4.1	0.632	1.1	1.0	16.8	ID	ID	ID	ID
	15:00	12.0	3.9	0.610	1.0	1.2	18.7	ID	ID	ID	ID
	16:00	8.7	3.3	0.608	1.3	1.2	13.7	ID	ID	ID	ID
	17:00	8.8	3.2	0.606	2.2	1.1	5.7	ID	ID	ID	ID
	18:00	9.5	3.7	0.636	3.8	1.1	3.8	ID	ID	ID	ID
	19:00	11.2	3.9	0.697	3.9	0.9	1.6	ID	ID	ID	ID
	20:00	10.3	3.9	0.699	3.4	1.1	0.8	ID	ID	ID	ID
	21:00	11.7	4.4	0.975	2.8	2.2	0.0	ID	ID	ID	ID
	22:00	13.8	4.2	0.858	5.3	1.1	2.1	ID	ID	ID	ID
	23:00	14.9	4.0	0.791	4.3	0.9	4.8	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	0:00	14.1	4.3	0.796	3.4	1.2	2.3	ID	ID	ID	ID
Min		**6.1**	**2.1**	**0.549**	**-0.7**	**0.3**	**0.0**	**ID**	**ID**	**ID**	**ID**
Max		**19.7**	**6.9**	**0.975**	**5.3**	**2.2**	**28.3**	**ID**	**ID**	**ID**	**ID**
Average		**11.5**	**4.0**	**0.650**	**1.4**	**0.9**	**8.3**	**ID**	**ID**	**ID**	**ID**
09/06/2019	1:00	12.9	4.5	0.755	1.9	1.1	4.2	ID	ID	ID	ID
	2:00	12.4	4.2	0.724	1.4	1.0	6.2	ID	ID	ID	ID
	3:00	12.4	4.2	0.686	0.7	1.1	4.0	ID	ID	ID	ID
	4:00	12.1	4.4	0.681	0.7	0.8	1.9	ID	ID	ID	ID
	5:00	14.2	4.6	0.672	0.0	1.0	1.5	ID	ID	ID	ID
	6:00	17.6	4.9	0.646	-0.1	0.8	1.2	ID	ID	ID	ID
	7:00	17.2	5.1	0.647	-0.4	0.9	3.3	ID	ID	ID	ID
	7:00	11.5	4.2	0.637	-0.5	0.7	0.3	ID	ID	ID	ID
	9:00	9.4	3.5	0.627	-0.4	0.6	-0.4	ID	ID	ID	ID
	10:00	11.8	4.5	0.624	-0.3	0.4	0.2	ID	ID	ID	ID
	11:00	8.1	3.6	0.617	-0.3	0.5	-0.9	ID	ID	ID	ID
	12:00	9.9	4.0	0.622	-0.4	0.6	4.8	ID	ID	ID	ID
	13:00	9.7	3.9	0.618	-0.5	0.4	3.2	ID	ID	ID	ID
	14:00	10.3	4.2	0.646	-0.1	0.5	6.0	ID	ID	ID	ID
	15:00	13.3	5.2	0.656	0.0	1.1	7.8	ID	ID	ID	ID
	16:00	15.2	5.6	0.637	0.3	0.8	7.2	ID	ID	ID	ID
	17:00	15.7	5.8	0.642	0.8	0.7	4.2	ID	ID	ID	ID
	18:00	16.9	6.5	0.672	1.1	0.6	4.5	ID	ID	ID	ID
	19:00	18.8	7.4	0.712	2.3	0.6	3.2	ID	ID	ID	ID
	20:00	24.5	9.5	0.752	3.4	0.8	2.0	ID	ID	ID	ID
	21:00	21.0	7.2	0.766	4.3	1.0	1.3	ID	ID	ID	ID
	22:00	22.0	7.0	0.708	2.8	0.9	1.6	ID	ID	ID	ID
	23:00	18.9	6.5	0.704	2.6	0.7	1.3	ID	ID	ID	ID
	0:00	22.4	6.6	0.641	0.4	0.6	0.8	ID	ID	ID	ID
Min		**8.1**	**3.5**	**0.617**	**-0.5**	**0.4**	**-0.9**	**ID**	**ID**	**ID**	**ID**
Max		**24.5**	**9.5**	**0.766**	**4.3**	**1.1**	**7.8**	**ID**	**ID**	**ID**	**ID**
Average		**14.9**	**5.3**	**0.671**	**0.8**	**0.8**	**2.9**	**ID**	**ID**	**ID**	**ID**
10/06/2019	1:00	24.2	8.7	0.645	0.9	0.8	3.7	ID	ID	ID	ID
	2:00	30.4	11.8	0.614	0.6	1.5	22.4	ID	ID	ID	ID
	3:00	28.4	10.8	0.580	-0.4	1.3	18.4	ID	ID	ID	ID
	4:00	33.1	11.2	0.579	-0.3	0.5	5.5	ID	ID	ID	ID
	5:00	34.8	10.8	0.585	-0.5	0.7	7.7	ID	ID	ID	ID
	6:00	42.8	15.5	0.597	0.9	0.9	5.6	ID	ID	ID	ID
	7:00	48.5	17.4	0.633	1.6	0.9	5.4	ID	ID	ID	ID
	8:00	48.6	17.8	0.714	1.3	1.0	5.6	ID	ID	ID	ID
	9:00	49.5	17.2	0.650	0.7	1.1	4.3	ID	ID	ID	ID
	10:00	49.8	17.3	0.611	0.3	0.8	4.0	ID	ID	ID	ID
	11:00	46.3	16.5	0.603	0.0	0.9	4.2	ID	ID	ID	ID
	12:00	45.6	16.7	0.598	0.3	0.8	4.1	ID	ID	ID	ID
	13:00	50.8	17.5	0.653	0.7	0.7	3.6	ID	ID	ID	ID
	14:00	52.0	17.5	0.664	0.9	0.9	2.6	ID	ID	ID	ID
	15:00	51.3	17.3	0.601	0.3	0.7	3.0	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	16:00	53.2	17.8	0.727	1.8	1.0	2.1	ID	ID	ID	ID
	17:00	58.4	18.3	0.703	1.6	1.2	2.0	ID	ID	ID	ID
	18:00	55.2	19.5	0.709	2.7	1.1	3.4	ID	ID	ID	ID
	19:00	54.3	19.6	0.668	3.0	1.2	3.4	ID	ID	ID	ID
	20:00	54.9	19.0	0.648	2.5	1.1	3.5	ID	ID	ID	ID
	21:00	54.8	18.9	0.652	1.5	0.9	4.3	ID	ID	ID	ID
	22:00	55.7	19.2	0.658	1.7	0.9	3.8	ID	ID	ID	ID
	23:00	56.3	19.2	0.612	0.7	0.9	3.0	ID	ID	ID	ID
	0:00	55.1	19.9	0.607	0.3	1.2	2.0	ID	ID	ID	ID
Min		**24.2**	**8.7**	**0.579**	**-0.5**	**0.5**	**2.0**	**ID**	**ID**	**ID**	**ID**
Max		**58.4**	**19.9**	**0.727**	**3.0**	**1.5**	**22.4**	**ID**	**ID**	**ID**	**ID**
Average		**47.3**	**16.5**	**0.638**	**1.0**	**1.0**	**5.3**	**ID**	**ID**	**ID**	**ID**
11/06/2019	1:00	50.7	18.6	0.599	0.0	0.9	2.2	ID	ID	ID	ID
	2:00	53.6	19.5	0.591	-0.2	0.5	2.2	ID	ID	ID	ID
	3:00	54.5	19.2	0.579	0.4	0.7	3.1	ID	ID	ID	ID
	4:00	55.6	18.9	0.564	0.7	1.0	3.1	ID	ID	ID	ID
	5:00	52.7	18.7	0.566	0.9	0.9	3.5	ID	ID	ID	ID
	6:00	53.5	18.9	0.597	0.7	0.8	4.6	ID	ID	ID	ID
	7:00	59.0	19.3	0.632	1.2	0.9	2.7	ID	ID	ID	ID
	7:00	61.2	19.1	0.715	2.1	1.0	2.0	ID	ID	ID	ID
	9:00	63.3	18.9	0.691	1.3	1.2	2.6	ID	ID	ID	ID
	10:00	56.9	18.5	0.620	0.7	1.1	2.3	ID	ID	ID	ID
	11:00	61.8	20.3	0.679	0.8	1.0	1.3	ID	ID	ID	ID
	12:00	63.8	19.8	0.683	1.4	1.2	1.9	ID	ID	ID	ID
	13:00	40.9	13.0	0.628	0.8	1.0	0.7	ID	ID	ID	ID
	14:00	18.4	7.6	0.596	0.0	0.8	0.0	ID	ID	ID	ID
	15:00	22.9	9.2	0.599	0.3	0.8	-0.8	ID	ID	ID	ID
	16:00	18.5	7.6	0.691	0.8	0.7	0.2	ID	ID	ID	ID
	17:00	22.3	9.3	0.821	4.4	1.1	4.9	ID	ID	ID	ID
	18:00	36.2	14.0	0.877	6.7	1.4	2.7	ID	ID	ID	ID
	19:00	46.3	16.8	0.742	6.0	1.7	0.5	ID	ID	ID	ID
	20:00	47.7	17.0	0.739	4.1	1.9	-0.5	ID	ID	ID	ID
	21:00	46.4	16.4	1.026	2.5	1.9	0.1	ID	ID	ID	ID
	22:00	45.7	15.8	0.792	3.9	1.9	-0.4	ID	ID	ID	ID
	23:00	45.5	15.5	0.762	2.3	1.4	0.4	ID	ID	ID	ID
	0:00	44.2	15.2	0.742	1.4	1.0	1.0	ID	ID	ID	ID
Min		**18.4**	**7.6**	**0.564**	**-0.2**	**0.5**	**-0.8**	**ID**	**ID**	**ID**	**ID**
Max		**63.8**	**20.3**	**1.026**	**6.7**	**1.9**	**4.9**	**ID**	**ID**	**ID**	**ID**
Average		**46.7**	**16.1**	**0.689**	**1.8**	**1.1**	**1.7**	**ID**	**ID**	**ID**	**ID**
12/06/2019	1:00	40.3	14.4	0.717	1.0	1.0	0.7	ID	ID	ID	ID
	2:00	26.8	10.6	0.698	-0.1	0.8	2.3	ID	ID	ID	ID
	3:00	30.9	11.8	0.693	0.6	0.9	2.2	ID	ID	ID	ID
	4:00	27.7	10.8	0.689	-0.1	1.1	9.8	ID	ID	ID	ID
	5:00	17.0	6.9	0.691	0.5	1.4	21.5	ID	ID	ID	ID
	6:00	20.0	6.9	0.683	-0.2	0.7	0.9	ID	ID	ID	ID
	7:00	21.0	7.2	0.676	-0.3	0.8	1.9	ID	ID	ID	ID

Date	Hour Ending At	PM_{10}	$PM_{2.5}$	CO	NO_2 [a]	SO_2 [a]	H_2S [a]	Benzene	Toluene	Ethylbenzene	Xylene
		µg/m³	µg/m³	ppm	ppb	ppb	ppb	ppb	ppb	ppb	ppb
	8:00	16.0	6.1	0.731	0.0	1.2	7.8	ID	ID	ID	ID
	9:00	12.6	4.9	0.792	1.8	1.3	10.7	ID	ID	ID	ID
	10:00	8.7	3.9	0.705	1.8	0.9	9.1	ID	ID	ID	ID
	11:00	11.0	5.6	0.797	4.9	1.1	0.6	ID	ID	ID	ID
	12:00	10.4	4.7	0.764	10.5	4.8	-0.6	ID	ID	ID	ID
	13:00	12.8	5.2	0.768	10.4	4.9	-1.0	ID	ID	ID	ID
	14:00	19.3	7.6	0.931	3.3	1.7	-0.4	ID	ID	ID	ID
	15:00	19.4	7.0	0.699	0.8	1.0	-0.7	ID	ID	ID	ID
	16:00	19.6	6.7	0.747	1.5	1.2	-1.0	ID	ID	ID	ID
	17:00	21.6	6.6	0.903	4.0	1.2	-0.7	ID	ID	ID	ID
	18:00	20.9	7.1	0.865	3.1	1.3	-0.6	ID	ID	ID	ID
	19:00	18.3	6.5	0.740	4.5	1.3	0.8	ID	ID	ID	ID
	20:00	14.9	5.8	0.717	2.8	1.3	0.5	ID	ID	ID	ID
	21:00	15.3	5.9	0.707	2.8	1.7	-0.4	ID	ID	ID	ID
	22:00	16.0	6.2	0.705	3.6	1.3	0.0	ID	ID	ID	ID
	23:00	15.7	5.9	0.696	2.1	1.2	-0.1	ID	ID	ID	ID
	0:00	15.0	5.7	0.691	1.8	1.2	0.1	ID	ID	ID	ID
Min		**8.7**	**3.9**	**0.676**	**-0.3**	**0.7**	**-1.0**	**ID**	**ID**	**ID**	**ID**
Max		**40.3**	**14.4**	**0.931**	**10.5**	**4.9**	**21.5**	**ID**	**ID**	**ID**	**ID**
Average		**18.8**	**7.1**	**0.742**	**2.5**	**1.5**	**2.6**	**ID**	**ID**	**ID**	**ID**

µg/m³ = microgram per cubic meter; CO = carbon monoxide; H_2S = hydrogen sulfide; ID = insufficient data; IO = Instrument offline; MM = maintenance mode; NO_2 = nitrogen dioxide; PF = pump failure; $PM_{2.5}$ = fine particulate matter (with aerodynamic diameter of less than 2.5 micrometers); PM_{10} = inhalable particulate matter (with aerodynamic diameter of less than 10 micrometers); PO = power outage; ppb = parts per billion; ppm = parts per million; SO_2 = sulfur dioxide; UM = unknown malfunction; ZS = nightly zero and span

[a] Normal analyzer drift may result in reported negative concentrations where ambient levels are low. In conformance to standard quality assurance practice, these are reported without adjustment.

APPENDIX E

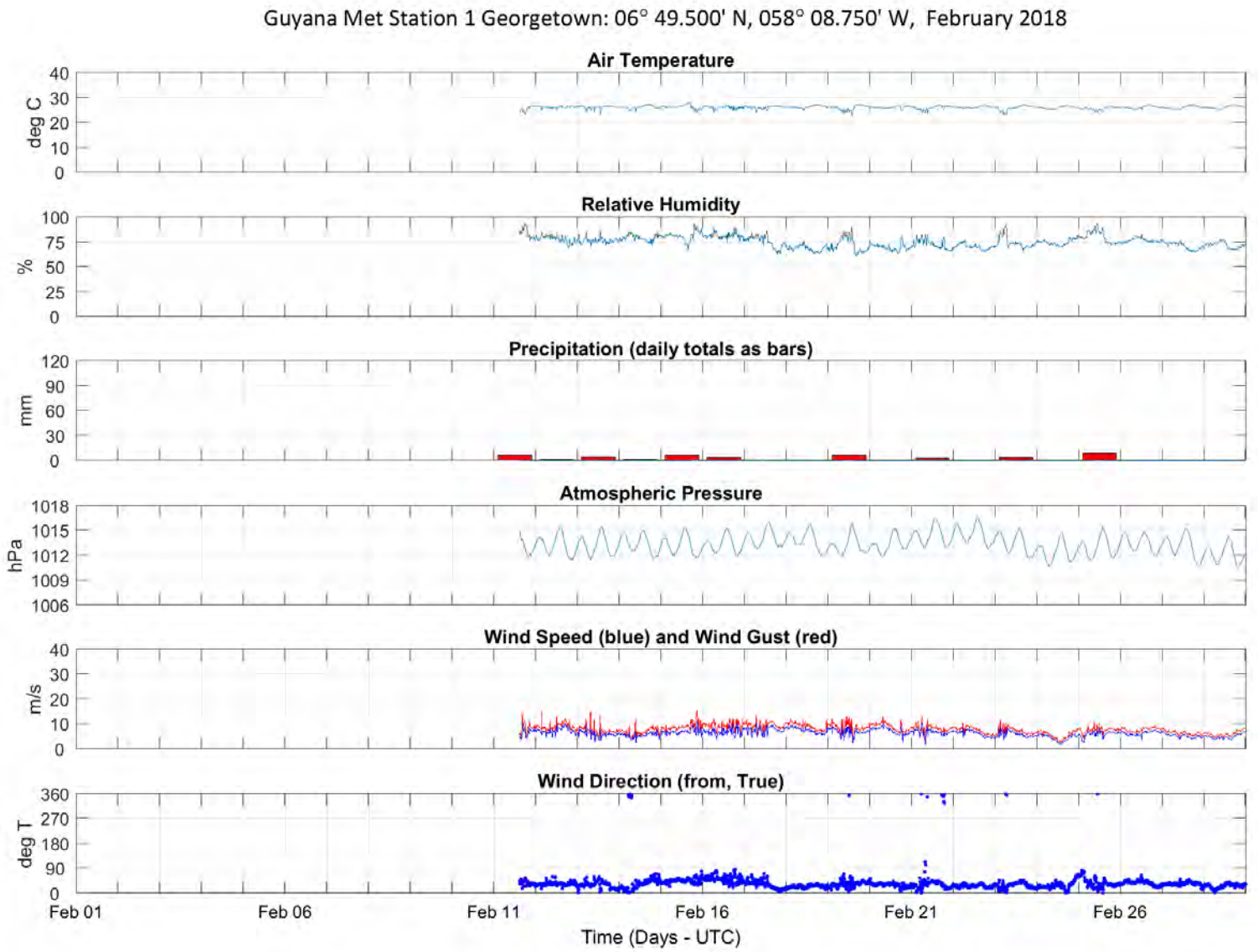
Onshore and Offshore Meteorological Data

Resubmitted without changes

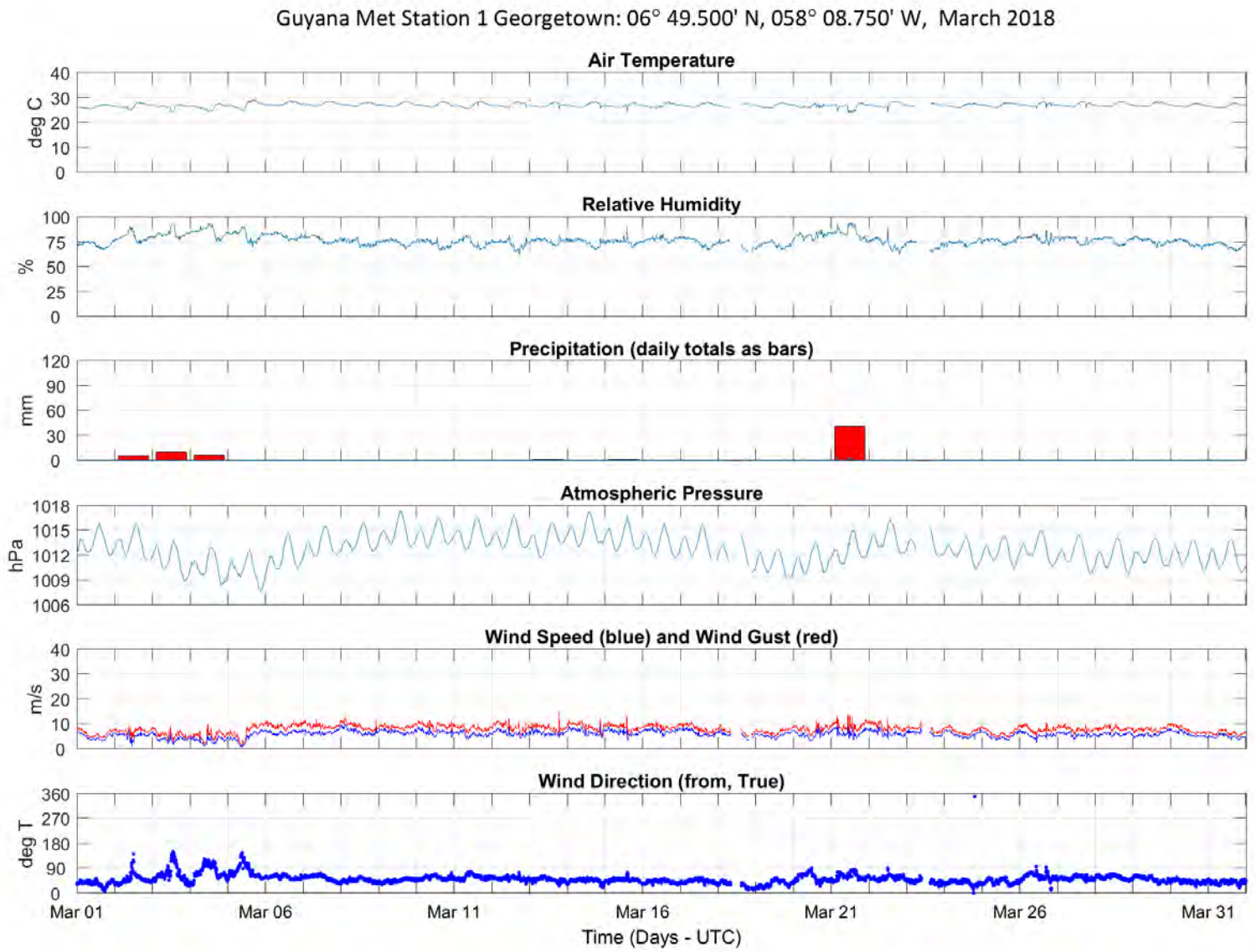
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Onshore Meteorological Data

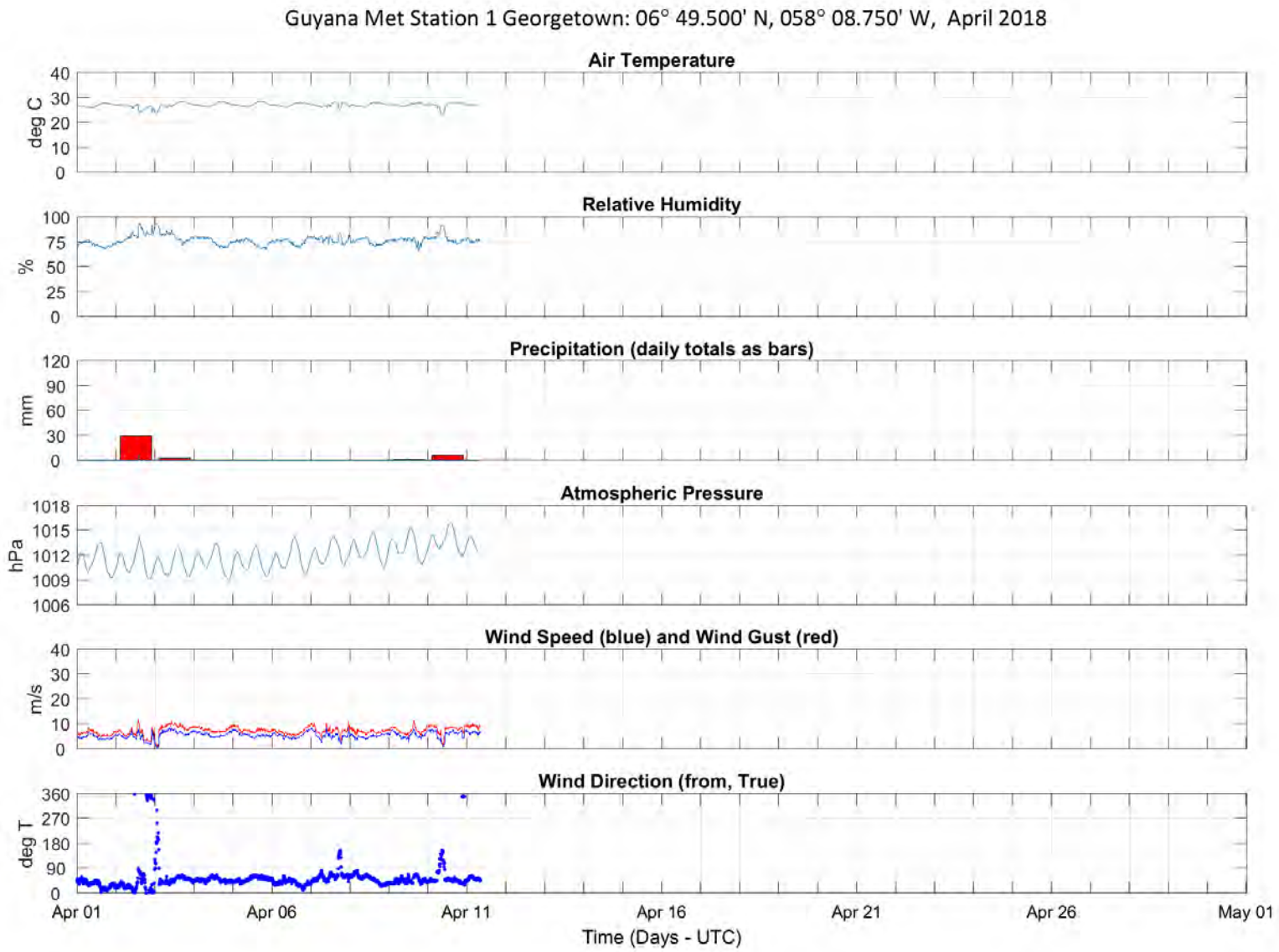
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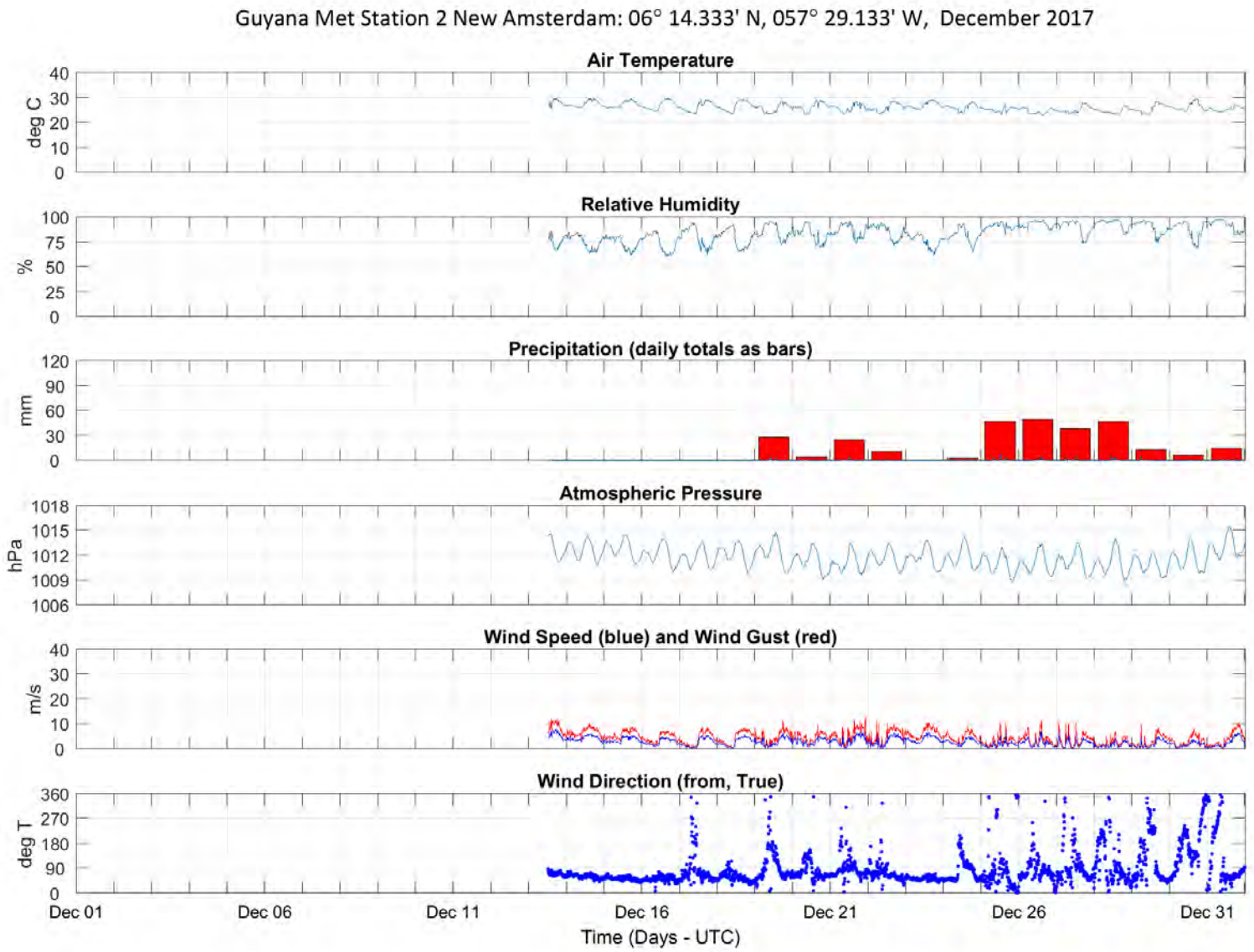
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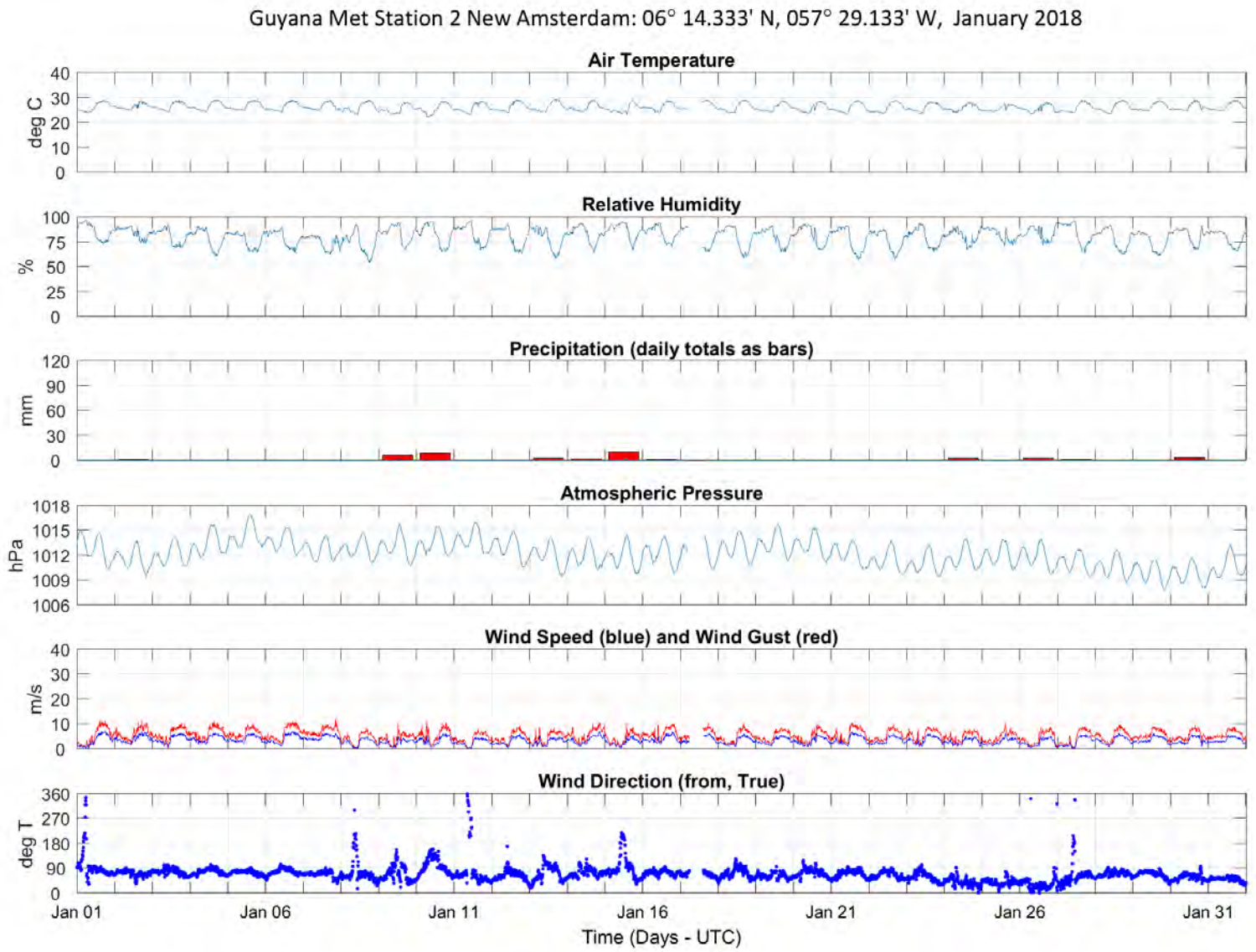
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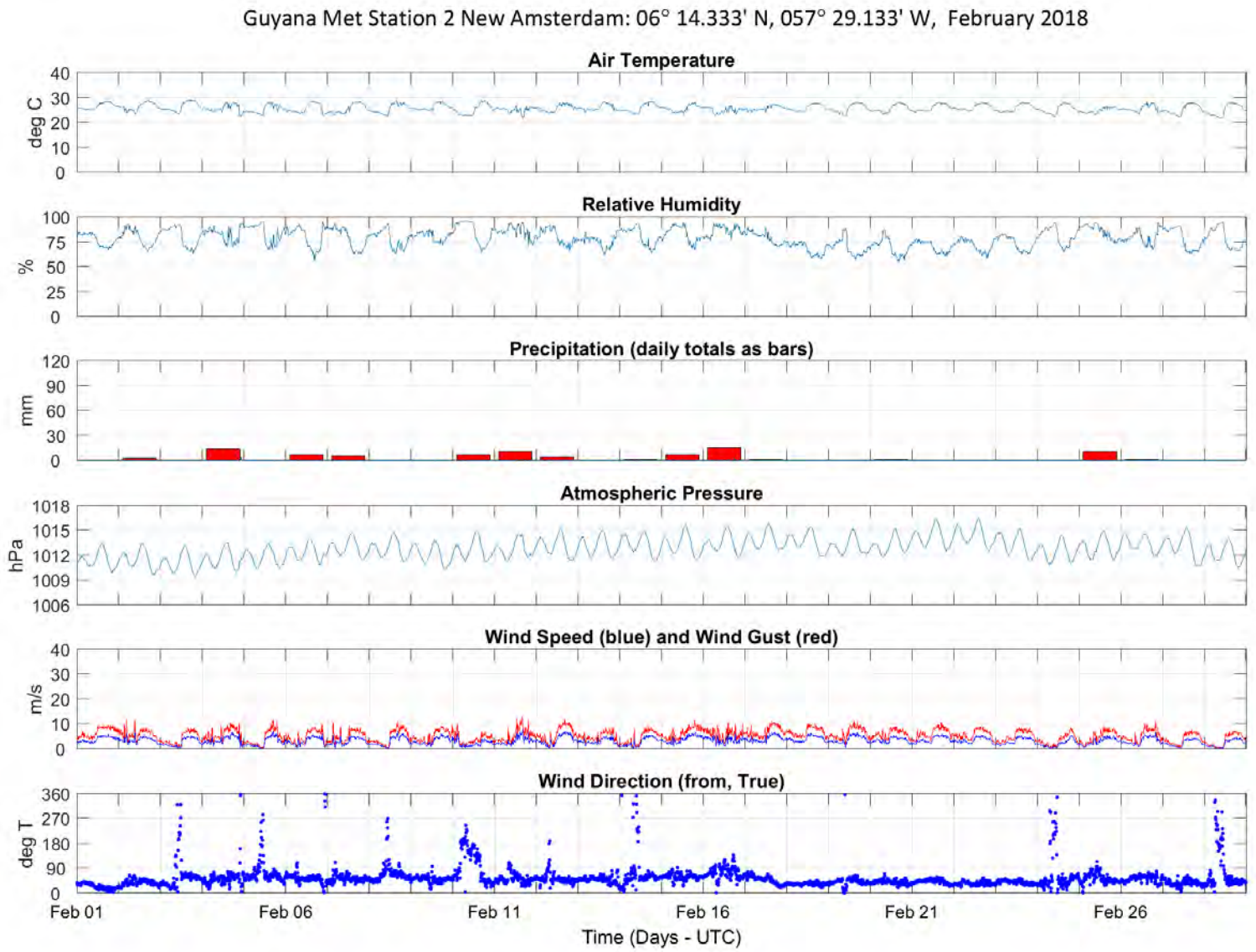
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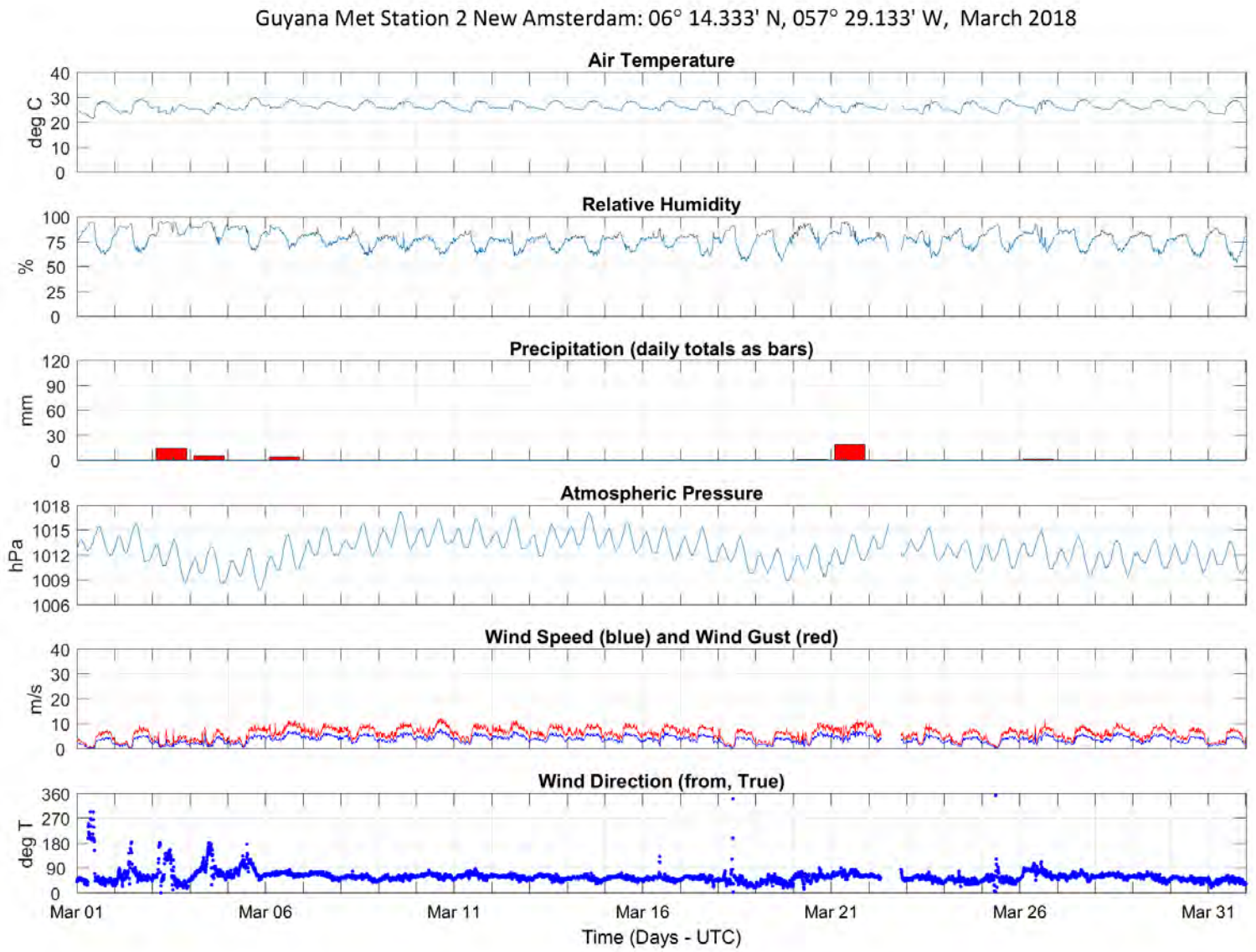
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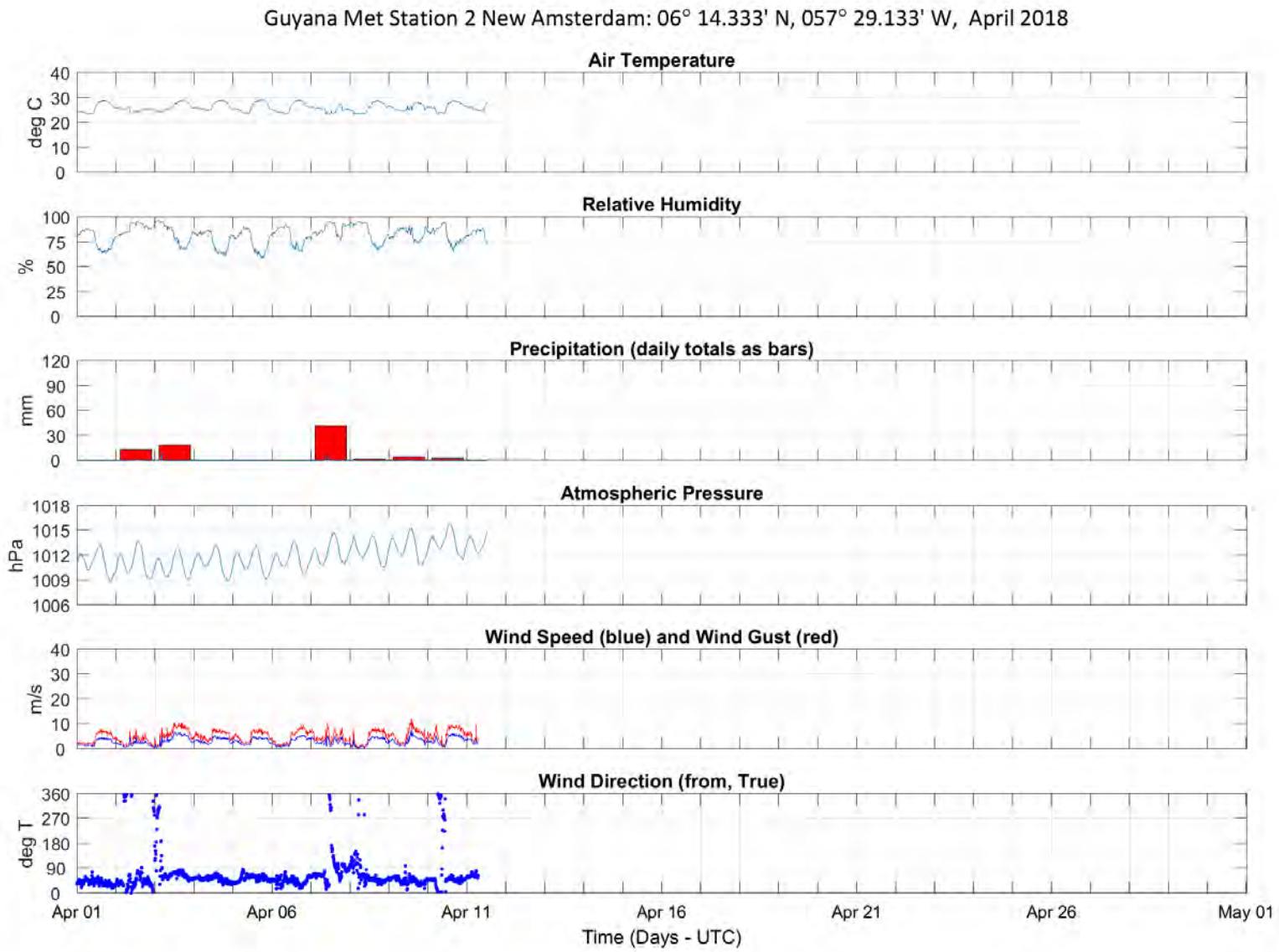
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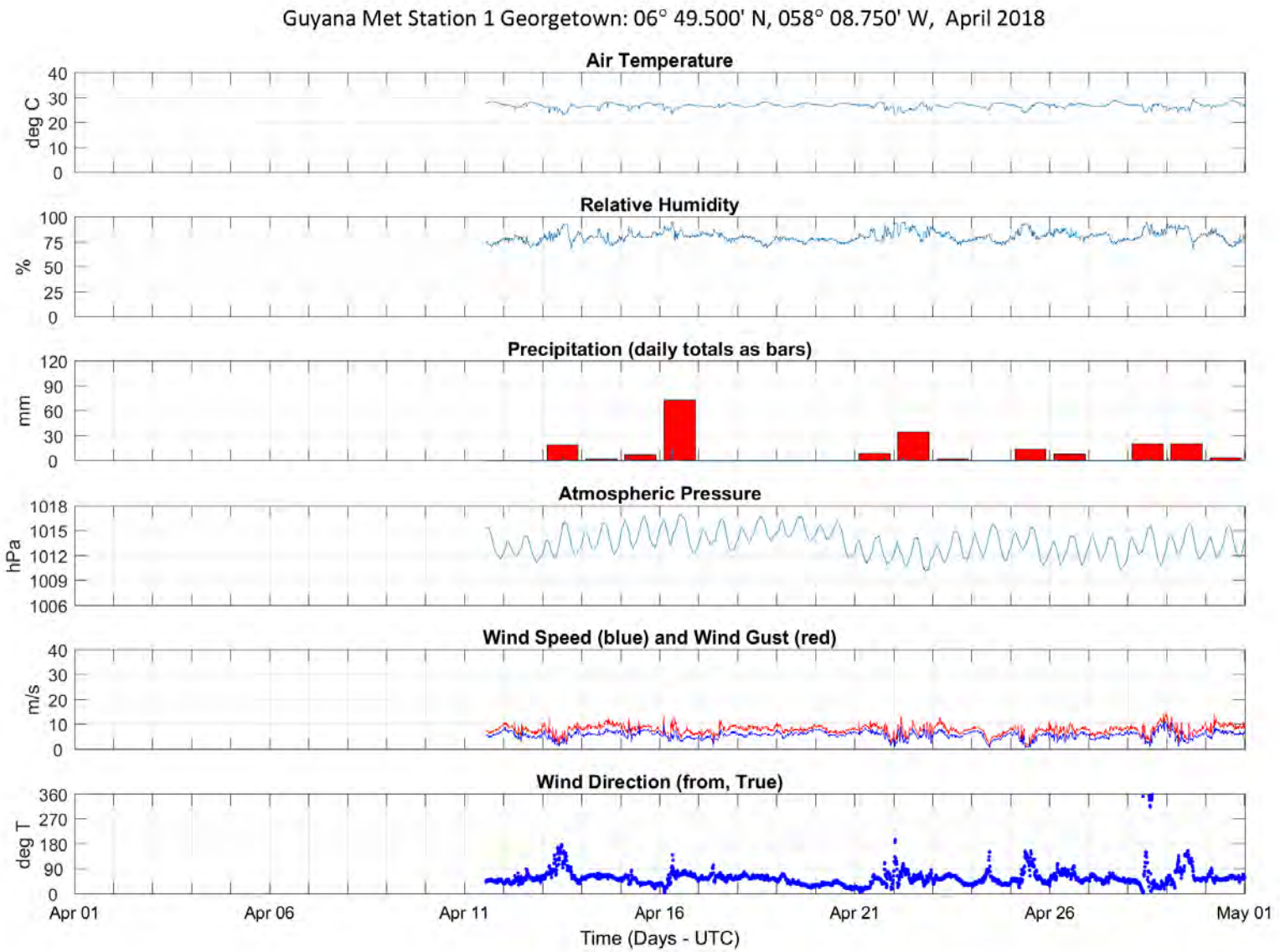
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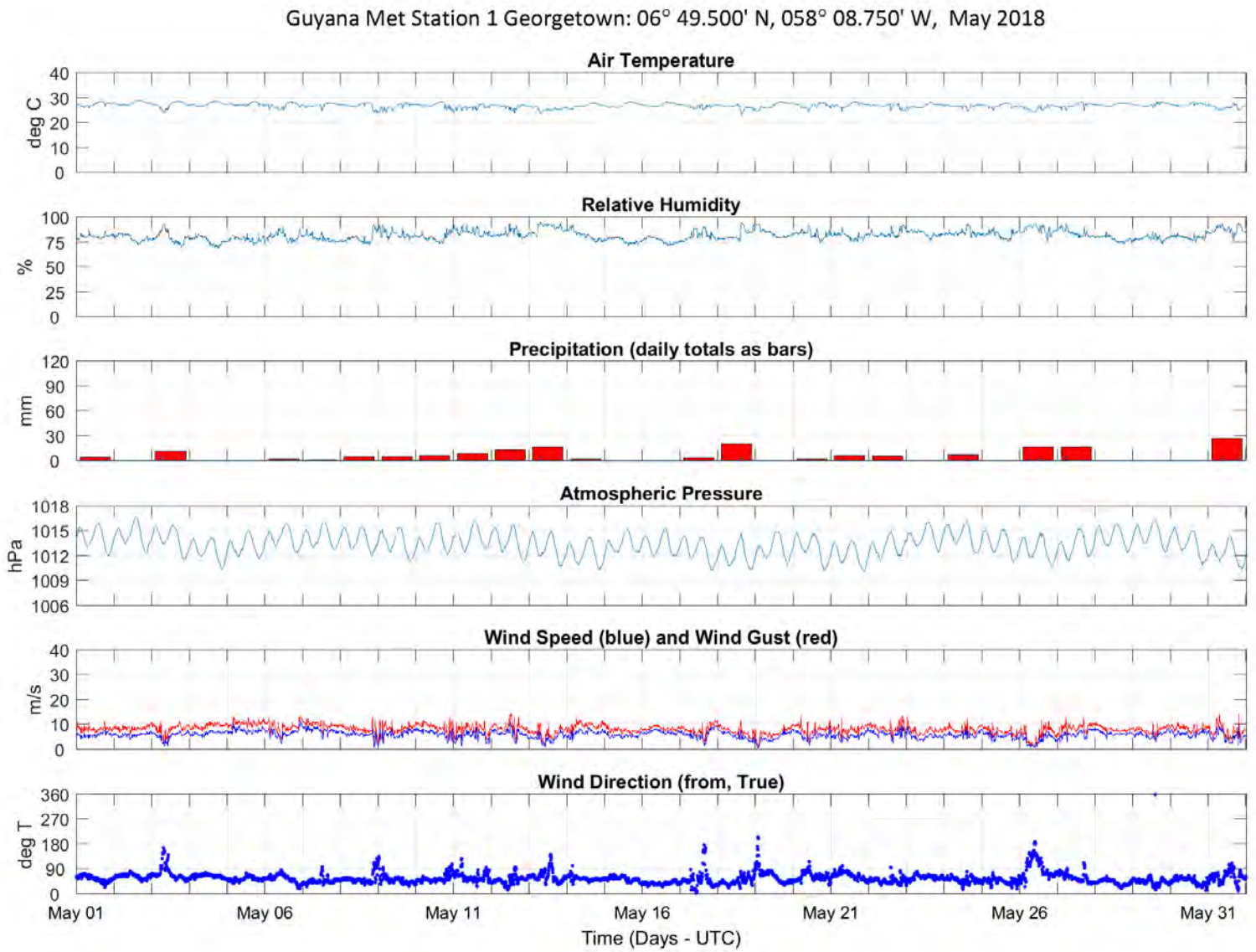
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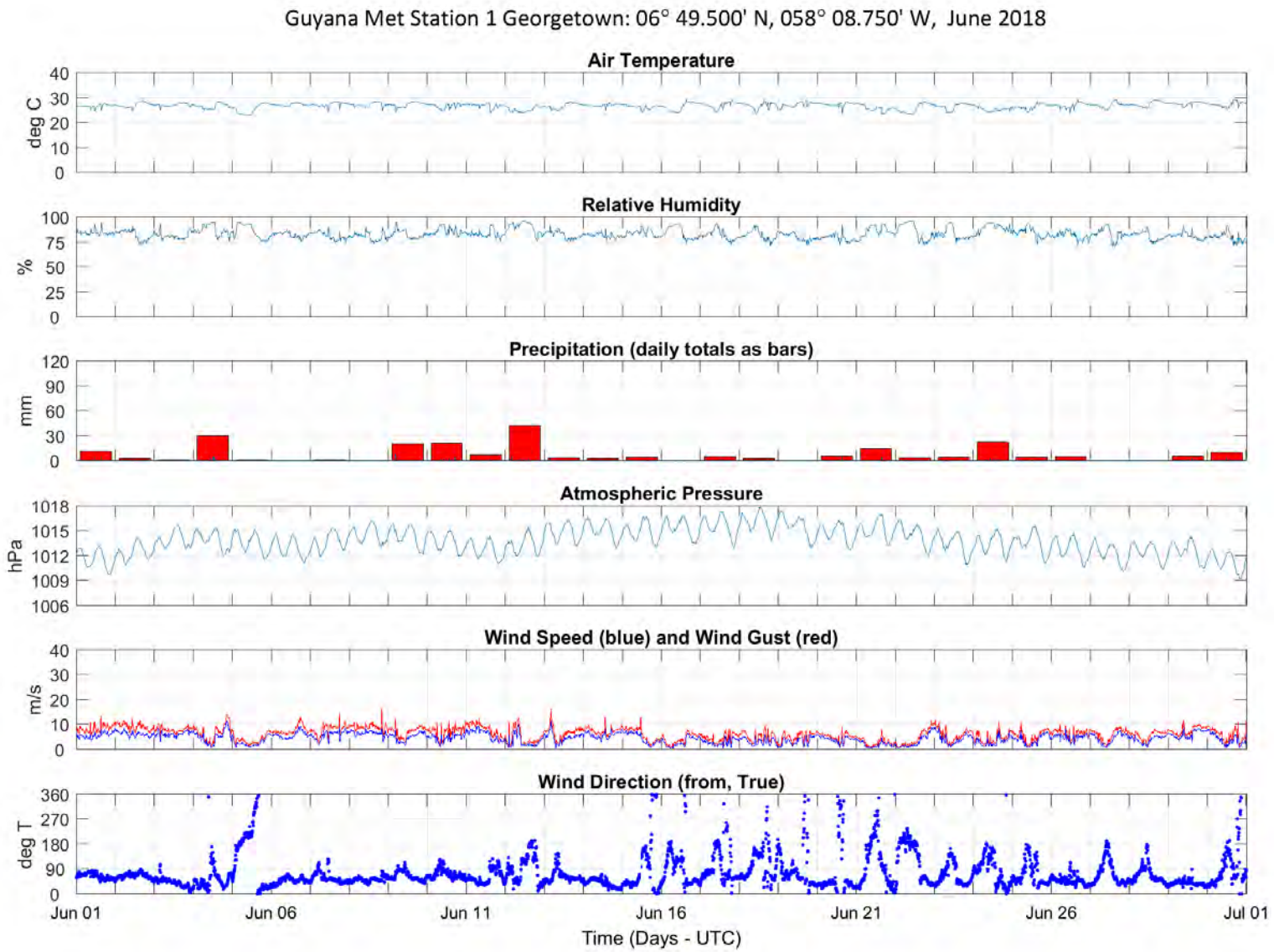
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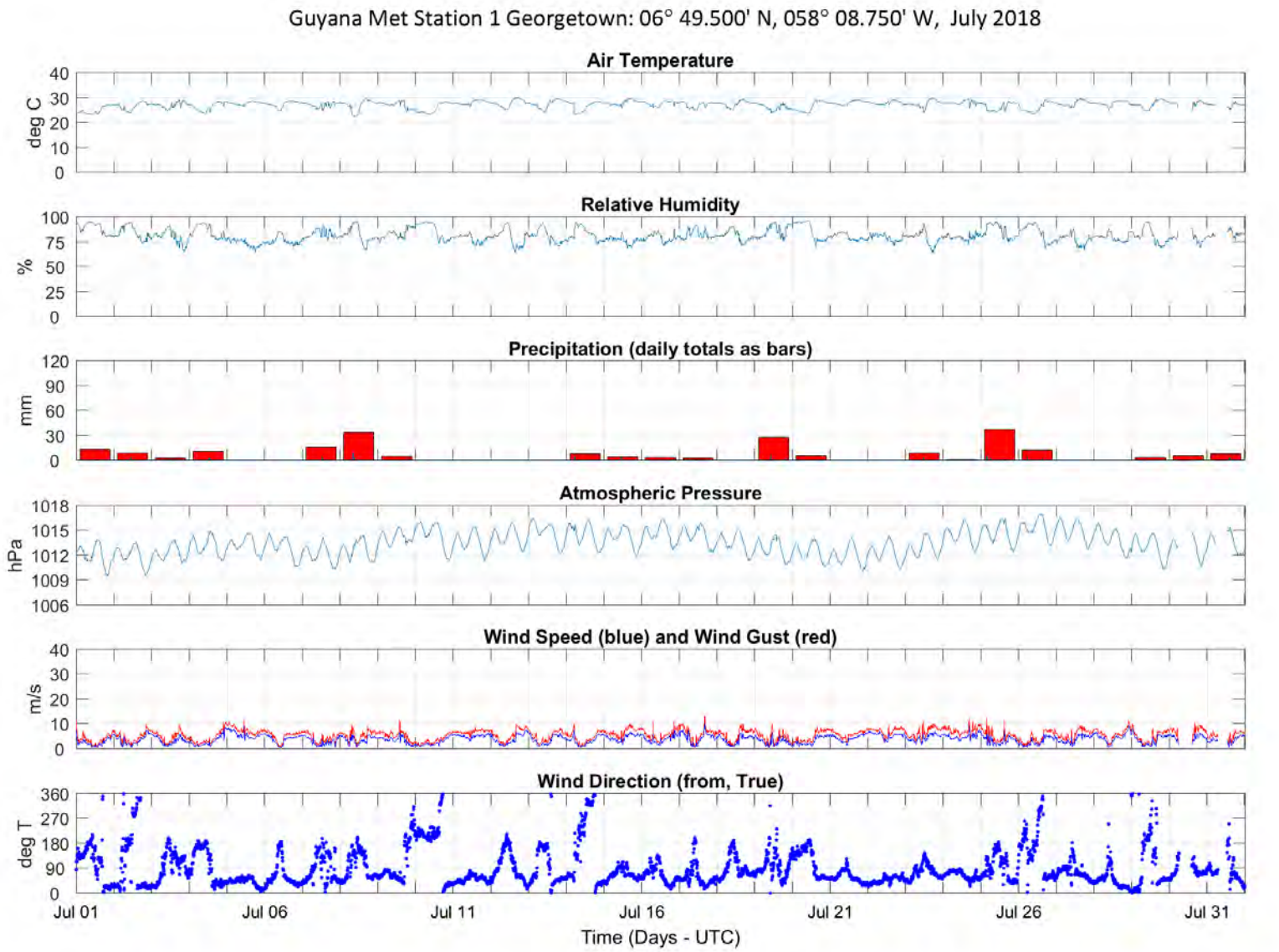
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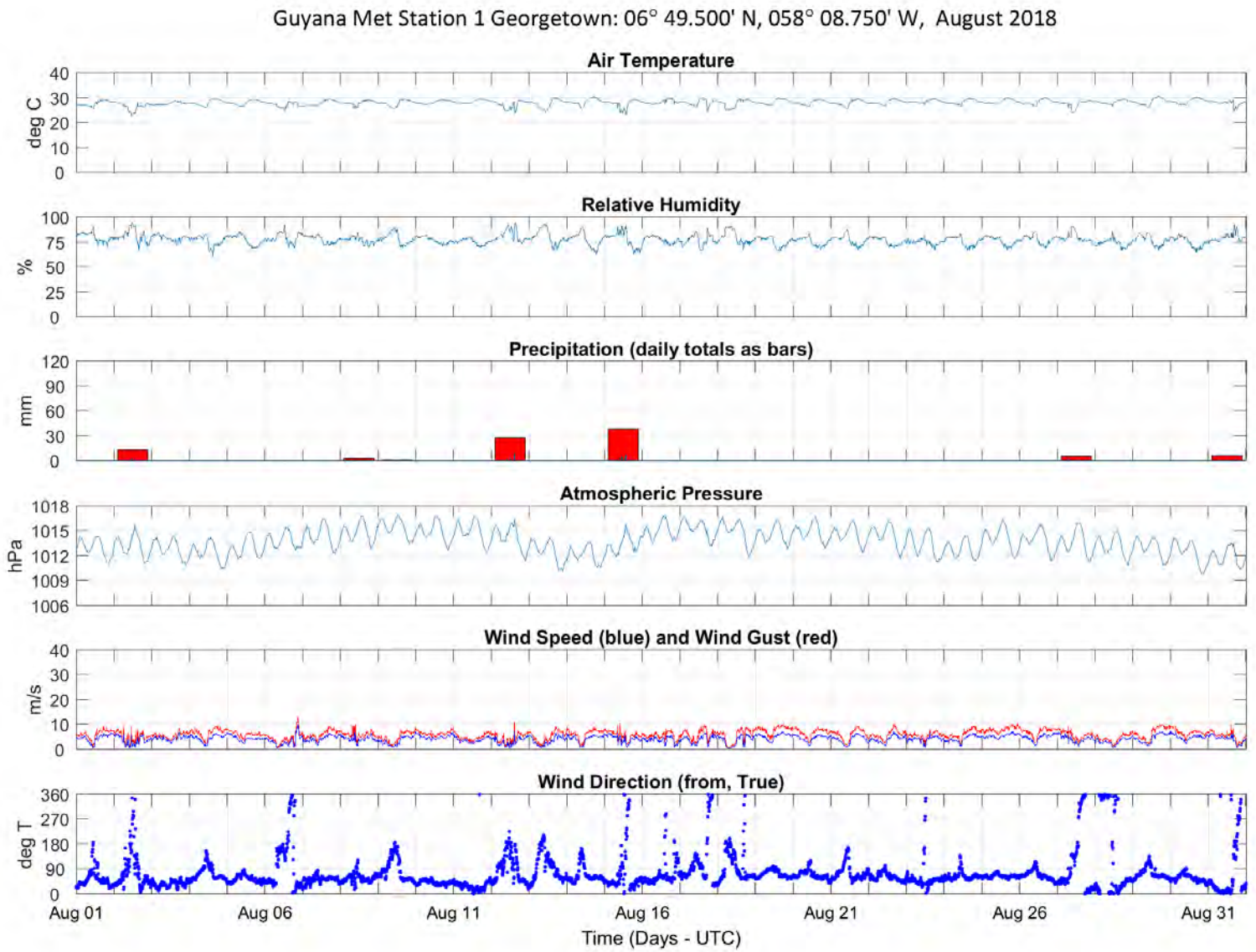
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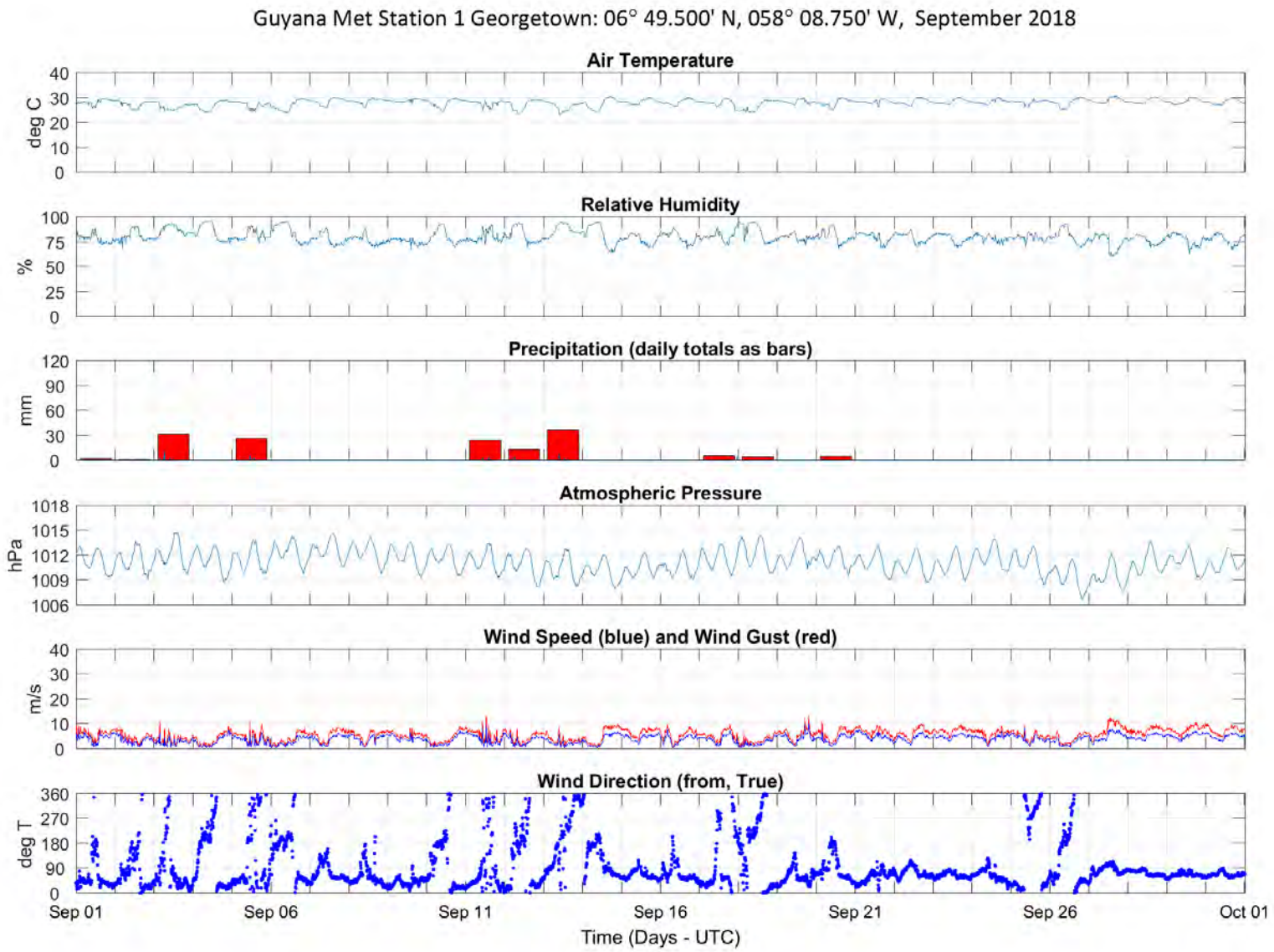
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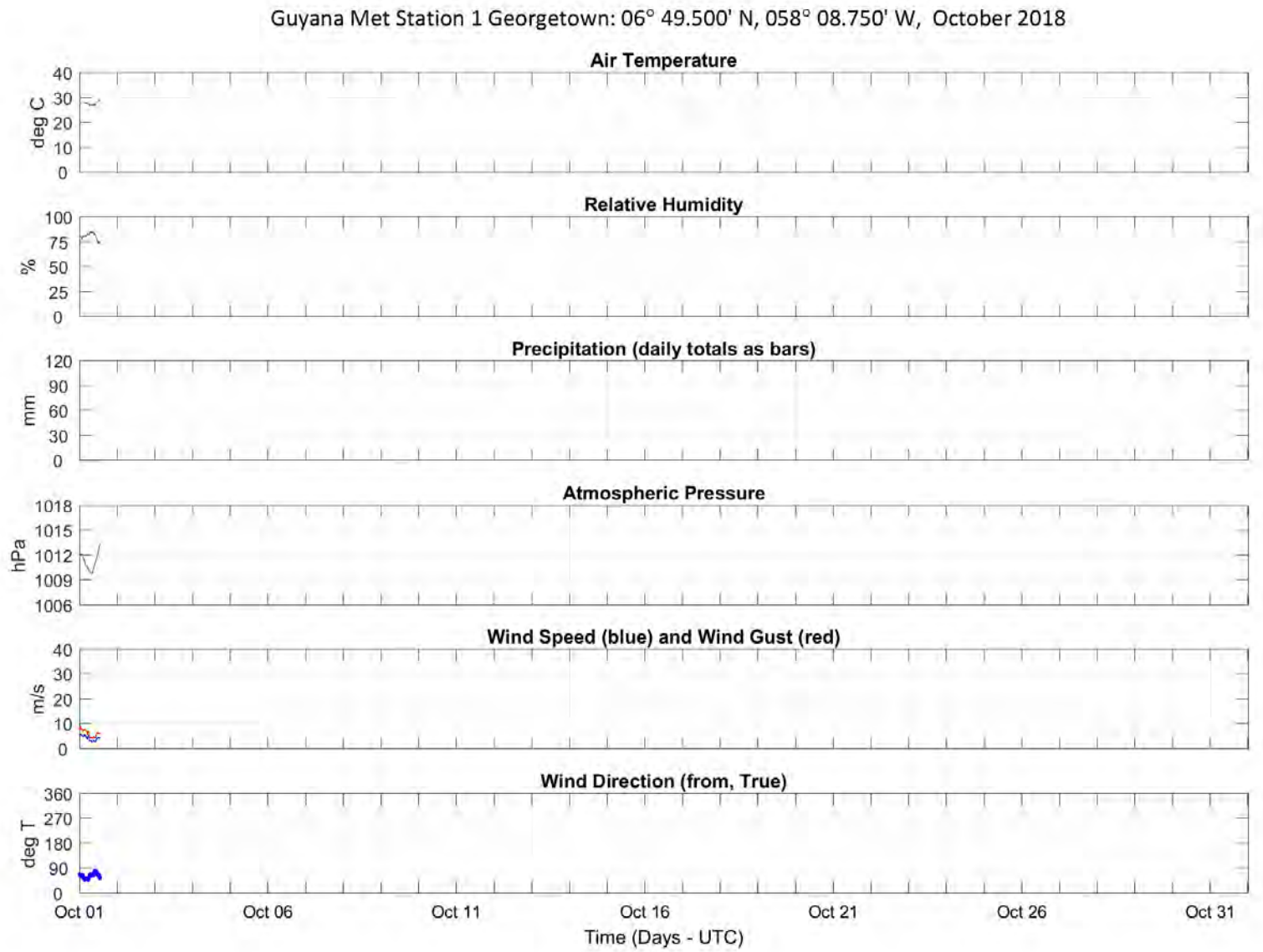
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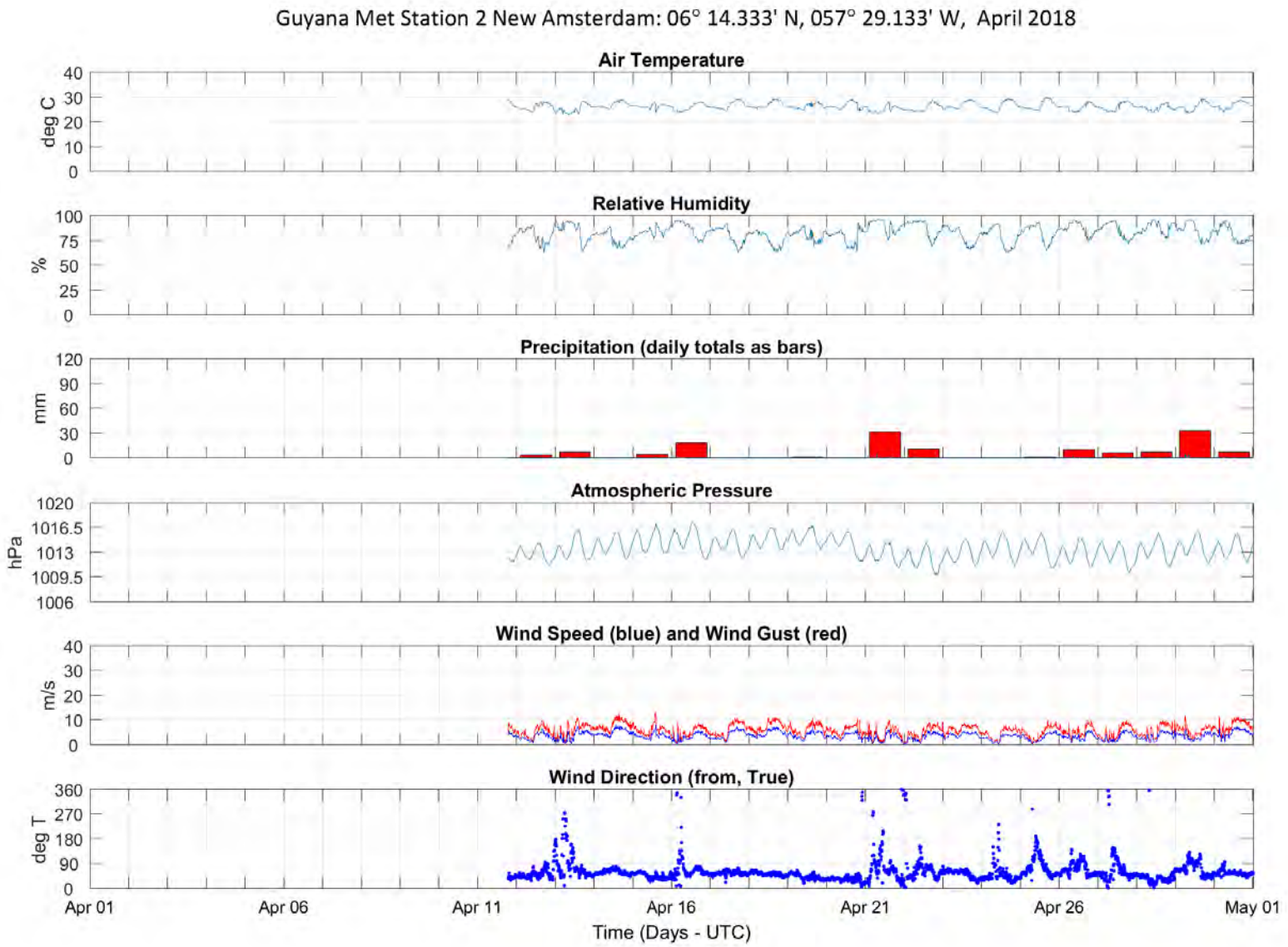
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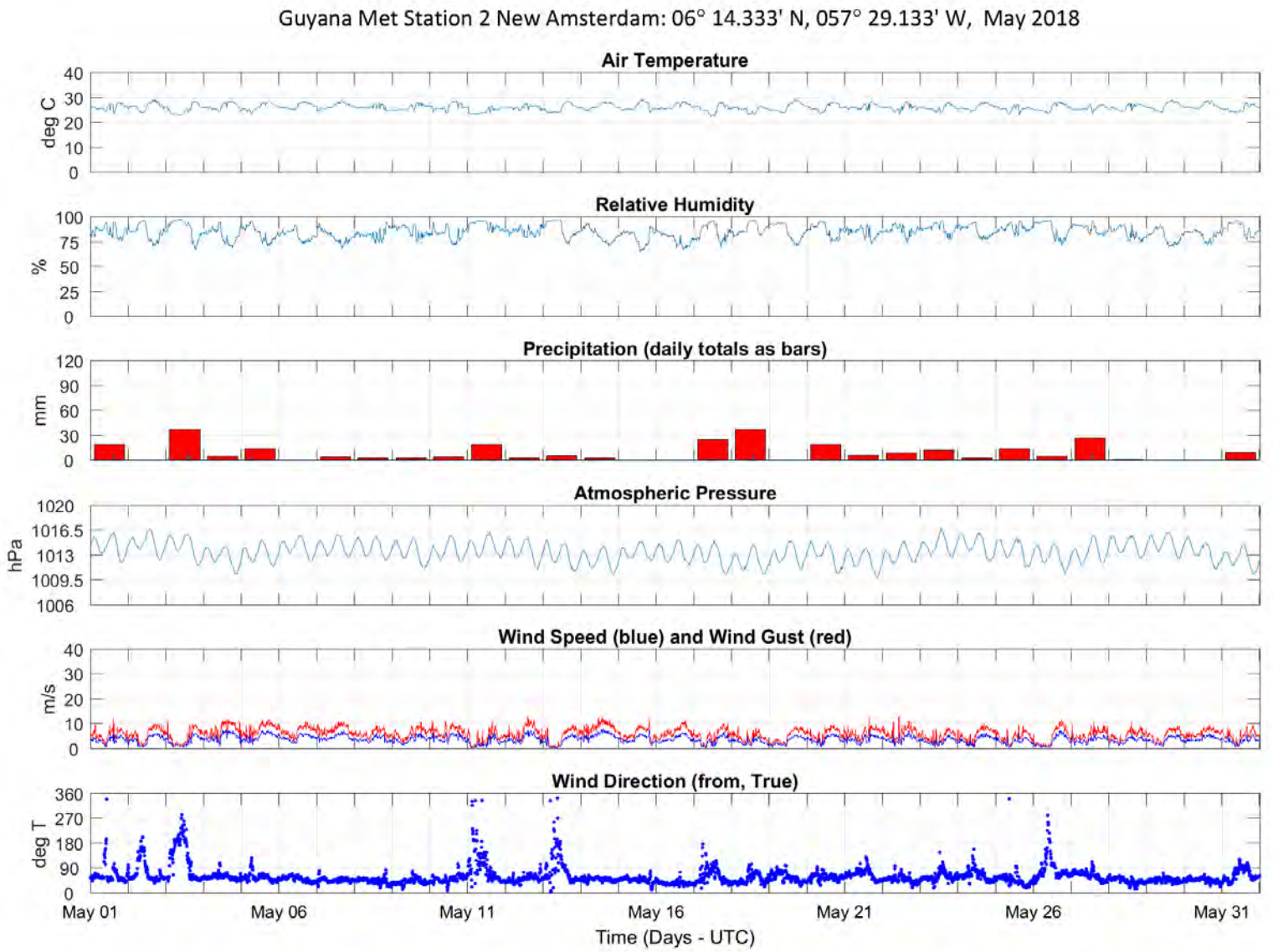
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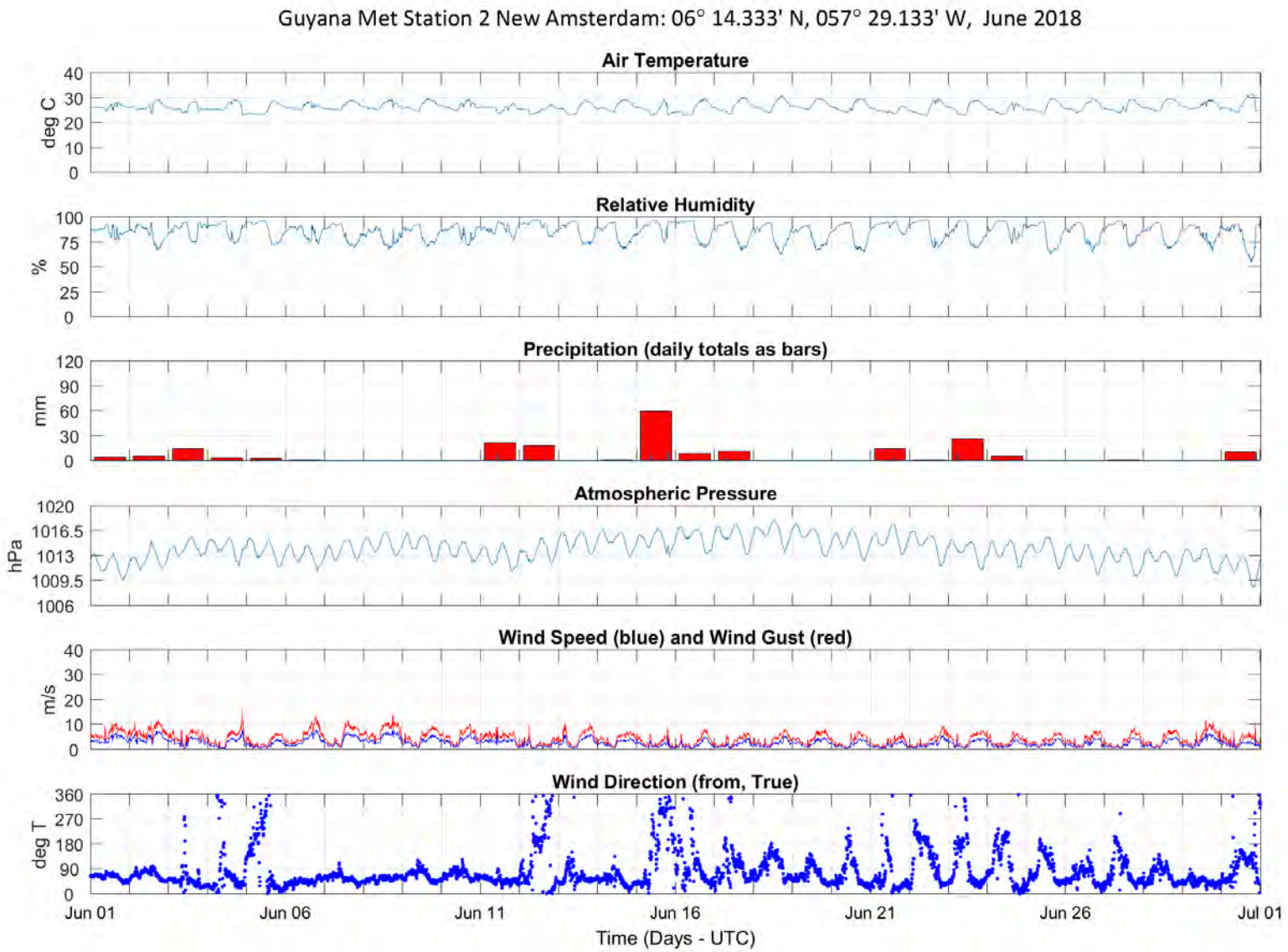
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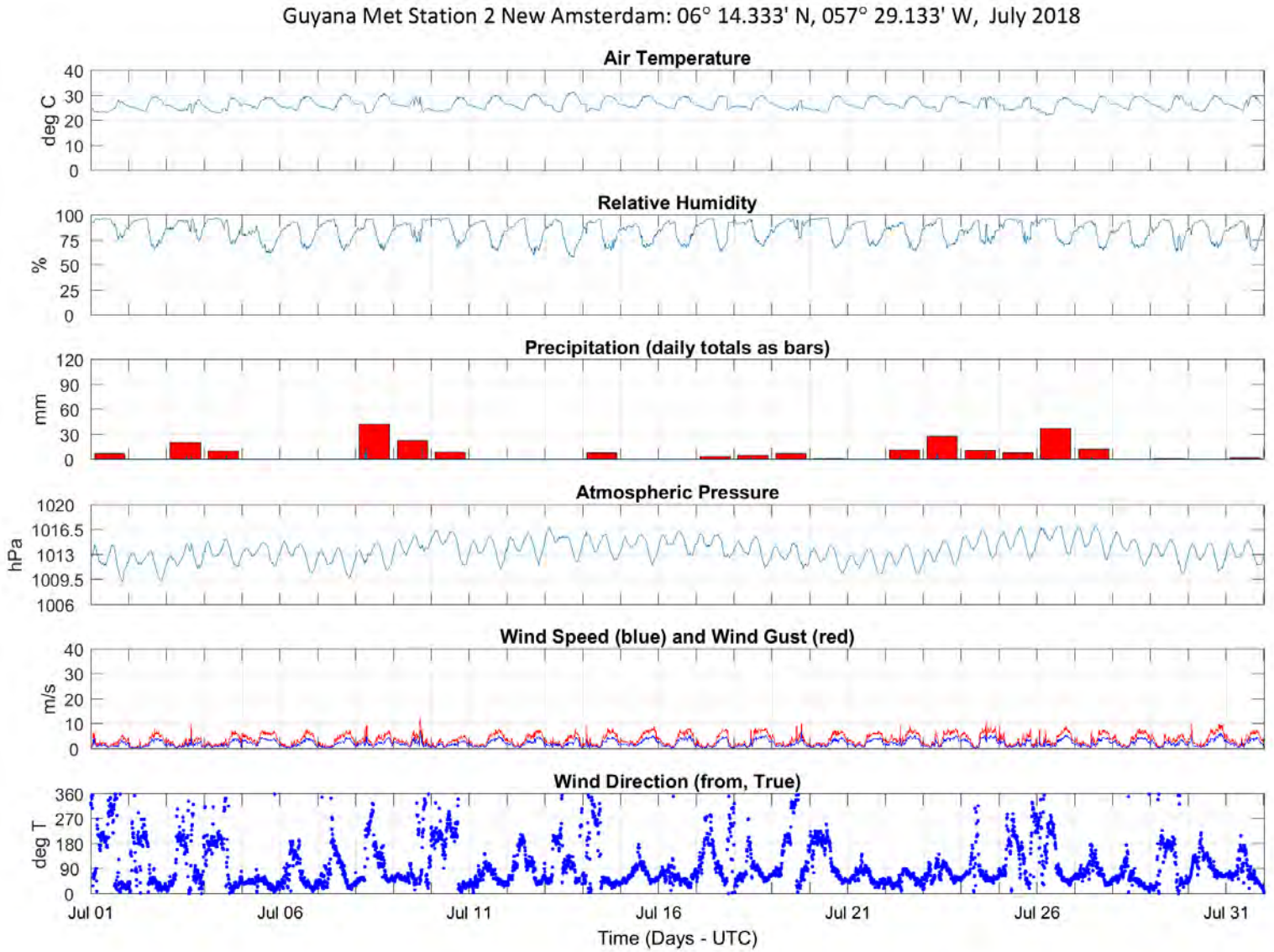
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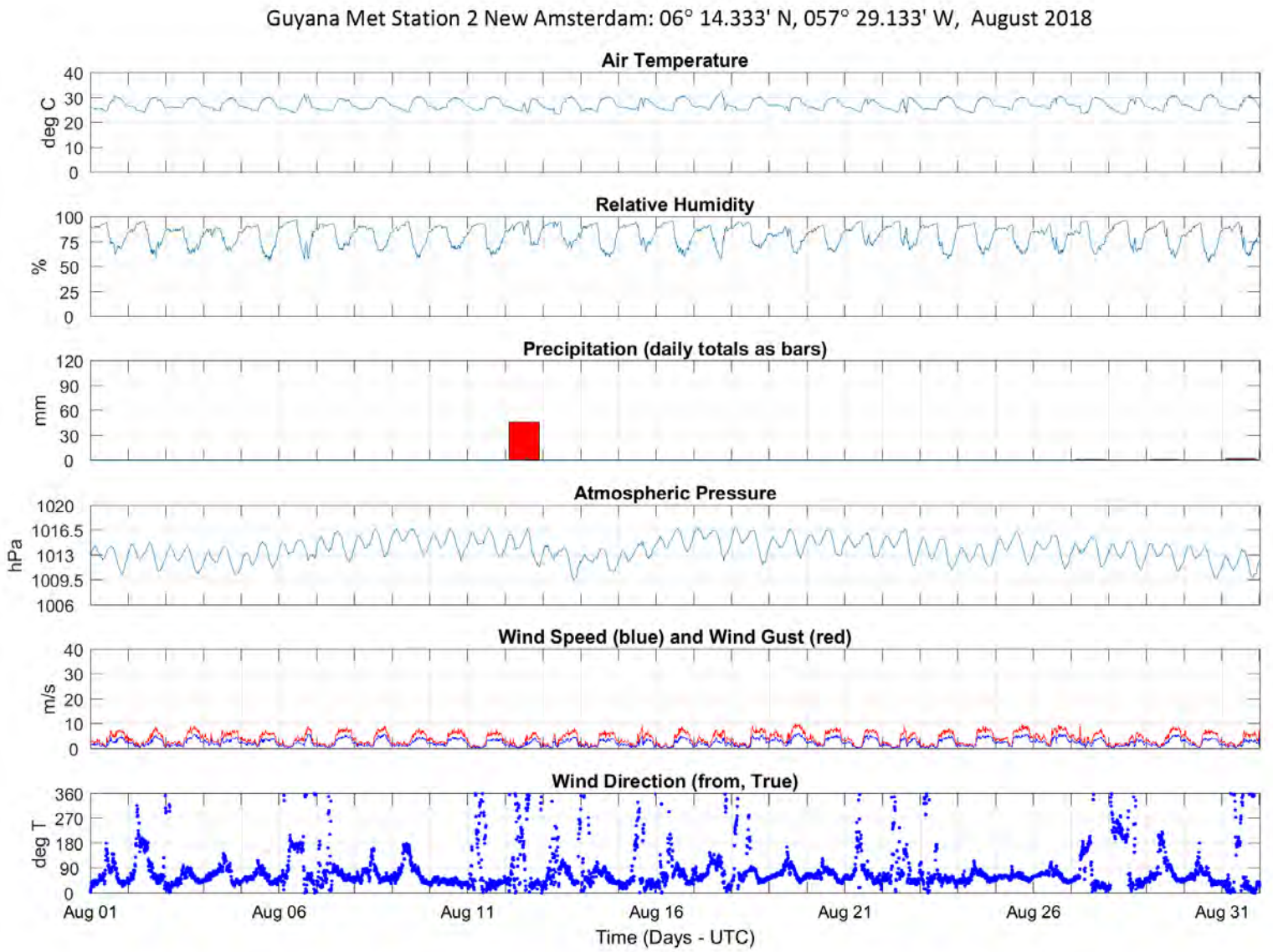
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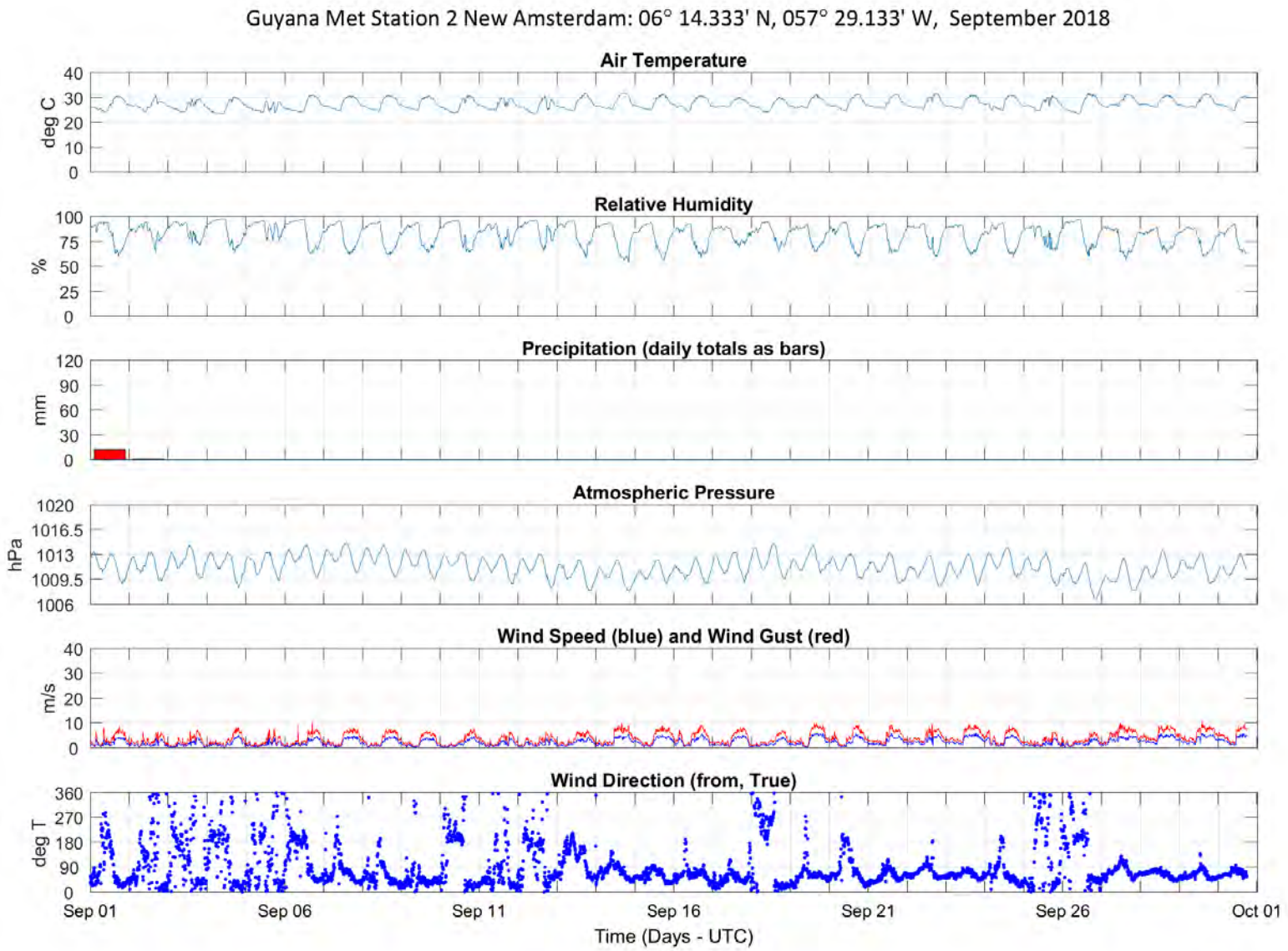
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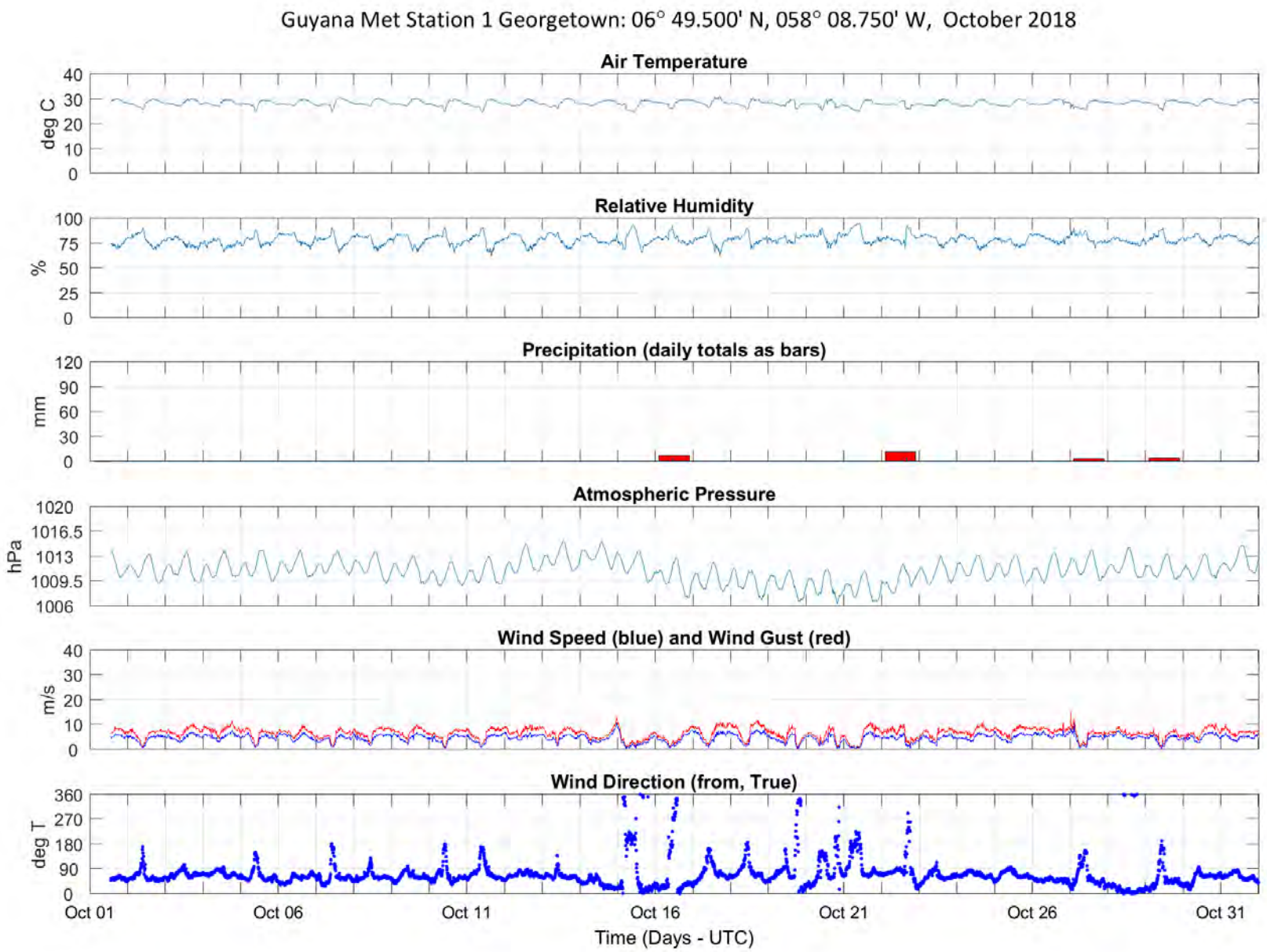
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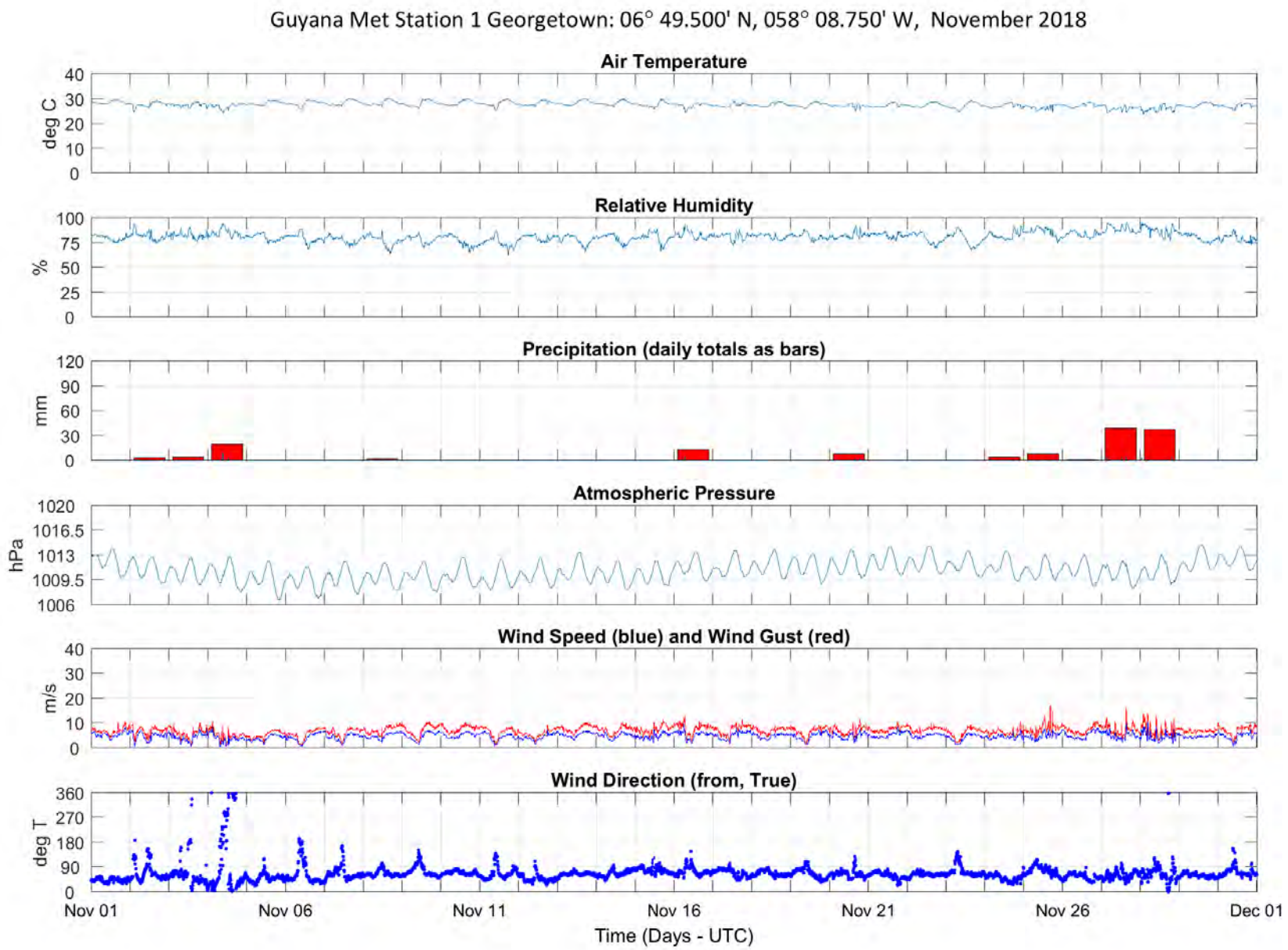


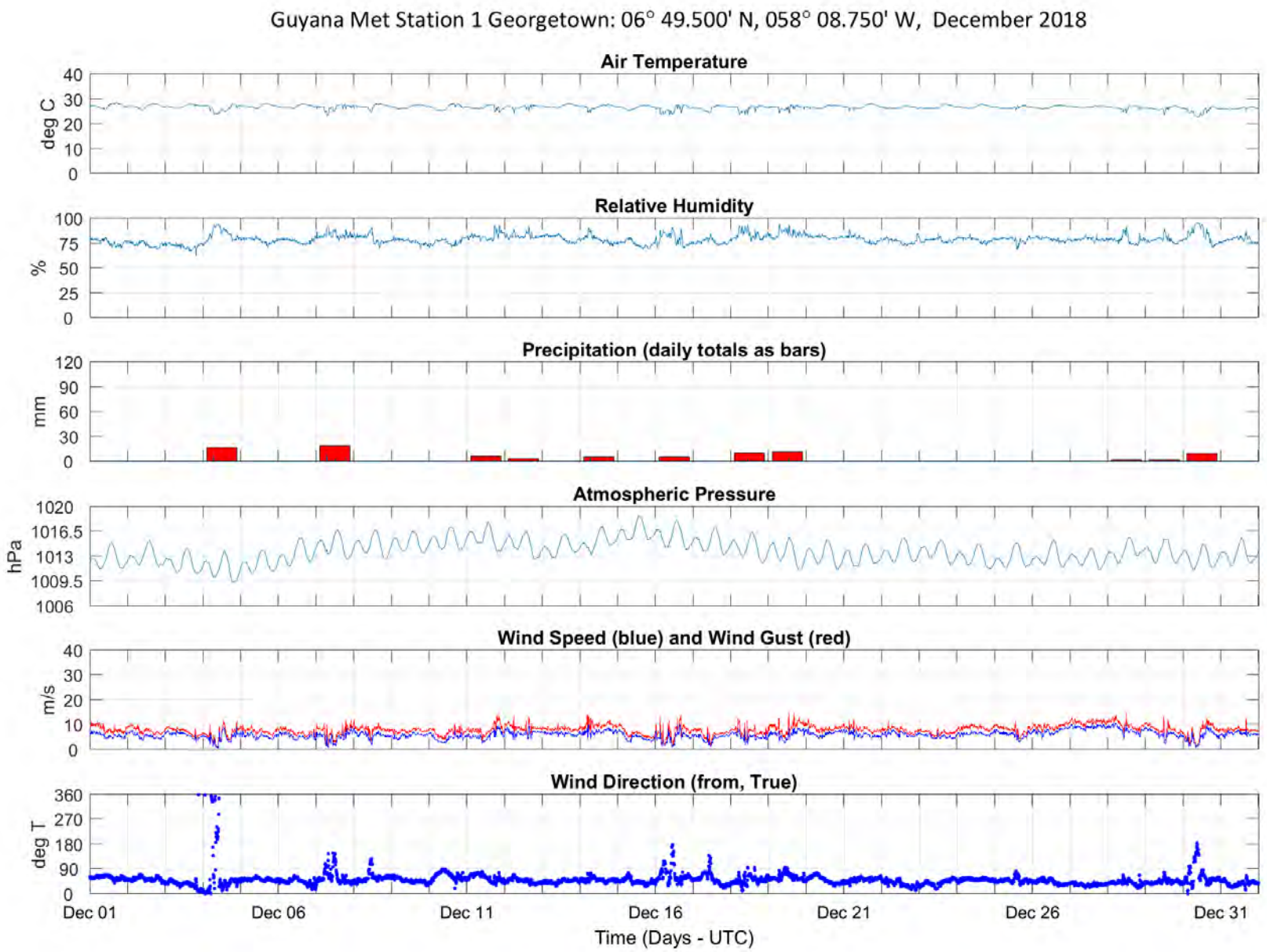
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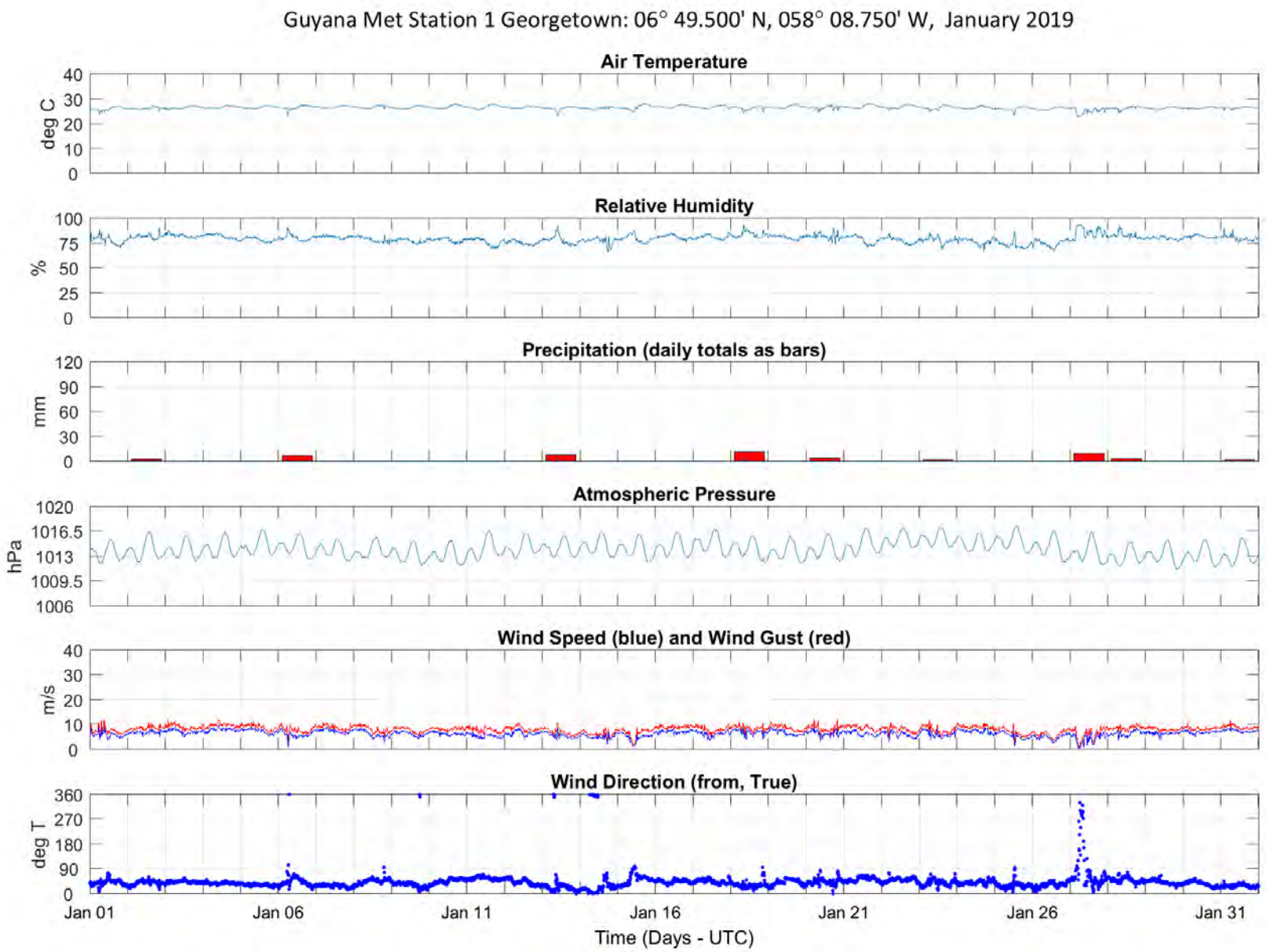


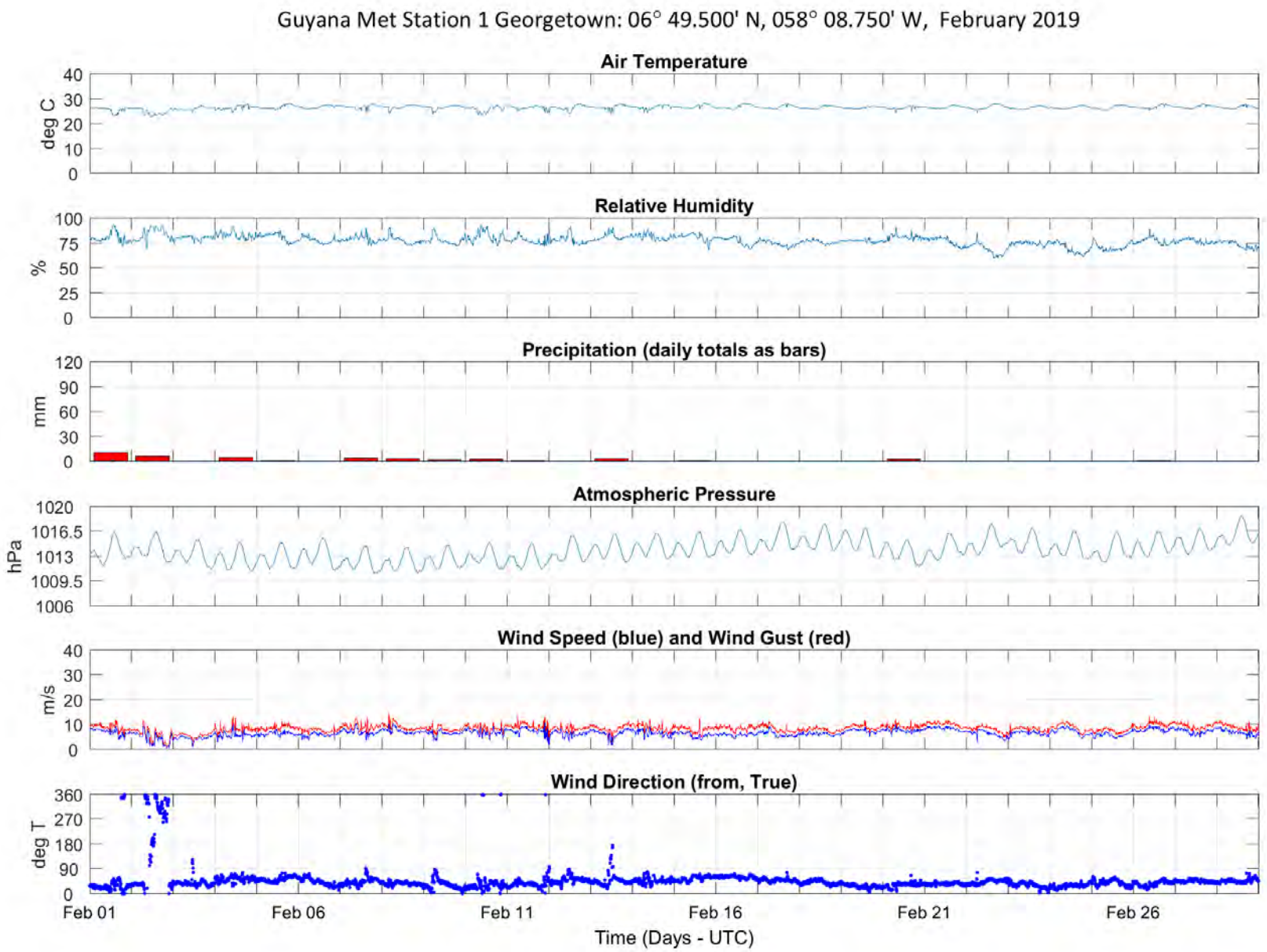
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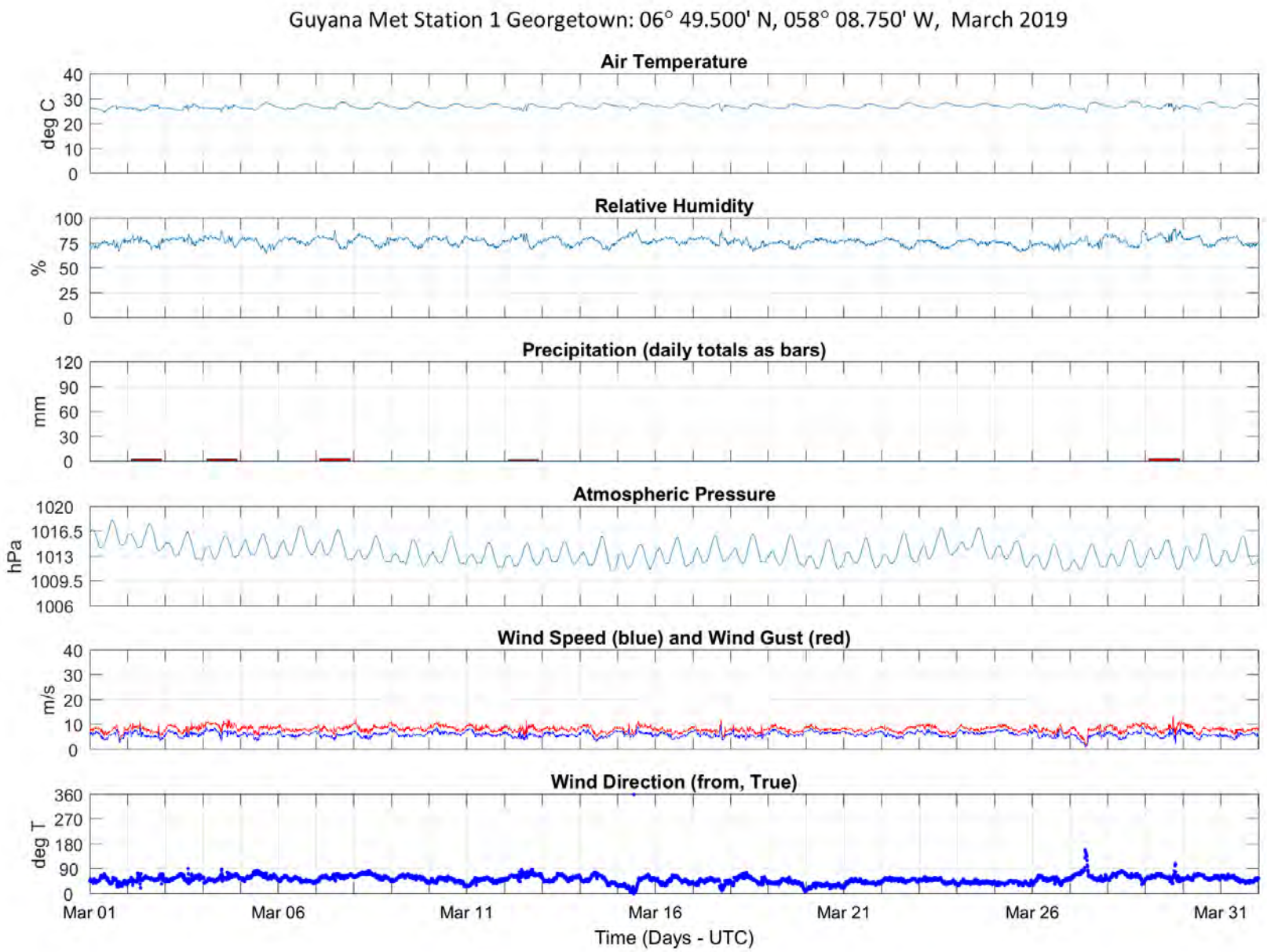

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, October 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)

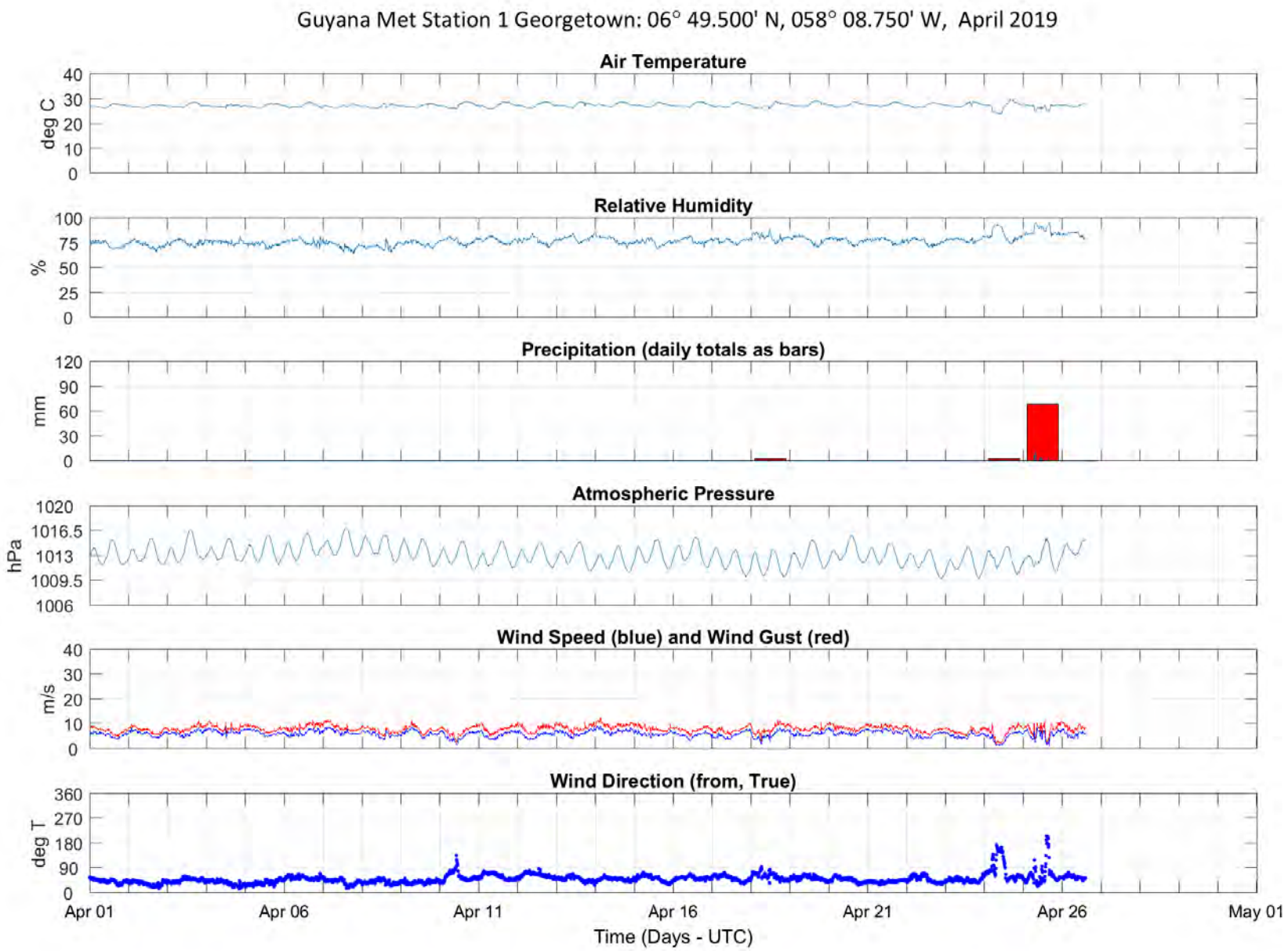

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, November 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)

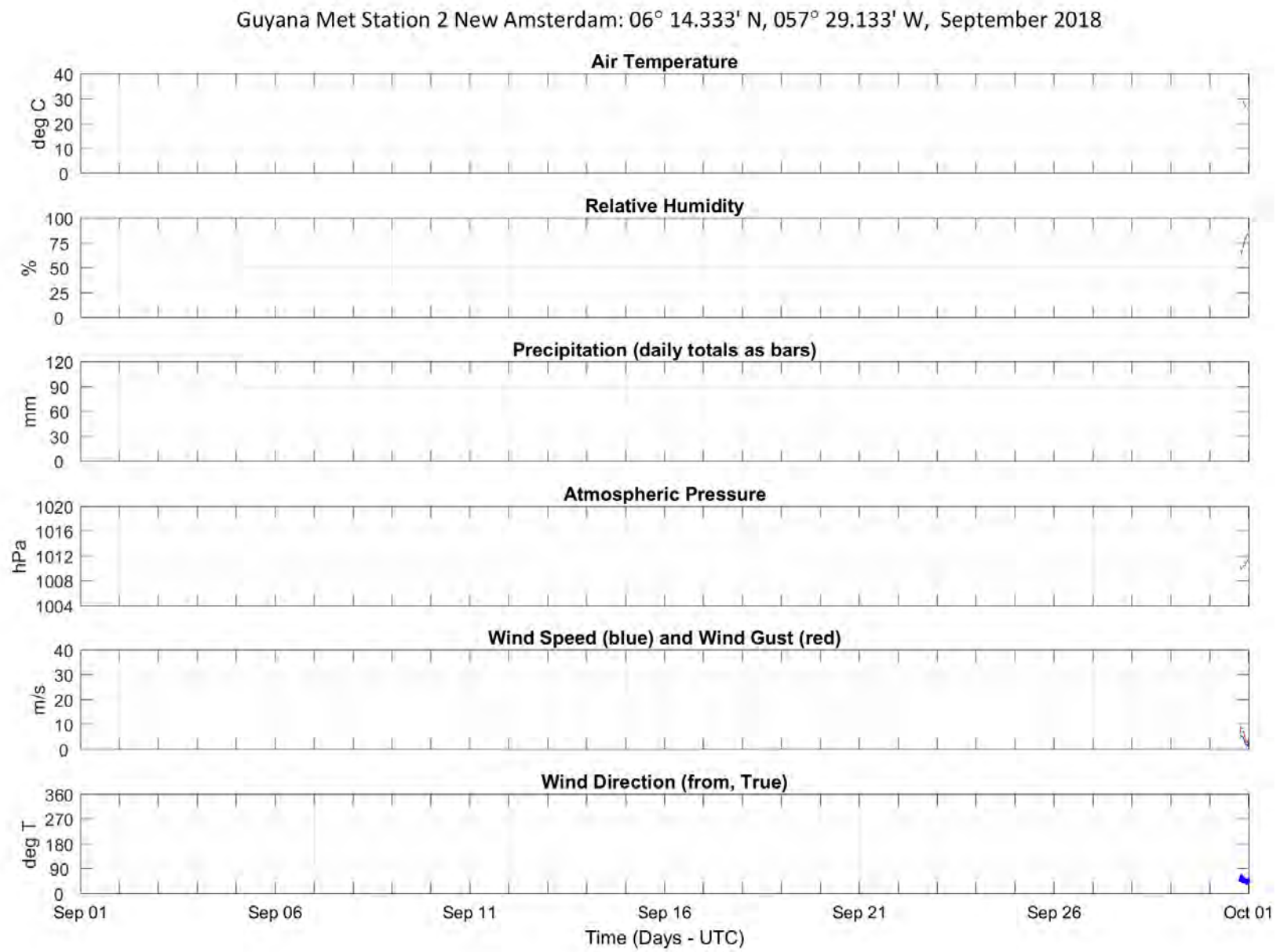

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, December 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Dec 01
Dec 06
Dec 11
Dec 16
Dec 21
Dec 26
Dec 31
Time (Days - UTC)

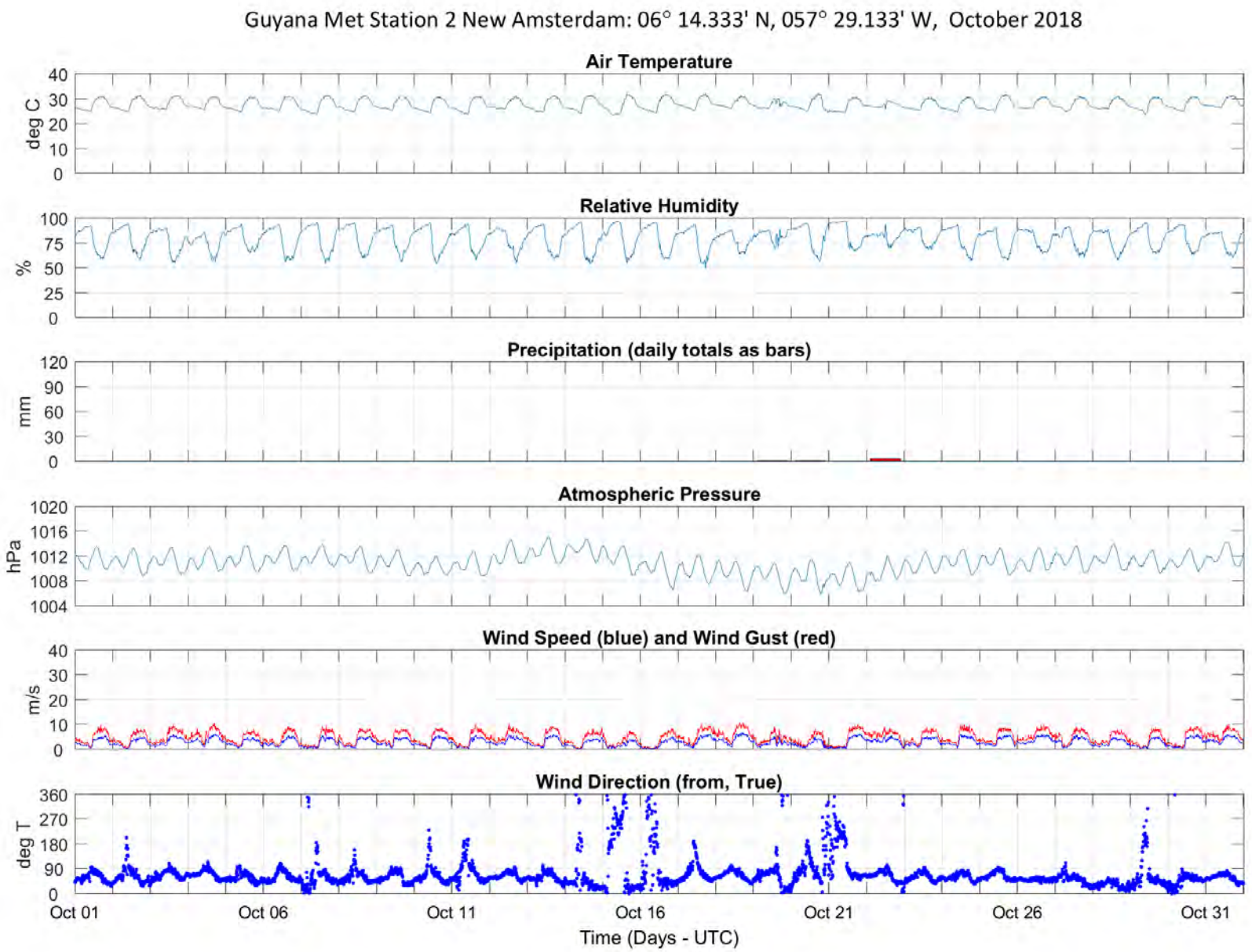

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, January 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Jan 01
Jan 06
Jan 11
Jan 16
Jan 21
Jan 26
Jan 31
Time (Days - UTC)

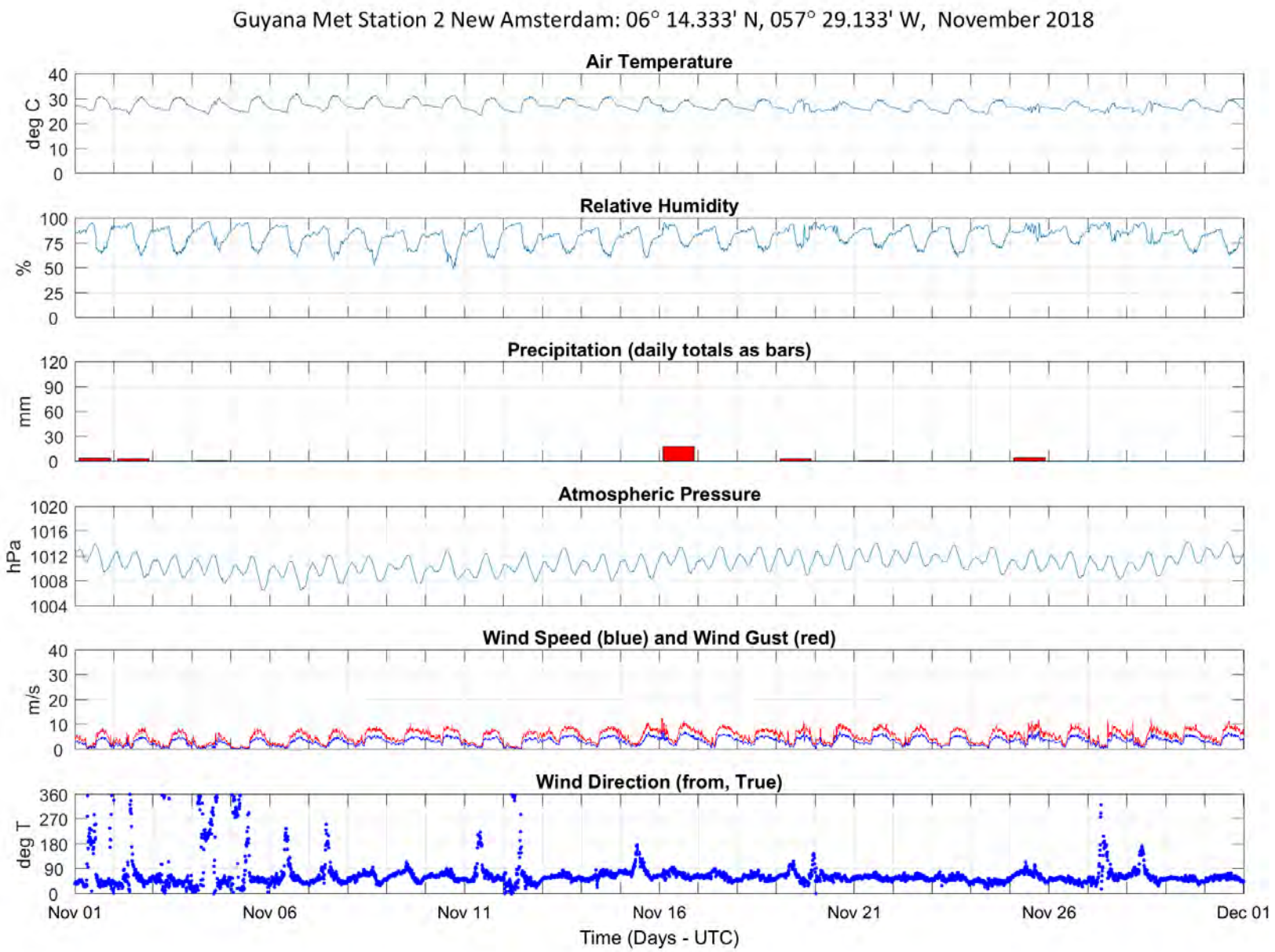

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, February 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Feb 01
Feb 06
Feb 11
Feb 16
Feb 21
Feb 26
Time (Days - UTC)

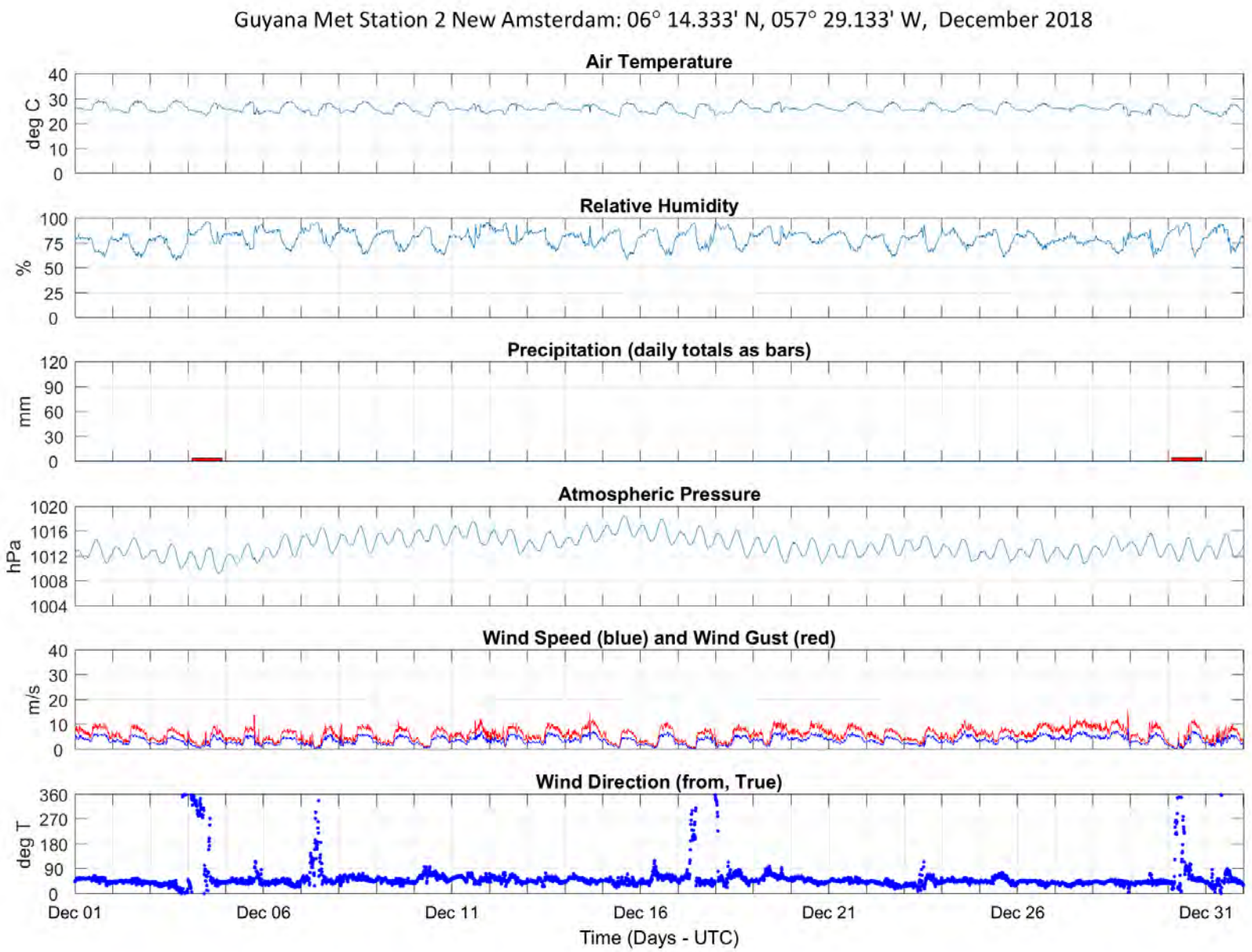

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, March 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Mar 01
Mar 06
Mar 11
Mar 16
Mar 21
Mar 26
Mar 31
Time (Days - UTC)

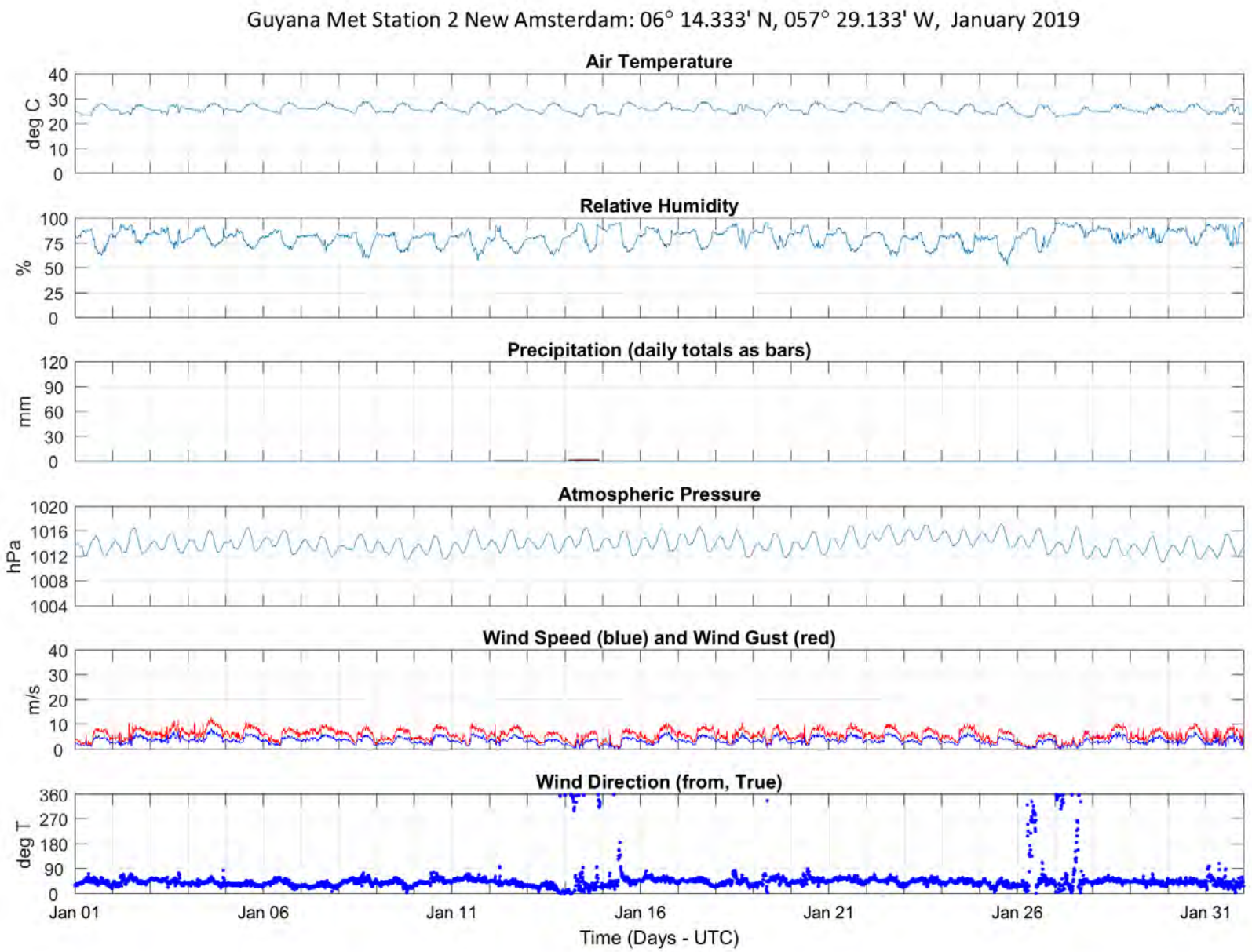

Guyana Met Station 1 Georgetown: 06° 49.500' N, 058° 08.750' W, April 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016.5
1013
1009.5
1006
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Apr 01
Apr 06
Apr 11
Apr 16
Apr 21
Apr 26
May 01
Time (Days - UTC)

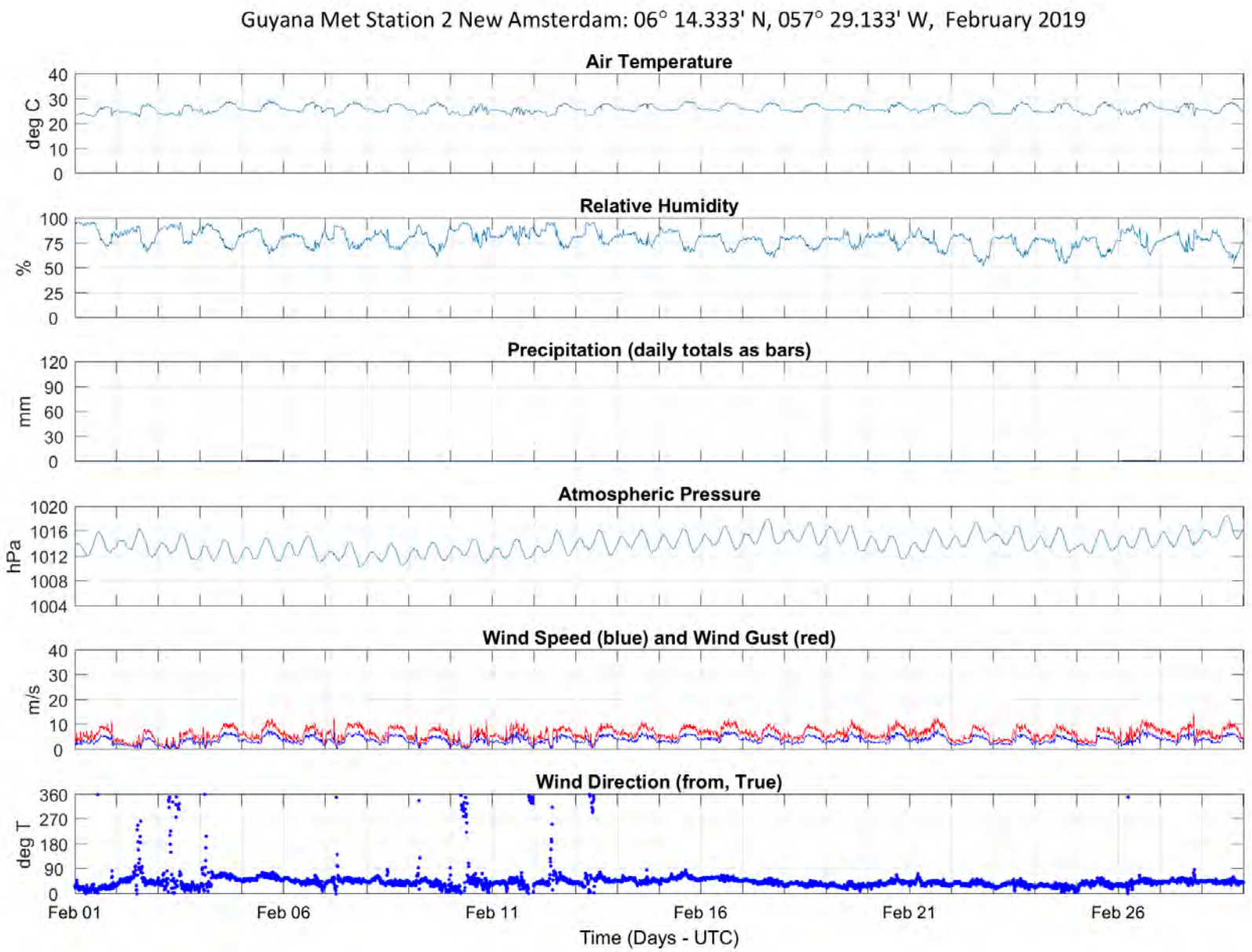

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, September 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Sep 01
Sep 06
Sep 11
Sep 16
Sep 21
Sep 26
Oct 01
Time (Days - UTC)

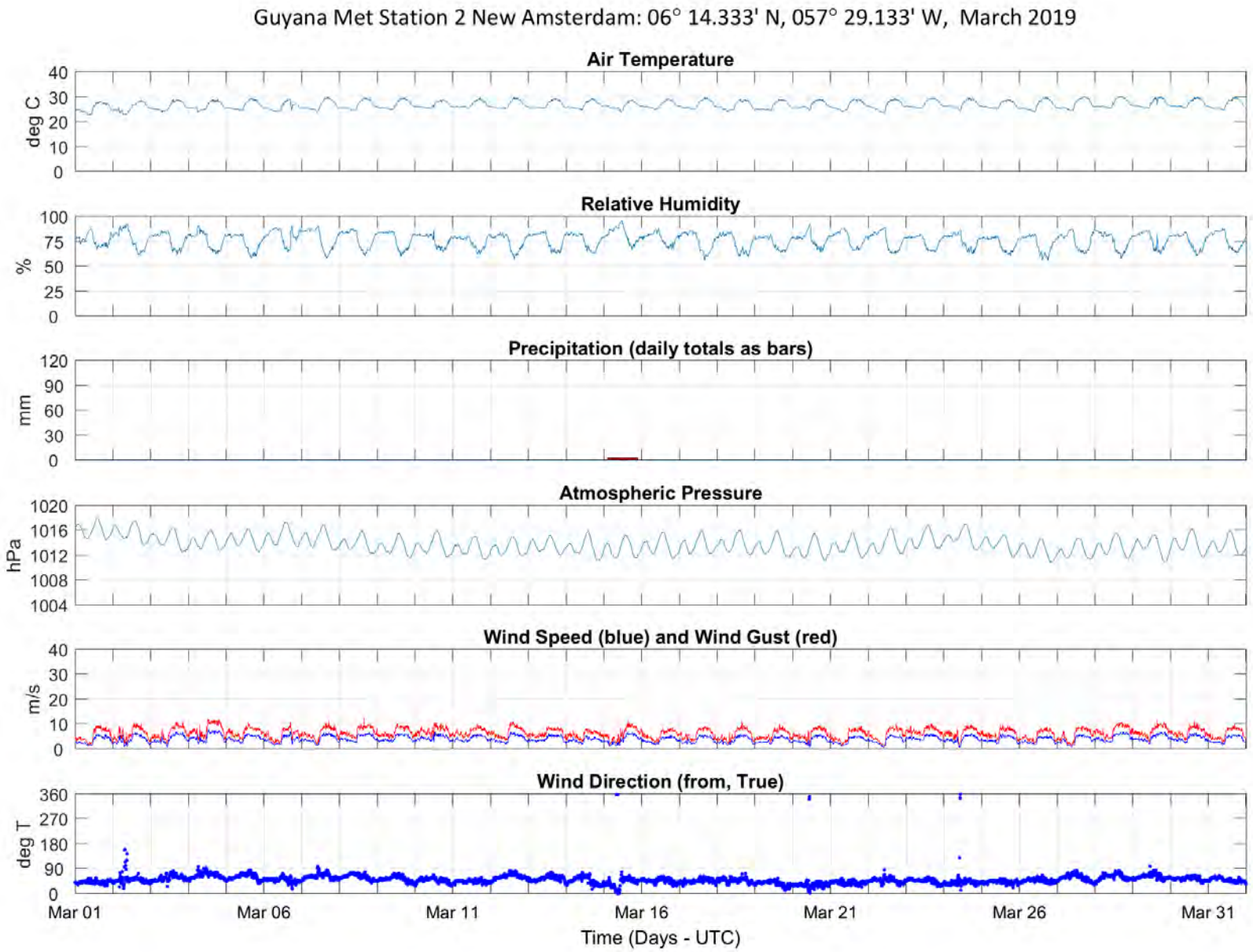

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, October 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Oct 01
Oct 06
Oct 11
Oct 16
Oct 21
Oct 26
Oct 31
Time (Days - UTC)

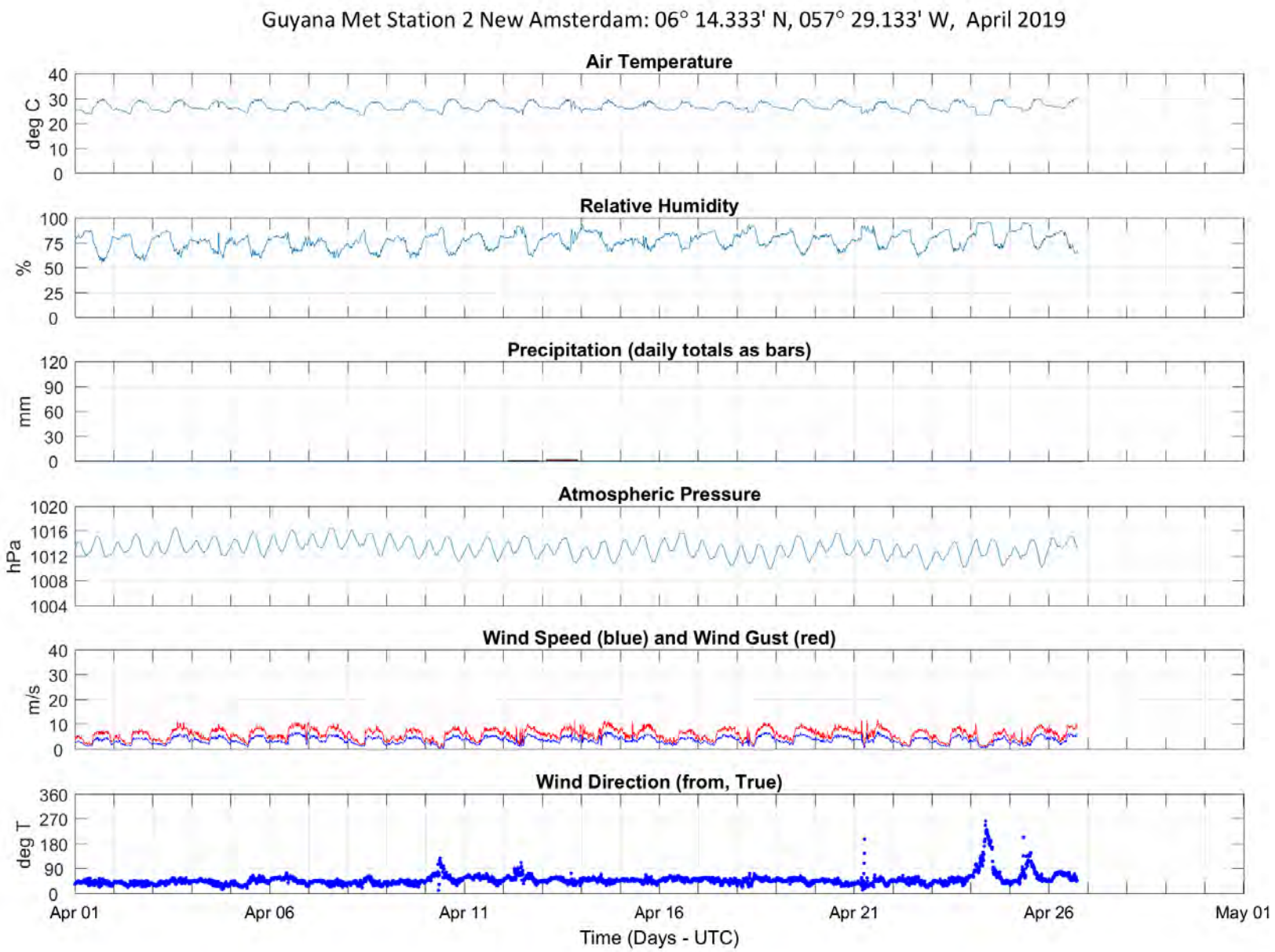

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, November 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Nov 01
Nov 06
Nov 11
Nov 16
Nov 21
Nov 26
Dec 01
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, December 2018
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Dec 01
Dec 06
Dec 11
Dec 16
Dec 21
Dec 26
Dec 31
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, January 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Jan 01
Jan 06
Jan 11
Jan 16
Jan 21
Jan 26
Jan 31
Time (Days - UTC)

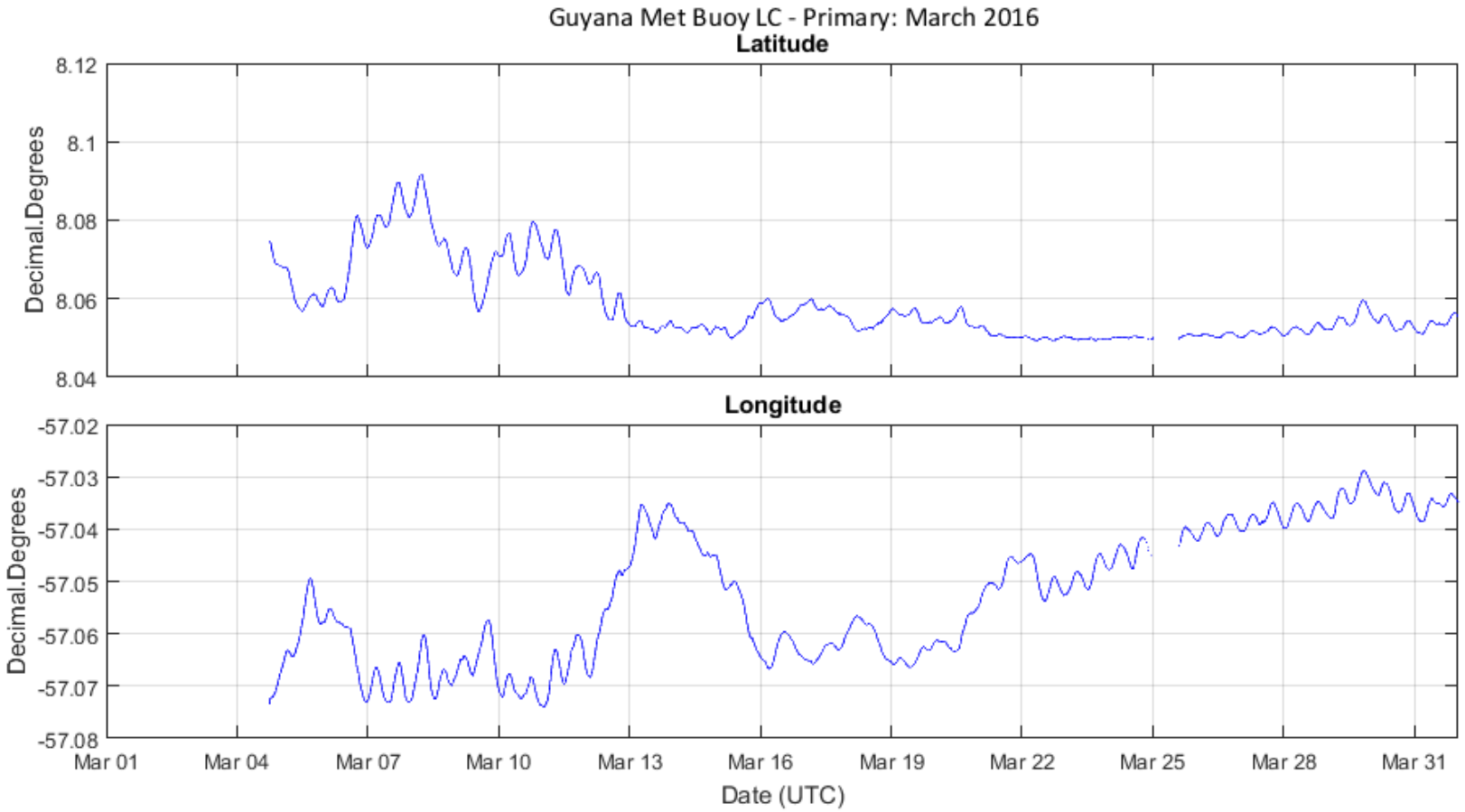

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, February 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Feb 01
Feb 06
Feb 11
Feb 16
Feb 21
Feb 26
Time (Days - UTC)


Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, March 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Mar 01
Mar 06
Mar 11
Mar 16
Mar 21
Mar 26
Mar 31
Time (Days - UTC)

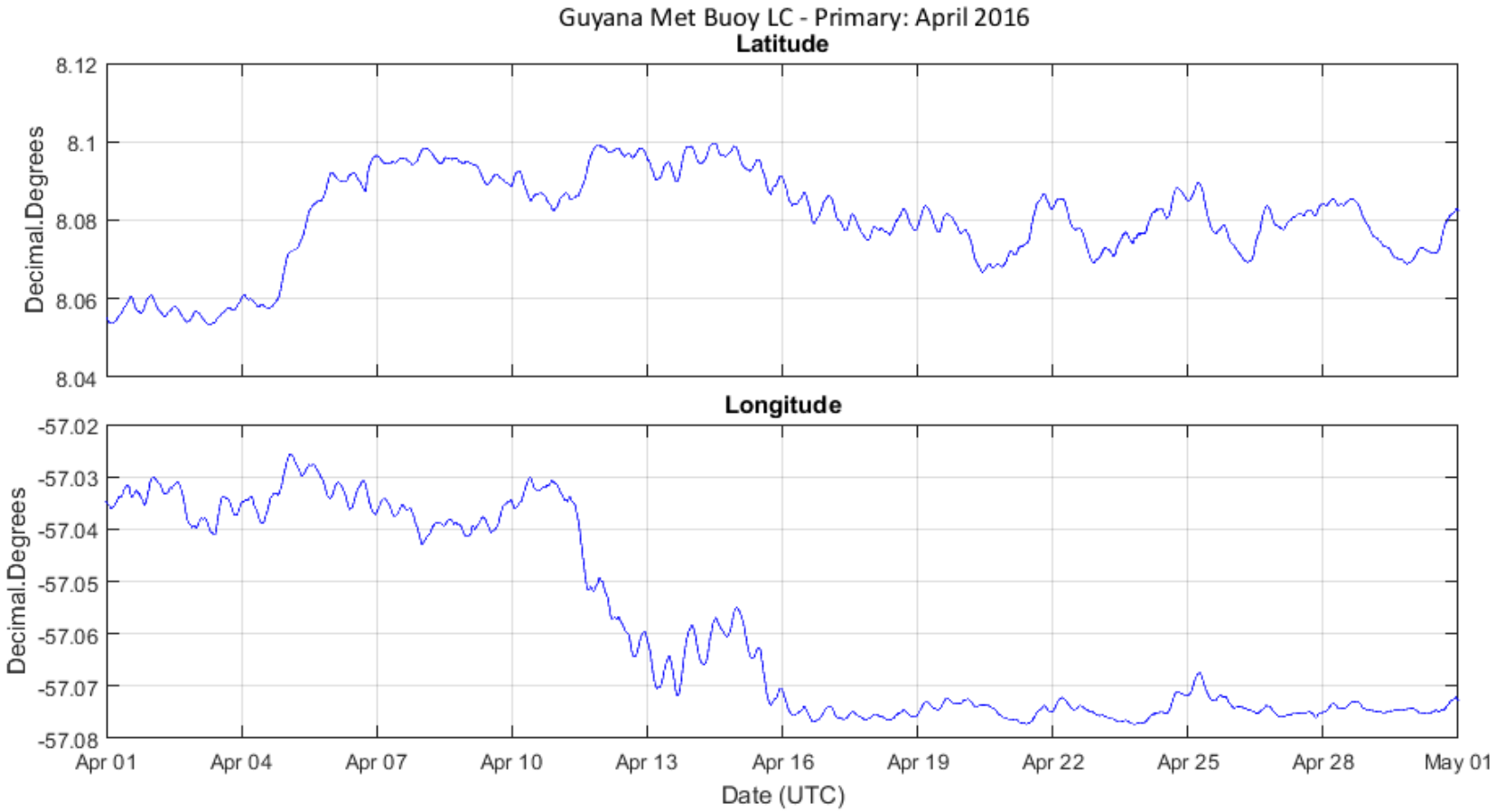

Guyana Met Station 2 New Amsterdam: 06° 14.333' N, 057° 29.133' W, April 2019
Air Temperature
deg C
40
30
20
10
0
Relative Humidity
%
100
75
50
25
0
Precipitation (daily totals as bars)
mm
120
90
60
30
0
Atmospheric Pressure
hPa
1020
1016
1012
1008
1004
Wind Speed (blue) and Wind Gust (red)
m/s
40
30
20
10
0
Wind Direction (from, True)
deg T
360
270
180
90
0
Apr 01
Apr 06
Apr 11
Apr 16
Apr 21
Apr 26
May 01
Time (Days - UTC)

Offshore Meteorological Data

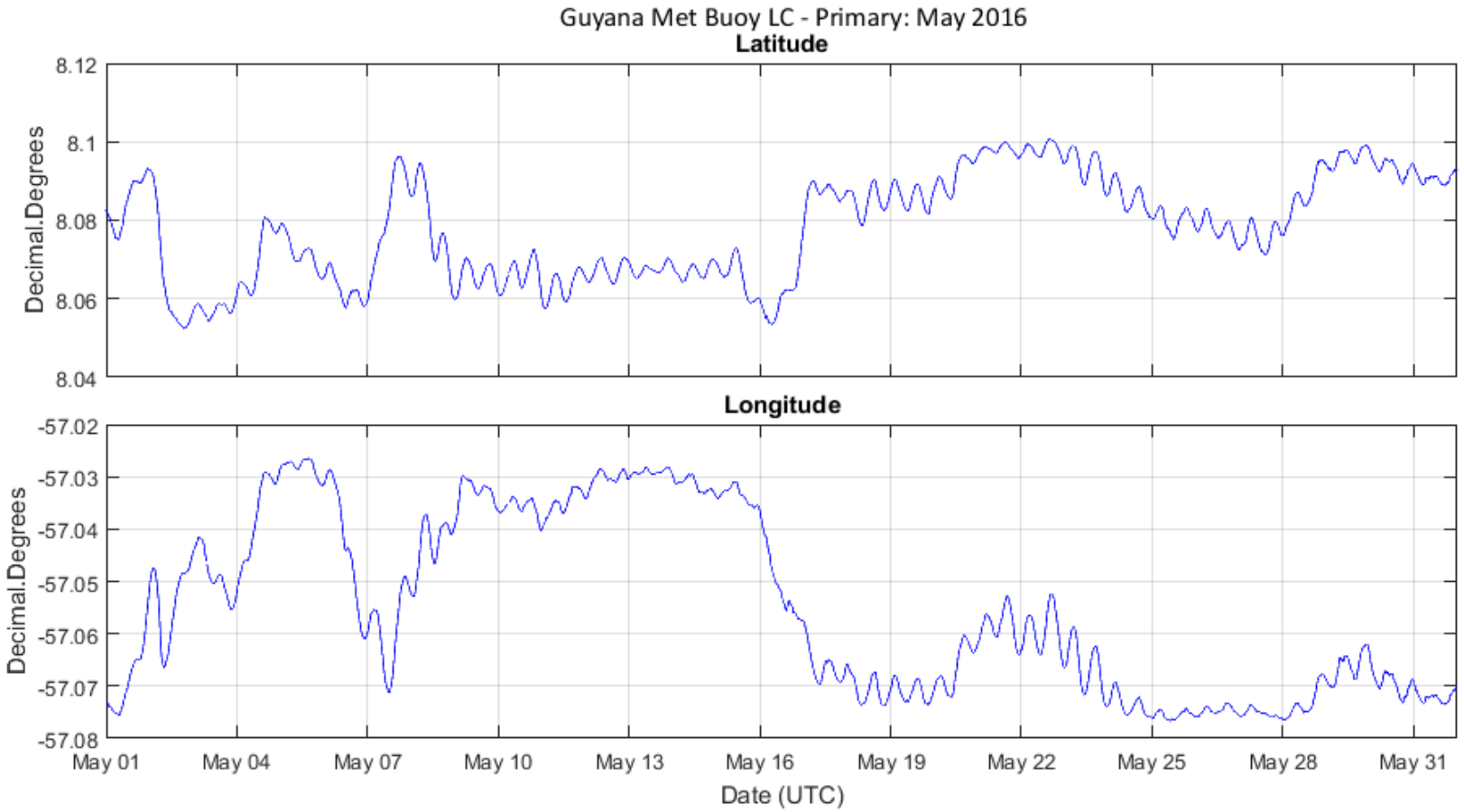
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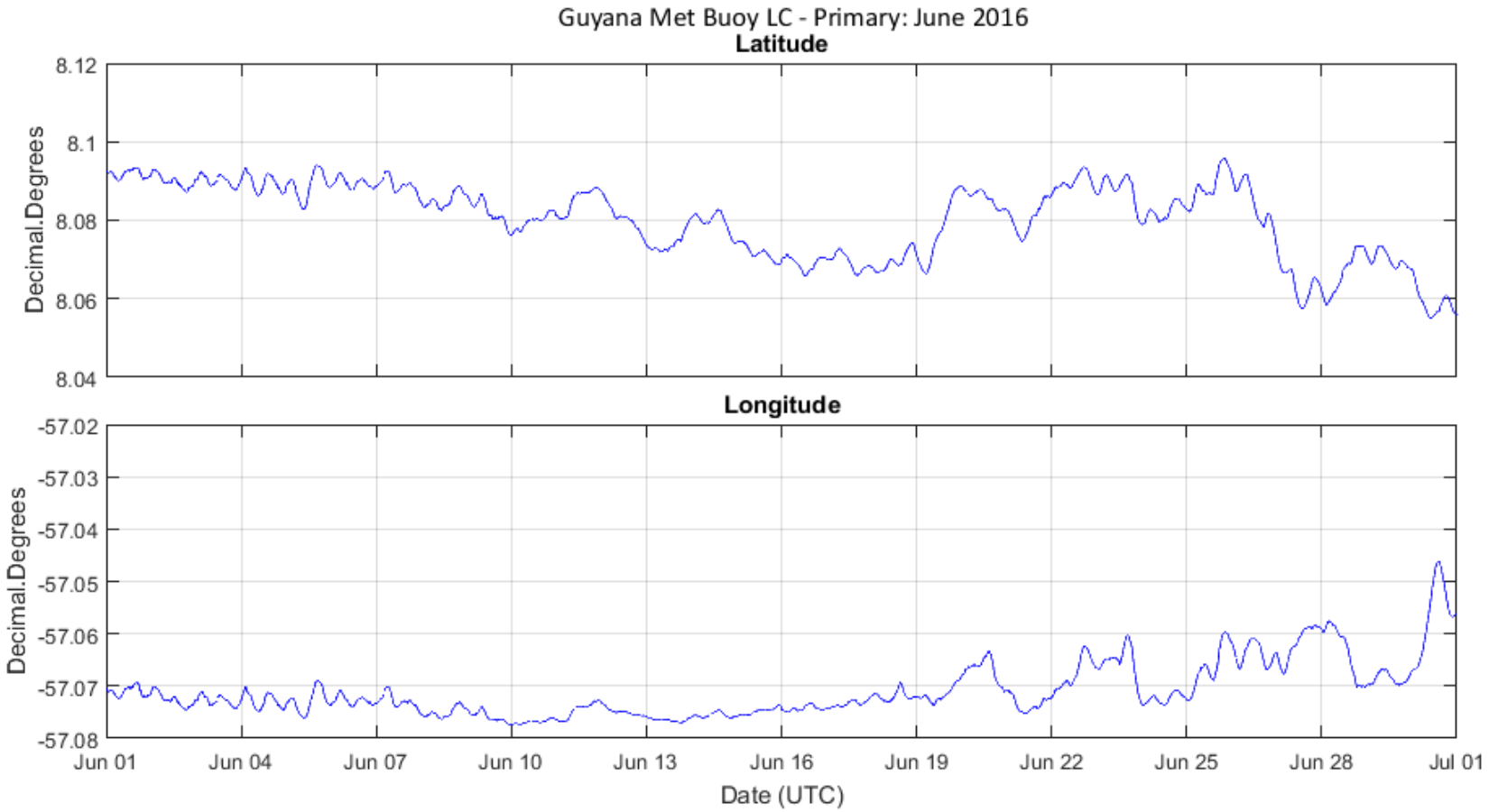
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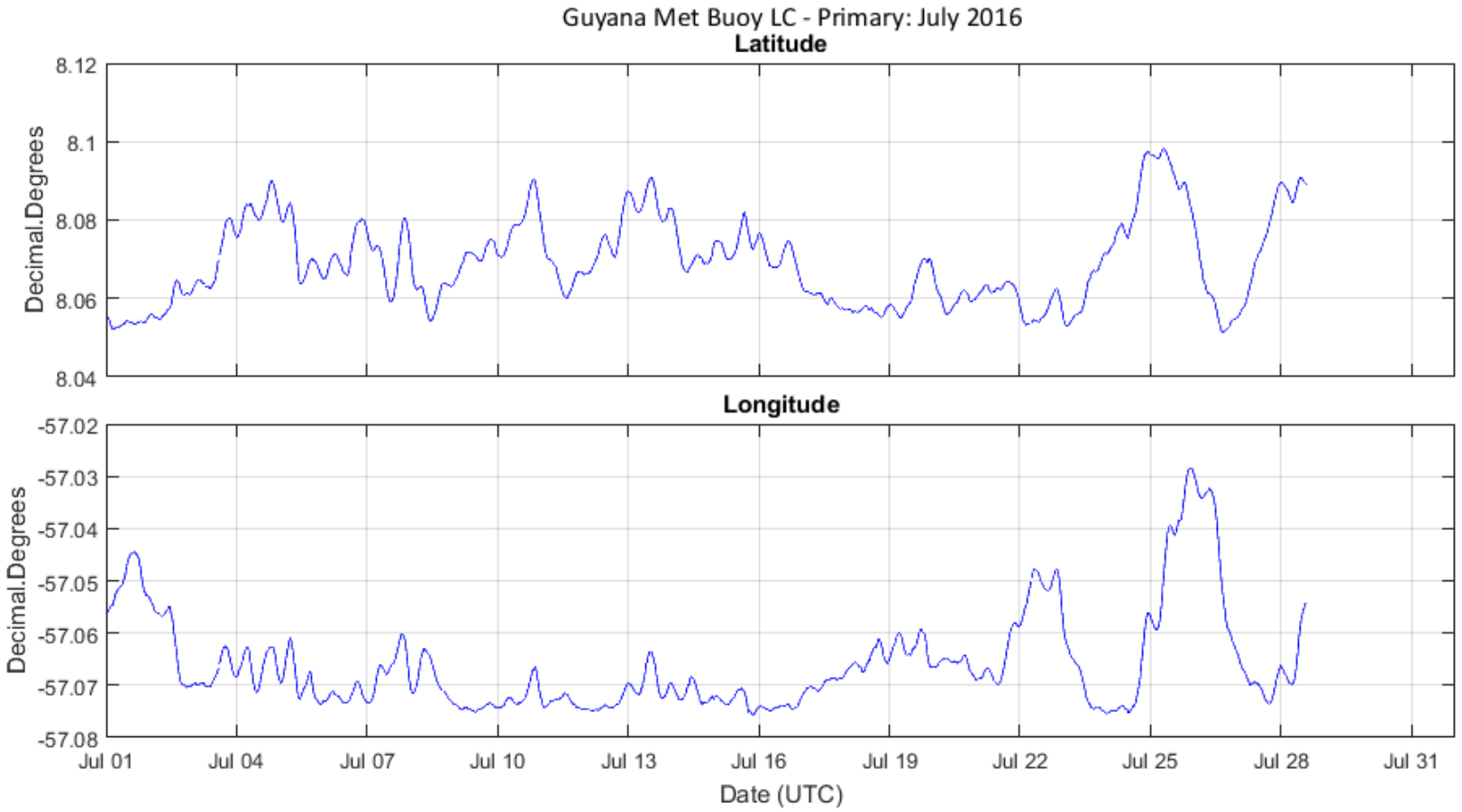
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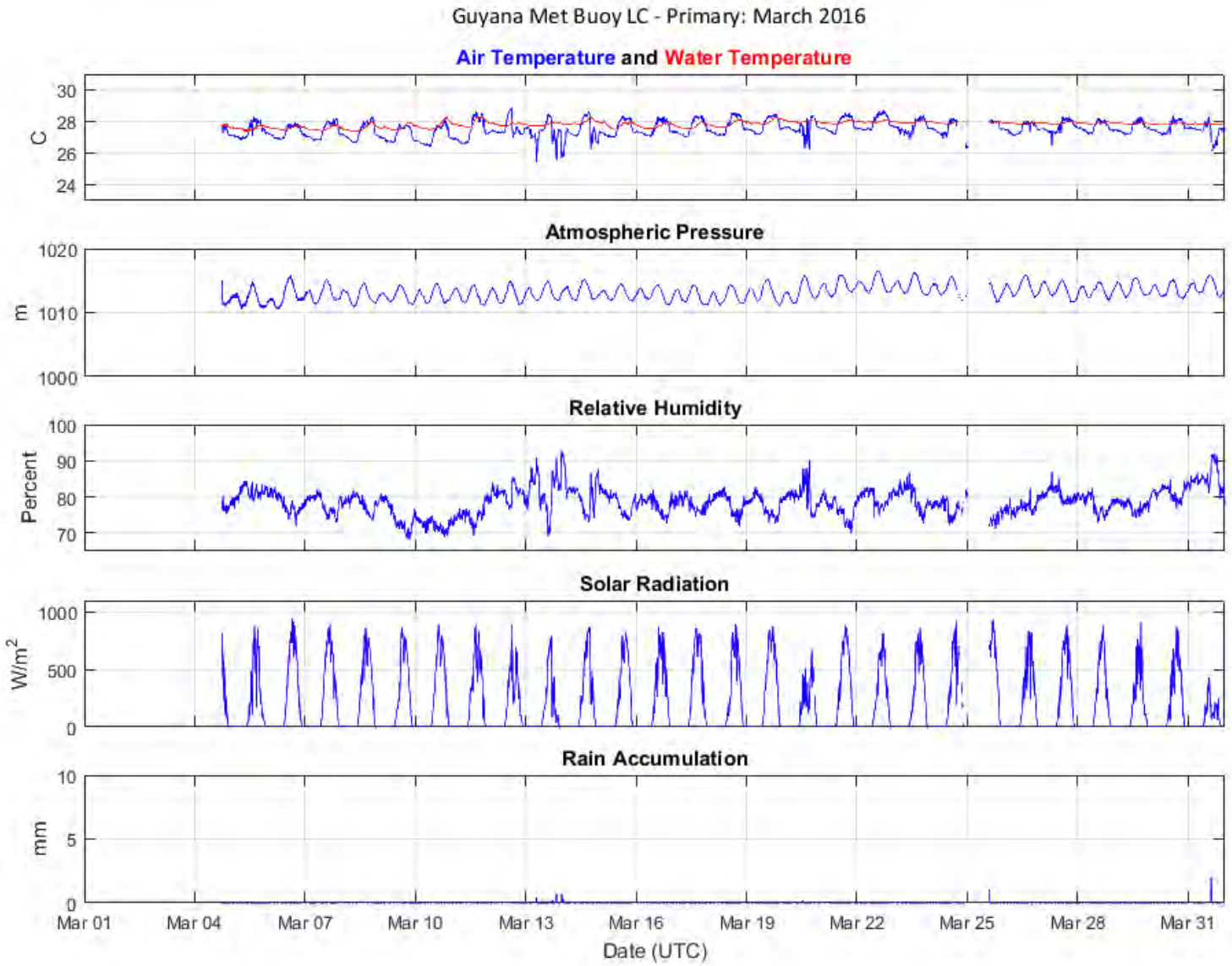
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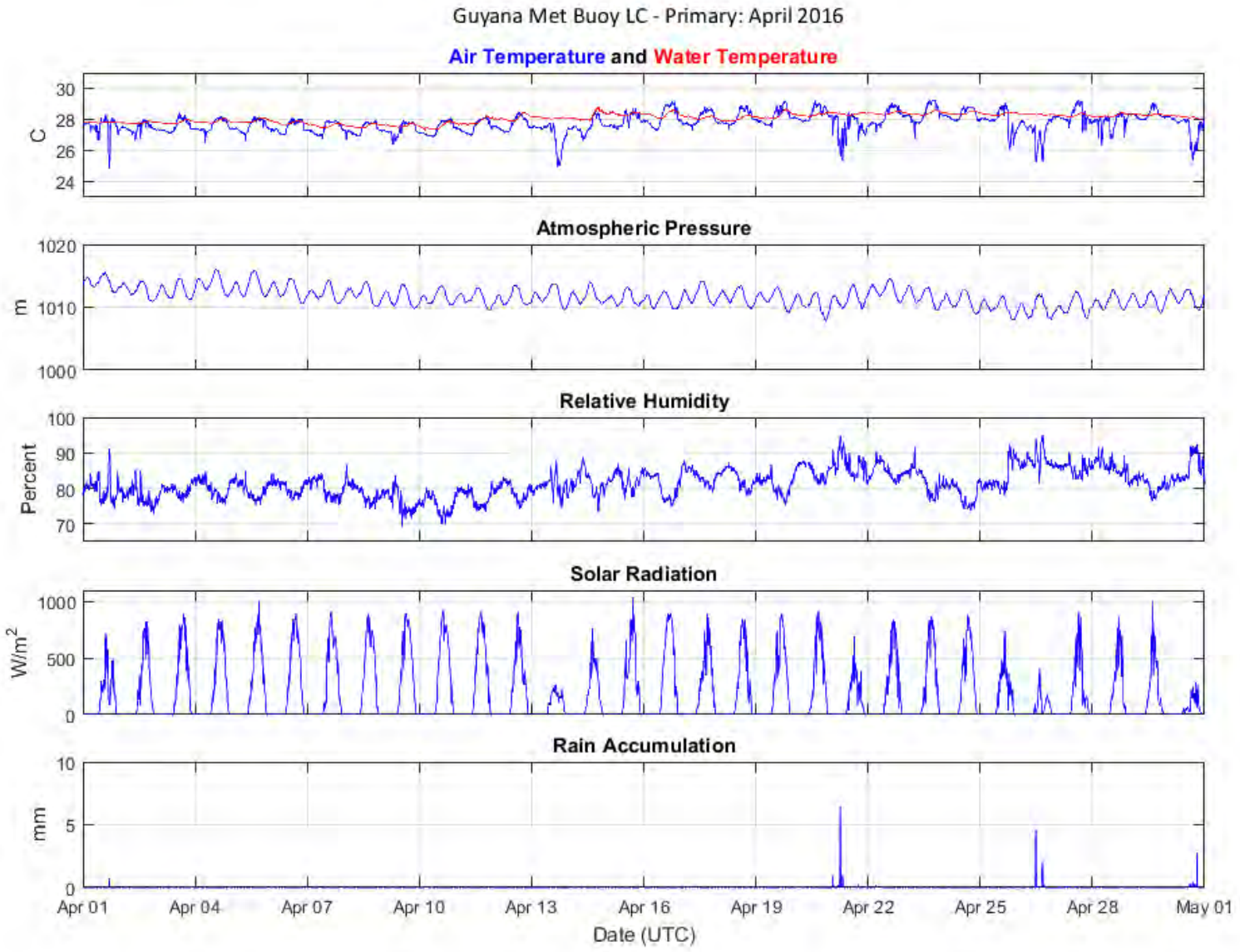
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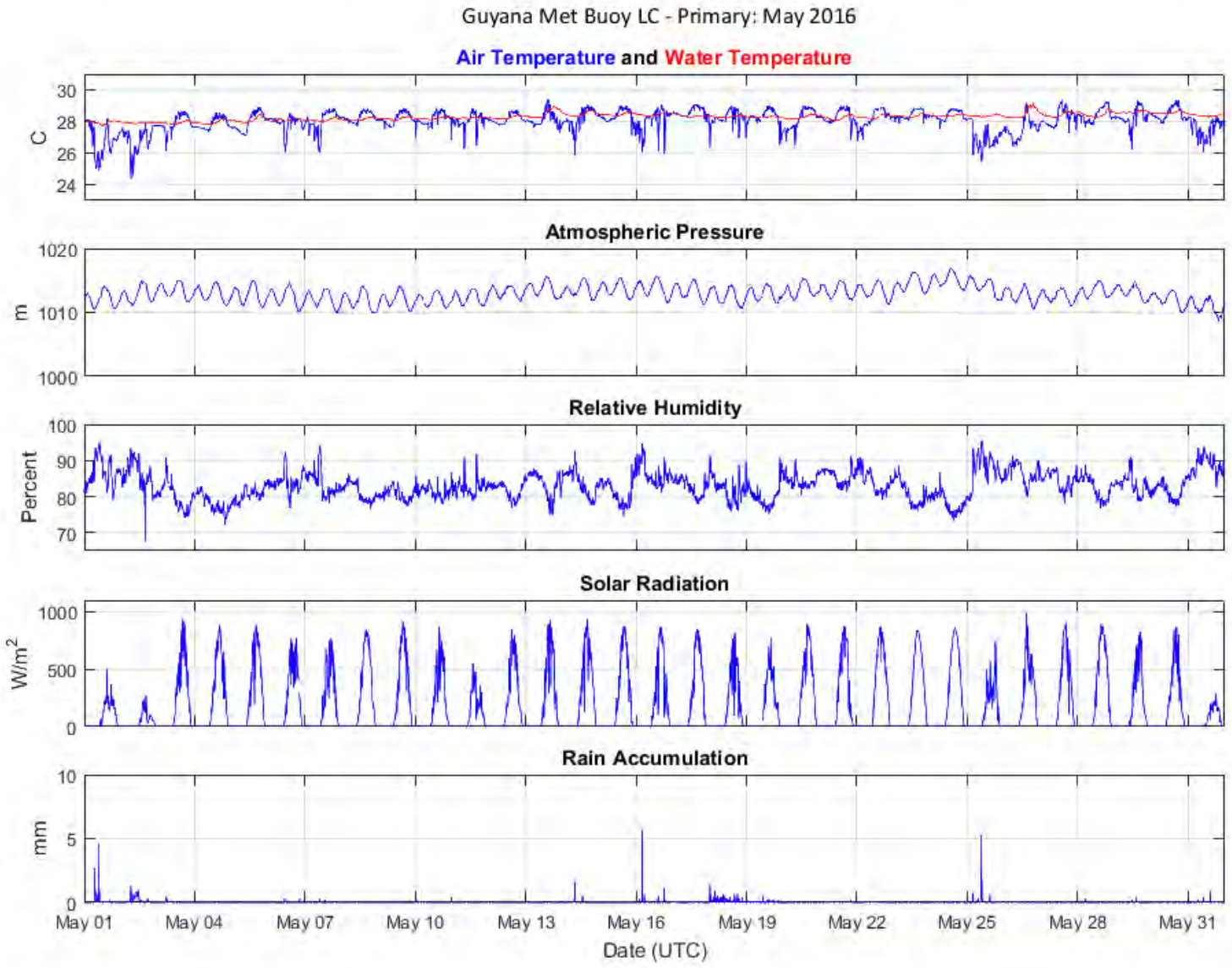
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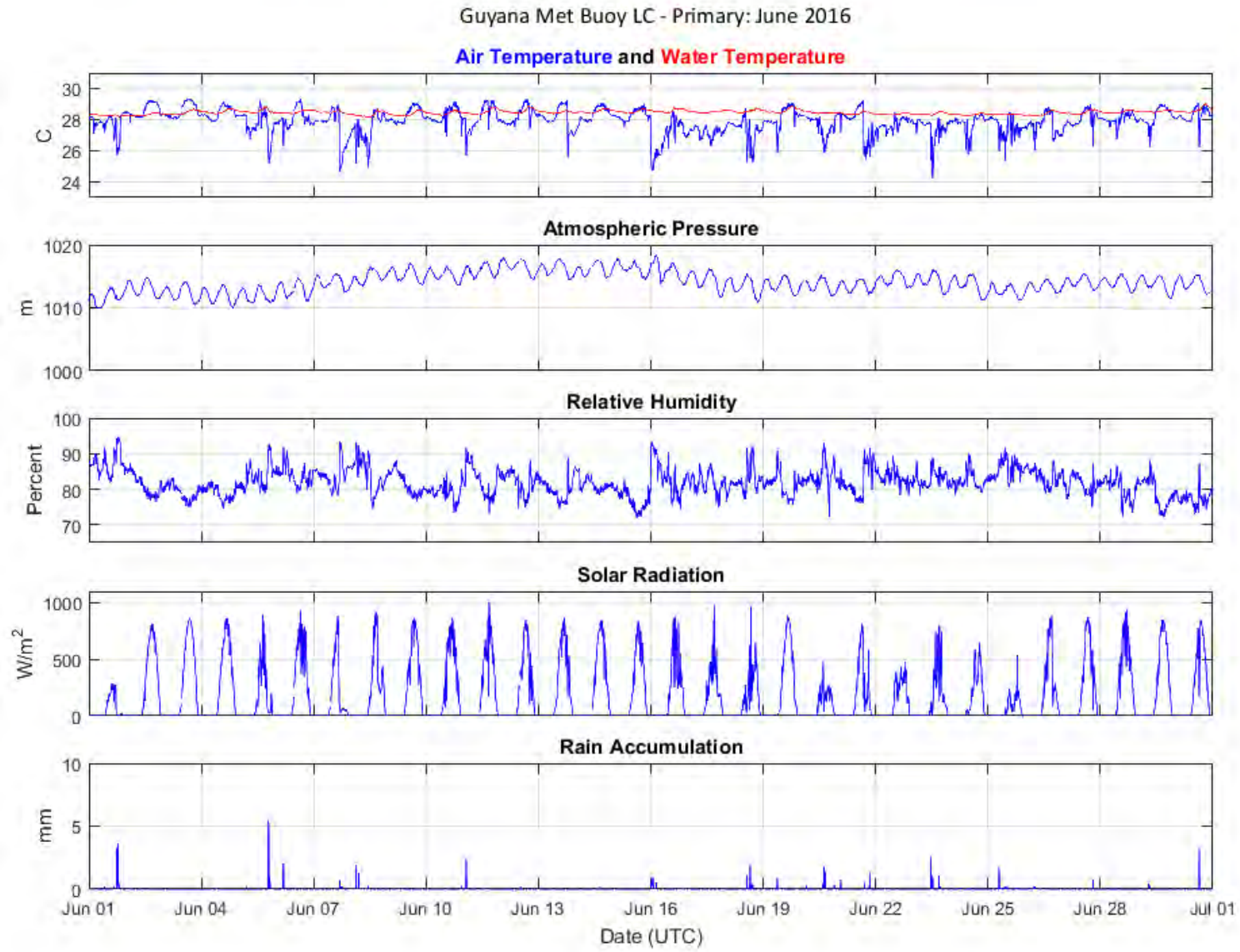
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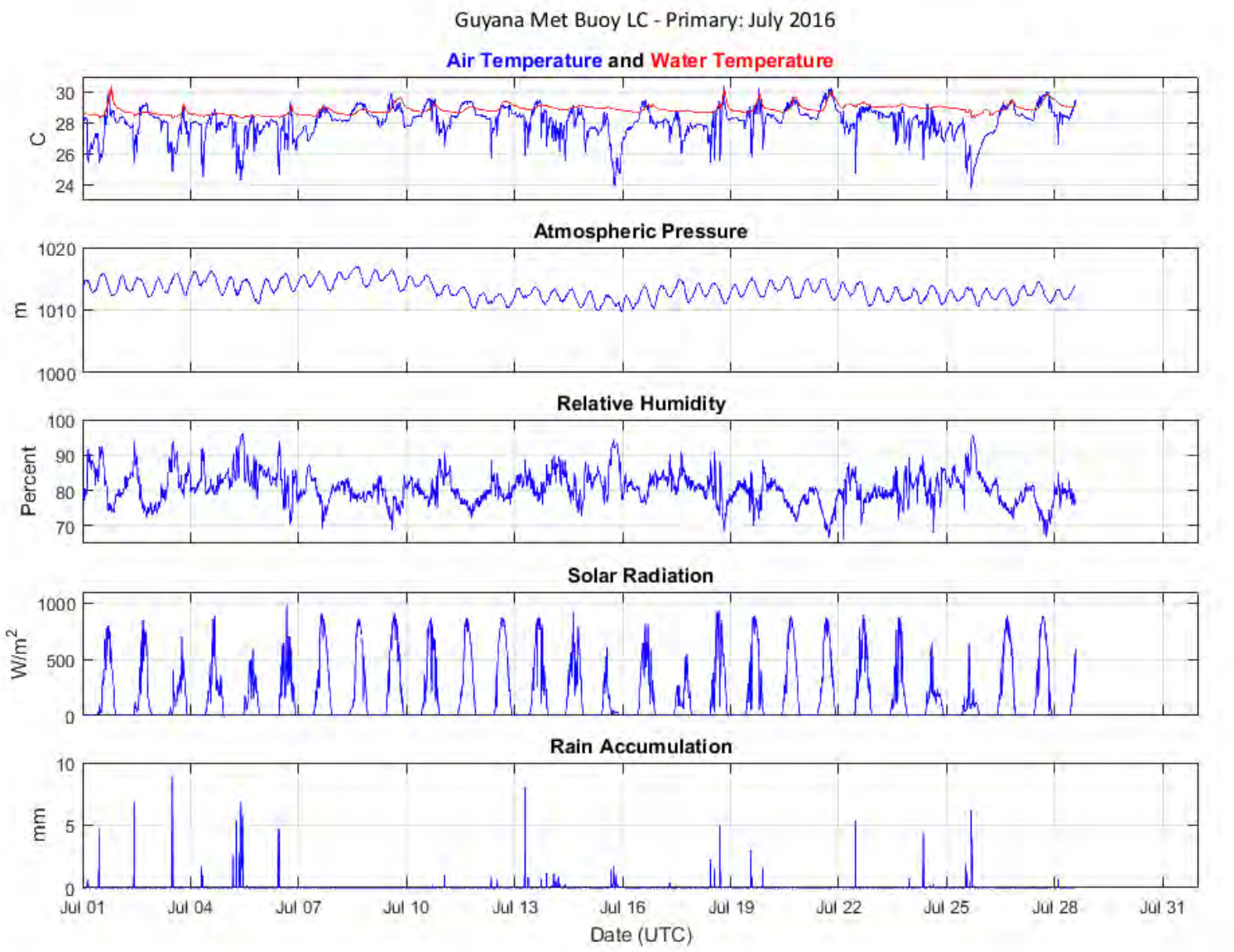
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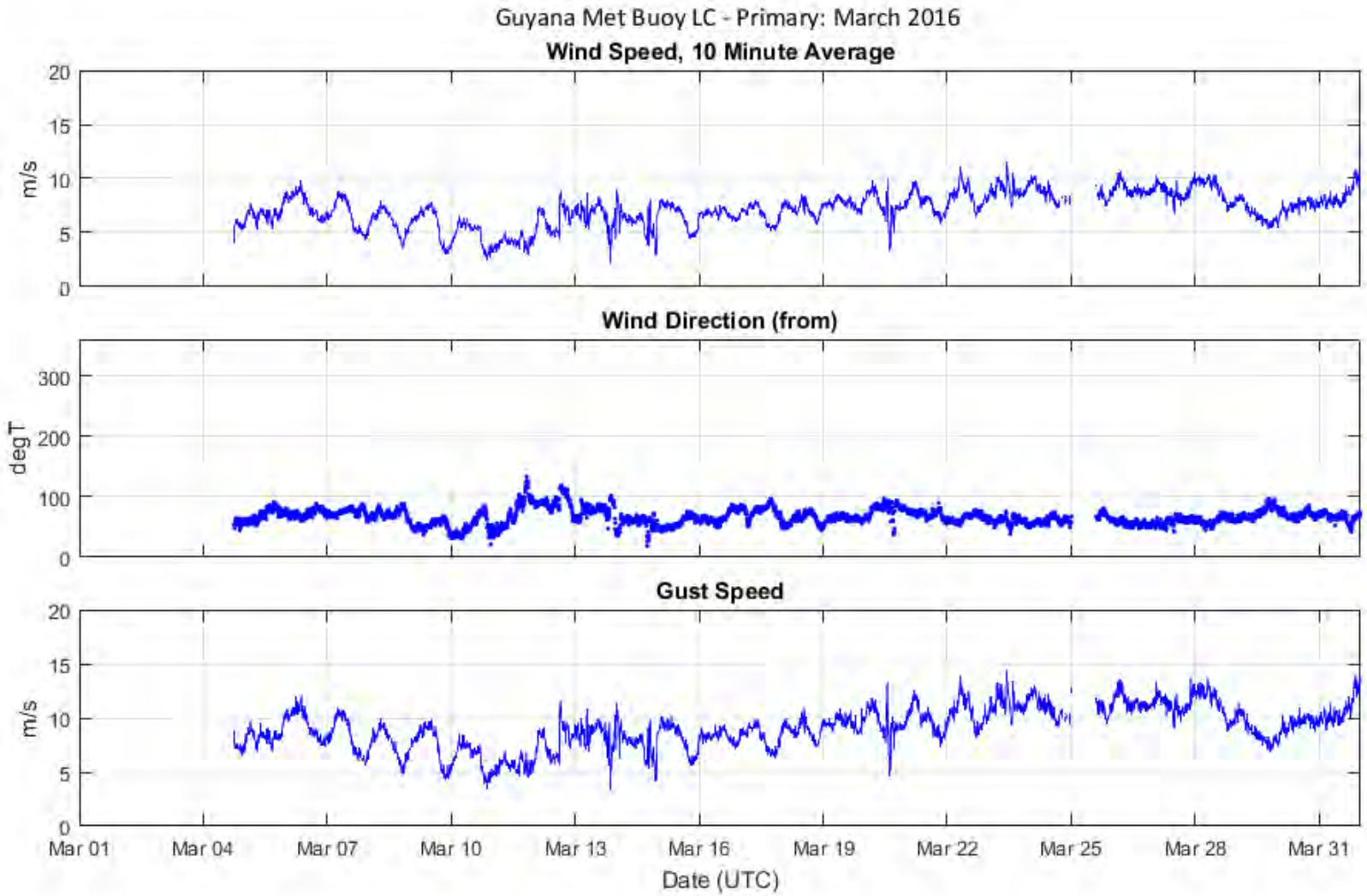
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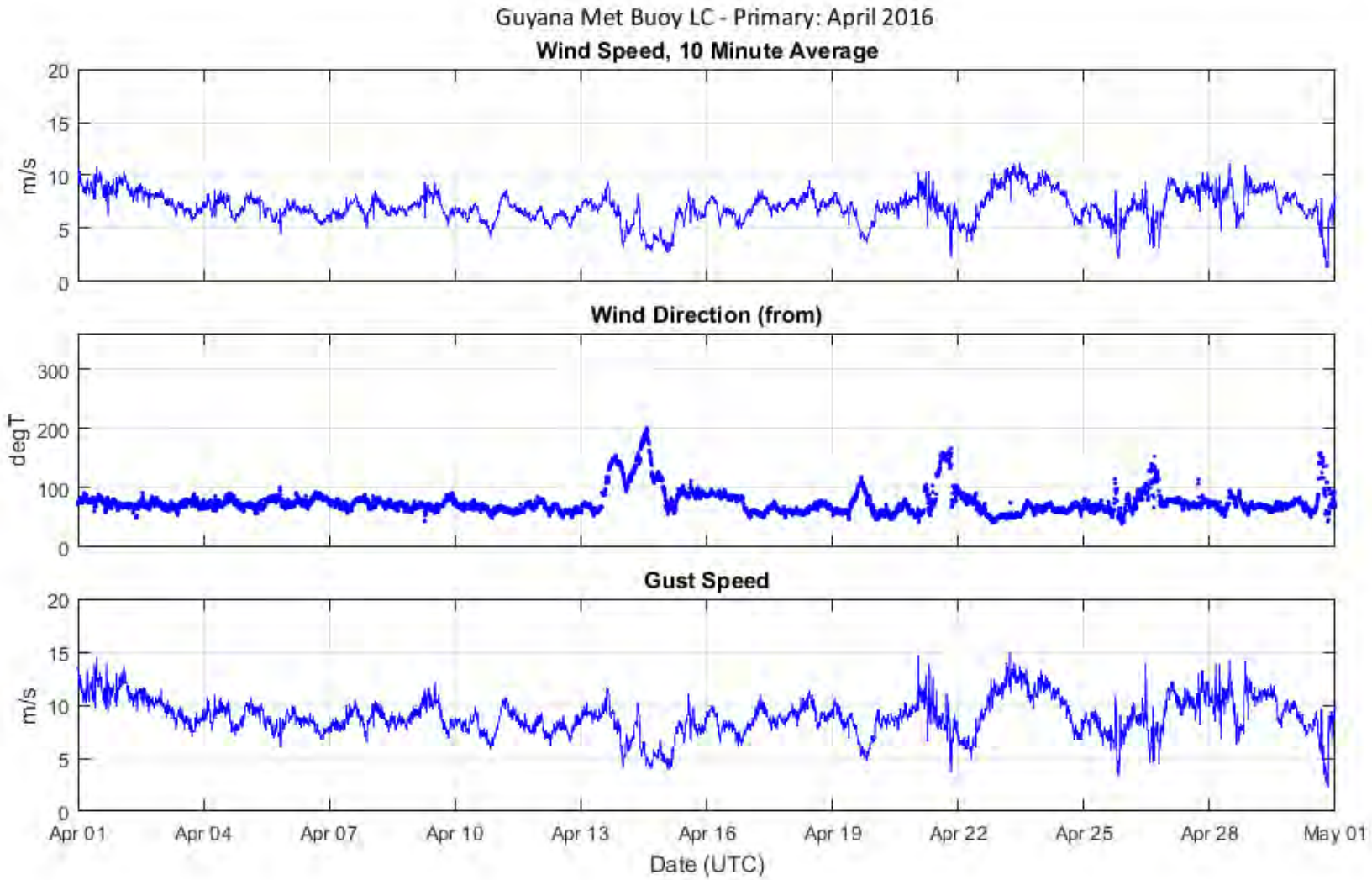
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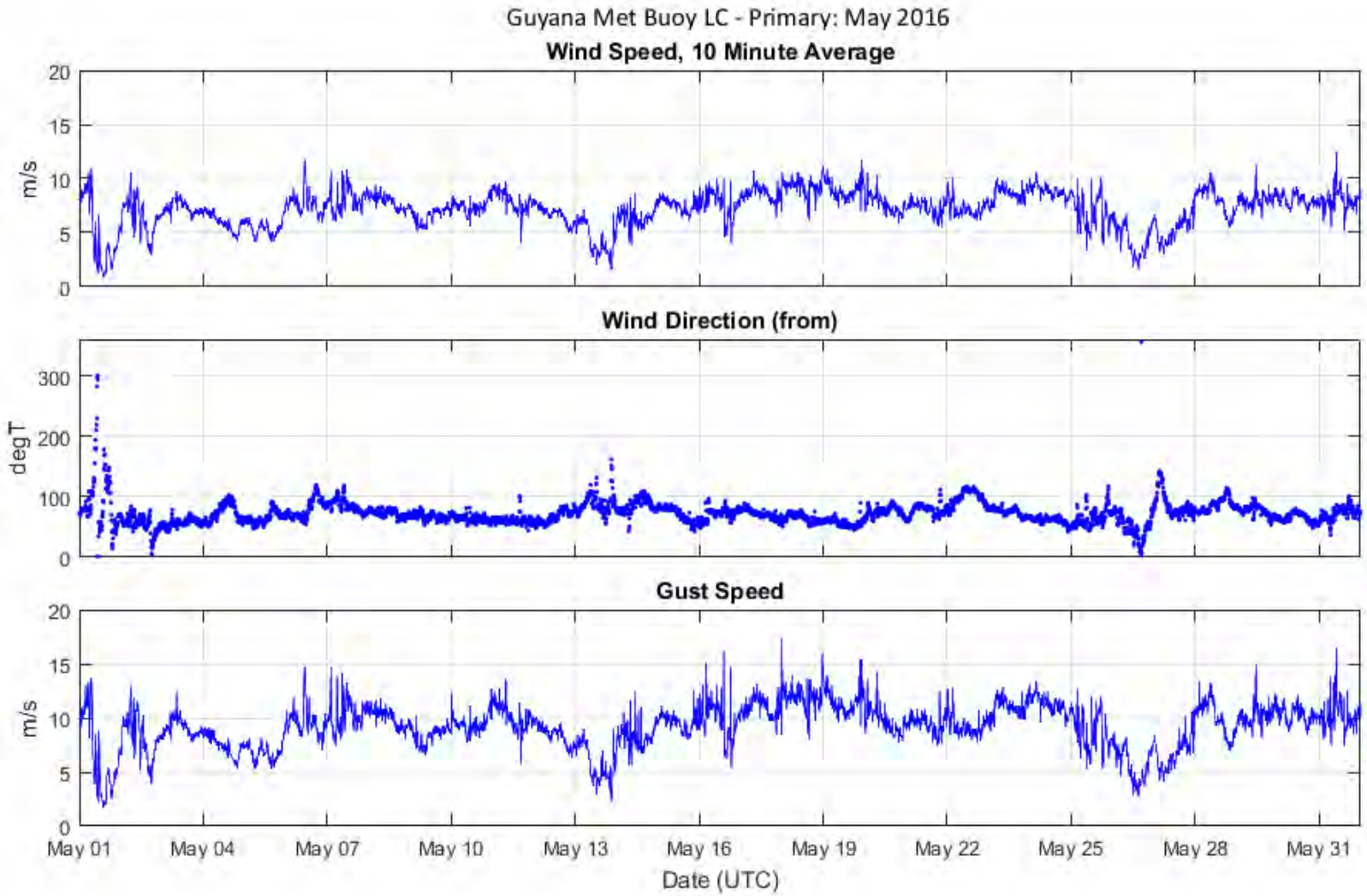
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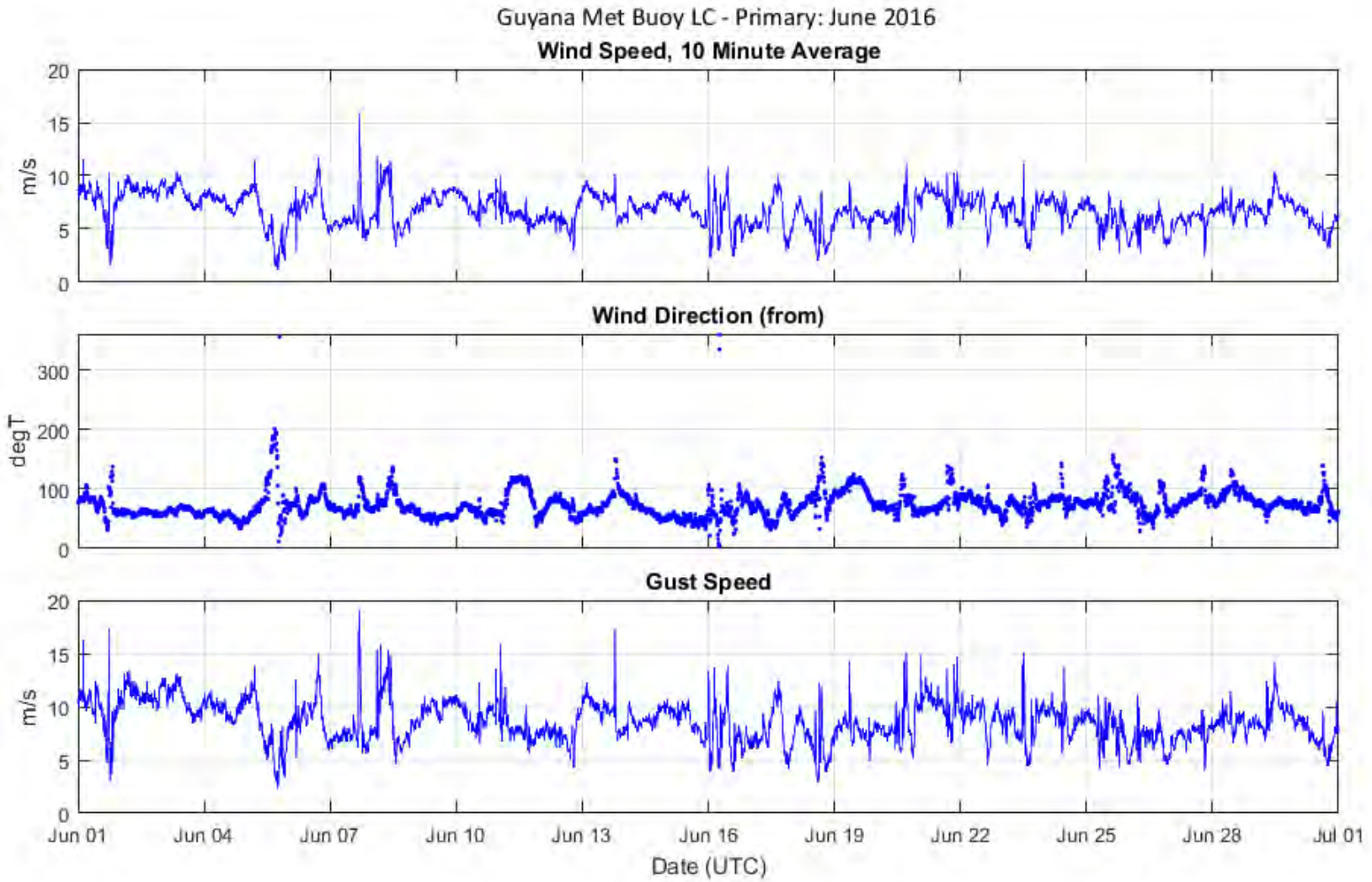
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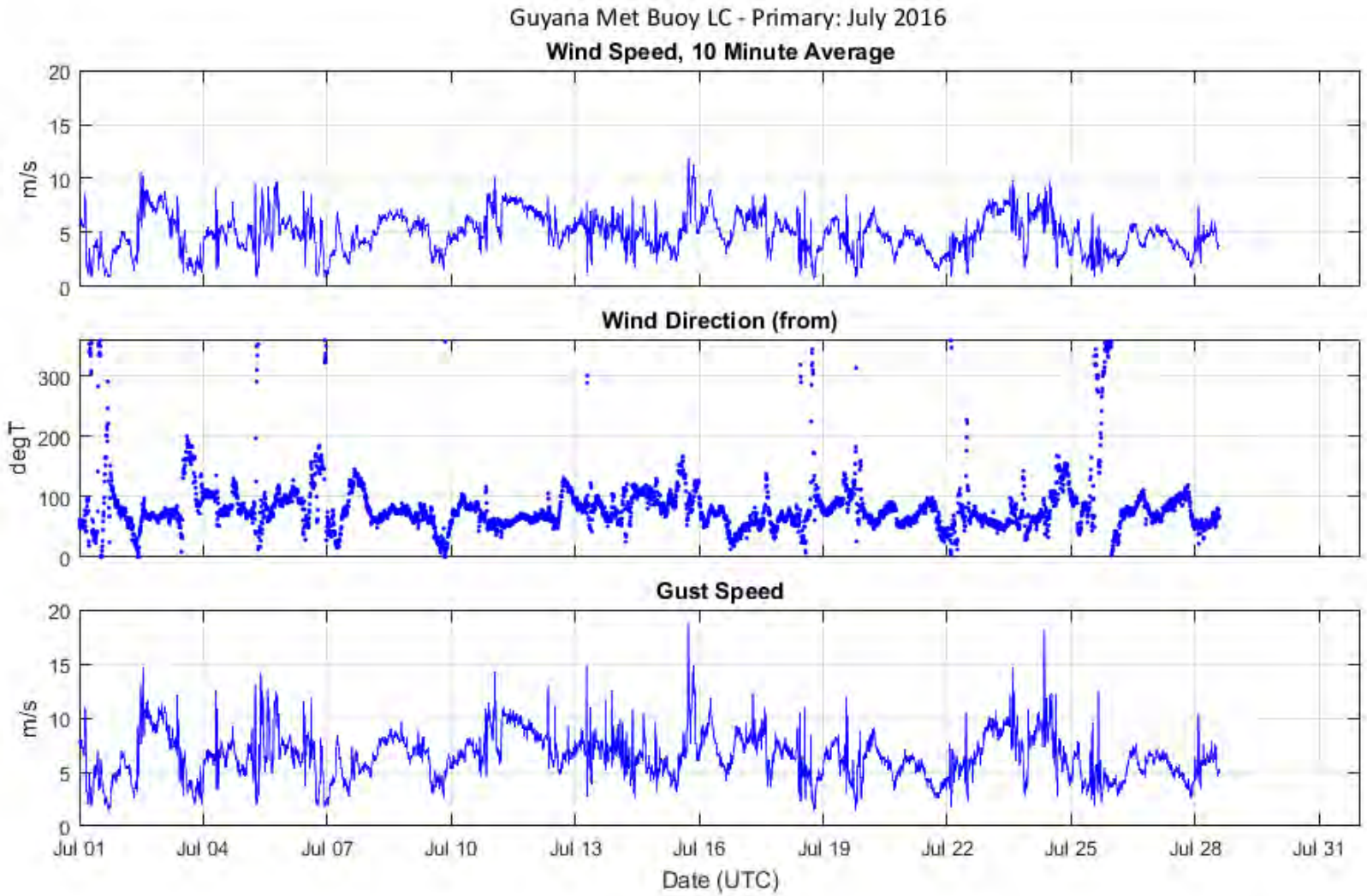
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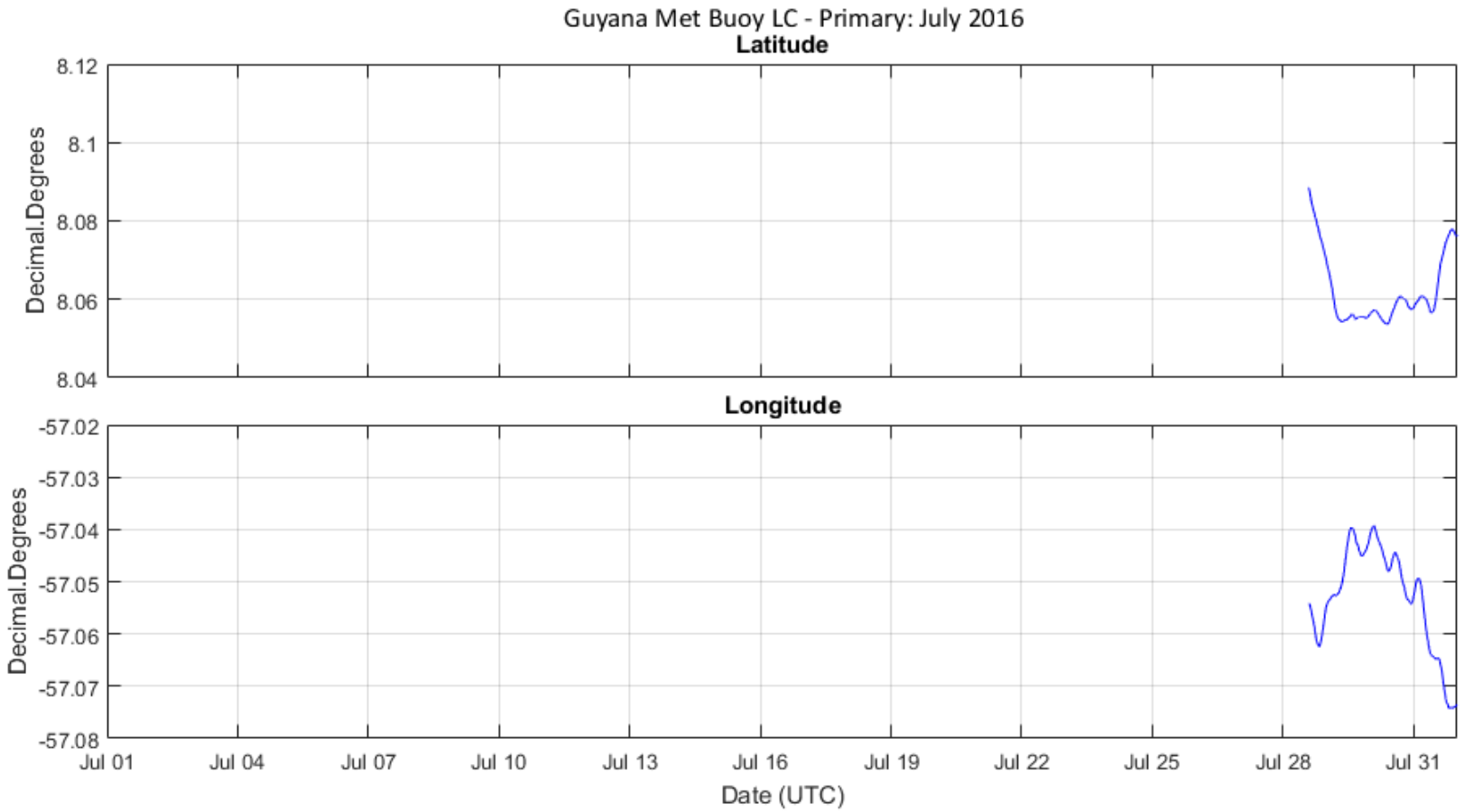
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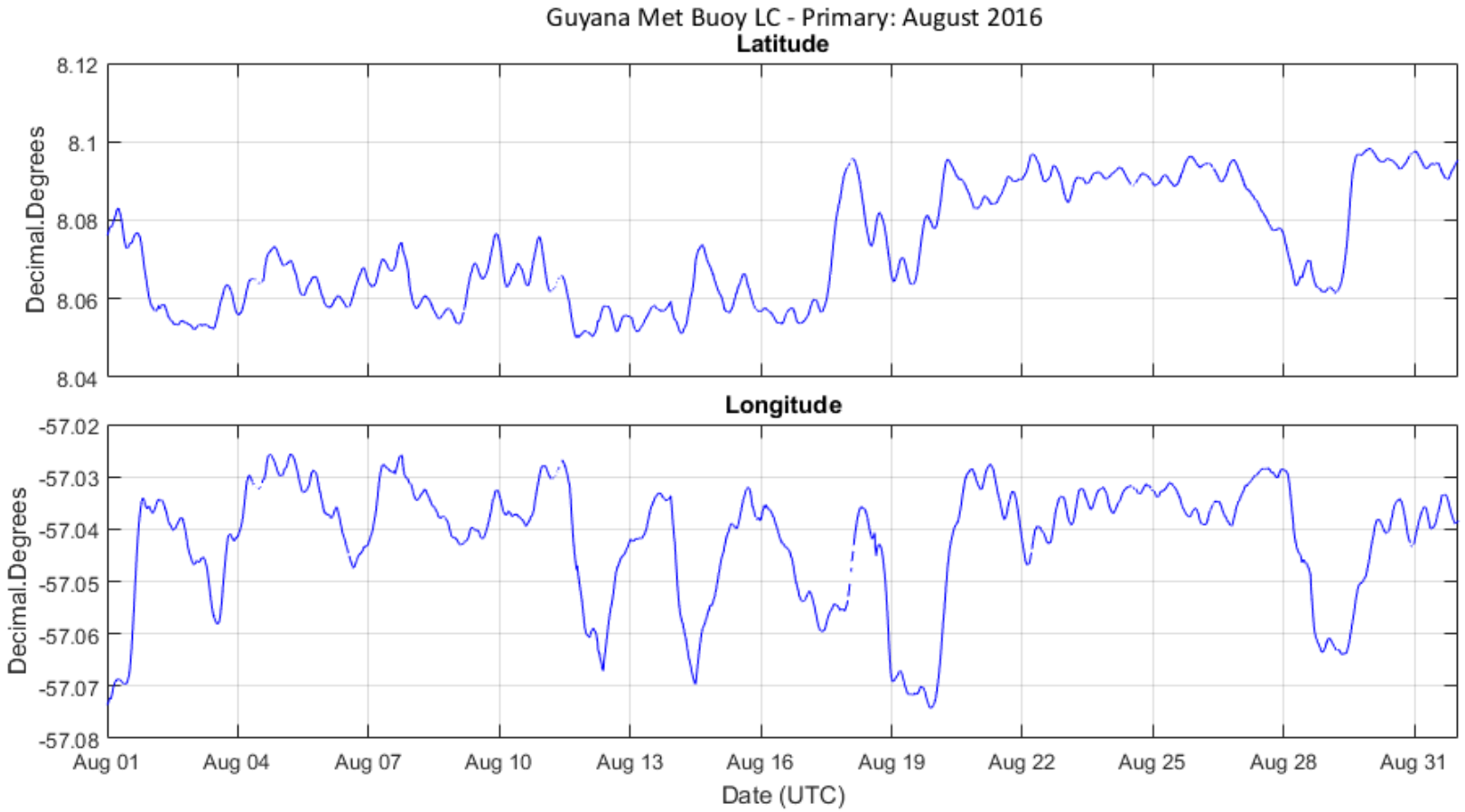
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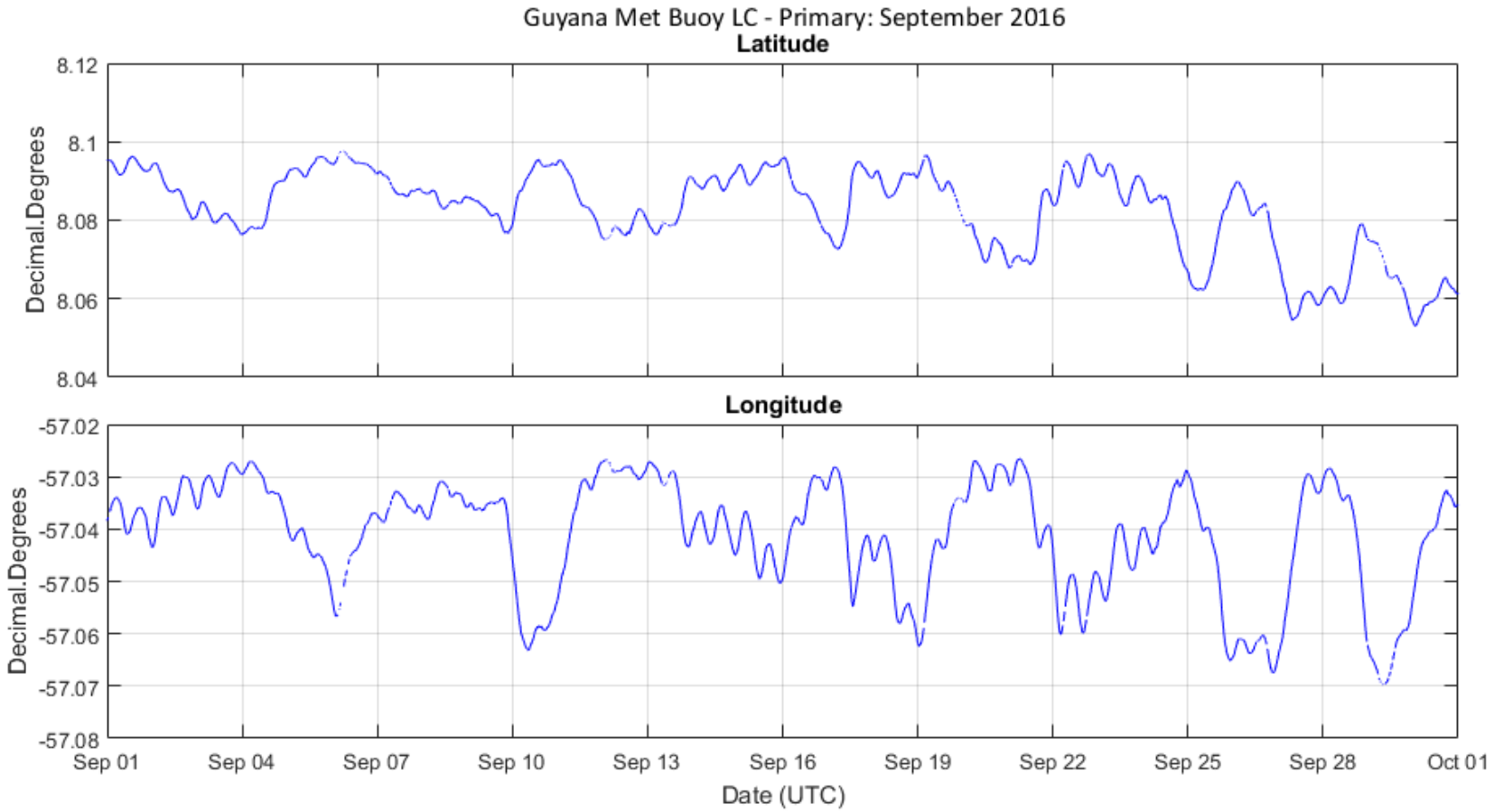
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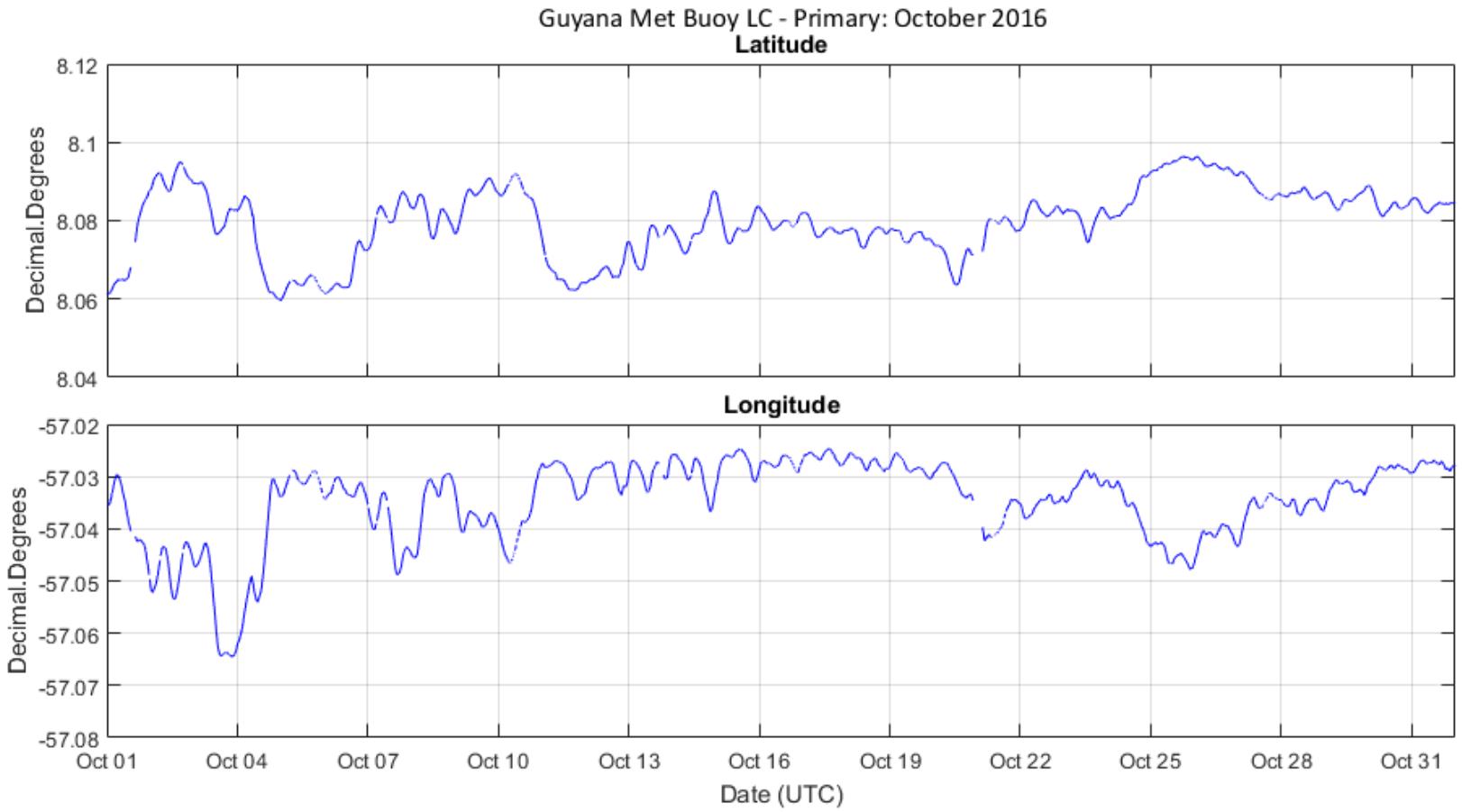
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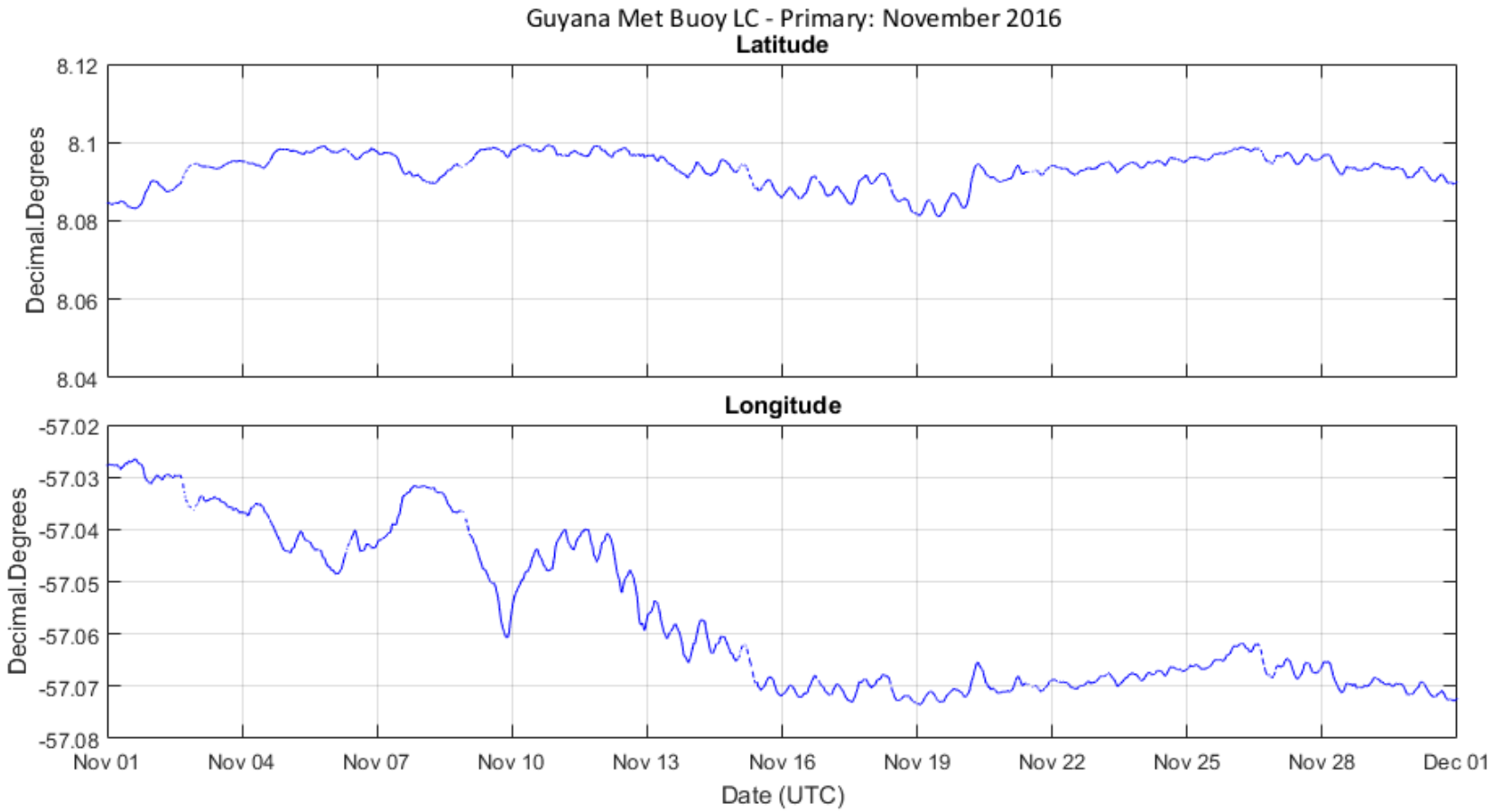
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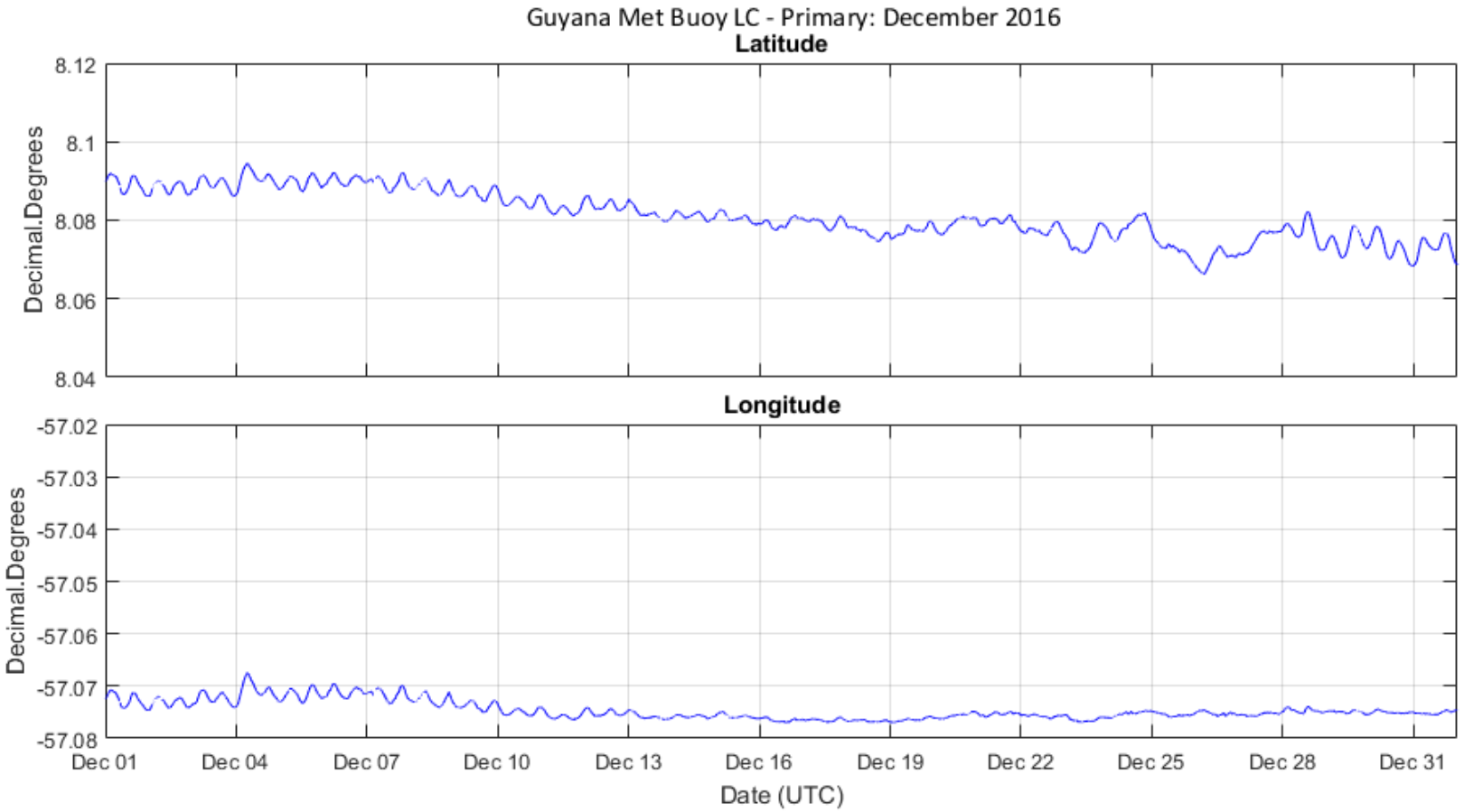
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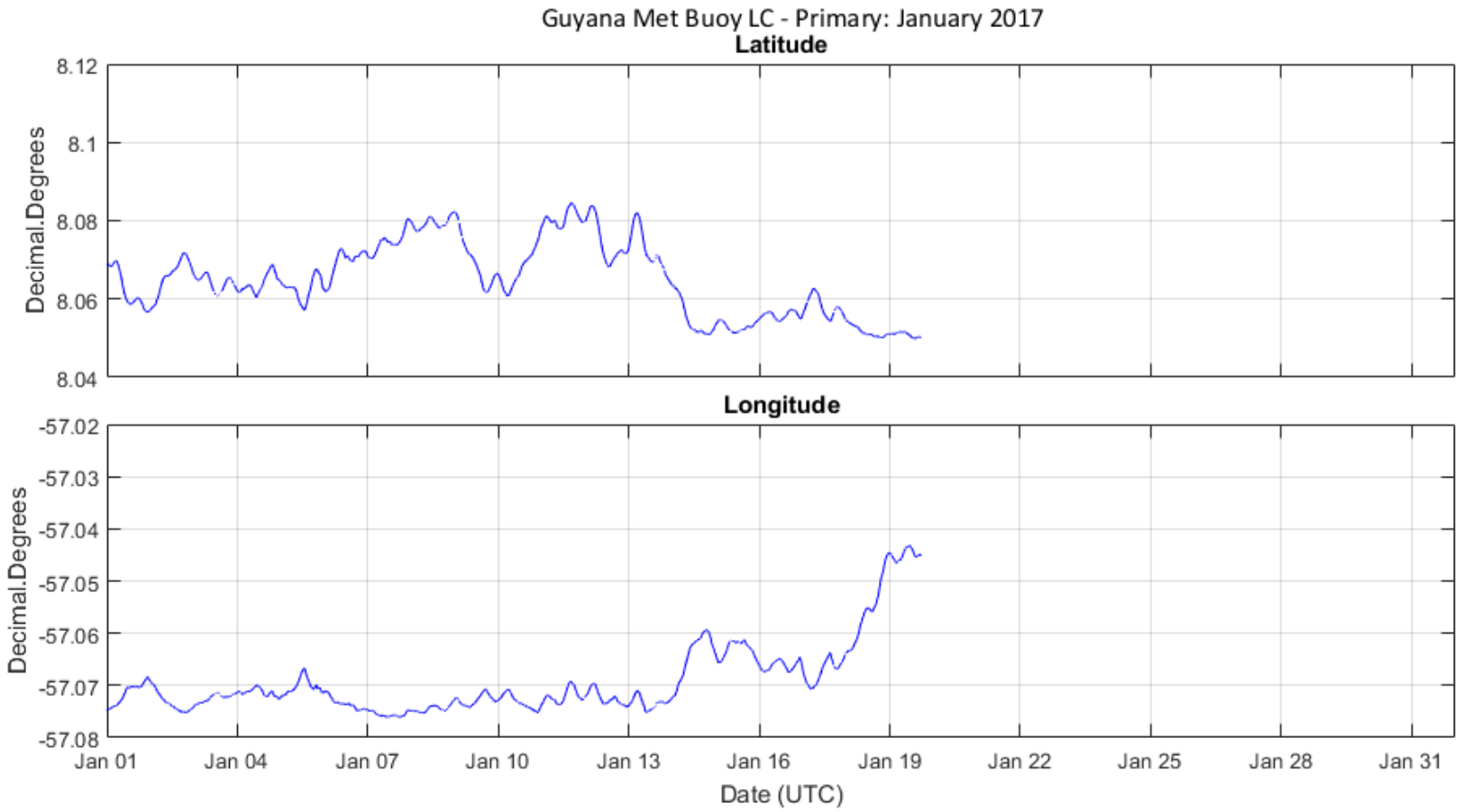
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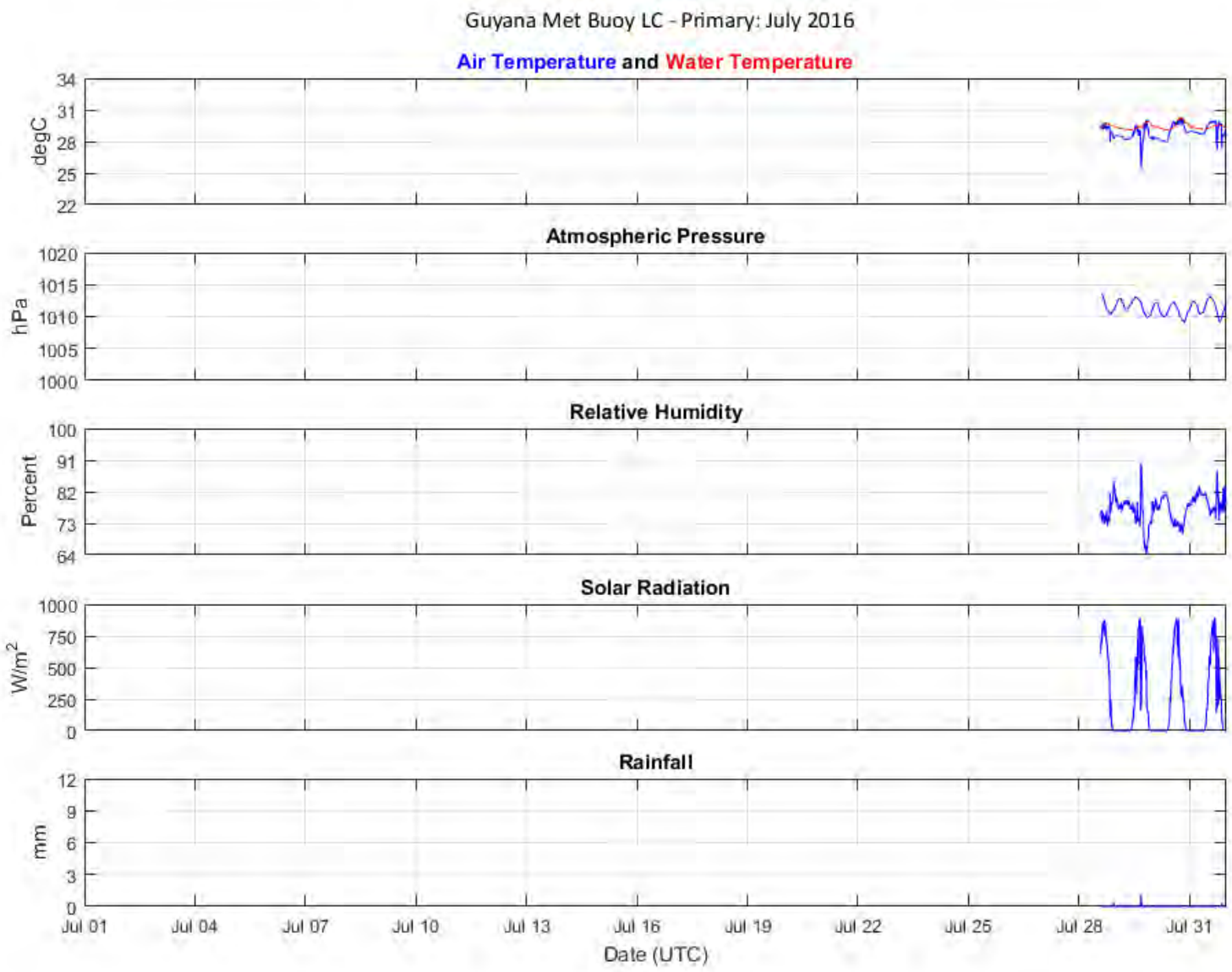
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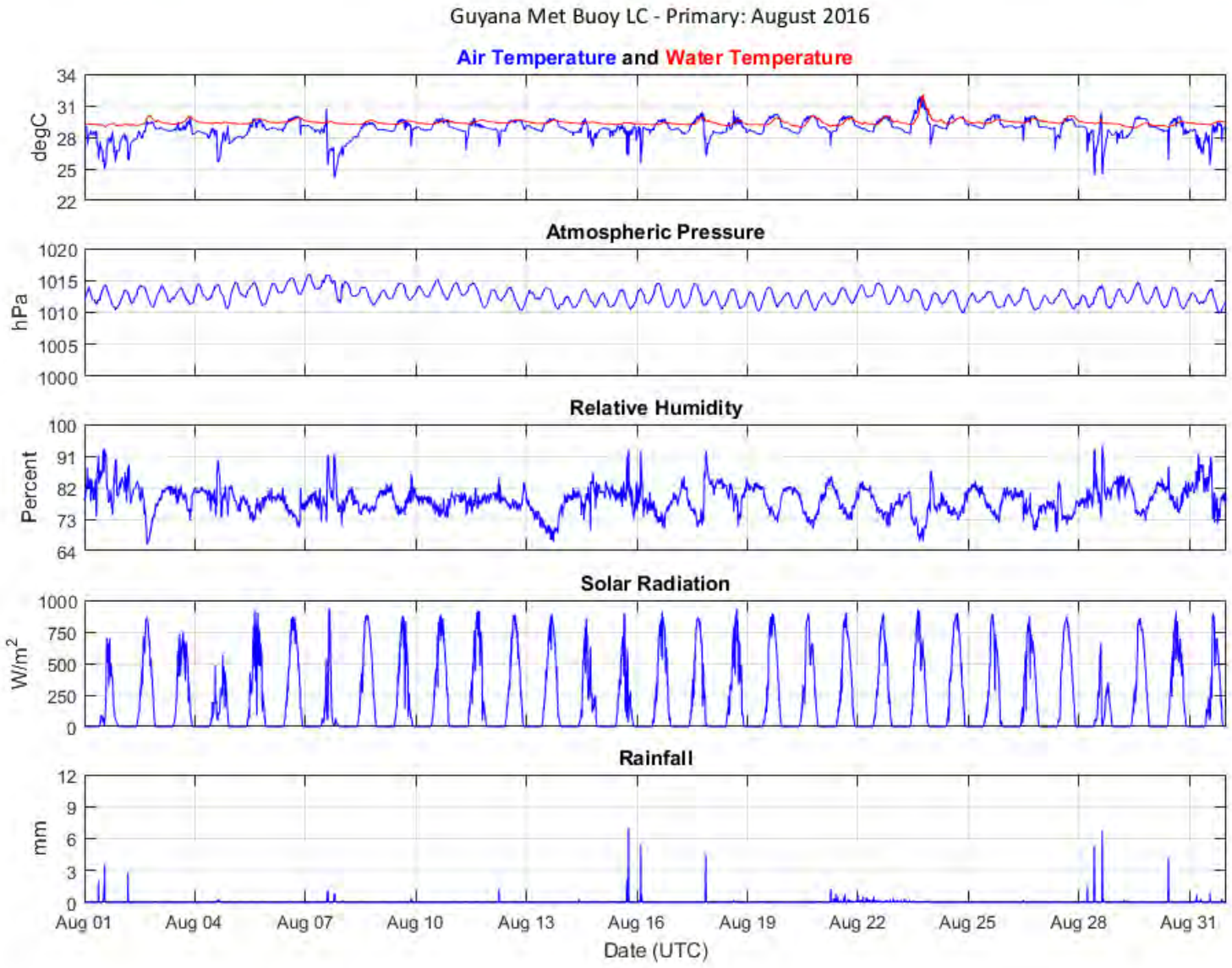
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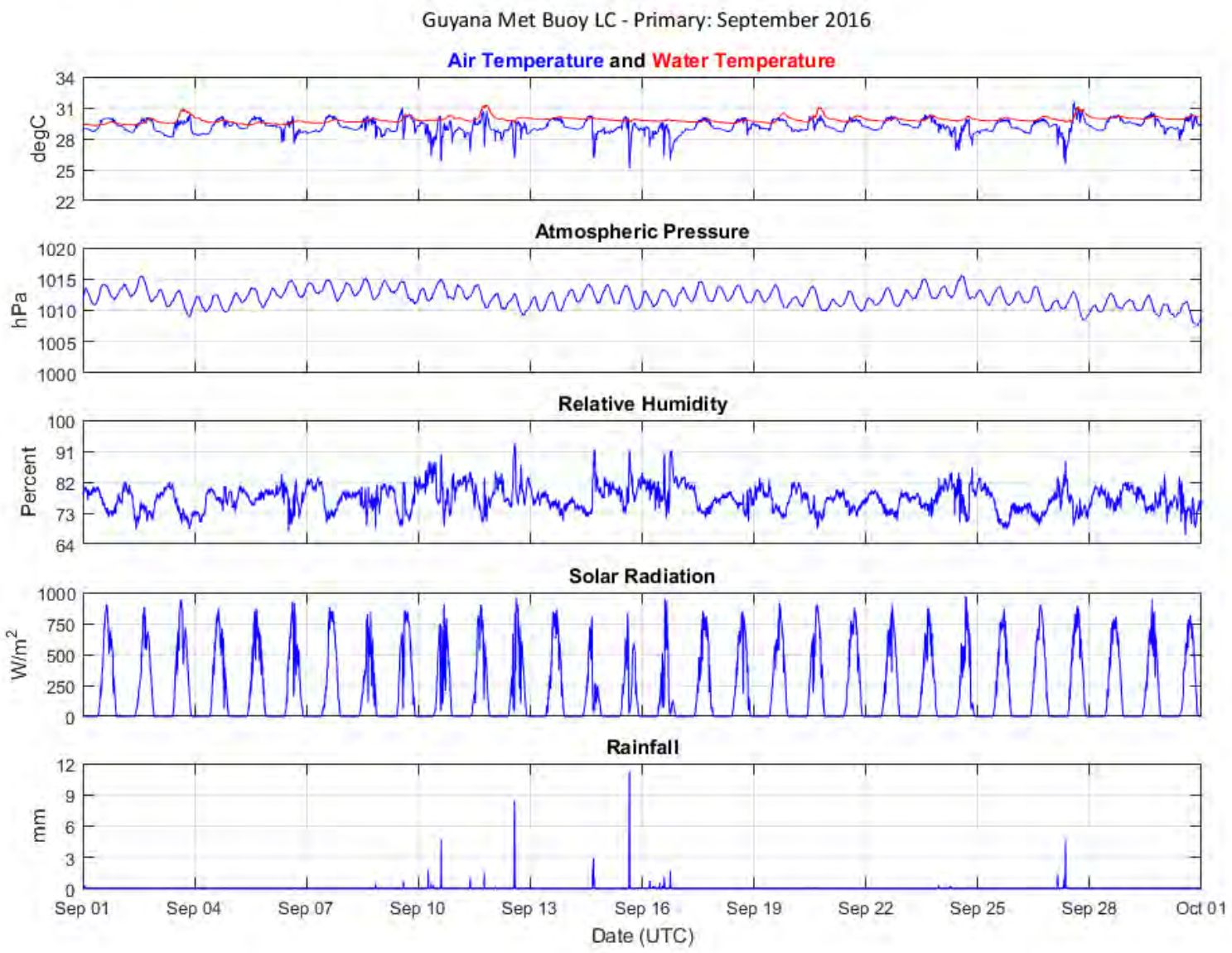
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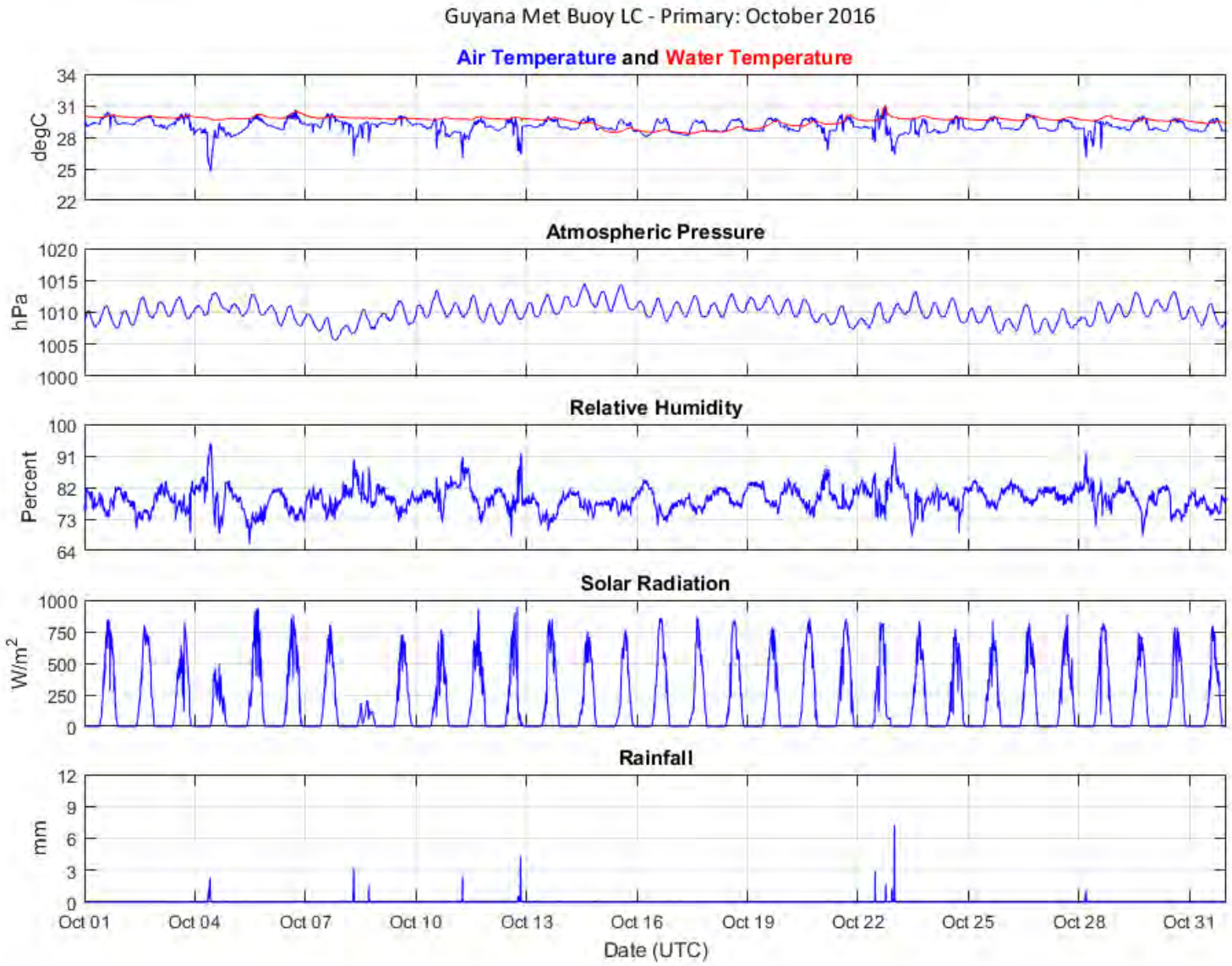
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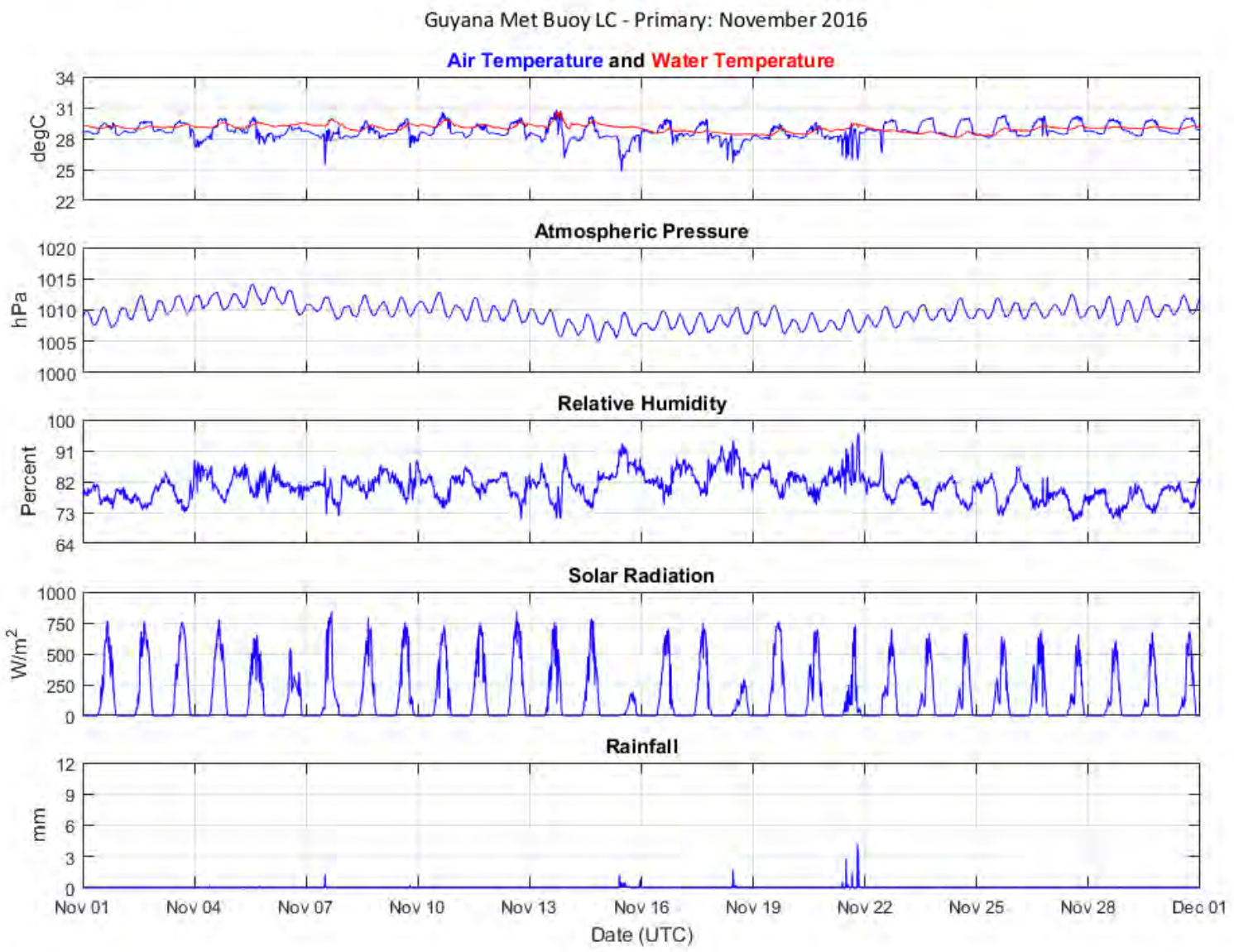
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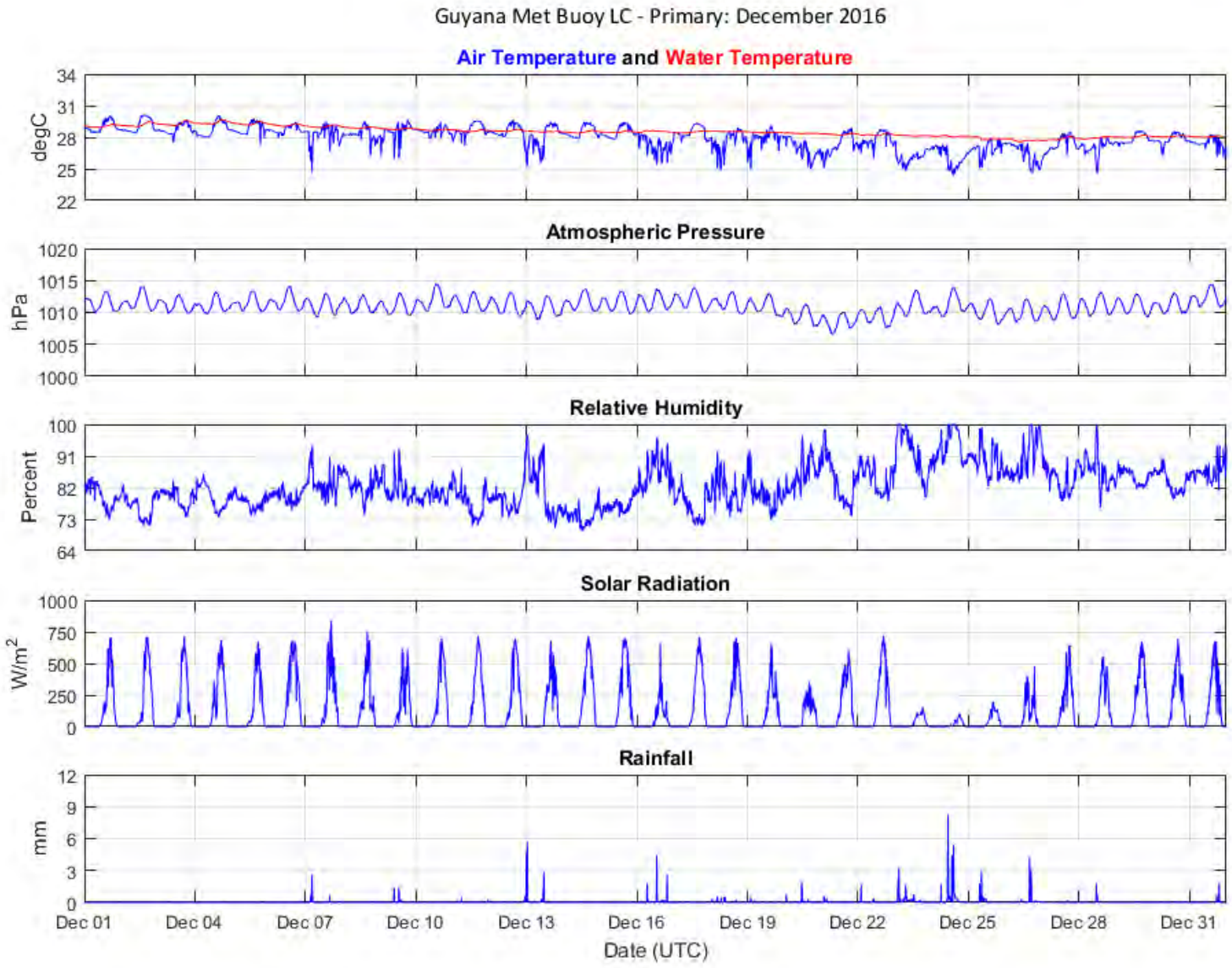
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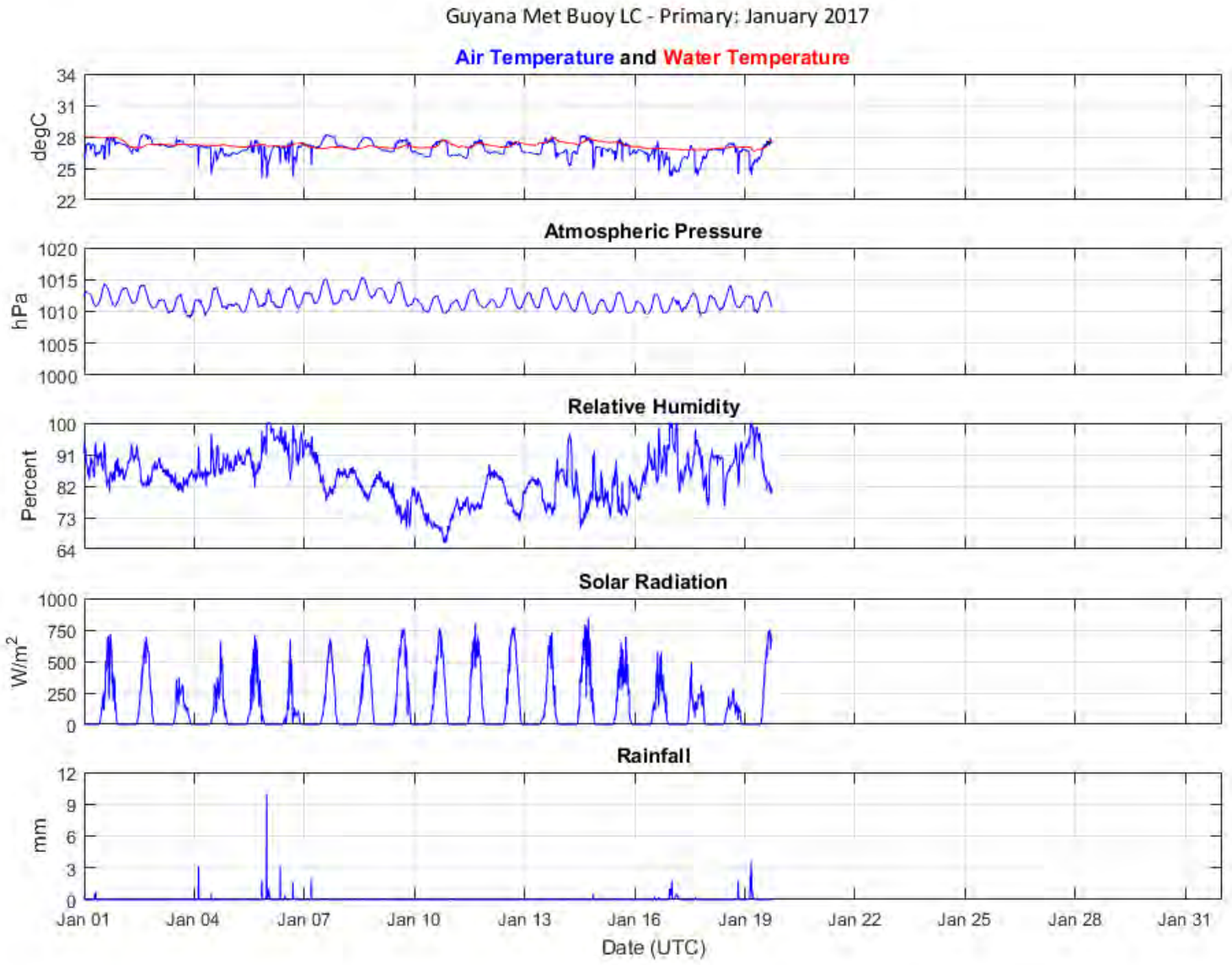
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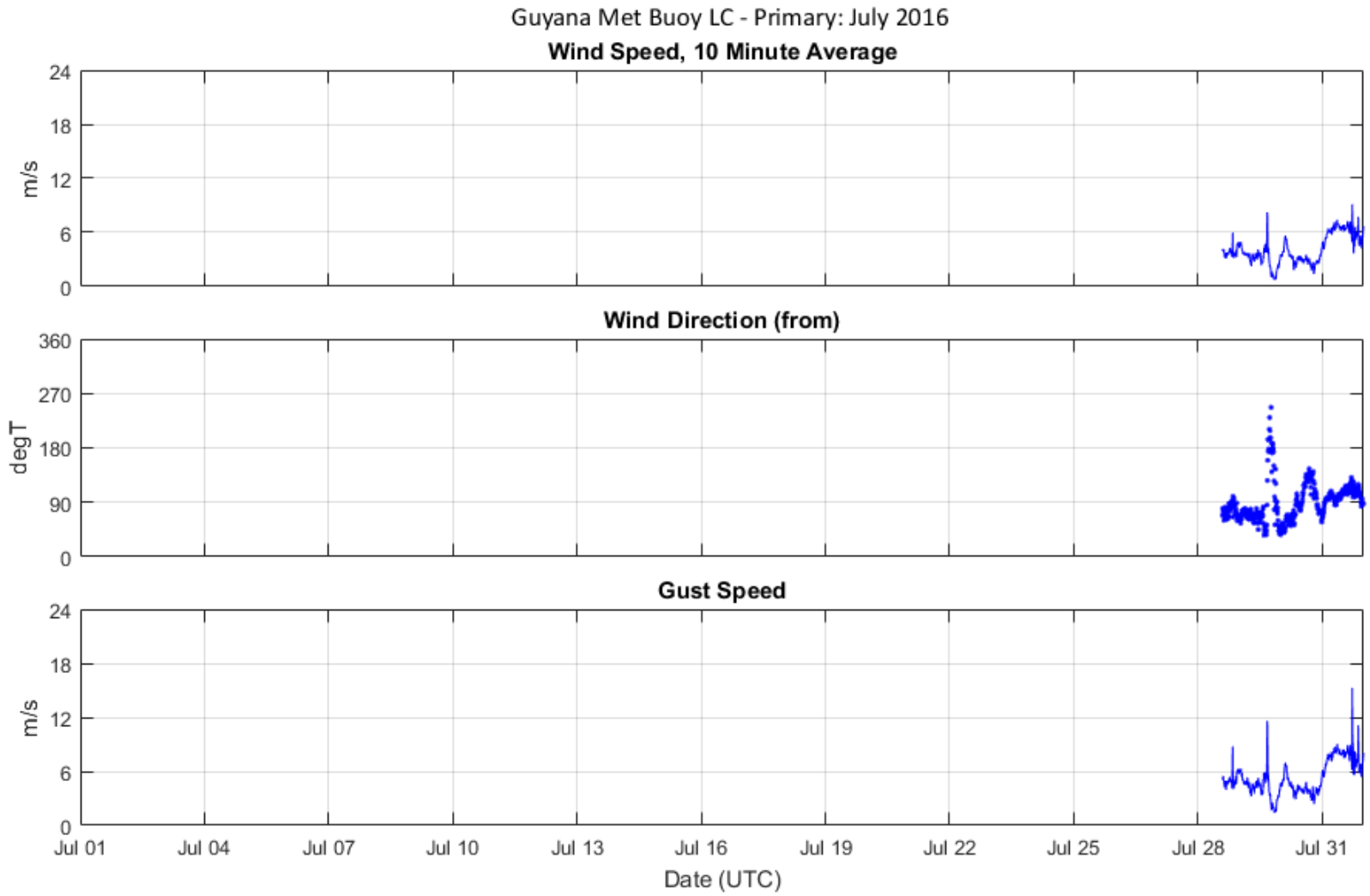
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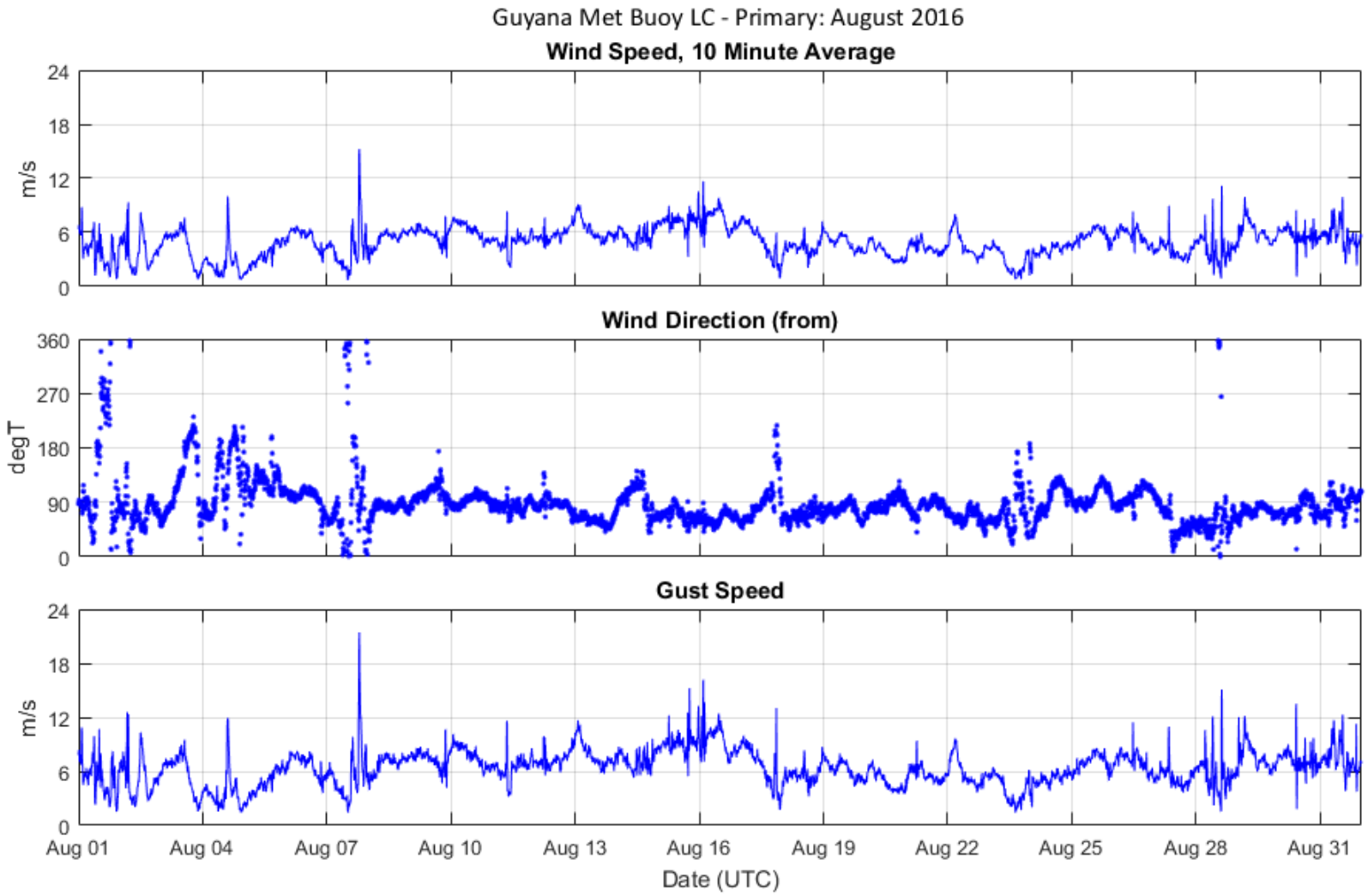
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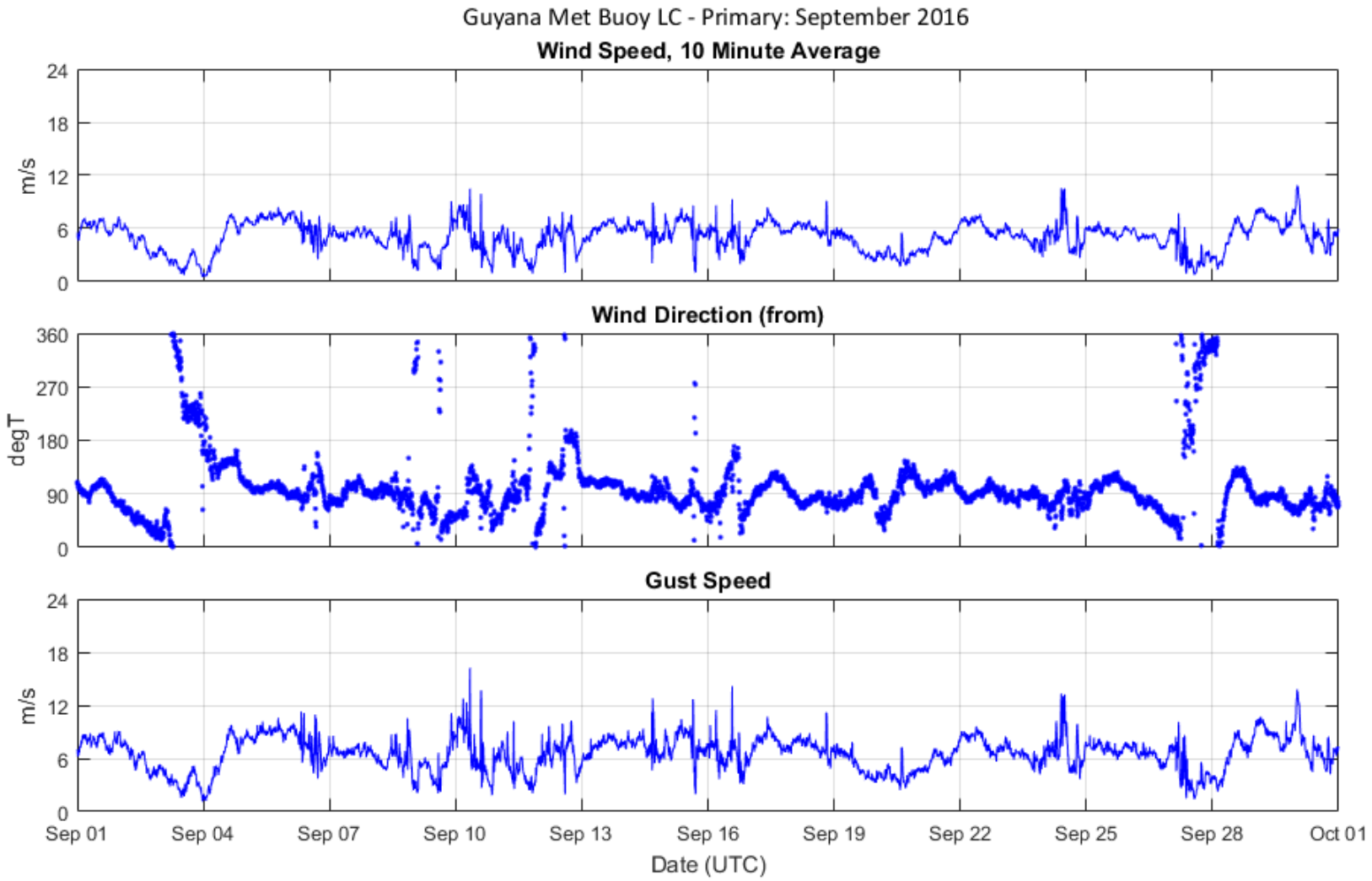
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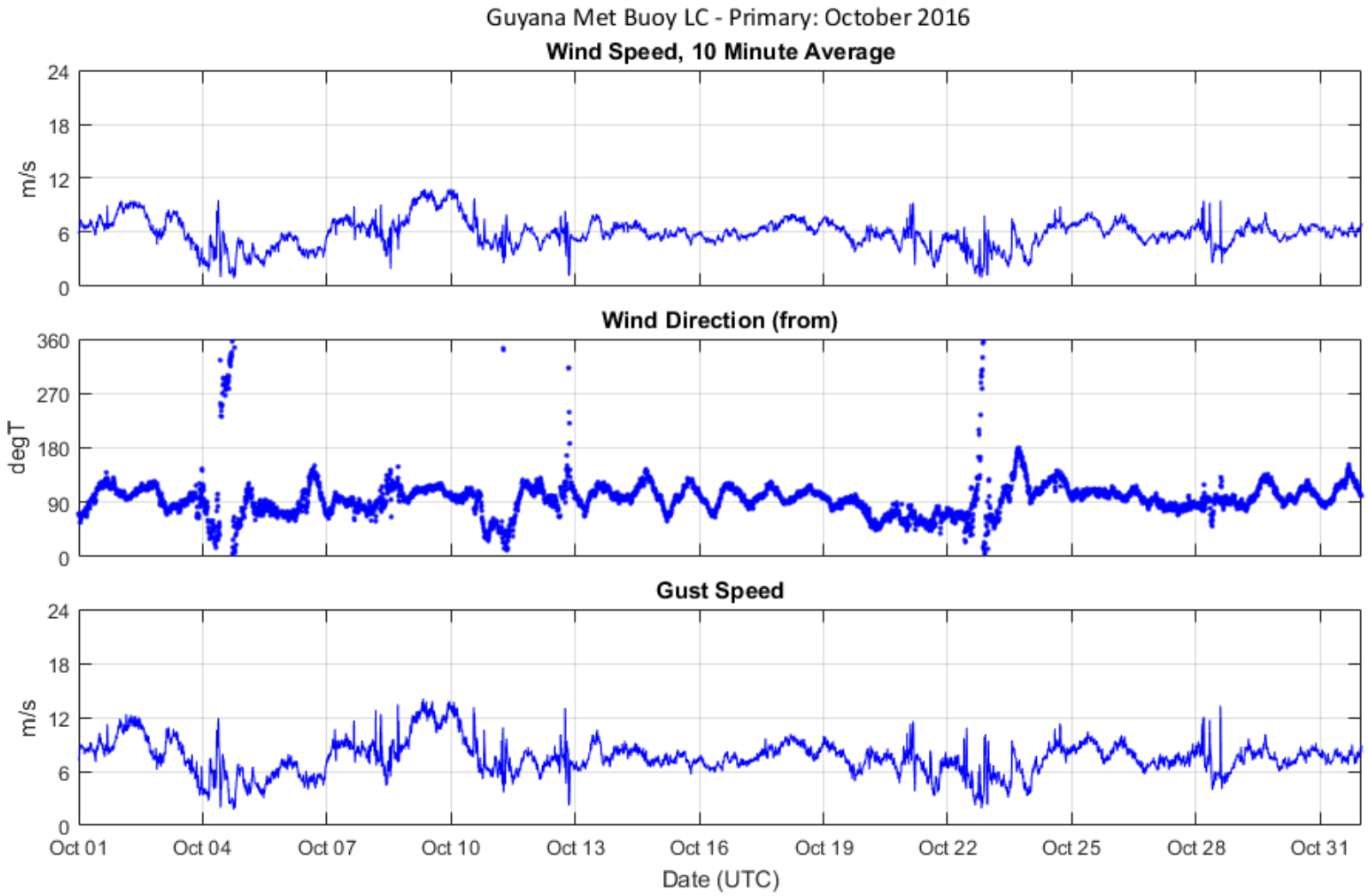
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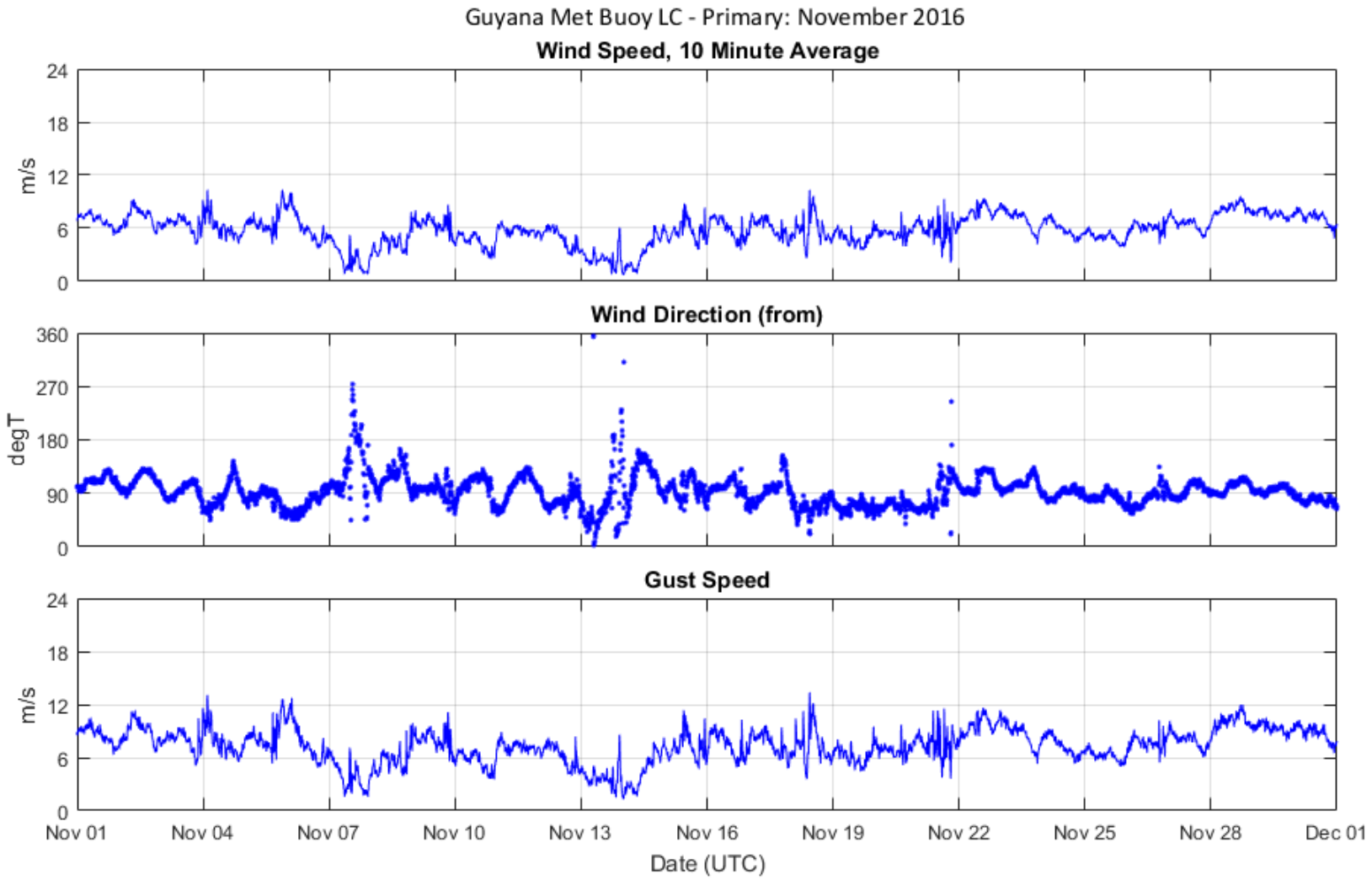
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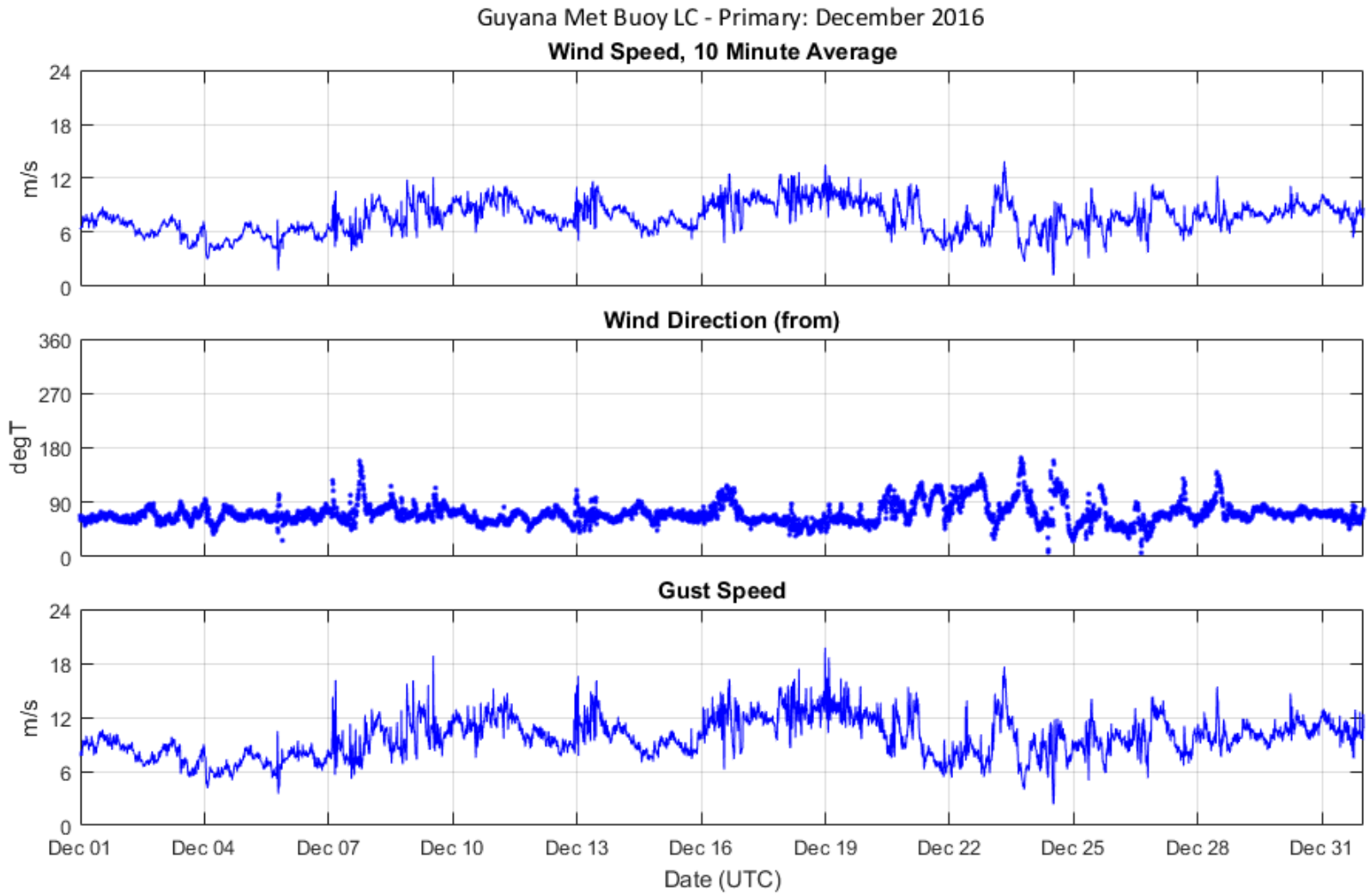
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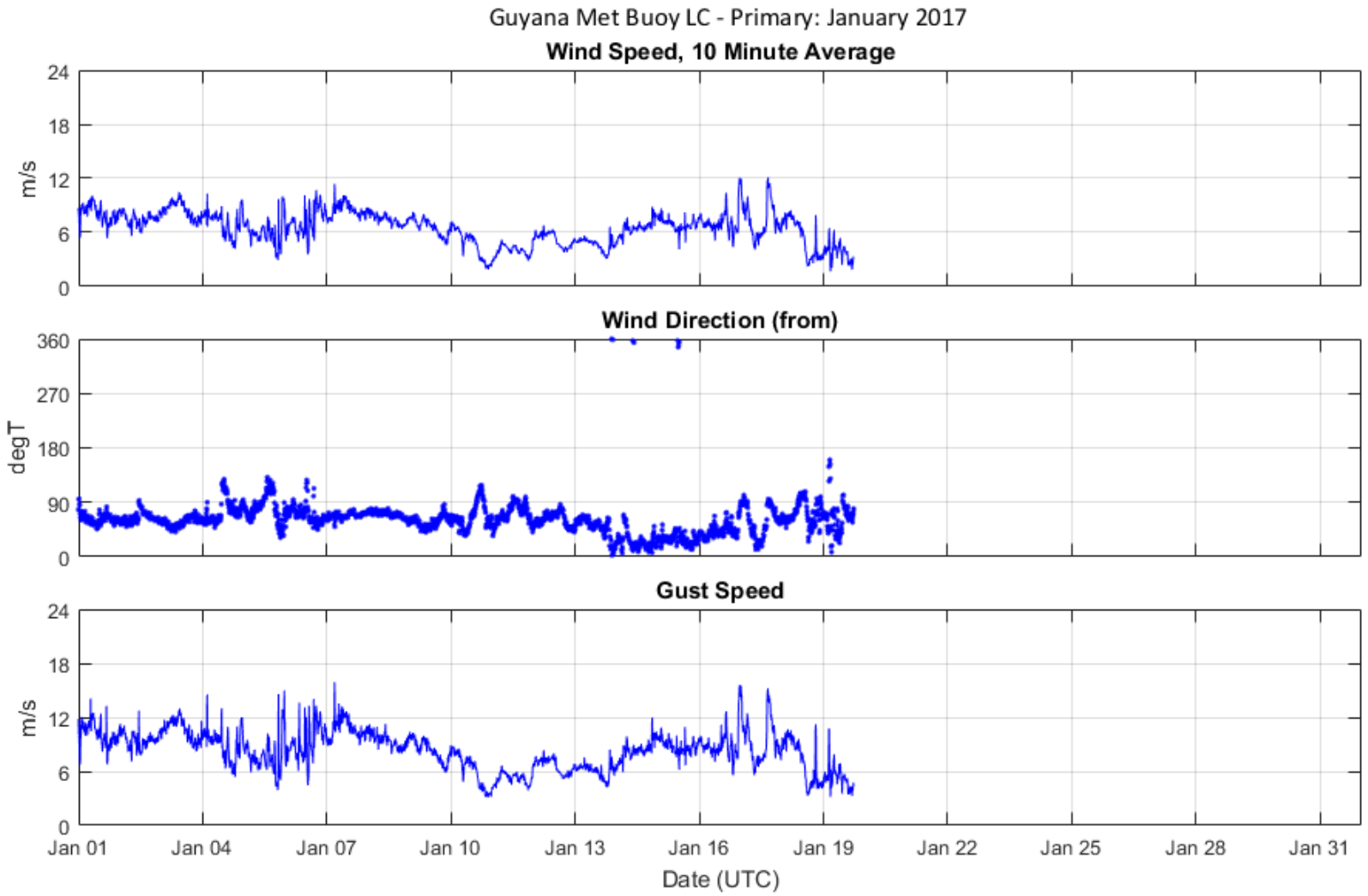
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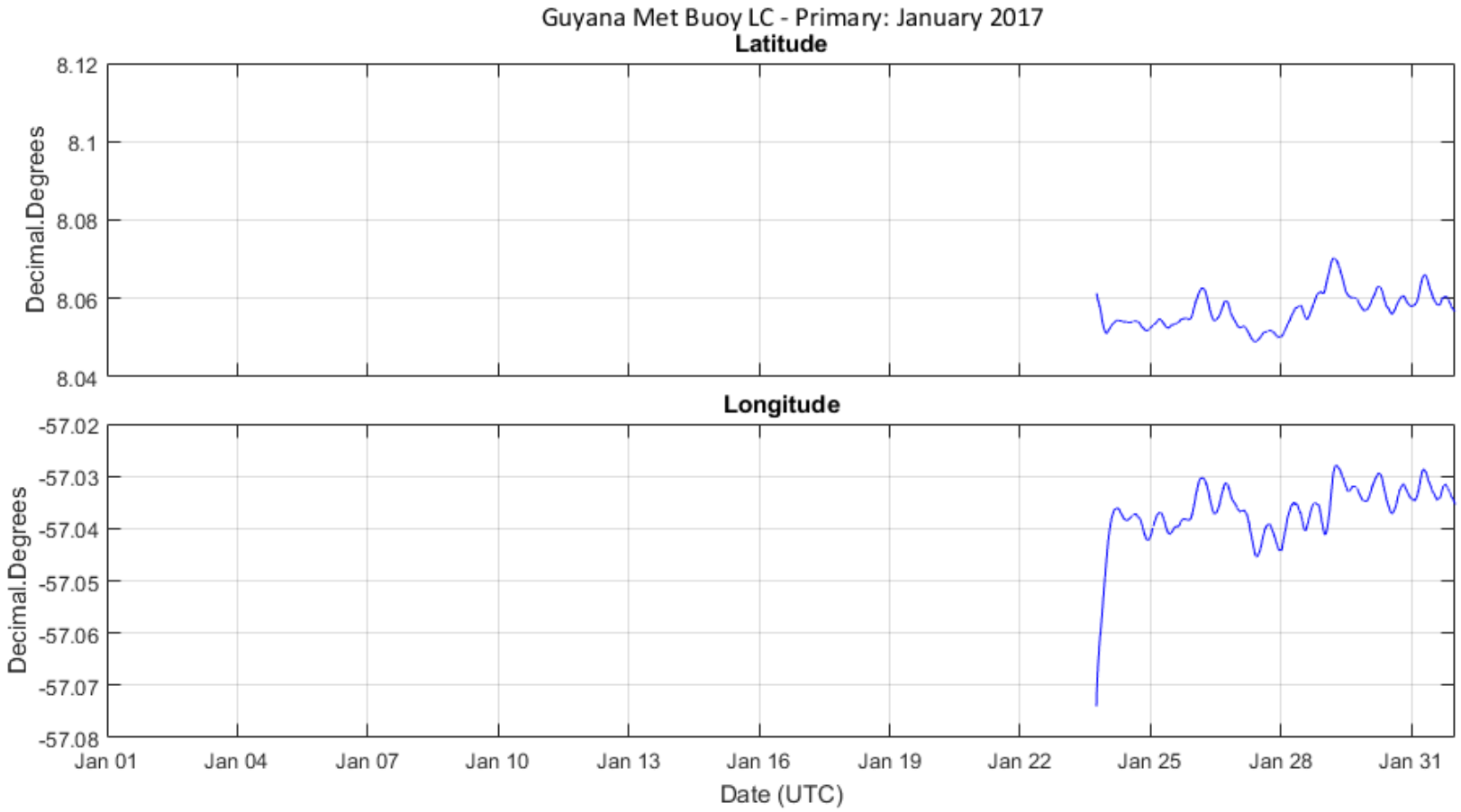
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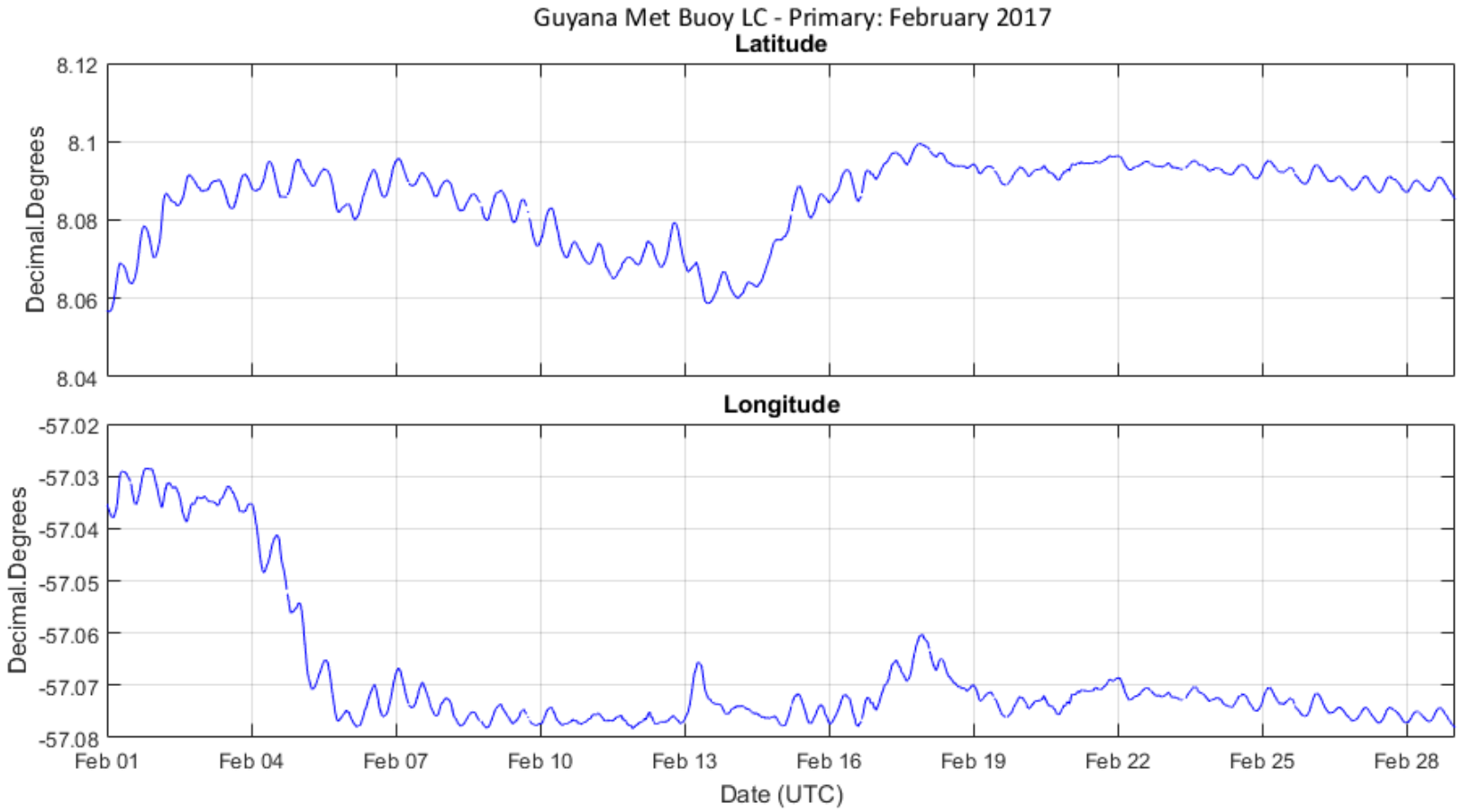
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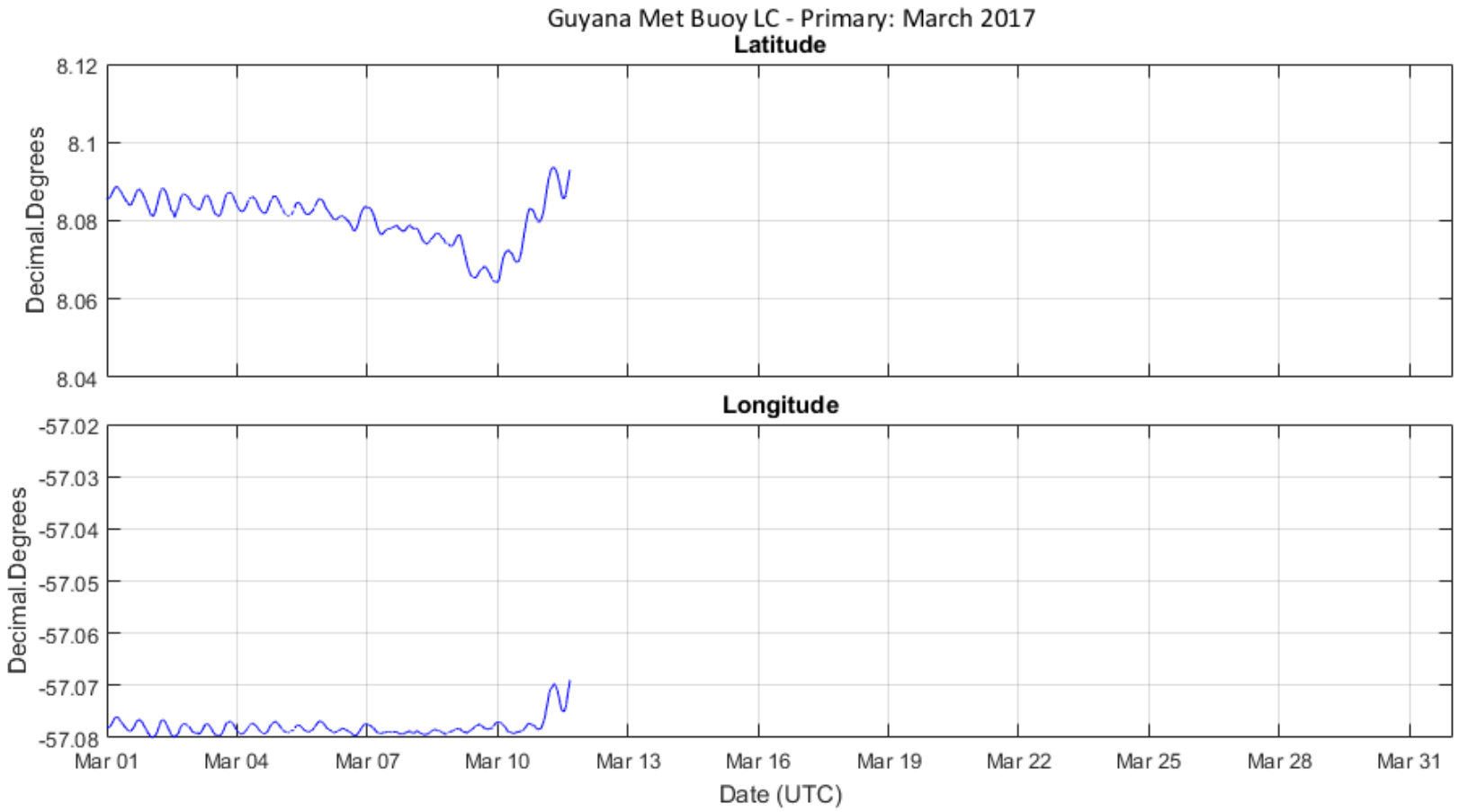
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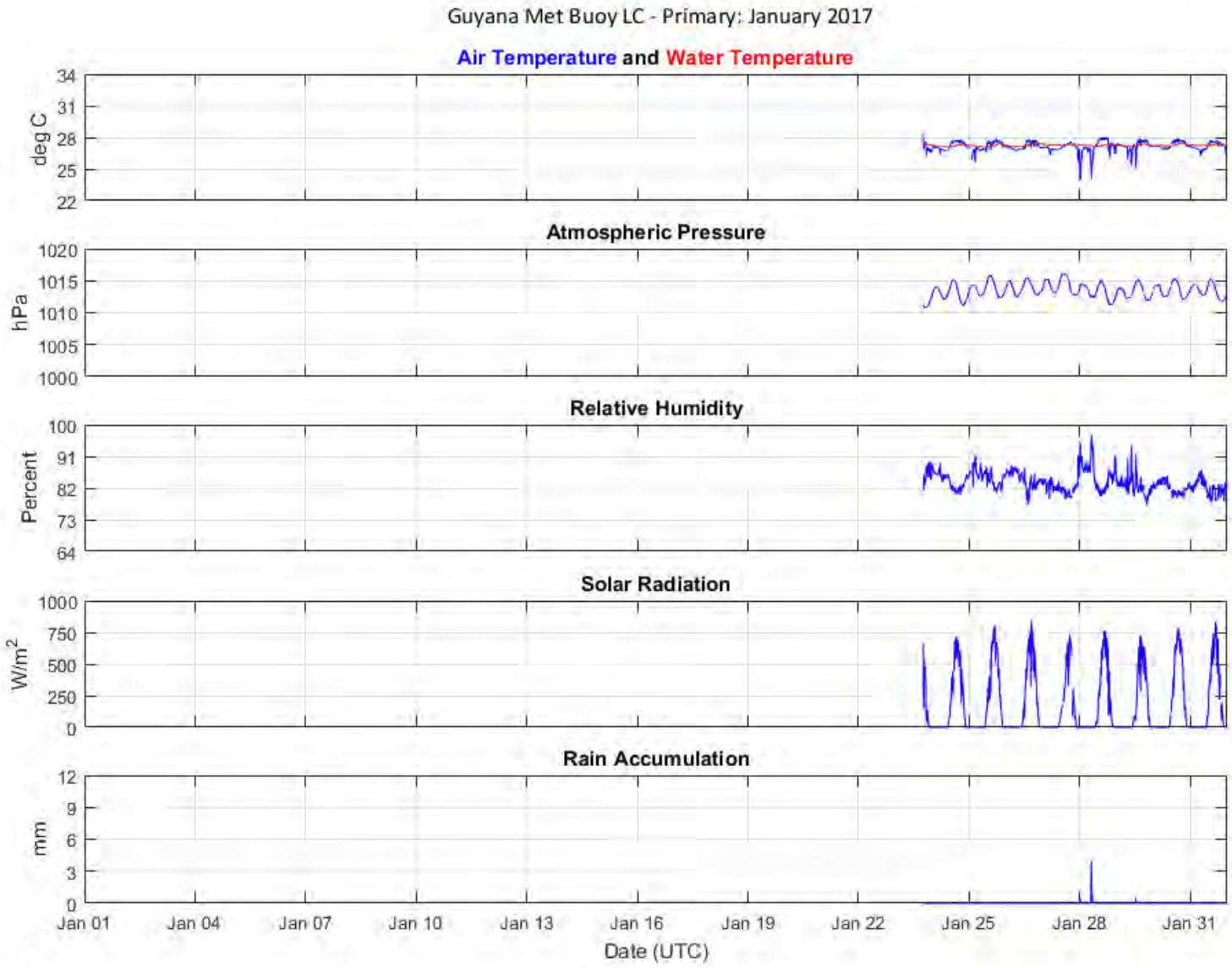
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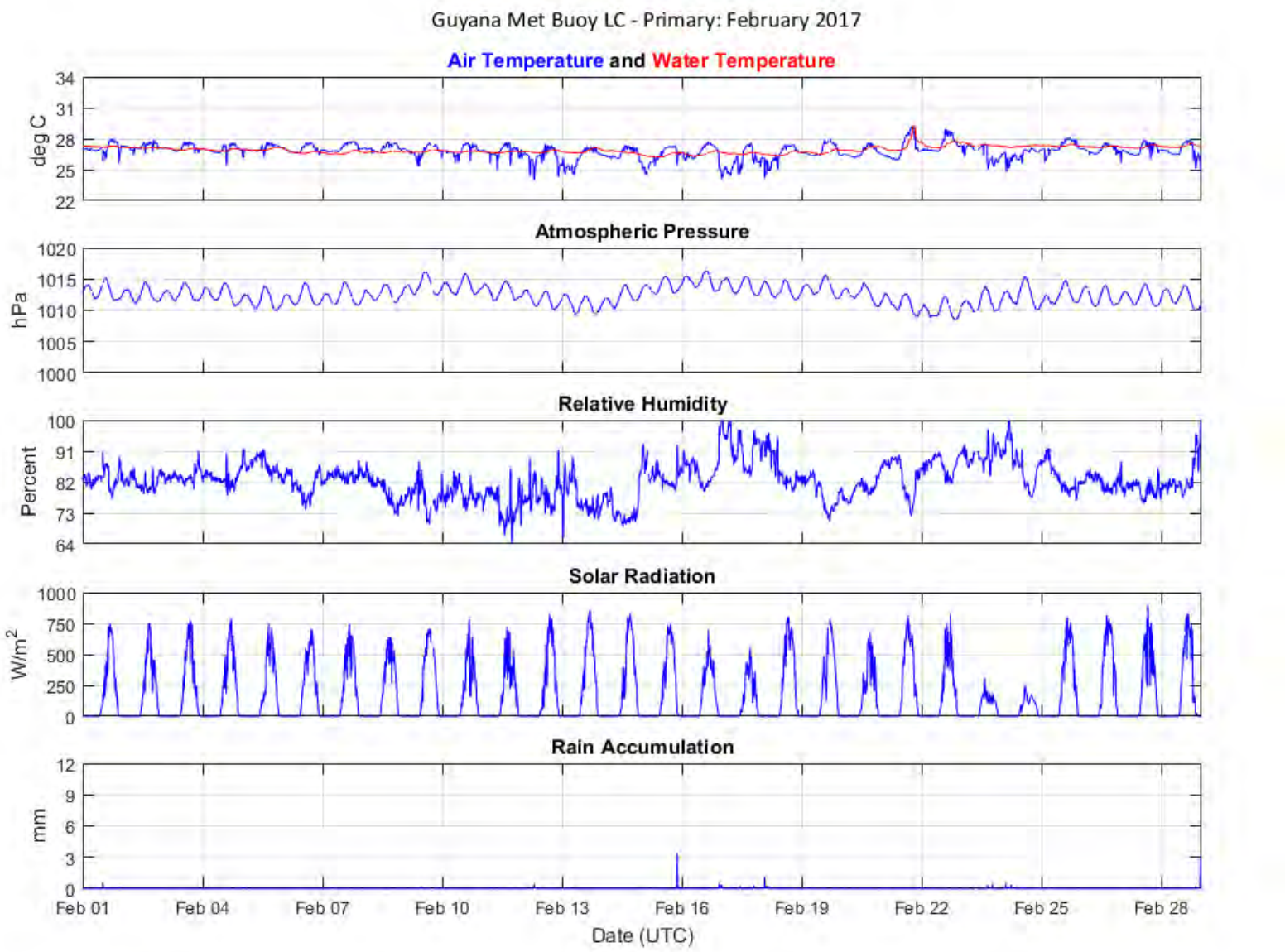
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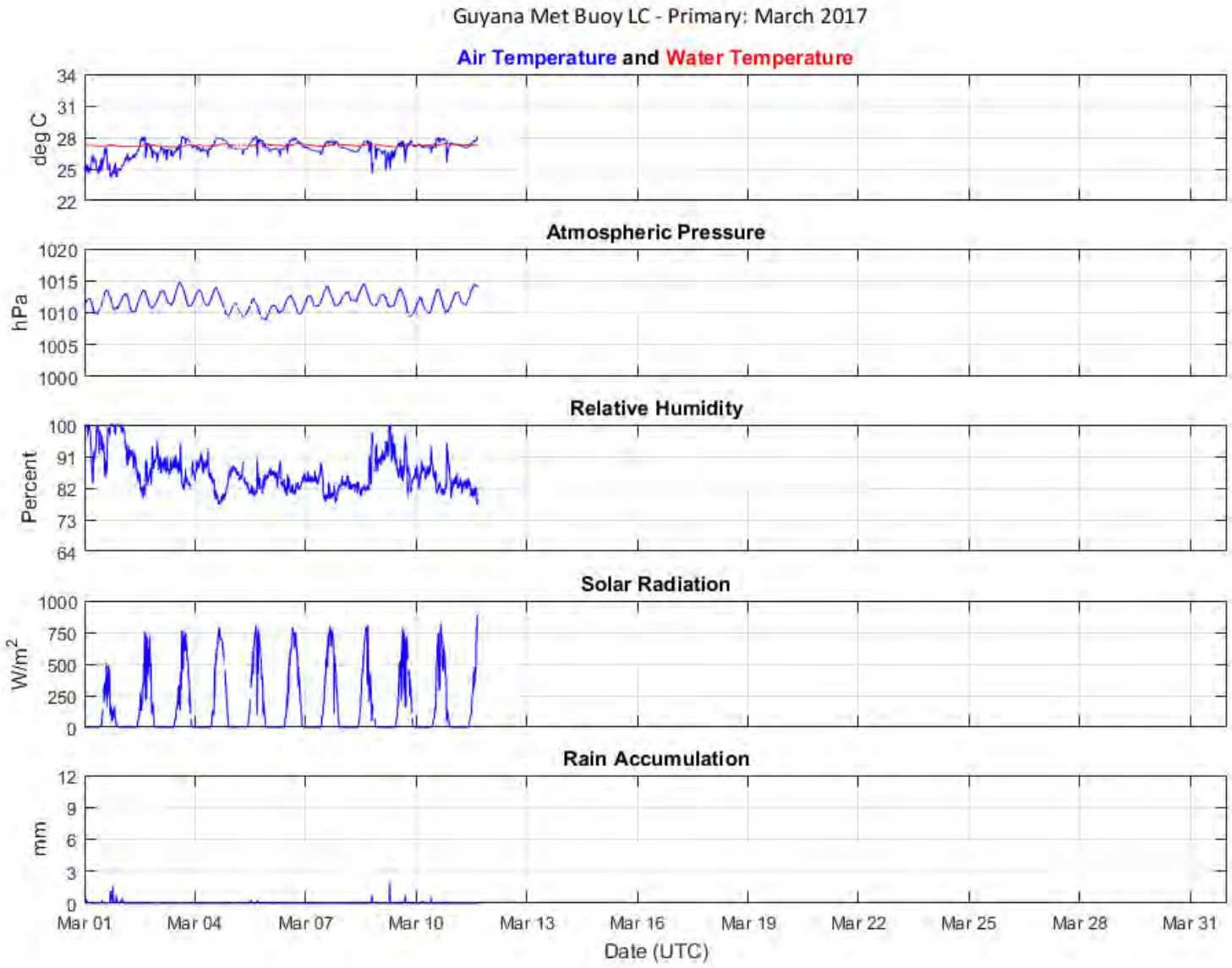
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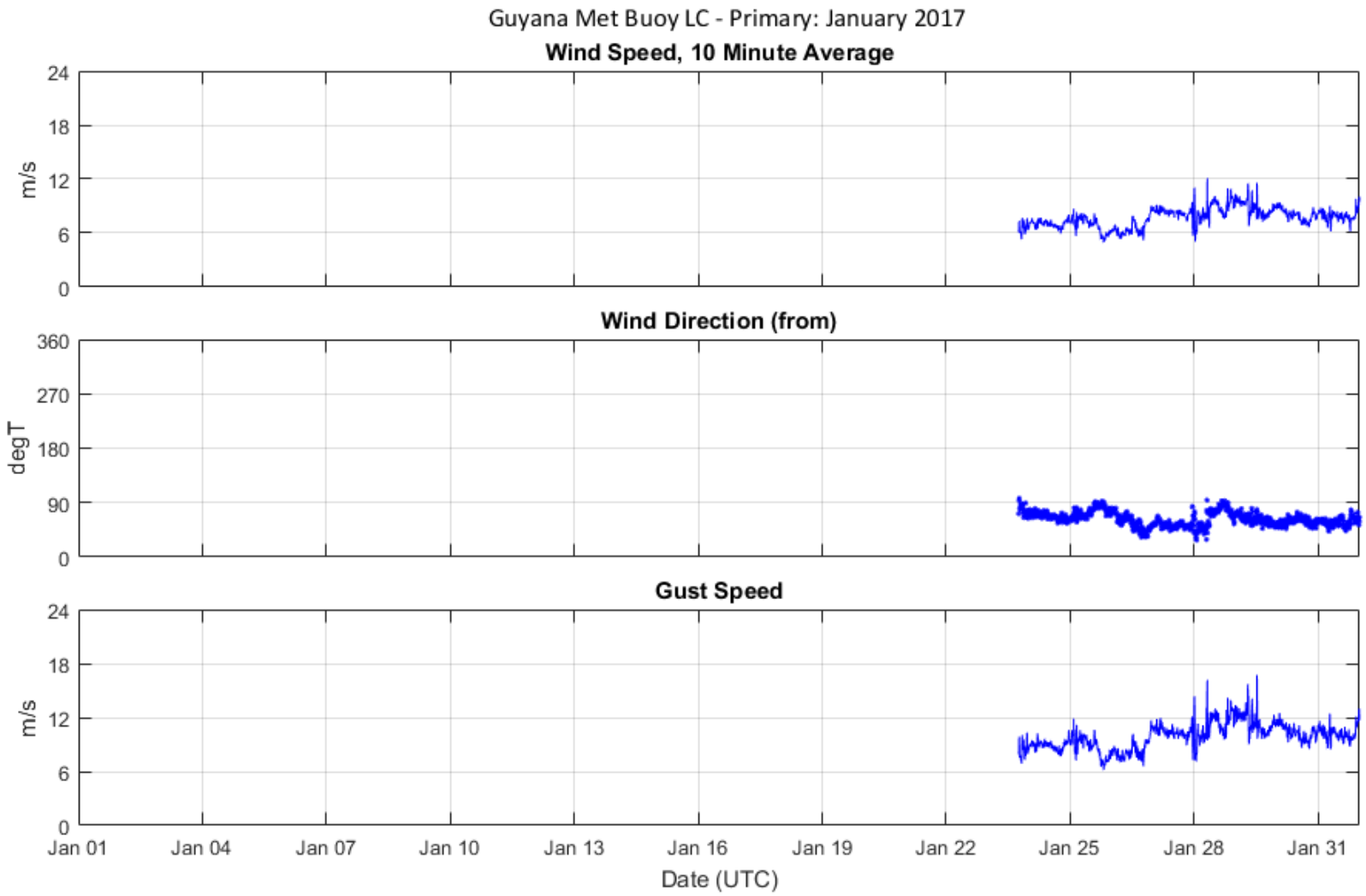
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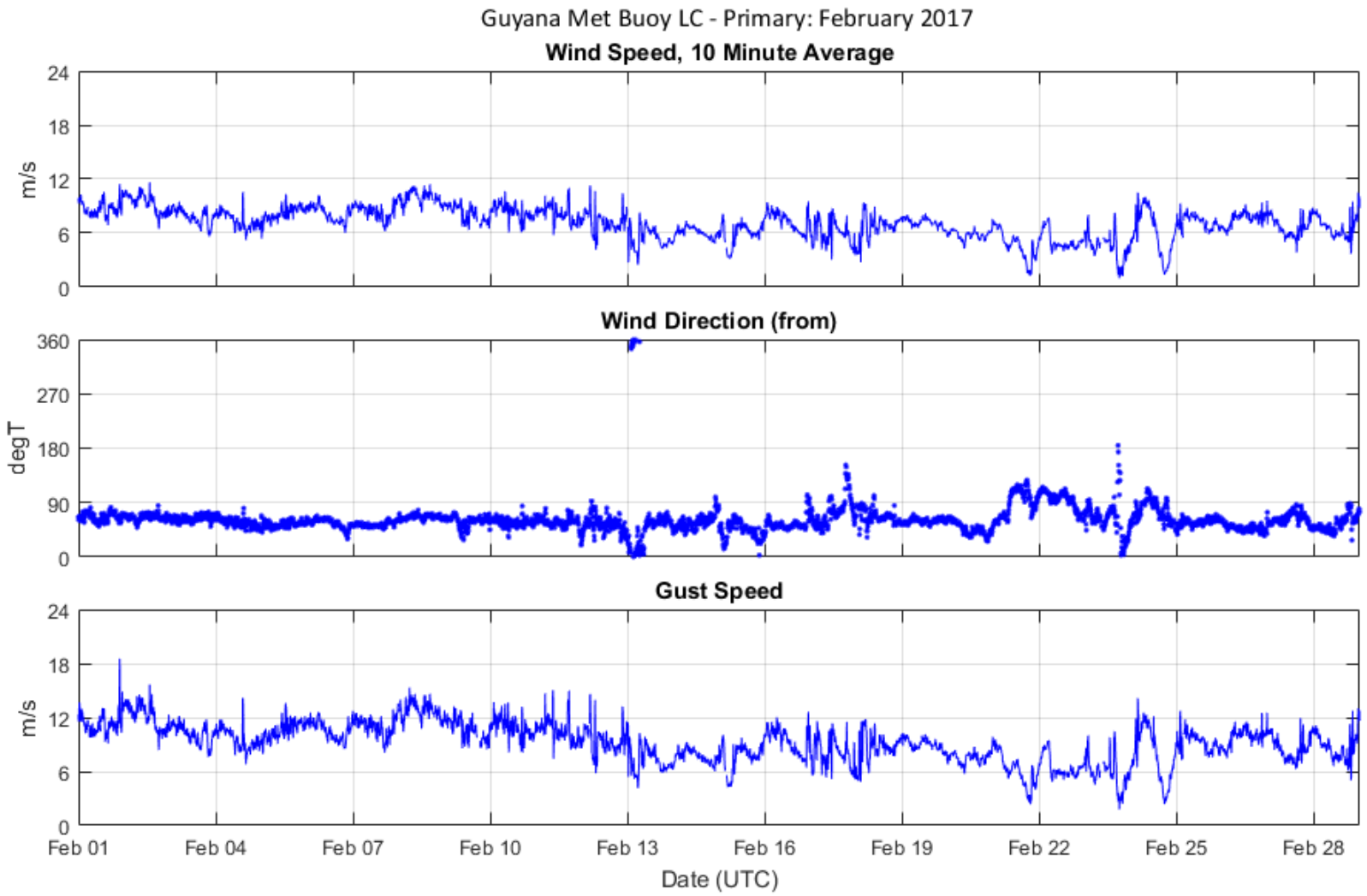
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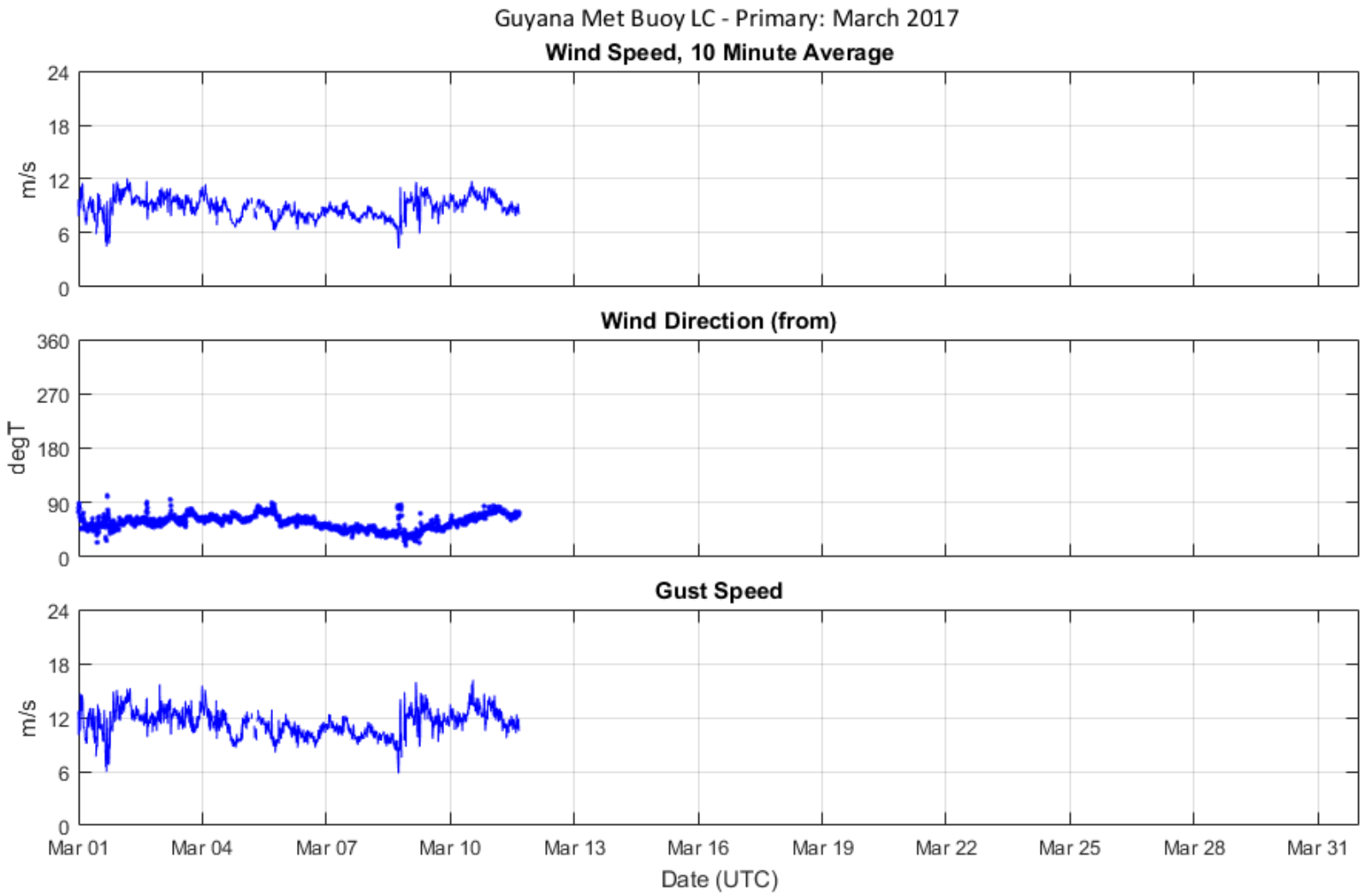
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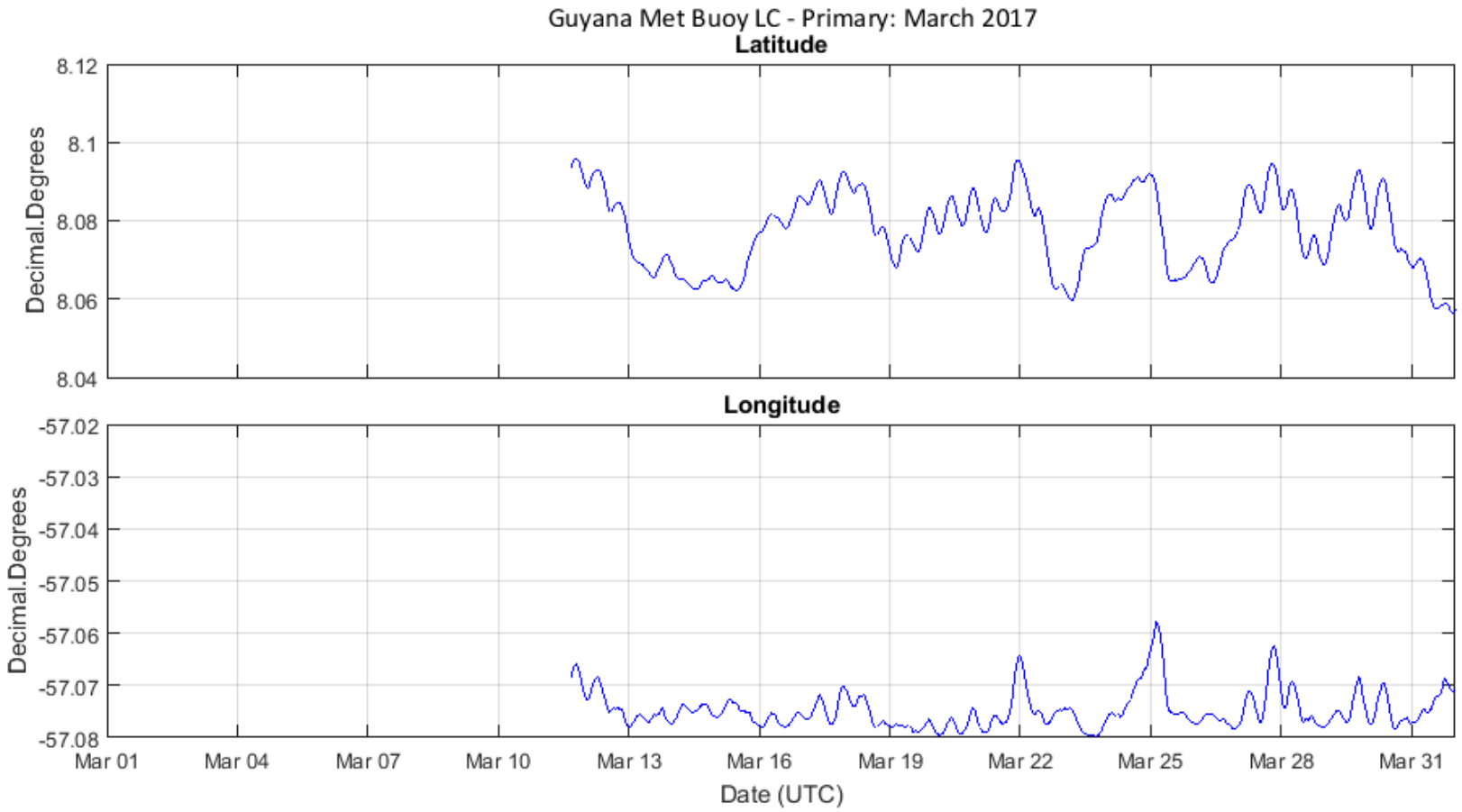
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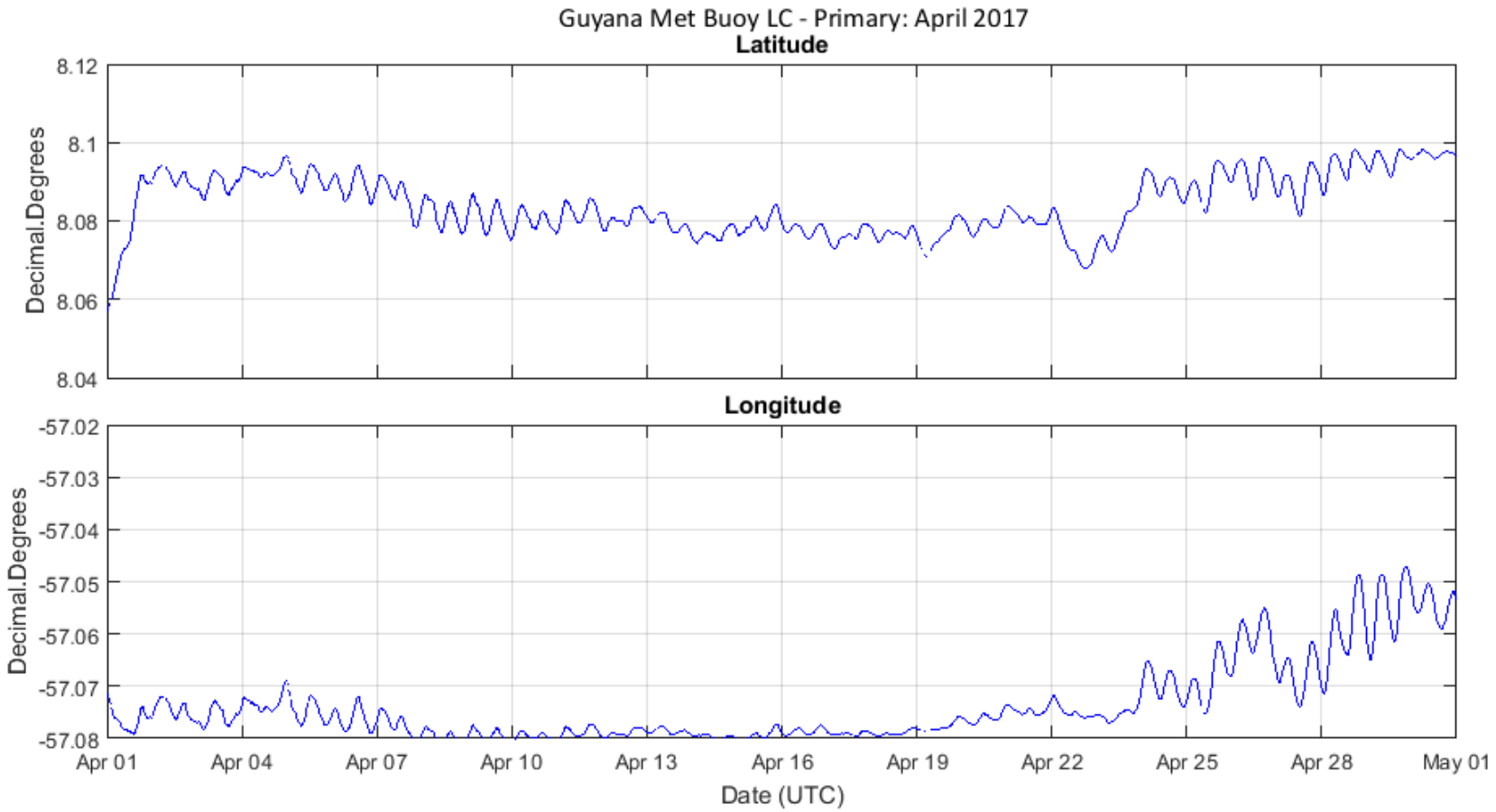
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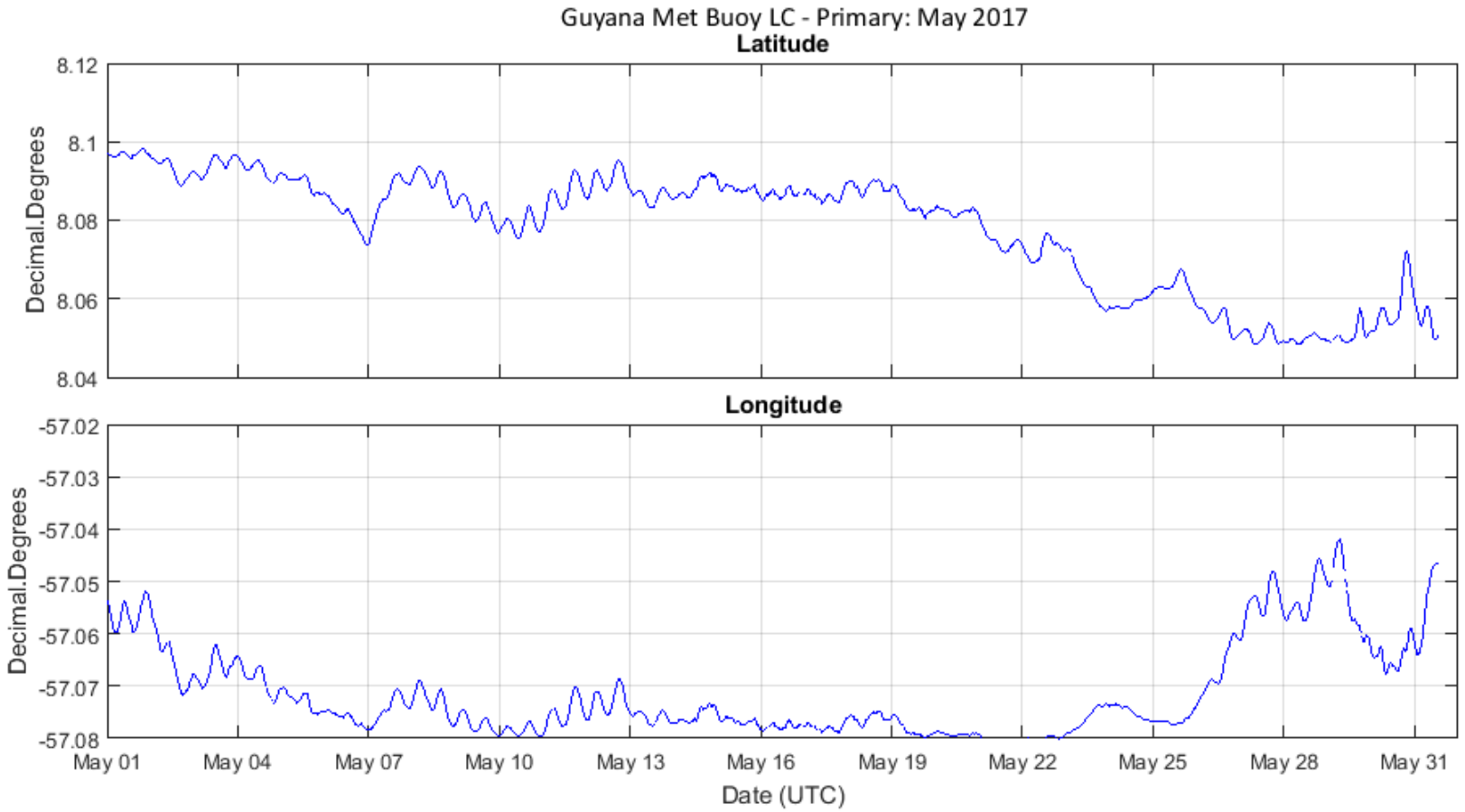
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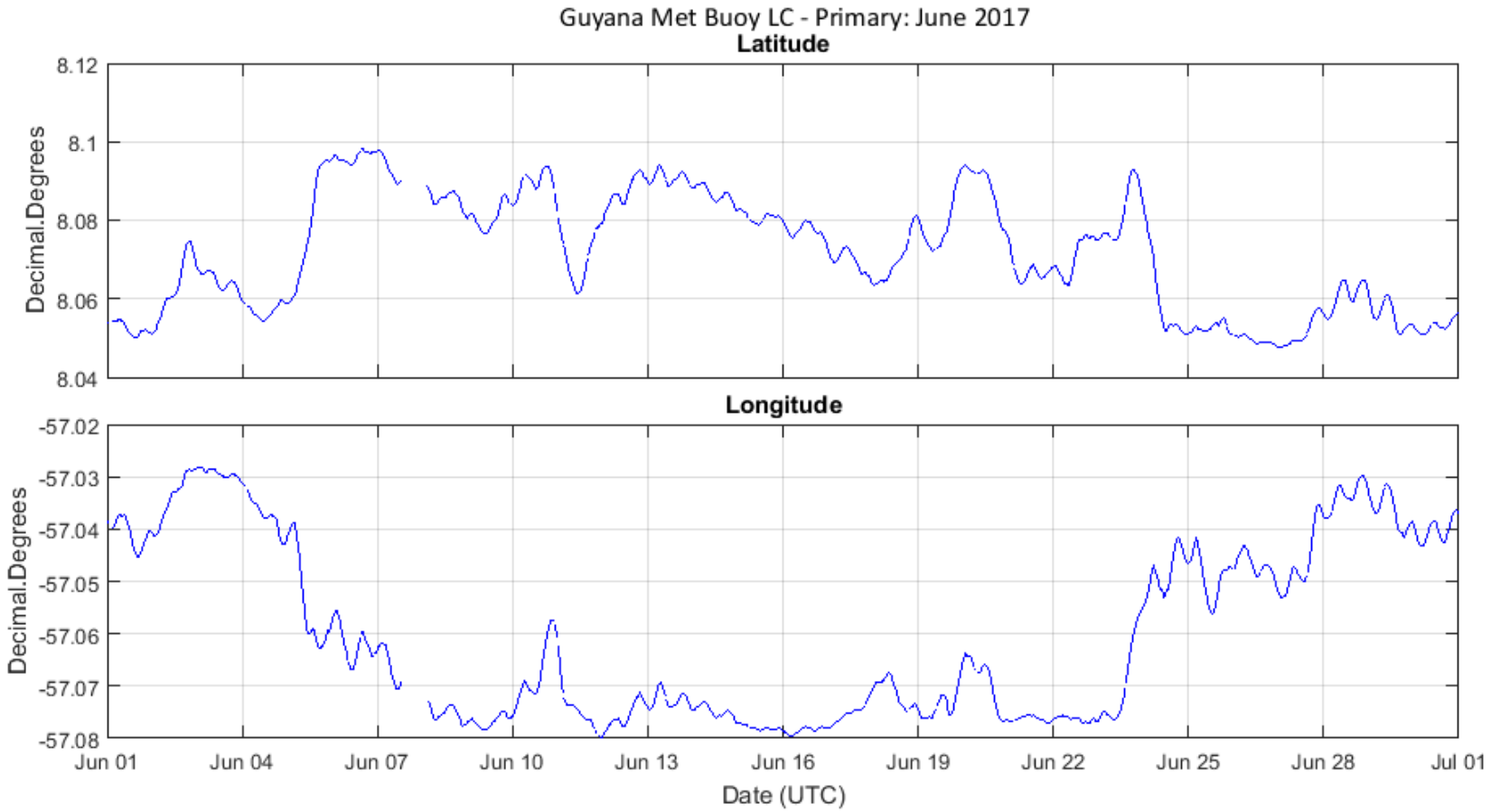
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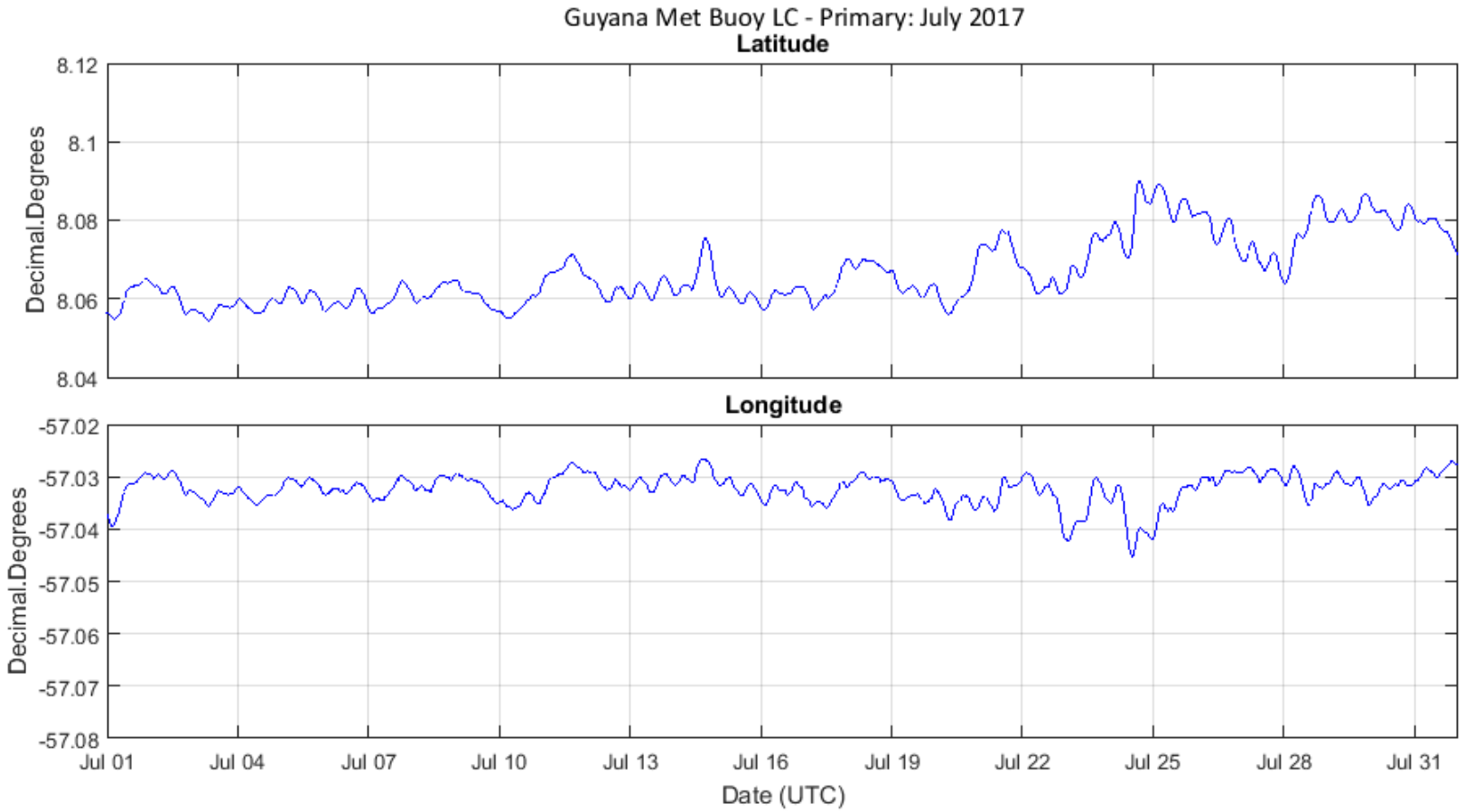
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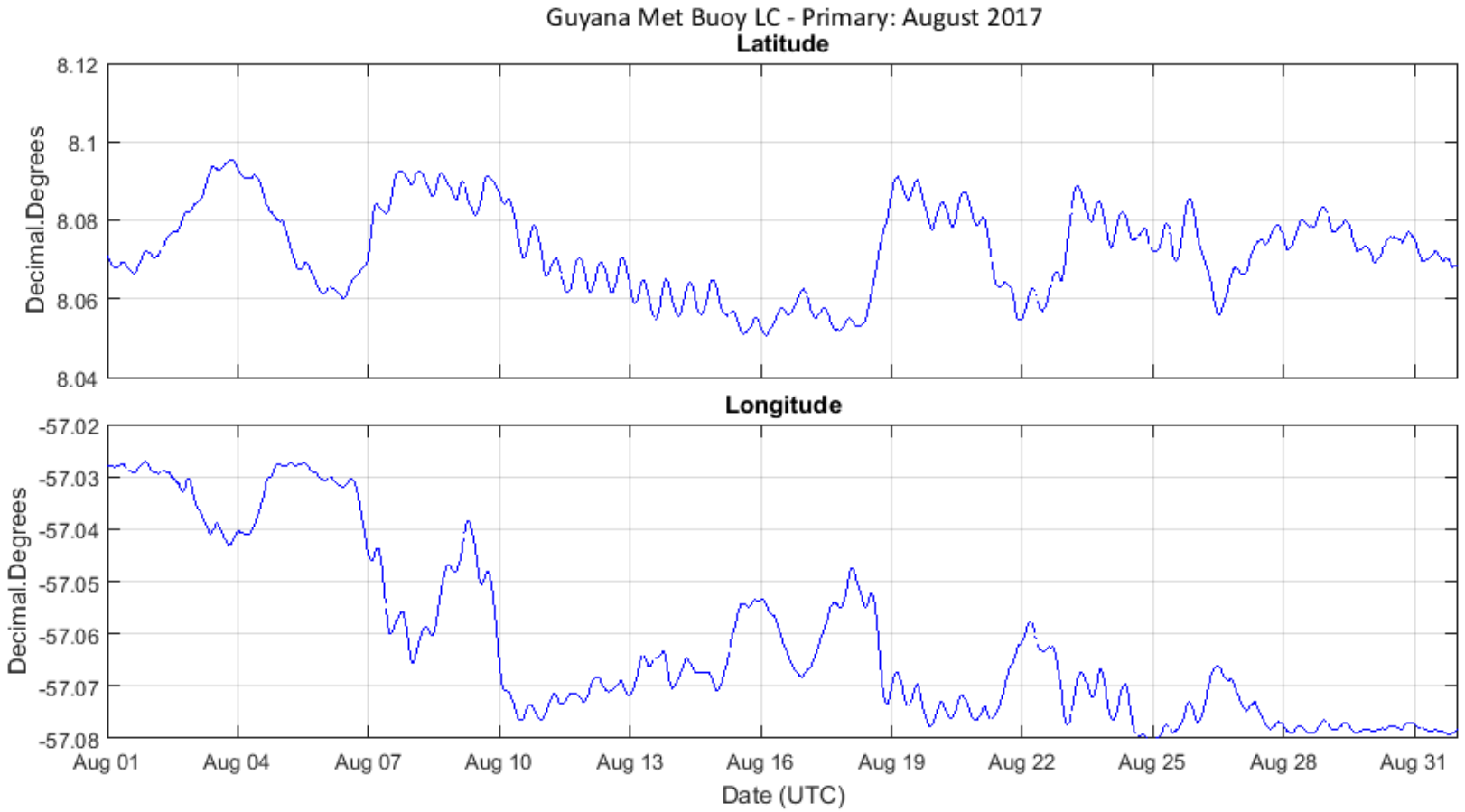
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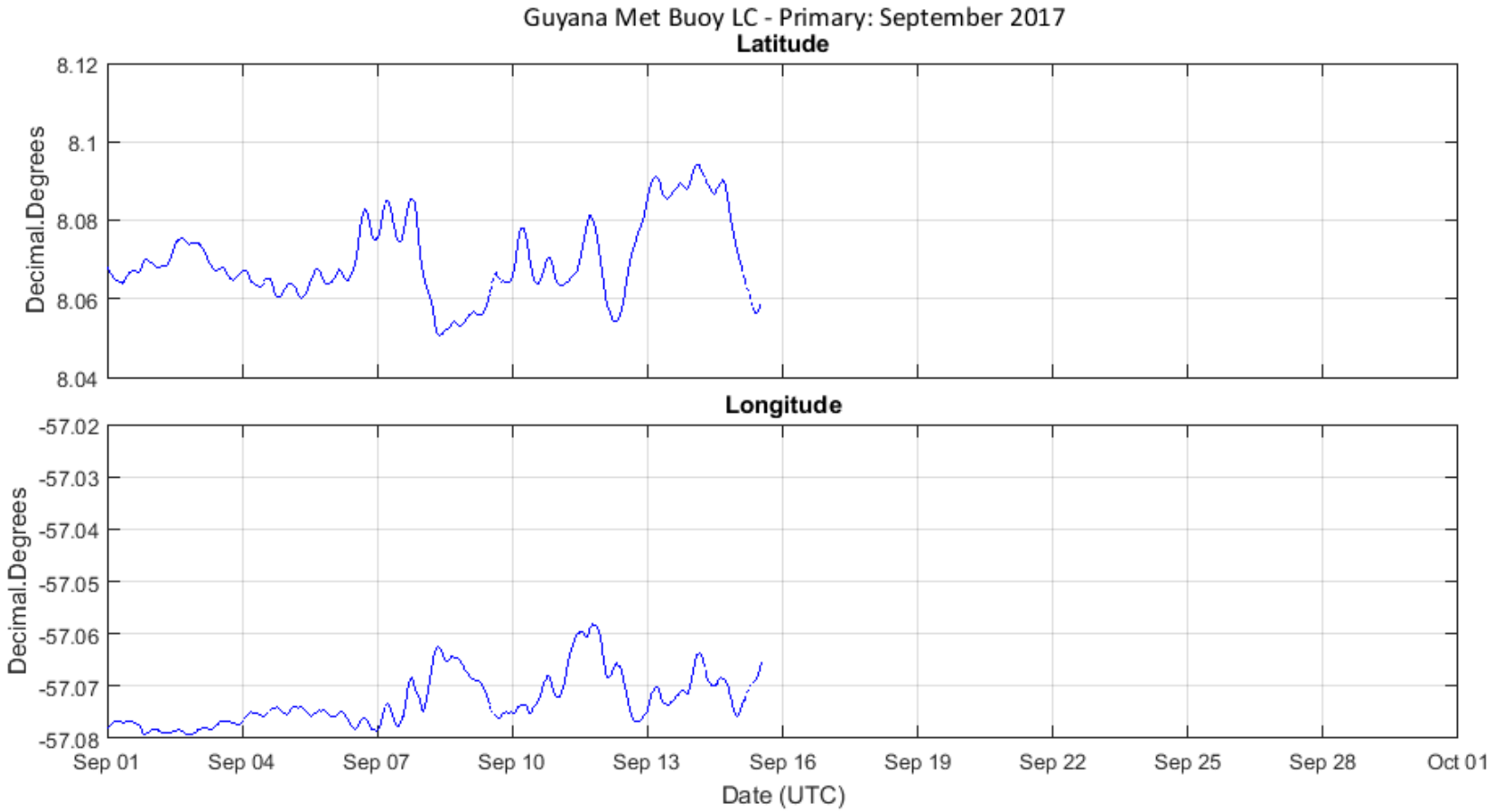
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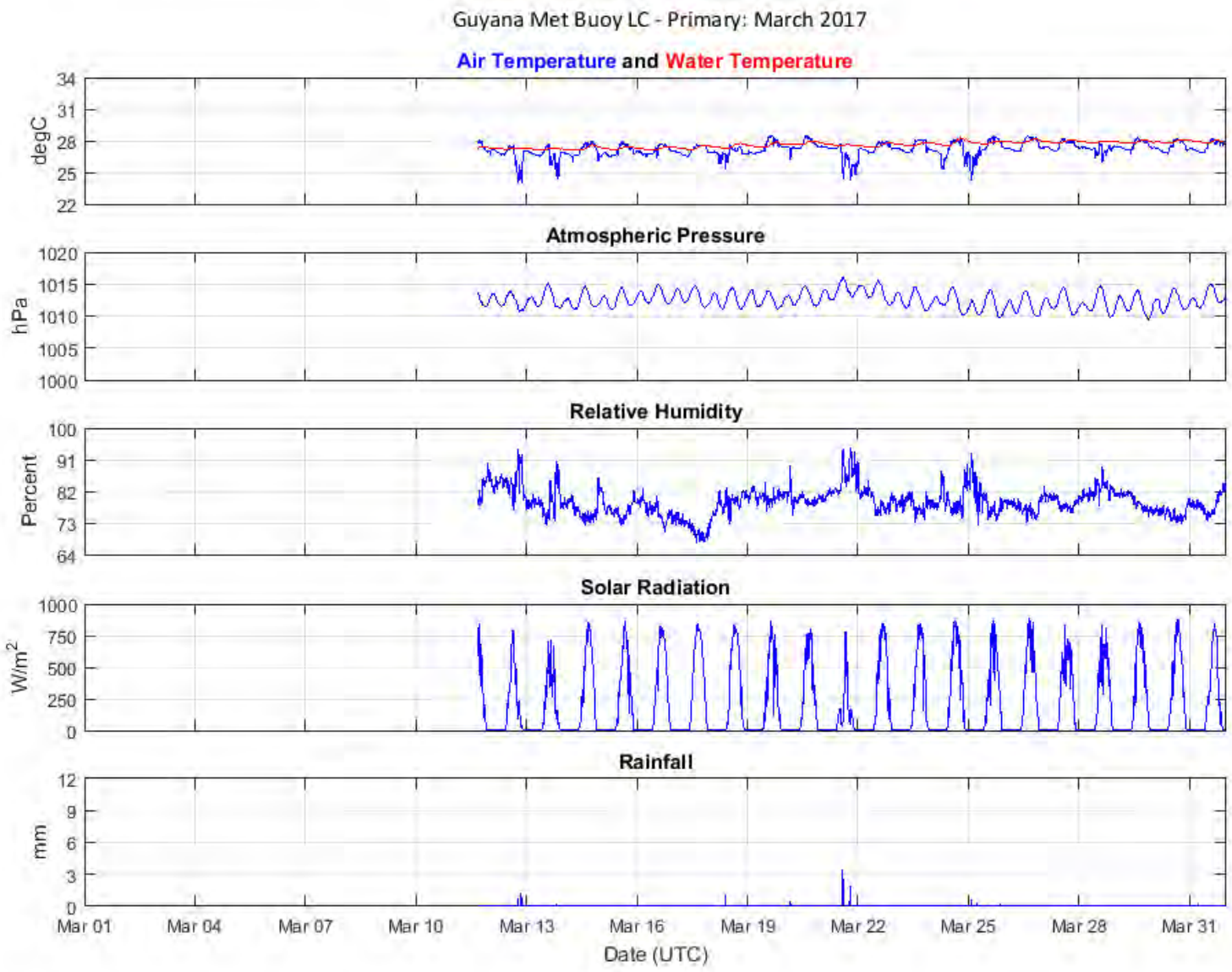
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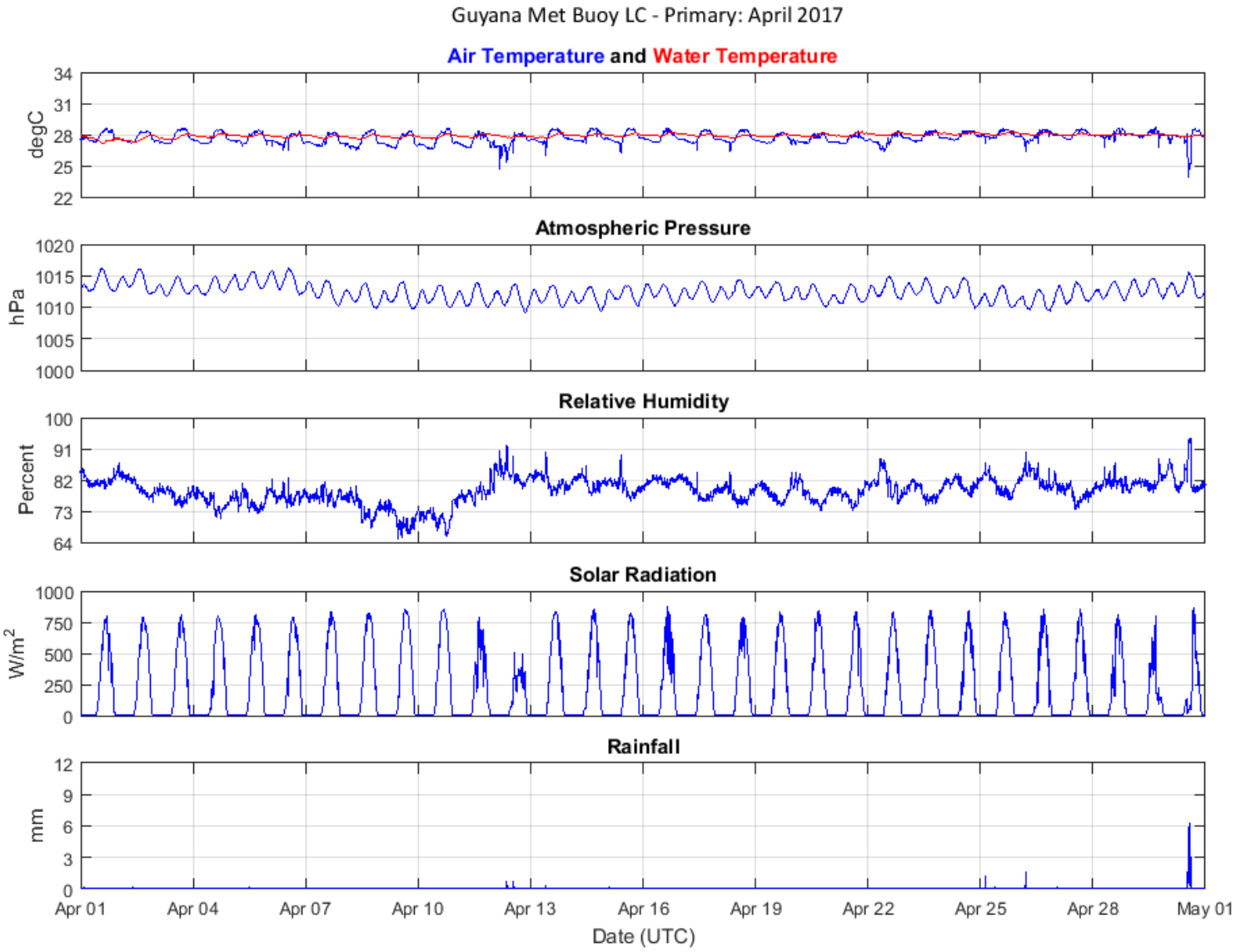
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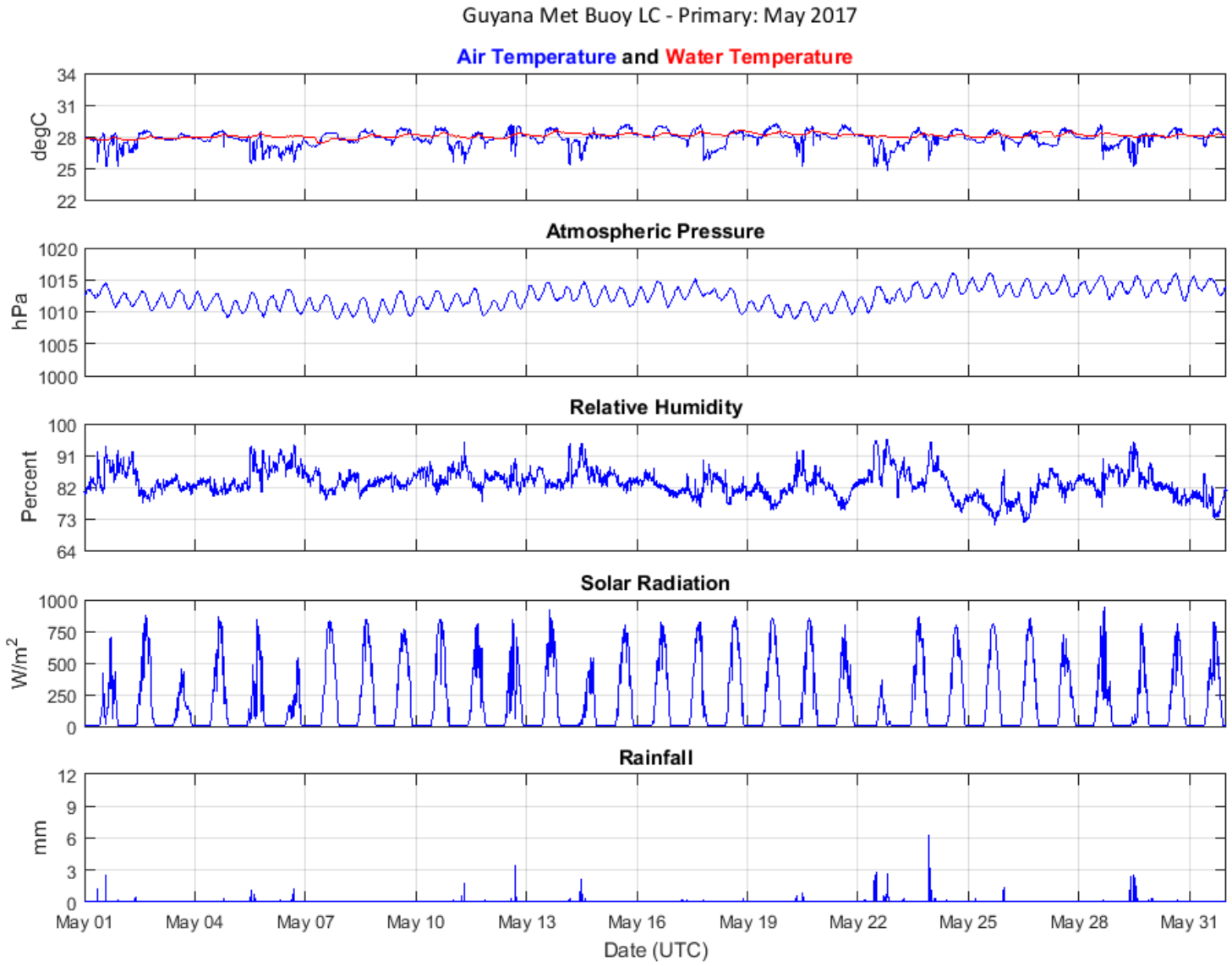
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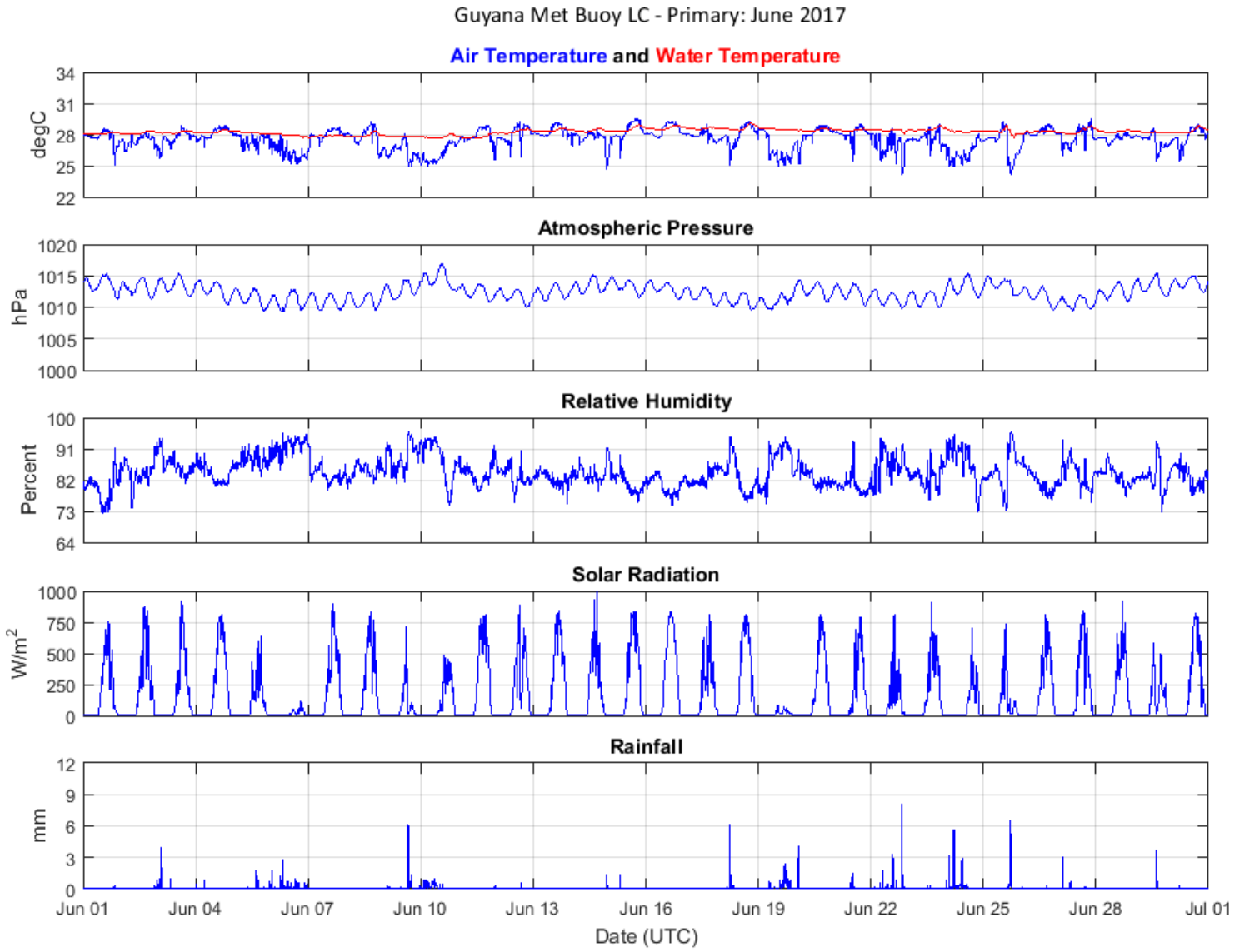
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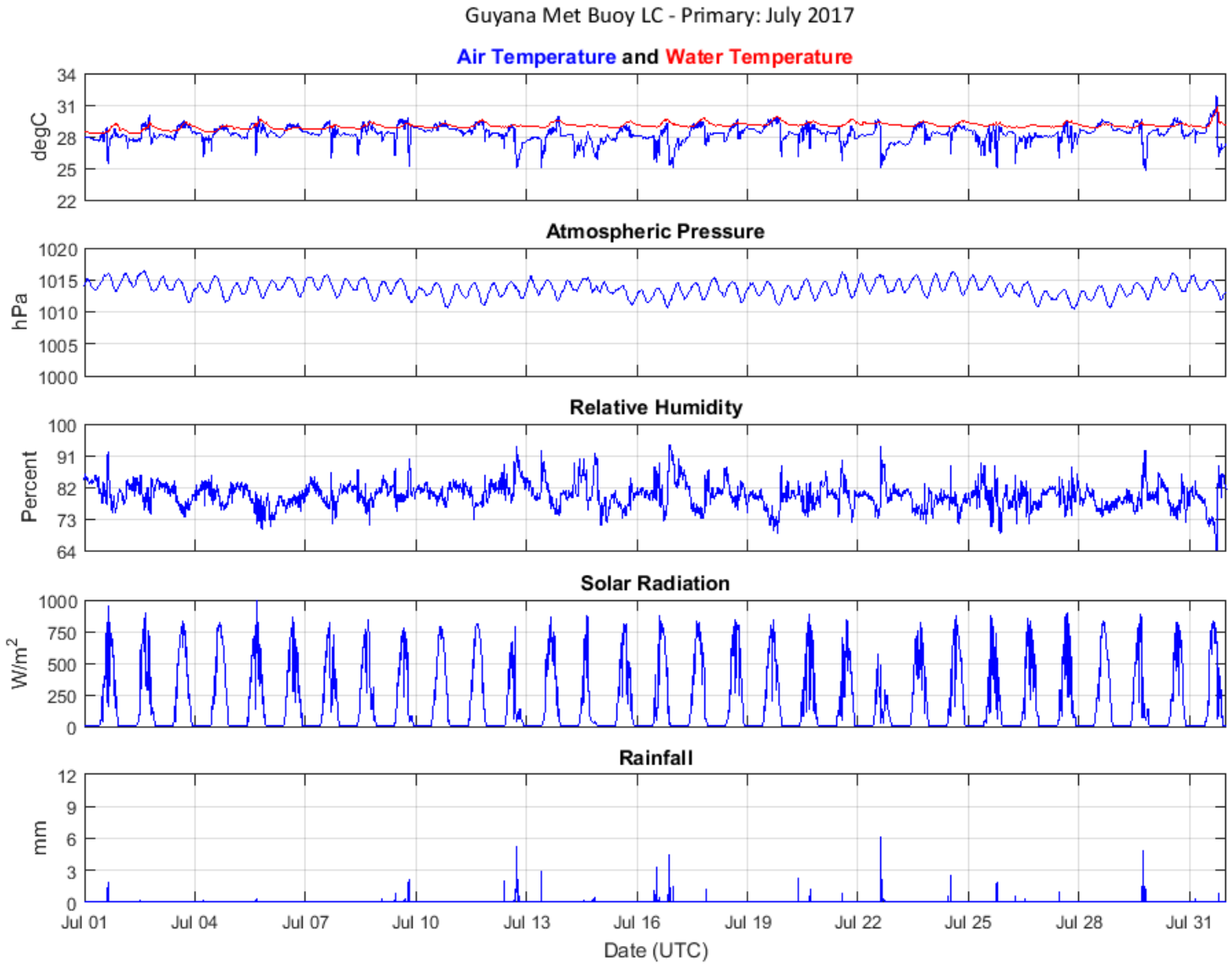
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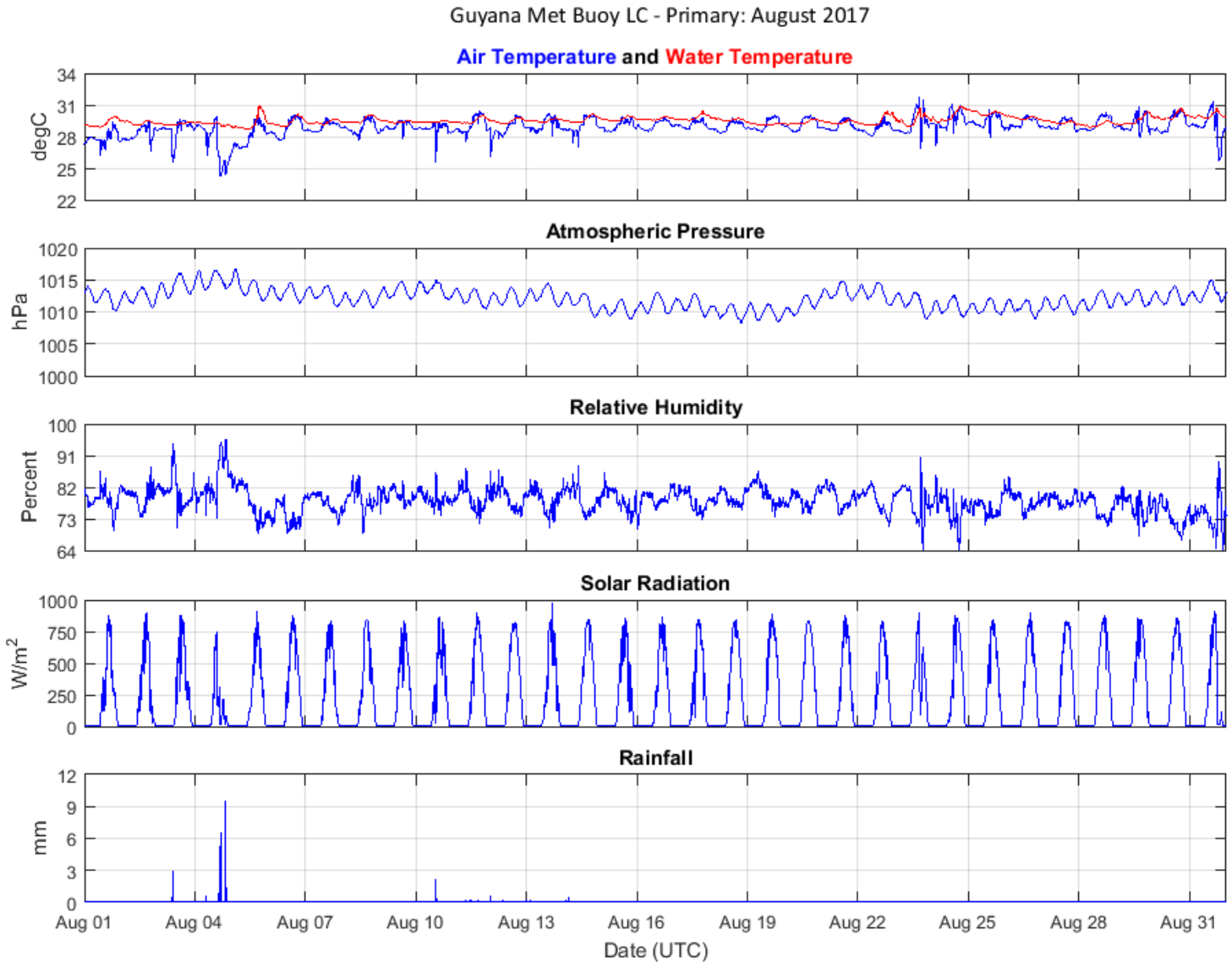
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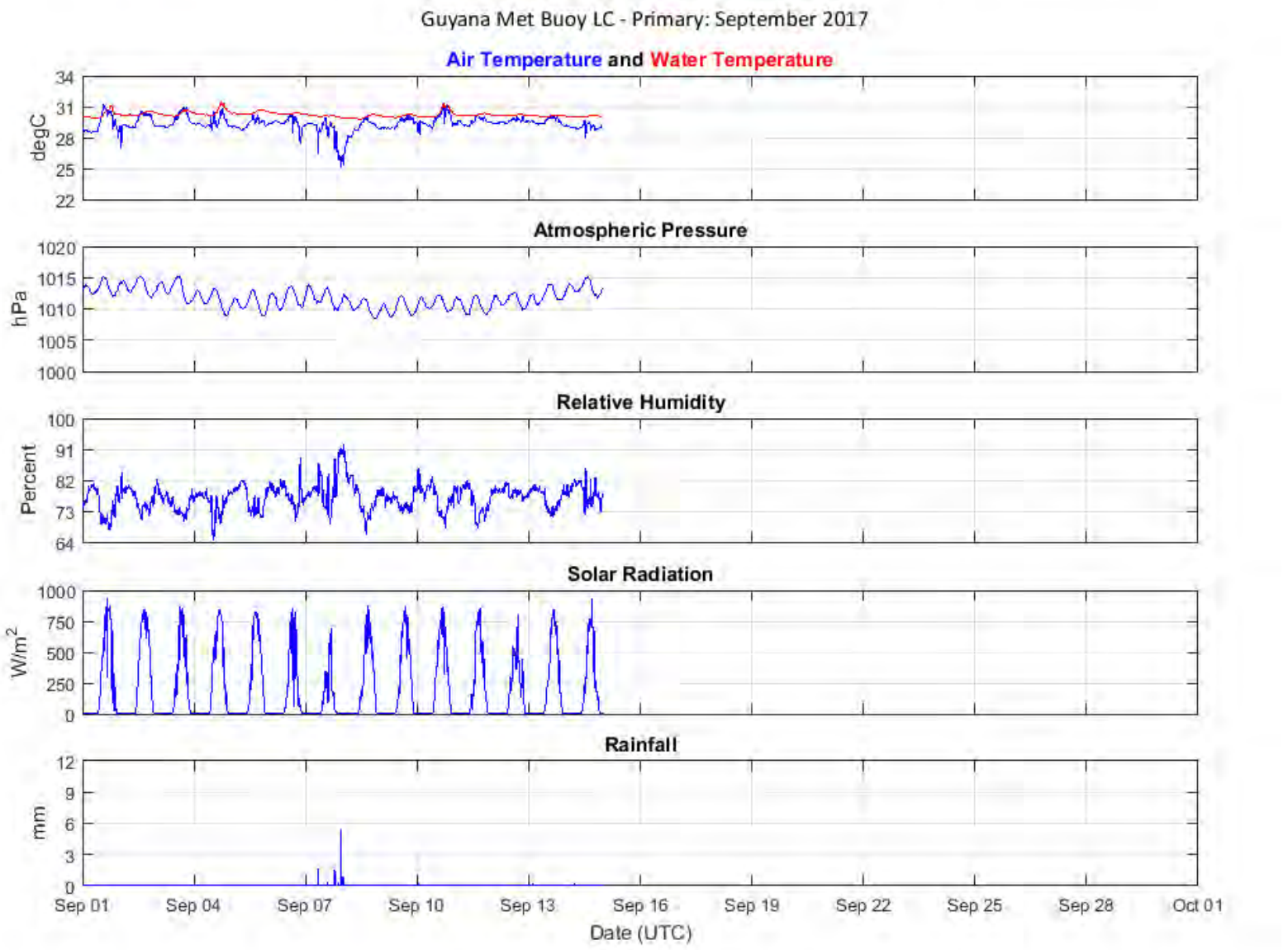
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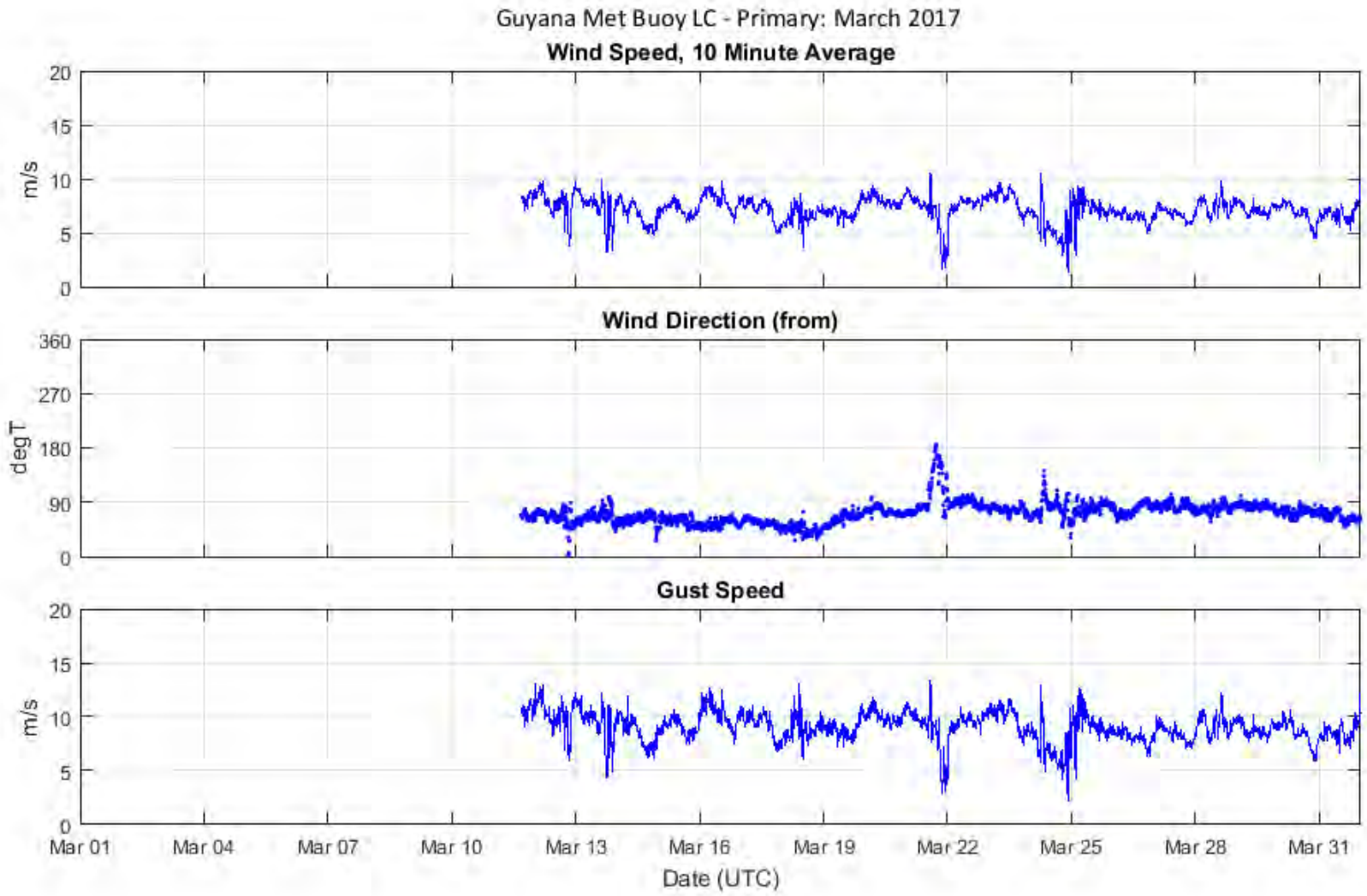
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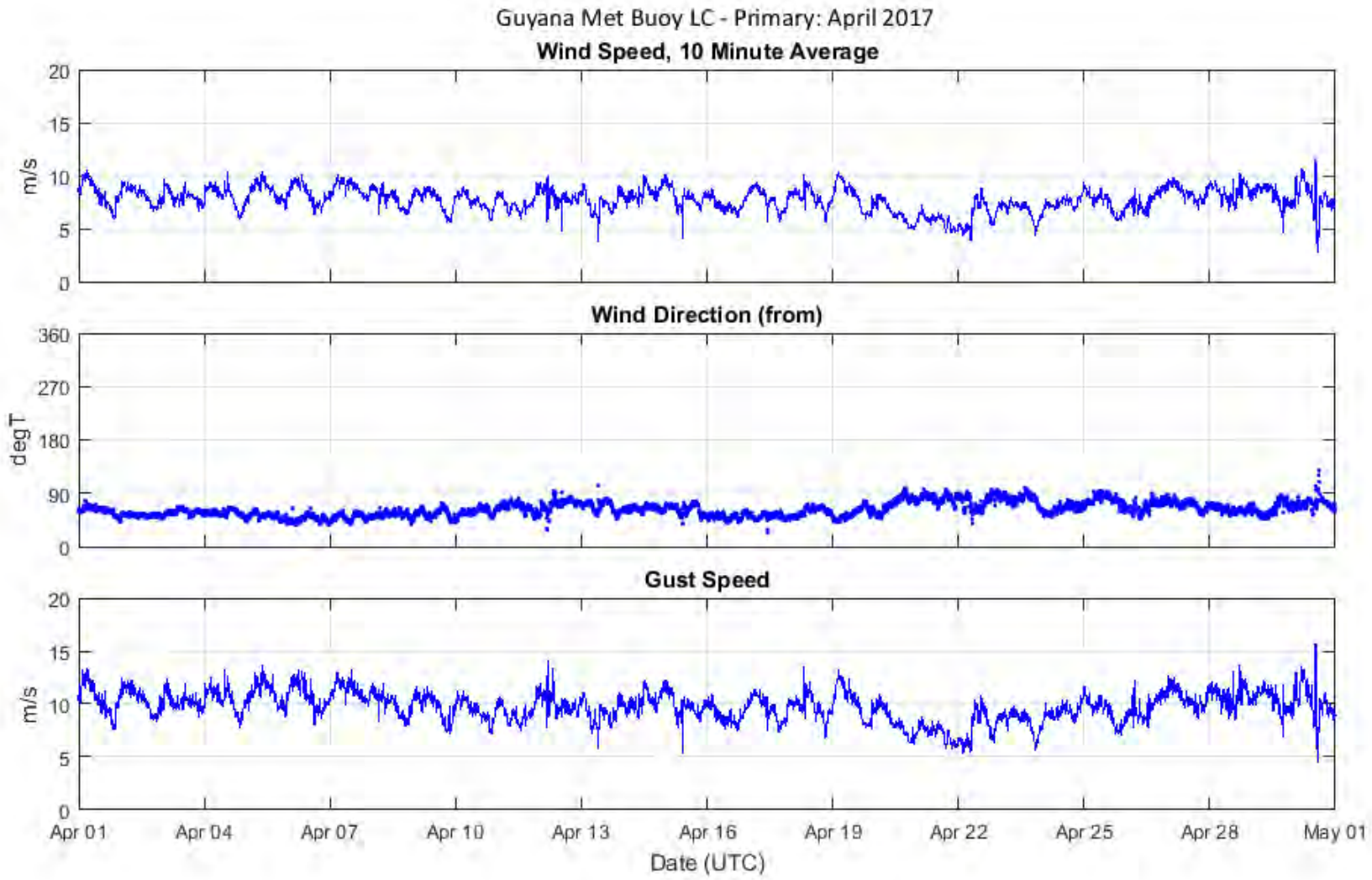
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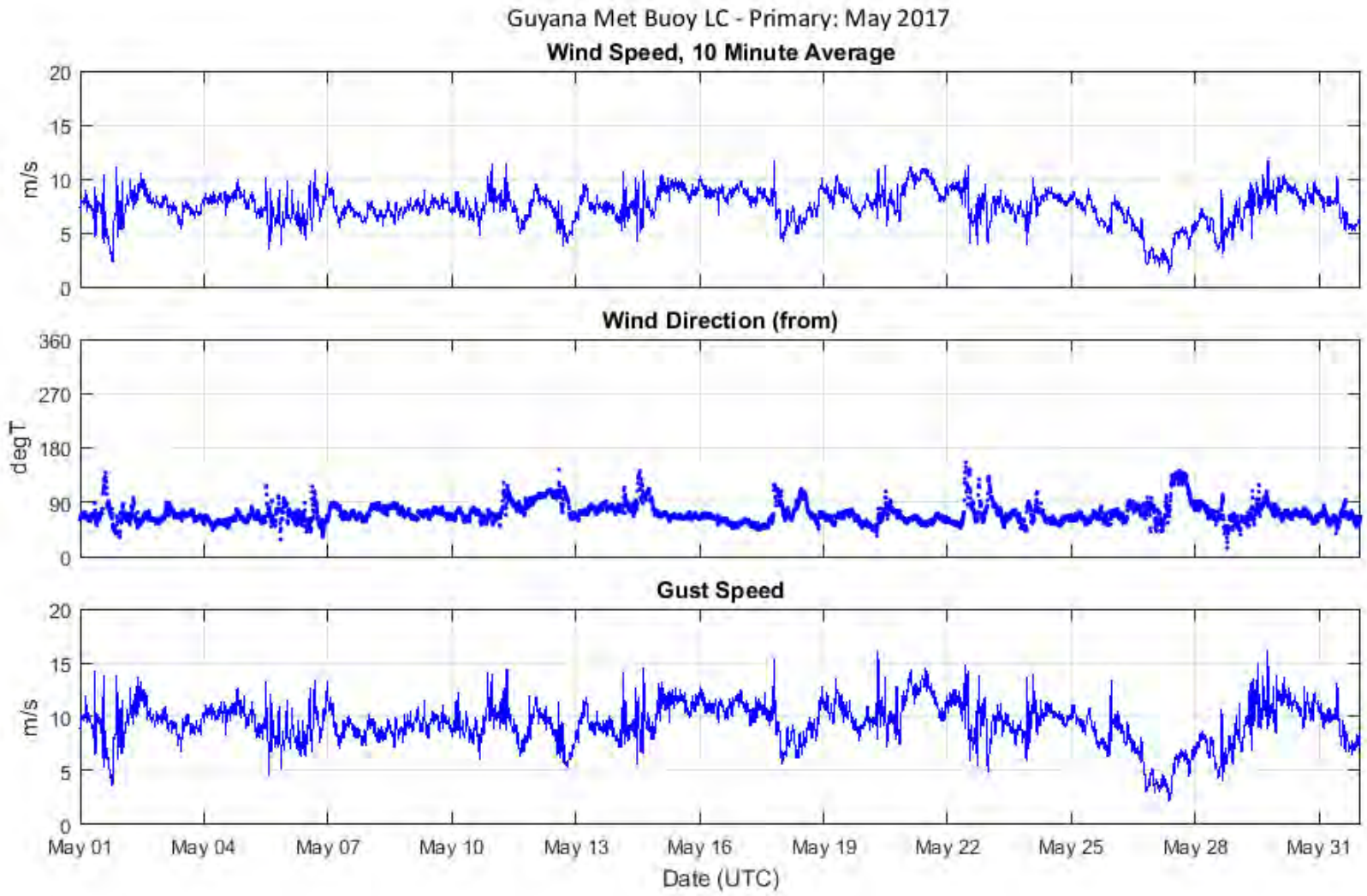
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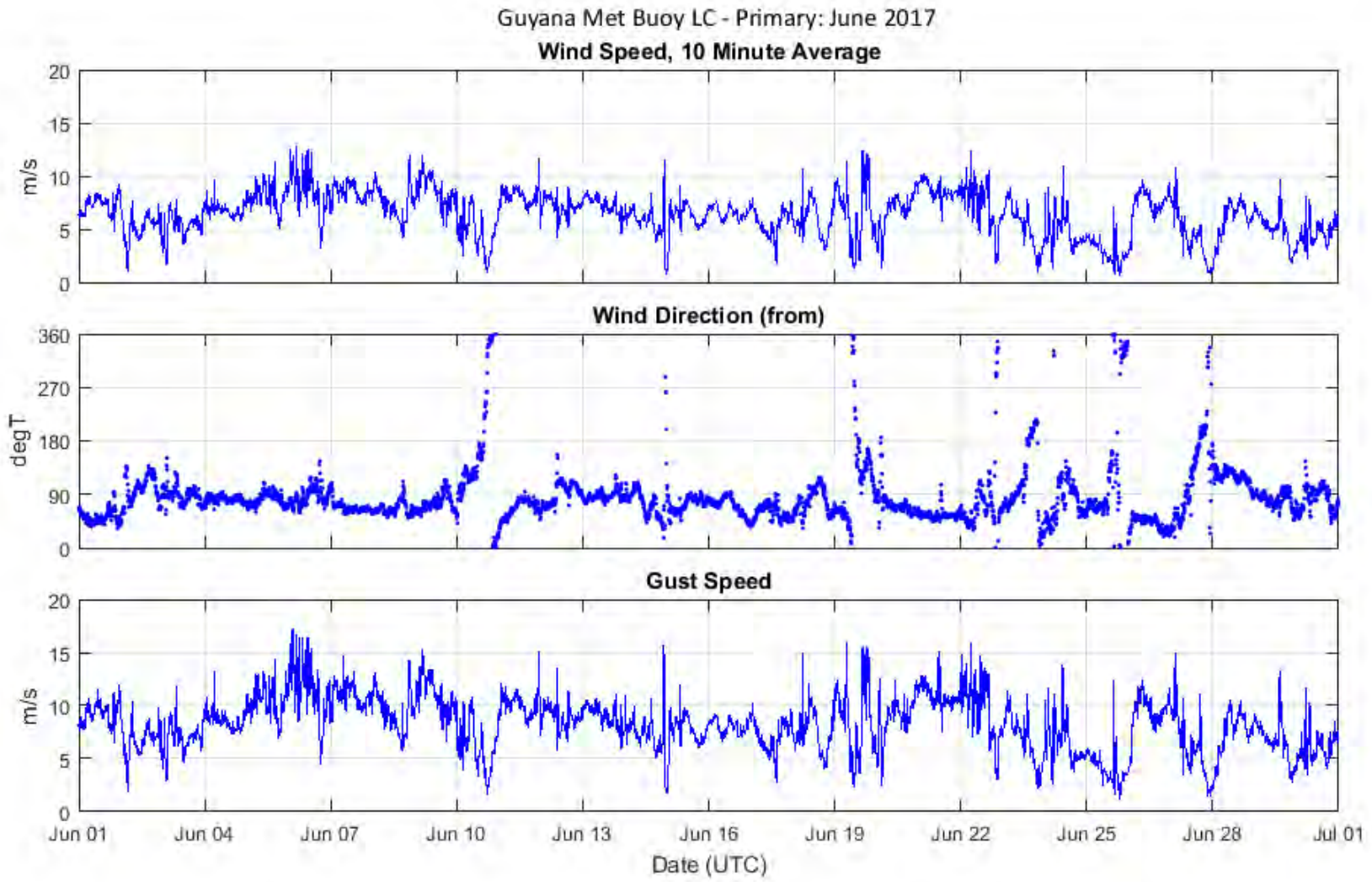
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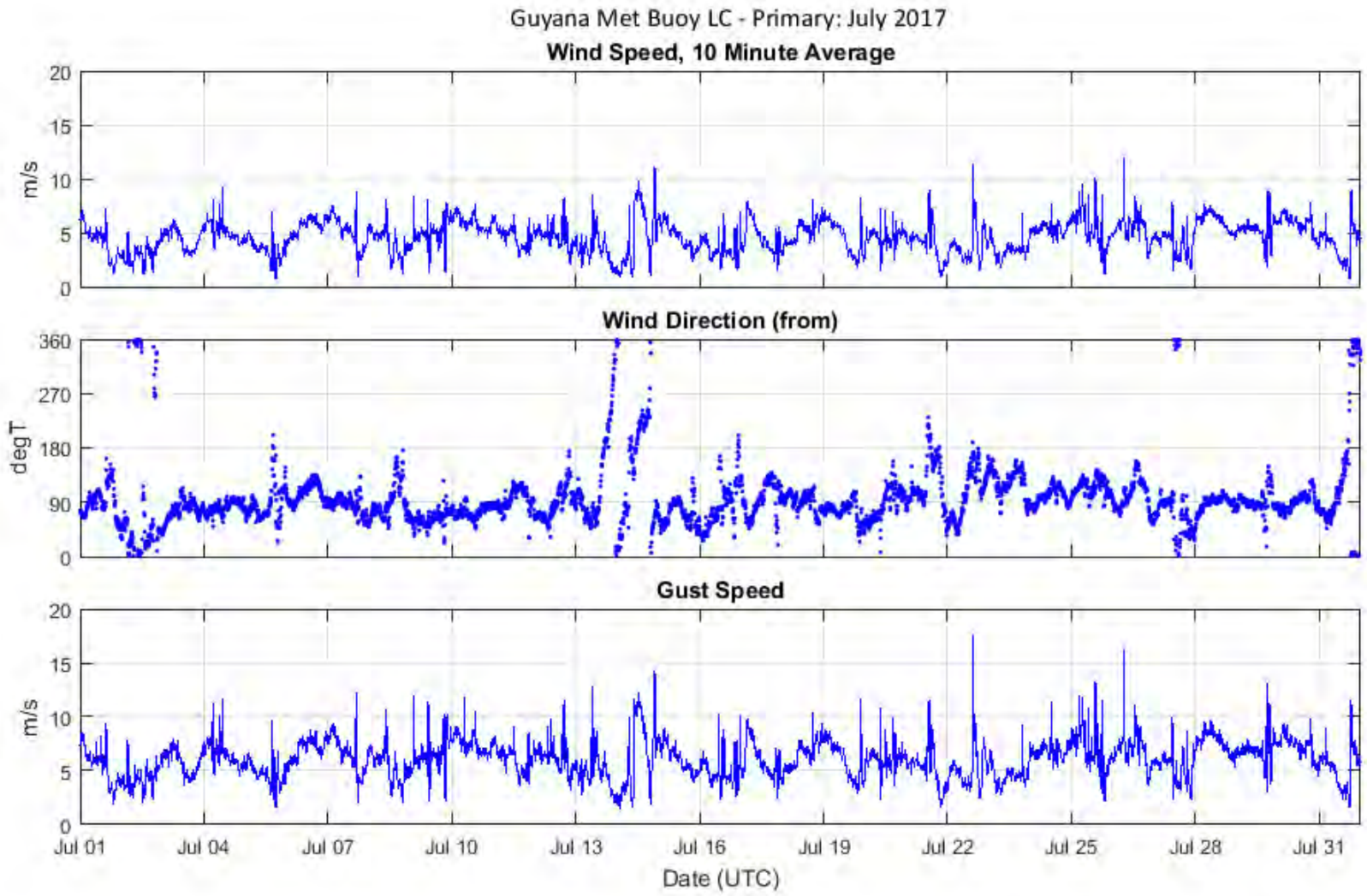
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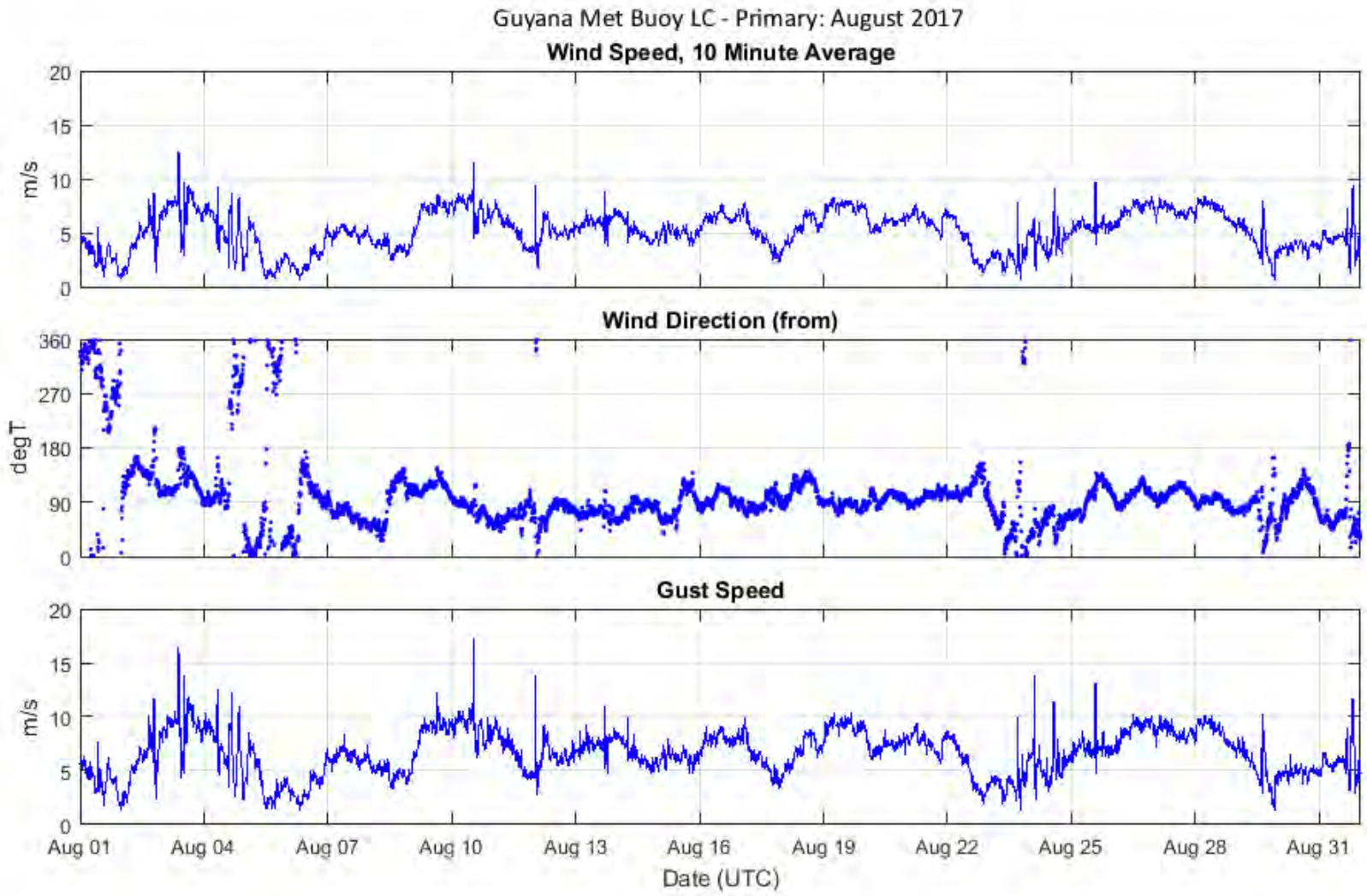
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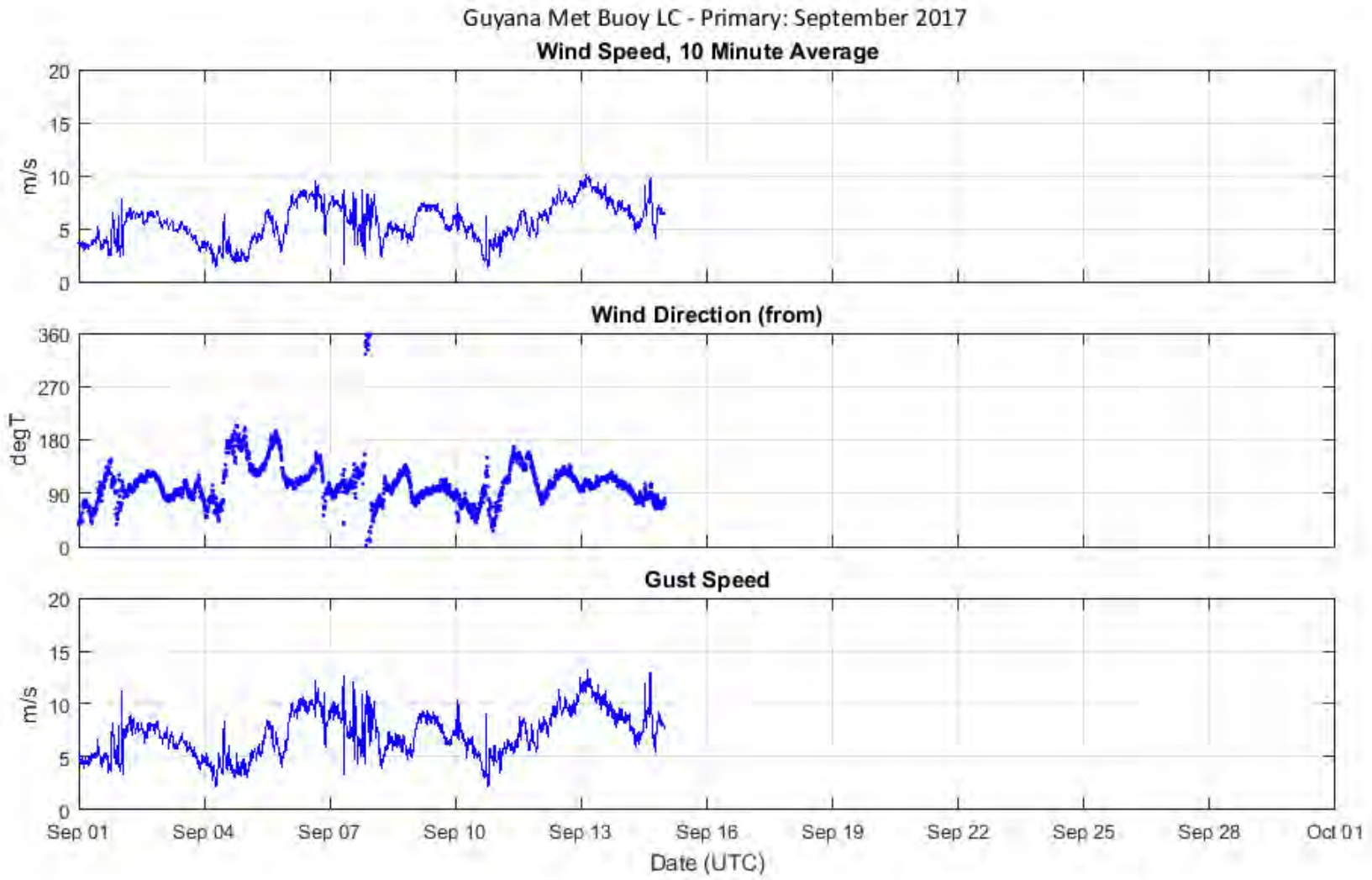
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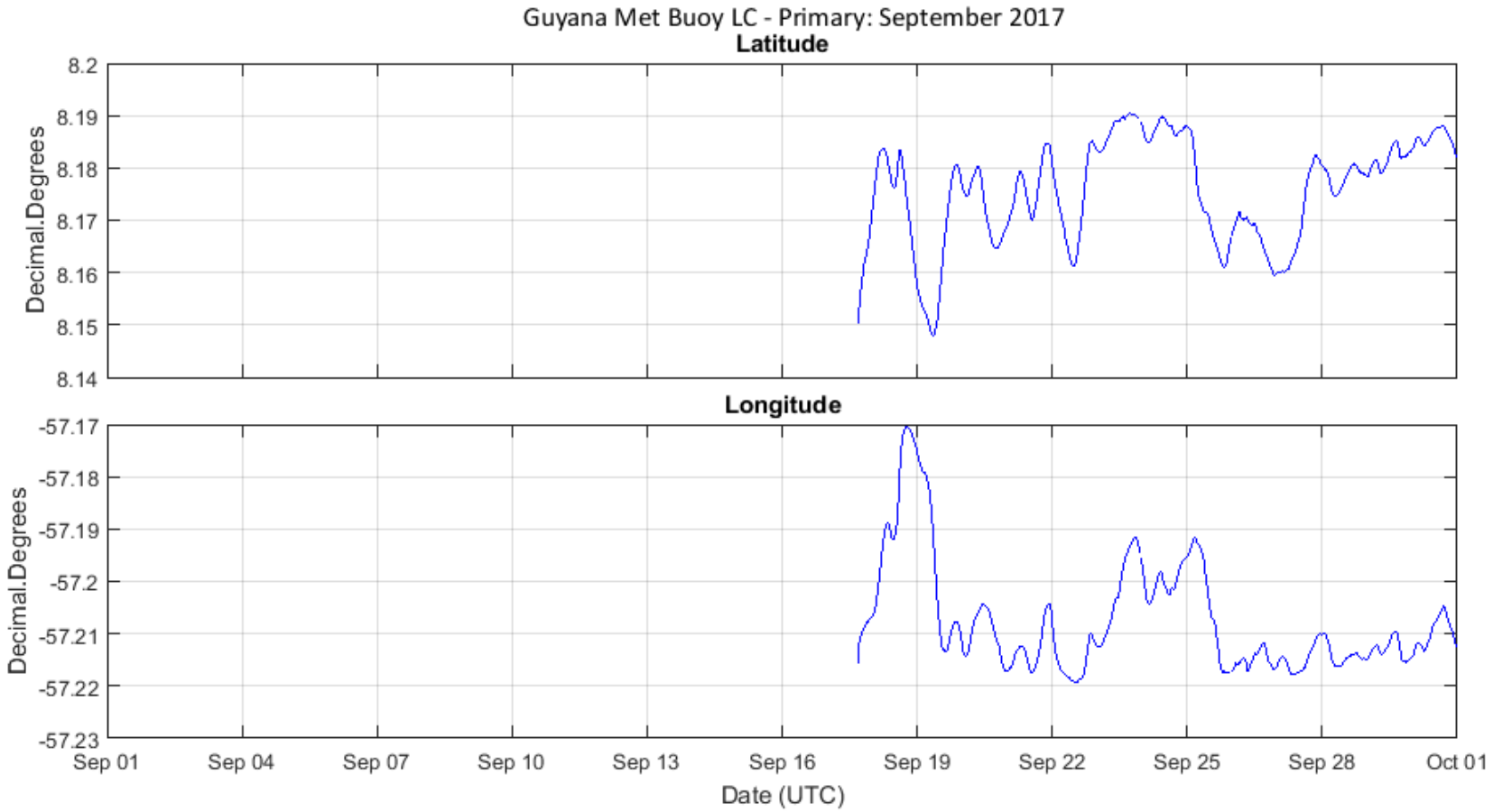
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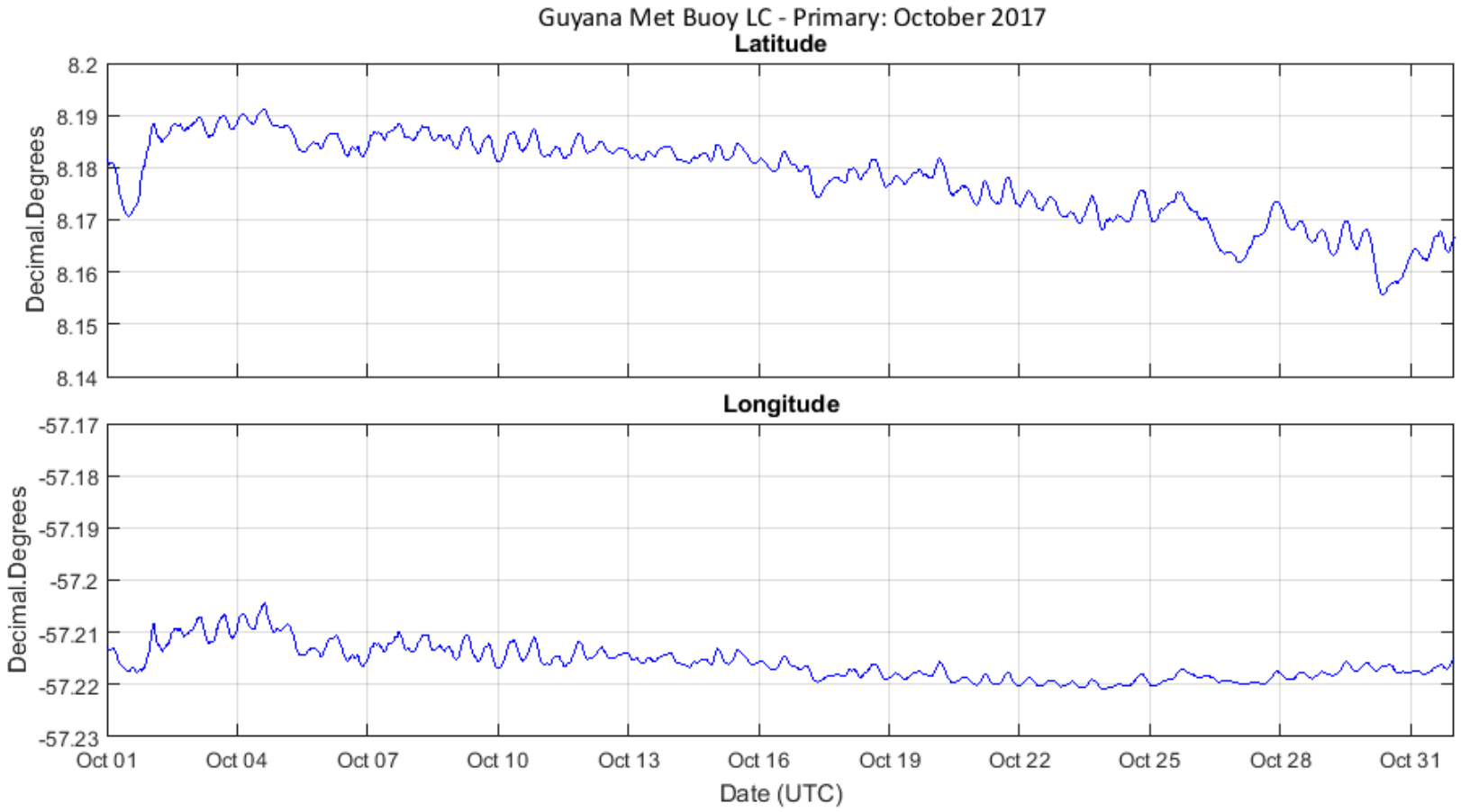
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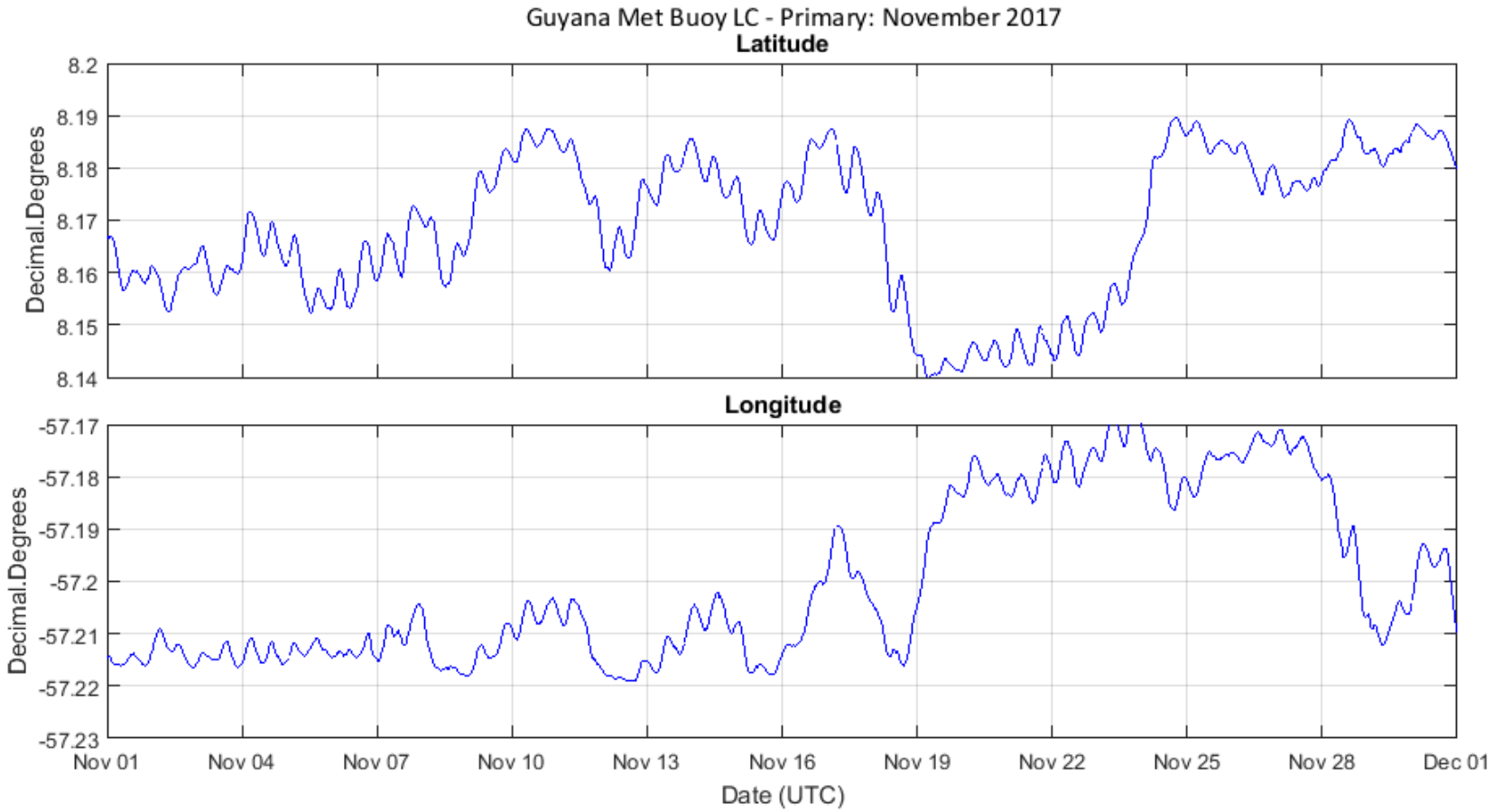
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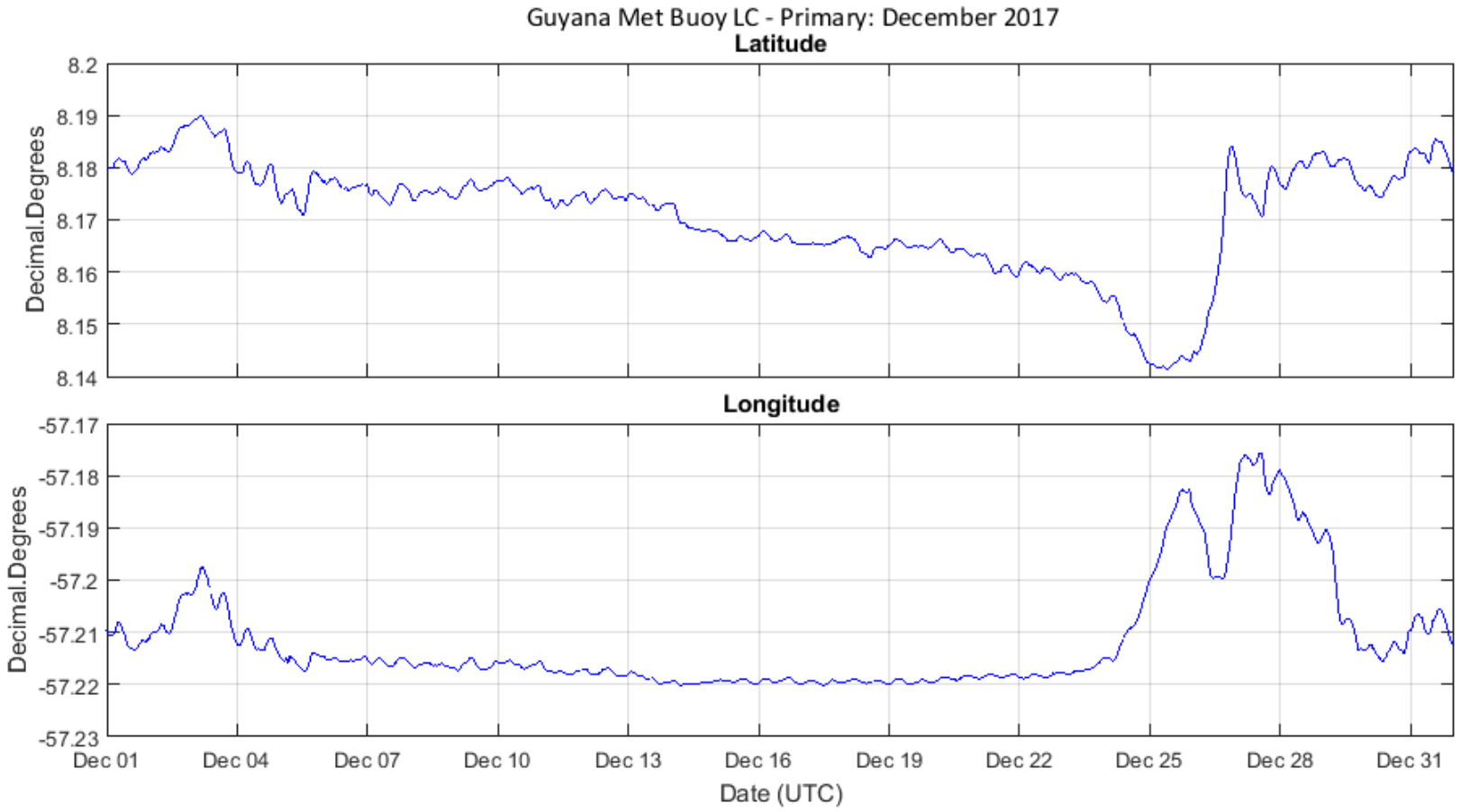
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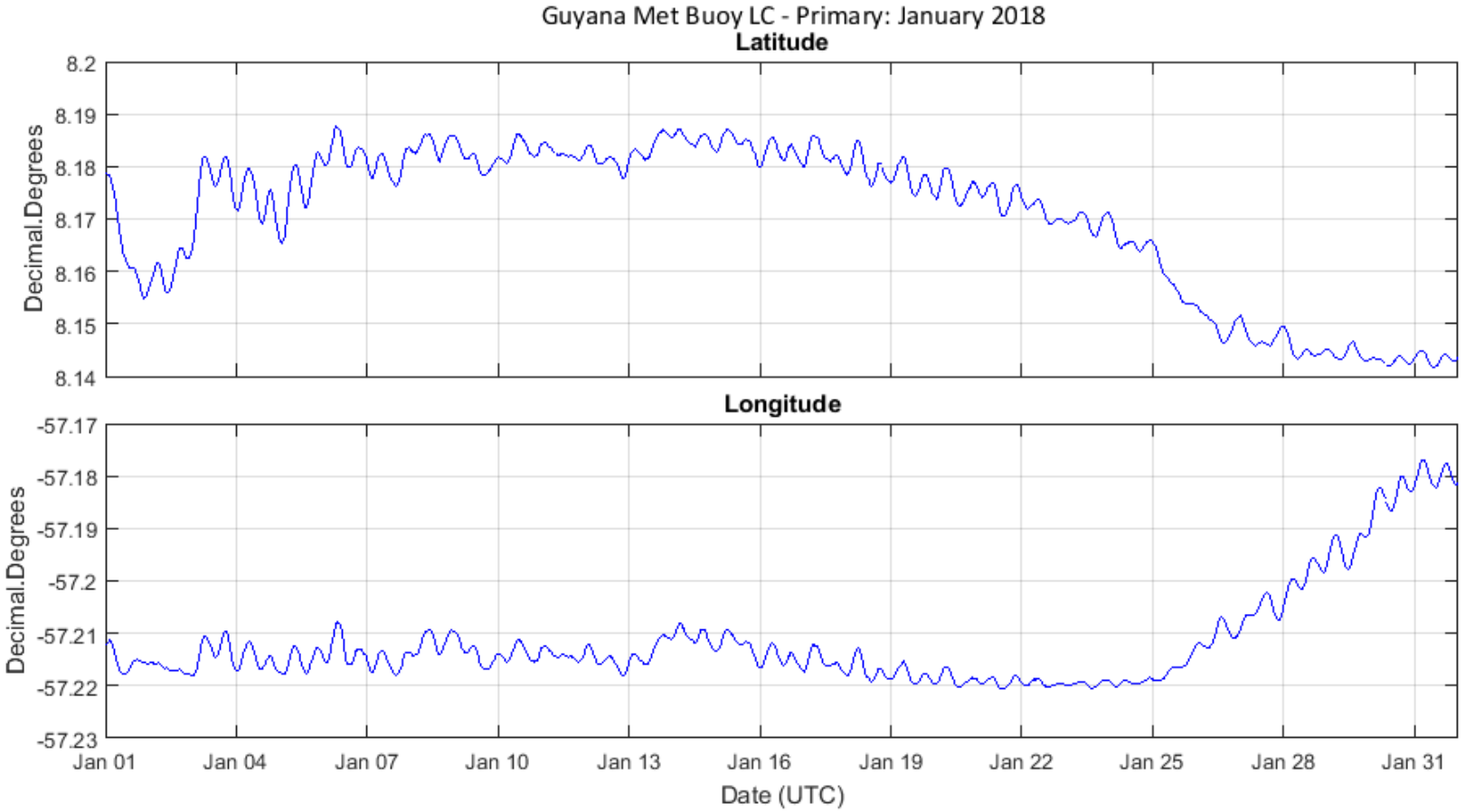
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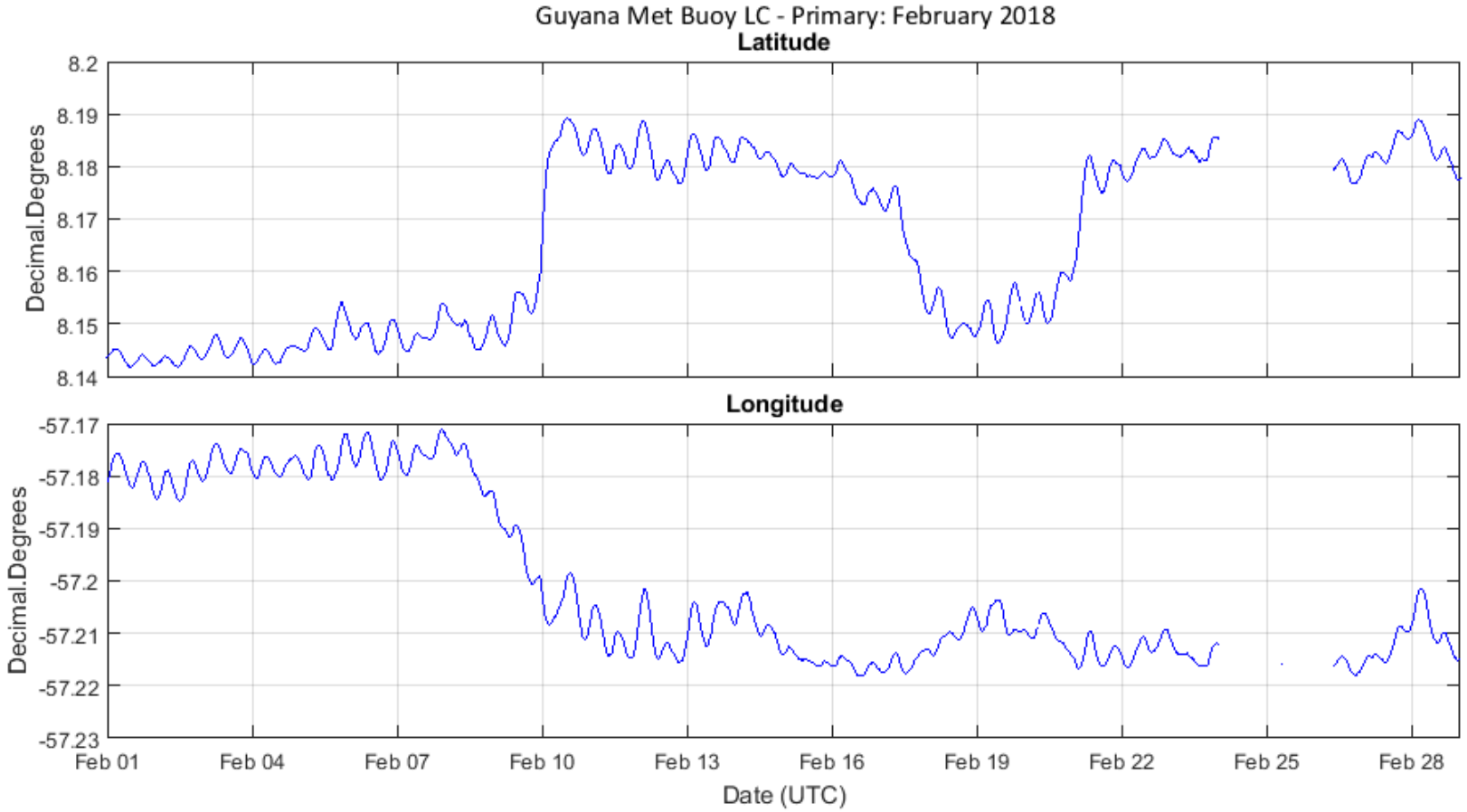
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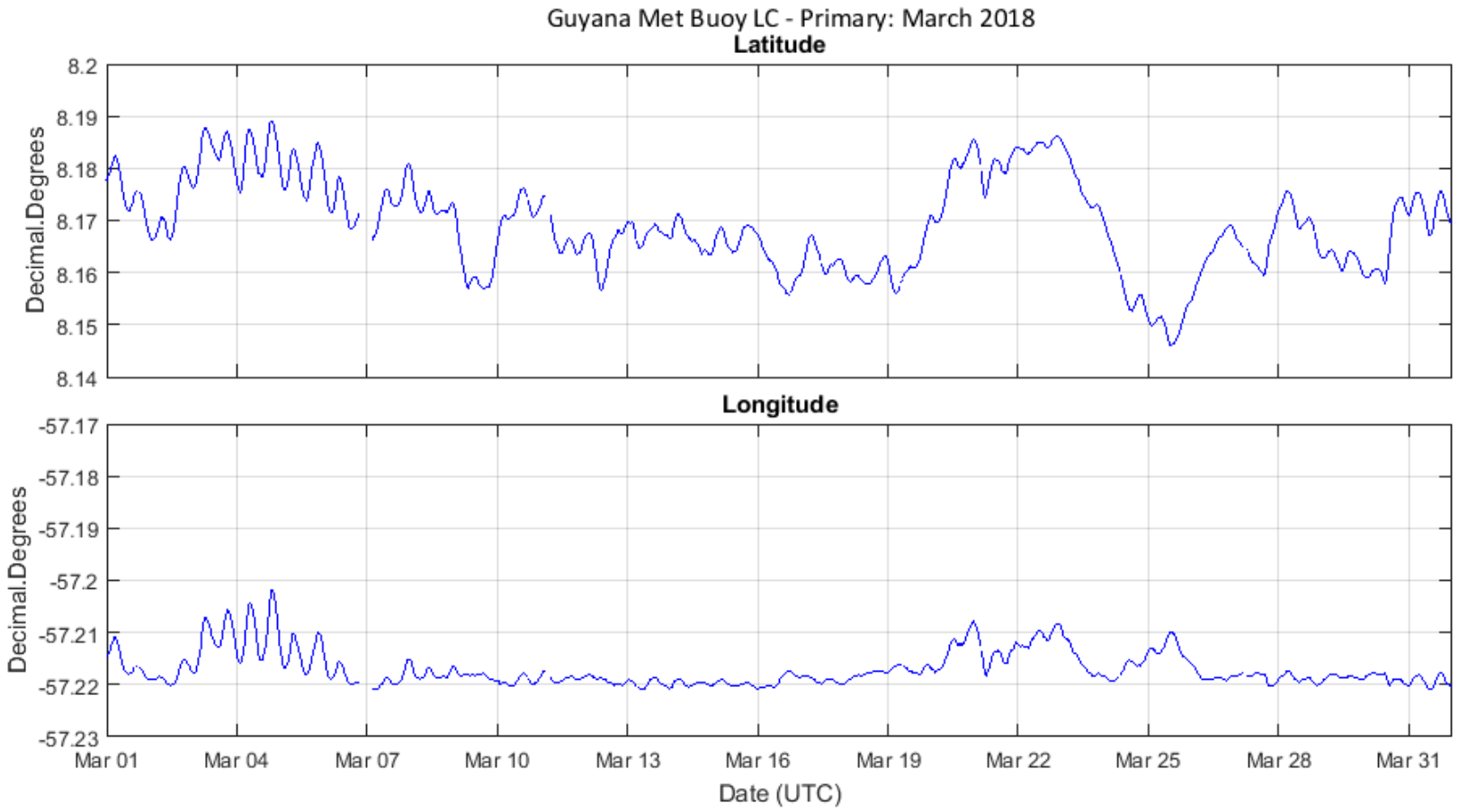
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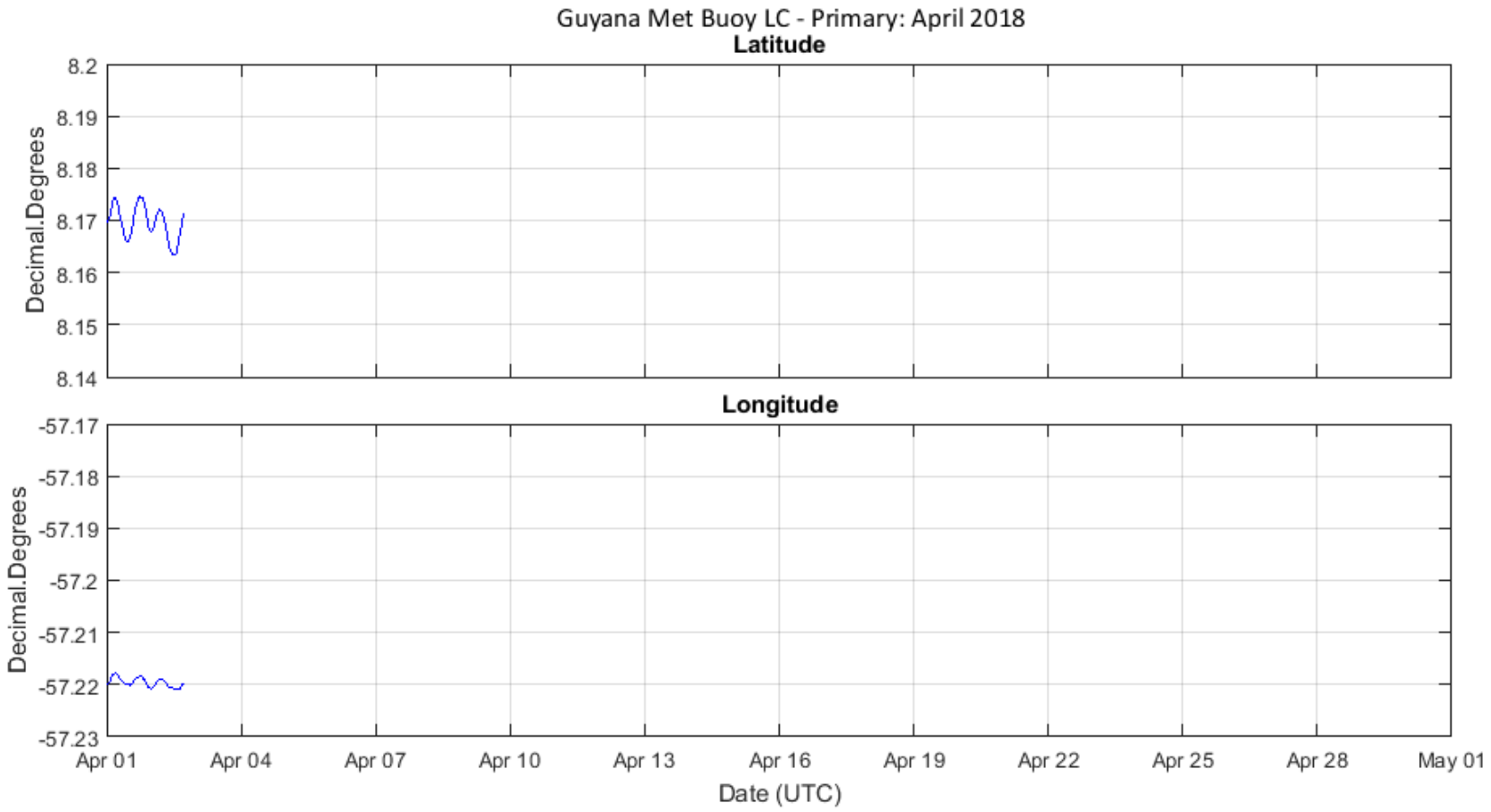
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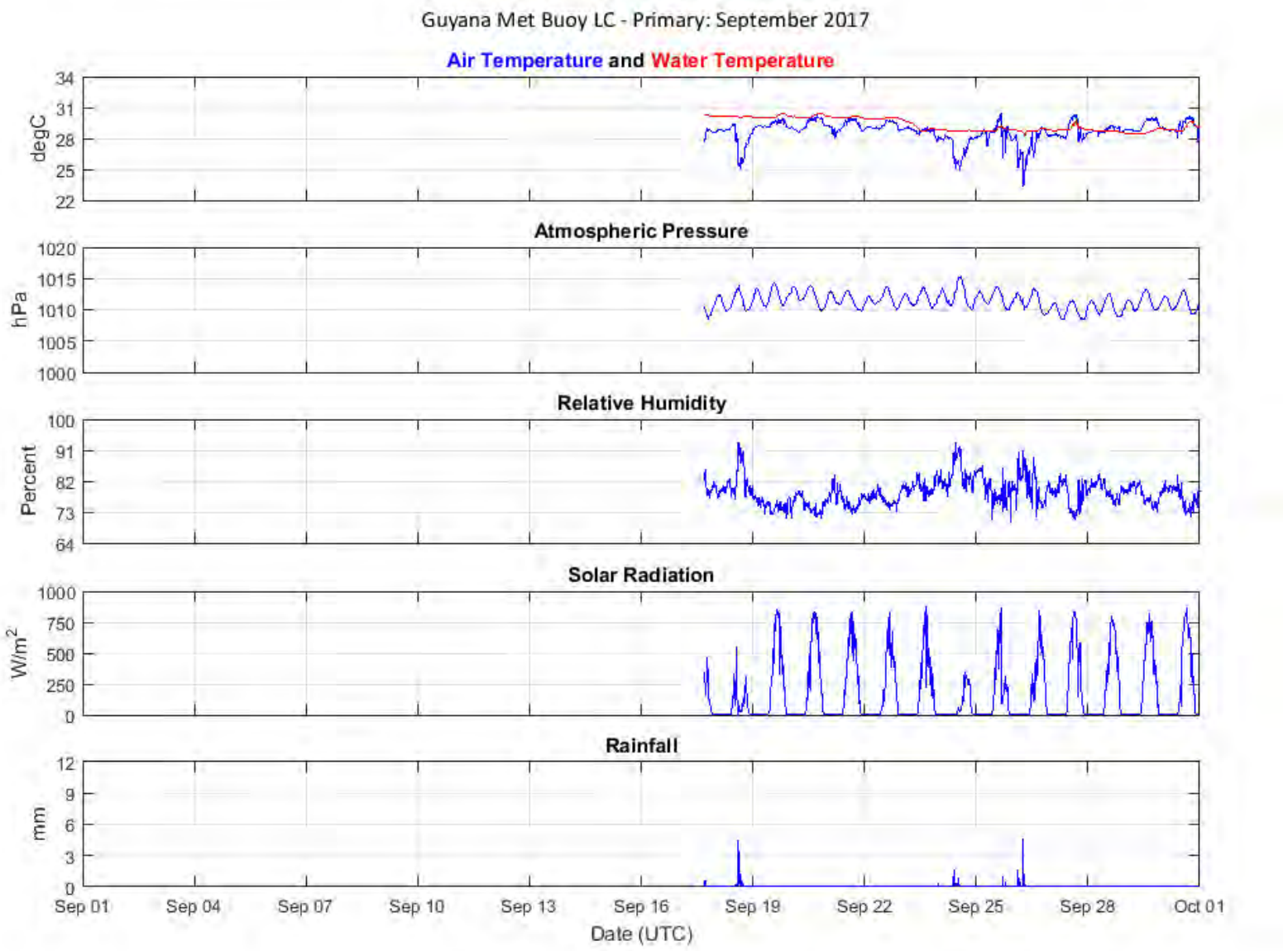
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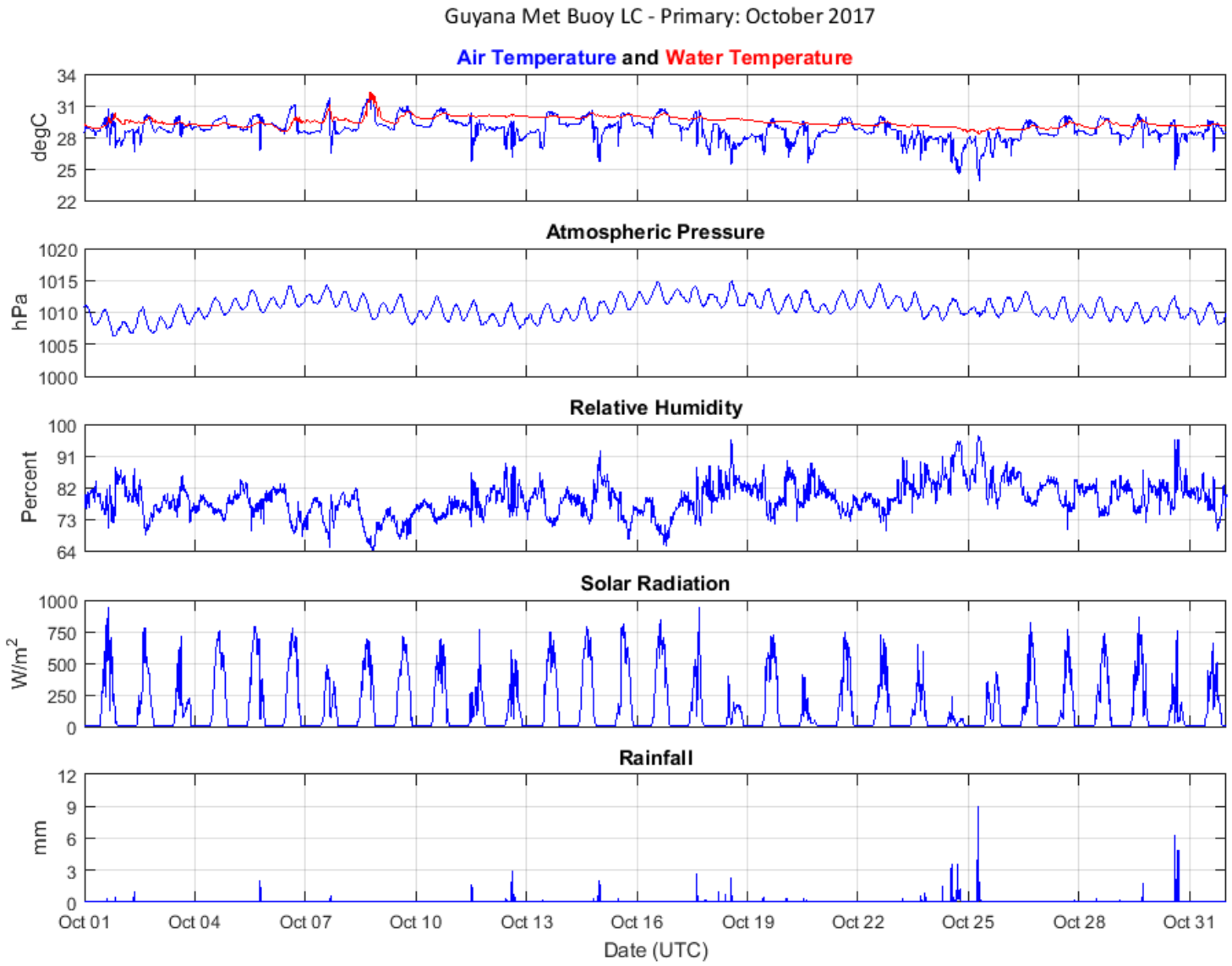
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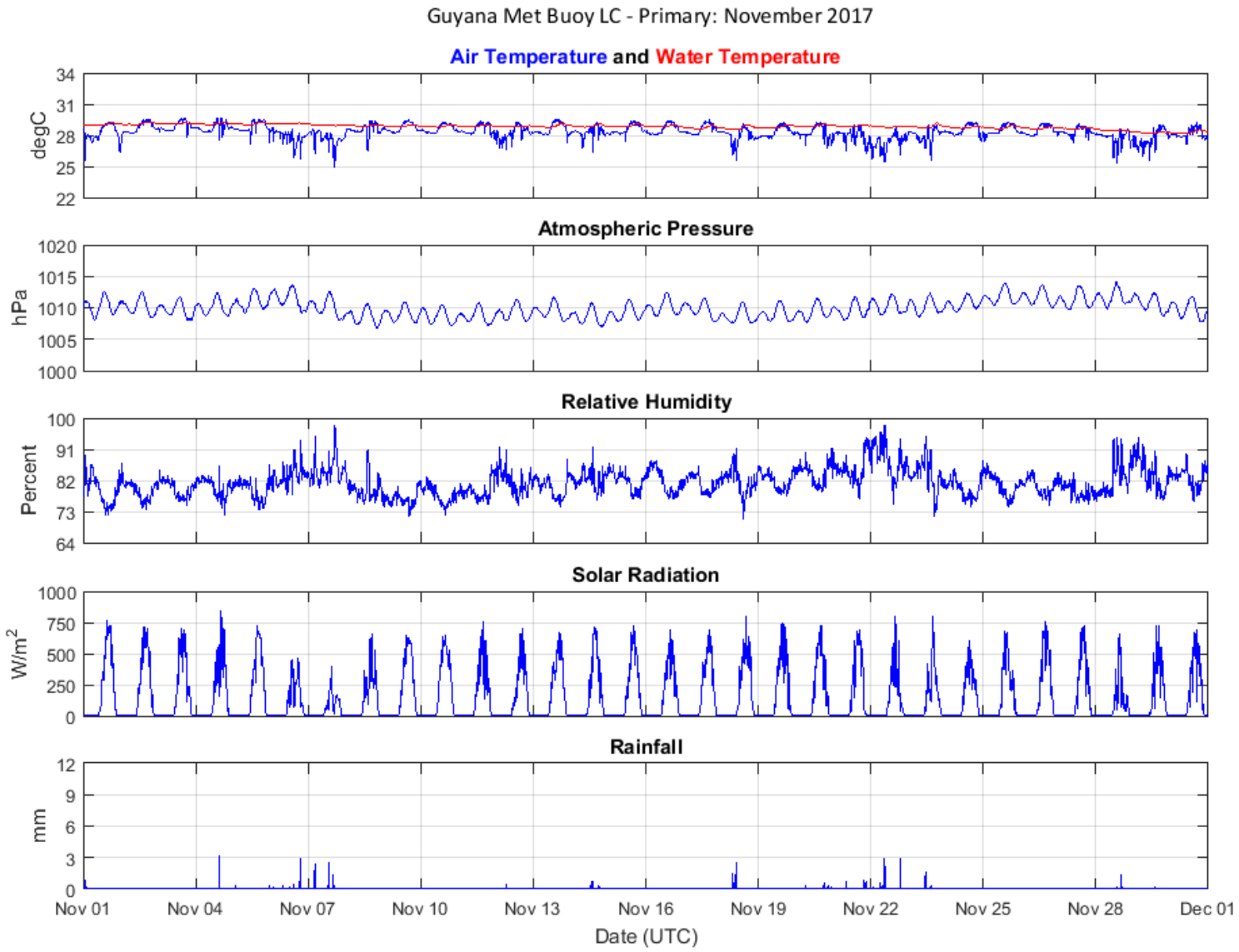
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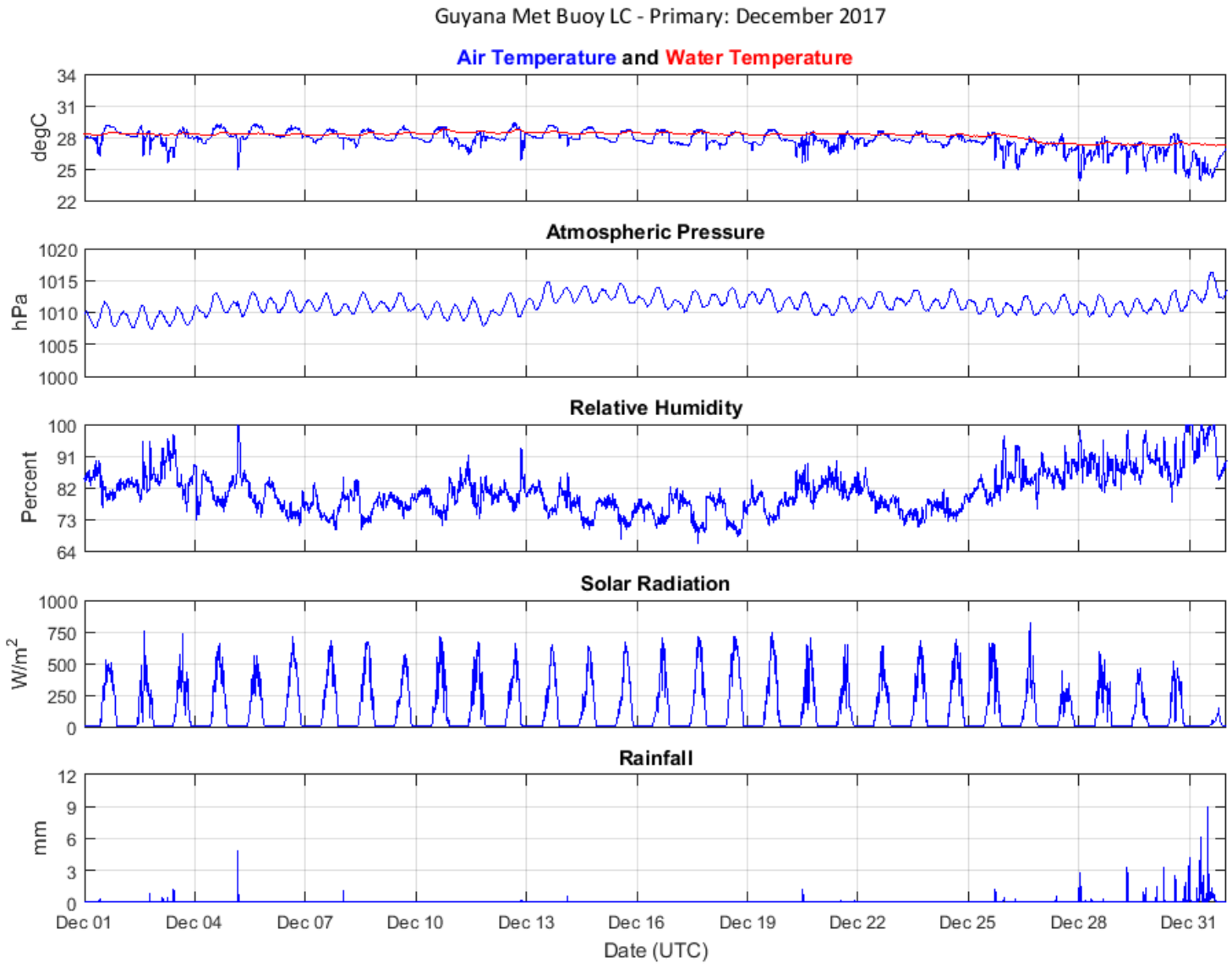
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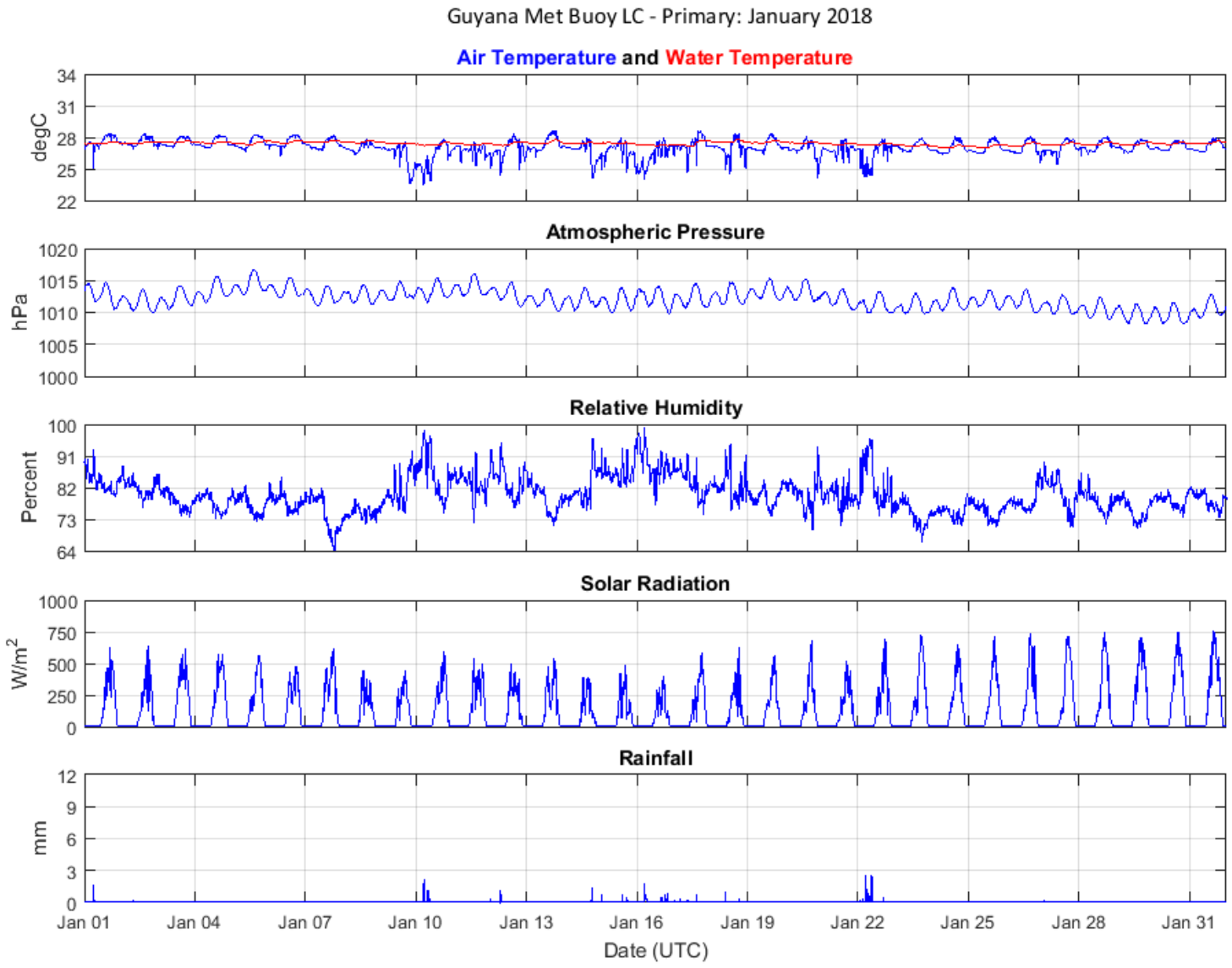
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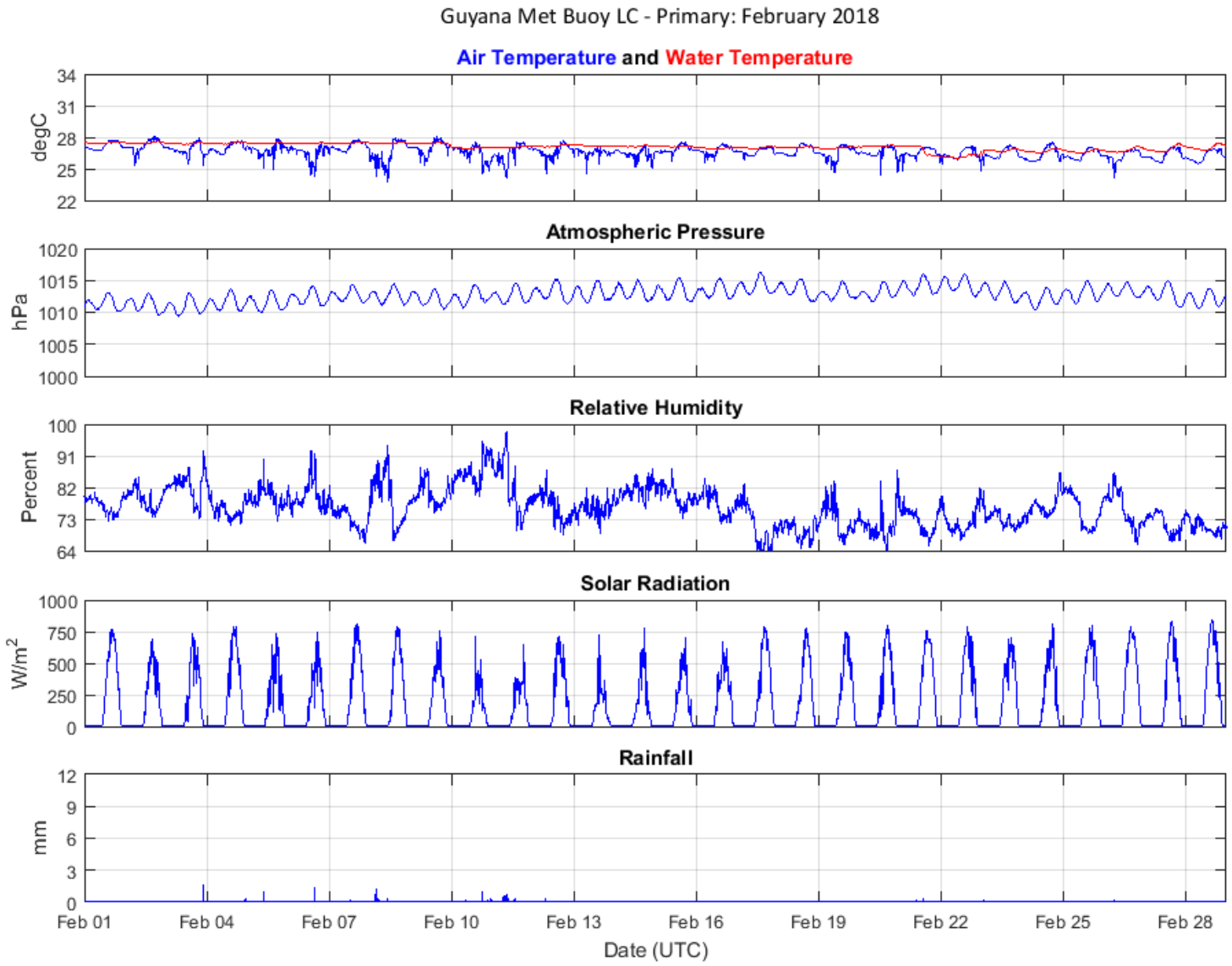
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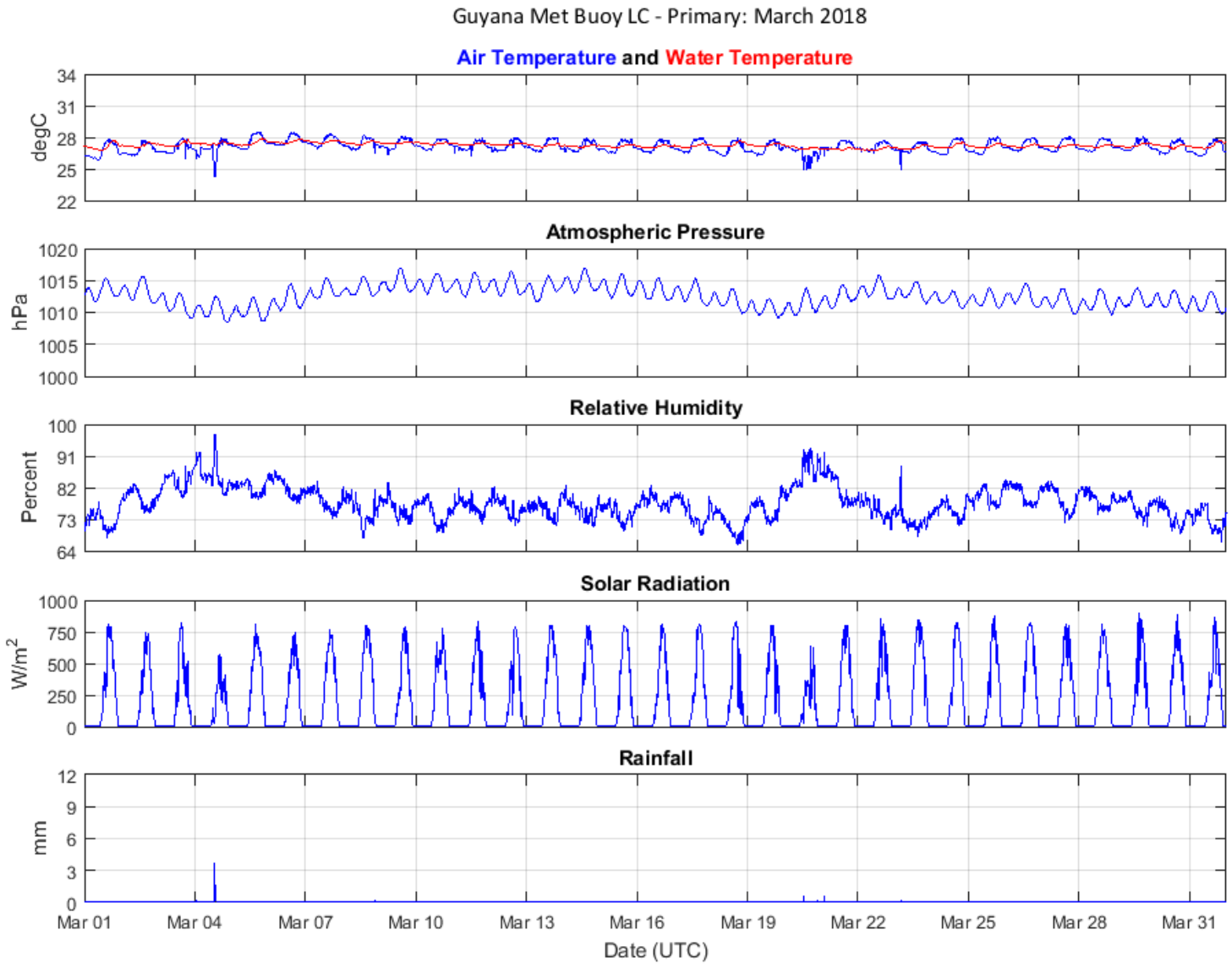
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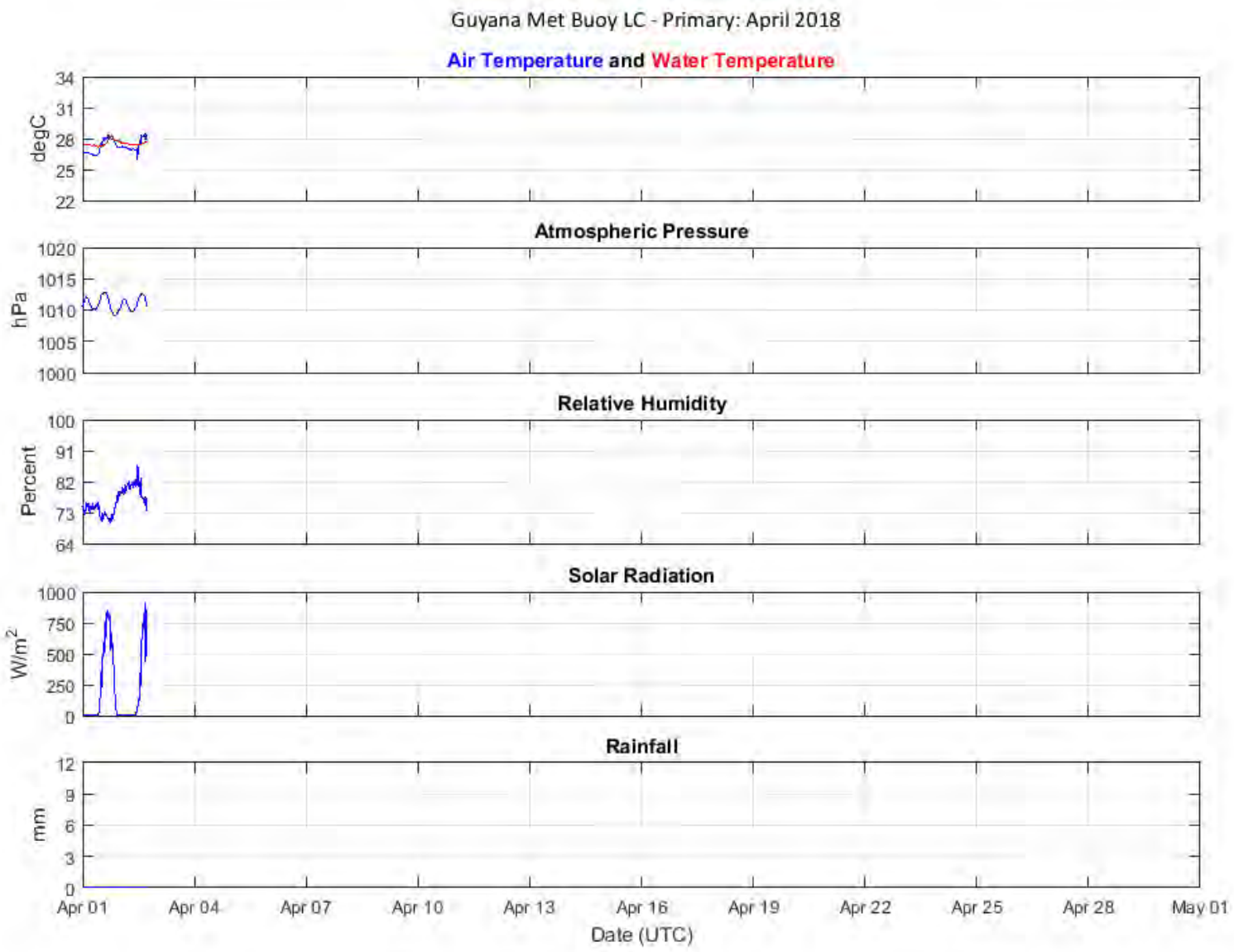
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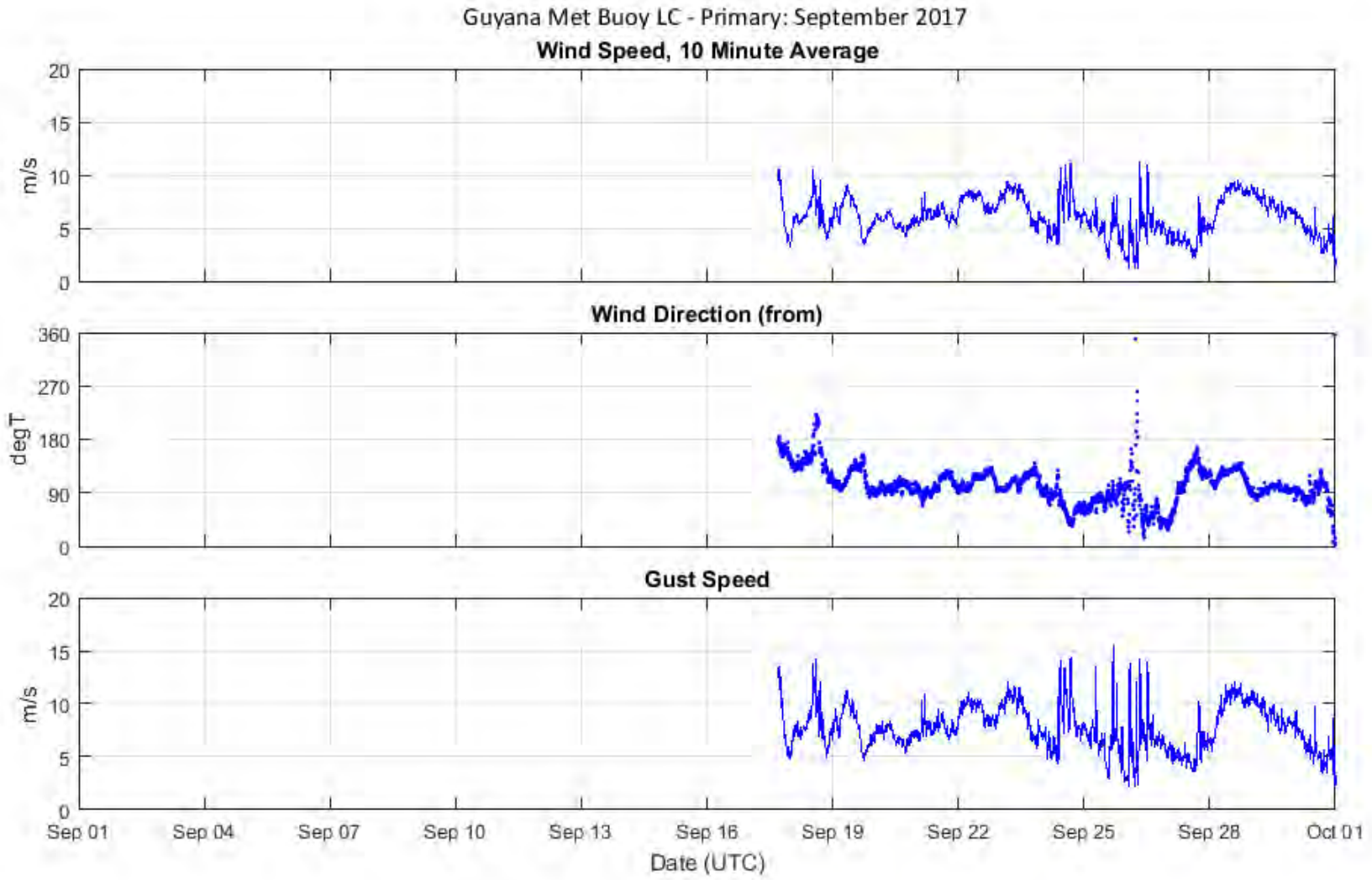
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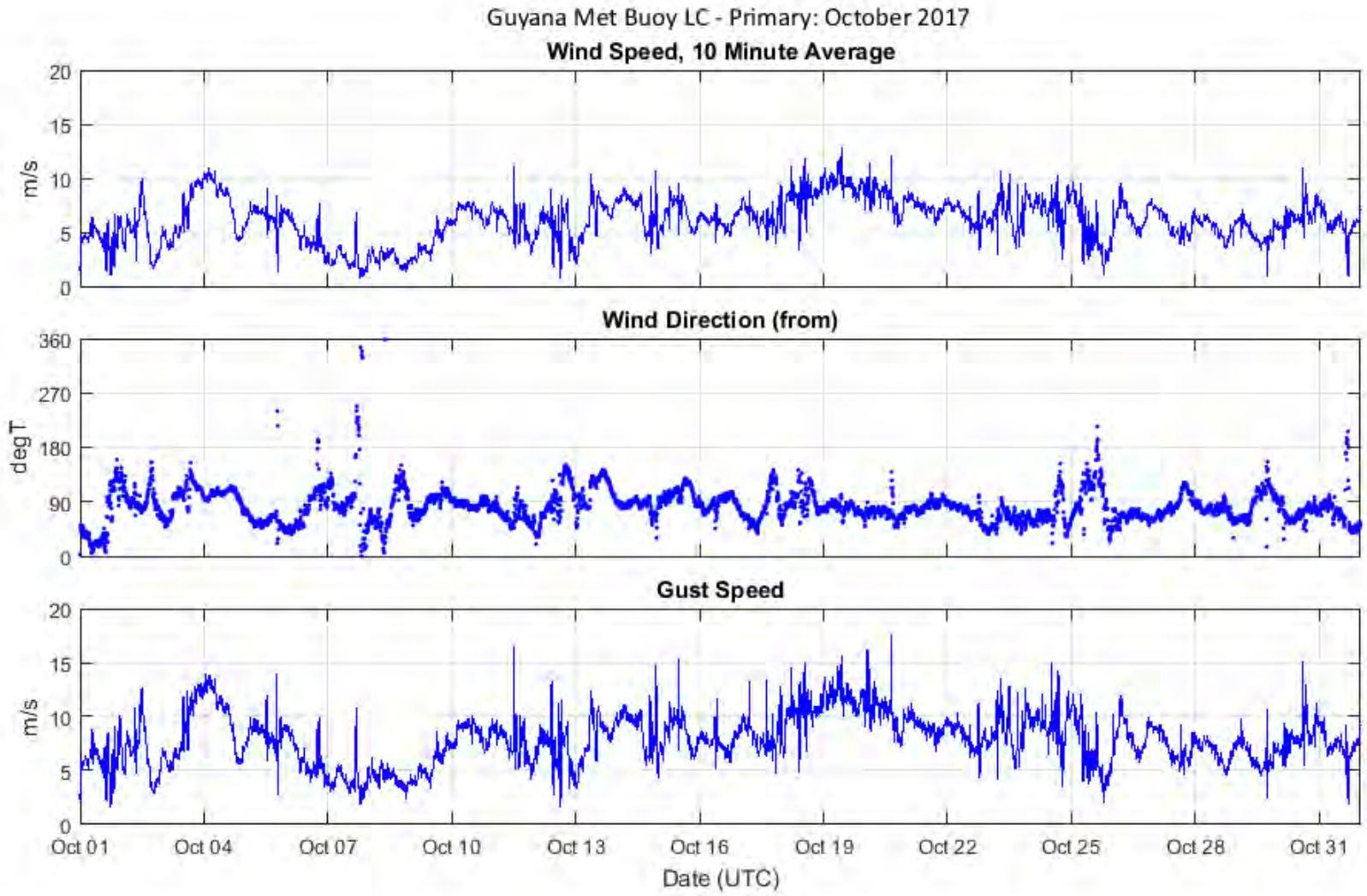
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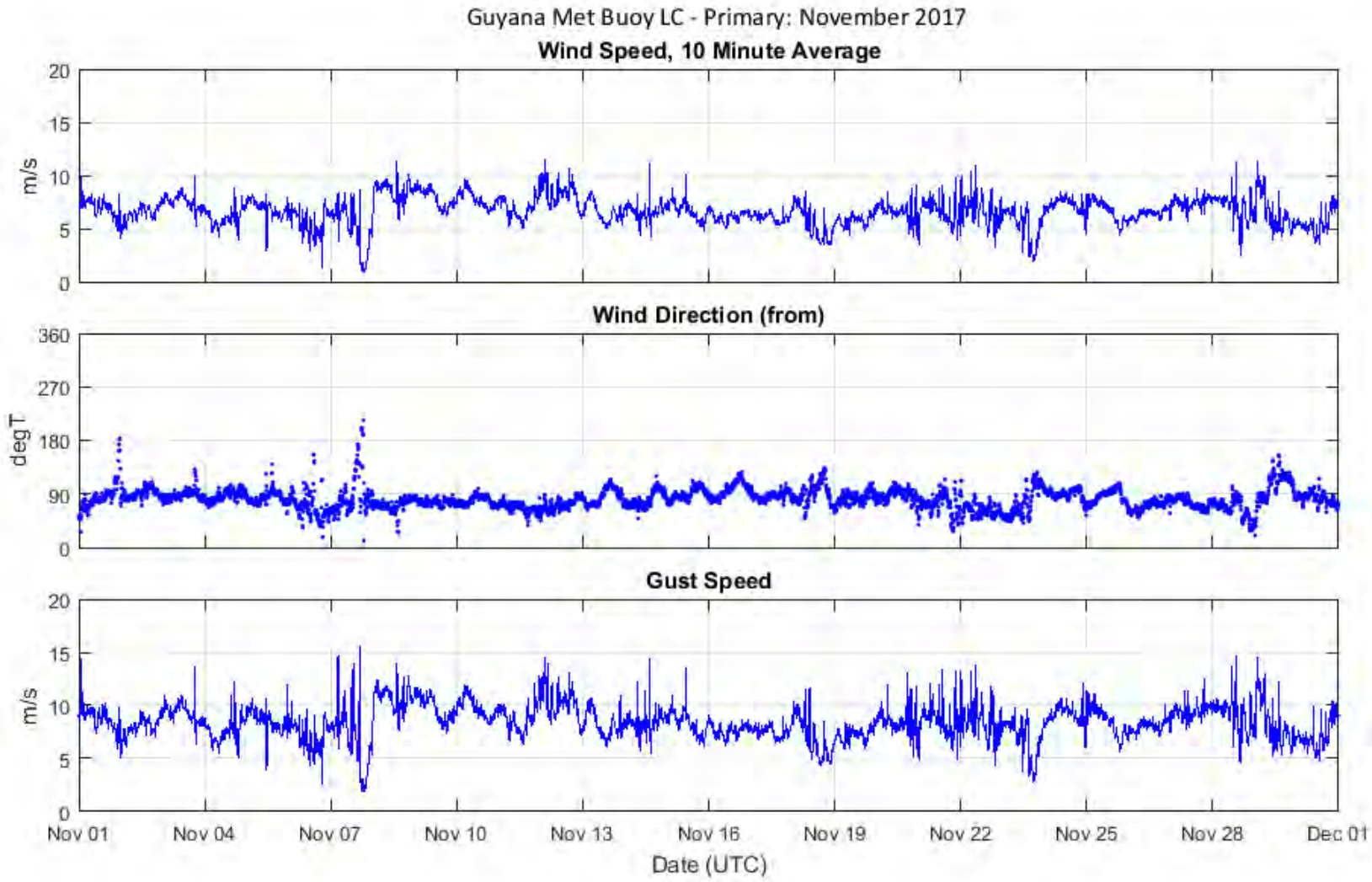
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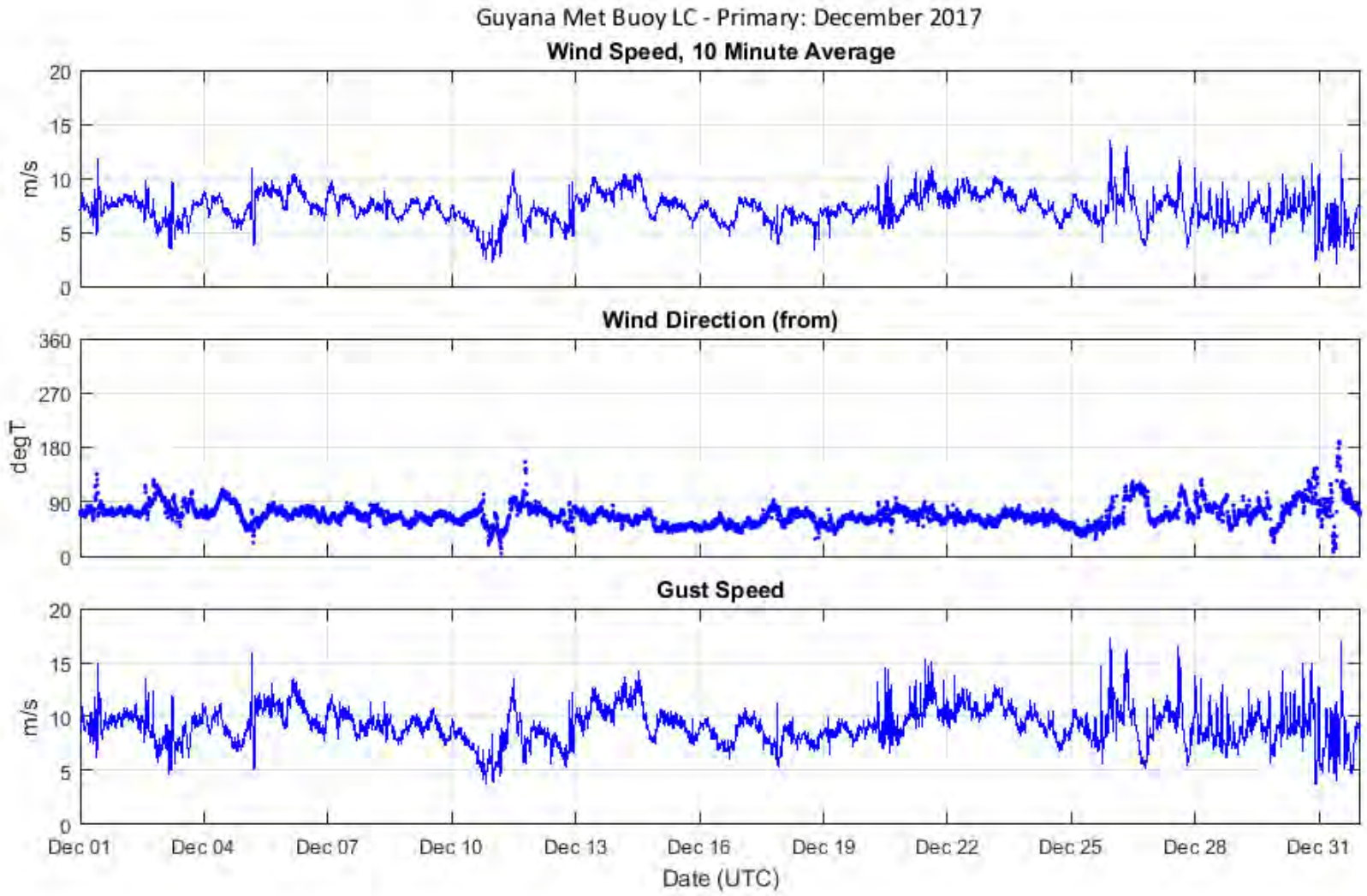
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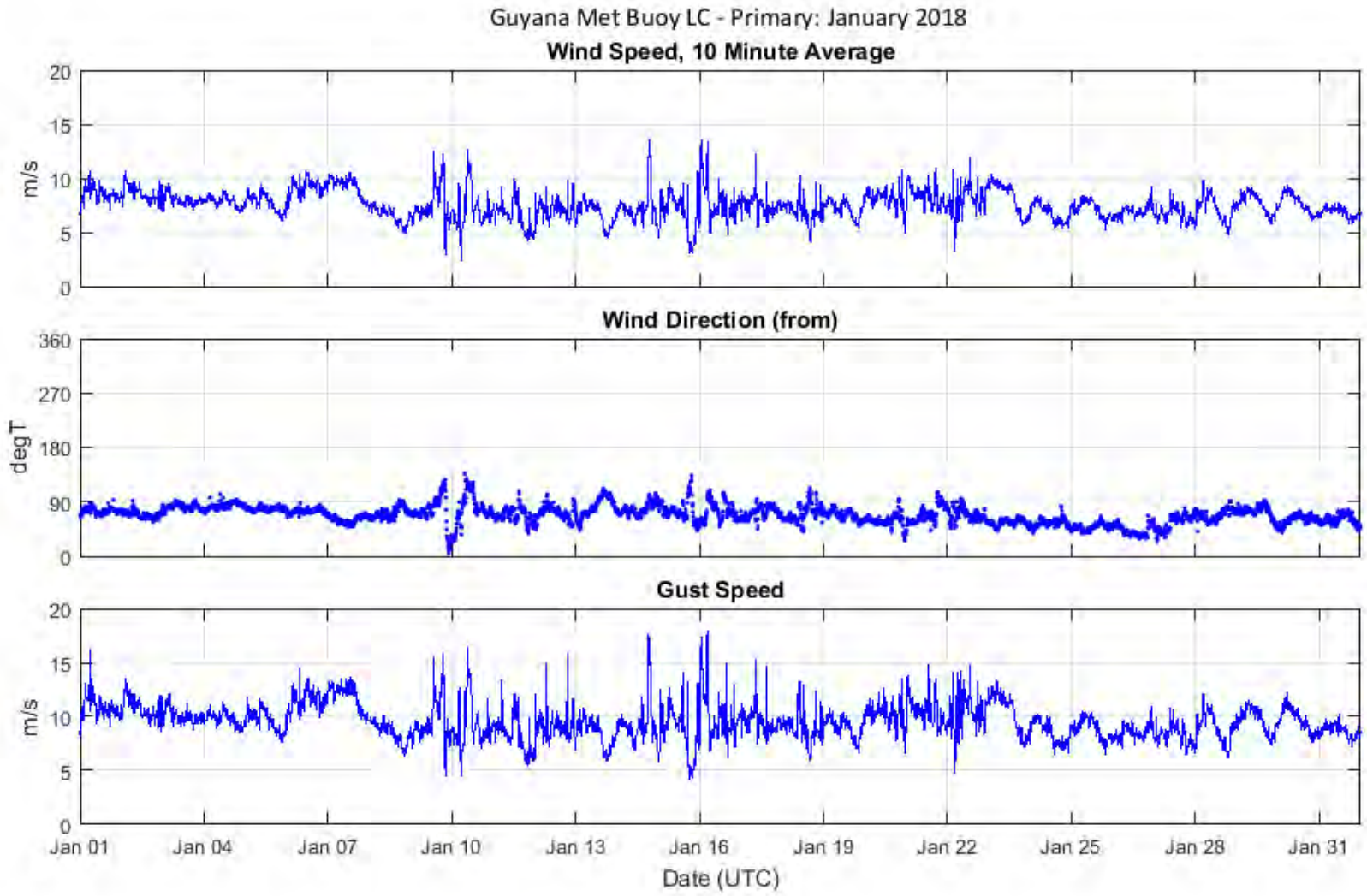
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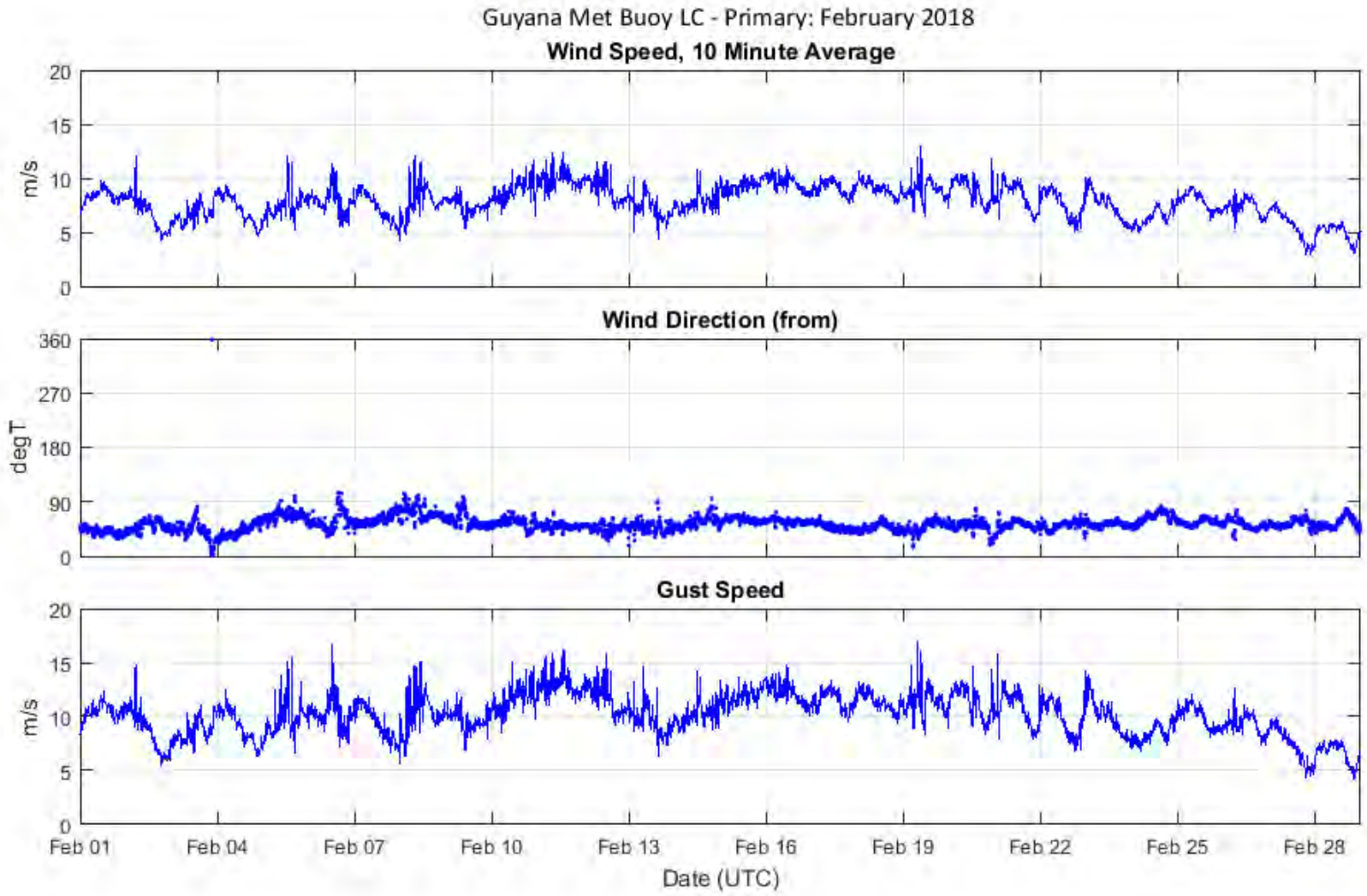
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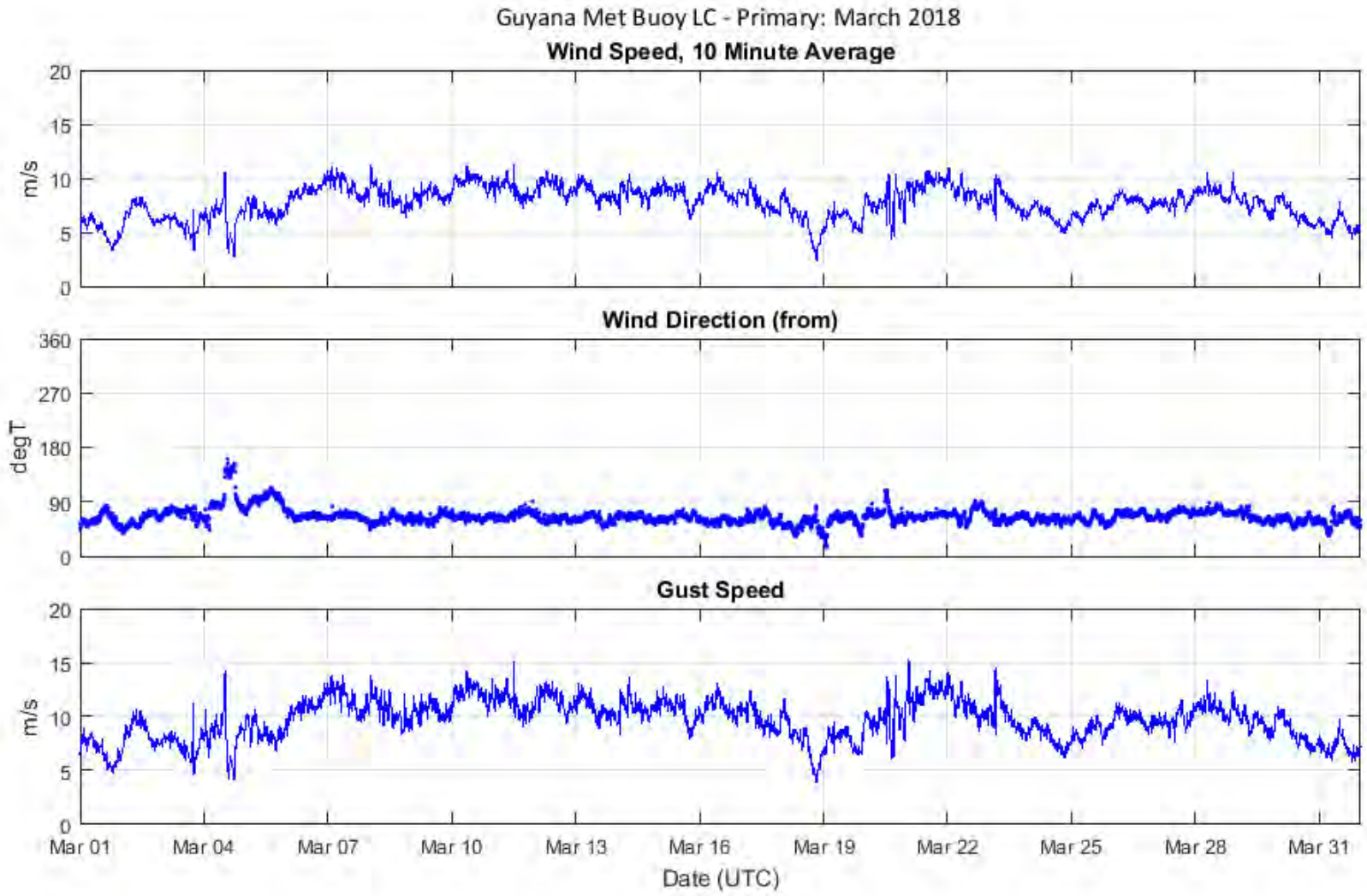
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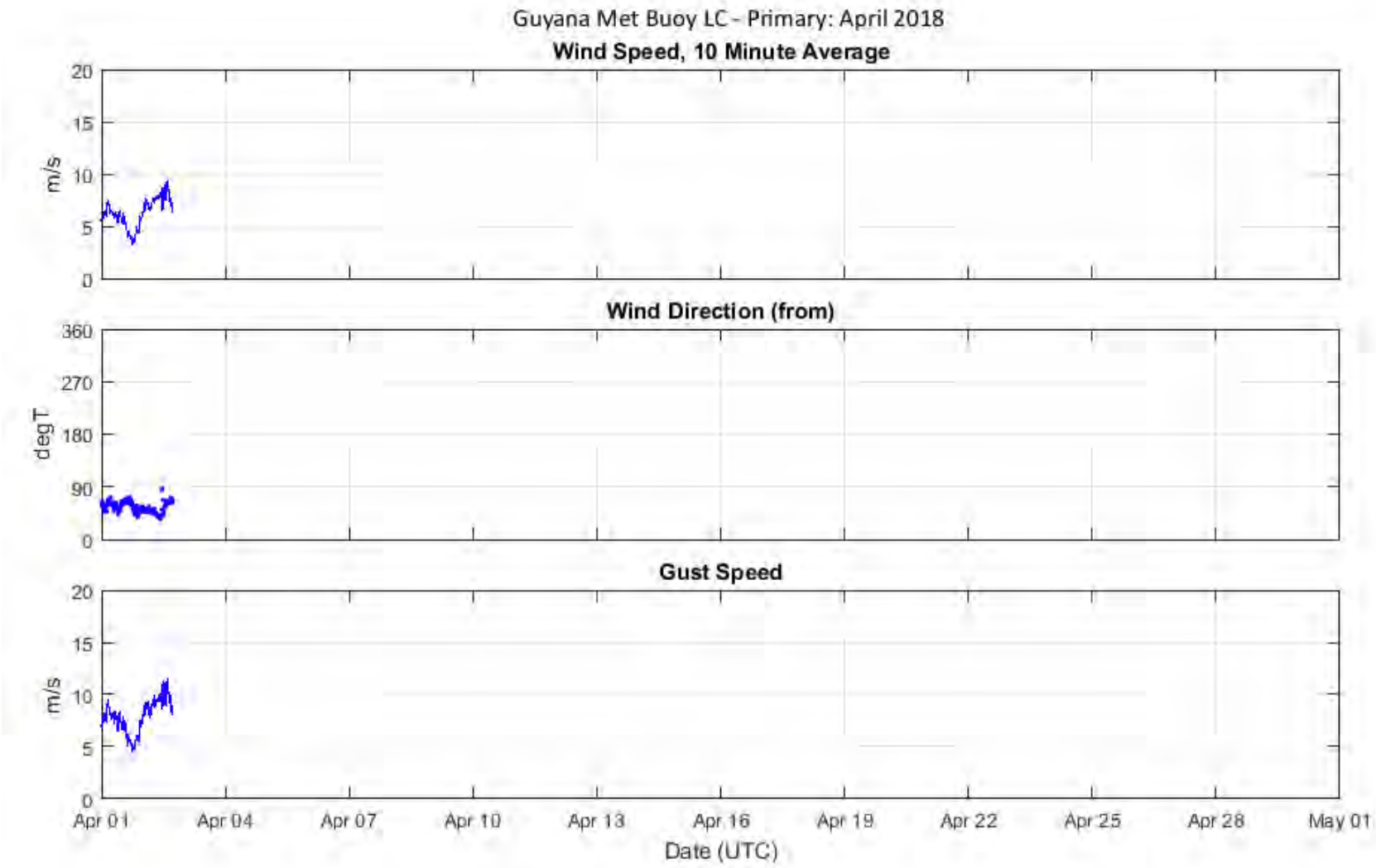
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APPENDIX F

Air Quality Modeling Report

Resubmitted without changes

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Esso Exploration and Production Guyana Limited

Air Quality Modeling Report

Payara Development Project

July 2019

Project No.: 0484443

The business of sustainability

ERM

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Acronyms and Abbreviations

Name	Description
µg/m^3	micrograms per cubic meter
am^3/hr	actual cubic meters per hour
Btu/scf	British thermal units per standard cubic foot
cal/sec	calories per second
CALPUFF	California PUFF model
CO	carbon monoxide
CO_2	carbon dioxide
FPSO	Floating Production, Storage, and Offloading (vessel)
EEPGL	Esso Exploration and Production Guyana Limited
ERM	Environmental Resources Management
H_2S	hydrogen sulfide
HHV	higher heating value
HP	high pressure
K	degrees Kelvin
LP	low pressure
LSBC	land-sea breeze circulation
m/s	meters per second
MMBtu/hr	million British thermal units per hour
MMscf/hr	million standard cubic feet per hour
NA	not applicable
NO_2	nitrogen dioxide
NOx	nitrogen oxides
PM	particulate matter
PM_{10}	particulate matter (aerodynamic diameter less than 10 microns)
$PM_{2.5}$	particulate matter (aerodynamic diameter less than 2.5 microns)
SO_2	sulfur dioxide
UTM	Universal Transverse Mercator (East or North)
WHO	World Health Organization
WRF	Weather Research and Forecasting (meteorological model)

1. INTRODUCTION

In support of the Payara Development Project (Project) Environmental Impact Assessment, Esso Exploration and Production Guyana Limited (EEPGL) commissioned Environmental Resources Management (ERM) to perform modeling of air emissions from planned Project activities. The purpose of this modeling was to estimate maximum Project-generated ground-level concentrations at onshore locations where community receptors could be exposed to these concentrations. Additionally, in support of the cumulative impact analysis for the Project, combined emissions from the Project and other reasonably foreseeable EEPGL offshore activities coinciding with the Project were also modeled.

This report provides a description of the modeling methodology—including source characteristics and emissions, receptor locations, model selection, and meteorological data development—and a summary of modeling results. Figure 1-1 displays the modeling domain used in this analysis, showing the locations of the main Project point sources (the Floating Production, Storage, and Offloading vessel [FPSO] and Payara Drill Center 5), and the boundary of Project-related area sources (including support vessels, construction vessels, and other sources without a fixed location), as configured for the modeling. Drill Center 5 was selected as the single location for modeling Project drilling activities in order to provide a conservative estimate of onshore ground-level concentrations. Onshore terrain elevations used in the modeling, as well as other EEPGL offshore activity point sources modeled in support of the cumulative impact assessment, are also depicted.

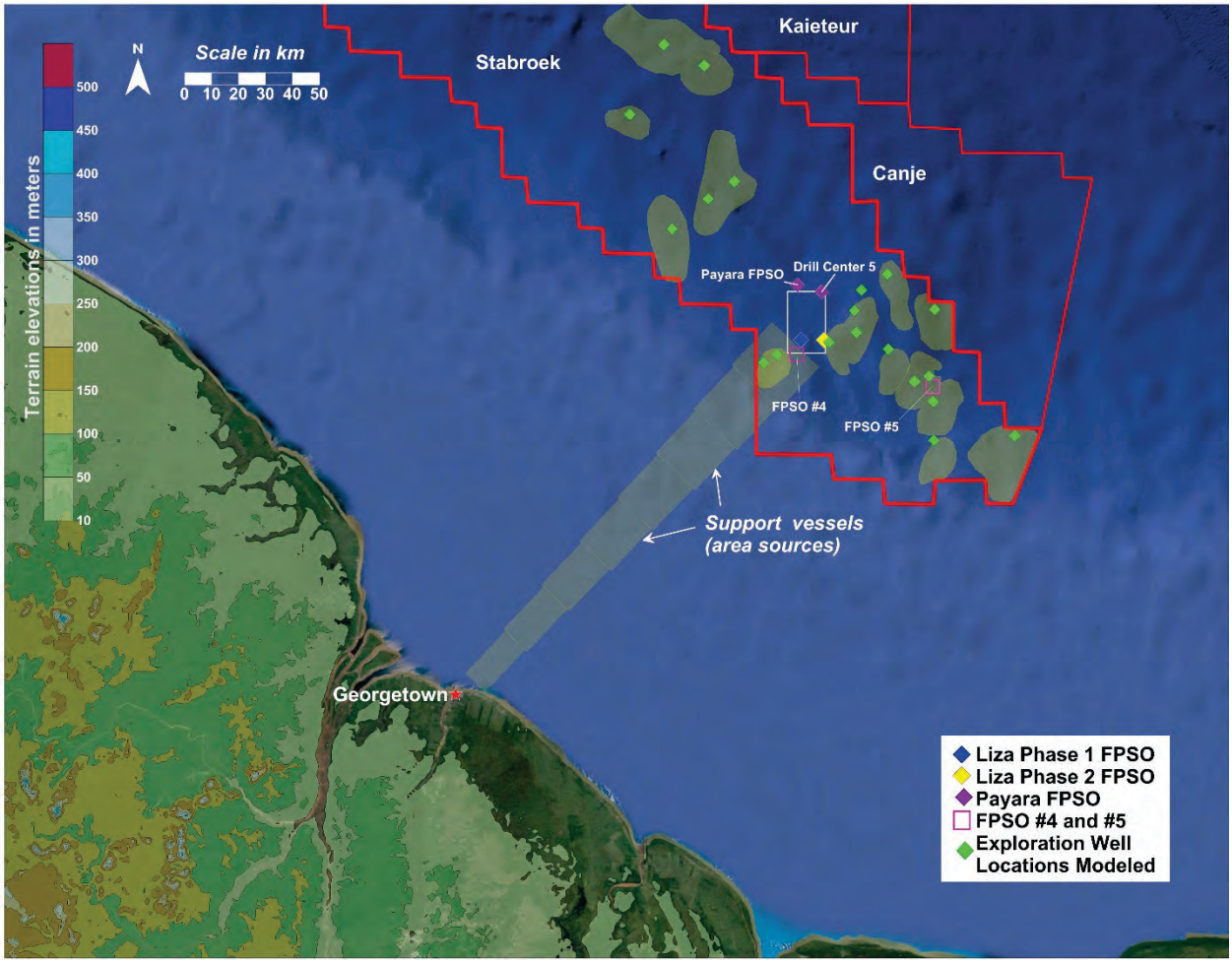


Figure 1-1: Air Quality Modeling Domain

2. AIR QUALITY MODELING METHODOLOGY

2.1 Modeled Activities

Emissions generated by the Project generally emanate from two source categories: (1) specific point sources such as the power-generating units and diesel engines on drill ships and on the FPSO, flares used (non-routinely) to combust produced gas when not consumed as fuel gas on the FPSO or re-injected, and vents; and (2) general area sources such as support vessels, construction vessels, tug boats, and helicopters.

For the cumulative impact assessment modeling, the following EEPGL offshore activities (in addition to the activities of Payara) were modeled:

- Exploration drilling through end of 2021;
- Liza Phase 1 Development Project (development well drilling and FPSO operation);
- Liza Phase 2 Development Project (development well drilling and FPSO operation);
- A fourth development project (referred to herein as “FPSO #4”; development well drilling and FPSO operation); and
- A fifth development project (referred to herein as “FPSO #5”; development well drilling and FPSO operation)

The specific source emissions modeled for these other EEPGL offshore activities were selected based on their currently forecasted timing (and locations, in the case of exploration drilling) relative to that of the Project. Figure 2-1 presents the cumulative impact assessment basis used for this purpose.

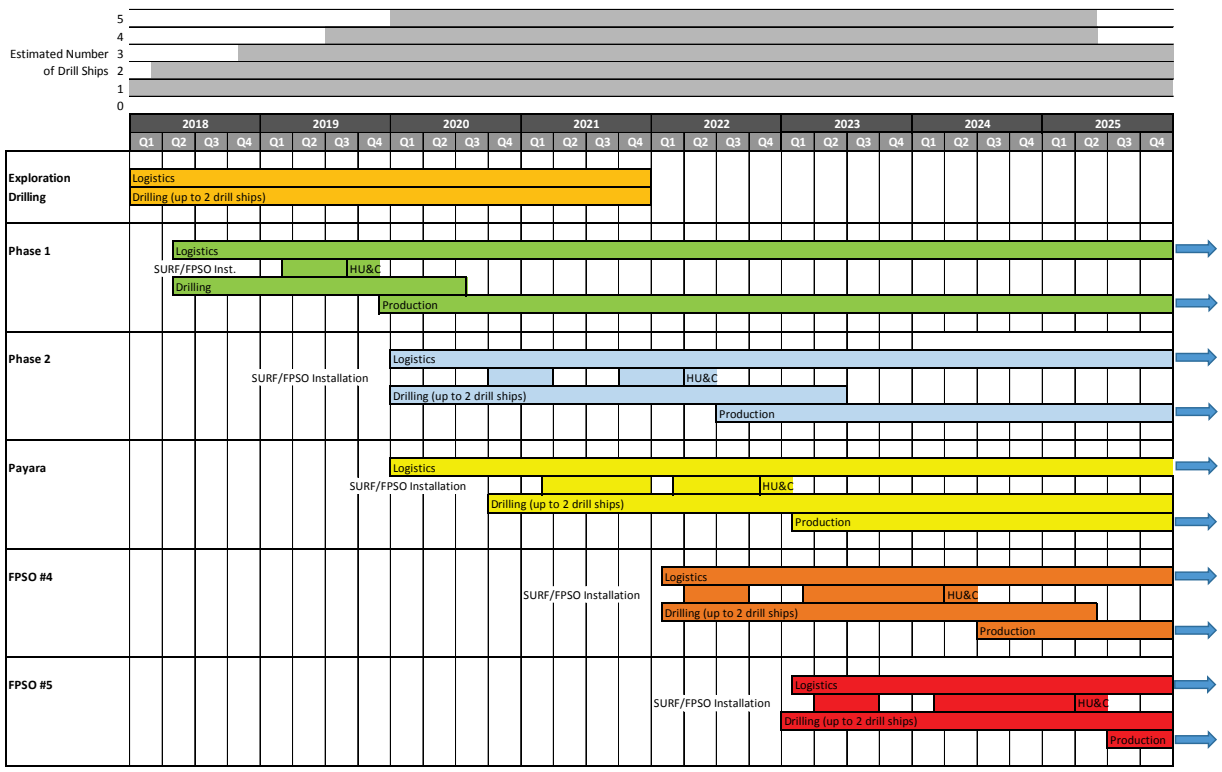


Figure 2-1: Cumulative Impact Assessment Basis for EEPGL Offshore Activities

2.2 Model Inputs: Source Characteristics and Emissions

Modeling “stack” sources involves first calculating plume rise (i.e., how high the plume rises due to momentum and buoyancy of the release). Plume rise is added to the physical stack height to determine final plume height, and the plume is tracked as it is transported downwind and dispersed by atmospheric turbulence. Stack parameters needed for model input include the physical stack height, internal diameter, exhaust velocity, elevation of the base of the stack, and exhaust temperature.

Table 2-1 displays the values for the Project parameters used in this analysis, along with the stack locations in Universal Transverse Mercator (UTM) coordinates. Table 2-1 also displays Project area source characteristics used for the modeling. These values are based on current knowledge of the Project design. It is noted that, due to the distance from Project sources to potential onshore receptors, modeled concentrations are not very sensitive to changes in stack parameters.

Table 2-1 also represents the parameters used for modeling the other five offshore EEPGL activities included in the cumulative impact assessment modeling, adjusted for locations as appropriate. Locations for modeled EEPGL activities are displayed on Figure 1-1.

Flares associated with the Project were modeled as point sources, with adjustments made to account for and maintain buoyancy of the hot plume. Table 2-2 displays the inputs and results of the calculations that were conducted to estimate an effective diameter and an effective stack height that accomplishes this goal. These parameters were used for all modeling that was conducted for non-routine flaring associated with the Project and with other EEPGL activities included in the cumulative impact assessment modeling, adjusted for locations as appropriate.

Table 2-1: Stack Parameters for Model Input

Name	UTM-E [a]	UTM-N [a]	Base Elevation	Height	Exhaust Flow	Exhaust Temp	Diameter	Exhaust Velocity
	meters	meters	meters	meters	am^3/hr	K	meters	m/s
FPSO Sources								
Combustion Turbines	499,750	905,900	30	28.00	638,716	803.15	3.100	23.507
Flare—HP Flaring [b]	499,750	905,900	30	169.12	NA	1,273.0	7.476	20.0
Flare—LP Flaring [b]	499,750	905,900	30	153.75	NA	1,273.0	3.997	20.0
Auxiliary Boiler (Heaters)	499,750	905,900	30	24.40	98,457	681.15	1.150	26.330
Essential Services Generators	499,750	905,900	30	15.50	14,791	578.15	0.305	56.234
Emergency Generators	499,750	905,900	30	3.20	15,229	719.15	0.300	59.845
Deck Cranes	499,750	905,900	30	28.90	7,360	795.55	0.522	9.539
Export Tanker	499,750	905,900	30	24.40	98,457	681.15	1.150	26.330
Drill Ship Sources								
Drill Center 5	508,750	903,333	0	22.00	73,470	682.60	0.800	40.601
Area Sources								
Support Vessels within Project Development Area	Note d		0	20.00	NA	NA	NA	NA
Support Vessels between shore and Project Development Area	Note c		0	10.00	NA	NA	NA	NA
Helicopters between shore and Project Development Area	Note c		0	300.00	NA	NA	NA	NA
General Project Development Area (Installation)	Note d		0	10.00	NA	NA	NA	NA

am^3/hr = actual cubic meters per hour; HP = high pressure; K = degrees Kelvin; LP = low pressure; m/s = meters per second; NA = not applicable; UTM-E = Universal Transverse Mercator East; UTM-N = Universal Transverse Mercator North

[a] Coordinates listed are for Payara Project sources.
[b] Effective height/diameter calculated based on heat release to maintain buoyancy flux.
[c] Area sources assumed to distribute emissions evenly between shore and Project Development Area.
[d] General area source in Project Development Area.

Table 2-2: Flare Calculations

Description	Gas Usage	Gas HHV	Total Heat Release	Total Heat Release	Sensible Heat Release	Effective Stack Diameter [a]	Physical Stack Height	Effective Stack Height [a]
	MMscf/hr	Btu/scf	MMBtu/hr	cal/sec	cal/sec	meters	meters	meters
Non-Routine Flaring								
HP	1.41	1,284.6	1,817.5	1.27E+08	5.73E+07	7.476	135	169.12
LP	0.30	1,707.4	519.6	3.64E+07	1.64E+07	3.997	135	153.75

Btu/scf = British thermal units per standard cubic foot; cal/sec = calories per second; HHV = higher heating value; HP = high pressure; LP = low pressure; MMBtu/hr = million British thermal units per hour; MMscf/hr = million standard cubic feet per hour

[a] Effective diameter and effective stack height calculated based on U.S. Environmental Protection Agency guidance, using 20 m/s exit velocity and 1,273 K exhaust temperature.

Emissions to air from the Project have been estimated based on a number of factors including activity levels, fuel types, equipment capacities, and standard emission factors that are published by the U.S. Environmental Protection Agency in the publication *AP-42: Compilation of Air Pollutant Emission Factors* (AP-42, USEPA 2018). As described in AP-42, an emission factor is a representative value that relates the quantity of a pollutant released to the atmosphere with an activity associated with the release of that pollutant. These factors are usually expressed as the weight of pollutant divided by a unit weight, volume, distance, or duration of the activity emitting the pollutant (e.g., milligrams of nitrogen oxides [NO_x] emitted per cubic meter of natural gas combusted). In most cases, these factors are averages of available data of an acceptable quality, and are generally assumed to be representative of long-term averages for a particular type of source.

Table 2-3 provides a summary of expected annual emissions from various planned Project activities for three time periods: 2020–2022 (development well drilling; subsea, umbilicals, risers, and flowlines [SURF] installation and commissioning; FPSO installation; and operation of related support vessels); 2023–2025 (continued development well drilling; operation of related support vessels; FPSO startup and associated temporary, non-routine flaring; beginning of production operations; and tanker loading); and 2026–2044 (production operations following cessation of drilling, including temporary, non-routine flaring; operation of related support vessels; and tanker loading). For each of the time periods, the annual emissions presented for each pollutant in Table 2-3 represents the maximum anticipated annual emissions for that pollutant for any of the years during the indicated time period. While there are some differences in emissions for different years within the time periods, they are relatively minor and the use of maximum emissions for the impact assessment provides a degree of conservatism in the results. Tables with detailed listings of Project emissions by year are provided in Attachment A. Table 2-4 presents the total emissions (over all sources) for the other EEPGL offshore activities that were modeled as part of the cumulative impact assessment.

Table 2-3: Annual Air Emissions Summary—Payara Project

Pollutant	Source Category	Annual Emissions (tonnes)		
		2020–2022	2023–2025	2026–2044
Nitrogen Oxides (NOx)	FPSO	0	2,730	2,635
	FPSO Flaring (temporary, non-routine)	0	865	165
	Tanker Loading	0	290	230
	Area Sources	3,110	3,365	1,670
	Drill Ships	1,675	1,675	0
	Total	4,785	8,925	4,700
Sulfur Dioxide (SO_2)	FPSO	0	140	140
	FPSO Flaring (temporary, non-routine)	0	150	30
	Tanker Loading	0	50	40
	Area Sources	110	120	60
	Drill Ships	60	60	0
	Total	170	520	270
Particulate Matter (PM)	FPSO	0	65	60
	FPSO Flaring (temporary, non-routine)	0	25	5
	Tanker Loading	0	25	20
	Area Sources	220	240	120
	Drill Ships	120	120	0
	Total	340	475	205
Carbon Monoxide (CO)	FPSO	0	695	675
	FPSO Flaring (temporary, non-routine)	0	4,685	880
	Tanker Loading	0	65	50
	Area Sources	650	705	350
	Drill Ships	350	350	0
	Total	1,000	6,500	1,955
Hydrogen Sulfide (H_2S)	FPSO Flaring (temporary, non-routine)	NA (no emissions)	<5	<1
Volatile Organic Compounds	All Sources	125	6,825	2,775
Greenhouse Gases (kilotonnes CO_2-equivalents)	All Sources	250	3,070	1,355

CO_2 = carbon dioxide; NA = not applicable
Notes:

1. The annual estimated totals generally reflect the current preliminary Project schedule and remain subject to adjustment.
2. Volatile organic compounds and greenhouse gas emissions are shown in this table but were not included in the impact assessment modeling, as no Guyana-specific ambient air quality criteria have been established for these substances.
3. PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns) standards and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) standards (a conservative assumption).
4. The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period, to reflect maximum possible short-term emission rates.

Table 2-4: Annual Air Emissions Summary—Other EEPGL Offshore Activities (Excluding Payara Project)

Pollutant	Source Category	Annual Emissions (tonnes)		
		2020–2022	2023–2025	2026–2044
Nitrogen Oxides (NOx)	All Sources	13,785	22,145	20,230
Sulfur Dioxide (SO_2)	All Sources	1,000	1,245	1,070
Particulate Matter (PM)	All Sources	720	1,030	925
Carbon Monoxide (CO)	All Sources	7,930	12,350	7,860
Hydrogen Sulfide (H_2S)	All Sources	<5	5	5
Volatile Organic Compounds	All Sources	15,640	23,170	18,745
Greenhouse Gases (kilotonnes CO_2-equivalents)	All Sources	2,995	6,260	5,185

CO_2 = carbon dioxide
Notes:

1. The annual estimated totals generally reflect preliminary assumptions regarding the schedule for other EEPGL activities and remain subject to adjustment.
2. Volatile organic compounds and greenhouse gas emissions are shown in this table but were not included in the impact assessment modeling, as no Guyana-specific or WHO ambient air quality criteria have been established for these substances.
3. PM emissions represent total PM; for the purpose of the impact assessment, the results from modeling of total PM values were used for comparison to both PM_{10} (particulate matter with an aerodynamic diameter less than 10 microns) standards and $PM_{2.5}$ (particulate matter with an aerodynamic diameter less than 2.5 microns) standards (a conservative assumption).
4. The emission rates in this table reflect annual totals. In some cases, the activities generating the emissions are not continuous during the year, or do not operate at full capacity throughout the year. For these sources, the annual emissions reflect this non-continuous operation over the year. However, for the purpose of modeling conducted to compare with short-term (up to 24-hour) guidelines, activities were assumed to be operating at full capacity for the simulated period, to reflect maximum possible short-term emission rates.

2.3 Receptors

A grid of potential receptor points was established for onshore areas, with a denser grid used in coastal areas (closer to the sources) and a coarser grid used in inland regions. For each pollutant, dispersion modeling was used to predict the maximum concentration at any time at any one of the onshore grid points; these maximum predicted concentrations were then compared to concentrations that may potentially result in significant impacts. Under this conservative approach, if the maximum predicted concentrations are determined to be not significant (i.e., less than the reference concentration), it follows that potential air quality impacts at any specific onshore receptor location also would be not significant. For this reason, specific locations of sensitive receptors were not identified at the onset of modeling. Figure 2-2 illustrates the potential receptor location grid used. At each potential receptor grid node, terrain elevations were specified and used by the California PUFF model (CALPUFF) to model plume interaction with onshore terrain.

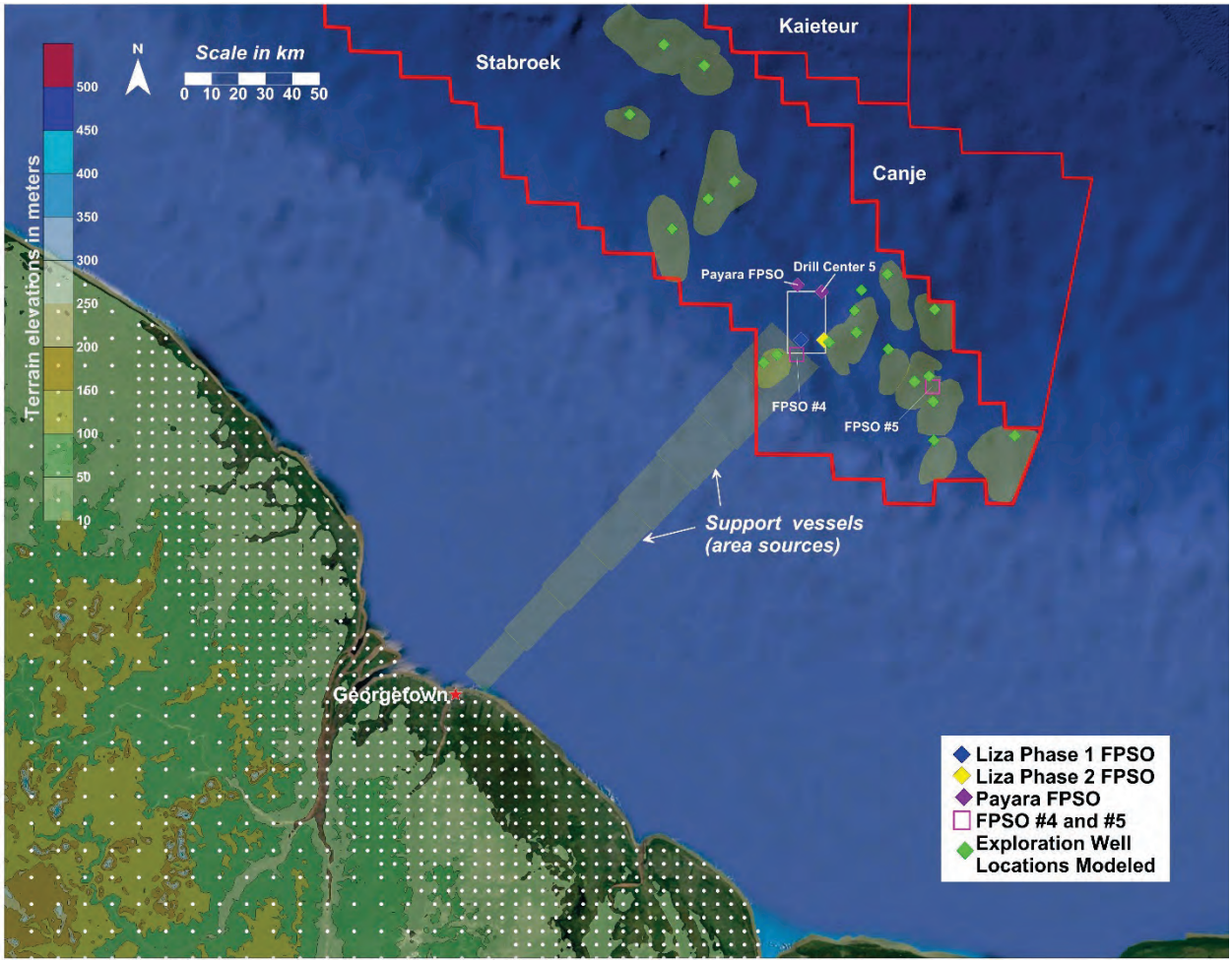


Figure 2-2: Potential Receptor Grid Used for Air Quality Modeling

2.4 Model Selection

The CALPUFF model (Version 7.2.1, level 150618) used in the assessment is a non-steady-state model used in the United States and around the globe for long-range transport and complex wind modeling. CALPUFF is a Lagrangian “puff” model that treats a plume as a series of puffs that it tracks as the wind carries the plume toward potential receptor locations. The selection of CALPUFF was based on the relatively large distance between the Project Development Area and the potential onshore receptors. The distance from the Project Development Area to the coastline of Georgetown is approximately 207 kilometers (128 miles). At this distance, emission plumes released from the point sources modeled would travel for approximately 10 hours, assuming an average wind speed of 5 meters (16.4 feet) per second (typical for the area). During this transport time, winds can change direction and speed. Accordingly, prediction of plume dispersion is most appropriately accomplished with a non-steady state model. Additionally, due to the vast differences in surface characteristics between open water and land, coastal areas frequently experience a classic meteorological phenomenon known as the land-sea breeze circulation (LSBC). This phenomenon is due to the diurnal surface temperature differences that develop between the land and the open water. LSBC effects can play an important role in the dispersion modeling analysis of emission sources as plumes interact with onshore receptors. CALPUFF, combined with gridded meteorological data, is capable of accounting for the LSBC phenomenon. CALPUFF was run for

each source individually and post-processing was used to calculate pollutant-specific totals for applicable averaging periods.

2.5 Meteorological Data

The Weather Research and Forecasting (WRF) model was used to develop hourly meteorology inputs for CALPUFF for 3 years—calendar years 2014, 2015, and 2016. WRF is a prognostic meteorological model that creates profiles of winds and temperature at grid points across a domain. The grid spacing chosen for this analysis was 12 kilometers (7.5 miles), so that a two-dimensional profile of hourly winds and temperature was developed every 12 kilometers (7.5 miles) within the domain shown in Figure 2-2. The profiles were used by CALPUFF to simulate the transport and dispersion of emission plumes from Project sources, allowing the model to calculate ambient constituent concentrations at potential receptor locations, accounting for changes in meteorology as the plumes travel downwind.

Illustrations of how the WRF model accounts for the effects on meteorological variables from height above the surface and underlying land use characteristics (i.e., overland and overwater) are provided in Figures 2-3 and 2-4. These figures display the locations of the 12-kilometer (7.5-mile) grid points (the WRF model was used to create profiles of wind and temperature for each of these locations). At every other grid point, wind roses were created to illustrate wind direction and speed frequencies at that location. Wind roses shown in Figure 2-3 were created from the profile of wind conditions 10 meters (33 feet) above the surface for the year 2014; wind roses shown in Figure 2-4 were created from the profile of wind conditions 240 meters (787 feet) above the surface for the year 2014 (240 meters is representative of typical plume heights for the larger Project sources). At a height of 240 meters (787 feet), the effects of the land surface on winds are considerably less pronounced than the effects at a height of 10 meters (33 feet). Figure 2-3 (10-meter level [33-foot]) shows a pronounced effect on wind speed over land, where surface friction acts to slow down the wind.

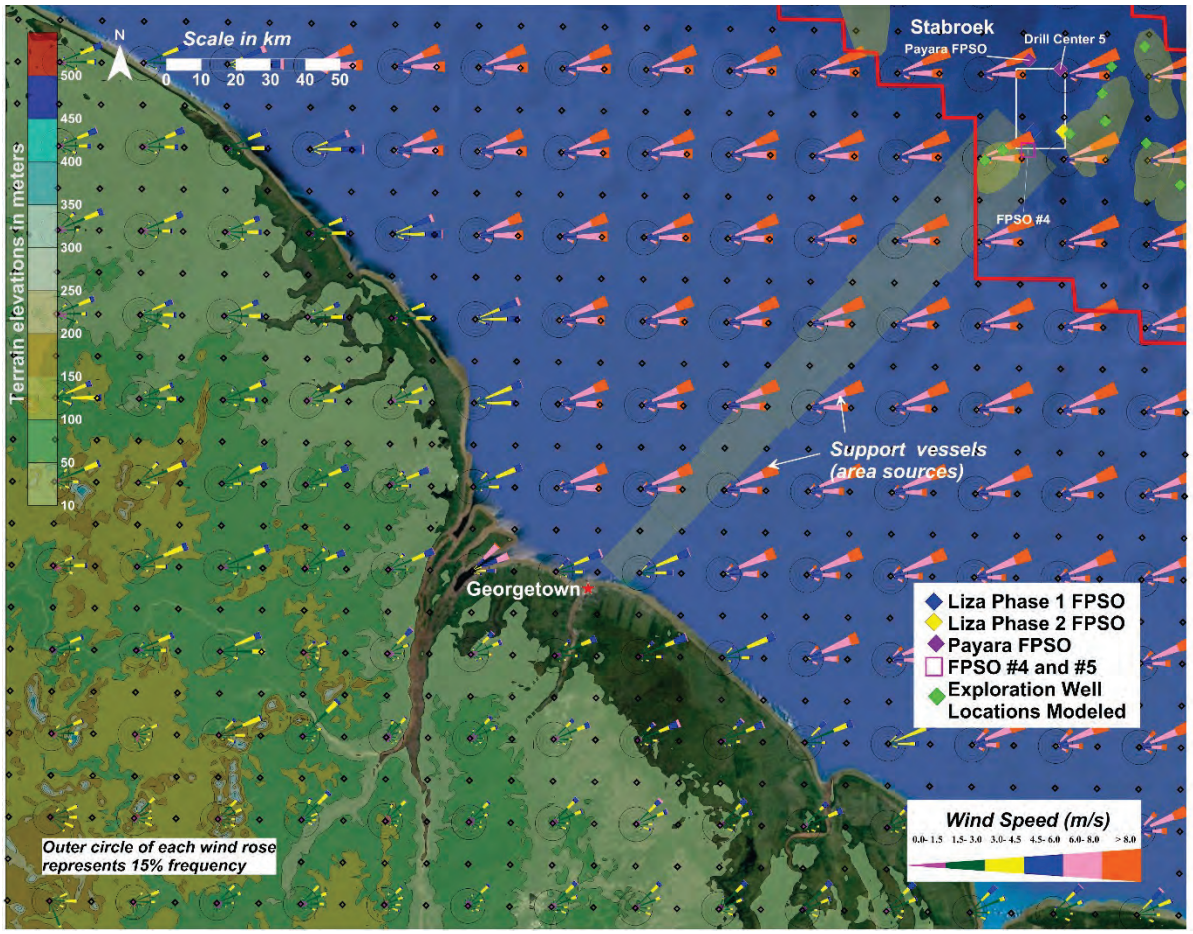


Figure 2-3: Wind Roses—10-Meter (33-Foot) Level (2014)

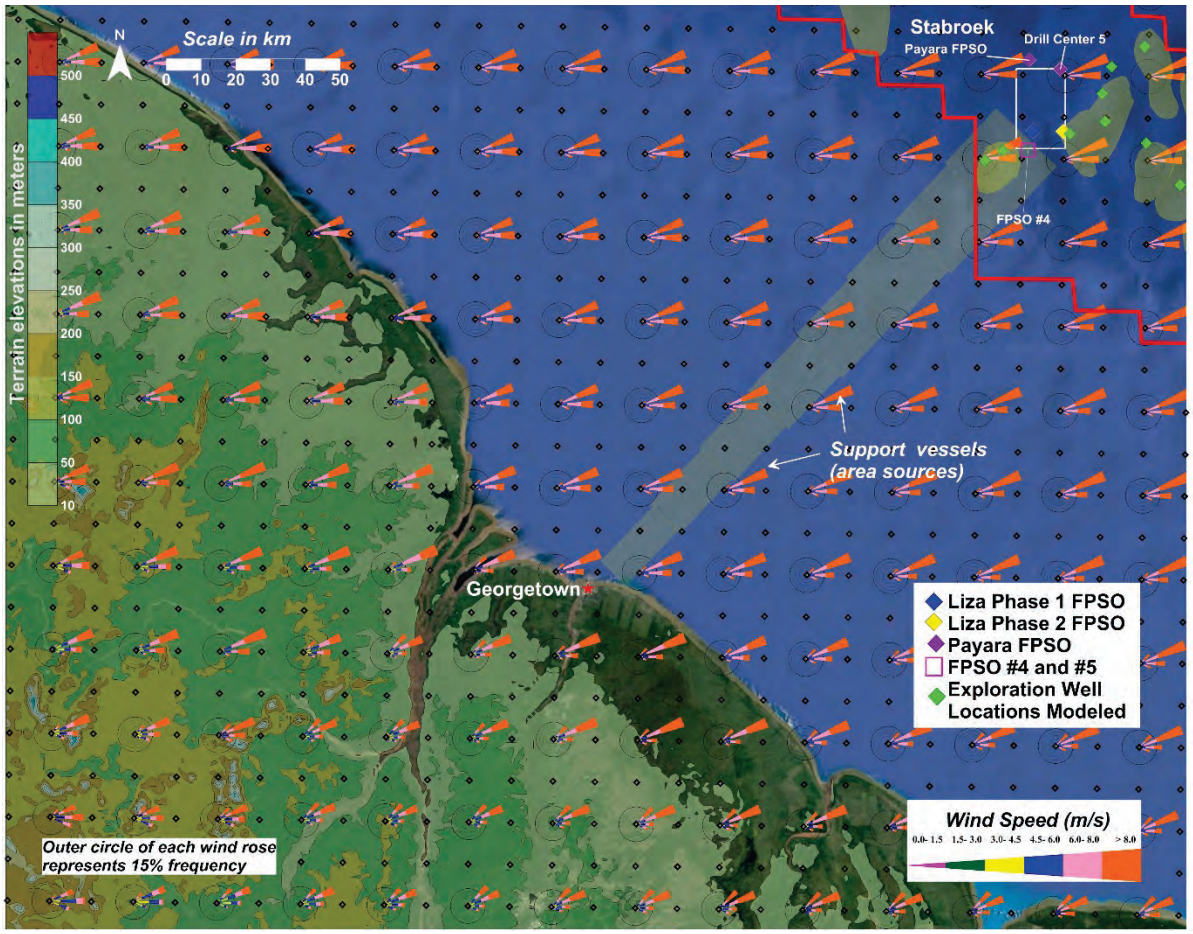


Figure 2-4: Wind Roses—240-Meter Level (787-Foot) (2014)

3. RESULTS

3.1 Ambient Air Quality Guidelines

Ambient air quality guidelines are concentration levels in air that are established to protect human health in locations where exposure can potentially occur. These generally include a margin of safety to ensure that vulnerable individuals are also protected. Guyana has not established specific ambient air quality standards; therefore, the guidelines used for reference in this assessment were those established by the World Health Organization (WHO). The WHO guidelines are summarized in Table 3-1. These guidelines were published in *WHO Air Quality Guidelines for Particulate Matter, Ozone, Nitrogen Dioxide and Sulfur Dioxide—Global Update 2005* (WHO 2005), except for carbon monoxide (CO) and hydrogen sulfide (H_2S), for which guidelines were published in WHO's *Air Quality Guidelines for Europe, 2nd edition, 2000* (WHO 2000).

Table 3-1: WHO Ambient Air Quality Guidelines

Pollutant	Averaging Period	Guideline Concentration (µg/m^3)
NO_2	1-hour	200
	Annual	40
SO_2	10-minute	500
	24-hour	20
PM_{10}	24-hour	50
	Annual	20
$PM_{2.5}$	24-hour	25
	Annual	10
CO	1-hour	30,000
	8-hour	10,000
H_2S	30-minute	7

Sources: WHO 2000; WHO 2005

µg/m^3 = micrograms per cubic meter; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

3.2 Predicted Concentrations and Comparison to Guidelines

Using the methodology described above, modeling was conducted with CALPUFF to predict maximum onshore ground-level concentrations of each pollutant as a result of emissions from Project sources. Model results were developed for each modeled pollutant, for each averaging period with an associated WHO guideline concentration (Table 3-1). Additionally, the cumulative impact analysis modeling scenario combined the results from the Project with modeled emissions from the other EEPGL offshore activities identified above.

All results are summarized in Table 3-2 (Project only) and Table 3-3 (Cumulative Scenario). For the Project only modeling, maximum predicted concentrations at any potential onshore receptor location are less than 2 percent of the applicable guideline for all pollutants and averaging periods. For the cumulative scenario, maximum predicted concentrations at any potential onshore receptor location are no more than 5.4 percent of the applicable guideline for all pollutants and averaging periods. These results are consistent with the expectation that onshore air quality impacts from the Project would be relatively small in magnitude, based on the distance of Project emissions sources from the nearest potential onshore receptors.

Table 3-2: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Project Only)

Pollutant	Averaging Period	WHO Guideline Concentration (µg/m³)	Maximum Predicted Onshore Concentration (µg/m³)			Percent of WHO Guideline		
			2020–2022	2023–2025	2026–2044	2020–2022	2023–2025	2026–2044
NO_2	1-hour	200	1.6	3.3	2.2	0.8%	1.7%	1.1%
	Annual	40	0.15	0.27	0.15	0.37%	0.68%	0.36%
SO_2	10 Minute	500	0.14	0.63	0.44	0.03%	0.13%	0.09%
	24 hour	20	0.03	0.13	0.09	0.13%	0.65%	0.45%
PM_{10}	24 hour	50	0.06	0.08	0.04	0.11%	0.16%	0.09%
	Annual	20	0.01	0.02	0.01	0.07%	0.09%	0.04%
$PM_{2.5}$	24 hour	25	0.06	0.08	0.04	0.22%	0.33%	0.18%
	Annual	10	0.01	0.02	0.01	0.14%	0.18%	0.07%
CO	1-hour	30,000	0.42	1.86	0.87	0.001%	0.006%	0.003%
	8-hour	10,000	0.31	1.12	0.55	0.003%	0.011%	0.005%
H_2S	30 minutes	7	NA	0.0010	0.0005	NA	0.015%	0.0065%

Sources: WHO 2000; WHO 2005

µg/m³ = micrograms per cubic meter; NA = not applicable; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

Table 3-3: Summary of Modeling Results—Maximum Predicted Concentrations at Potential Onshore Receptor Locations (Cumulative Scenario)

Pollutant	Averaging Period	WHO Guideline Concentration (µg/m³)	Maximum Predicted Onshore Concentration (µg/m³)			Percent of WHO Guideline		
			2020–2022	2023–2025	2026–2044	2020–2022	2023–2025	2026–2044
NO_2	1-hour	200	6.1	10.8	9.8	3.0%	5.4%	4.9%
	Annual	40	0.47	0.86	0.80	1.2%	2.2%	2.0%
SO_2	10 Minute	500	1.14	1.95	1.87	0.23%	0.39%	0.37%
	24 hour	20	0.35	0.62	0.60	1.8%	3.1%	3.0%
PM_{10}	24 hour	50	0.17	0.29	0.27	0.34%	0.58%	0.53%
	Annual	20	0.03	0.05	0.05	0.16%	0.27%	0.23%
$PM_{2.5}$	24 hour	25	0.17	0.29	0.27	0.68%	1.2%	1.1%
	Annual	10	0.03	0.05	0.05	0.33%	0.54%	0.45%
CO	1-hour	30,000	2.73	4.62	4.02	0.009%	0.015%	0.013%
	8-hour	10,000	1.88	3.29	2.95	0.019%	0.033%	0.029%
H_2S	30 minutes	7	0.0001	0.0014	0.0009	0.001%	0.019%	0.013%

Sources: WHO 2000; WHO 2005

µg/m³ = micrograms per cubic meter; NA = not applicable; NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter (aerodynamic diameter less than 2.5 microns); PM_{10} = particulate matter (aerodynamic diameter less than 10 microns); SO_2 = sulfur dioxide

4. REFERENCES

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ATTACHMENT A TABLES—DETAILED PAYARA PROJECT EMISSIONS BY YEAR

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Table 1a: NOx Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Modeled for Each Time Period			Emissions (tonnes) Per Year									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.0	2614	2614	0	0.0	0.0	2614	2614	2614	2614	2614	2614	2614
HP Flaring	0.00	566.1	105.8	0.0	0.0	0.00	566.09	85.4	92.2	96.0	105.8	103.1	101.3
LP Flaring	0.00	294.5	55.0	0.0	0.0	0.00	294.46	44.4	48.0	49.9	55.0	53.6	52.7
Auxiliary Boiler (Heaters)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Essential Services Gens	0.0	101.7	7.8	0.0	0.0	0.0	101.7	7.8	7.8	7.8	7.8	7.8	7.8
Emergency Generators	0.0	0.2	0.2	0.0	0.0	0.0	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Deck Cranes	0.0	9.9	9.9	0.0	0.0	0.0	5.0	9.9	9.9	9.9	9.9	9.9	9.9
Export Tanker	0.0	289.8	226.2	0.0	0.0	0.0	256.2	289.8	286.2	226.2	186.6	151.8	132.6
Drill Center 5	1670	1670	0.0	209	1670	1670	1670	1670	1670	0.0	0.0	0.0	0.0
Support Vessels in Project Development Area	1376	1537	1094	0	579	1376	1537	1537	1537	1094	1094	1094	1094
Support Vessels between shore and Project Development Area	688.1	768.5	547.2	27.7	289.7	688.1	768.5	768.5	768.5	547.2	547.2	547.2	547.2
Helicopters between shore and Project Development Area	17.4	30.0	24.5	0.7	17.4	17.4	30.0	30.0	30.0	24.5	24.5	24.5	24.5
General Project Development Area (Installation)	1028	1028	0.0	0.0	1028	1028	1028	0.0	0.0	0.0	0.0	0.0	0.0
Sum	**4780**	**8909**	**4685**	**237**	**3585**	**4780**	**8871**	**7057**	**7064**	**4670**	**4645**	**4606**	**4584**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; NOx = nitrogen oxides

Table 1b: NOx Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614	2614
HP Flaring	100.8	100.8	98.0	89.2	79.7	70.9	74.4	65.8	56.5	71.9	81.2	68.6	67.8	28.1	28.1
LP Flaring	52.4	52.4	51.0	46.4	41.4	36.9	38.7	34.2	29.4	37.4	42.2	35.7	35.3	14.6	14.6
Auxiliary Boiler (Heaters)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Essential Services Gens	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
Emergency Generators	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Deck Cranes	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9	9.9
Export Tanker	119.4	107.4	99.0	93.0	83.4	76.2	72.6	67.8	64.2	72.6	69.0	61.8	57.0	0.0	0.0
Drill Center 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Support Vessels in Project Development Area	1094	1094	1094	1094	1094	1094	1094	1094	1094	1094	1094	1094	1094	1094	1094
Support Vessels between shore and Project Development Area	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2	547.2
Helicopters between shore and Project Development Area	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.5
General Project Development Area (Installation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	**4570**	**4558**	**4546**	**4526**	**4502**	**4482**	**4483**	**4466**	**4448**	**4480**	**4490**	**4464**	**4458**	**4340**	**4340**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; NOx = nitrogen oxides

Table 2a: SO_2 Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Modeled for Each Time Period			Emissions (tonnes) Per Year									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.00	136.04	136.04	0.00	0.00	0.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0
HP Flaring	0.00	95.6	17.9	0.00	0.0	0.00	95.57	14.4	15.6	16.2	17.9	17.4	17.1
LP Flaring	0.00	49.7	9.3	0.00	0.0	0.00	49.71	7.5	8.1	8.4	9.3	9.1	8.9
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.00	3.41	0.26	0.00	0.00	0.00	3.41	0.26	0.26	0.26	0.26	0.26	0.26
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deck Cranes	0.00	0.33	0.33	0.00	0.00	0.00	0.17	0.33	0.33	0.33	0.33	0.33	0.33
Export Tanker	0.00	48.59	37.92	0.00	0.00	0.00	42.95	48.59	47.98	37.92	31.29	25.45	22.23
Drill Center 5	56.00	56.00	0.00	7.00	56.00	56.00	56.00	56.00	56.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	46.14	51.54	36.70	0.00	19.43	46.14	51.54	51.54	51.54	36.70	36.70	36.70	36.70
Support Vessels between shore and Project Development Area	23.07	25.77	18.35	0.93	9.71	23.07	25.77	25.77	25.77	18.35	18.35	18.35	18.35
Helicopters between shore and Project Development Area	2.12	3.65	2.99	0.08	2.12	2.12	3.65	3.65	3.65	2.99	2.99	2.99	2.99
General Project Development Area (Installation)	34.47	34.47	0.00	0.00	34.47	34.47	34.47	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**161.8**	**505.1**	**259.8**	**8.0**	**122**	**162**	**499.3**	**344.1**	**345.3**	**257.2**	**253.1**	**246.6**	**242.9**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; SO_2 = sulfur dioxide

Table 2b: SO_2 Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0	136.0
HP Flaring	17.0	17.0	16.5	15.1	13.4	12.0	12.6	11.1	9.5	12.1	13.7	11.6	11.5	4.7	4.7
LP Flaring	8.9	8.9	8.6	7.8	7.0	6.2	6.5	5.8	5.0	6.3	7.1	6.0	6.0	2.5	2.5
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26	0.26
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deck Cranes	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
Export Tanker	20.02	18.01	16.60	15.59	13.98	12.78	12.17	11.37	10.76	12.17	11.57	10.36	9.56	0.00	0.00
Drill Center 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70	36.70
Support Vessels between shore and Project Development Area	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35	18.35
Helicopters between shore and Project Development Area	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99	2.99
General Project Development Area (Installation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**240.6**	**238.6**	**236.4**	**233.2**	**229.1**	**225.6**	**225.9**	**222.9**	**219.9**	**225.3**	**227.1**	**222.6**	**221.6**	**201.9**	**201.9**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; SO_2 = sulfur dioxide

Table 3a: H_2S Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Modeled for Each Time Period			Emissions (tonnes) Per Year									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP Flaring	0.00E+00	1.40E+00	2.62E-01	0.00	0.0	0.00	1.40	0.2	0.2	0.2	0.3	0.3	0.3
LP Flaring	0.00E+00	7.29E-01	1.36E-01	0.00	0.0	0.00	0.73	0.1	0.1	0.1	0.1	0.1	0.1
Auxiliary Boiler (Heaters)	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deck Cranes	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Export Tanker	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Drill Center 5	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels between shore and Project Development Area	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helicopters between shore and Project Development Area	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Project Development Area (Installation)	0.00E+00	0.00E+00	0.00E+00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.000E+00	2.131E+00	3.984E-01	0.00	0.00	0.00	2.13	0.32	0.35	0.36	0.40	0.39	0.38

FPSO = Floating Production, Storage, and Offloading (vessel); H_2S = hydrogen sulfide; HP = high pressure; LP = low pressure

Table 3b: H_2S Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
HP Flaring	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.1
LP Flaring	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.0	0.0
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deck Cranes	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Export Tanker	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Drill Center 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels between shore and Project Development Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Helicopters between shore and Project Development Area	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
General Project Development Area (Installation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	0.38	0.38	0.37	0.34	0.30	0.27	0.28	0.25	0.21	0.27	0.31	0.26	0.26	0.11	0.11

FPSO = Floating Production, Storage, and Offloading (vessel); H_2S = hydrogen sulfide; HP = high pressure; LP = low pressure

Table 4a: PM Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Modeled for Each Time Period			Emissions (tonnes) Per Year									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.00	53.91	53.91	0.00	0.00	0.00	53.91	53.91	53.91	53.91	53.91	53.91	53.91
HP Flaring	0.00	16.2	3.0	0.00	0.00	0.0	16.18	2.44	2.64	2.74	3.03	2.95	2.90
LP Flaring	0.00	8.4	1.6	0.00	0.00	0.0	8.42	1.27	1.37	1.43	1.57	1.53	1.51
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.00	7.15	0.55	0.00	0.00	0.00	7.15	0.55	0.55	0.55	0.55	0.55	0.55
Emergency Generators	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Deck Cranes	0.00	0.70	0.70	0.00	0.00	0.00	0.35	0.70	0.70	0.70	0.70	0.70	0.70
Export Tanker	0.00	20.37	15.90	0.00	0.00	0.00	18.01	20.37	20.12	15.90	13.12	10.67	9.32
Drill Center 5	117.40	117.40	0.00	14.67	117.40	117.40	117.40	117.40	117.40	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	96.73	108.05	76.93	0.00	40.73	96.73	108.05	108.05	108.05	76.93	76.93	76.93	76.93
Support Vessels between shore and Project Development Area	48.37	54.02	38.47	1.94	20.36	48.37	54.02	54.02	54.02	38.47	38.47	38.47	38.47
Helicopters between shore and Project Development Area	1.23	2.11	1.72	0.05	1.23	1.23	2.11	2.11	2.11	1.72	1.72	1.72	1.72
General Project Development Area (Installation)	72.26	72.26	0.00	0.00	72.26	72.26	72.26	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**335.98**	**460.57**	**192.79**	**16.7**	**252.0**	**336.0**	**457.9**	**360.8**	**360.9**	**192.4**	**190.0**	**187.4**	**186.0**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; PM = particulate matter

Table 4b: PM Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91	53.91
HP Flaring	2.88	2.88	2.80	2.55	2.28	2.03	2.13	1.88	1.62	2.05	2.32	1.96	1.94	0.80	0.80
LP Flaring	1.50	1.50	1.46	1.33	1.18	1.05	1.11	0.98	0.84	1.07	1.21	1.02	1.01	0.42	0.42
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55
Emergency Generators	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Deck Cranes	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70
Export Tanker	8.39	7.55	6.96	6.54	5.86	5.36	5.10	4.77	4.51	5.10	4.85	4.34	4.01	0.00	0.00
Drill Center 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93	76.93
Support Vessels between shore and Project Development Area	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47	38.47
Helicopters between shore and Project Development Area	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72	1.72
General Project Development Area (Installation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**185.1**	**184.2**	**183.5**	**182.7**	**181.6**	**180.7**	**180.6**	**179.9**	**179.3**	**180.5**	**180.7**	**179.6**	**179.2**	**173.5**	**173.5**

FPSO = Floating Production, Storage, and Offloading (Vessel); HP = high pressure; LP = low pressure; PM = particulate matter

Table 5a: CO Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Modeled for Each Time Period			Emissions (tonnes) Per Year									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.00	669.73	669.73	0.00	0.00	0.00	669.7	669.7	669.7	669.7	669.7	669.7	669.7
HP Flaring	0.00	3080.2	575.8	0.00	0.00	0.0	3080.18	464.95	501.90	522.44	575.82	560.76	551.18
LP Flaring	0.00	1602.2	299.5	0.00	0.00	0.0	1602.23	241.85	261.08	271.76	299.53	291.69	286.71
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.00	21.18	1.63	0.00	0.00	0.00	21.18	1.63	1.63	1.63	1.63	1.63	1.63
Emergency Generators	0.00	0.04	0.04	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Deck Cranes	0.00	2.07	2.07	0.00	0.00	0.00	1.04	2.07	2.07	2.07	2.07	2.07	2.07
Export Tanker	0.00	60.38	47.13	0.00	0.00	0.00	53.38	60.38	59.63	47.13	38.88	31.63	27.63
Drill Center 5	347.93	347.93	0.00	43.49	347.93	347.9	347.93	347.93	347.93	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	286.69	320.22	228.01	0.00	120.71	286.7	320.22	320.22	320.22	228.01	228.01	228.01	228.01
Support Vessels between shore and Project Development Area	143.34	160.11	114.00	5.76	60.36	143.3	160.11	160.11	160.11	114.00	114.00	114.00	114.00
Helicopters between shore and Project Development Area	3.63	6.24	5.11	0.14	3.63	3.6	6.24	6.24	6.24	5.11	5.11	5.11	5.11
General Project Development Area (Installation)	214.15	214.15	0.00	0.00	214.15	214.2	214.15	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**995.7**	**6484.5**	**1943.1**	**49.4**	**746.8**	**995.7**	**6476.4**	**2275.2**	**2330.6**	**1861.9**	**1934.8**	**1904.7**	**1886.1**

CO = carbon monoxide; FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure

Table 5b: CO Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7	669.7
HP Flaring	548.44	548.44	533.39	485.48	433.46	385.55	404.72	358.18	307.53	391.03	441.68	373.23	369.13	152.86	152.86
LP Flaring	285.29	285.29	277.45	252.53	225.48	200.55	210.52	186.31	159.97	203.40	229.75	194.15	192.01	79.51	79.51
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63	1.63
Emergency Generators	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04
Deck Cranes	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07	2.07
Export Tanker	24.88	22.38	20.63	19.38	17.38	15.88	15.13	14.13	13.38	15.13	14.38	12.88	11.88	0.00	0.00
Drill Center 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	228.01	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0	228.0
Support Vessels between shore and Project Development Area	114.00	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0	114.0
Helicopters between shore and Project Development Area	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11	5.11
General Project Development Area (Installation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**1879.2**	**1876.7**	**1852.1**	**1778.0**	**1696.9**	**1622.6**	**1651.0**	**1579.2**	**1501.5**	**1630.2**	**1706.4**	**1600.9**	**1593.6**	**1253.0**	**1253.0**

CO = carbon monoxide; FPSO = Floating Production, Storage, and Offloading (Vessel); HP = high pressure; LP = low pressure

Table 6a: VOC Emissions by Year—Payara Project

Source Sector	Emissions (Tonnes) for Each Time Period			Emissions (tonnes) Per Year									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.00	13.97	13.97	0.00	0.0	0.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
HP Flaring	0.00	2767.6	517.4	0.00	0.0	0.00	2767.63	417.8	450.97	469.42	517.39	503.86	495.25
LP Flaring	0.00	1439.6	269.1	0.00	0.0	0.00	1439.65	217.3	234.58	244.18	269.13	262.10	257.62
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Essential Services Gens	0.00	2.60	0.20	0.00	0.0	0.0	2.6	0.2	0.2	0.2	0.2	0.2	0.2
Emergency Generators	0.00	0.00	0.00	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deck Cranes	0.00	0.25	0.25	0.00	0.0	0.0	0.1	0.3	0.3	0.3	0.3	0.3	0.3
Tanks	0.00	313.76	244.90	0.00	0.0	0.0	277.4	313.8	309.9	244.9	202.0	164.4	143.6
Vessel Loading	0.00	2147.8	1676.4	0.0	0.0	0.0	1899	2148	2121	1676	1383	1125	983
Export Tanker	0.00	7.42	5.79	0.00	0.0	0.0	6.6	7.4	7.3	5.8	4.8	3.9	3.4
Drill Center 5	42.74	42.74	0.00	5.34	42.7	42.7	42.7	42.7	42.7	0.0	0.0	0.0	0.0
Support Vessels in Project Development Area	35.22	39.34	28.01	0.00	14.8	35.2	39.3	39.3	39.3	28.0	28.0	28.0	28.0
Support Vessels between shore and Project Development Area	17.61	19.67	14.01	0.71	7.4	17.6	19.7	19.7	19.7	14.0	14.0	14.0	14.0
Helicopters between shore and Project Development Area	0.01	0.01	0.01	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Project Development Area (Installation)	26.31	26.31	0.00	0.00	26.3	26.3	26.3	0.0	0.0	0.0	0.0	0.0	0.0
Sum	**121.89**	**6821.1**	**2770.1**	**6.1**	**91.3**	**121.9**	**6534.8**	**3220.2**	**3240.0**	**2697.2**	**2432.7**	**2115.7**	**1939.0**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; VOC = volatile organic compound

Table 6b: VOC Emissions by Year—Payara Project

Source Sector	Emissions (tonnes) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
HP Flaring	492.79	492.79	479.26	436.22	389.48	346.43	363.65	321.83	276.33	351.35	396.86	335.36	331.67	137.35	137.35
LP Flaring	256.34	256.34	249.30	226.91	202.60	180.20	189.16	167.41	143.74	182.76	206.43	174.45	172.53	71.44	71.44
Auxiliary Boiler (Heaters)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Essential Services Gens	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Emergency Generators	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Deck Cranes	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Tanks	129.3	116.3	107.2	100.7	90.3	82.5	78.6	73.4	69.5	78.6	74.7	66.9	61.7	0.0	0.0
Vessel Loading	885	796	734	689.2	618.1	564.7	538.1	502.5	475.8	538.1	511.4	458.0	422.4	0.0	0.0
Export Tanker	3.1	2.7	2.5	2.4	2.1	2.0	1.9	1.7	1.6	1.9	1.8	1.6	1.5	0.0	0.0
Drill Center 5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Support Vessels in Project Development Area	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
Support Vessels between shore and Project Development Area	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0	14.0
Helicopters between shore and Project Development Area	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
General Project Development Area (Installation)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum	**1822.8**	**1720.6**	**1628.5**	**1511.9**	**1359.1**	**1232.3**	**1227.8**	**1123.3**	**1023.5**	**1209.1**	**1247.6**	**1092.8**	**1046.3**	**265.2**	**265.2**

FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure; VOC = volatile organic compound

Table 7a: Greenhouse Gas (Kilotonnes CO_2-equivalents)

Source Sector	Emissions (Kilotonnes CO_2-equivalents) for Each Time Period			Emissions (Kilotonnes CO_2-equivalents) for Each Time Period									
	const. 2020-2022	oper/drill 2023-2025	operations 2026-2044	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Combustion Turbines	0.00	892.0	892.0	0.0	0.00	0.00	892.0	892.0	892.0	892.0	892.0	892.0	892.0
HP Flaring	0.00	1239.5	231.7	0.0	0.00	0.00	1239.5	187.1	202.0	210.2	231.7	225.7	221.8
LP Flaring	0.00	644.8	120.5	0.0	0.00	0.00	644.8	97.3	105.1	109.4	120.5	117.4	115.4
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.00	5.25	0.40	0.00	0.00	0.00	5.25	0.40	0.40	0.40	0.40	0.40	0.40
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deck Cranes	0.00	0.26	0.51	0.00	0.00	0.00	0.26	0.51	0.51	0.51	0.51	0.51	0.51
Tanks	0.00	1.16	0.84	0.00	0.00	0.00	1.16	1.31	1.29	1.02	0.84	0.68	0.60
Vessel Loading	0.00	8.38	6.10	0.00	0.00	0.00	8.38	9.48	9.36	7.40	6.10	4.96	4.34
Export Tanker	0.00	13.23	9.63	0.00	0.00	0.00	13.23	14.96	14.78	11.68	9.63	7.84	6.85
Drill Center 5	86.22	86.22	0.00	10.78	86.22	86.22	86.22	86.22	86.22	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	71.04	79.35	56.50	0.00	29.91	71.04	79.35	79.35	79.35	56.50	56.50	56.50	56.50
Support Vessels between shore and Project Development Area	35.52	39.68	28.25	1.43	14.96	35.52	39.68	39.68	39.68	28.25	28.25	28.25	28.25
Helicopters between shore and Project Development Area	3.11	5.34	4.37	0.12	3.11	3.11	5.34	5.34	5.34	4.37	4.37	4.37	4.37
General Project Development Area (Installation)	53.07	53.07	0.00	0.00	53.07	53.07	53.07	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**248.96**	**3068.24**	**1350.8**	**12.3**	**187**	**249**	**3068**	**1414**	**1436**	**1322**	**1351**	**1339**	**1331**

CO_2 = carbon dioxide; FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure

Table 7b: Greenhouse Gas (Kilotonnes CO_2-equivalents) Emissions by Year—Payara Project

Source Sector	Emissions (Kilotonnes CO_2-equivalents) Per Year														
	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044
Combustion Turbines	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0	892.0
HP Flaring	220.7	220.7	214.6	195.4	174.4	155.2	162.9	144.1	123.8	157.4	177.7	150.2	148.5	61.5	61.5
LP Flaring	114.8	114.8	111.7	101.6	90.7	80.7	84.7	75.0	64.4	81.9	92.5	78.1	77.3	32.0	32.0
Auxiliary Boiler (Heaters)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Essential Services Gens	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.40	0.00	0.00
Emergency Generators	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deck Cranes	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.51	0.00	0.00
Tanks	0.54	0.48	0.45	0.42	0.38	0.34	0.33	0.31	0.29	0.33	0.31	0.28	0.26	0.00	0.00
Vessel Loading	3.90	3.51	3.24	3.04	2.73	2.49	2.37	2.22	2.10	2.37	2.26	2.02	1.86	0.00	0.00
Export Tanker	6.16	5.55	5.11	4.80	4.31	3.93	3.75	3.50	3.31	3.75	3.56	3.19	2.94	0.00	0.00
Drill Center 5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Support Vessels in Project Development Area	56.50	56.50	56.50	56.50	56.50	56.50	56.50	56.50	56.50	56.50	56.50	56.50	56.50	0.00	0.00
Support Vessels between shore and Project Development Area	28.25	28.25	28.25	28.25	28.25	28.25	28.25	28.25	28.25	28.25	28.25	28.25	28.25	0.00	0.00
Helicopters between shore and Project Development Area	4.37	4.37	4.37	4.37	4.37	4.37	4.37	4.37	4.37	4.37	4.37	4.37	4.37	0.00	0.00
General Project Development Area (Installation)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sum	**1328**	**1327**	**1317**	**1287**	**1255**	**1225**	**1236**	**1207**	**1176**	**1228**	**1258**	**1216**	**1213**	**985**	**985**

CO_2 = carbon dioxide; FPSO = Floating Production, Storage, and Offloading (vessel); HP = high pressure; LP = low pressure

APPENDIX G

Underwater Sound Modeling Report

Resubmitted without changes

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Underwater Sound Assessment for Payara Development Project EIA; Offshore Guyana; Stabroek Block

Submitted to:

Mike Jenkerson
ExxonMobil Exploration Co.
Houston, TX

20 Jun 2019

Request: Assess the applicability of the previously modeled underwater sound levels associated with the Liza Phases 1 and 2 Development Projects for the Payara Development Project.

In December 2016, JASCO Applied Sciences (JASCO) carried out a modeling study for Esso Exploration and Production Guyana Limited (EEPGL) to predict underwater sound levels associated with the Liza Phase 1 Development Project located within the Stabroek Block (Matthews et al. 2016). This analysis was also applied to Liza Phase 2 Development Project in 2018, due to being a virtually identical project at an adjacent site, with very similar environmental conditions. Recently, new locations for sound sources have been proposed as part of the Payara Development Project (Figure 1). The Payara drill centers (DCs) are located 3 to 20 km away from the Liza DCs; the Payara Floating Production, Storage, and Offloading (FPSO) vessel is located approximately 20 km north of the Liza Phase 1 FPSO vessel. JASCO was asked to assess the need for re-modeling distances to injury and disturbance thresholds for the Payara sound source locations.

The sound footprints for the Liza Phase 1 scenarios were modeled to estimate distances to sound level threshold criteria for marine mammals based on:

- Injury, as defined by Southall et al. (2007), Wood et al. (2012), and Finneran (2015). These sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SEL) for 24 hours of operation.
- Behavioral disturbance, as defined by the U.S. National Marine Fisheries Service (HESS 1999, NMFS 2013). These sound footprints were calculated as unweighted sound pressure level (SPL) thresholds of 120 dB re 1 µPa (non-impulsive sources) and 160 dB re 1 µPa (impulsive sources).

We assume that the same criteria would be used for the Payara project to assess the effects on marine mammals.

We were advised by EEPGL that the planned Payara infrastructure and work activities are similar to those already modeled for Liza Phase 1, and thus we assume that the estimated source levels and scenarios described in the Liza Phase 1 work are valid for Payara development.

In 2016, we modeled sound propagation with JASCO's Marine Operations Noise Model (MONM) and JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM). These models produce depth-, range-, and azimuth-dependent sound fields associated with environmental parameters (including bathymetry, geoacoustic properties, and underwater sound speed profile) that are specific to the Stabroek Block area. At the time, no site-specific information was available for developing geoacoustic properties or sound speed profiles. Thus, generic profiles for the modeled region were developed based on publicly available data (Rucker 1967, Hamilton 1980, Teague et al. 1990, Carnes 2009, Maxon Consulting Inc. 2014). These profile estimates provided conservative sound propagation results within the modeled area, which extended up to 100 km from the Liza Phase 1 FPSO vessel. Because of the relative proximity of the Payara sound source locations to the Liza Phase 1 sound source locations, we consider the Liza Phase 1 profiles to be appropriate estimates of the environmental parameters for the Payara activities.

The main difference between the Liza Phase 1 and Payara locations is that the water is about 500 meters deeper near the Payara development (Figure 1). The impact of the sources being in deeper water would certainly be to lower the sound levels received throughout the modelling area, and therefore would present even less danger to marine populations.

Therefore, based on the bathymetric relationship between the Liza Phase 1 and Payara sound source locations, the homogeneous environmental properties over a large area that encompasses both the Liza and Payara projects development areas, and the similarity in noise-producing activities for the two projects, we estimate that model results for the Payara scenarios would present little changes in the distances (and if anything, shorter distances) to marine mammal injury thresholds provided for Liza Phase 1. A new assessment of underwater sound levels would be recommended if different criteria to assess the effect on marine life are used, new (more site-specific) geoacoustic information is available, or the nature of the Payara operations differ from Liza Phase 1.

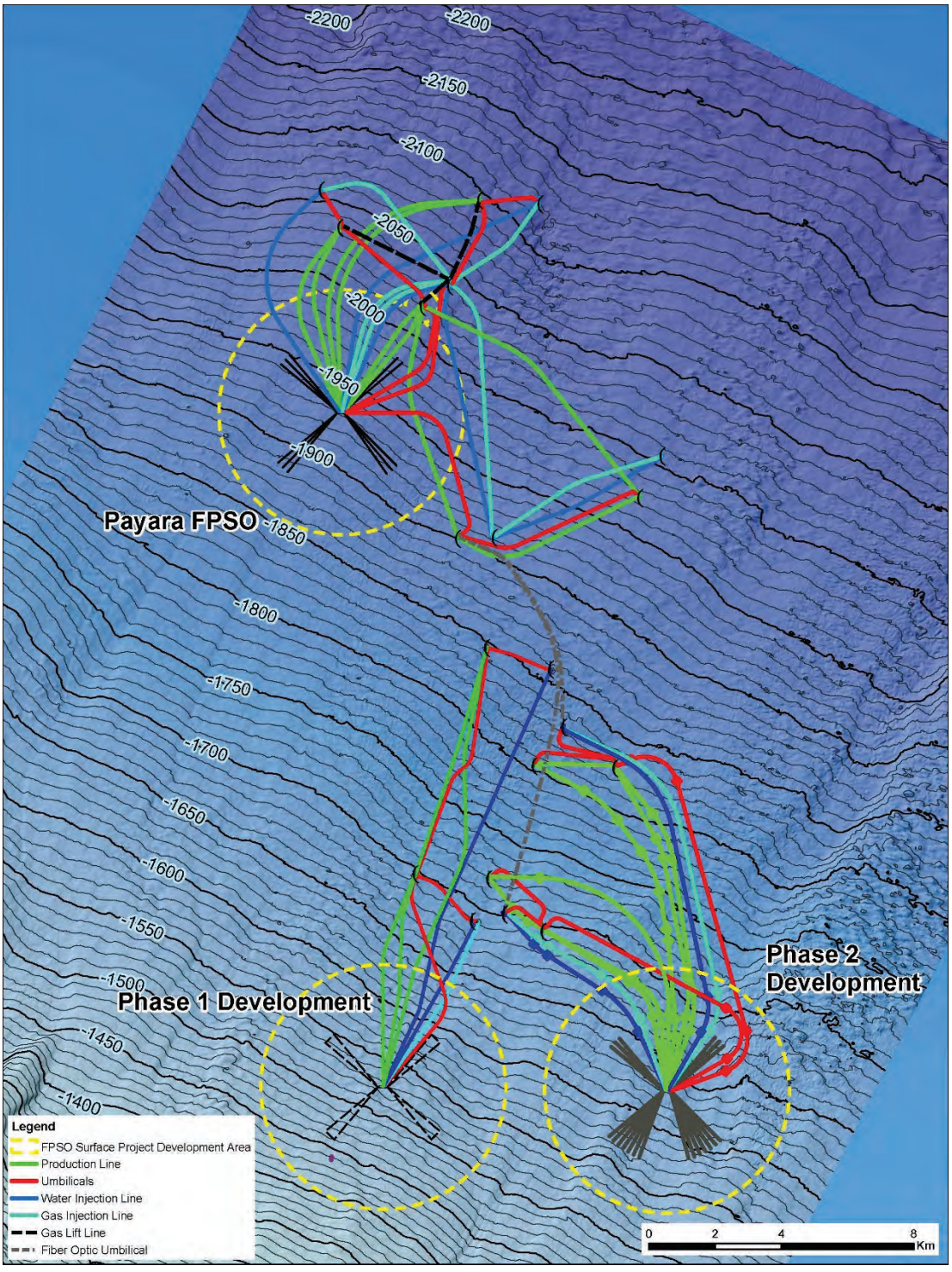


Figure 1. Phase 1 Project layout and proposed Phase 2 Project layout. Figure provided by ERM.

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Underwater Sound Associated with Liza Phase 1 Project Activities

Offshore Guyana Stabroek Block

Submitted to:

Mike Jenkerson
ExxonMobil Exploration Co.
Houston, TX
Contract: MSA A2346975, WA 1296

Authors:

Marie-Noël R. Matthews
Angela Schlesinger
Isabelle Gaboury

10 July 2019

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JASCO Applied Sciences (Canada) Ltd.
202–32 Troop Avenue
Dartmouth, NS B3B 1Z1 Canada
Tel: +1-902-405-3336
Fax: +1-902-405-3337
www.jasco.com



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3.0	2016 Dec 02	S. Carr	Added results for underwater impact pile driving scenarios.
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Executive Summary

This underwater sound modeling study predicts underwater sound levels associated with the Liza Phase 1 Development Project (hereinafter referred to as the Project). The Project is designed to develop and produce oil in the ExxonMobil Liza field, located within the Stabroek Block, approximately 190 km offshore central Guyana. The modeled Project activities include drilling development wells, installing and operating a Floating Production Storage and Offloading (FPSO) vessel, and installing Subsea, Umbilical, Riser, and Flowline (SURF) equipment. Sound footprints from representative sound sources, including vessels, a vertical seismic profile (VSP) source, and underwater impact pile driving equipment, were considered. The model results were used to estimate distances to marine mammal injury thresholds, based on best available science.

The underwater sound fields were modeled for water column sound speed profiles representative of April. This time corresponds with lowest surface temperatures, which lead to upward sound refraction and longer-distance sound propagation. The obtained results therefore ensure cautionary estimates of the distances to received sound level thresholds.

Six scenarios were modeled to simulate the following:

1. The operation of a Floating Production Storage and Offloading (FPSO) vessel,
2. The installation of the FPSO vessel, which includes the associated installation and support vessels,
3. The operation of a drill ship and a pipelaying vessel at one of the two drill centers, approximately 13 km north of the FPSO,
4. The operation of a VSP source in the vicinity of the drill centers,
5. Underwater impact pile driving of SURF equipment piles at one of the two drill centers, approximately 13 km north of the FPSO, and
6. Underwater impact pile driving of anchor mooring piles at the FPSO location.

The models produced estimates of the sound fields in M-weighted SEL_{24h} and peak sound pressure levels (PK). The sound fields account for source-specific sound emission characteristics (Section 4.1) and site-specific environmental parameters (Section 4.2). The estimated sound fields are applicable to other locations within the Project area, where site-specific environmental parameters are similar.

For scenarios 1 through 3, the distances to injury thresholds from vessels are small (<10 m). Distances to low- and mid-frequency cetacean injury thresholds for the VSP source were estimated for three sets of acoustic effects criteria. The distances vary from ≤35 m for mid-frequency cetaceans to ≤143 m for low-frequency cetaceans. Distances to the same thresholds for underwater impact pile driving operations are the longer than for the other scenarios. The distances vary from 100 to 762 m for mid-frequency cetaceans and from 1,025 to 1,375 m for low-frequency cetaceans. The sound levels at or above injury thresholds for impact pile driving were found close to the ocean bottom, at depths >1,000 m.

1. Introduction

JASCO Applied Sciences (JASCO) carried out a modeling study for Esso Exploration and Production Guyana Limited (EEPGL) to predict underwater sound levels associated with the Liza Phase 1 Development Project (hereinafter referred to as the Project) located within the Stabroek Block, approximately 190 km offshore central Guyana (Figure 1). The Project activities include installing and operating a Floating Production, Storage, and Offloading (FPSO) vessel, installing and operating Subsea Umbilical, Riser, and Flowline (SURF) equipment, as well as associated development drilling at two drill centers in the Liza field. Each drill center consists of an underwater injection (I) and a production (P) component, tied to the FPSO by the SURF equipment. Installing this Project infrastructure will require the use of multiple vessels, including drill ships, pipelaying vessels, tugs, barges, support, and supply vessels of various sizes. During production operations, the FPSO will be moored. Hydrocarbons produced from the wells will be offloaded onto tankers. This offloading operation may also require the use of tugs, while supply vessels will regularly dock alongside the FPSO.

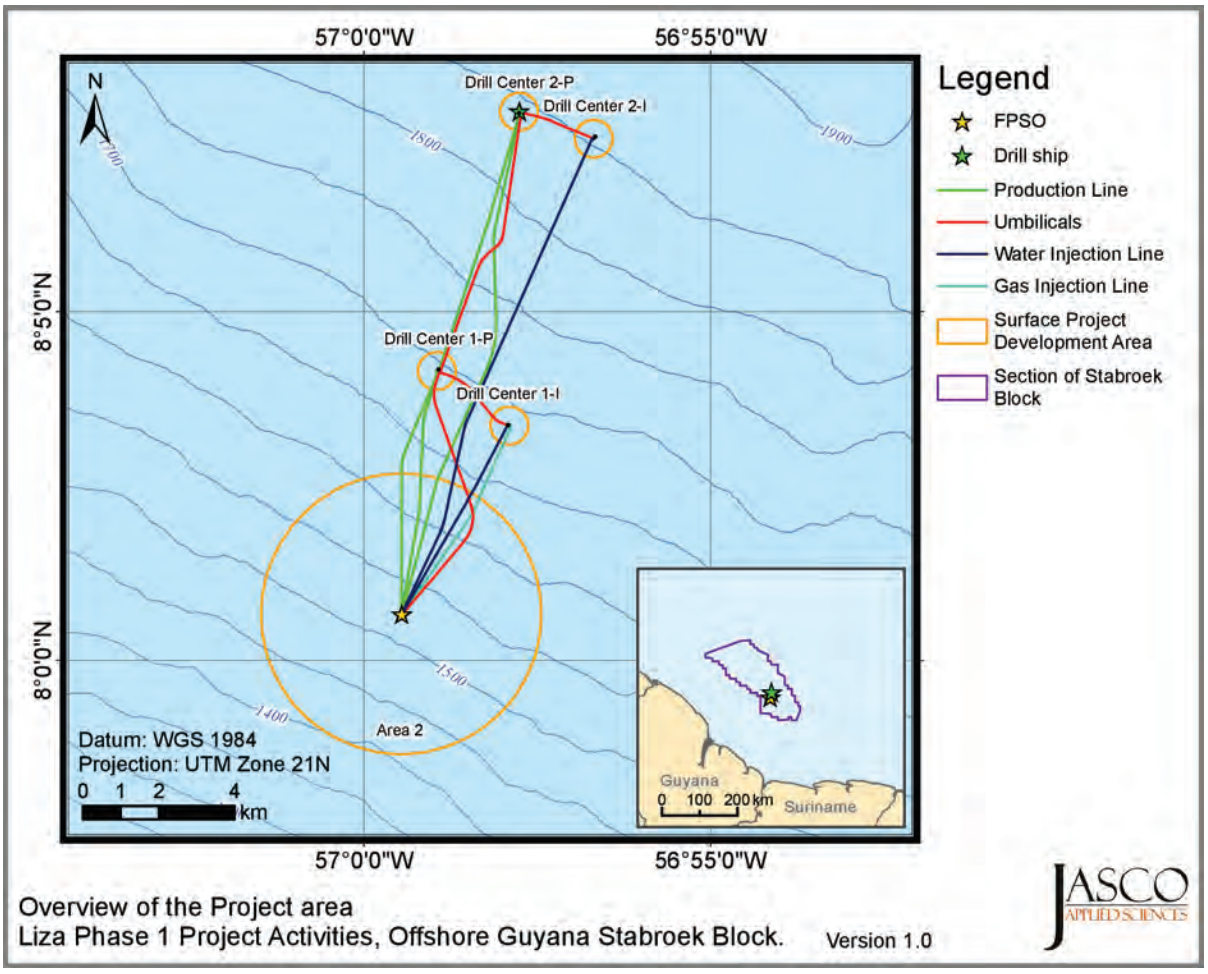


Figure 1. Overview of the Guyana Stabroek project area.

Six scenarios were considered in this modeling study, which include:

1. The operation of an FPSO vessel,
2. The installation of the FPSO vessel, which includes mooring the FPSO, and using several installation and service vessels, and
3. The installation of subsea flowlines and risers and operation of Drill Center 2-P, approximately 13 km north of the FPSO, which includes the operation of a drill ship, a pipelaying vessel, and multiple service vessels,
4. The operation of a VSP source in the vicinity of Drill Centers 2-P and 2-I,
5. The installation of piles for SURF equipment at Drill Center 2-P through underwater impact pile driving, and
6. The installation of anchor mooring piles at the FPSO location through underwater impact pile driving.

The specific vessels, the characteristics of the VSP source, as well as the specifications of the piles and driving hammer are at present unknown. Measurements from surrogate vessels, including the FPSO, drill ship, pipelaying vessel, tugs, and support vessels, were used to derive the acoustic characteristics of the vessels that will likely be used in the operations. The VSP source considered here is a six-element air gun array with a total volume of 1200 in^3. The source pressure signature of this array was modeled with JASCO's Airgun Array Source Model (AASM). This model accounts for individual element volume and position within the array. All modeled piles were 25 m in length, and 5 m in diameter. The modeled impact hammer model is the MENCK 500T, with underwater settings. It was assumed that it will take 5 hours to drive each pile, and that one pile will be driven per 24 hour period. The forcing function transferred from the hammer to the pile was modeled using the GRLWEAP model (GRLWEAP, Pile Dynamics 2010); the sound signature along the pile was modeled using JASCO's pile vibration and near-field sound radiation model (MacGillivray 2014).

Sound propagation was modeled with JASCO's Marine Operations Noise Model (MONM) and JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM). These models produced depth, range, and azimuth dependent sound fields associated with environmental parameters, including bathymetry, that are specific to the Stabroek Block area.

The sound footprint for each scenario was modeled to estimate distances to sound level thresholds based on injurious criteria prescribed by Southall et al. (2007) and Finneran (2015). The sound footprints were calculated as frequency-weighted (M-weighted) sound exposure levels (SEL) for 24 hours of operation.

Section 2 describes the acoustic effect criteria for this study. Definitions of the different metrics associated with the criteria are provided in Appendix A.1. Section 3 discusses the methodology for predicting the source levels and modeling the sound propagation. Section 4 describes the various input parameters pertinent to this study. Section 5 presents the results in two formats: tables of maximum and 95% distances to sound level thresholds and a sound field contour map showing the directivity of the various sound level threshold contours for the VSP source and impact pile driving operations. Section 6 presents an analysis of the results.

1.1. Modeled Scenarios

Various vessels were involved in the first three scenarios, including tugs, supply vessels, and support vessels. At the time of this study, the exact location and description of each vessel were unknown. The modeled scenarios represent an estimate of the general location of each vessel for a 24 hour period; the surrogate vessels provide estimates of the sound emission levels for the proposed vessel fleet. Table 1 and Figures 2–4 list the vessels, their operational state, and their location. Scenario 4 involves a VSP source operating near Drill Center 2-P (Table 1; Figure 4). Scenarios 5 and 6 represent the installation of SURF equipment and FPSO anchor mooring piles using an underwater impact pile driver (Table 1; Figure 5).

Table 1. List of vessels for each modeled scenario. FPSO: Floating Production Storage and Offloading; VSP: Vertical Seismic Profile.

Scenario	Vessel/Source type	Operational state	Location		UTM Coordinates	
			Latitude (°)	Longitude (°)	Easting (m)	Northing (m)
1	FPSO	Moored, not using main engines	8.010982	−56.990920	501000	885512
	Tanker	Idle, held in position by tugs	8.010955	−56.984305	501729	885509
	2 x tugs	Using dynamic positioning	8.010276, 8.011651	−56.987445, −56.987427	501383, 501385	885434, 885586
	Large tug	Using dynamic positioning	8.010955	−56.983479	501820	885509
	Supply vessel	Using dynamic positioning	8.011326	−56.991873	500895	885550
2	FPSO	Using main engine	8.010982	−56.990920	501000	885512
	2 x FPSO supply barges	Using dynamic positioning	8.000010, 8.010665	−56.991447, −56.991719	500942, 500912	884299, 885477
	2 x tugs	Using dynamic positioning	8.010213, 8.000769	−56.991447, −56.991447	500942, 500942	885427, 884383
	FPSO major work vessel	Using dynamic positioning	8.010629	−56.989732	501131	885473
	2 x supply vessels	Using dynamic positioning	8.011326, 7.993162	−56.991873, −56.983788	500895, 501786	885550, 883542
	3 x support vessels	Using dynamic positioning	8.011724, 7.989020, 8.010286	−56.989187, −56.996910, −56.989586	501191, 500340, 501147	885594, 883084, 885435
	Fast supply vessel	Using dynamic positioning	8.010673	−56.969304	503382	885478
	Light construction vessel	Using dynamic positioning	8.011299	−56.989777	501126	885547
3	Drill ship	Drilling and maintenance work	8.131187	−56.962605	504119	898801
	Large crane vessel	Using dynamic positioning	8.130906	−56.963123	504062	898770
	Light construction vessel	Using dynamic positioning	8.131431	−56.963277	504045	898828
	Multiple service vessel	Using dynamic positioning	8.134623	−56.958293	504594	899181
	Pipelaying vessel	Laying pipe	8.117347	−56.964095	503955	897271
	2 x barges	Towed by tugs	8.117428, 8.101734	−56.963841, −56.962799	503983, 504098	897280, 895545
	2 x tugs	Using dynamic positioning	8.117546, 8.102494	−56.963705, −56.962798	503998, 504098	897293, 895629
	2 x supply vessels	Using dynamic positioning	8.130734, 8.117799	−56.963059, −56.964268	504069, 503936	898751, 897321
	3 x support vessels	Using dynamic positioning	8.134479, 8.114625, 8.141861	−56.966644, −56.968507, −56.975277	503674, 503469, 502723	899165, 896970, 899981
	Field intervention vessel	Using dynamic positioning	8.141768	−56.949605	505551	899971
4	VSP source	Up to 40 pulses in 24 hours	8.128535	−56.953837	505085	898508
	VPS support vessel	Using dynamic positioning; deploying the VSP source	8.128535	−56.953837	505085	898508
5	Underwater impact pile driving	Driving SURF equipment piles at Drill Center 2-P	8.131187	−56.962605	504119	898801
6	Underwater impact pile driving	Driving FPSO anchor mooring piles at the FPSO	8.010982	−56.990920	501000	885512

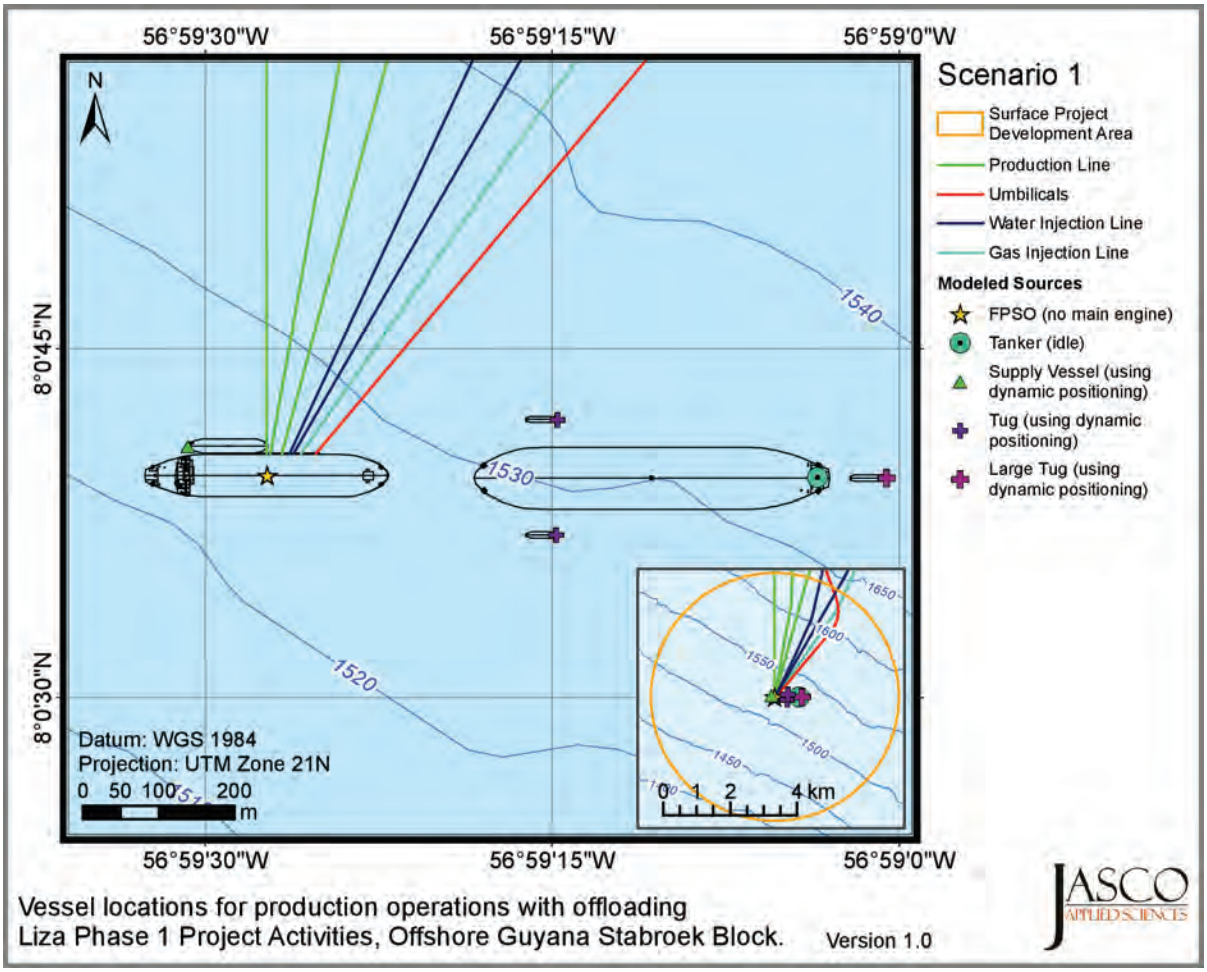


Figure 2. Scenario 1: Location of modeled vessels.

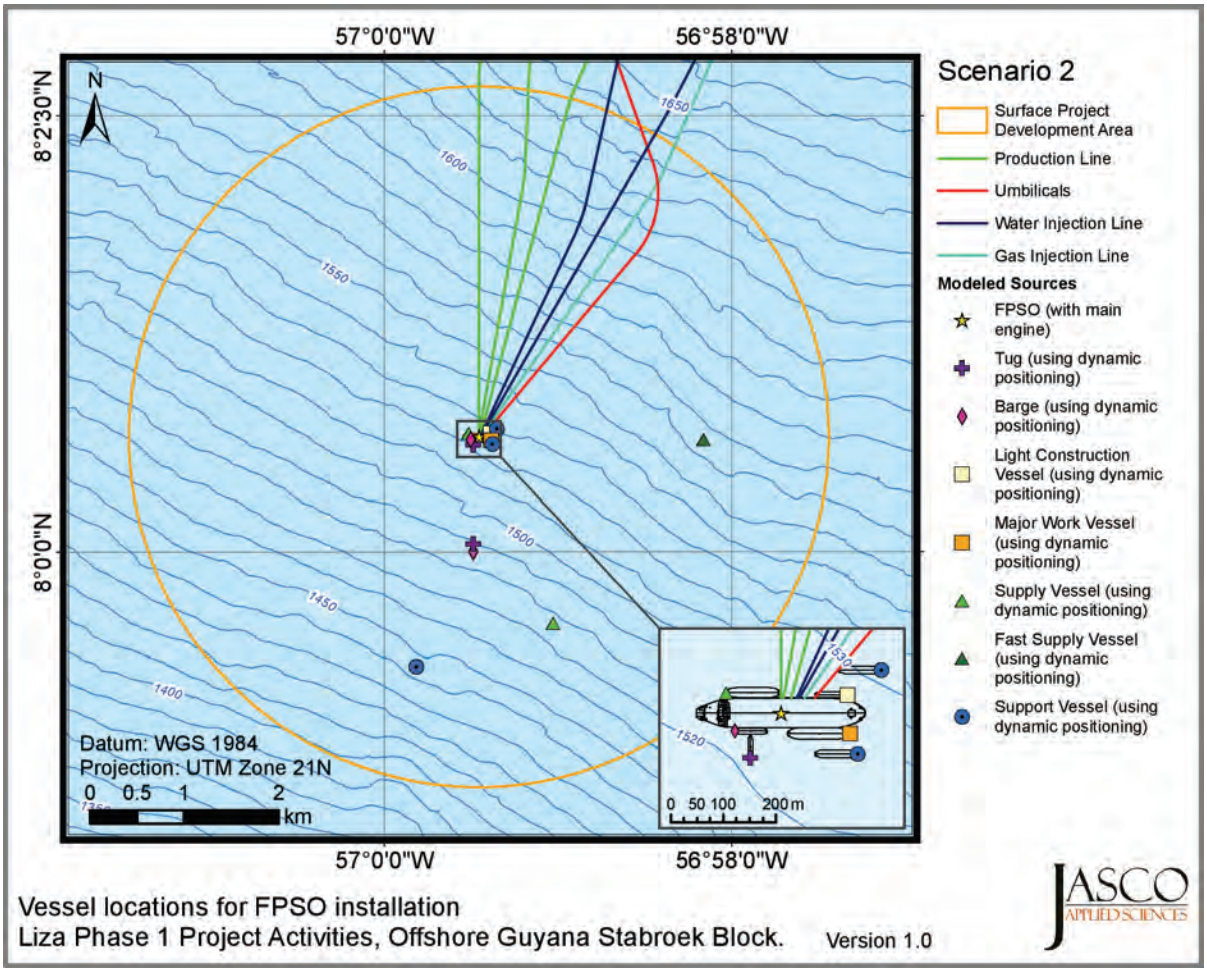


Figure 3. Scenario 2: Location of modeled vessels.

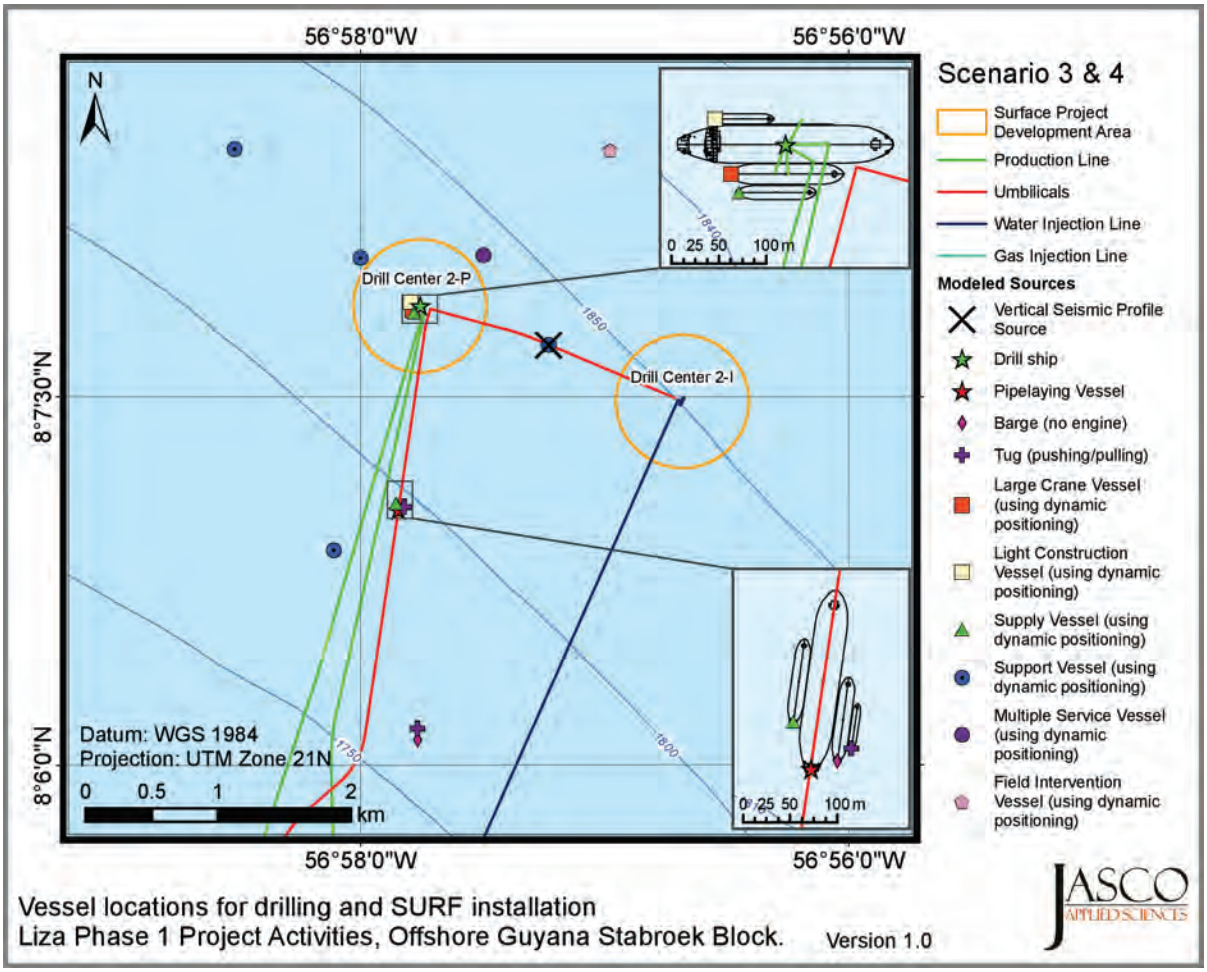


Figure 4. Scenarios 3 and 4: Location of modeled vessels and the VSP source at Drill Center 2.

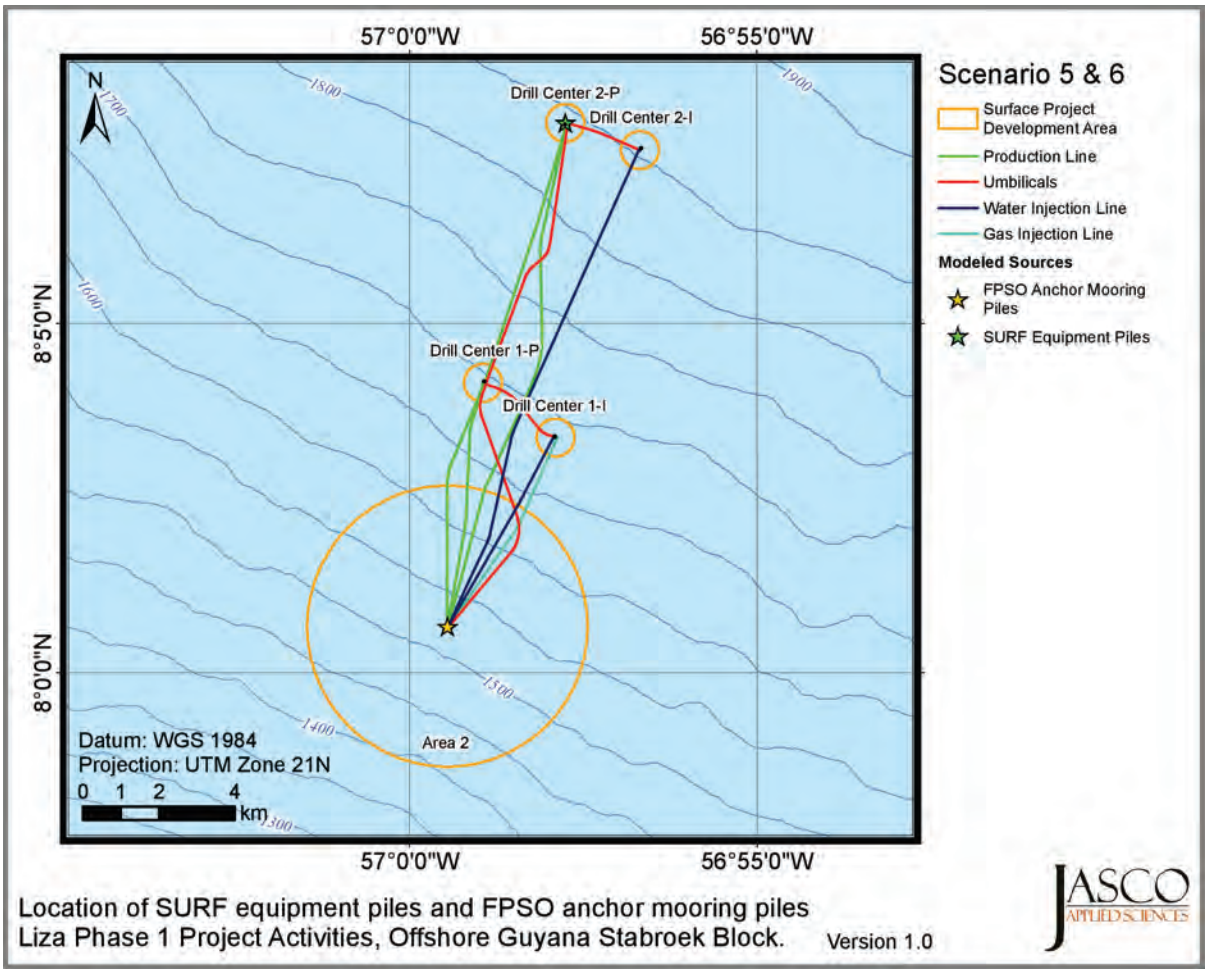


Figure 5. Scenarios 5 and 6: Location of modeled underwater impact pile driving operations at Drill Center 2-P and the FPSO (Area 2).

2. Acoustic Effects Criteria

Underwater sound can affect marine fauna in various ways. The question of which acoustic exposure levels might cause injury to marine mammals is still an active research. Since 2007, several expert groups have investigated SEL and peak pressure-based assessment approaches for injury using methods similar to those applied for humans, and a few key papers have been published on the topic. Those publications are reviewed, and the relative criteria discussed, in Appendix A.2. In the present section we propose specific thresholds used in other recent studies that are the most likely candidates for more widespread use; we caution readers, however, that assessment criteria are likely to evolve in the near future as research is progressing rapidly in this field.

Results of this modeling study are presented in terms M-weighted sound exposure level (SEL; $L_{E,24h}$) and peak pressure level (PK; L_{pk}) thresholds for injury to low- and mid-frequency cetaceans, based on two sets of criteria (Table 2): Southall et al. (2007) and Finneran (2015). These criteria have been chosen to include standard thresholds and thresholds suggested by the best available science, as reviewed and discussed in Appendix A.2. Low-frequency cetaceans, including baleen whales, and mid-frequency cetaceans, including dolphins and small whales, have been observed within or near the Project area. This study therefore focuses only on these marine mammal hearing groups.

Table 2. Marine mammal injury (Permanent Threshold Shift (PTS) onset) thresholds based on Southall et al. (2007), and Finneran (2015). PK and SPL in dB re 1 µPa; weighted SEL (24 hours) in dB re 1 µPa²·s.

Hearing group	Impulsive source				Non-impulsive source		
	Southall et al. (2007)		Finneran (2015)		Southall et al. (2007)		Finneran (2015)
	PK	Weighted SEL_{24h}	PK	Weighted SEL_{24h}	PK	Weighted SEL_{24h}	Weighted SEL_{24h}
Low-frequency cetaceans	230	198	230	192	230	215	207
Mid-frequency cetaceans	230	198	230	187	230	215	199

3. Methods

Underwater acoustic field for the studied vessels were modeled using JASCO's Marine Operations Noise Model (MONM), which is based on source levels derived from measurements of surrogate vessels.

Three complementary acoustic models were used to predict the underwater acoustic field for the studied seismic source. The pressure signatures and directional source levels of the VSP source were predicted with JASCO's Air gun Array Source Model (AASM). The acoustic fields around the array, in terms of M-weighted SEL_{24h}, were modeled with MONM. JASCO's Full Waveform Range-dependent Acoustic Model (FWRAM) was used to determine peak pressure levels as a function of azimuth, depth, and range from the array.

The acoustic source signature for impact pile driving operations was modeled using JASCO's physical model of pile vibration and near-field sound radiation (MacGillivray 2014), in conjunction with the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010). The acoustic fields, in terms of M-weighted SEL_{24h} and peak pressure levels, were modeled with JASCO's FWRAM.

M-weighting was applied for two hearing groups to weight the importance of received sound levels according to their constituent frequencies.

3.1. Modeling Acoustic Source Levels

3.1.1. Vessels

Several types of vessels were modeled in this study, including an FPSO, a drill ship, a pipelaying vessel, tugs, barges, supply vessels, and support vessels. The vessels characteristics are presented in Section 4.1.1. Underwater sound that radiates from vessels is produced mainly by propeller and thruster cavitation (Ross 1976, §8.6), with a small fraction produced by sound transmitted through the hull, such as sound from engines, gearing, and other mechanical systems (Spence et al. 2007). Sound levels thus tend to be the highest when propulsion systems are used at high power. For example, during dynamic positioning in high currents or winds, or transiting at high speeds. A vessel's sound signature depends on the vessel's size, power output, and propulsion system characteristics (e.g., blade shape and size). Vessels produce broadband acoustic energy with most of the energy emitted below a few kilohertz. Sound from onboard machinery, particularly sound below 200 Hz, dominates the sound spectrum before cavitation begins—normally around 8 to 12 knots on many commercial vessels (Spence et al. 2007).

At the time of this study, the specific vessels engaged in installing and operating at the drill centers were unknown. Generalized source spectra were computed by comparing the expected specifications of the vessels to that of surrogate vessels for which source levels were available. Source levels for the surrogate were derived from measured received levels during various operational states. To account for the differences between the specification of the modeled and surrogate vessels, the spectra of the surrogates were corrected by the power ratings of the modeled and reference vessels:

$$S(f,P) = S_0(f) + 10\log\left(\frac{P}{P_0}\right) \quad (1)$$

where S_0 is the reference spectrum and P_0 is the reference power rating (Ross 1976, §8.6). When needed, surrogate spectra were extrapolated using −2 dB per decade at frequencies below 100 Hz and −1 dB per decade at frequencies above 1000 Hz (Ross 1976, §8.6).

3.1.2. Vertical Seismic Profile Source

The VSP source considered here is a six-element air gun array with a 1200 in^3 total volume. The source characteristics are presented in Section 4.1.2. The source levels and directivity of the VSP array were predicted with JASCO's Air gun Array Source Model (AASM; MacGillivray 2006a). This model is based on the physics of oscillation and radiation of air gun bubbles described by Ziolkowski (1970). The model solves the set of parallel differential equations that govern bubble oscillations. AASM also accounts for nonlinear pressure interactions between air guns, port throttling, bubble damping, and generator-injector (GI) gun behavior that are discussed by Dragoset (1984), Laws et al. (1990), and Landro (1992). AASM includes four empirical parameters that were tuned so model output matches observed air gun behavior. The model parameters fit to a large library of empirical data using a "simulated annealing" global optimization algorithm. These data are measurements of the signatures of Bolt 600/B guns ranging in volume from 5 to 185 in^3 (Racca and Scrimger 1986).

While air gun signatures are highly repeatable at low frequencies, which are used for seismic imaging, at higher frequencies their sound emissions have a large random component that cannot be predicted using a deterministic model. Therefore, AASM uses a stochastic simulation to predict the high-frequency (560−25,000 Hz) sound emissions of individual air guns, using a data-driven multiple-regression model. The multiple-regression model is based on a statistical analysis of a large collection of high quality seismic source signature data recently obtained from the Joint Industry Program (JIP) on Sound and Marine Life (Mattsson and Jenkerson 2008). The stochastic model uses a Monte-Carlo simulation to simulate the random component of the high-frequency spectrum of each element in an array. The mean high-frequency spectra from the stochastic model augment the low-frequency signatures from the physical model, allowing AASM to predict source levels at frequencies up to 25,000 Hz.

AASM produces a set of "notional" signatures for each array element based on:

- Array layout
- Volume, tow depth, and firing pressure of each air gun
- Interactions between different elements in the array

These notional signatures are the pressure waveforms of the individual elements at a standard reference distance of 1 m; they account for the interactions with the other elements in the array. The signatures are summed with the appropriate phase delays to obtain the far-field source signature of the entire array in all directions. This far-field array signature is filtered into 1/3-octave-bands to compute the source levels of the array as a function of frequency band and azimuthal angle in the horizontal plane (at the source depth), after which it is considered to be a directional point source in the far field.

A seismic array consists of many sources and the point-source assumption is invalid in the near field where the array elements add incoherently. The maximum extent of the near field of an array (R_{nf}) is:

$$R_{nf} < \frac{l^2}{4\lambda} \tag{1}$$

where λ is the sound wavelength and l is the longest dimension of the array (Lurton 2002, §5.2.4). For example, an array length of l = 2 m yields a near-field range of 1.5 m at 2 kHz. Beyond this R_{nf} range, the array is assumed to radiate like a directional point source and is treated as such for propagation modeling.

The interactions between individual elements of the array create directionality in the overall acoustic emission. Generally, this directionality is prominent mainly at frequencies in the mid-range between tens of hertz to several hundred hertz. At lower frequencies, with acoustic wavelengths much larger than the separation distances between array elements, the directionality is small. At higher frequencies, the pattern of lobes is too finely spaced to be resolved and the effective directivity is less.

3.1.3. Impact Pile Driving

A physical model of pile vibration and near-field sound radiation is used to calculate source levels of piles. The physical model employed in this study computes the underwater vibration and sound radiation of a pile by solving the theoretical equations of motion for axial and radial vibrations of a cylindrical shell. These equations of motion are solved subject to boundary conditions, which describe the forcing function of the hammer at the top of the pile and the soil resistance at the base of the pile (Figure 6). Damping of the pile vibration due to radiation loading is computed for Mach waves emanating from the pile wall. The equations of motion are discretised using the finite difference (FD) method and are solved on a discrete time and depth mesh.

In order to model the sound emissions of the piles, it was also necessary to model the force of the pile driving hammers. The force at the top of the pile was computed using the GRLWEAP 2010 wave equation model (GRLWEAP, Pile Dynamics 2010), which includes a large database of simulated hammers—both impact and vibratory—based on the manufacturer's specifications. The forcing functions from GRLWEAP were used as inputs to the FD model to compute the resulting pile vibrations.

The sound radiating from the pile itself is simulated using a vertical array of discrete point sources. The point sources are centered on the pile axis. Their amplitudes are derived using an inverse technique, such that their collective particle velocity—calculated using a near-field wave-number integration model—matches the particle velocity in the water at the pile wall. The sound field propagating away from the vertical source array is then calculated using a time-domain acoustic propagation model (e.g., FWRAM; Appendix A.5.3). MacGillivray (2014) describes the theory behind the physical model in more detail.

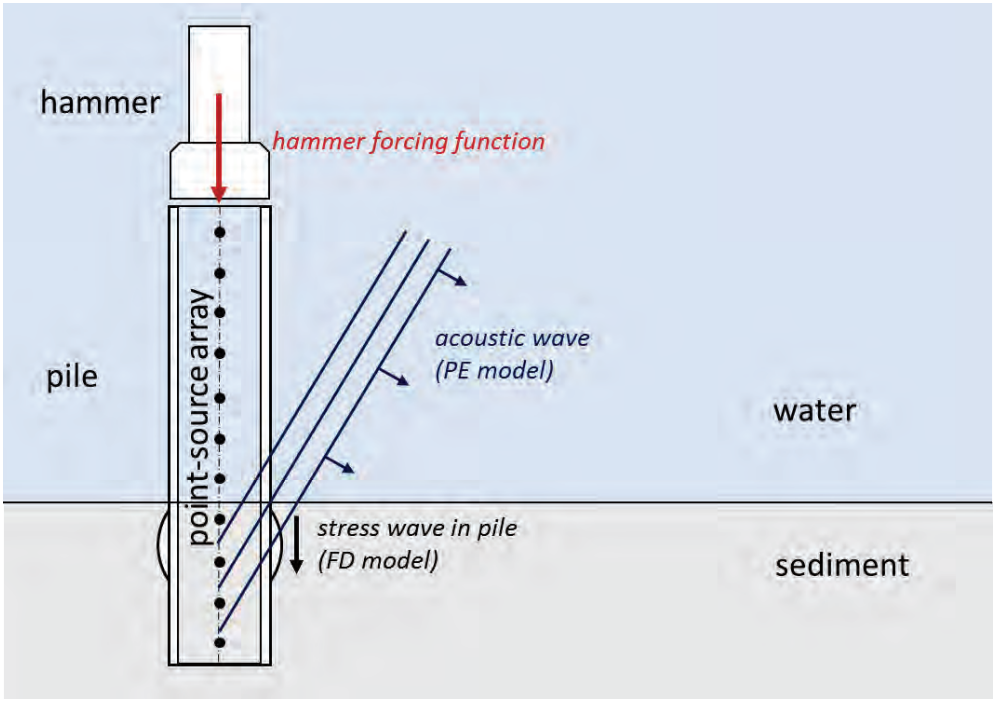


Figure 6. Physical model geometry for impact driving of a cylindrical pile (vertical cross-section). The hammer forcing function is used with the finite difference (FD) model to compute the stress wave vibration in the pile. A vertical array of point sources is used with the parabolic equation (PE) model to compute the acoustic waves that the pile wall radiates.

3.2. Modeling Sound Propagation

Underwater sound propagation (i.e., transmission loss) for the vessels and the VSP source exposure levels was predicted with JASCO's MONM (see Appendix A.5.2). The model computes received SEL (per-pulse SEL for impulsive sources) for directional sources located at a specified depth. It incorporates site-specific environmental properties including a bathymetric grid of the modeled area, in-water sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor. The model computes acoustic fields in three dimensions by modeling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source.

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, from 10 Hz to 32 kHz, are modeled to include the majority of acoustic energy emitted by the source. Sound propagation at frequencies from 5 to 32 kHz was modeled by modifying the transmission loss at 5 kHz with the frequency- and range-dependent absorption coefficient for sea water (François and Garrison 1982a). Although mostly insignificant at lower frequencies, absorption coefficients were also applied from 10 Hz to 5 kHz for consistency. The broadband underwater sound field, expressed in terms of M-weighted per-pulse SEL, was computed by filtering and summing the received 1/3-octave-band levels.

JASCO's FWRAM (see Appendix A.5.3) was used to determine peak pressure levels from the VSP source and per-pulse SEL from pile driving operations. FWRAM uses the same computational algorithm as MONM, but computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source such as an underwater pile (MacGillivray and Chapman 2012).

The parabolic equation (PE) approximation used in FWRAM (Appendix A.5.3) is valid for sound propagating within a vertical angle range of at least 45° above and below the horizontal plane at the source depth (the exact angle depends on the environment). In the case of underwater impact pile driving, where the pile extends only over a fraction of the water column, the received levels above the pile (propagating at a >45° angle from the horizontal plane) may be underestimated using this model. The main acoustic waves around the pile propagate, however, at an angle of ~17° from the horizontal plane (Reinhall and Dahl 2011). FWRAM therefore provides a valid estimate of the distances to injury thresholds, which occur well within the PE approximation angle.

This approach, combined with the pile driving source model, accurately estimates spectral levels within the 10–800 Hz band where most of the energy from impact pile driving is concentrated. An extrapolation method (Zykov et al. 2016) was used to extend the modeled levels in 1/3-octave-bands up to 25 kHz, by applying a −2 dB per 1/3-octave-band roll-off coefficient to the per-pulse SEL value starting at the 800 Hz band. The acoustic energy levels at these higher frequencies are required to correctly assess the acoustic fields against Finneran (2015) criteria. The broadband underwater sound field, expressed in terms of M-weighted per-pulse SEL, was computed by filtering and summing the received 1/3-octave-band levels.

The injury thresholds evaluated here account for the total acoustic energy a marine mammal is subjected to within a defined period (24 hours in the present case). In the present study, the M-weighted SEL_{24h} were obtained by assuming a stationary scenario. With this simplified approach the acoustic energy (SEL) for 1 sec (for non-impulsive sources) or a single pulse (for impulsive sources) at a particular location was replicated in situ to estimate the cumulative metric. For a given number (N) of source activity seconds or of acoustic pulse events over a 24-hour period, SEL_{24h} was thus computed using the basic formula:

$$\mathrm{SEL}_{24h} = \mathrm{SEL} + 10\log_{10}(N) \ . \qquad (2)$$

By assuming stationary sources, the method provides conservative estimates of the maximum extent of each sound level isopleth. This approach also yields notional values that are not strongly dependent on the environment or on the position of each source, which simplifies comparisons between different source types and acoustic effect criteria.

Although a more complex analysis would be outside the scope of this study, an important consideration that qualifies the cumulative received level estimates is that individuals of most species do not remain stationary throughout the exposure period. Their dose accumulation, therefore, depends on their movement and would likely be lower than for a stationary receiver. A second issue is that animals tend to recover from the sub-injurious effects of sound exposure over time; the paradigm of a strictly dosimetric accumulation is not therefore altogether correct, but the recovery period of most species is unknown.

3.3. Calculating Distances to Acoustic Effect Thresholds

The underwater sound fields predicted by the propagation models were sampled so that the received sound level at each location in the horizontal plane was taken to be the maximum value over all modeled depths for that location. Two distances from the source are reported for each sound level: 1) R_{max}, the maximum range at which the given sound level was encountered in the modeled maximum-over-depth sound field over all azimuths, and 2) $R_{95\%}$, the maximum range at which the given sound level was encountered after the 5% farthest such points were excluded (Figure 7). The $R_{95\%}$ is used because the maximum-over-depth sound field footprint is often non-circular and can include anomalous protrusions along a few azimuths. Regardless of the geometric shape of the maximum-over-depth footprint, $R_{95\%}$ is the predicted range encompassing at least 95% of the area (in the horizontal plane) that would be exposed to sound at or above that level. The difference between R_{max} and $R_{95\%}$ depends on the source directivity and the heterogeneity of the acoustic environment. The $R_{95\%}$ excludes ends of protruding areas or small isolated acoustic foci not representative of the nominal ensonification zone.

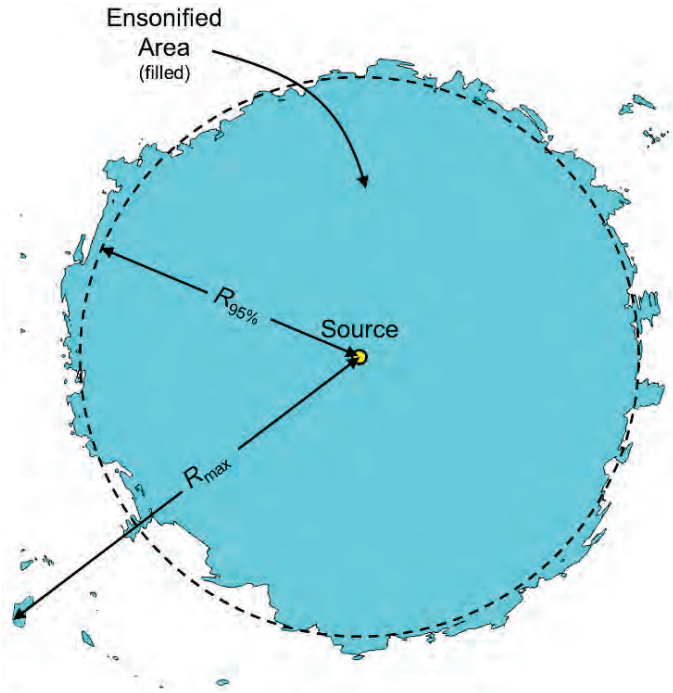


Figure 7. Example of an area ensonified to an arbitrary sound level showing R_{max} and $R_{95\%}$ radii.

4. Model Parameters

4.1. Acoustic Source Parameters

4.1.1. Vessels

A surrogate source vessel was chosen to represent each of the proposed vessels modeled in this study (Table 3). For vessels where the surrogate was significantly different in length, width, draft, or power, the surrogate's spectrum was adjusted based on the ratio of available power between the proposed and surrogate vessel (Section 3.1.1).

In Scenario 1 (Table 1; Figure 2), three tugs held the tanker in position (i.e., the tanker's main engine and propulsion system were idling or off). Thus, the sound levels from the tanker were neglected in the modeled scenario because they will be significantly lower (by at least 10 dB) than sounds from the tugs.

In Scenario 2 (Table 1; Figure 3), sound levels from the fast supply vessel, a small craft approximately 19 m long with a draft of less than 1 m, were also expected to be significantly lower (~150 dB re 1 µPa @ 1 m; Funk et al. 2008 §3.7) than sound levels from the adjacent vessels. This vessel was excluded from the modeled scenario.

The specific characteristics of the Floating Production Storage and Offloading (FPSO) that will be used in this project are unknown at present. The spectra used in Scenarios 1 and 2 were derived from the recordings of six FPSOs during various operational stages (Erbe et al. 2013). In Scenario 1, the FPSO was expected to be moored and operating; its spectrum was modeled using the 5th percentile 1/3-octave-band spectrum derived from all the FPSO source spectra recorded. In Scenario 2, tugs positioned the FPSO during installation and mooring. Such operations were expected to be noisier than in Scenario 1; the FPSO spectrum was modeled using the 95th percentile 1/3-octave-band spectrum derived from all the source spectra recorded.

Since the tugs in each scenario will be engaged in various activities (e.g., transiting at various speed, pulling and pushing vessels, handling cables and anchors), the spectra of the surrogate tug, recorded during transit at half and full speed and during anchor pulling, were averaged to produce a mean 1/3-octave-band spectrum.

The source depth for vessels other than the drill ship was based on the depth at which cavitation from the propulsion system was expected to occur. Gray and Greenley (1980) estimate that the center of the cavitation volume occurs below the propeller blade arc, by an amount equal to ~15% of the propeller diameter. The modeled source depth was estimated by:

$$Z_s = D - 0.85 \times \phi_{prop} \tag{3}$$

where Z_s is the source depth, D is the depth at the bottom of the propeller (often equal to the draft) of the proposed vessel, and $\varnothing_{\text{prop}}$ is the diameter of its propeller.

During drilling operations, sound will be generated at many locations along the drill shaft. For the purpose of this study, the sound was assumed to be concentrated at the top of the drill shaft; the source depth was equal to the operational draft of the drill ship (12 m).

Table 3. Specifications of proposed and surrogate vessels used to estimate source levels.

Vessel type	Proposed vessel								Surrogate vessel							
	Name	Length (m)	Breadth (m)	Draft (m)	Max. power (kW)	Bollard pull (t)	Main propulsion	Propeller diameter (m)	Name	Length (m)	Breadth (m)	Draft (m)	Max. power (kW)	Bollard pull (t)	Main propulsion	Reference
FPSO	Unknown	Unknown	Unknown	Unknown, assumed 10 and 16	Unknown	n/a	Unknown	Unknown, assumed 5.5	Average between	209–340	Unknown	10.8–16	n/a	n/a	n/a	Erbe et al. (2013)
FPSO major work vessel	*Normand Installer*	124	28	7.3	31360	n/a	4 x tunnel thrusters, 1 x retractable azimuth thruster, 2 x controllable pitch propellers in nozzles	4.5	DSV *Fu Lai*	107.1	19.4	Unknown	7400	56	4 x thrusters, 2 x controllable pitch propellers	MacGillivray (2006b)
FPSO supply barge Supply vessel Support vessel	*Hannah Chouest*	85	18	6	7200	n/a	Unknown	Unknown, assumed 3.2								
Light construction vessel Field intervention vessel	MEO *Ranger*	64	16	5.4	5000	n/a	2 x tunnel thrusters, 2 x Z-drive propeller	2.7								
Large crane vessel	*Normand Installer*	124	28	7.3	31360	n/a	4 x tunnel thrusters, 1 x retractable azimuth thruster, 2 x controllable pitch propellers in nozzles	4.5								
Multiple service vessel	*7 Pacific*	134	24	6.75	17300	n/a	3 x stern azimuth thrusters, 1 x retractable bow azimuth thruster, 2 x bow tunnel thrusters	3.2								
Tug	Unknown	Unknown	Unknown	Unknown, assumed 5.5	Unknown	80	Azimuth stern drive	Unknown, assumed 3.2	*Britoil 51*	45	12	5.5	6600	90	2 x fixed pitch nozzeled propellers	Hannay et al. (2004)
Tug (large)	Unknown	Unknown	Unknown	Unknown, assumed 5.4	Unknown	120	Azimuth stern drive	Unknown, assumed 3.2	*Britoil 61*	51	13	5.4	10500	130	2 x controllable pitch nozzeled propellers	Adjusted from *Britoil 51* based on power
Drill ship	*Stenna Carron*	228	42	12	Unknown	n/a	6 x thrusters	n/a	*Stena Forth*	228	41	12	1750	n/a	6 x thrusters	Kyhn et al. (2009)
Pipelaying vessel	*7 Borealis*	182	46	8.5–11.35	45622	n/a	4 x azimuth thrusters, 1 x tunnel thruster	3	*Castoro*	191	35	10	Unknown	n/a	2 x variable pitch propellers, 1 x bow thruster	MacGillivray (2006b)

4.1.2. Vertical Seismic Profile Source

The Schlumberger High-performance Magnum six-gun array (1200 in³ total volume) was modeled as a surrogate VSP source in Scenario 4. The array consists of two vertically-triangular air gun clusters with in-line separations of 2 m. The first cluster has three 150 in³ elements with 0.9 m separation, the second cluster has three 250 in³ elements with a 1.1 m separation. In both clusters, the center air gun is shallower. The elements are fired simultaneously at 2000 psi air pressure. The array was modeled at a 4.5 m depth (the center of the clusters). It is estimated that the VSP source will produce 20–40 pulses within 6–12 hours of operation. Figure 8 illustrates the element distribution in the horizontal (*x*-*y*) plane, and Table 4 shows the array specifications.

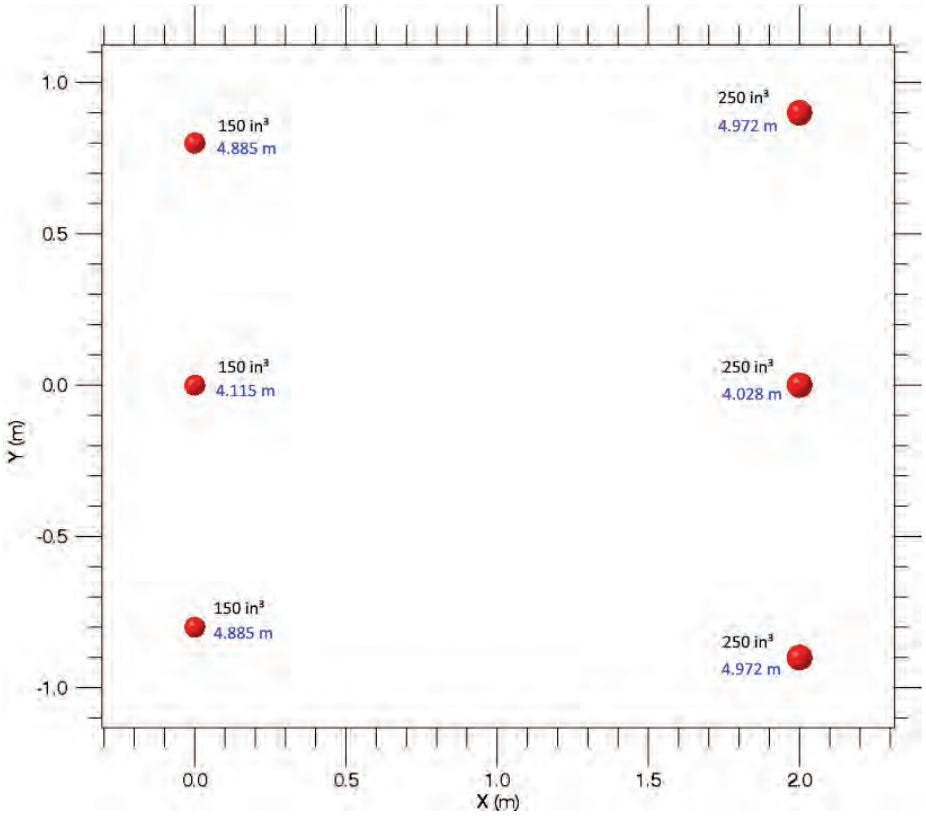


Figure 8. Layout of the High-performance Magnum six-gun array (1200 in³ total volume, 4.5 m depth), composed of 6 elements. Black labels indicate element volume in cubic inches; blue labels indicate the depth of the element relative to the sea surface.

Table 4. Relative positions of the elements within the 1200 in^3 array.

Element	*x* (m)	*y* (m)	*z* (m)	Volume (in^3)
1	0.0	0.000	4.115	150
2	0.0	−0.445	4.885	150
3	0.0	0.445	4.885	150
4	−2.0	0.000	4.028	250
5	−2.0	−0.545	4.972	250
6	−2.0	−0.545	4.972	250

4.1.3. Impact Pile Driving

Impact pile driving of cylindrical steel piles was modeled at two locations (Scenarios 5 and 6; Table 1). At both locations, the water depth was much deeper (1524.4 m and 1842.7 m) than the length of the pile (25 m long; 5 m in diameter). The MENCK 500T underwater hammer was used as the impact pile driver. A generic pile helmet, with a weight 1/5 that of the hammer (Parola 1970), was assumed with the default parameters of the hammer in the GRLWEAP 2010 wave equation model.

Information on the penetration rate per blow was unknown at the time of this study. The maximum number of strikes per minute (38) for the modeled hammer was assumed over a driving period of 5 hours. One driving period was assumed to occur every 24 hours.

4.2. Environmental Parameters

4.2.1. Bathymetry

Bathymetry data, covering an area of approximately 23 × 21 km centered on the modeled sites, was provided by EEPGL. For the long-range modeling (up to 100 km from the FPSO and the drill ship), this grid was extended using data from SRTM15+ (v1.0; Becker et al. 2009, Sandwell et al. 2014) global bathymetry grid, with a resolution of 30 arc-seconds (~460 × 460 m at the studied latitude), to produce a 150 × 150 km region. The data were re-gridded, by minimum curvature gridding, onto a Universal Transverse Mercator (UTM) Zone 21 coordinate projection with a regular grid spacing of 100 × 100 m.

4.2.2. Geoacoustics

The geoacoustic properties of surficial seabed layers depend on the sediment type. As the porosity decreases, the compressional sound speed, sediment bulk density, and compressional attenuation increase. For each modeled location, MONM assumes a single geoacoustic profile of the seafloor for the entire modeled area. The acoustic properties required by MONM are:

- Sediment bulk density,
- Compressional-wave (or P-wave) speed,
- P-wave attenuation in decibels per wavelength,
- Shear-wave (or S-wave) speed, and
- S-wave attenuation, also in decibels per wavelength.

Along the Guyana coast, suspended Amazonian sediments and fluvial mud from various Guyana rivers are transported eastward with the Guiana Current. This large volume of sediment deposition results in a thick (estimated up to 30 m; Rucker 1967) and fairly uniform layer of fine-grained sediment (Maxon

Consulting Inc. 2014). This surficial sediment layer, also characterized by a low concentration of organic carbon (Maxon Consulting Inc. 2014), overlays a mixture of sand and clay ~30–100 m thick (Rucker 1967).

The estimated geoacoustic profile (Table 5) was based on empirical formulas presented by Hamilton (1980). Without information from recent boreholes, a generic geoacoustic profile for silt-clay sediments was used with a 1.3 m/s per meters below the seafloor (mbsf) sound-speed gradient. The density and P-wave attenuation coefficients were taken from Hamilton (1980).

Table 5. Geoacoustic properties of the sub-bottom sediments as a function of depth, in meters below the seafloor (mbsf). Within each depth range, each parameter varies linearly within the stated range.

Depth (mbsf)	Material	Density (g/cm^3)	P-wave speed (m/s)	P-wave attenuation **(dB/λ)**	S-wave speed (m/s)	S-wave attenuation **(dB/λ)**
0–30	Silt-clay	1.45–1.49	1500–1539	0.17–0.18	200	3.0
30–100	Sand-clay	1.83–2.00	1623–1700	1.21–2.00		
100–500	Sand-clay	2.00	1700–2100	2.00		
>500	Sand-clay	2.00	2100	2.00		

4.2.3. Ocean Sound Speed Profile

The ocean sound speed profiles for the modeled sites were derived from temperature and salinity profiles from the U.S. Naval Oceanographic Office's *Generalized Digital Environmental Model V 3.0* (GDEM; Teague et al. 1990, Carnes 2009). GDEM provides an ocean climatology of temperature and salinity for the world's oceans on a latitude-longitude grid with 0.25° resolution, with a temporal resolution of one month, based on global historical observations from the U.S. Navy's Master Oceanographic Observational Data Set (MOODS). The climatology profiles include 78 fixed depth points to a maximum depth of 6800 m (where the ocean is that deep). The GDEM temperature-salinity profiles were converted to sound speed profiles according to the equations of Coppens (1981):

$$\begin{aligned} c(z,T,S,\phi) &= 1449.05 + 45.7t - 5.21t^2 - 0.23t^3 \\ &\quad + \left(1.333 - 0.126t + 0.009t^2\right)(S-35) + \Delta \\ \Delta &= 16.3Z + 0.18Z^2, \quad Z = \frac{z}{1000}\left[1 - 0.0026\cos(2\phi)\right], \quad t = \frac{T}{10} \end{aligned} \tag{4}$$

where z is water depth (m), T is temperature (°C), S is salinity (psu), and ϕ is latitude (radians).

Mean monthly sound speed profiles were derived from the GDEM profiles at the FPSO and drill ship locations. There are no significant variations in sound speed with geographical location. Monthly variations in sound speed are also minimal, although the profile in April tends to be mostly upward refracting in the top 100 m (Figure 9). This month is therefore expected to promote longest range propagation and was used for all modeled scenarios.

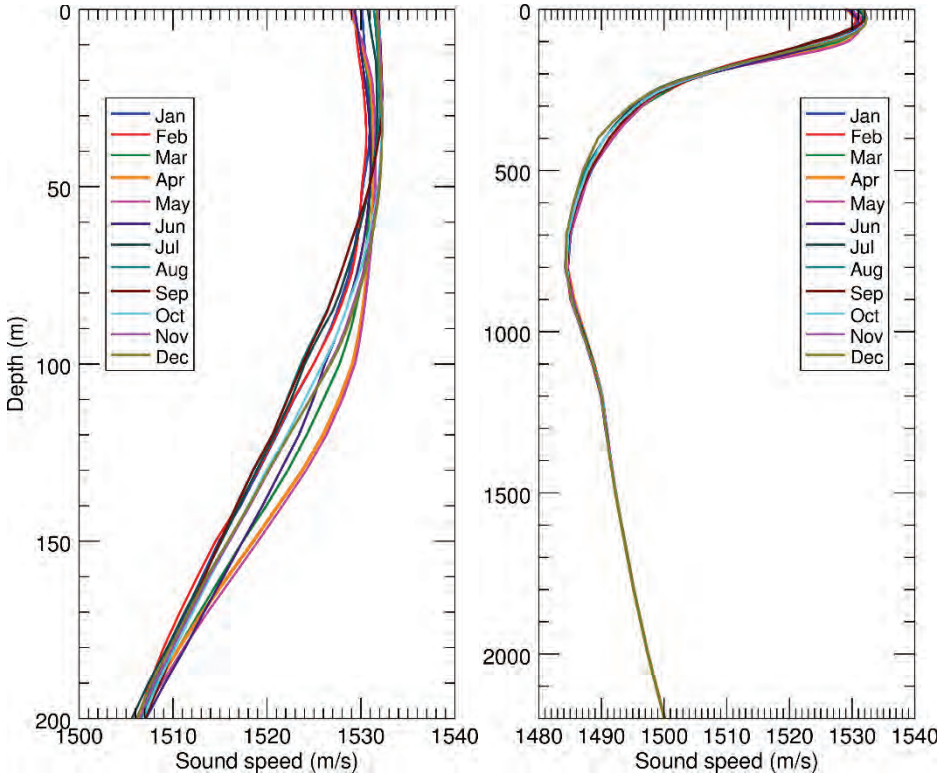


Figure 9. Mean monthly sound speed profiles (left: top 200 m; right: entire water column) at the FPSO location (08° 00' 39.53" N, 056° 59' 27.31" W) derived from data obtained from *GDEM V 3.0* (Teague et al. 1990, Carnes 2009).

4.3. Sound Propagation Modeling Zones

For the purposes of assessing sound levels with MONM, the sound field was modeled up to distances of 2 and 20 km from the FPSO (Scenarios 1 and 2) and the drill ship (Scenario 3), with a horizontal separation of 5 and 20 m between receiver points along the modeled radials. The horizontal angular separation between radials was 2.5°, for a total of N = 144 radial planes. Receiver depths were chosen to span the entire water column over the modeled areas, from 1 to 5000 m, with step sizes increasing with depth.

FWRAM modeled synthetic pulses of the VSP source up to 20 km, along four radials (0, 90, 180, and 270° from the tow direction) to compute peak pressure levels. The horizontal range step was set at 20 m. The tow direction was 293°. The same parameters were used to model sound from pile driving operations, the range step was however adjusted to 2 m up to 200 m from the source, and 25 m thereafter.

5. Results

5.1. Source Levels

5.1.1. Vessels

Figures 10–14 show the estimated 1/3-octave-band source levels for the modeled vessels. The broadband (10 Hz to 32 kHz) source levels vary from 173.4 dB re 1 µPa for the light construction and field intervention vessel to 196.1 dB re 1 µPa for the large tug. Although source levels may vary substantially during different operations, these modeled spectra represent a conservative average over a 24 hour period.

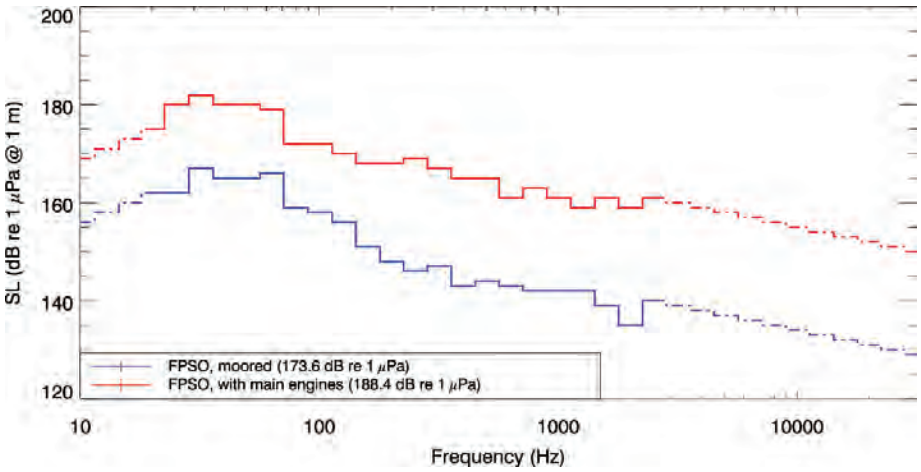


Figure 10. Estimated source level spectra for the FPSO. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

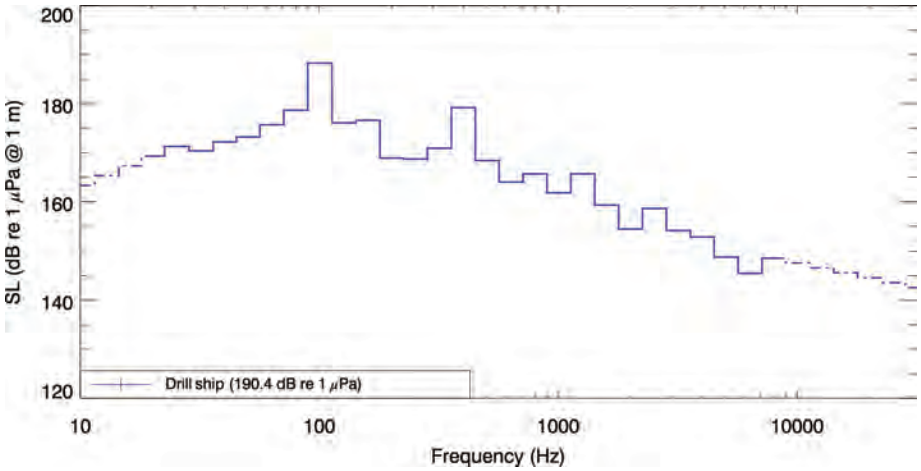


Figure 11. Estimated source level spectrum for the drill ship. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

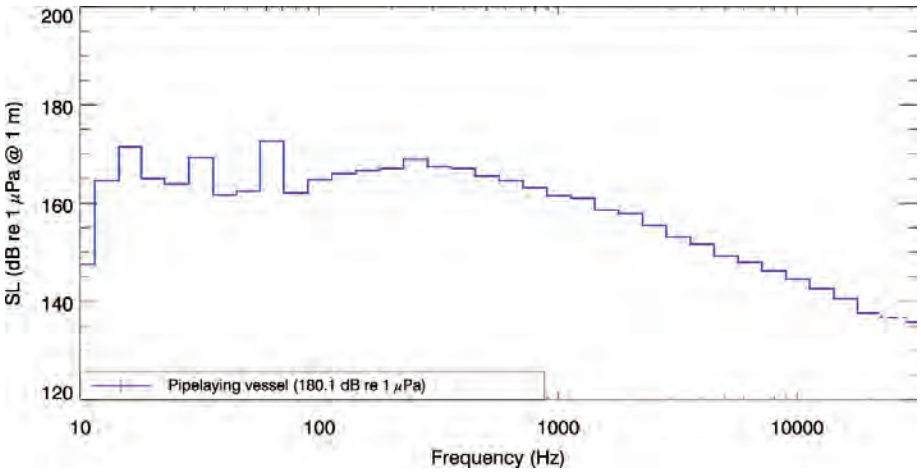


Figure 12. Estimated source level spectrum for the pipelaying vessel. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

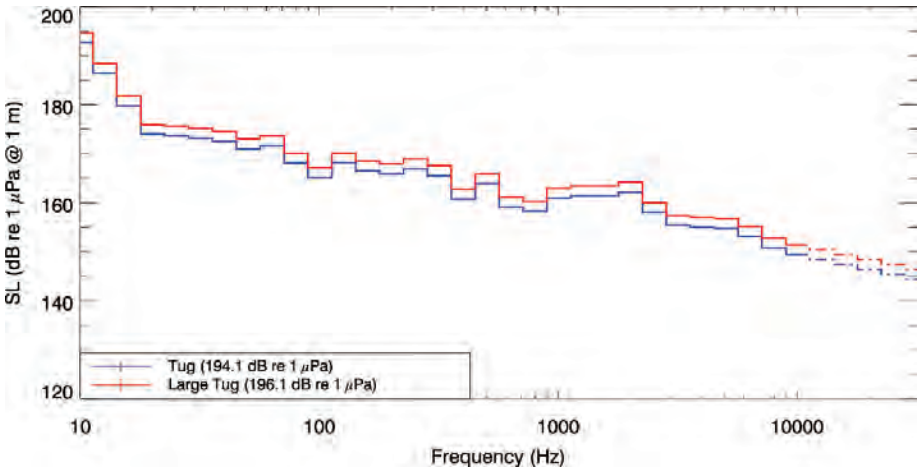


Figure 13. Estimated source level spectra for the tugs. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

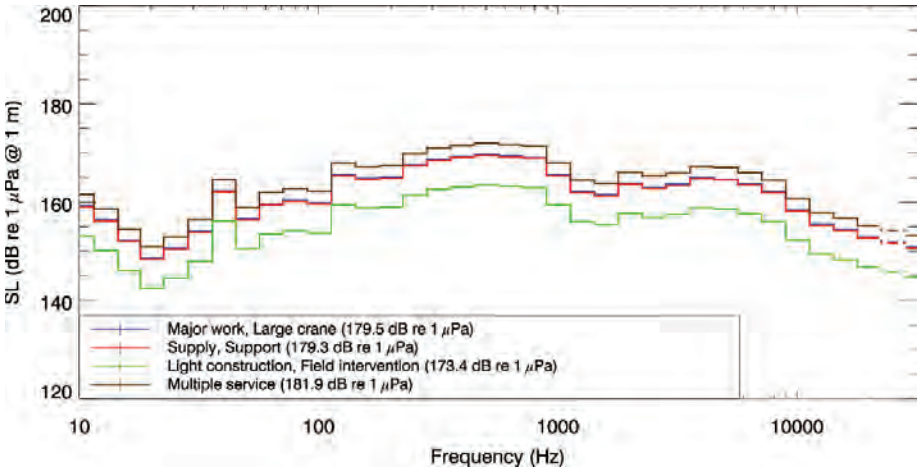


Figure 14. Estimated source level spectra for the various support vessels. Dashed lines represent extrapolated levels based on Ross' spectrum (Ross 1976).

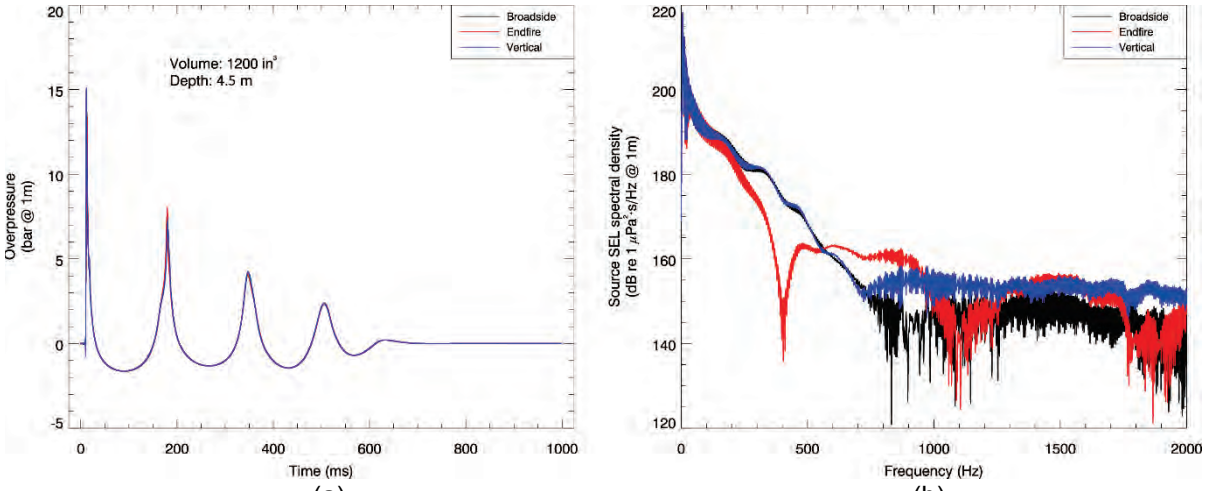
5.1.2. Vertical Seismic Profile Source

The pressure signatures of the individual array elements and the composite 1/3-octave-band source levels of the array, as functions of azimuthal angle (in the horizontal plane), were modeled with AASM (Section 3.1.2). While effects of surface reflected signals on bubble oscillations and inter-bubble interactions are accounted for in the notional pressure signatures of each element by AASM, the surface-reflected signal (i.e., surface ghost) is not shown in the far-field source signature plots below. The acoustic propagation models account for those surface reflections, which are a property of the propagating medium rather than the source.

Figure 15 shows the horizontal overpressure signatures (broadside–perpendicular to the tow direction, and endfire–parallel to the tow direction), the vertical overpressure signature, and corresponding power spectrum levels for the 1200 in^3 array at a 4.5 m tow depth. The signatures consist of a strong primary peak, related to the initial release of high-pressure air, followed by a series of pulses associated with bubble oscillations. Most energy is produced at frequencies below 600 Hz. Frequency-dependent peaks and nulls in the spectrum result from interference among elements in the array, and depend on the volumes and relative locations of the element.

Table 6 shows the broadband SPL and unweighted per-pulse SEL source levels.

Horizontal 1/3-octave-band source levels are shown as a function of band center frequency and azimuth (Figure 16). As discussed in Section 3.1.1, directivity in the sound field is most noticeable at frequencies from ~316 to 2000 Hz.



(a) (b)

Figure 15. Predicted source level details for the 1200 in^3 array. (a) The overpressure signature and (b) the power spectrum in the broadside (perpendicular to tow direction), endfire (directly aft of the array), and downward (vertical) directions.

Table 6. Source level specifications in the horizontal plane for the 1200 in^3 array, for a 4.5 m tow depth.

Direction	Peak pressure level (dB re 1 **µPa @ 1** m)	SPL (dB re 1 **µPa @** 1 m)	Unweighted per-pulse SEL (dB re 1 **µPa**^{2}·s **@** 1 m)	
			10–2000 Hz	2000–25000 Hz
Broadside (no surface ghost)	243.5	225.7	219.4	172.8
Endfire (no surface ghost)	242.6	225.6	219.3	176.9
Vertical (no surface ghost)	243.6	225.7	219.4	176.4
Vertical (with surface ghost)	243.6	224.3	219.8	179.4

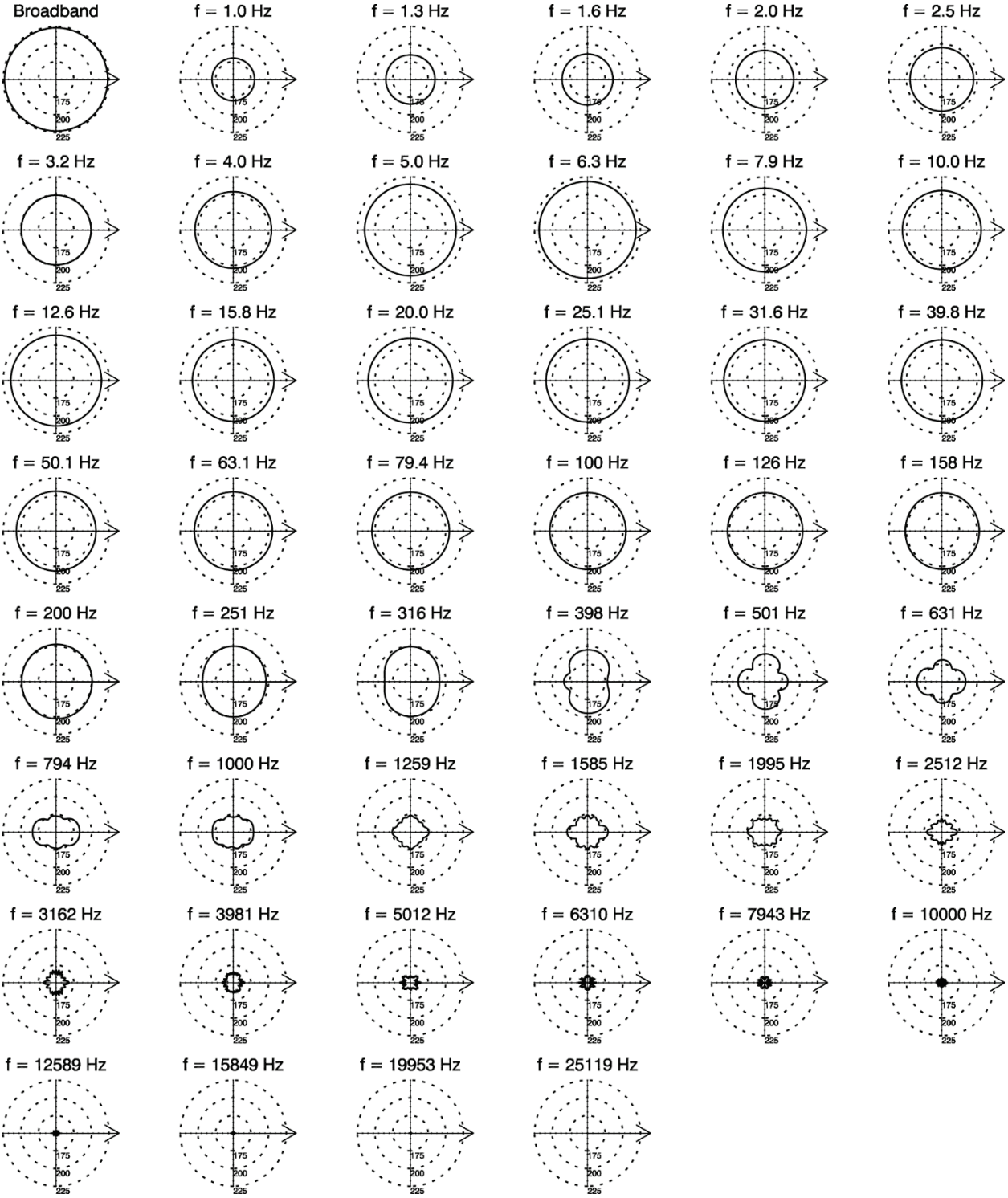


Figure 16. Directionality of the predicted horizontal source levels for the 1200 in^3 array, 10–25,000 Hz.Source levels (in dB re 1 µPa^2·s) are shown as a function of azimuth for the center frequencies of the 1/3-octave-bands modeled; frequencies are shown above the plots. Tow direction is to the right and tow depth is 4.5 m.

5.1.3. Impact Pile Driving

The forcing function at the top of the pile (Figure 17) was modeled using the GRLWEAP 2010 wave equation model. The forcing function consists of a strong primary peak, related to the initial contact of the ram and helmet, followed by a series of pulses associated with the ram-helmet oscillations. JASCO's pile driving source model estimated equivalent source signatures every 2 m along the pile. Figure 18 presents the signature of the monopoles at the top, center, and bottom of the pile. The first peak of these signatures represents the initial pile deformation traveling down the pile; its amplitude decreases and arrival time increases with depth along the pile.

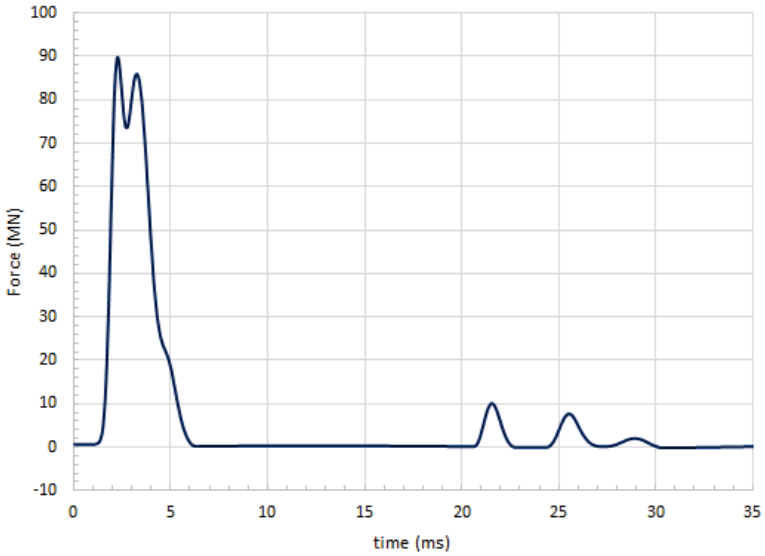


Figure 17. Force at the top of a pile during impact driving of a 25-m long, 5-m wide cylindrical steel pile with the MENCK 500T (underwater) hammer.

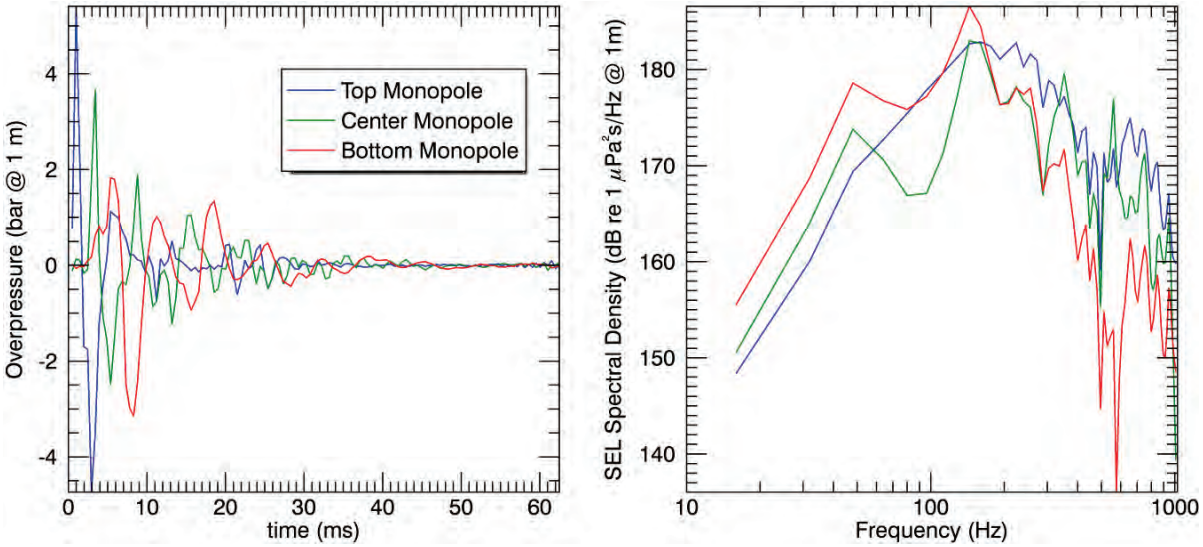


Figure 18. Predicted overpressure signature of three monopoles along the modeled pile: top (in water), center (in water), and bottom (in substrate).

5.2. Sound Fields

5.2.1. Vessels

This section includes the distances to marine mammal injury thresholds resulting from the presence of vessels (Table 7). For the purpose of estimating M-weighted SEL_{24h} in this study, all vessels were assumed stationary, operating over 90% of a 24 hour period. Peak pressure level thresholds for injury criteria were not reached; distances to peak pressure levels are not presented below.

The tabulated values represent the maximum R_{max} and $R_{95\%}$ from any vessels present in a scenario.

Table 7. Scenarios 1–3: Distances (m) to marine mammal injury for non-impulsive sources.

Hearing group	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)
Scenario 1						
Low-frequency cetaceans	215	6	6	207	< 5	< 5
Mid-frequency cetaceans	215	< 5	< 5	199	< 5	< 5
Scenario 2						
Low-frequency cetaceans	215	< 5	< 5	207	< 5	< 5
Mid-frequency cetaceans	215	-	-	199	-	-
Scenario 3						
Low-frequency cetaceans	215	9	9	207	6	6
Mid-frequency cetaceans	215	< 5	< 5	199	-	-

5.2.2. Vertical Seismic Profile Source

This section presents the distances to marine mammal injury thresholds for the VSP source in Scenario 4. To estimate distances to marine mammal injury thresholds in M-weighted SEL_{24h}, one operational period was modeled (i.e., it was assumed that the VSP source produces 40 pulses in 24 hours). Distances to peak pressure level thresholds are either not reached or less than distances to M-weighted SEL_{24h} thresholds for injury criteria (Table 8); distances to peak pressure levels are not presented below. In Figure 19, area ensonified at or above injury thresholds are compared; the range to the Mid-frequency cetacean injury threshold based on Finneran (2015) was below the minimum resolvable range.

Table 8. Scenario 4: Distances (m) to marine mammal injury thresholds for the VSP source.

Hearing group	Southall et al. (2007)			Finneran (2015)		
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	$R_{95\%}$ (m)
Low-frequency cetaceans	198	73	68	192	39	36
Mid-frequency cetaceans	198	35	32	187	-	-

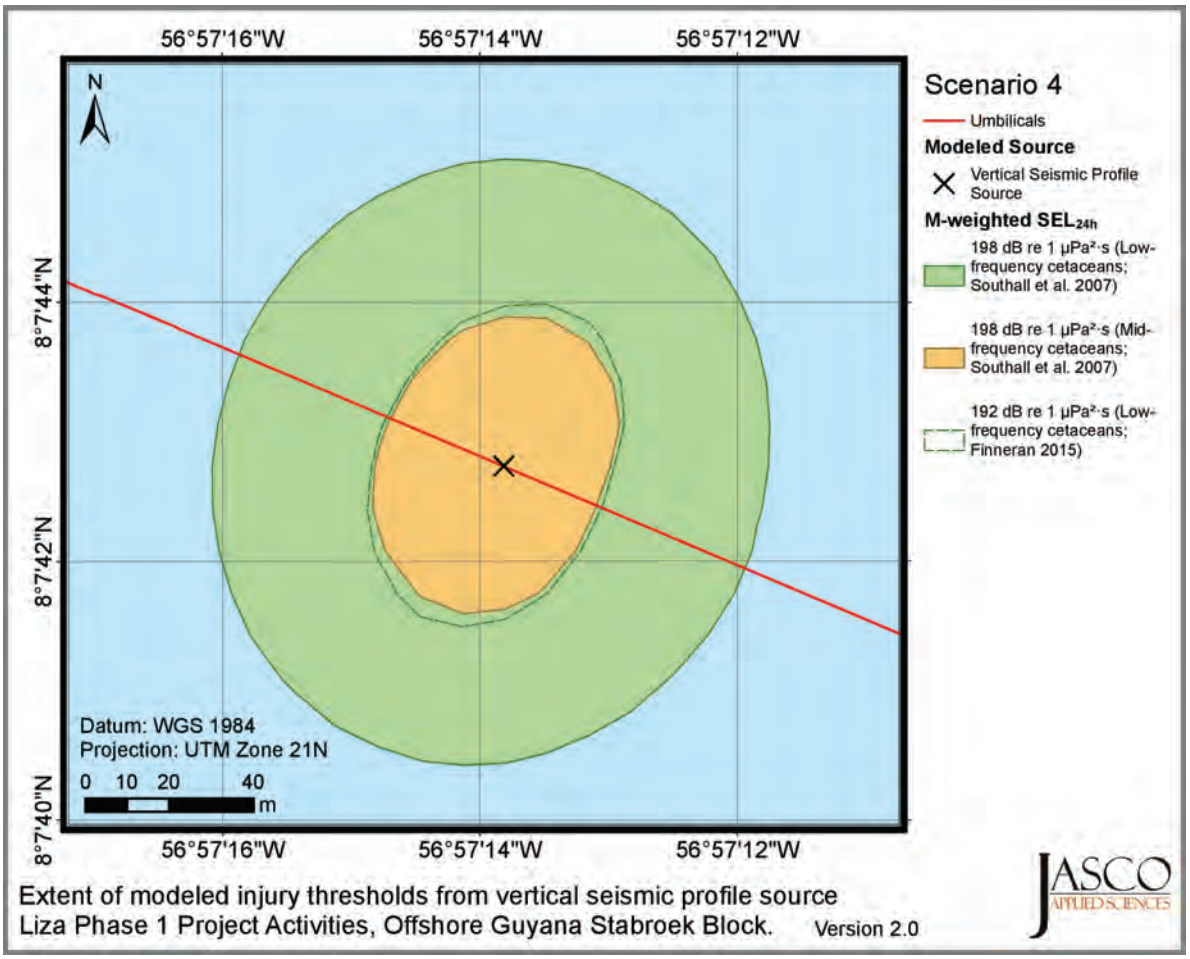


Figure 19. Scenario 4: Sound level contour map showing the extend of the maximum-over-depth M-weighted SEL_{24h} from the VSP source for marine mammal injury thresholds based on Southall et al. (2007) and Finneran (2015).

5.2.3. Impact Pile Driving

This section presents the distances to marine mammal injury thresholds for the underwater pile driving operations in Scenarios 5 and 6. To estimate distances to marine mammal injury thresholds in M-weighted SEL_{24h}, we assumed that one pile was driven for 5 hours, at a rate of 38 strikes per minute, every 24 hours. Distances to peak pressure level thresholds were either not reached or were less than distances to M-weighted SEL_{24h} thresholds for injury criteria; distances to peak pressure levels are not presented.

Tables 9–10, and Figures 20–23, present the distances to marine mammal injury thresholds at Drill Center 2-P and the FPSO, respectively. Figures 21–22 and 24–25 present vertical slices of the corresponding M-weighted SEL_{24h} fields, east of the piles. The parabolic equation (PE) approximation used in FWRAM (Section 3.2) is estimated to be valid for sound propagating up to 45° from the horizontal plane at the source depth. This angle is indicated by the black dash line in each slice.

Table 9. Scenario 5: Distances (m) to marine mammal injury thresholds for the underwater pile driving operations at Drill Center 2-P.

Hearing group	Southall et al. (2007)		Finneran (2015)	
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)
Low-frequency cetaceans	198	1,300	192	1,025
Mid-frequency cetaceans	198	762	187	136

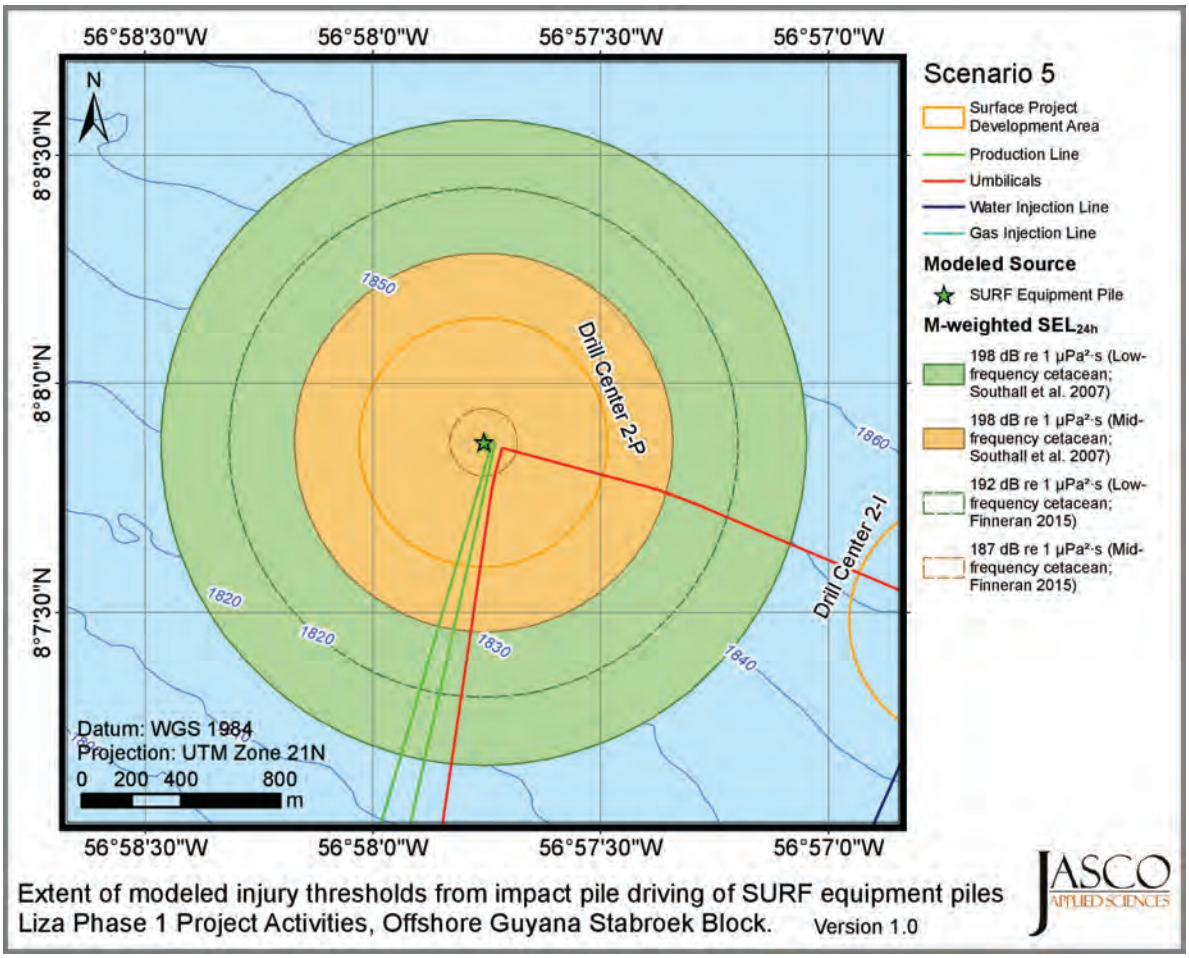


Figure 20. Scenario 5: Sound level contour map showing the extend of the maximum-over-depth M-weighted SEL_{24h} from impact pile driving for marine mammal injury thresholds based on Southall et al. (2007) and Finneran (2015).

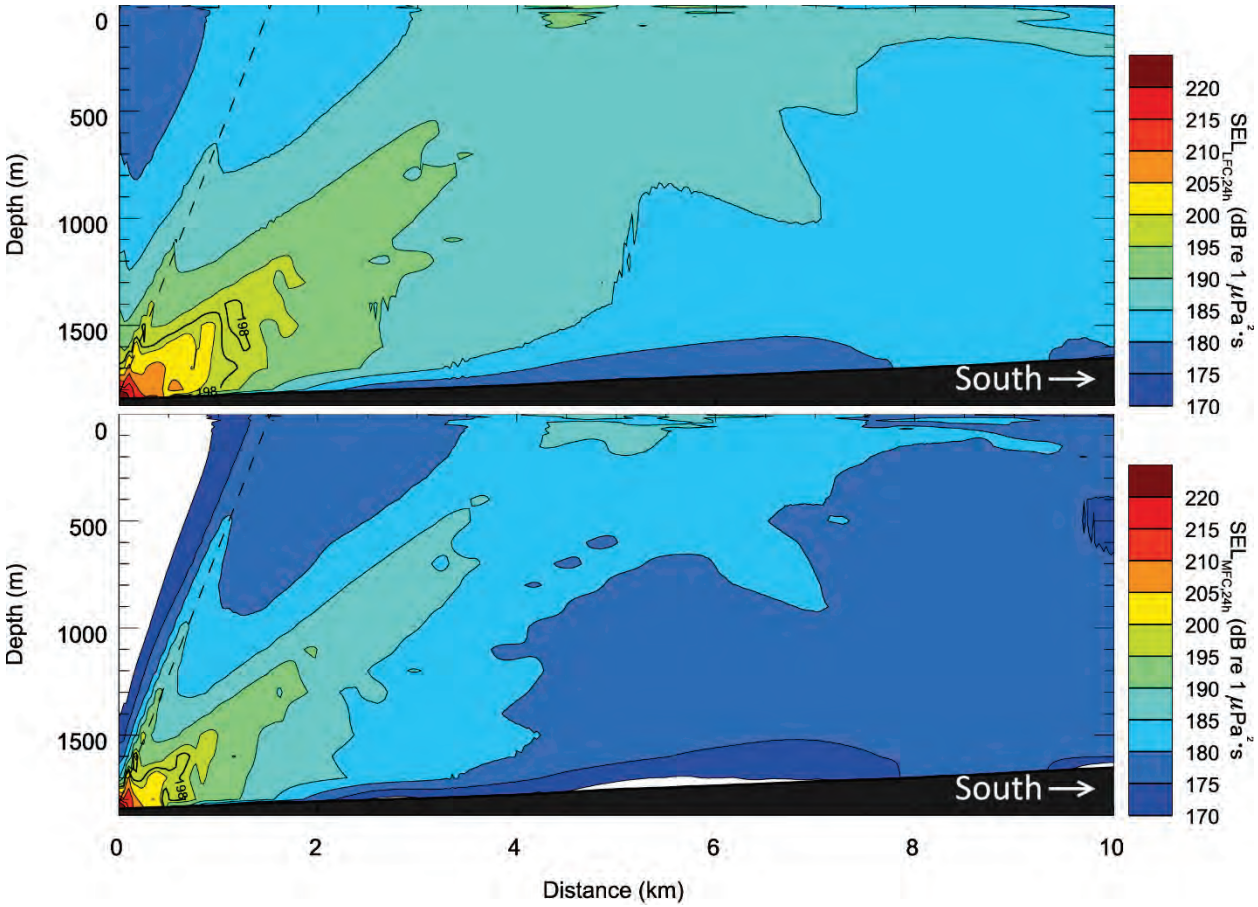


Figure 21. Scenario 5: Estimated M-weighted SEL_{24h} based on Southall et al. (2007), propagating south of the pile at Drill Center 2-P. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

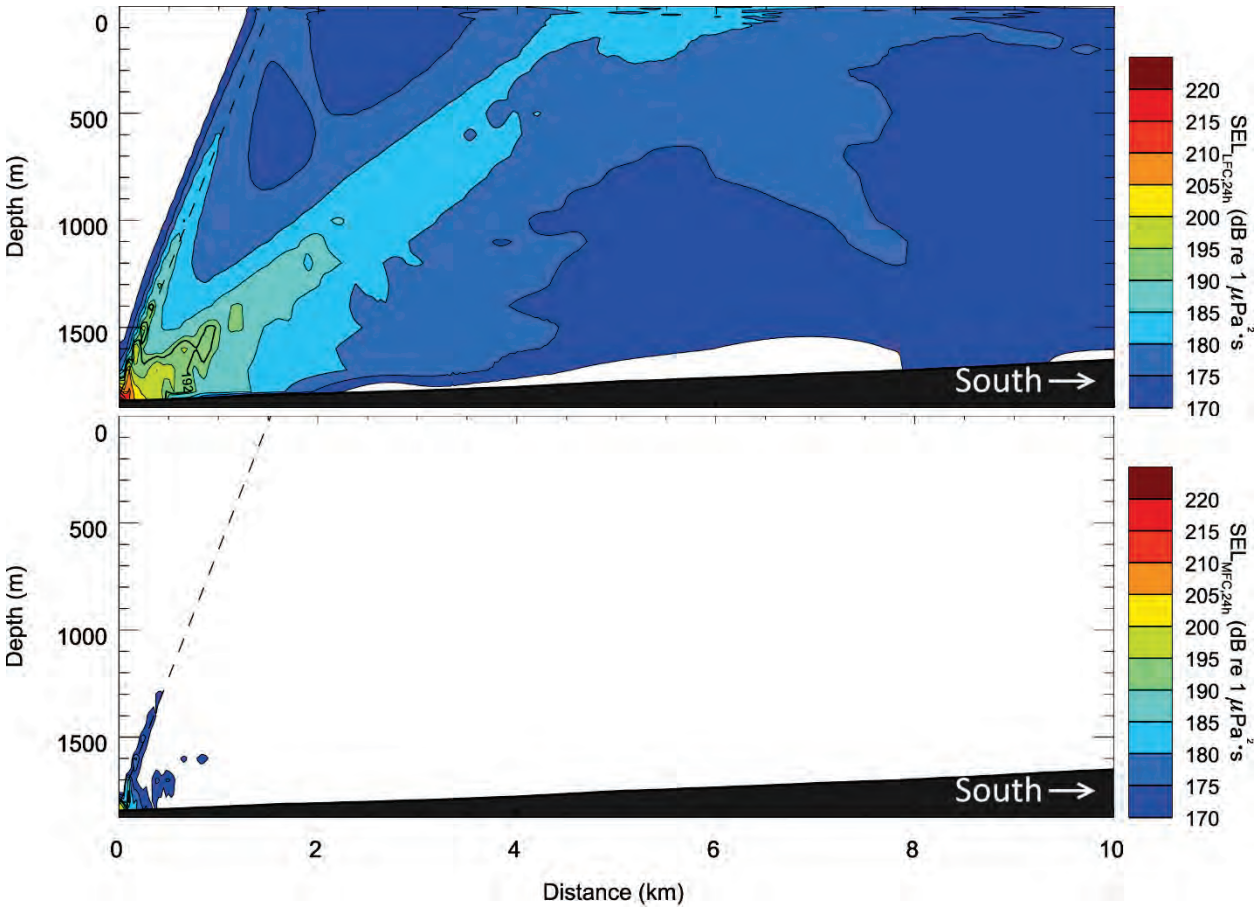


Figure 22. Scenario 5: Estimated M-weighted SEL_{24h} based on Finneran (2015), propagating south of the pile at Drill Center 2-P. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

Table 10. Scenario 6: Distances (m) to marine mammal injury thresholds for the underwater pile driving operations at the FPSO location.

Hearing group	Southall et al. (2007)		Finneran (2015)	
	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)	Threshold (M-weighted SEL_{24h}; dB re 1 µPa²·s)	R_{max} (m)
Low-frequency cetaceans	198	1,375	192	1,075
Mid-frequency cetaceans	198	725	187	100

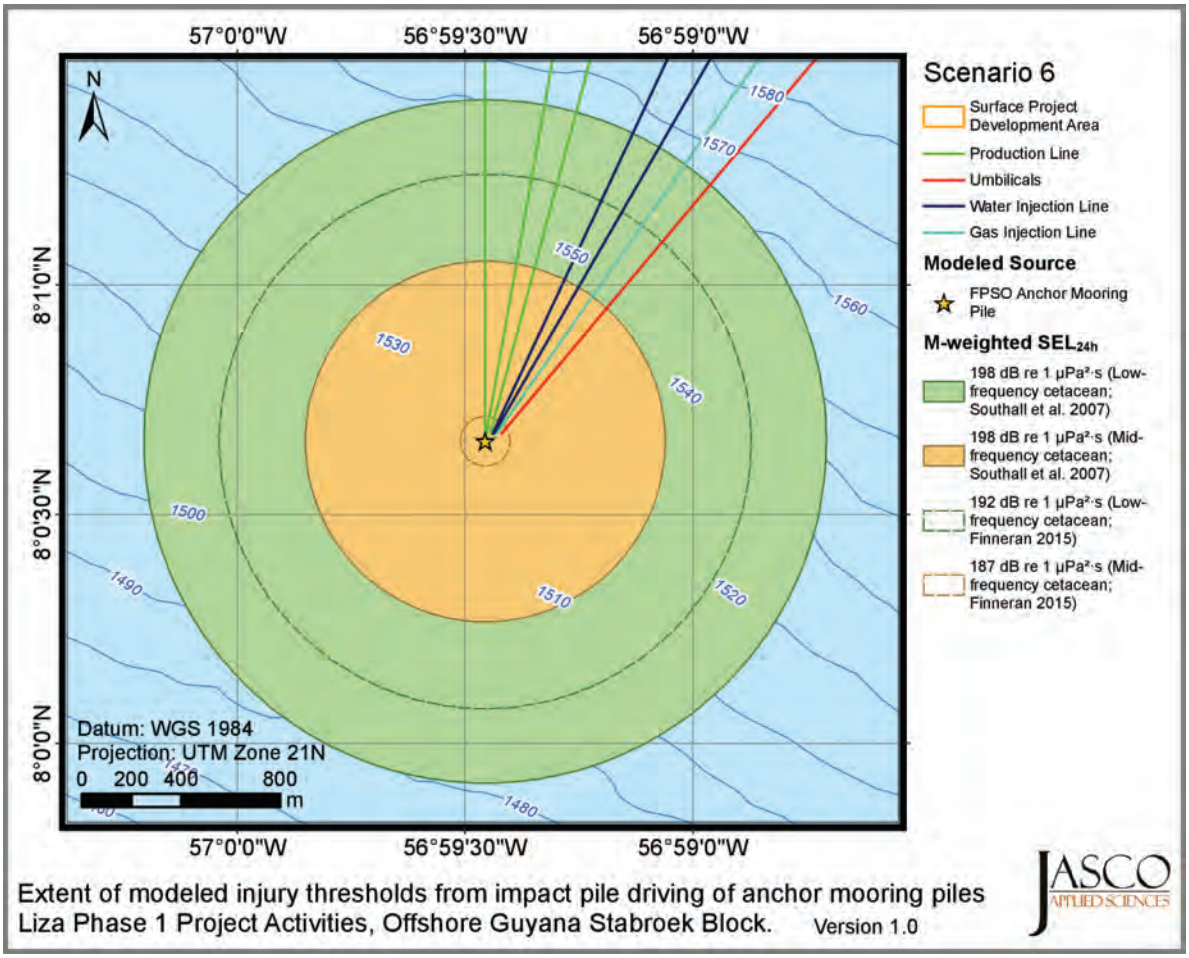


Figure 23. Scenario 6: Sound level contour map showing the extend of the maximum-over-depth M-weighted SEL_{24h} from impact pile driving for marine mammal injury thresholds based on Southall et al. (2007) and Finneran (2015).

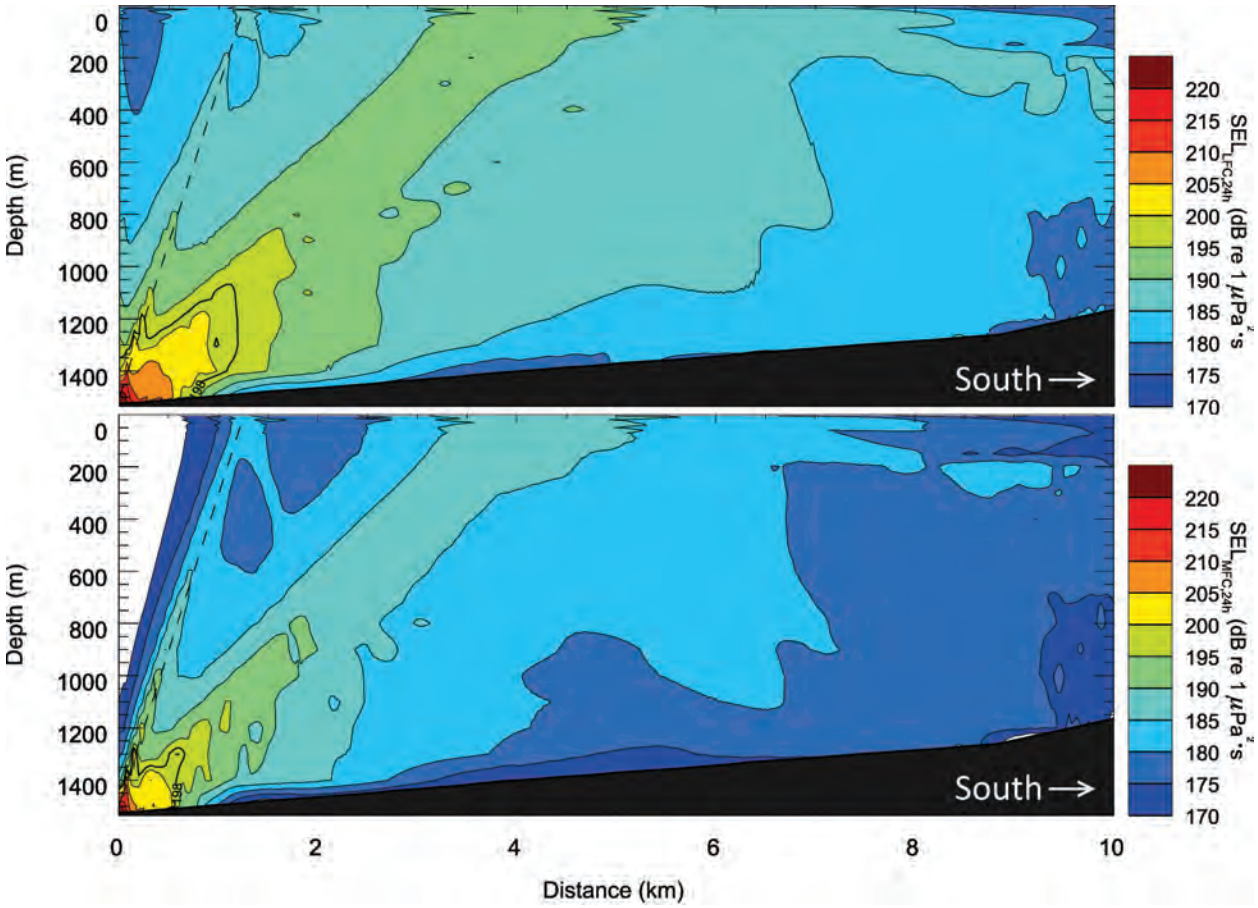


Figure 24. Scenario 6: Estimated M-weighted SEL_{24h} based on Southall et al. (2007), propagating south of the FPSO anchor mooring piles. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

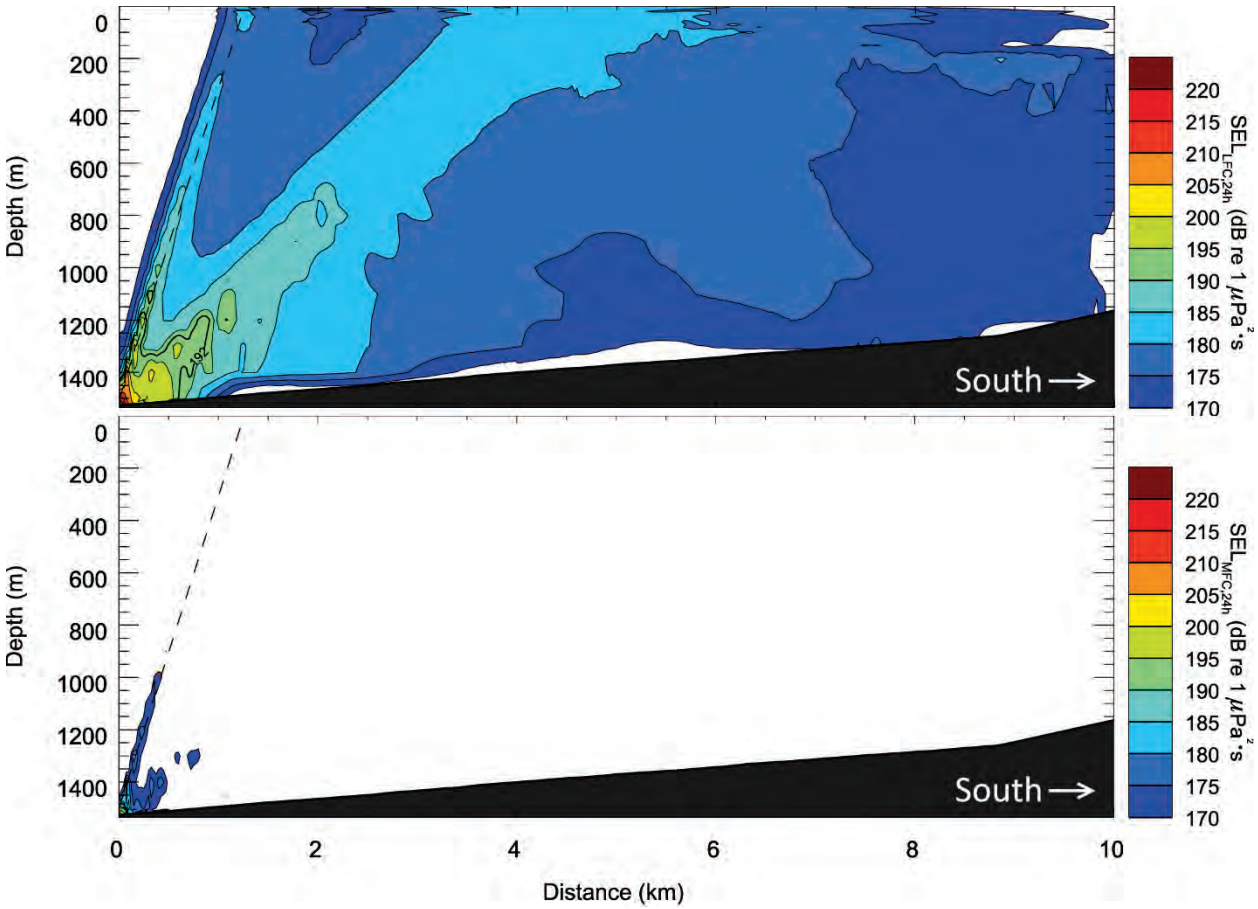


Figure 25. Scenario 6: Estimated M-weighted SEL_{24h} based on Finneran (2015), propagating south of the FPSO anchor mooring piles. The thicker black lines indicate sound level isopleths corresponding to the injury thresholds for (top) low- and (bottom) mid-frequency cetaceans. The dash line indicates the limiting angle below which the model is valid; received levels above the source (left of the dash line) are expected to be underestimated. The dark area at the bottom of the plot shows decreasing water depth.

6. Discussion

The estimated broadband source levels of vessels varied from 173.4 dB re 1 µPa at 1 m for the light construction and field intervention vessels, to 196.1 dB re 1 µPa at 1m for the large tug. Although source levels may vary substantially during operations, the modeled source level spectra of the vessels represent conservative averages over a 24 hour period.

For scenarios 1 through 3, the distances to injury thresholds from vessels were small: <10 m for all species, thus essentially insignificant relative to the size of the vessels. The distances to injury thresholds were similar for Southall et al. (2007) and Finneran (2015) criteria (Table 7). These results assume that the vessels were stationary for 24 hours and the animal was present within the stated distance for the entire accumulation period (24 hours).

The broadband (10–25,000 Hz) per-pulse SEL source level of the VSP source was 219–220 dB re 1 µPa^2·s @ 1 m in all directions (Table 6). Distances (R_{max}) to injury thresholds for mid-frequency cetaceans were 35 m based on Southall et al. (2007) and below the minimum resolvable range based on Finneran (2015); for low-frequency cetaceans they were 73 and 39 m, respectively (Table 8). For this source, the injury thresholds based on Finneran (2015) were generally lower than for Southall et al. (2007) due to the steeper roll-off at low frequencies of the weighting functions for the former. Because most of the energy from the VSP source lies below 600 Hz (Figure 15), Finneran's weighting yields a greater discount than Southall et al. (2007) (see Appendix A.4).

Distances to injury thresholds were longer for impact pile driving than for other operations. Across both modelled sites, for mid-frequency cetaceans the maximum ranges were 762 m based on Southall et al. (2007) and 136 m based on Finneran (2015); for low-frequency cetaceans they were 1,375 m and 1,075 m, respectively (Tables 9–10). The differences in ranges between the two sites were minor. The sound levels at or above injury thresholds were found close to the ocean bottom, at depths >1,000 m. Low-frequency cetacean species present in the area are not expected to dive to those depths and, therefore, should never be exposed to injurious sound levels from pile driving activities. A few species within the mid-frequency hearing group, such as some dolphins, may feed at depths greater than 1,000 m and could therefore be affected by pile driving sound. The amount of time these animals spend below 1,000 m is, however, limited due to their need to resurface to breathe, which reduces the probability of injury.

Glossary

1/3-octave-band
Non-overlapping passbands that are one-third of an octave wide (where an octave is a doubling of frequency). Three adjacent 1/3-octave-bands make up one octave. One-third-octave-bands become wider with increasing frequency. See also octave.

90%-energy time window
The time interval over which the cumulative energy rises from 5% to 95% of the total pulse energy. This interval contains 90% of the total pulse energy. Symbol: T_{90}.

90% root-mean-square sound pressure level (90% SPL)
The root-mean-square sound pressure levels calculated over the 90%-energy time window of a pulse. Used only for pulsed sounds.

Air gun
A device that has a chamber of compressed air, which is "fired" (quickly released) to produce a pulse of acoustic energy.

A-weighting
Frequency-selective weighting for human hearing in air that is derived from the inverse of the idealized 40-phon equal loudness hearing function across frequencies.

absorption
The conversion of acoustic energy into heat, which is captured by insulation.

ambient noise
All-encompassing sound at a given place, usually a composite of sound from many sources near and far (ANSI S1.1-1994 R2004), e.g., shipping vessels, seismic activity, precipitation, sea ice movement, wave action, and biological activity.

attenuation
The gradual loss of acoustic energy from absorption and scattering as sound propagates through a medium.

auditory weighting function (frequency-weighting function)
Auditory weighting functions account for marine mammal hearing sensitivity. They are applied to sound measurements to emphasize frequencies that an animal hears well and de-emphasize frequencies they hear less well or not at all (Southall et al. 2007, Finneran and Jenkins 2012, NOAA 2013).

azimuth
A horizontal angle relative to a reference direction, which is often magnetic north or the direction of travel. In navigation it is also called bearing.

background noise
Total of all sources of interference in a system used for the production, detection, measurement, or recording of a signal, independent of the presence of the signal (ANSI S1.1-1994 R2004). Ambient noise detected, measured, or recorded with a signal is part of the background noise.

bandwidth
The range of frequencies over which a sound occurs. Broadband refers to a source that produces sound over a broad range of frequencies (e.g., seismic sources, vessels) whereas narrowband sources produce sounds over a narrow frequency range (e.g., sonar) (ANSI/ASA S1.13-2005 R2010).

bar
Unit of pressure equal to 100 kPa, which is approximately equal to the atmospheric pressure on Earth at sea level. 1 bar is equal to 10^6 Pa or 10^{11} µPa.

broadband sound level
The total sound pressure level measured over a specified frequency range. If the frequency range is unspecified, it refers to the entire measured frequency range.

broadside direction
Perpendicular to the travel direction of a source. Compare with endfire direction.

cavitation
A rapid formation and collapse of vapor cavities (i.e., bubbles or voids) in water, most often caused by a rapid change in pressure. Fast-spinning vessel propellers typically cause cavitation, which creates a lot of sound.

cetacean
Any animal in the order Cetacea. These are aquatic, mostly marine mammals and include whales, dolphins, and porpoises.

compressional wave
A mechanical vibration wave in which the direction of particle motion is parallel to the direction of propagation. Also called primary wave or P-wave.

continuous sound
A sound whose sound pressure level remains above ambient sound during the observation period (ANSI/ASA S1.13-2005 R2010). A sound that gradually varies in intensity with time, for example, sound from a marine vessel.

decibel (dB)
One-tenth of a bel. Unit of level when the base of the logarithm is the tenth root of ten, and the quantities concerned are proportional to power (ANSI S1.1-1994 R2004).

endfire direction
Parallel to the travel direction of a source. See also broadside direction.

ensonified
Exposed to sound.

equal-loudness contour
A curve or curves that show, as a function of frequency, the sound pressure level required to cause a given loudness for a listener having normal hearing, listening to a specified kind of sound in a specified manner (ANSI S1.1-1994 R2004).

far-field
The zone where, to an observer, sound originating from an array of sources (or a spatially-distributed source) appears to radiate from a single point. The distance to the acoustic far-field increases with frequency.

fast-average sound pressure level
The time-averaged sound pressure levels calculated over the duration of a pulse (e.g., 90%-energy time window), using the leaky time integrator from Plomp and Bouman (1959) and a time constant of 125 ms. Used only for pulsed sounds.

fast Fourier transform (FFT)
A computationally efficiently algorithm for computing the discrete Fourier transform.

frequency
The rate of oscillation of a periodic function measured in cycles-per-unit-time. The reciprocal of the period. Unit: hertz (Hz). Symbol: *f*. 1 Hz is equal to 1 cycle per second.

geoacoustic
Relating to the acoustic properties of the seabed.

hearing group
Grouping of marine mammal species with similar hearing ranges. Commonly defined hearing groups include low-, mid-, and high-frequency cetaceans, pinnipeds in water, and pinnipeds in air.

hearing threshold
The sound pressure level that is barely audible for a given individual in the absence of significant background noise during a specific percentage of experimental trials.

hertz (Hz)
A unit of frequency defined as one cycle per second.

high-frequency cetacean
The functional hearing group that represents odontocetes specialized for using high frequencies.

intermittent sound
A level of sound that abruptly drops to the background noise level several times during the observation period.

impulsive sound
Sound that is typically brief and intermittent with rapid (within a few seconds) rise time and decay back to ambient levels (NOAA 2013, ANSI S12.7-1986 R2006). For example, seismic sources and impact pile driving.

low-frequency cetacean
The functional hearing group that represents mysticetes (baleen whales).

mid-frequency cetacean
The functional hearing group that represents some odontocetes (dolphins, toothed whales, beaked whales, and bottlenose whales).

M-weighting
The process of band-pass filtering loud sounds to reduce the importance of inaudible or less-audible frequencies for broad classes of marine mammals. “Generalized frequency weightings for various functional hearing groups of marine mammals, allowing for their functional bandwidths and appropriate in characterizing auditory effects of strong sounds” (Southall et al. 2007).

mysticete
Mysticeti, a suborder of cetaceans, use their baleen plates, rather than teeth, to filter food from water. They are not known to echolocate, but use sound for communication. Members of this group include rorquals (Balaenopteridae), right whales (Balaenidae), and the gray whale (*Eschrichtius robustus*).

non-impulsive sound
Sound that is broadband, narrowband or tonal, brief or prolonged, continuous or intermittent, and typically does not have a high peak pressure with rapid rise time (typically only small fluctuations in decibel level)

that impulsive signals have (ANSI/ASA S3.20-1995 R2008). For example, marine vessels, aircraft, machinery, construction, and vibratory pile driving (NIOSH 1998, NOAA 2015).

octave
The interval between a sound and another sound with double or half the frequency. For example, one octave above 200 Hz is 400 Hz, and one octave below 200 Hz is 100 Hz.

odontocete
The presence of teeth, rather than baleen, characterizes these whales. Members of the Odontoceti are a suborder of cetaceans, a group comprised of whales, dolphins, and porpoises. The toothed whales' skulls are mostly asymmetric, an adaptation for their echolocation. This group includes sperm whales, killer whales, belugas, narwhals, dolphins, and porpoises.

otariid
A common term used to describe members of the Otariidae, eared seals, commonly called sea lions and fur seals. Otariids are adapted to a semi-aquatic life; they use their large fore flippers for propulsion. Their ears distinguish them from phocids. Otariids are one of the three main groups in the superfamily Pinnipedia; the other two groups are phocids and walrus.

parabolic equation method
A computationally-efficient solution to the acoustic wave equation that is used to model transmission loss. The parabolic equation approximation omits effects of back-scattered sound, simplifying the computation of transmission loss. The effect of back-scattered sound is negligible for most ocean-acoustic propagation problems.

peak sound pressure level (peak SPL)
The maximum instantaneous sound pressure level, in a stated frequency band, within a stated period. Also called zero-to-peak sound pressure level. Unit: decibel (dB).

percentile level, exceedance
The sound level exceeded *n* % of the time during a measurement.

permanent threshold shift (PTS)
A permanent loss of hearing sensitivity caused by excessive acoustic exposure. PTS is considered auditory injury.

phocid
A common term used to describe all members of the family Phocidae. These true/earless seals are more adapted to in-water life than are otariids, which have more terrestrial adaptations. Phocids use their hind flippers to propel themselves. Phocids are one of the three main groups in the superfamily Pinnipedia; the other two groups are otariids and walrus.

pinniped
A common term used to describe all three groups that form the superfamily Pinnipedia: phocids (true seals or earless seals), otariids (eared seals or fur seals and sea lions), and walrus.

point source
A source that radiates sound as if from a single point (ANSI S1.1-1994 R2004).

power spectrum density
The acoustic signal power per unit frequency as measured at a single frequency. Unit: $\mu Pa^2/Hz$, or $\mu Pa^2 \cdot s$.

power spectral density level
The decibel level ($10\log_{10}$) of the power spectrum density, usually presented in 1 Hz bins. Unit: dB re 1 $\mu Pa^2/Hz$.

pressure, acoustic
The deviation from the ambient hydrostatic pressure caused by a sound wave. Also called overpressure. Unit: pascal (Pa). Symbol: *p*.

pressure, hydrostatic
The pressure at any given depth in a static liquid that is the result of the weight of the liquid acting on a unit area at that depth, plus any pressure acting on the surface of the liquid. Unit: pascal (Pa).

received level
The sound level measured at a receiver.

Root-mean-square sound pressure level (SPL)
See sound pressure level.

shear wave
A mechanical vibration wave in which the direction of particle motion is perpendicular to the direction of propagation. Also called secondary wave or S-wave. Shear waves propagate only in solid media, such as sediments or rock. Shear waves in the seabed can be converted to compressional waves in water at the water-seabed interface.

signature
Pressure signal generated by a source.

sound
A time-varying pressure disturbance generated by mechanical vibration waves travelling through a fluid medium such as air or water.

sound exposure
Time integral of squared, instantaneous frequency-weighted sound pressure over a stated time interval or event. Unit: pascal-squared second ($Pa^2 \cdot s$) (ANSI S1.1-1994 R2004).

sound exposure level (SEL)
A cumulative measure related to the sound energy in one or more pulses. Unit: dB re 1 $\mu Pa^2 \cdot s$. SEL is expressed over the summation period (e.g., per-pulse SEL [for seismic sources], single-strike SEL [for pile drivers], 24-hour SEL).

sound field
Region containing sound waves (ANSI S1.1-1994 R2004).

sound pressure level (SPL)
The decibel ratio of the time-mean-square sound pressure, in a stated frequency band, to the square of the reference sound pressure (ANSI S1.1-1994 R2004).

For sound in water, the reference sound pressure is one micropascal (p_0 = 1 µPa) and the unit for SPL is dB re 1 µPa:

$$\mathrm{SPL} = 10\log_{10}\left(p^2 / p_0^2\right) = 20\log_{10}\left(p / p_0\right)$$

Unless otherwise stated, SPL refers to the root-mean-square sound pressure level. See also 90% sound pressure level and fast-average sound pressure level.

sound speed profile
The speed of sound in the water column as a function of depth below the water surface.

source level (SL)
The sound pressure level measured 1 meter from a theoretical point source that radiates the same total sound power as the actual source. Unit: dB re 1 µPa @ 1 m.

spectrum
An acoustic signal represented in terms of its power (or energy) distribution compared with frequency.

temporary threshold shift (TTS)
Temporary loss of hearing sensitivity caused by excessive acoustic exposure.

transmission loss (TL)
The decibel reduction in sound level between two stated points that results from sound spreading away from an acoustic source subject to the influence of the surrounding environment. Also called propagation loss.

wavelength
Distance over which a wave completes one oscillation cycle. Unit: meter (m). Symbol: λ.

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Zykov, M.M., T.J. Deveau, and D. Zeddies. 2016. *Modelling Underwater Sound Associated with Constructing Canaport Energy East Marine Terminal: Impact and Vibratory Pile Driving Noise*. Document Number 01161, Version 3.0. Technical report by JASCO Applied Sciences for Stantec Consulting Ltd.

If applied, the frequency weighting of an acoustic event should be specified, as in the case of M-weighted SEL (e.g., $L_{E,LFC,24h}$; Appendix A.3). The use of fast, slow, or impulse exponential-time-averaging or other time-related characteristics should else be specified.

A.1.1. 1/3-Octave Band Analysis

The distribution of a sound's power with frequency is described by the sound's spectrum. The sound spectrum can be split into a series of adjacent frequency bands. Splitting a spectrum into 1 Hz wide bands, called passbands, yields the power spectral density of the sound. This splitting of the spectrum into passbands of a constant width of 1 Hz, however, does not represent how animals perceive sound.

Because animals perceive exponential increases in frequency rather than linear increases, analyzing a sound spectrum with passbands that increase exponentially in size better approximates real-world scenarios. In underwater acoustics, a spectrum is commonly split into 1/3-octave-bands, which are one-third of an octave wide; each octave represents a doubling in sound frequency. The center frequency of the ith 1/3-octave-band, $f_c(i)$, is defined as:

$$f_c(i) = 10^{i/10} , \tag{A-5}$$

and the low (f_{lo}) and high (f_{hi}) frequency limits of the ith 1/3-octave-band are defined as:

$$f_{lo} = 10^{-1/20} f_c(i) \quad \text{and} \quad f_{hi} = 10^{1/20} f_c(i) . \tag{A-6}$$

The 1/3-octave-bands become wider with increasing frequency, and on a logarithmic scale the bands appear equally spaced (Figure A-1). The acoustic modeling spans from band 10 ($f_c(10)$ = 10 Hz) to band 45 ($f_c(45)$ = 32 kHz).

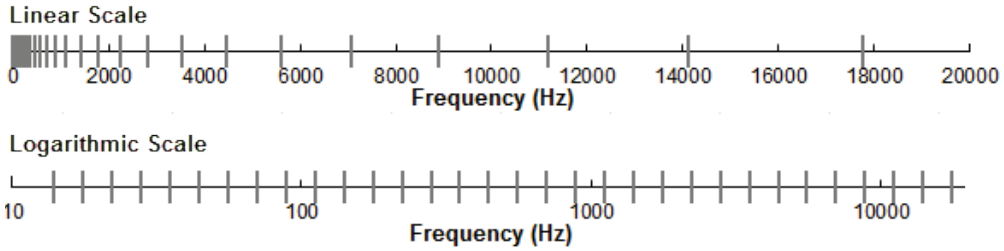


Figure A-1. One-third-octave-bands shown on a linear frequency scale and on a logarithmic scale.

The sound pressure level in the ith 1/3-octave-band $(L_b^{(i)})$ is computed from the power spectrum $S(f)$ between f_{lo} and f_{hi}:

$$L_b^{(i)} = 10 \log_{10} \left(\int_{f_{lo}}^{f_{hi}} S(f) df \right) . \tag{A-7}$$

Summing the sound pressure level of all the 1/3-octave-bands yields the broadband sound pressure level:

$$\text{Broadband SPL} = 10 \log_{10} \sum_i 10^{L_b^{(i)}/10} . \tag{A-8}$$

Figure A-2 shows an example of how the 1/3-octave-band sound pressure levels compare to the power spectrum of an ambient noise signal. Because the 1/3-octave-bands are wider with increasing frequency, the 1/3-octave-band SPL is higher than the power spectrum, especially at higher frequencies. Acoustic

A.2.2. Vessel Sounds

Underwater sound that radiates from vessels is produced mainly by propeller and thruster cavitation, with a smaller fraction of sound produced by sound transmitted through the hull, such as by engines, gearing, and other mechanical systems. Sound levels tend to be the highest when thrusters are used to position the vessel and when the vessel is transiting at high speeds. A vessel's sound signature depends on the vessel's size, power output, propulsion system (e.g., conventional propellers vs. Voith Schneider propulsion), and the design characteristics of the given system (e.g., blade shape and size). A vessel produces broadband acoustic energy with most of the energy emitted below a few kilohertz. Sound from onboard machinery, particularly sound below 200 Hz, dominates the sound spectrum before cavitation begins—normally around 8–12 knots on many commercial vessels (Spence et al. 2007). Sound from vessels typically raises the background sound level by tenfold or more (Arveson and Vendittis 2000).

A.2.3. Vertical Seismic Profile Sources

Seismic air guns generate pulsed acoustic energy by releasing a highly compressed air bubble into the water that expands and then collapses. These sources produce frequencies from several hertz to a few kilohertz, with larger element volumes producing lower frequencies and higher sound levels.

During a vertical seismic profiling, a stationary source array is deployed from either a drill ship or a closely stationed auxiliary vessel. A single element produces an approximately omnidirectional sound field, emitting acoustic energy equally in all directions. For all seismic surveys, source array layouts and firing delays are configured to achieve higher sound energy emission levels in the vertical direction where the pulses from all elements add in-phase. Lower levels of sound energy are emitted in other directions. Source arrays might show significant directionality in the horizontal direction due to the phase delay between pulses because the elements are horizontally separated.

A.2.4. Impact Pile Driving

Impact pile driving consists of infixing piles of various shapes and materials into the ground by striking the top end of the pile with a ram. In its simplest form, pile driving is achieved by a free-falling ram directly striking the pile. After the strike, the ram is raised and the action repeated until a sufficient portion of the pile penetrates the ground. Additional equipment can be used for higher efficiency or to accomplish activities such as driving fully submerged piles. For example, free-falling pile drivers have generally been replaced by more sophisticated mechanisms that control downward and upward movement of the ram. Cushion materials can be installed between the ram and the drive head. Aside from redistributing some of the energy from the hammer impact and protecting the contact surfaces from damage, the cushion also allows some control on the maximum amplitude and duration of the force applied to the pile.

After each strike, the initial radial deformation at the top of the pile wall caused by impact compression rapidly travels downward along the pile, generating in the process a pressure wave in the water column. Because of the properties of the material, the deformation travels down the pile faster than the speed of sound in water, resulting in a radiating pressure wave that resemble a Mach cone with a cone angle of ~17° (Reinhall and Dahl 2011).

A.3. Acoustic Effect Criteria

A.3.1. Marine Mammals

It has been long recognized that marine mammals can be adversely affected by underwater anthropogenic sound. For example, Payne and Webb (1971) suggested that communication distances of fin whales are reduced by shipping sounds. Subsequently, similar concerns arose regarding effects of other underwater sound sources and the possibility that impulsive sources could cause auditory injury. This led to a series of workshops held in the late 1990s, conducted to address acoustic mitigation requirements for seismic surveys and other underwater sound sources (NMFS 1998, ONR 1998, HESS 1998, Nedwell and Turnpenny 1998, Ellison and Stein 1999).

The U.S. National Oceanic and Atmospheric Administration's (NOAA) National Marine Fisheries Service (NMFS) considered recommendations from these workshops and adopted a set of interim thresholds for assessing injury and disturbance due to both impulsive and non-impulsive, or continuous sound, types of acoustic sources (e.g., NOAA 1998). We refer to these thresholds as the NMFS SPL criteria. Regulatory agencies in many countries have applied these criteria since the early 2000s, but recent advances in assessment approaches are starting to replace them.

The NMFS SPL criteria for acoustic exposure injury to marine mammals were set according to recommendations for cautionary estimates of sound levels leading to onset of permanent hearing threshold shift (PTS). These criteria prescribe injury thresholds of 190 dB re 1 µPa SPL for pinnipeds and 180 dB re 1 µPa SPL for cetaceans (NMFS 2013). A corresponding injury threshold was not defined for non-impulsive sounds at that time. NMFS indicates that the SPL criteria should be used for all sources including sonars and explosives (NMFS 2013). These injury thresholds are applied to individual acoustic pulses and do not consider the overall duration of the sound or its acoustic frequency distribution.

Criteria that do not take into account exposure duration or acoustic spectra are generally insufficient for assessing hearing injury. Human workplace noise assessments consider the SPL as well as the duration of exposure and sound spectral characteristics. For example, the International Institute of Noise Control Engineering (I-INCE) and the Occupational Safety and Health Administration (OSHA) suggests thresholds in C-weighted peak pressure level and A-weighted time-average sound level (dB(A)[1] L_{eq}). They also suggest exchange rates that increase the allowable thresholds for each halving or doubling of exposure time. This approach assumes that hearing damage depends on the relative loudness perceived by the human ear. It also assumes that the ear might partially recover from past exposures, particularly if there are periods of quiet nested within the overall exposure.

In recognition of shortcomings of the SPL-only based injury criteria, in 2005 NMFS sponsored the Noise Criteria Group to review literature on marine mammal hearing to propose new acoustic exposure criteria (NMFS 2013). Some members of this expert group published a landmark paper (Southall et al. 2007) that suggested assessment methods similar to those applied for humans. The resulting recommendations introduced dual acoustic injury criteria for impulsive sounds that included peak pressure level thresholds and cumulative SEL_{24h} thresholds, where the subscripted *24h* refers to the 24 hour accumulation period for calculating SEL. The peak pressure level criterion is not frequency weighted whereas the SEL_{24h} is frequency weighted according to one of four marine mammal species hearing groups: Low-, Mid- and High-Frequency Cetaceans (LFC, MFC, and HFC respectively) and Pinnipeds in Water (PINN). These weighting functions are referred to as M-weighting filters (analogous to the A-weighting filter for human; Appendix A.4.1). The SEL_{24h} thresholds were obtained by extrapolating measurements of onset levels of Temporary Threshold Shift (TTS) in belugas by the amount of TTS required to produce Permanent Threshold Shift (PTS) in chinchillas. The Southall et al. (2007) recommendations do not specify an exchange rate, which suggests that the thresholds are the same regardless of the duration of exposure (i.e., it infers a 3 dB exchange rate).

[1] The "A" refers to a specific frequency-dependent filter shaped according to a human equal loudness contour.

where *G*(f) is the weighting function amplitude (in dB) at the frequency *f* (in Hz), and *a* and *b* are the estimated lower and upper hearing limits, respectively, which control the roll-off and passband of the weighting function. The parameters *a* and *b* are defined uniquely for each hearing group (Table A-1). The auditory weighting functions recommended by Southall et al. (2007) are shown in Figure A-3.

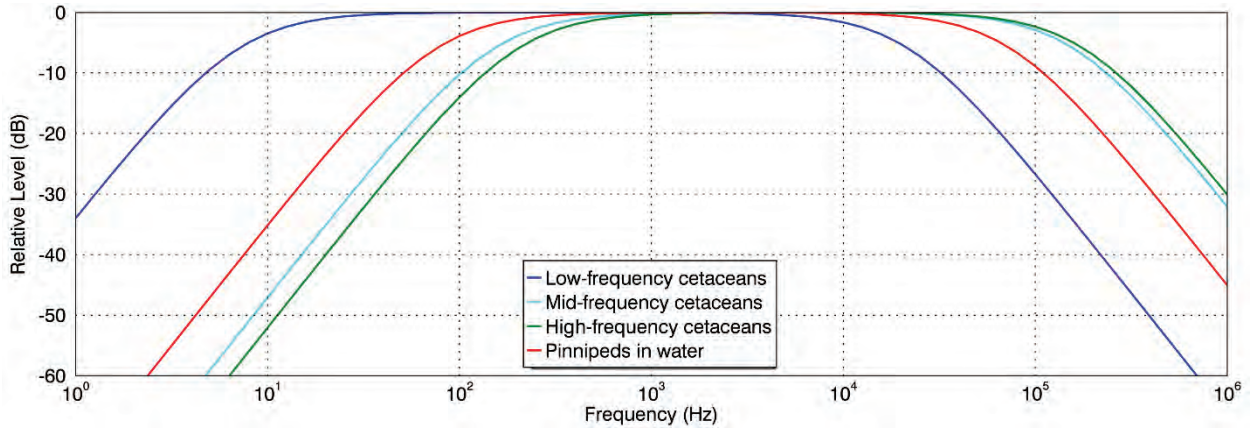


Figure A-3. Auditory weighting functions for functional marine mammal hearing groups as recommended by Southall et al. (2007).

Table A-1. Parameters for the auditory weighting functions recommended by Southall et al. (2007).

Hearing group	Southall et al. (2007)	
	a (Hz)	*b* (Hz)
Low-frequency cetaceans (LFC)	7	22,000
Mid-frequency cetaceans (MFC)	150	160,000
High-frequency cetaceans (HFC)	200	180,000
Pinnipeds in water (Pw)	75	75,000

A.4.2. Finneran 2015

In 2015, a U.S. Navy Technical Report by Finneran (2015) recommended new auditory weighting functions. The overall shape of the auditory weighting functions is similar to human A-weighting functions, which follows the sensitivity of the human ear at low sound levels. The new frequency-weighting function is:

$$G(f) = K + 10\log_{10}\left[\left(\frac{(f/f_{lo})^{2a}}{\left[1+(f/f_{lo})^{2}\right]^{a}\left[1+(f/f_{hi})^{2}\right]^{b}}\right)\right], \quad \text{(A-10)}$$

Although the inclusion of some species changed (e.g., the addition of hourglass (*Lagenorhynchus cruciger*) and Peale's (*Lagenorhynchus australis*) dolphins to the high-frequency functional hearing group), the five recommended functional hearing groups remained those presented in the Finneran and Jenkins (2012). Table A-2 lists the frequency-weighting parameters for each hearing group; Figure A-4 shows the resulting frequency-weighting curves.

Table A-2. Parameters for the auditory weighting functions recommended by Finneran (2015).

Hearing group	*a*	*b*	f_{lo} (Hz)	f_{hi} (kHz)	*K* (dB)
Low-frequency cetaceans	1.5	2	380	13,000	0.43
Mid-frequency cetaceans	1.6	2	7,400	110,000	1.02
High-frequency cetaceans	1.7	2	16,000	150,000	1.63
Phocid pinnipeds in water	2.0	2	770	27,000	0.49
Otariid pinnipeds in water	0.8	2	1,300	37,000	0.38

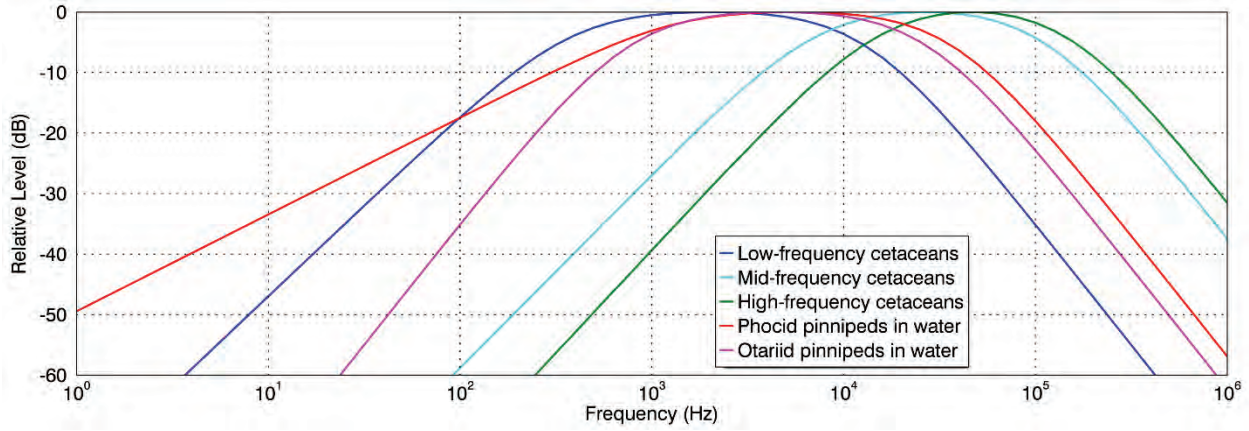


Figure A-4. Auditory weighting functions for functional marine mammal hearing groups as recommended by Finneran (2015).

A.5. Sound Propagation Models

A.5.1. Transmission Loss

The propagation of sound through the environment was modeled by predicting the acoustic transmission loss—a measure, in decibels, of the decrease in sound level between a source and a receiver some distance away. Geometric spreading of acoustic waves is the predominant way by which transmission loss occurs. Transmission loss also happens when the sound is absorbed and scattered by the seawater, and absorbed scattered, and reflected at the water surface and within the seabed. Transmission loss depends on the acoustic properties of the ocean and seabed; its value changes with frequency.

If the acoustic source level (SL), expressed in dB re 1 µPa @ 1 m, and transmission loss (TL), in units of dB, at a given frequency are known, then the received level (RL) at a receiver location can be calculated in dB re 1 µPa @ 1 m by:

$$\mathrm{RL} = \mathrm{SL} - \mathrm{TL} \, . \qquad \text{(A-11)}$$

A.5.2. Acoustic Propagation with MONM

Underwater sound propagation (i.e., transmission loss) at frequencies of 10 Hz to 2 kHz was predicted with JASCO's Marine Operations Noise Model (MONM). MONM computes received per-pulse SEL for directional impulsive sources, and SEL over 1 s for non-impulsive sources, at a specified source depth.

MONM computes acoustic propagation via a wide-angle parabolic equation solution to the acoustic wave equation (Collins 1993) based on a version of the U.S. Naval Research Laboratory's Range-dependent

Acoustic Model (RAM), which has been modified to account for a solid seabed (Zhang and Tindle 1995). The parabolic equation method has been extensively benchmarked and is widely employed in the underwater acoustics community (Collins et al. 1996). MONM accounts for the additional reflection loss at the seabed, which results from partial conversion of incident compressional waves to shear waves at the seabed and sub-bottom interfaces, and it includes wave attenuations in all layers. MONM incorporates the following site-specific environmental properties: a bathymetric grid of the modeled area, underwater sound speed as a function of depth, and a geoacoustic profile based on the overall stratified composition of the seafloor.

MONM computes acoustic fields in three dimensions by modeling transmission loss within two-dimensional (2-D) vertical planes aligned along radials covering a 360° swath from the source, an approach commonly referred to as N×2-D. These vertical radial planes are separated by an angular step size of $\Delta\theta$, yielding N = 360°/$\Delta\theta$ number of planes (Figure A-5).

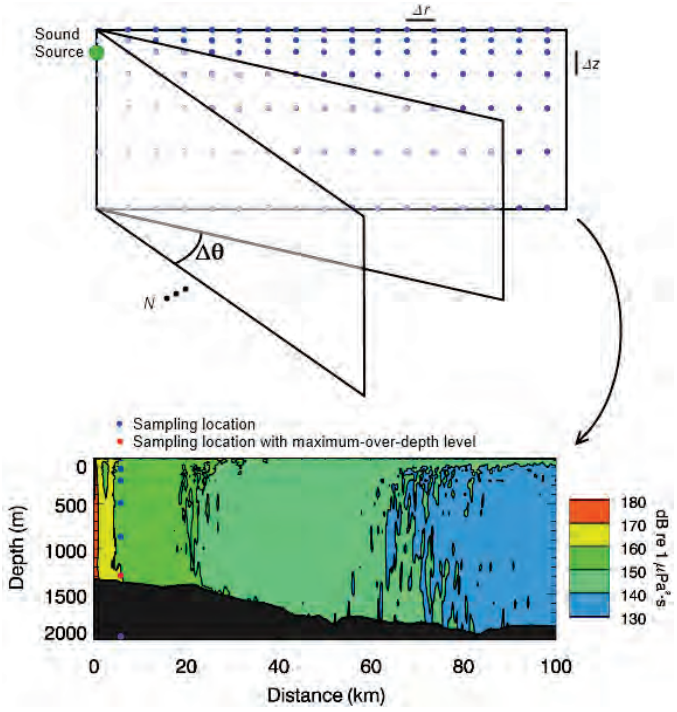


Figure A-5. The N×2-D and maximum-over-depth modeling approach used by MONM.

MONM treats frequency dependence by computing acoustic transmission loss at the center frequencies of 1/3-octave-bands. Sufficiently many 1/3-octave-bands, starting at 10 Hz, are modeled to include the majority of acoustic energy emitted by the source. At each center frequency, the transmission loss is modeled within each of the N vertical planes as a function of depth and range from the source. The 1/3-octave-band received per-pulse SEL are computed by subtracting the band transmission loss values from the directional source level in that frequency band. Composite broadband received SEL are then computed by summing the received 1/3-octave-band levels.

The frequency-dependent transmission loss computed by MONM may be corrected to account for the attenuation of acoustic energy by molecular absorption in seawater. The volumetric sound absorption is quantified by an attenuation coefficient, expressed in units of decibels per kilometer (dB/km). The absorption coefficient depends on the temperature, salinity, and pressure of the water as well as the sound frequency. In general, the absorption coefficient increases with the square of frequency. The absorption of acoustic wave energy has a noticeable effect (>0.05 dB/km) at frequencies above 1 kHz. For example, at 10 kHz the absorption loss over 10 km distance can exceed 10 dB. This coefficient for seawater can be computed according to the formulae of François and Garrison (1982b, b), which

consider the contributions of pure seawater, magnesium sulfate, and boric acid. The formula applies to all oceanic conditions and frequencies from 200 Hz to 1 MHz. For this project, absorption coefficients were computed and applied for all modeled frequencies. Because of the computational expense associated with parabolic equation modeling at frequencies at or above several kHz and the relative importance of absorption at such frequencies, the transmission loss in each frequency band between 6 and 32 kHz was approximated from the transmission loss computed at 5 kHz by applying the correct frequency-dependent absorption coefficient in each band.

The received per-pulse SEL sound field within each vertical radial plane is sampled at various ranges from the source, generally with a fixed radial step size. At each sampling range along the surface, the sound field is sampled at various depths, with the step size between samples increasing with depth below the surface. The step sizes are chosen to provide increased coverage near the depth of the source and at depths of interest in terms of the sound speed profile. For areas with deep water, sampling is not performed at depths beyond those reachable by marine mammals. The received per-pulse SEL at a surface sampling location is taken as the maximum value that occurs over all samples within the water column, i.e., the maximum-over-depth received per-pulse SEL. These maximum-over-depth per-pulse SEL are presented as color contours around the source.

MONM's predictions have been validated against experimental data from several underwater acoustic measurement programs conducted by JASCO (Hannay and Racca 2005, Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010, Racca et al. 2012a, Racca et al. 2012b, Martin et al. 2015).

An inherent variability in measured sound levels is caused by temporal variability in the environment and the variability in the signature of repeated acoustic impulses (sample sound source verification results is presented in Figure A-6). While MONM's predictions correspond to the averaged received levels, cautionary estimates of the threshold radii are obtained by shifting the best fit line (solid line, Figure A-6) upward so that the trend line encompasses 90% of all the data (dashed line, Figure A-6).

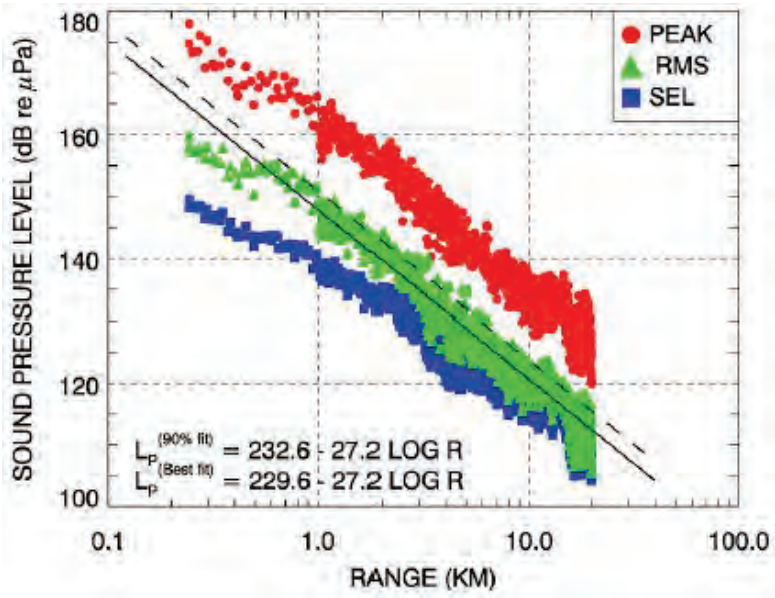


Figure A-6. Peak and SPL and per-pulse SEL versus range from a 20 in^3 air gun array. Solid line is the least squares best fit to SPL. Dashed line is the best fit line increased by 3.0 dB to exceed 90% of all SPL values (90th percentile fit) (Ireland et al. 2009, Figure 10).

Sound source verification results show that this 90th percentile best-fit is, on average, 3 dB higher than the original best fit line for sources in water depths greater than 20 m (Aerts et al. 2008, Funk et al. 2008, Ireland et al. 2009, O'Neill et al. 2010, Warner et al. 2010). Consequently, a safety factor of 3 dB is

customarily added to the predicted received levels to provide cautionary results reflecting the inherent variability of sound levels in the modeled area.

The transmission loss computed by MONM can be further corrected to account for the attenuation of acoustic energy by molecular absorption in seawater. The volumetric sound absorption is quantified by an attenuation coefficient, expressed in units of decibels per kilometer (dB/km). The absorption coefficient depends on the temperature, salinity, and pressure of the water as well as the sound frequency. In general, the absorption coefficient increases with the square of frequency. The absorption of acoustic wave energy has a noticeable effect (>0.05 dB/km) at frequencies above 1 kHz. At 10 kHz, the absorption loss over a 10 km distance can exceed 10 dB. This coefficient for seawater can be computed according to the formulae of François and Garrison (1982b, 1982a), which consider the contribution of pure seawater, magnesium sulfate, and boric acid. The formulae apply to all oceanic conditions and frequencies from 200 Hz to 1 MHz.

A.5.3. Acoustic Propagation with FWRAM

For impulsive sounds, time-domain representations of the pressure waves generated in the water are required to calculate peak pressure level or to accuratly model sound propagating away from a vertical source array. For this study, synthetic pressure waveforms were computed using FWRAM, which is a time-domain acoustic model based on the same wide-angle parabolic equation (PE) algorithm as MONM. FWRAM computes synthetic pressure waveforms versus range and depth for range-varying marine acoustic environments, and it takes the same environmental inputs as MONM (bathymetry, water sound speed profile, and seabed geoacoustic profile). Unlike MONM, FWRAM computes pressure waveforms via Fourier synthesis of the modeled acoustic transfer function in closely spaced frequency bands. FWRAM employs the array starter method to accurately model sound propagation from a spatially distributed source (MacGillivray and Chapman 2012).

Synthetic pressure waveforms were modeled over the frequency range 10–2048 Hz, inside a 1 s window. The synthetic pressure waveforms were post-processed, after applying a travel time correction, to calculate PK and SEL metrics versus range and depth from the sources.

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APPENDIX H

Hard Seafloor Feature Report

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FUGRO

Desktop Study Analysis of Hard Seafloor Features

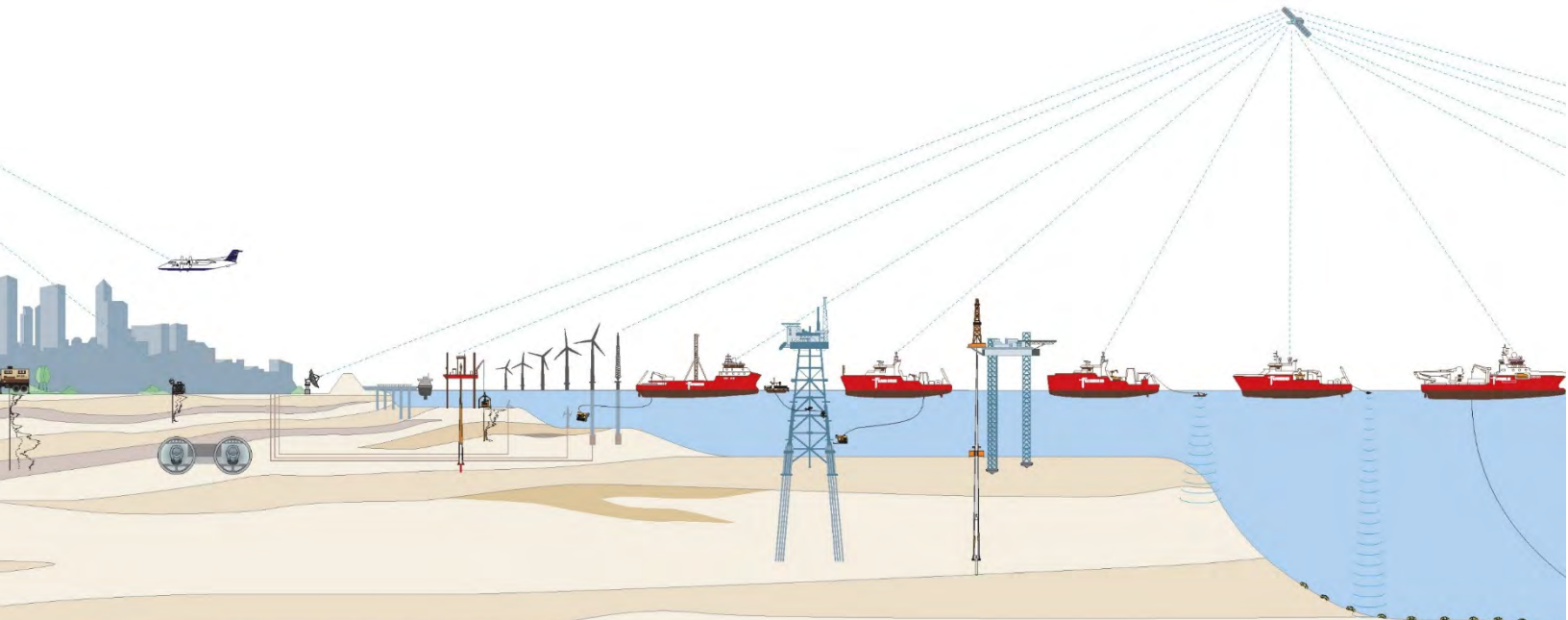
Payara and Liza Developments, Offshore Guyana

Date of Report: 24 May 2019
Date of Field Work: 17 September to 26 December 2018

Fugro Document No.: 1901-1538-HSFDTS

Esso Exploration and Production Guyana Limited

EEPGL



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Desktop Study Analysis of Hard Seafloor Features

Payara and Liza Developments, Offshore Guyana

Date of Report: 24 May 2019
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Esso Exploration and Production Guyana Limited

EEPGL

Prepared for:

Esso Exploration and Production Guyana Limited
c/o ExxonMobil Exploration Company
22777 Springwoods Village Parkway
Spring, Texas 77389
USA

Rev0	Draft	G. Harris-Bryant / K. Rovang / M. John / K.J. Campbell	L. E. Bush / S. Varnell	K.J. Campbell	24 April 2019
Rev1	Final	G. Harris-Bryant / K. Rovang / M. John / K.J. Campbell	S. Varnell	K.J. Campbell	24 May 2019
Issue	**Document Status**	**Prepared**	**Checked**	**Approved**	**Date**

Document No. 1901-1538-HSFDTS
24 May 2019

Fugro USA Marine, Inc.
6100 Hillcroft Ave
PO Box 740010
Houston, TX 77274
Phone: 713-369-5600
Fax: 713-778-6816

Esso Exploration and Production Guyana Limited
c/o ExxonMobil Exploration Company
22777 Springwoods Village Pkwy
Spring, TX 77389

Attention: Mr. Patrick Lee

Desktop Study Analysis of Hard Seafloor Features
Payara and Liza Developments, Offshore Guyana

Fugro USA Marine, Inc. (Fugro), is pleased to present this desktop study report for Esso Exploration & Production Guyana Limited's (EEPGL's) Payara and Liza deepwater development areas offshore Guyana. This report describes the distribution, estimated areal density, and general nature of small but hard seafloor features (HSFs) and associated fauna found scattered across much of the development areas. The purpose of this study is to give a preliminary characterization of the HSFs and associated fauna, make a preliminary determination of how common the HSFs may be in the deep ocean globally, and potentially provide a basis for planning more detailed investigation of HSFs. The work is principally based on analysis of side scan sonar (SSS) survey data and seafloor photographs.

This work was carried out as authorized by EEPGL P.O. number 4501462651 dated 14 March 2019 and issued under Agreement A2656233 dated 14 August 2018. This report was prepared in general accordance with ExxonMobil Development Company's request for proposal received via email from Patrick Lee dated 15 February 2019, in accordance with Fugro proposal submitted via email from Kerry J. Campbell to Patrick Lee dated 4 March 2019, and as otherwise agreed with EEPGL's representative, Patrick Lee.

Fugro appreciates the opportunity to be of service to you on this project as your geoscience and environmental consultants. Please contact us if you have questions or if we can be of further assistance.

Sincerely,
FUGRO USA MARINE, INC.

Morgan John
Supervising Geoscientist

Steve Varnell, P.G., C.E.G
Senior Consultant Geoscientist

STATE OF TEXAS
Stephen L. Varnell
Geology
License #11337
LICENSED
PROFESSIONAL GEOSCIENTIST

Geraint Harris-Bryant
Chief Enviromental Scientist

Kat Rovang
Project Geoscientist | GIS Analyst

Kerry J. Campbell, P.G.
Principal Consultant

STATE OF TEXAS
Kerry J. Campbell
Geology
1904
LICENSED
PROFESSIONAL GEOSCIENTIST

Copies submitted: 1 Digital Copy

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EXECUTIVE SUMMARY

This report was prepared by Fugro USA Marine, Inc., as authorized by EEPGL P.O. number 4501462651 dated 14 March 2019 and issued under Agreement A2656233 dated 14 August 2018.

This desktop study presents first-order estimate results of the number and spatial coverage of hard seafloor features (HSFs) identified in autonomous underwater vehicle (AUV) geophysical data that cover the Payara Field Development (PFD) and Liza Field Development (LFD) areas. A first-order estimate of the biological coverage and abundance coincident to HSFs was also performed using seafloor photographs. Furthermore, a literature review and an internal Fugro experience review were conducted to determine the 'uniqueness' of abundance of HSFs on a global scale.

HSFs are numerous coarser-grained to hard rocky areas <1 m to 4 m in diameter as interpreted on the AUV geophysical data and photographs. HSFs are generally flat; however, appear as a mound-like feature on the AUV multibeam bathymetry (maximum relief is <50 cm). Subtle depressions are also observed surrounding the HSF which are typically <50 cm deep. A small portion of an HSF was sampled in a 2018 Fugro Environmental Baseline Survey box core (EBSBC005) providing evidence of a thin, stratified 'crust' on the seafloor. HSFs are interpreted as fluid expulsion features resulting from dewatering and/or degassing of buried turbidites and mass transport deposits (MTDs). Some vents could still be active based on water-column anomalies that were identified in the sub-bottom profiler (SBP) data and appear to correlate with the HSFs.

Spatial distributions of HSFs were estimated from auto-mapping techniques using AUV SSS data and AUV photographs. Based on the widespread AUV SSS coverage, HSF densities are estimated to range from <500 to ~8,000 HSFs per km^2 (under-sampling of HSFs may be as much as ~20% due to data resolution limitations). Based on AUV photographs, HSF densities are estimated to range from 8,659 to 16,881 HSFs per km^2. The two auto-mapping results (AUV SSS vs AUV photographs) show obvious discrepancies; however, we believe this is due to resolution limitations with the AUV SSS data and limited coverage with the AUV photographs. Even the higher densities of HSFs estimated from the AUV photographic data analysis suggest that HSFs cover less than 1% of the seafloor across the Payara and northern Liza Field Development areas.

Environmental-biological analysis of HSFs was performed through detailed analysis of AUV photographs of 80 HSFs, supplemented by video and photographs acquired during the EBS conducted within the PFD area. Epifaunal coverage on the HSFs was generally low, ranging from 0% (no visible fauna) to 45% cover (mean of 11%). The dominant taxa present, in terms of both coverage and abundance, were sponges (phylum Porifera). The most abundant taxon overall was a glass sponge (Hexactinellida) tentatively identified as *Poliopogon amadou*. All epifauna identified were ubiquitous deepwater taxa and no sensitive communities/species (e.g. chemosynthetic communities and corals) were identified from the HSF community.

Literature searches and an internal check of Fugro's global experience revealed no directly comparable geological features similar to the HSFs reported here.

Conclusions

i. HSFs are unique geologic features in Fugro's experience and direct comparisons have not been identified from published literature.

ii. It is probable that HSFs are formed by dewatering and/or degassing of underlying sediments and concretion of material through chemical/microbiological processes at the seafloor.

iii. HSFs support an epifaunal community that is ubiquitous on deepwater hard substrata within the region and elsewhere in the world.

iv. HSFs are widespread within the Payara and northern Liza Field Development areas and the proposed developments are unlikely to impact the viability of those epifaunal communities which are present in the long term.

Recommendations

i. Further visual inspection of HSFs to gain high resolution imagery of the features and their biological communities.

ii. Further physical sampling of HSFs to allow geotechnical/geochemical testing of the HSF material and taxonomic analysis of dominant epifauna.

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APPENDICES

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ABBREVIATIONS

AUV	Autonomous underwater vehicle
CS	Camera site
EBS	Environmental baseline survey
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental impact assessment
EMDC	ExxonMobil Development Company
FPSO	Floating production storage and offloading
FUSAMI	Fugro USA Marine, Inc.
HSF	hard seafloor feature
LFD	Liza Field Development
MBES	Multibeam echosounder (provides water depth and seafloor reflectivity data)
MDAC	Methane-derived authigenic carbonates
MSL	Mean sea level
MTC	Mass transport *complex* (complex of multiple submarine debris flow, slide or slump deposits)
MTD	Mass transport *deposit* (individual submarine debris flow, slide or slump deposit)
PFD	Payara Field Development
PSU	Practical salinity units
ROV	Remotely operated vehicle
SBP	Sub-bottom profiler
SSS	Side scan sonar
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984
WCA	Water column anomaly

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1. INTRODUCTION

This report describes the distribution, estimated areal density, and general nature of small but hard seafloor features (HSFs) and associated fauna found scattered across much of the proposed Payara and Liza deepwater development areas, offshore Guyana (Map 1).

1.1 Purpose

The purpose of this study is to give a preliminary characterization of the HSFs and associated fauna, make a preliminary determination of how common the HSFs may be in the deep ocean globally, and potentially provide a basis for planning more detailed investigation of HSFs.

1.2 Scope

The scope is limited principally to analysis of side scan sonar (SSS) survey data and of seafloor photographs. The SSS data and photos were collected during pre-development autonomous underwater vehicle AUV and shallow sampling survey campaigns of the proposed Payara and Liza Field Development areas (Fugro, 2016a, 2017, and 2019a). However, these large sub-regional surveys were not designed specifically to collect data for HSF analysis. Approximately 8,500 line-km of SSS data were used for mapping the HSFs found in the Payara and Liza areas. About 14,000 seafloor photographs were collected over eight AUV camera sites within Payara of which a representative subsample was analyzed in detail (one camera line per site; 80 HSFs total). We also did a limited literature search and an internal Fugro experience search in an attempt to determine how common the HSFs may be globally. A small amount of hard seafloor material recovered from one box core EBSBC5 (Fugro, 2019b) that sampled an HSF by chance is undergoing lab analysis and results will be reported separately.

1.3 SSS/Photo Reconciliation

Estimates of HSF areal density based on analysis of SSS data and separately on analysis of seafloor photos are noticeably different. This is not surprising given the several differences between, and the respective limitations of, these two methods. Further discussions are noted primarily in Section 6. Detailed reconciliation of the discrepancy is beyond the scope of this preliminary HSF characterization.

1.4 Report Organization

The text is organized by task as defined by Exxon in the original request for proposal. Figures and summary tables are embedded in the text. Page- and tabloid-size maps and three large-format charts follow the text. Appendix A and Appendix B follow the large-size charts.

1.5 Technical Contributors

Morgan John, Supervising Geoscientist, was the geoscience lead, and Kat Rovang, Project Geoscientist/GIS Analyst, provided geoscience and GIS support. Geraint Harris-Bryant, Chief Environmental Scientist, was the biological and photo analysis lead. Shane Smith, Deputy Geoscience Manager, assisted with the literature search. Steve Varnell, Senior Consultant Geoscientist, and Jo Lusted, Ecology Group Survey Manager, provided technical review. Kerry J. Campbell, Principal Consultant, provided geoscience input and overall project management.

2. GEOPHYSICAL/GEOLOGICAL DESCRIPTION OF HSFs

This section provides descriptions, geophysical properties, and estimated areal density of the HSFs based on the AUV multibeam echosounder (MBES) bathymetry and backscatter, side scan sonar (SSS), and sub-bottom profiler (SBP) data collected within Exxon's Payara Field Development (PFD) and Liza Field Development (LFD) areas. Further information such as potential hazards and constraints considerations regarding HSFs can be found in Fugro, 2019c and Fugro, 2018 (HSFs referred to as "speckles" in the 2018 Liza report).

2.1 Hard Seafloor Features (HSFs)

Numerous HSFs are observed throughout the PFD area and northern portion of the LFD area. Water depths where HSF are principally observed within the PFD and LFD areas range from 1,500 m below mean sea level (MSL) to 2,195 m below MSL (Chart 1). However, these features appear as individual anomalies of high-intensity MBES backscatter and high SSS reflectivity that create a "speckle" pattern on the seafloor (see inset maps on Chart 2). Based on the AUV MBES and SSS data, HSFs are individually <1 m to 4 m in diameter and can appear as subtle mound-like feature <50 cm above the ambient seafloor. AUV SBP data show HSFs correlate well with seabed disturbances and diffractions at the seafloor. Many AUV SBP water column anomalies (WCAs) also were identified above HSFs suggesting potentially active dewatering and/or degassing of underlying shallow buried turbidites and mass transport deposits (MTDs); however, WCAs may be attributed to anomalous reflections caused by the hard composition of the HSFs (Fugro, 2019c). HSF areal density also correlate well with the thickness of Soil Unit PY1 (stratified sediments) and Soil Unit PY2 (shallow regional mass transport complex (MTC) sediments). The thinner Soil Unit PY1 and the thicker Soil Unit PY2 (especially where Soil Unit PY2 comprises younger, stacked MTDs), the denser the HSFs cover the seafloor (Fugro, 2019c).

Higher-resolution AUV geophysical data and photographs collected from eight low-altitude (~6 m above the seafloor) camera survey sites, and photographs from an EBS drop camera (Station EBSDDV5; Fugro, 2019b) show HSFs comprise principally of rocky, gravelly material. No active seeps were detected from the photographs. Fugro sampled an HSF from environmental baseline survey box core EBSBC5 which provided evidence of a thin, stratified 'crust' on the seafloor (Figure 2.1).



Figure 2.1: Hard Seafloor Feature Subsample from box core station EBSBC5 (Fugro, 2019b) sent to Houston, Texas (scale in centimeters).

2.2 Charts

Large-format charts accompanying this report are presented at a scale of 1:65,000, and are as follows:

i. **Chart 1: Water Depth** derived from AUV MBES bathymetry data collected over the PFD and LFD areas.
ii. **Chart 2: Representative Distribution of Hard Seafloor Features within the Liza and Payara AUV Survey Areas** produced by auto-mapping HSFs using SSS data over the PFD and LFD areas. Zoom-in inset maps show SSS mosaics within the PFD and LFD areas. The other two zoom-in maps show AUV photomosaics of HSFs located southeast of the Pacora-1 well.
iii. **Chart 3: Estimated Areal Density of Hard Seafloor Features within the Liza and Payara AUV Survey Areas** produced by converting the auto-mapped HSF polygons in Chart 2 to points. An estimated areal density raster was generated using the points within a defined neighborhood of 1 km² across the PFD and LFD areas. Warmer colors indicate a greater estimated density of HSFs (per km²). Cooler colors indicate of lower estimated density of HSFs (per km²).

2.3 Methodology for Extracting Estimated Areal Density of HSFs from AUV Side Scan Sonar Data

ESRI ArcGIS 10.4.1 was used to auto-map HSFs using the AUV low- and high- frequency SSS mosaics. The low-frequency SSS mosaics cover large areas of the PFD (~400 km²) and LFD (~500 km²) areas. The high-frequency SSS mosaics cover only eight small areas (0.40 km² total) southeast of the Pacora-1 well. High reflectivity areas from the SSS mosaics were isolated, extracted, and converted to polygons. Drill cuttings from existing wells that produce similar high SSS reflectivity areas were cleaned from the HSF polygon dataset. No other features within the PFD and LFD areas produced high reflectivity in the SSS mosaics except data artifacts. Data artifacts and duplicated auto-mapping within the overlapping Payara and Liza SSS mosaics were also cleaned from the final HSF polygon dataset. Based on the observation of the auto-mapping results, it is estimated that HSF auto-mapping methods may have been under sampled by some ~20% (see Section 6.1).

The auto-mapped polygons were then converted to points and used to generate an estimated areal point density raster (Chart 3). A defined neighborhood of 1 km² was used across the low-frequency SSS-derived points that cover the PFD and LFD areas. A defined neighborhood of 1 m² was used across the high-frequency SSS-derived points that cover the eight AUV camera sites located southeast of the Pacora-1 well.

2.4 Results from Extracting Estimated Areal Density of HSFs from AUV Side Scan Sonar Data

The estimated areal density raster produced from the low-frequency SSS data auto-mapping show concentrations of HSFs distributed across the seafloor within the PFD and LFD areas. Each color-classified region on Chart 3 represents an estimated range of HSFs per km². Warmer colors indicate a greater estimated density of HSFs (per km²). Cooler colors indicate a lower estimated density of HSFs (per km²). Map 2 shows the estimated areal density around proposed Payara floating production storage and offloading (FPSO) anchor locations is as high as 7,000 per km² at the northwest cluster and as low as 1,000 at the southeast cluster. Map 3 shows the estimated areal density at proposed Payara drill center locations is typically 2,000 to 3,000 HSFs per km², but can be as high as 6,000 HSFs per km² at drill center PY2-P and as low as 500 per km² at drill center PY1-I and DC5-I.

The estimated areal density produced from the high-frequency SSS data auto-mapping at the eight AUV camera sites produced comparable results to the low-frequency SSS mosaic auto-mapping (Table 2.1).

Table 2.1: Summary of Point Density Analyses, Payara and Liza Field Development Areas

SSS Dataset	Search Neighborhood	Minimum Number of HSFs	Maximum Number of HSFs	Average Number of HSFs
Low Frequency Payara and Liza AUV SSS Data (0.50 m per pixel)	1 km²	0	7,617	761
High Frequency Payara AUV SSS Camera Data (0.10 m per pixel)	1 m²	0.8	8	0.0006

Note: The table above show the comparable estimated areal density results between the low- and high-frequency SSS-derived auto-mapping; however, a scale factor from m^2 to km^2 (1000^2) must be applied due to 1) the differences in data coverage and resolution between the SSS datasets and 2) the difference in neighboring window used.

A linear density analysis was also conducted to verify the alignment between the estimated areal density zones produced from the tool and the actual occurrence of auto-mapped polygons along randomly generated 1 km lines isolated to each color-classified zone within a 0.5-m buffer (0.25 m on either side). From those estimates, the Table 2.2 describes the minimum, maximum, and average population of intersecting HSFs within each color-classified zone of lines. A case example using this table would be, within the green area (4,000 to 5,000 HSFs per km^2), one would expect as little as 4 HSFs and as many as 23 HSFs (11 mean) per kilometer along a flowline.

Table 2.2: Summary of Linear Density Analysis, Payara and Liza Field Development Areas

Color-Classified Zone	Density Range (per km²)	Minimum Number of Intersecting HSFs per km	Maximum Number of Intersecting HSFs per km	Average Number of Intersecting HSFs per km	Pertaining Payara AUV Camera Sites (CS) Nos.
Magenta	0 – 1,000	0	4	1	CS 1
Purple	1,000 – 2,000	0	6	3	CS 1
Dark Blue	2,000 – 3,000	1	10	7	CS 1
Blue	3,000 – 4,000	3	15	9	CS 2
Green	4,000 – 5,000	4	23	11	CS 2, CS 3, and CS 4
Yellow	5,000 – 6,000	10	21	16	CS 3, CS 4, CS 5, and CS 6
Orange	6,000 – 7,000	14	26	19	CS 4, CS 6, CS 7, and CS 8
Red	7,000 – 8,000	16	35	23	CS 7

3. BIOLOGICAL/ENVIRONMENTAL ANALYSIS OF HSFs

Detailed analysis of the estimated areal density, and the physical properties and biological community characteristics of the HSFs was undertaken using AUV photographs at eight camera sites southeast of the Pacora-1 well. Further information regarding the composition of the HSFs biological communities was also inferred from drop-down camera data acquired during the PFD area EBS campaign (Fugro, 2019b).

3.1 Methodology for Extracting Estimated Areal Density of HSFs from AUV Photographs

In order to provide a sufficiently detailed analysis within the time available for production of this study, only a subset of the AUV photographs was analyzed. Between five and ten AUV camera survey lines were run over each camera site. A single line from each site was selected to characterize HSFs present. The number of HSFs along each line were counted and then ten HSFs were random selected to determine physical and biological community characteristics; only HSFs that were completely visible in a single photograph were selected for analysis. Table 3.1 presents a summary of the analysis. A detailed log with the coordinates and physical characteristics of all HSFs analyzed is provided in Appendix B. Sections 3.1.1 and 3.1.2 describe the analysis procedure from AUV camera data. Figure 3.1 provides an annotated example of the analysis.

Table 3.1: Summary of AUV Camera Survey Lines Analyzed, Payara AUV Camera Sites

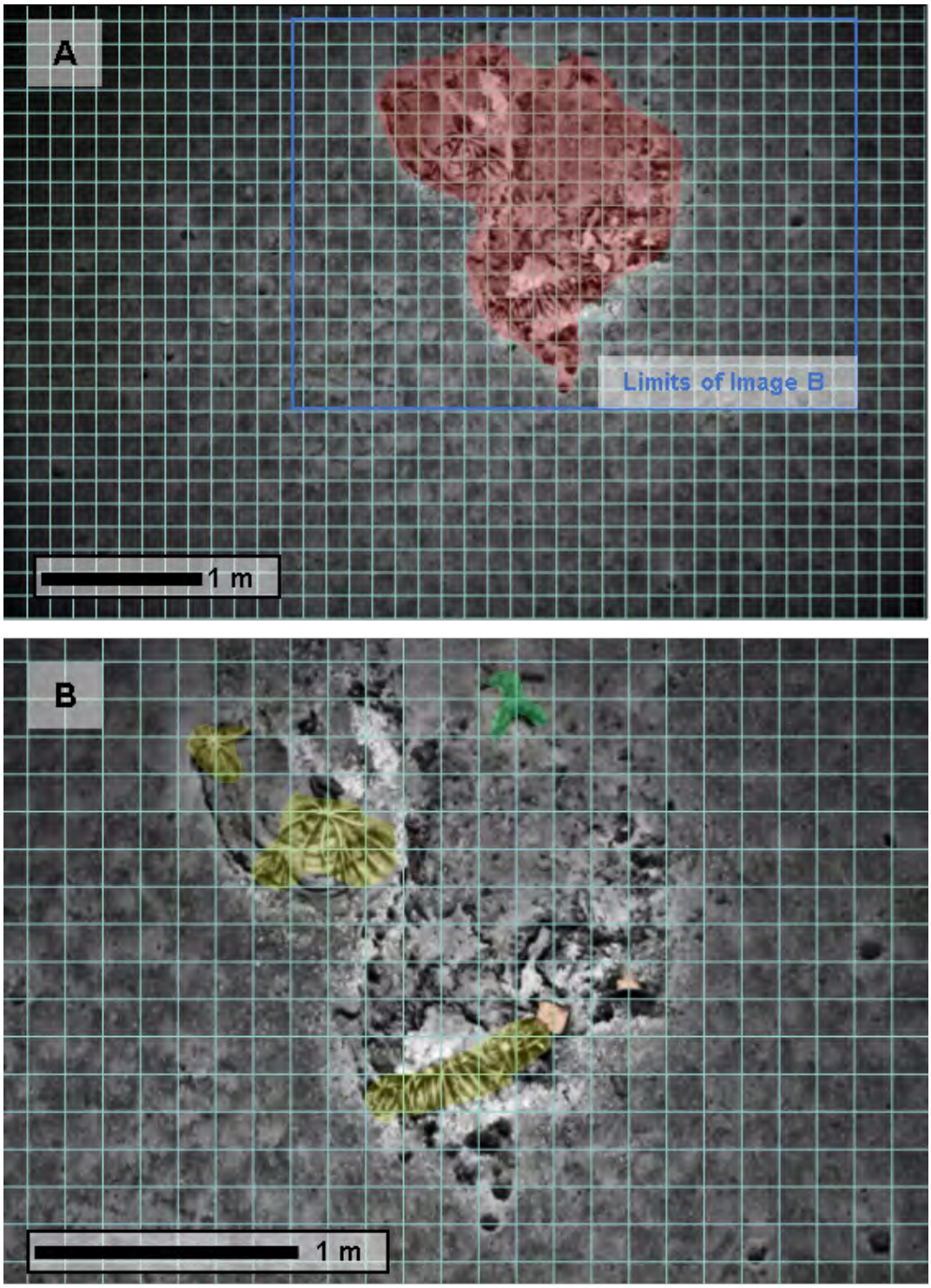
Geodetic Parameters: WGS84 UTM Zone 21N								
Site	Line	Start of Line			End of Line			Survey Heading [°]
		Easting [m]	Northing [m]	Depth [m MSL]	Easting [m]	Northing [m]	Depth [m MSL]	
1	G18R3004	497,659.7	912,642.2	2,049.4	498,032.4	912,341.1	2,039.1	132
2	G18R3009	499,674.6	912,420.5	2,043.3	500,235.1	912,136.3	2,039.6	119
3	G18R3014	499,324.1	911,901.7	2,029.2	498,898.4	912,119.4	2,033.9	295
4	G18R3021	499,988.4	911,534.8	2,025.7	500,469.8	911,856.1	2,036.9	54
5	G18R3029	500,762.3	911,552.1	2,033.3	501,309.1	911,705.0	2,044.1	73
6	G18R3034	499,231.3	911,469.6	2,020.8	498,806.4	911,687.7	2,024.6	295
7	G18R3040	499,102.7	910,751.0	2,004.0	499,504.9	910,333.0	1,997.5	137
8	G18R3045	499,293.1	910,076.5	1,990.3	499,723.2	909,873.2	1,993.1	117

Notes:
* = Mean AUV heading for all images acquired
MSL = Mean Sea Level

3.1.1 AUV Photograph Methodology for Physical Characterisation of HSFs

In order to determine to physical dimensions of the HSFs, the images of each feature were loaded into mapping software *Surfer V9* and superimposed with a grid that differentiates the photographs into 50-pixel wide squares. The following measurements were generated by counting the grid squares superimposed on the imagery and multiplying these by a scaling factor (50 pixels = 14.22 cm):

- HSF length (maximum dimension along its longest axis)
- HSF width (maximum dimension along the axis perpendicular to its longest axis)
- HSF area (generated by counting all grid squares superimposed on the HSF)



Note: Site 8, Line G18R3045, Image 0000020489F.tif
Image A: Interpreted HSF outline (red highlight) used to calculate length (800 pixels = 2.0 m), width (600 pixels = 1.8 m) and area (365,000 pixels = 2.1 m^2)
Image B: Coverage of taxa present: Brissingida (yellow) = 10 % (8 individuals); Hexactinellida (orange) = 1 % (2 colonies); indeterminate (green) = 1 % (1 colony). Total faunal coverage = 12 %.

Figure 3.1: Diagram of Imagery Analysis Methodology

Density of HSFs and an estimated overall coverage of HSFs on the seafloor have been calculated using each AUV camera line. These have been extrapolated to derive an estimate of mean HSF total coverage for the eight AUV camera survey sites. When counting, HSFs that were only partially visible at the edges of the camera's field of view were partially counted (0.25, 0.5 or 0.75) to avoid overestimated density.

These measurements were used to derive estimates of the likely range of HSF dimensions across the PFD and LFD areas and to extrapolate the overall estimated areal coverage of HSFs on the seafloor. This is contrasted with the auto-mapping performed using the AUV geophysical data discussed in Section 2. This methodology only provides an approximation of HSF physical dimensions, but this level of accuracy is deemed adequate for this study. More accurate scaling of the features could be achieved only by performing full photo-mosaicking (image rectification and georeferencing) of data to correct for water column diffraction and lens curvature and to compensate for slight changes in AUV altitude, pitch, and roll.

3.1.2 AUV Photograph Methodology for Biological Characterisation of HSFs

The epifauna present on each HSF was identified to the lowest practicable level and quantified in term of both percentage cover and abundance counts of individual taxa. Taxa that were not directly associated with HSFs (i.e. pelagic taxa and those inhabiting adjacent sediments) were not included in the quantitative analysis, but comments regarding the identities of these have been added to Appendix B.

The total cover (%) was typically rounded to the nearest 10% of the total HSF area, although taxa contributing lower coverage than 10% were also given nominal cover classifications of 1% (representing taxa that appeared to occupy less than 2.5% of the HSF) and 5% (taxa that appeared to occupy 2.5% to 7.5% of the HSF). The total cover (%) assigned only attempts to quantify the percentage of photograph area occupied by each taxon. Although a few of the epifaunal taxa present had encrusting growth forms, this percentages assigned do not quantify the area of the HSF with which they are in direct contact. This is a standard limitation when analyzing any marine community from photographs.

A further limitation when analyzing marine fauna from photographic data is the inability to achieve high levels of taxonomic resolution (e.g. to identify animals to genus/species level), which typically requires physical examination of captured specimens. Taxonomic resolution in this study is further reduced, as deepwater taxa are poorly documented globally. Although the AUV photographs are of high quality, the relatively low resolution and lack of color further complicated the identification of taxa and may have resulted in smaller, cryptic taxa being missed during data analysis. Because of these factors, records have been maintained at a purposefully high taxonomic level (family level or higher), but attempts have been made to differentiate the morphs (visually differentiable taxa) evident from the data and some tentative identifications made where literature suggest that species may occur in comparable habitats.

3.2 AUV Photograph Results

3.2.1 Physical Characteristics of HSFs

Table 3.2 summarizes the physical characteristics of the 80 HSFs analyzed and provides derived estimated areal density of HSFs on each AUV camera survey line. A detailed log with the coordinates and physical characteristics of all HSFs analyzed is provided in Appendix B. Example photographs showing variations in HSF size and morphology are provided in Figure 3.2.

The HSFs range from 0.3 m to 2.8 m (mean 1.4 m) in length and range from 0.3 m to 2.8 m (mean 1.1 m) in width. As these measurements suggest, most HSFs are circular shape, but there were a number that were more irregular. Using the grid overlay method as described in section 3.1.1, the area of individual HSFs ranges from 0.1 m^2 to 3.8 m^2 (mean 1.1 m^2). The largest HSFs analyzed were observed at Camera Sites 5, 7, and 8 where HSFs of greater than 2 m^2 were recorded.

The number of HSFs recorded and analyzed per line range from 25 (Camera Site 1) to 46 (Camera Sites 6) total HSFs. HSF densities range from 8,659 (Camera Site 2) to 16,881 (Camera Site 6) HSFs per km^2. The derived estimated density of HSFs across the total camera survey area was 12,091 HSFs per km^2. The estimated coverage of HSFs along the AUV lines analyzed ranged 0.26% (Camera Site 3) to 1.49% (Camera Site 5) of the seafloor. This was extrapolated to derive an overall estimate of coverage for the total camera survey area of 0.85% of the seafloor. Higher densities of HSFs, and generally larger HSFs, were apparent at Camera Sites 5, 6, 7, and 8. This corresponds well with the auto-mapping of HSF using AUV geophysical data is discussed in Section 2.

The topography of the HSFs was hard to estimate from AUV photograph plan view, but most appeared to have little or no relief (less than 20 cm high). The oblique-view photographs acquired using a drop-down camera system during the EBS (Fugro, 2019b) clearly identified HSFs that were flat and barely protruded above the ambient seafloor (<5 cm relief). Localized sediment accumulation was evident on the ocean bottom current side of several HSFs analyzed, with the leeward edges of the features sometimes exposed above the sediment (Figure 3.2, Photograph C).

Although most HSFs observed from the AUV photographs show little relief from the seafloor, some features comprised small mounds with irregularly rounded structures and one HSF featured irregular, concentric ridge-like features (Figure 3.2, Photograph D). Discussion of the potential significance of these morphologies is provided in Section 6.

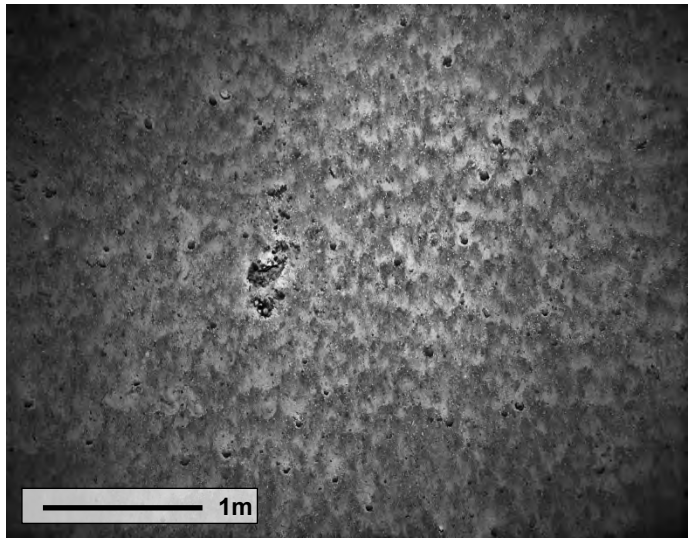
Table 3.2: Summary of HSF Physical Characteristics, PFD Area AUV Camera Sites

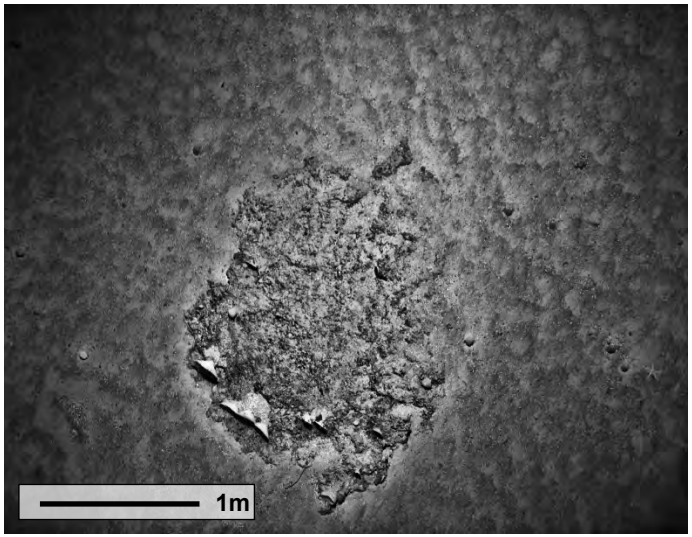
Site	AUV Line		HSF Dimensions			AUV Line Length [m] †	AUV Line Coverage [m²] ‡	Total Number HSFs per Line	Estimated Density [HSFs per km²]	Coverage [% of seabed] #
			Length [m]	Width [m]	Area * [m²]					
1	G18R3004	Min	0.7	0.6	0.6	479	2,730	25	9,158	0.46
		Max	2.0	1.7	2.0					
		Mean	1.4	1.0	1.2					
		SD	0.4	0.3	0.5					
2	G18R3009	Min	0.9	0.3	0.1	628	3,580	31	8,659	0.43
		Max	1.8	1.4	1.8					
		Mean	1.3	0.9	0.8					
		SD	0.4	0.4	0.5					
3	G18R3014	Min	0.7	0.7	0.4	478	2,725	36	13,211	0.26
		Max	1.7	1.1	1.0					
		Mean	0.8	0.8	0.8					
		SD	0.3	0.2	0.2					
4	G18R3021	Min	0.7	0.4	0.3	579	3,300	34	10,303	0.62
		Max	2.8	1.6	2.2					
		Mean	1.2	0.9	0.8					
		SD	0.6	0.3	0.6					
5	G18R3029	Min	1.1	1.0	0.6	568	3,238	37	11,427	1.49
		Max	2.8	2.6	3.8					
		Mean	1.8	1.5	1.6					
		SD	0.5	0.6	1.3					
6	G18R3034	Min	0.3	0.3	0.1	478	2,725	46	16,881	1.01
		Max	1.8	1.7	1.9					
		Mean	1.2	1.0	1.0					
		SD	0.6	0.4	0.6					
7	G18R3040	Min	0.9	0.6	0.4	580	3,306	44	13,309	0.80
		Max	2.1	1.7	2.1					
		Mean	1.5	1.1	1.2					
		SD	0.4	0.4	0.6					

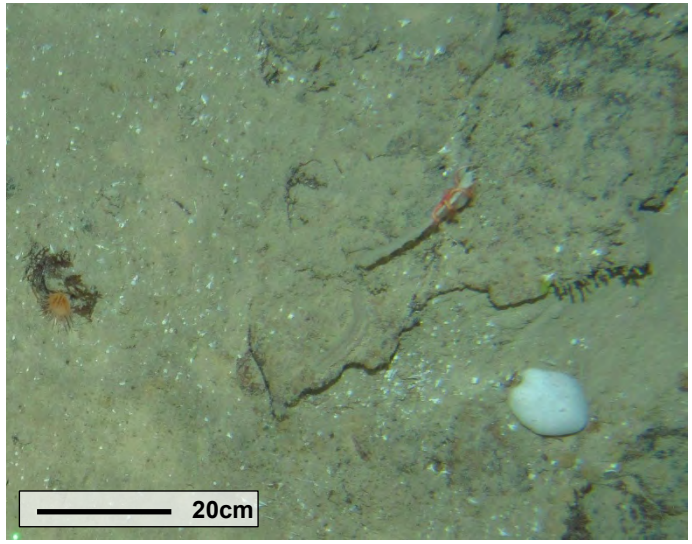
Site	AUV Line		HSF Dimensions			AUV Line Length [m] †	AUV Line Coverage [m²] ‡	Total Number HSFs per Line	Estimated Density [HSFs per km²]	Coverage [% of seabed] #
			Length [m]	Width [m]	Area * [m²]					
8	G18R3045	Min	1.2	1.0	0.8	476	2,713	41	15,112	0.91
		Max	2.8	2.0	3.2					
		Mean	1.8	1.5	1.9					
		SD	0.5	0.3	0.6					
Survey Area Overall		**Min**	**0.3**	**0.3**	**0.1**	**4,266 (Total AUV Line Length)**	**24,316 (Total AUV Line Coverage)**	**294 (Grand Total)**	**12,091**	**0.85**
		Max	**2.8**	**2.8**	**3.8**					
		Mean	**1.4**	**1.1**	**1.1**					
		SD	**0.5**	**0.5**	**0.7**					

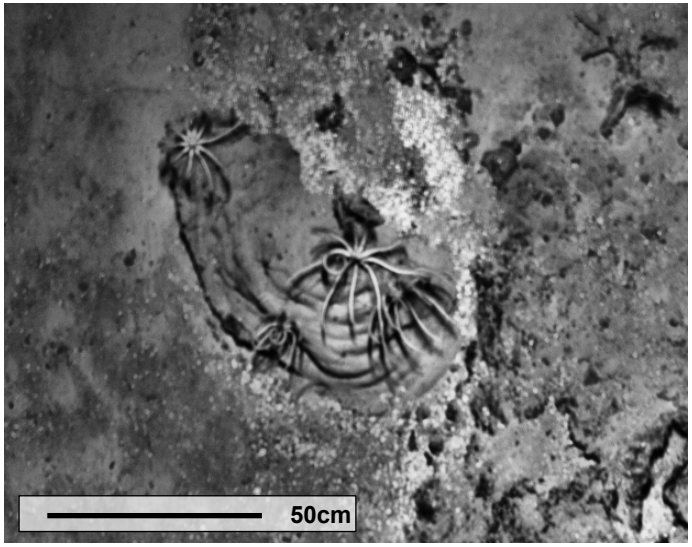
Notes:

* = area generated by counting all grid squares superimposed on the HSF
† = straight line distance from start to end of line
‡ = based on nominal camera field of view width of 5.7 m
= based on mean HSF area for AUV line/area, multiplied by the total number of HSFs recorded and divided by AUV line coverage
AUV = autonomous underwater vehicle
HSF = hard seabed feature









A: Site 2, Line G18R3009, Image 0000004421F.tif

A small HSF (0.9 m length by 0.3 m width, 0.1 m^2 area). This HSF is largely covered by sediment, with patchy outcrops along its length.

B: Site 5, Line G18R3029, Image 0000006877FN.tif

The largest of the HSFs identified from the analyzed dataset (2.6 m length by 2.6 m width, 3.8 m^2 area).

C: EBS Transect EBSDDV36, Image EBSDDV36_01.jpg

Drop-down camera image showing sediment accumulation on the upstream edge of an HSF, with undercutting on the leeward edge.

D: Site 8, Line G18R3045, Image 0000020489F.tif

An elevated HSF mound (ca. 20 cm relief) with a defined, ridge-like morphology.

Figure 3.2: Example photographs presenting variations in HSF size and morphology, PFD Area AUV Camera Sites

3.2.2 Biological Characteristics of HSFs

3.2.2.1 Epifaunal Community Statistics

A summary of the biological cover of the HSFs analyzed in detail is provided in Table 3.4, which provides summary statistics for epifaunal percentage cover, diversity (number of taxa) and abundance; the dominant taxa identified from each of the AUV camera survey lines are also listed. Full interpretative logs, detailing the cover and abundance of all taxa identified are provided in Appendix B.

The biological coverage on the HSFs analyzed in detail ranged from 0% (no visible epifauna) to 45% cover; the mean coverage derived from the analyzed dataset was 11%. In most cases, the highest levels of coverage were identified on smaller HSFs where single larger organisms covered significant portions of the features.

The diversity of taxa associated with HSFs appeared low, with between 0 and 4 taxa identified from the features analyzed in detail (mean of 2 taxa). The abundance of epifauna observed ranged from 0 to 17 individuals/colonies, with mean abundance per HSF of 4 individuals/colonies. While faunal diversity and abundance appeared low, it is highly probable that several cryptic taxa were overlooked within the area (see limitations detailed in Section 3.1.2).

3.2.2.2 Epifaunal Community Composition

A complete listing of the taxa identified from the detailed analysis of HSF imagery data is provided in Table 3.3. This also lists the mean coverage and abundance of taxa and their frequency of occurrence from the 80 HSFs analyzed. Example photographs of the fauna identified are presented in Figures 3.3 and 3.4; where possible color photographs from the EBS drop-down camera operations have been presented.

The most frequently occurring and abundant taxon overall, and that which contributed the highest level of epifaunal cover on the HSFs, was a distinctive ‘elephant ear’ sponge that has been tentatively identified as the Hexactinellid (glass sponge) *Poliopogon amadou*. This sponge contributed a mean coverage of 5.0% on the HSFs analyzed and was estimated to occur at an abundance of 2.2 colonies per HSF. Other poriferans (sponges) also were prominent in the HSF community, although these could not be identified with any degree of confidence and most were jointly quantified within a grouping of indeterminate taxa, which contributed a mean coverage of 2.7% of the HSFs and occurred at an abundance of 1.2 colonies per HSF; this grouping was the second most abundant and frequently occurring taxon within the dataset analyzed. More distinctive poriferan morphs that could be distinguished from the AUV images included a massive (fleshy) morph, a sponge with prominent osculae (pores) and a small spherical sponge, thought likely to be an Hexactinellid.

The only cnidarian that could be confidently identified from the imagery analysis was the black coral *Bathypathes* sp. This taxon was only identified from a single HSF and therefore made an inconsequential contribution to the overall faunal coverage (0.1%) and abundance (less than 0.1 colonies per HSF) within the area. The indeterminate grouping of taxa listed in Table 3.3 may also include cnidarians; a small, dark

colored and irregularly branched coral or hydroid (possibly an antipatharian) was observed from the drop-down camera data acquired during the EBS and may have formed part of this indeterminate grouping.

The third most frequently recorded taxon, contributing the third highest coverage and abundance on HSFs, was a brisingid seastar tentatively identified as *Freyella elegans*. This species occurred on 18.8% of HSFs, contributing a mean coverage of 1.4% of their area and a mean abundance of 0.3 individuals per HSF. Other echinoderms identified from the AUV images included brittlestars that may belong to the family Ophionereidae (as identified from EBS sample analysis; Fugro, 2019b) and indeterminate seastars and crinoids. None of these occurred at high frequency (recorded from 8.8% or fewer of the HSFs) and their contribution to epifaunal cover and abundance was minimal.

The only fish observed in association with an HSF was an eelpout of the family Zoarcidae, which was recorded in association with a single feature. Because this is errant and will not remain in situ on the feature, coverage was not quantified. Although this taxon could not be identified beyond family level with any degree of confidence, it is possibly a member of the snake eelpout genus *Lycodonus*.

Table 3.3: Epifaunal Taxa Associated with HSFs in the PFD Area AUV Camera Sites

Phyla	Taxa	Mean Coverage [%] *	Mean Abundance [N]*	Frequency (No.) †	Frequency [%] †
PORIFERA (Sponges)	Porifera (indeterminate)	2.7	1.2	41	51.3
	Porifera (massive)	0.6	0.1	3	3.8
	Hexactinellida? (spherical)	0.7	0.2	12	15.0
	Porifera (osculate)	0.1	< 0.1	1	1.3
	Hexactinellida (*Poliopogon amadou*?)	5.0	2.2	57	71.3
CNIDARIA (Corals)	*Bathypathes* sp.	0.1	< 0.1	1	1.3
ECHINODERMATA (Seastars and Urchins)	Crinoidea	0.1	0.1	4	5.0
	Ophiuroidea (Ophionereidae?)	0.1	0.1	7	8.8
	Asteroidea	0.2	0.1	6	7.5
	Brisingida (*Freyella elegans*?)	1.4	0.3	15	18.8
CHORDATA (Fish)	Zoarcidae	N/A	< 0.1	1	1.3
N/A	Indeterminate	0.8	0.2	13	16.3

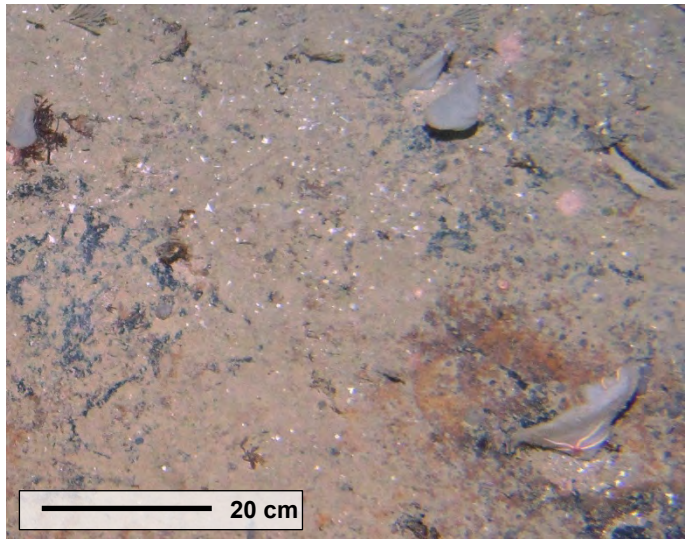
Notes:
* = mean coverage and abundance per HSF
† = frequency of occurrence within the analyzed AUV imagery subset of 80 images
HSF = hard seabed feature

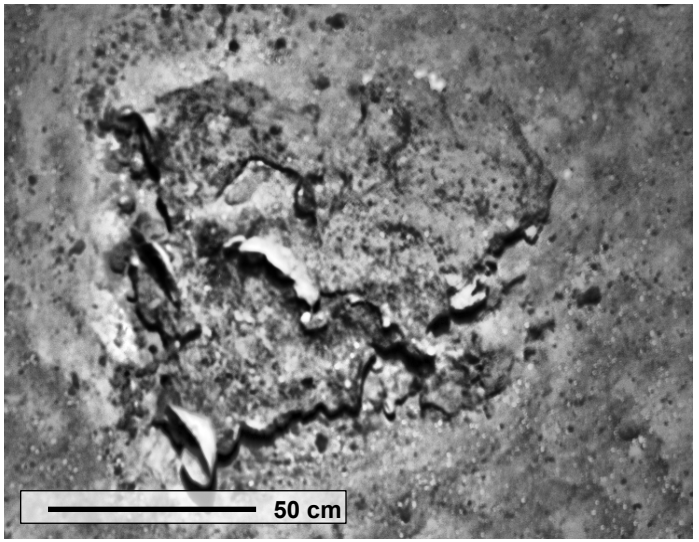
Table 3.4: Summary of HSF Biological Characteristics, PFD Area AUV Camera Sites

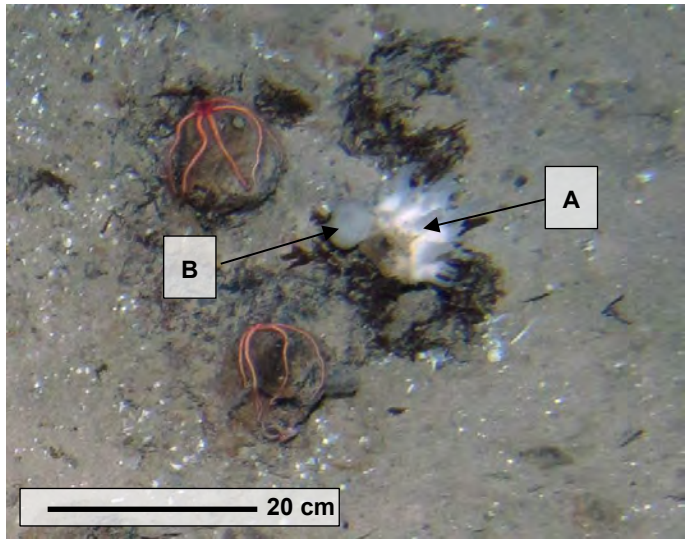
Site	AUV Line		Epifaunal Community Statistics*			Dominant Taxa†		
			Coverage [%]	Taxa [S]	Abundance [N]	Taxa	Coverage [%]	Abundance [N]
1	G18R3004	Min	1	1	1	Hexactinellida (*Poliopogon amadou*?)	6.0	2.3
		Max	20	3	7	Brissingida (*Freyella elegans*?)	0.5	0.1
		Mean	8	2	3	Porifera (indeterminate)	0.5	0.1
		SD	5	1	2	Hexactinellida (spherical)	0.5	0.1
2	G18R3009	Min	0	0	0	Hexactinellida (*Poliopogon amadou*?)	8.0	1.9
		Max	40	3	13	Porifera (indeterminate)	3.0	1.9
		Mean	16	2	5	Porifera (massive)	3.0	0.3
		SD	11	1	4	Brissingida (*Freyella elegans*?)	1.0	0.2
3	G18R3014	Min	0	0	0	Porifera (indeterminate)	4.5	1.4
		Max	25	3	6	Hexactinellida (*Poliopogon amadou*?)	3.6	0.9
		Mean	1	1	1	Brissingida (*Freyella elegans*?)	1.0	0.2
		SD	9	1	2	Ophionereidae	0.1	0.1
4	G18R3021	Min	5	1	1	Porifera (indeterminate)	5.0	1.9
		Max	45	4	10	Hexactinellida (*Poliopogon amadou*?)	4.5	1.5
		Mean	14	2	5	Hexactinellida (spherical)	2.1	0.7
		SD	13	1	3	Brissingida (*Freyella elegans*?)	2.0	0.3
5	G18R3029	Min	1	1	1	Hexactinellida (*Poliopogon amadou*?)	3.0	3.5
		Max	11	3	12	Porifera (indeterminate)	1.0	1.4
		Mean	6	2	6	Indeterminate	0.6	0.2
		SD	3	1	4	Hexactinellida (spherical)	0.5	0.3
6	G18R3034	Min	0	0	0	Porifera (indeterminate)	3.0	0.8
		Max	20	3	5	Indeterminate	2.5	0.7
		Mean	11	2	3	Hexactinellida (*Poliopogon amadou*?)	2.0	0.7
		SD	6	1	2	Hexactinellida (spherical)	0.5	0.1
7	G18R3040	Min	10	1	1	Hexactinellida (*Poliopogon amadou*?)	6.5	2.9
		Max	25	4	7	Brissingida (*Freyella elegans*?)	2.5	0.5
		Mean	15	2	5	Porifera (indeterminate)	2.1	0.9
		SD	5	1	2	Porifera (massive)	1.5	0.2

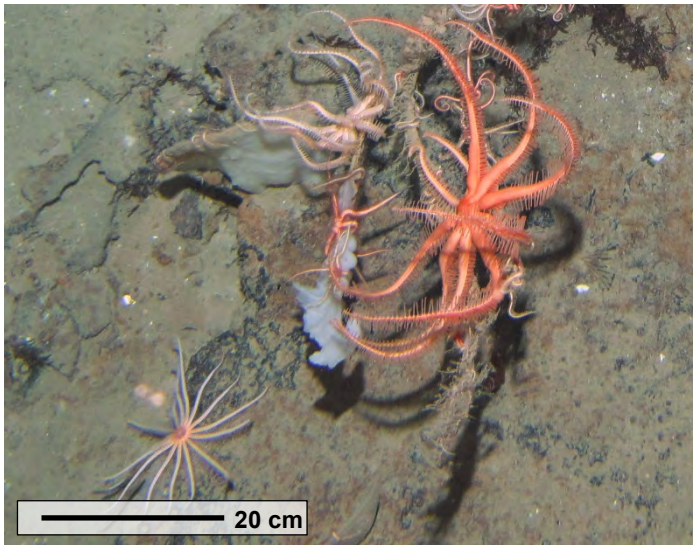
Site	AUV Line		Epifaunal Community Statistics*			Dominant Taxa†		
			Coverage [%]	Taxa [S]	Abundance [N]	Taxa	Coverage [%]	Abundance [N]
8	G18R3045	Min	5	1	3	Hexactinellida (*Poliopogon amadou*?)	6.1	4.2
		Max	25	4	17	Porifera (indeterminate)	2.6	1.3
		Mean	15	3	8	Indeterminate	2.6	1.0
		SD	6	1	4	Brissingida (*Freyella elegans*?)	2.0	1.0
Survey Area Overall		**Min**	**0**	**0**	**0**	**Hexactinellida (*Poliopogon amadou*?)**	**5.0**	**2.2**
		Max	**45**	**4**	**17**	**Porifera (indeterminate)**	**2.7**	**1.2**
		Mean	**11**	**2**	**4**	**Brissingida (*Freyella elegans*?)**	**1.4**	**0.3**
		SD	**9**	**1**	**3**	**Indeterminate**	**0.8**	**0.2**

Notes:
* = statistics expressed per HSF analyzed
† = dominant taxa listed in order of decreasing coverage, statistics expressed as mean values per HSF for each AUV line analyzed (10 images)
AUV = autonomous underwater vehicle
HSF = hard seabed feature









A: EBS Transect EBSDDV5, Image EBSDDV5_018.jpg

Four 'elephant ear' sponges (Hexactinellida; *Poliopogon amadou*?), with brittlestars (Ophiuroidea; Ophionereidae?).

B: Site 4, Line G18R3021, Image 0000010827FN.tif

Six Hexactinellida (*Poliopogon amadou*?), representing 20% coverage on an HSF.

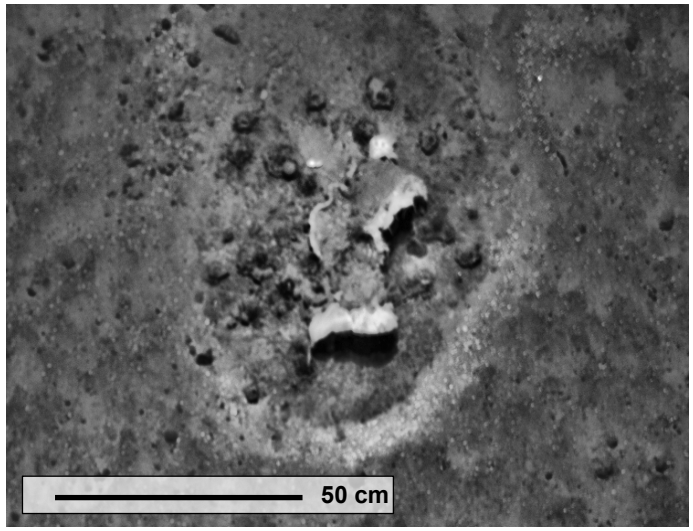
C: EBS Transect EBSDDV36, Image EBSDDV36_15.jpg

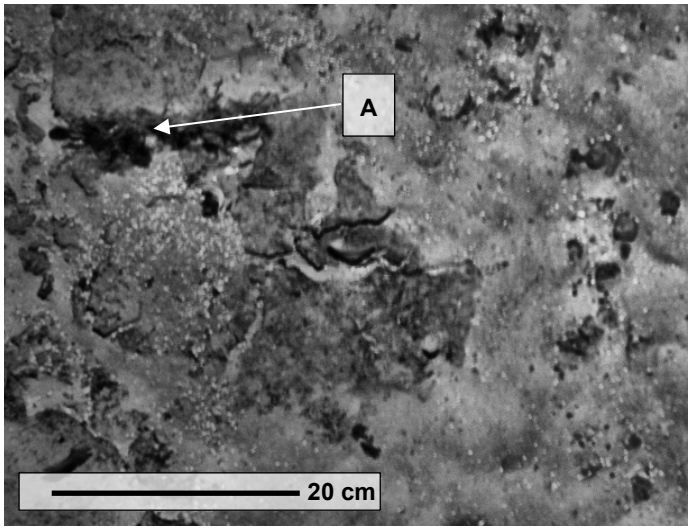
An indeterminate hexactinellid (glass) sponge (A) and spherical hexactinellid sponge (B) with Ophiuroidea (Ophionereidae?).

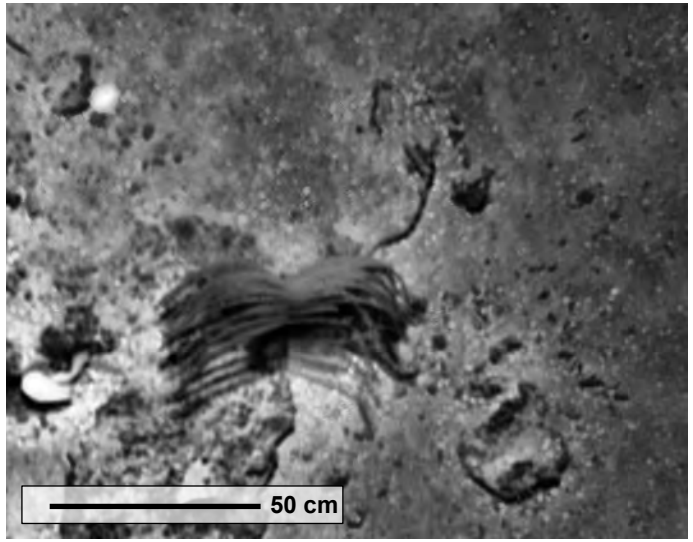
D: EBS Transect EBSDDV5, Image EBSDDV5_018.jpg

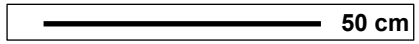
Three seastars (Brissingida; *Freyella elegans*?) with sponges and Ophiuroidea (Ophionereidae?).

Figure 3.3: Example photographs presenting HSF epifauna, PFD Area AUV Camera Sites









A: Site 2, Line G18R3009, Image 000004483FN.tif

Three colonies of a fleshy sponge (Porifera; massive) contributing 30% of the cover on an HSF.

B: Site 5, Line G18R3029, Image 000006877FN.tif

An indeterminate taxon (possible black coral; Antipatharia) (A) contributing 10% of the cover of an HSF.

C: Site 8, Line G18R3045, Image 0000020657FN.tif

A black coral (*Bathypathes* sp.) contributing 10% coverage on an HSF.

Other taxa are sponges (Hexactinellida; spherical) and 'elephant ear' sponges (Hexactinellida; *Poliopogon amadou*?).

D: Site 1, Line G18R3004, Image 000002662FN.tif
An eelpout (Zoarcidae) adjacent to an HSF.

Figure 3.4: Example photographs presenting HSF epifauna, PFD Area AUV Camera Sites

4. FUGRO'S GLOBAL EXPERIENCE WITH HSFs

The Fugro team that produced this report reached out to its internal global network and across several different departments and requested information and experience on features that matched the geological and biological descriptions of the HSFs identified offshore Guyana. This generated several discussions and comparisons of several features (e.g. seafloor pits, pockmarks, expulsion mounds, and various seafloor hardgrounds and outcrops) that may be or may be closely related to HSFs found in the PFD and LFD areas. However, it was determined by the reporting team that, to our knowledge, Fugro has not encountered the same or similar features, nor the abundance of these features in such close proximity to each other, in any previous surveys performed to date.

5. LITERATURE SEARCH FOR HSFs

A literature review was undertaken to determine if HSFs similar to those present in the PFD and LFD areas have been discovered in near proximity, within the region, or elsewhere in the world. The seafloor in many areas around the world contain fluid seeps. The fluid may be hydrocarbon, hydrothermal, volcanic, or groundwater and in some instances, seeps are associated with concretions of the fluids they emit (Judd and Hovland, 2007). Fluid seeps (fluid not specified) have been documented to occur on the Guyana shelf and slope south of the Payara and Liza fields (Yallup, 2018).

5.1 Geological Literature Review

No identical geological features were found within published literature, so the review was widened to draw comparisons with other features, including iron concretions, hiatus concretions, bioherms, and features associated with seabed seeps and related dewatering and/or degassing processes.

5.1.1 Iron Concretions

Based on the appearance of the one sample that was retrieved from the seafloor (Figure 2.1), the HSFs likely contain an iron component. Horizons that contain iron carbonate concretions within a claystone/mudstone are present in Middle Jurassic age sedimentary rocks in Poland (Witkowska, 2012) and have been studied for over 200 years (Gedl and Kaim, 2012). The iron concretions occur in specific horizons. Concretions are typically tens of centimeters long and are oval and have been flattened vertically. Concretions may coalesce to form larger structures. The presence of concretions in individual layers or horizons is associated with pore waters expelled from the underlying sediments by mechanical compaction.

These concretions have been interpreted as having an early diagenetic origin for the concretions based on several lines of evidence (Witowska, 2012). Based on the flattened nature of the concretions, concretion formation took place prior to or very early in mechanical compaction due to burial. Microstructures within the concretions reflect in situ growth prior to mechanical compaction of surrounding sediments. The occurrence close to higher intensity bioturbation suggests relatively shallow formation. Siderite forms in anoxic conditions, which suggests these concretions formed below the redox boundary. Conditions remained in place for an extended period of time due to a lowered sedimentation rate. Detailed mineralogy supports these conclusions (Witkowska, 2012). It must be noted that these concretions are smaller in size than what is observed at Payara, being on the order of centimeters to a few tens of centimeters and these likely formed in shallower waters than those observed at Payara.

5.1.2 Hiatus Concretions

Hiatus Concretions described as concretions that were formed in early diagenesis that underwent one or more periods of exhumation during sedimentary hiatuses (Zatón et al., 2010). Given the low sedimentation rates in the Payara area, this must be considered a possibility. The process of formation may be on the order of hundreds of years, and when combined with long hiatuses and biologic activity, may act as mobile rock grounds on which biologic communities live (Zatón et al., 2010). Hiatus concretions often appear to be the result of biologic activity during the slowing of sedimentation and were likely exhumed by episodic downslope transport or bottom currents (Zatón et al., 2010). As with the iron concretions described above, hiatus concretions observed in the literature are of a slightly smaller scale than those observed in the Payara

area, however, one could easily envision the images in Figure 3 of Zatón et al. (2010) resulting in the photographs and SSS images obtained in the Payara area.

5.1.3 Bioherms and Lithoherms

Bioherms and related seabed features are present around the globe (Wheeler et al., 2001, Grasmueck et al., 2007) and show a very similar SSS signal to that observed in the PFD area. Wheeler et al. (2001) show several SSS images that, upon first glance, appear quite similar to those in Payara. However, the scales of the bioherms are significantly larger (on the order of several 10s to hundreds of meters) and have a different topographic expression (Grasmueck et al., 2007) than the HSFs observed in the PFD area.

5.1.4 Methane-Derived Authigenic Carbonates

Methane-derived authigenic carbonates (MDAC) are formed by the microbial oxidation of released gases or methane-rich water and are well documented in published literature. Although examination of photographic data and preliminary testing of a sample of HSF material suggested that the HSFs within the Payara Field Development area are unlikely to be carbonates (see Section 6), and the underlying geology of the field is not conducive to the formation of pockmarks and associated MDAC, further analysis is required before such well-documented fluid seep features can be fully excluded.

MDAC has been reported from pockmarks (depressions formed by the explosive release of seabed fluids) throughout the world's seas where surface sediments and underlying geology are suitable for their formation (Hovland and Judd, 1988). In certain areas, MDACs forms more extensive, high relief structures, which are often referred to as 'bubbling reefs'; examples of these features include the carbonate chimneys that have been identified from the Kattegat, Adriatic Sea, Black Sea and Brazilian and US waters (Ceramicola et al., 2018) and the carbonate slabs of the Irish Sea (JNCC, 2019).

MDAC in proximity to ongoing fluid seeps can be associated with a range of specialized chemotrophic organisms, while the concretions, including those where seepage has ceased, also provide reef-like habitat for numerous mobile and sessile species, creating a rich and diverse habitat. MDAC is of nature conservation interest and is a protected feature in Europe under the EC Habitats Directive (JNCC, 2019).

5.1.5 Asphalt Extrusions

Asphalt extrusions or seeps have been reported from a few deep-water locations around the world including offshore Angola (Jones et al., 2014) and the Gulf of Mexico. Similar asphalt seeps have also been recently discovered in south-eastern Brazil at depths of 2,652 m to 2,752 m on the lower slope of the North São Paulo Plateau (Fujikura et al., 2017). Various forms of asphalt were identified to have been extruded onto the seafloor at this location forming areas of hard habitat including lump types, linearly extruding types, scattered stick types, mound types and reticulate filling type in the fissures of mudstone outcrops. While the researchers found evidence of the asphalt seeps remaining active at the Brazil site, it was postulated that the release of chemical species such as methane is insufficient to sustain chemosynthetic communities and is thus biological inactive. Nevertheless, the hard substrate did provide enough stable surface for the attachment of epifaunal species including sponges and echinoderms, supporting a local community that is distinct from the surrounding soft sediment habitat.

5.2 Biological Literature Review

As the review of published literature failed to confirm the means of geologic formation of the HSFs identified from the Payara Field Development Area, it was not possible to directly compare its epifaunal community with that of directly equivalent habitats. Instead, a broader review of deepwater hard substrata communities was undertaken to assist with identification of the community present, and to provide context as to its constituent epifauna's distribution, rarity and potential conservation value.

The marine fauna that colonize any benthic habitat will be limited by the physical oceanographic conditions that prevail within it. Examination of past survey reports for the PFD and LFD (Fugro, 2016b and 2019b) suggest bottom temperatures within the field ranged from 2ºC to 3ºC and that seabed salinities will be approximately 37 practical salinity units (PSU). This suggested that conditions may be appropriate for colonization by a range of Atlantic (or cosmopolitan) deepwater fauna and even by coldwater fauna reported at shallow depths at polar latitudes. In the Liza Field Environmental Impact Assessment (EIA), ERM (2017) presented current velocity data that suggested moderate seabed currents (speed not given) in a south-easterly direction; this deep flow was considered consistent with the influence of the Deep Western Boundary Current. Evidence of this flow direction was evident in the current study (see Section 6). This flow of water may facilitate larval recruitment to the PFD and LFD areas, and ensure a consistent food supply to the filter feeding taxa that were predominant on the HSFs within it.

Porifera (sponges) are the dominant phylum represented in the HSF community and the most abundant amongst these was a growth form often colloquially termed 'elephant's ear' sponges. These were initially thought likely to be members of the demosponge family Axinellidae, but examination of drop-down photographic images, suggested these were more fragile and translucent in appearance than is typical of axinellids. A subsequent literature search suggested they may instead be members of Hexactinellida (glass sponges) and they have tentatively been identified as the white morph of *Poliopogon amadou*. This species has been reported from deepwater environments (2,400 m to 2,790 m water depth) from the eastern Atlantic and mid-Atlantic ridge (Xavier et al. 2015) and from asphalt seep habitats offshore Brazil (Fujikura et al., 2017). Due to its distinctive morphology, this was the only poriferan that could be even tentatively identified from the HSF community, but other sponge morphs were distinguished. Drop down camera images identified two further potential Hexactinellids from the area, but research could not confirm the identity of either species.

Another conspicuous member of the HSF community was a brisingid seastar, which was tentatively identified from photographic data as *Freyella elegans.* This species is thought to have a worldwide distribution in deepwater (Downey, 1986). The only other taxon that could be identified with any degree of confidence was the antipatharian (black coral) *Bathypathes* sp. This genus is globally distributed and has been identified by Fugro from deepwater habitats offshore Africa and Asia. Two species within this genus, *B. patula* and *B. alternata*, also have been documented from the Gulf of Mexico (Brooke and Schroeder, 2007).

6. DISCUSSION OF HSF FINDINGS

This section discuses a synthesis of results between the geophysical/geological and biological/environmental analyses discussed in Sections 2 and 3, respectively.

6.1 Comparisons of Estimated Areal Density Results of HSFs

The densities of HSFs estimated from automated mapping of the features from low- and high- frequency SSS datasets suggested the maximum density of HSFs within the PFD and LFD areas would be approximately 8,000 HSFs per km^2. Estimates from analysis of AUV photographs are considerably higher than this, suggesting densities of between 8,659 and 16,881 HSFs per km^2 from the AUV lines analyzed. Explanation for the discrepancy between density results attained in the camera-based methodology compared to the geophysical-based methodology are as follows:

- **Differences in data resolution:** AUV low-frequency SSS data is limited to 50-cm pixels and the high-frequency SSS data is limited to 10-cm pixels. Any features smaller than these resolutions may not be resolved or accounted for in the auto-mapping thresholds. Despite the high resolution (~3 cm) of the AUV photographs, results are highly likely to be biased due to the small sample size.
- **Differences in survey coverage:** AUV low-frequency SSS data covers a wide extent (~900 km^2 total) of the seafloor of the PFD and LFD areas. The AUV high-frequency and photography datasets only cover a very small portion of the PFD area. Only a small subset of camera photographs was then analyzed in detail to derive estimated density statistics then extrapolated the full extent of the total area of the AUV camera survey sites.
- **Data artifacts** within the Payara and Liza SSS mosaics were also cleaned from the final HSF polygon dataset; however, some along track bias from data artifacts is still observed (Chart 2).
- **Auto-mapping techniques:** A single auto-mapping reflectivity (i.e. gain) threshold was used to extract HSFs from the SSS data, minimum size threshold cleaning, and vector smoothing of the polygons may have reduced the total number of HSFs included in the final dataset.

Despite the limitations of data and methodology and the discrepancy between density results, the density maps generated from the geophysical data complementary spatial variations when compared to the AUV photograph-derived density results (Map 4 and Table 3.2). Map 4 shows that AUV Camera Sites 1 and 2 are within zones with the lowest HSF density and these sites were similarly shown to have the lowest HSF density from the AUV photograph analysis. Additionally, AUV Camera Sites 6, 7, and 8 are within zones with the highest HSF density and these sites also were shown to have the highest HSF density from the AUV photograph analysis.

6.2 Physical and Biological Characteristics of HSFs

Although detailed analysis of AUV photographic data failed to provide a definitive answer regarding the likely origins of the HSFs, the review of the physical morphology of the features may provide some evidence that could feed in to further study. The morphology of the HSFs was typically flat, although some more complex structures were evident. From one AUV photograph (Figure 3.2d), an irregularly concentric ridge-

like morphology was observed. It is possible that this indicates formation from micro-seepage; however, it is more likely caused by ocean bottom current depositing sediments on one side.

The epifaunal community identified in association with HSFs was dominated by groups that are widespread, or cosmopolitan, within deepwater hard substratum habitats. Due to the presence of the attachment substrata provided by the HSFs, the overall coverage and abundance of epifauna present was far higher than typically present on deepwater sediments. Faunal density appeared comparable to that of asphalt seeps identified from published studies (Jones et al. 2014; Fujikura et al., 2017) but lower than that widely reported from active seep sites (e.g. Ceramicola et al., 2018; Judd and Hovland, 2007) where high densities of chemosynthetic organisms can occur.

The dominant fauna within the community were all filter feeding organisms, predominantly sponges. Deepwater sponge aggregations have attracted some conservation interest globally, due to their longevity and the fact that, when in dense aggregations, they provide biogenic habitat that support other organisms. There is legislation to protect deepsea sponge communities in Europe and the wider North East Atlantic (OSPAR, 2010) although this does not extend to afford protection to sponge communities found in water depths comparable to the PFD and LFD areas. The global importance of deep sea sponge communities has been recognized under United Nations General Assembly resolution 61/105 which calls for the protection of vulnerable marine ecosystems (FAO, 2009).

As most sponges are slow growing and long-lived, populations will not rapidly recover after impacts. Sponges are particularly sensitive to impacts from sedimentation, which may block their filter feeding structures. The sponge community associated with the HSFs appears likely to extend throughout the Payara Field Development Area, with no clear variation observed in the density or diversity of sponges present across the features investigated. While direct physical impact of these communities during field development is inevitable and some impacts due to sedimentation may be predicted, it is believed that the sponge community is suitably dispersed across the wider area that these impacts will be unlikely to reduce the long-term viability of sponge populations in the Payara Field Development Area.

There was no evidence of other internationally recognized sensitive or protected communities from the dataset analyzed (e.g. cold-water corals and chemosynthetic communities). ERM (2017) state that two cold-water coral species (*Madrepora oculata* and *Solenosmilia variabilis*) are reported offshore of Guyana, but the locations and the extent of their distribution has not been published. Neither species was identified from the photographic datasets analyzed. One genus of black coral (*Bathypathes* sp.) and what is thought to be a smaller species of antipatharian were also occasionally observed; neither are habitat-modifying species (i.e. those that form the reefs and or soft coral gardens considered for protection).

7. CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

i. The HSFs are very unusual, if not unique, geological features that cover some 1% of the seafloor in the area surveyed, have a wide variance in size but all are small, and are covered by ubiquitous biological entities.

ii. HSF areal density estimates based on photo analysis are likely to be more accurate than those developed from analysis of SSS data, which are likely to be an estimated 20% lower than actual densities.

iii. Although some HSFs would be unavoidably disturbed by Payara development activities due to their variable but relatively high areal density throughout the proposed Payara Field Development area, the potential environmental impact on HSFs is likely to be minimal given that the epifaunal communities, when present, are commonly found elsewhere in the deep ocean.

iv. We do not have adequate information to reliably characterize the physical properties of the hard materials associated with HSFs or of the underlying substrate.

v. Consequently, we cannot assess the potential engineering significance of HSFs to flowline/umbilical design, or the potential impact on suction pile installation or performance.

vi. Additional sampling and characterizing the physical properties of HSFs is thus warranted.

vii. While the epifaunal coverage and diversity of HSFs was notably higher than seen from surrounding sediment habitats, it was low in comparison to active seep sites elsewhere in the world. It is likely that smaller, cryptic species were not visible from the AUV data.

viii. The epifaunal community present was dominated by sponges (phylum Porifera) and the most frequently occurring species present (tentatively identified as *Poliopogon amadou*) is widespread on deepwater hard substrata throughout the Atlantic. Other taxonomic groups present are also ubiquitous in deepwater environments locally, and elsewhere in the world.

ix. No sensitive communities/species (e.g. chemosynthetic communities or corals) were identified from the HSF community.

x. Because the HSF geological features and epifaunal communities utilizing them are widespread within the survey area, it appears unlikely that the planned Payara and northern Liza Field Development areas will have a significant long-term impact on their viability.

7.2 Recommendations

i. Further characterize the physical properties of materials comprising HSFs and its associated biological communities:

- Use the results of this report in conjunction with the AUV SSS data and AUV and EBS photos to design a program to observe, document (insitu photos/videos), sample, and analyze representative HSFs and associated biological communities. ROVs would likely be required to be certain that the targeted sampling locations are achieved.
- Based on results of sampling, develop and execute an appropriate lab testing program.
- Based on results of sampling, analyze dominant epifaunal taxa in the laboratory.
- Prepare a report that synthesizes all field and lab data, develops a representative characterization of the HSFs, and assesses the potential engineering impacts on proposed development activities.

ii. If appropriate, use results of the HSF characterization to modify proposed development plans.

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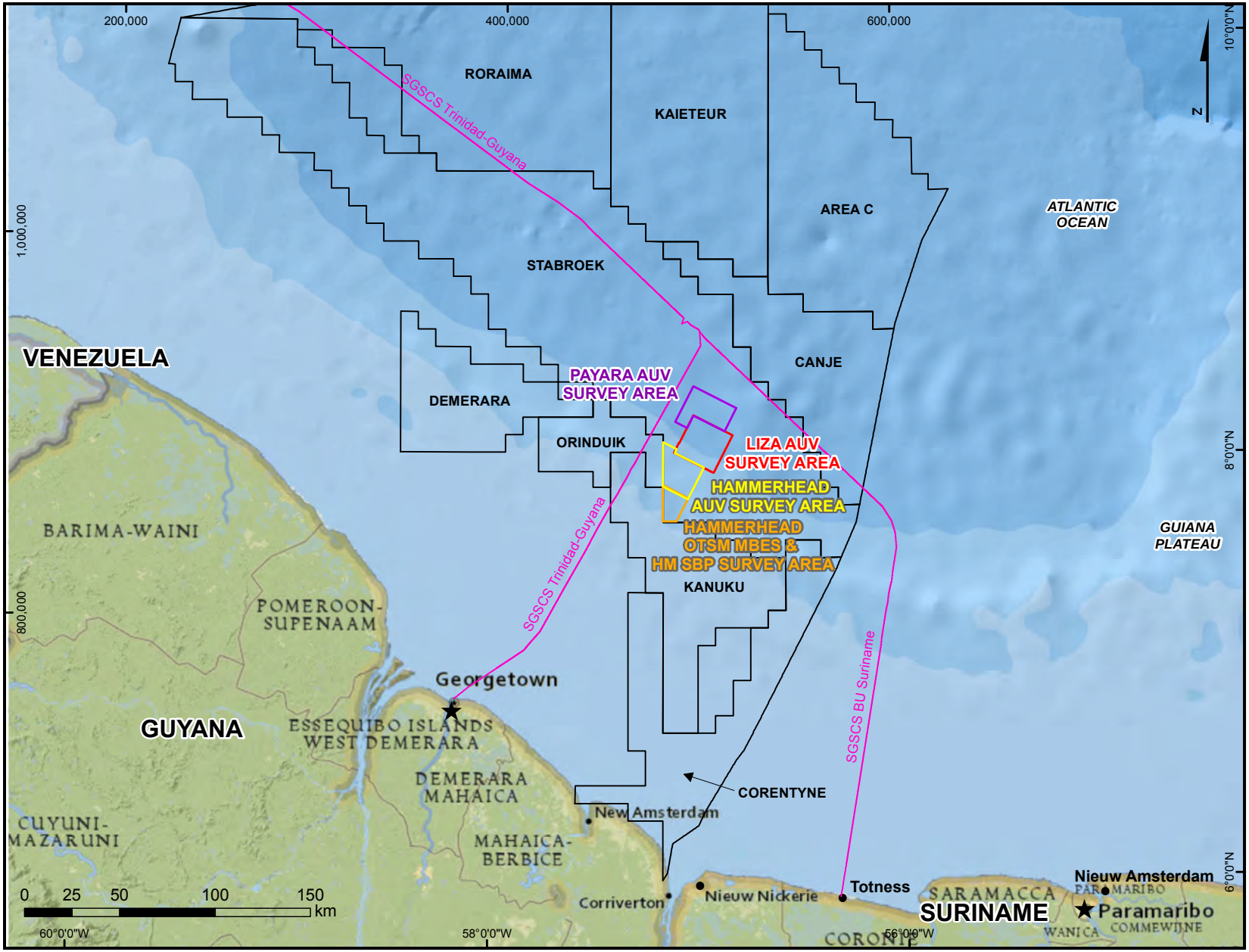
MAPS AND CHARTS

The following page size and 11x17-format maps include:

Map 1: General Location Map
Map 2: Estimated Areal Density of Hard Seafloor Features Per Square Kilometer at Proposed Payara Anchor Pile Locations
Map 3: Estimated Areal Density of Hard Seafloor Features Per Square Kilometer at Proposed Payara Drill Center Locations
Map 4: Hard Seafloor Features Estimated Areal Density Map with Payara AUV Camera Sites

The following large-format charts include:

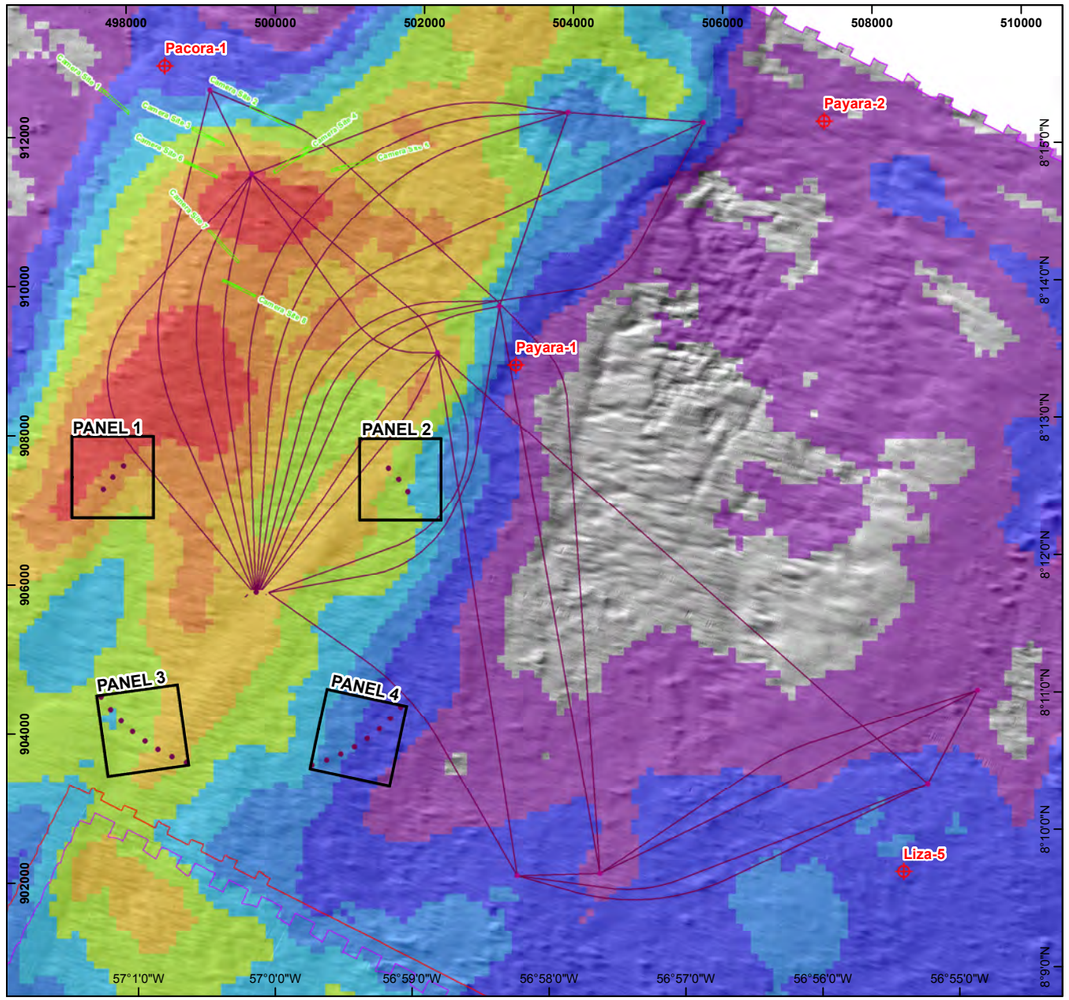
Chart 1: Water Depth
Chart 2: Representative Distribution of Hard Seafloor Features within the Liza and Payara AUV Survey Areas
Chart 3: Estimated Areal Density of Hard Seafloor Features within the Liza and Payara AUV Survey Areas



Background image is a National Geographic basemap provided by ESRI.
Coordinate Grid: WGS 1984 UTM Zone 21N, meters

GENERAL LOCATION MAP

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Note: Proposed Payara Field Layout provided by ExxonMobil on 18 Jan 2019, proposed FPSO Anchor Pile Locations provided by ExxonMobil on 05 Feb 2019, and proposed Drill Center Locations provided by ExxonMobil on 29 Mar 2019.

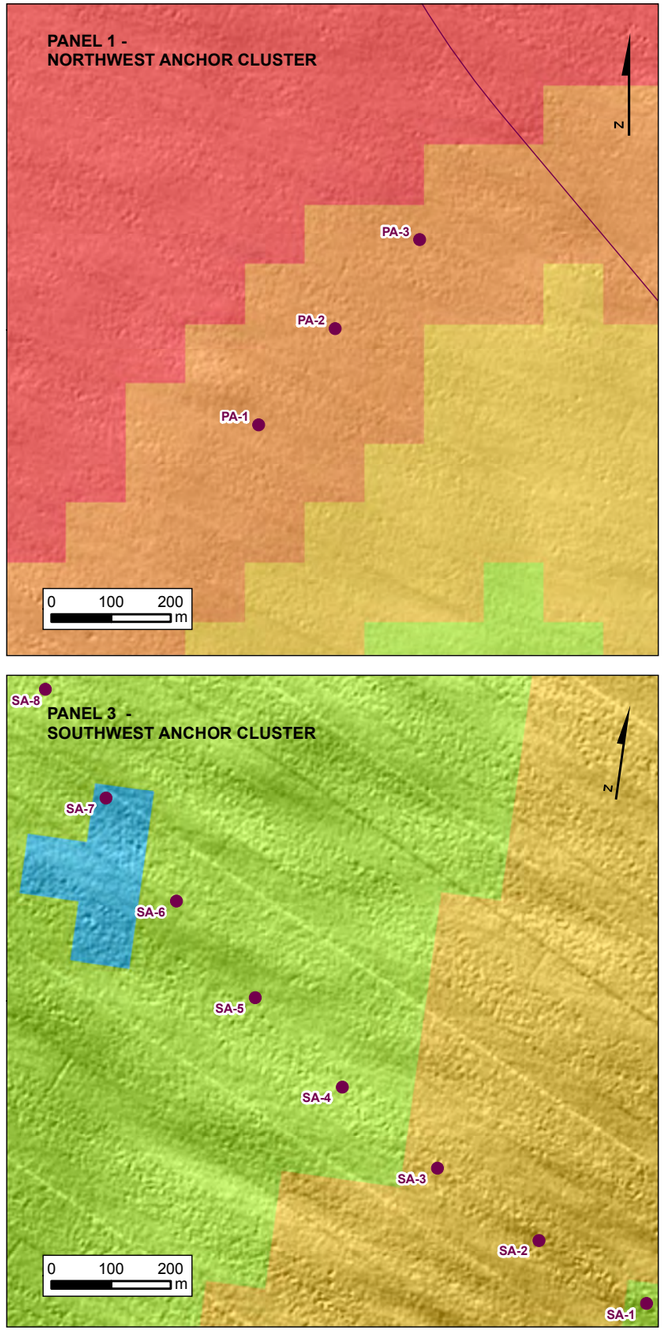
Coordinate Grid: WGS 1984 UTM Zone 21N, Meters
HSFs = Hard Seafloor Features

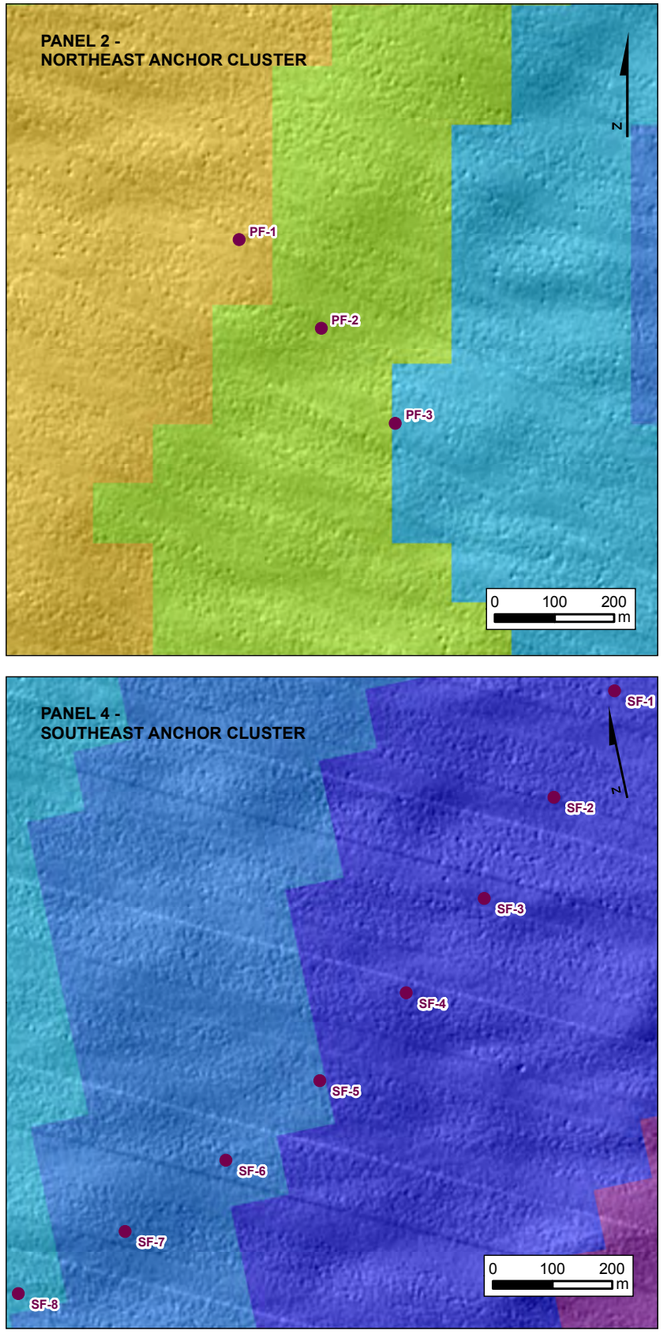
LEGEND

- Existing Well
- Proposed Payara Drill Center Locations
- Proposed Payara FPSO Anchor Pile Locations
- Proposed Payara Field Layout
- Payara AUV MBES Data Extent
- Payara AUV MBES Camera Data Extents
- Liza AUV MBES Data Extent

Estimated Areal Density of Individual Hard Seafloor Features (per km²)

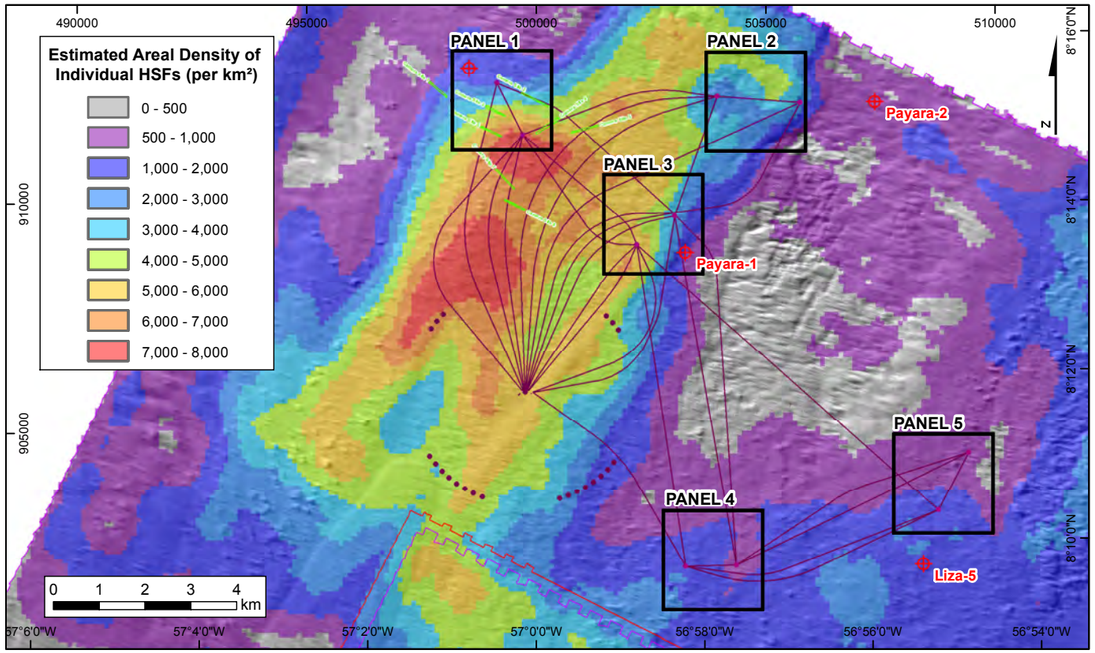
< 500	500 - 1,000	1,000 - 2,000	2,000 - 3,000	3,000 - 4,000	4,000 - 5,000	5,000 - 6,000	6,000 - 7,000	7,000 - 8,000

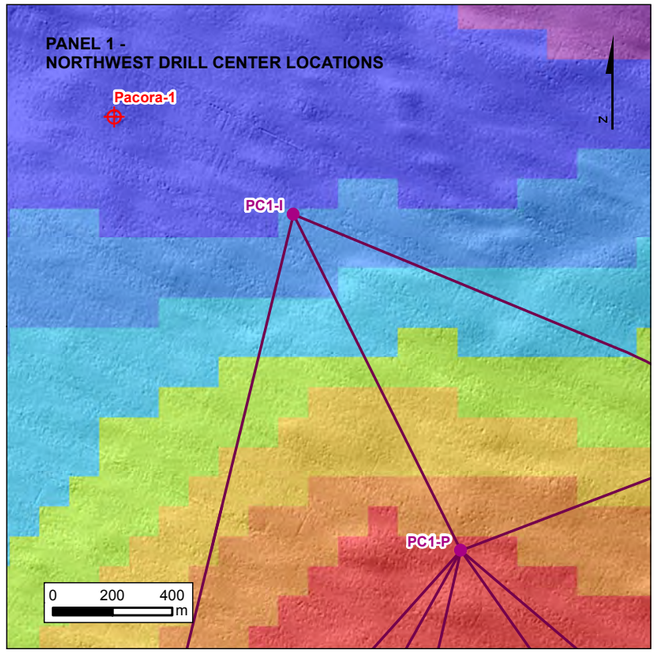


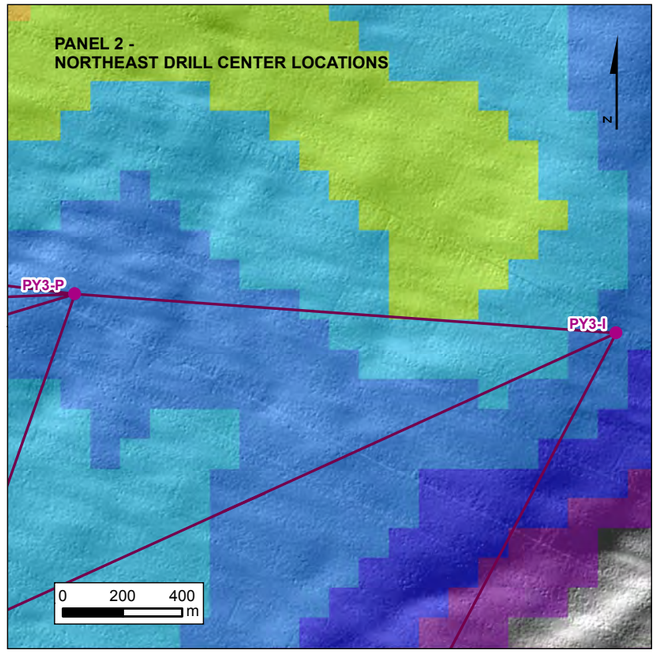


ESTIMATED AREAL DENSITY OF HARD SEAFLOOR FEATURES PER SQUARE KILOMETER AT PROPOSED PAYARA ANCHOR PILE LOCATIONS

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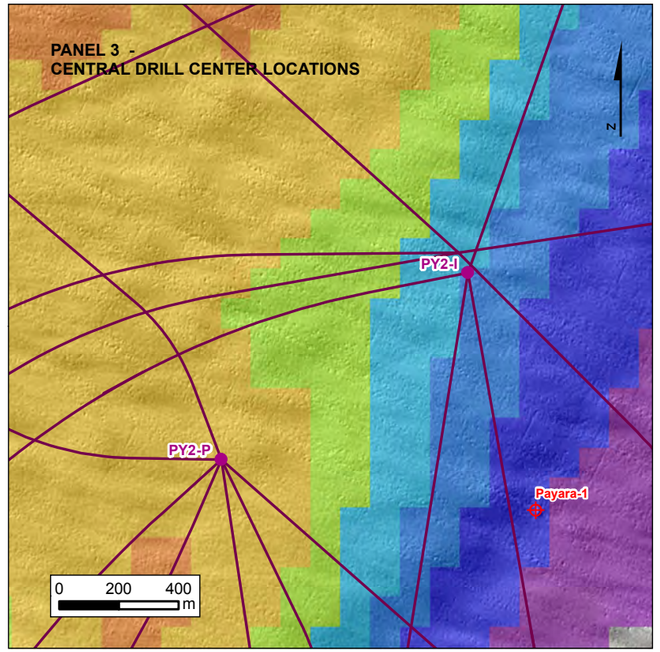
HSFs = Hard Seafloor Features

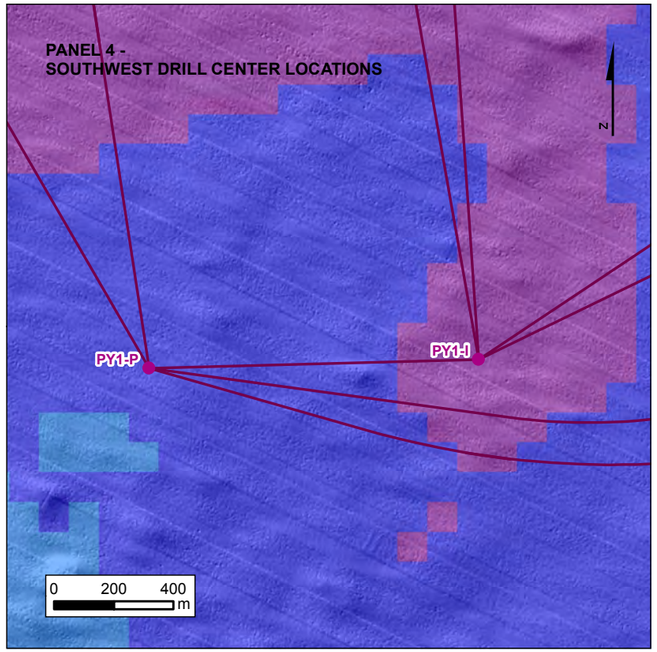
Coordinate Grid:
WGS 1984 UTM Zone 21N, Meters

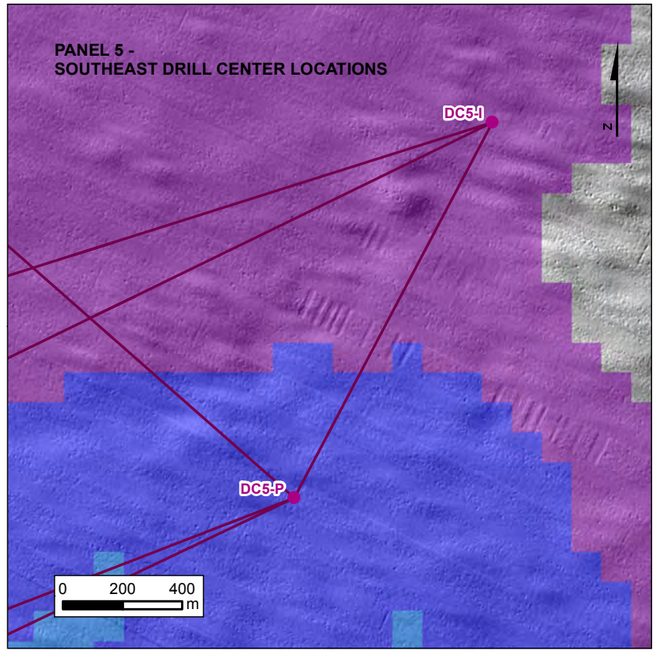
Note: Proposed Payara Field Layout provided by ExxonMobil on 18 Jan 2019, proposed FPSO Anchor Pile Locations provided by ExxonMobil on 05 Feb 2019, and proposed Drill Center Locations provided by ExxonMobil on 29 Mar 2019.

LEGEND

- Existing Well
- Proposed Payara Drill Center Locations
- Proposed Payara FPSO Anchor Pile Locations
- Proposed Payara Field Layout
- Payara AUV MBES Data Extent
- Payara AUV MBES Camera Data Extents
- Liza AUV MBES Data Extent

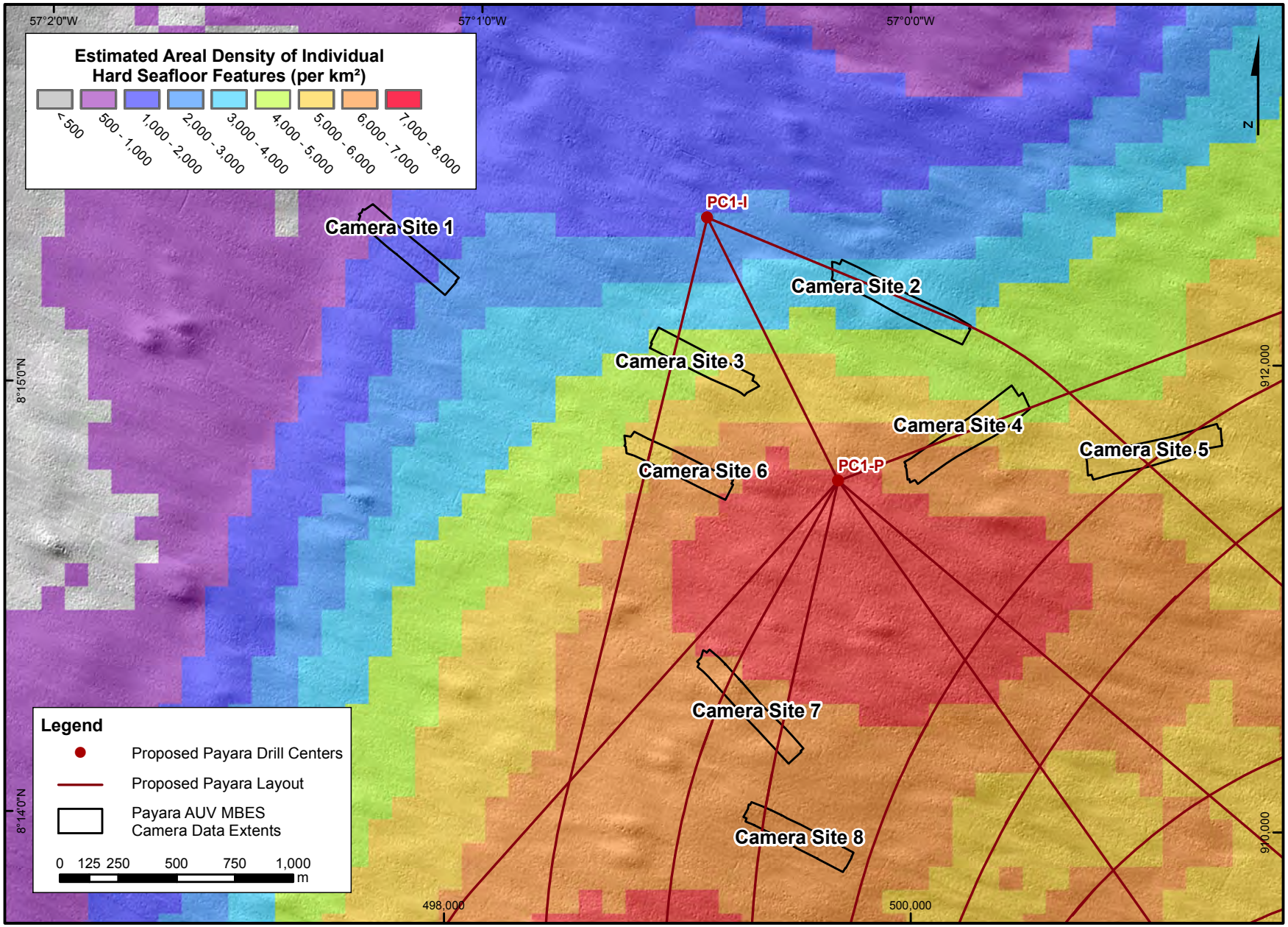






ESTIMATED AREAL DENSITY OF HARD SEAFLOOR FEATURES PER SQUARE KILOMETER AT PROPOSED PAYARA DRILL CENTER LOCATIONS

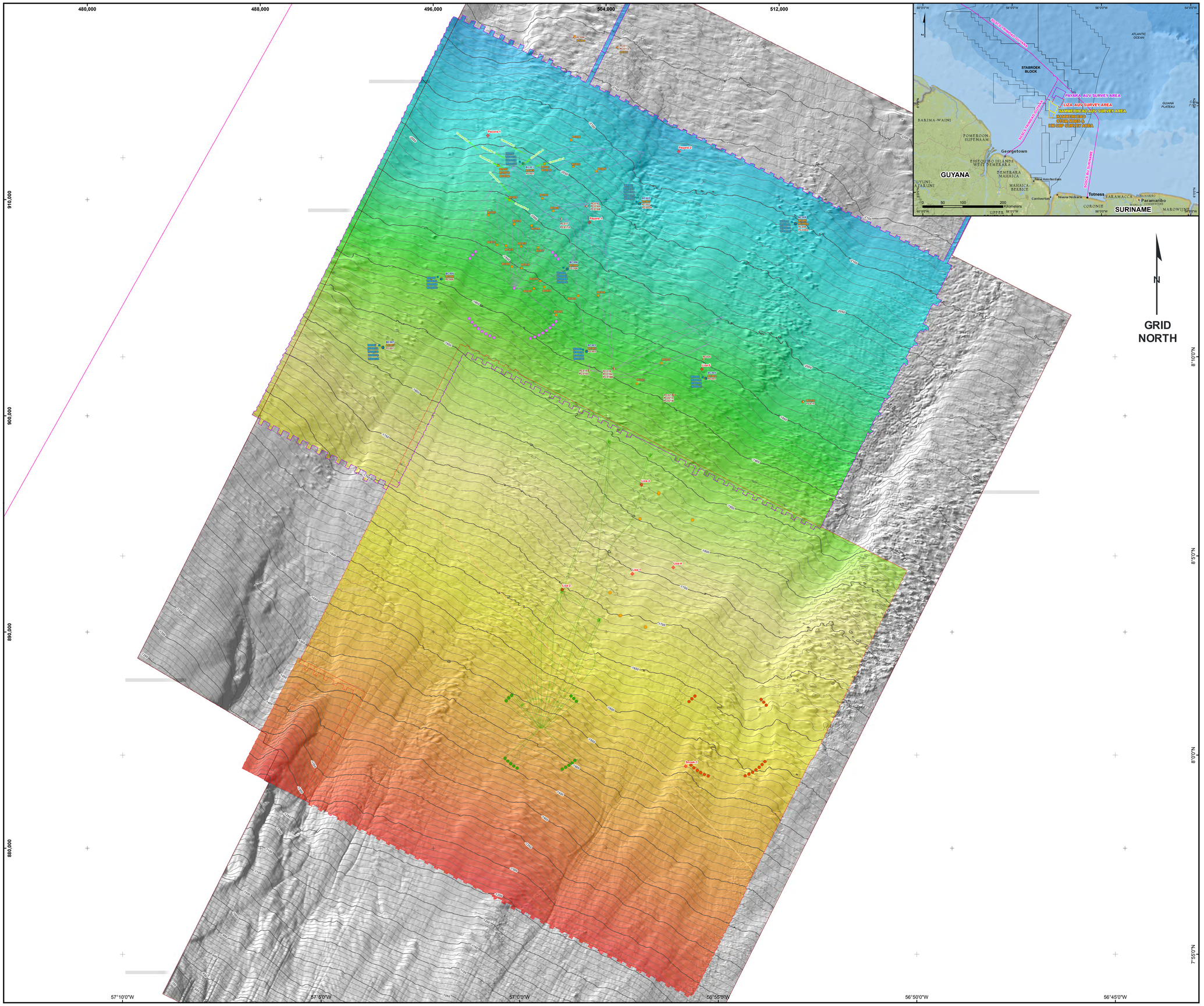
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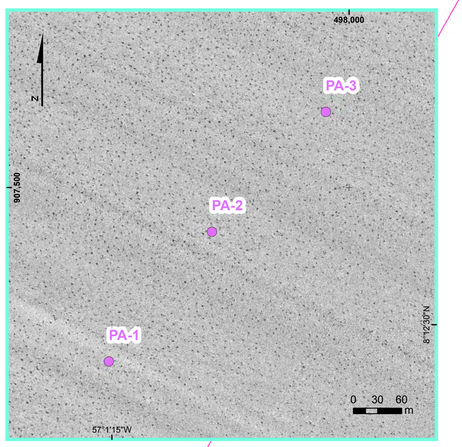
Coordinate Grid: WGS 1984 UTM Zone 21N, meters

HARD SEAFLOOR FEATURES ESTIMATED AREAL DENSITY MAP WITH PAYARA AUV CAMERA SITES

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480,000
488,000
496,000
504,000
512,000
910,000
900,000
890,000
880,000
57°10'0"W
57°5'0"W
57°0'0"W
56°55'0"W
56°50'0"W
56°45'0"W
8°10'0"N
8°5'0"N
8°0'0"N
7°55'0"N
GRID NORTH
Pacora-1
Pacora-2
Pacora-3
Pacora-4
Pacora-5
Payara-1
Payara-2
Payara-3
Payara-4
Payara-5
Liza-1
Liza-2
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ZOOM-IN INSET - EXAMPLES OF HARD SEAFLOOR FEATURES WITHIN PAYARA SURVEY AREA (THE DARKER THE SHADING, THE HIGHER THE SIDE SCAN SONAR REFLECTIVITY)

480,000 488,000 496,000 504,000 512,000

910,000 900,000 890,000 880,000

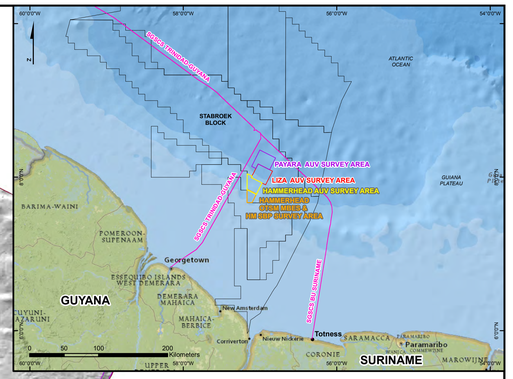
LINE BIAS DUE TO SIDE SCAN SONAR GAIN ARTIFACT

AUV CAMERA MOSAIC INSET

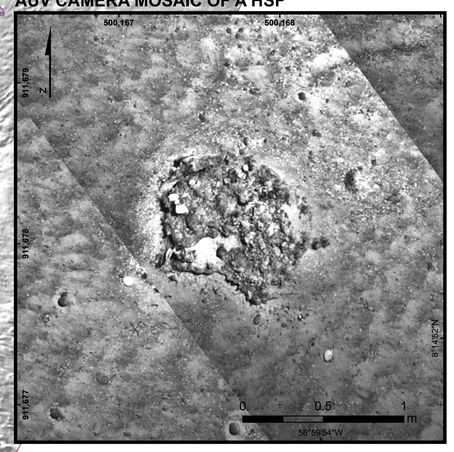
AUV CAMERA MOSAIC INSET

GRID NORTH

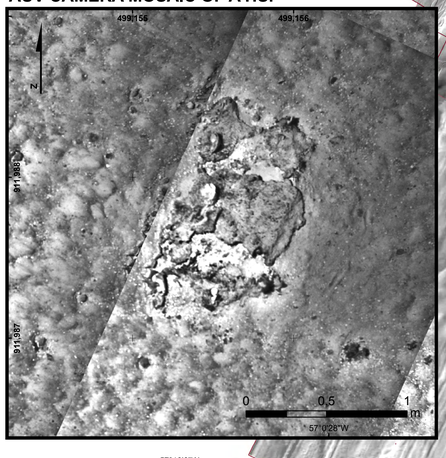
SHARP TERMINATION OF HARD SEAFLOOR FEATURES (HSFs) WITHIN LIZA AREA IS CAUSED BY AN AREAL CLIPPING TO REMOVE WHERE HSFs ARE NOT RESOLVABLE OR DON'T EXIST IN THE SIDE SCAN SONAR DATA



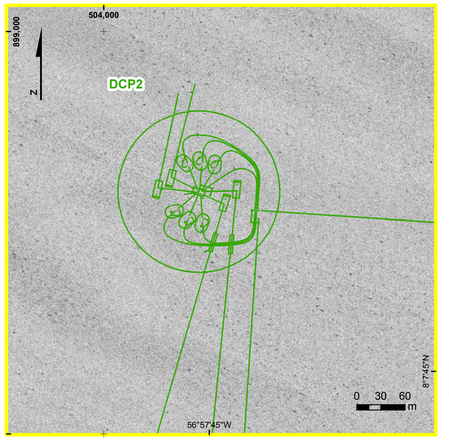
CAMERA SITE 4 - ZOOM-IN INSET AUV CAMERA MOSAIC OF A HSF



CAMERA SITE 3 - ZOOM-IN INSET AUV CAMERA MOSAIC OF A HSF



ZOOM-IN INSET - EXAMPLES OF HARD SEAFLOOR FEATURES WITHIN LIZA SURVEY AREA (THE DARKER THE SHADING, THE HIGHER THE SIDE SCAN SONAR REFLECTIVITY)



57°10'0"W 57°5'0"W 57°0'0"W 56°55'0"W 56°50'0"W 56°45'0"W

8°0'0"N 7°55'0"N

BASE MAP INFORMATION

- WELL LOCATION
- PROPOSED PAYARA FPSO ANCHOR PILE LOCATION (PROVIDED BY EXXON - 05 FEB 2019)
- PROPOSED PAYARA DRILL CENTER LOCATION (PROVIDED BY EXXON - 29 MAR 2019)
- PROPOSED PAYARA FIELD LAYOUT (GYPY_ED_UDLAY_10_0005_000 PROVIDED BY EXXON - 18 JAN 2019)
- PROPOSED LIZA DESTINY FPSO ANCHOR PILE LOCATION (PROVIDED BY EXXON - 05 APRIL 2017)
- PROPOSED LIZA DESTINY FIELD LAYOUT (INF_GYLZ-ED-UDLAY-10-0201-REV2B PROVIDED BY EXXON - 05 JAN 2017)
- PROPOSED LIZA UNITY FPSO ANCHOR PILE LOCATION (PROVIDED BY EXXON - 08 FEB 2019)
- PROPOSED LIZA UNITY DRILL CENTER LOCATION (PROVIDED BY EXXON - 05 FEB 2019)

PAYARA EXPLORATIONS

- GEOTECHNICAL BOX CORE
- GEOTECHNICAL PISTON CORE
- EBS BOX CORE SAMPLE
- EBS WATER SAMPLE
- SGSCS CABLE LOCATIONS AS-LAID
- UNIDENTIFIED SUBSEA CABLE
- LEASE BLOCKS
- 2019 HAMMERHEAD AUV MBES DATA EXTENT (DATA BINNED AT 3 m)
- 2019 HAMMERHEAD PROPOSED OTSM MBES & HM SBP SURVEY AREA
- 2018 PAYARA AUV MBES DATA EXTENT (DATA BINNED AT 3 m)
- 2018 PAYARA AUV MBES CAMERA DATA EXTENT (DATA BINNED AT 25 cm)
- 2016 AND 2017 LIZA AUV MBES DATA EXTENT (DATA BINNED AT 3 m)
- 3DX DATA EXTENT DATA PROVIDED BY EEPGL (DATA BINNED AT 12.5 m)

INTERPRETIVE INFORMATION

SUN ILLUMINATION PARAMETERS:
AZIMUTH: 315°
SUN ELEVATION: 45°

HILLSHADE
SHADOW — DARK
SUN REFLECTION — LIGHT

- HARD SEAFLOOR FEATURES (HSFs) (THESE FEATURES WERE AUTO-MAPPED USING AUV SIDE SCAN SONAR DATA; SMALL INDIVIDUAL POLYGONS DELINEATE REPRESENTATIVE AREAL DENSITY)
- SBP WATER COLUMN ANOMALIES

NOTES:

1. BASED ON THE AUV SIDE SCAN SONAR, MULTIBEAM ECHOSOUNDER (MBES) BACKSCATTER, AND PHOTOGRAPHS FUGRO COLLECTED OVER THE PAYARA AREA (2018) AND LIZA AREA (2016 AND 2017), HARD SEAFLOOR FEATURES (HSFs) ARE INTERPRETED TO BE COARSER-GRAINED, ROCKY MATERIAL LESS THAN 1 m TO 4 m IN DIAMETER THAT RESIDE IN DEPRESSIONS THAT ARE LESS THAN 15 m IN DIAMETER AND LESS THAN 50 cm DEEP. THE ORIGIN OF HSFs IS INTERPRETED TO BE FROM DEWATERING, POSSIBLY LOW-LEVELS OF BIOGENIC DEGASSING, OF VERY SHALLOW UNDERLYING SEDIMENT LAYERS, SPECIFICALLY FROM BURIED TURBIDITES AND MASS TRANSPORT DEPOSITS.

2. HSFs WERE ***AUTO-MAPPED*** USING PAYARA AND LIZA AUV SIDE SCAN SONAR DATA IN ORDER TO PROVIDE A REPRESENTATIVE REGIONAL ESTIMATED AREAL DENSITY OF HSFs. THE HSFs ARE NOT DETECTABLE IN THE 3DX DATA.

3. TOTAL NUMBER OF ***AUTO-MAPPED*** HSFs IN PAYARA AREA TOTAL SOME 750,000 INDIVIDUAL FEATURES. TOTAL NUMBER OF ***AUTO-MAPPED*** HSFs IN LIZA AREA TOTAL JUST UNDER 400,000 INDIVIDUAL FEATURES.

4. BASED ON THE OBSERVED ***AUTO-MAPPED*** RESULTS, WE ESTIMATE THE ***AUTO-MAPPING*** TECHNIQUES MAY HAVE UNDERSAMPLED (I.E. NOT MAPPED) HSFs BY APPROXIMATELY ~20%, THUS THE TOTAL NUMBER OF ***AUTO-MAPPED*** HSFs GIVEN IN NOTE 3 SHOULD BE INCREASED BY 20%. SOME AREAS MAY HAVE A HIGHER OR LOWER PERCENTAGE OF MAPPED HSFs COMPARED TO OTHER AREAS (SEE FUGRO, 2019)

5. LINE BIAS FROM SIDE SCAN SONAR DATA ARTIFACTS, SUCH AS GAIN IRREGULARITIES, WERE FILTERED OUT AS MUCH AS POSSIBLE WITHOUT REMOVING BULK NUMBERS OF HSFs.

6. THE ZOOM-IN INSETS DISPLAY AUV CAMERA PHOTOMOSAICS OF HSFs AND SIDE SCAN SONAR MOSAICS THAT WERE GENERATED FROM INDIVIDUAL AND OVERLAPPING AUV SIDE SCAN SONAR LINE DATA AT 50-cm PIXEL RESOLUTION.

7. FUGRO ESVII AUV COLLECTED SIDE SCAN SONAR DATA USING AN EDGETECH MODEL 2205 FULL SPECTRUM SIDE SCAN SONAR SYSTEM WITH SIMULTANEOUS FREQUENCIES (240 AND 540 kHz) WITHIN THE PAYARA SURVEY AREA (2018). FUGRO ESIV AUV COLLECTED SIDE SCAN SONAR DATA USING AN EDGETECH MODEL 2200 FULL SPECTRUM SIDE SCAN SONAR SYSTEM WITH SIMULTANEOUS FREQUENCIES (105 AND 410 kHz) WITHIN THE LIZA SURVEY AREA (2016 AND 2017).

8. THE BACKGROUND GRAYSCALE SEAFLOOR RENDERING IMAGE WAS DERIVED FROM AUV MBES DATA (BINNED AT 3 m) AND 3DX SEAFLOOR PICKS (BINNED AT 12.5 m).

9. PROPOSED AND REPORTED INFRASTRUCTURE AND LEASE BLOCK INFORMATION PROVIDED BY EXXONMOBIL.

SPHEROID:	WGS_1984	FLATTENING:	1/F=298.257223563
SEMI MAJOR AXIS:	a=6,378,137.00 m	SCALE FACTOR:	0.9996
PROJECTION:	TRANSVERSE MERCATOR	CENTRAL MERIDIAN:	-57°00'00"W
DATUM:	WGS 1984	LAT. ORIGIN:	00°00'00"
ZONE:	UTM ZONE 21 NORTH	FALSE EASTING:	500,000 m
GRID UNITS:	METERS	FALSE NORTHING:	0,000,000 m

SCALE = 1:65,000

0 500 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000
Meters

REPRESENTATIVE DISTRIBUTION OF HARD SEAFLOOR FEATURES WITHIN THE LIZA AND PAYARA AUV SURVEY AREAS

PAYARA AND LIZA FIELD DEVELOPMENT AREAS, OFFSHORE GUYANA

ESSO EXPLORATION AND PRODUCTION GUYANA LTD

CONTOUR INTERVAL: N/A	
DATUM: SEAFLOOR	
VELOCITY: N/A	
POSITIONING BY: SEE NOTE 7	DRAFTED BY: K. ROVANG & M.JOHN
INTERPRETED BY: M. JOHN & K. ROVANG	CHECKED BY: M.JOHN & K. J. CAMPBELL
DATE: 24 MAY 2019	GIS: PAYARA_Chart02_HSFs
JOB NO.: 02.1803-1430	REVISION NO.: REV 01

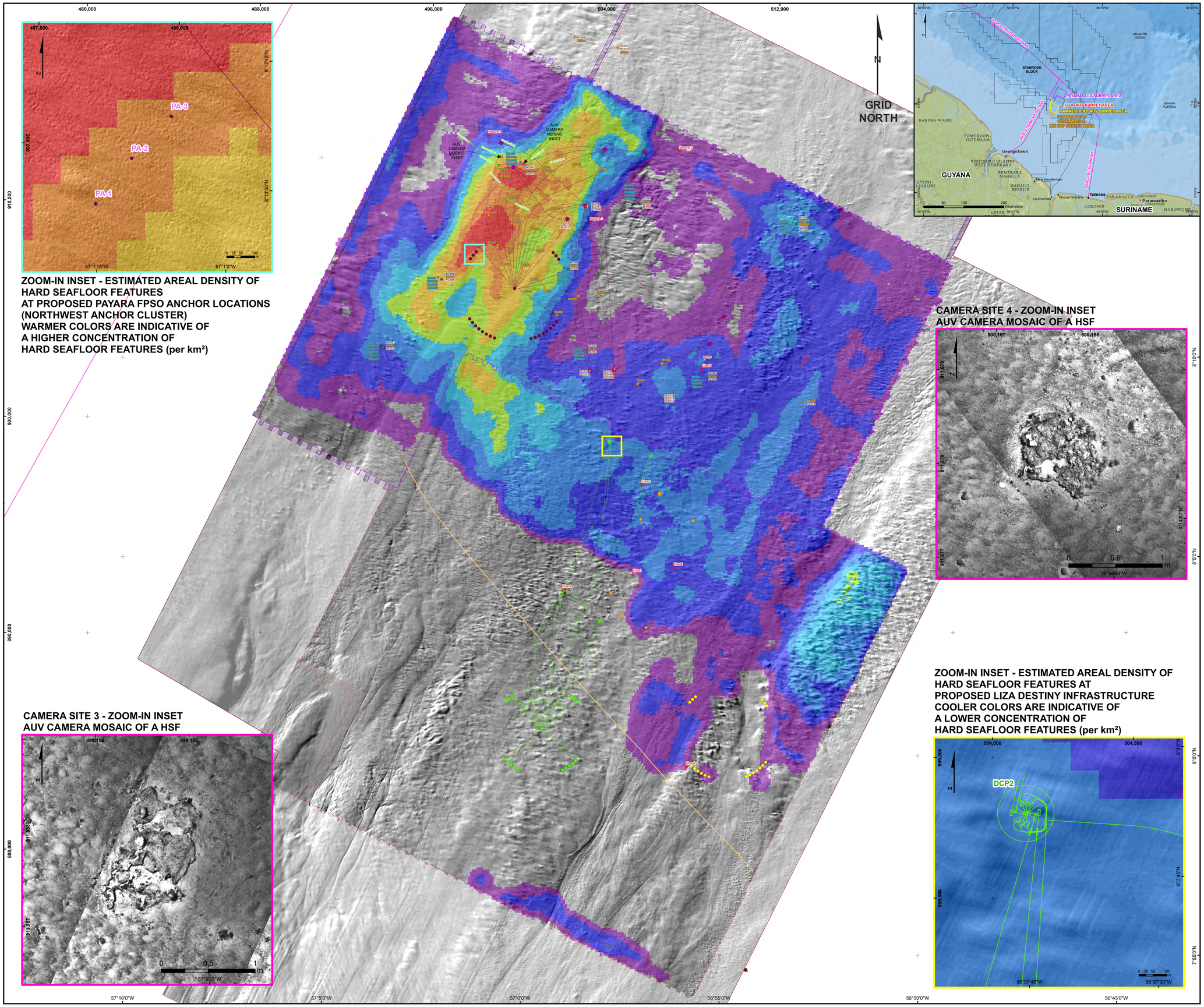
CHART 2

EEPGL

MAP PREPARED BY:
FUGRO USA MARINE, INC
6100 HILLCROFT
HOUSTON, TEXAS 77081
PHONE: 713-369-5600
WWW.FUGRO.COM

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ZOOM-IN INSET - ESTIMATED AREAL DENSITY OF HARD SEAFLOOR FEATURES AT PROPOSED PAYARA FPSO ANCHOR LOCATIONS (NORTHWEST ANCHOR CLUSTER) WARMER COLORS ARE INDICATIVE OF A HIGHER CONCENTRATION OF HARD SEAFLOOR FEATURES (per km²)



CAMERA SITE 4 - ZOOM-IN INSET AUV CAMERA MOSAIC OF A HSF

CAMERA SITE 3 - ZOOM-IN INSET AUV CAMERA MOSAIC OF A HSF

ZOOM-IN INSET - ESTIMATED AREAL DENSITY OF HARD SEAFLOOR FEATURES AT PROPOSED LIZA DESTINY INFRASTRUCTURE COOLER COLORS ARE INDICATIVE OF A LOWER CONCENTRATION OF HARD SEAFLOOR FEATURES (per km²)

BASE MAP INFORMATION

- WELL LOCATION
- PROPOSED PAYARA DRILL CENTER LOCATION (PROVIDED BY EXXON - 29 MAR 2019)
- PROPOSED PAYARA FPSO ANCHOR PILE LOCATION (PROVIDED BY EXXON - 05 FEB 2019)
- PROPOSED PAYARA FIELD LAYOUT (GYPY_ED_UDLAY_10_0005_000 PROVIDED BY EXXON - 18 JAN 2019)
- PROPOSED LIZA DESTINY FPSO ANCHOR PILE LOCATION (PROVIDED BY EXXON - 05 APRIL 2017)
- PROPOSED LIZA DESTINY FIELD LAYOUT (INF_GYLZ-ED-UDLAY-10-0201-REV2B PROVIDED BY EXXON - 05 JAN 2017)
- PROPOSED LIZA UNITY FPSO ANCHOR PILE LOCATION (PROVIDED BY EXXON - 08 FEB 2019)
- PROPOSED LIZA UNITY DRILL CENTER LOCATION (PROVIDED BY EXXON - 05 FEB 2019)

PAYARA EXPLORATIONS

- GEOTECHNICAL BOX CORE
- GEOTECHNICAL PISTON CORE
- EBS BOX CORE SAMPLE
- EBS WATER SAMPLE
- SGSCS CABLE LOCATIONS AS-LAID
- UNIDENTIFIED SUBSEA CABLE
- LEASE BLOCKS
- 2019 HAMMERHEAD AUV MBES DATA EXTENT (DATA BINNED AT 3 m)
- 2019 HAMMERHEAD PROPOSED OTSM MBES & HM SBP SURVEY AREA
- 2018 PAYARA AUV MBES DATA EXTENT (DATA BINNED AT 3 m)
- 2018 PAYARA AUV MBES CAMERA DATA EXTENT (DATA BINNED AT 25 cm)
- 2016 AND 2017 LIZA AUV MBES DATA EXTENT (DATA BINNED AT 3 m)
- 3DX DATA EXTENT DATA PROVIDED BY EEPGL (DATA BINNED AT 12.5 m)

INTERPRETIVE INFORMATION

ESTIMATED AREAL DENSITY OF INDIVIDUAL HARD SEAFLOOR FEATURES (per km²)

- 0 - 500
- 500 - 1,000
- 1,000 - 2,000
- 2,000 - 3,000
- 3,000 - 4,000
- 4,000 - 5,000
- 5,000 - 6,000
- 6,000 - 7,000
- 7,000 - 8,000

SUN ILLUMINATION PARAMETERS:

AZIMUTH: 315°
SUN ELEVATION: 45°

HILLSHADE

SHADOW — DARK
SUN REFLECTION — LIGHT

NOTES:

1. BASED ON THE AUV SIDE SCAN SONAR, MULTIBEAM ECHOSOUNDER (MBES) BACKSCATTER, AND PHOTOGRAPHS FUGRO COLLECTED OVER THE PAYARA AREA (2018) AND LIZA AREA (2016 AND 2017), HARD SEAFLOOR FEATURES (HSFs) ARE INTERPRETED TO BE COARSER-GRAINED, ROCKY MATERIAL LESS THAN 1 m TO 4 m IN DIAMETER THAT RESIDE IN DEPRESSIONS THAT ARE LESS THAN 15 m IN DIAMETER AND LESS THAN 50 cm DEEP. THE ORIGIN OF HSFs IS INTERPRETED TO BE FROM DEWATERING, POSSIBLY LOW LEVELS OF BIOGENIC DEGASSING OF VERY SHALLOW UNDERLYING SEDIMENT LAYERS, SPECIFICALLY FROM BURIED TURBIDITES AND MASS TRANSPORT DEPOSITS.

2. THE ***AUTO-MAPPED*** HSF POLYGONS IN CHART 2 WERE CONVERTED TO POINTS AND USED TO GENERATE AN ESTIMATED AREAL DENSITY WITHIN A DEFINED NEIGHBORHOOD OF 1 km². WARMER COLORS INDICATE A GREATER ESTIMATED DENSITY OF HSFs (PER km²). COOLER COLORS INDICATE A LOWER ESTIMATED DENSITY OF HSFs (PER km²).

3. THE COLOR-CLASSIFIED ZOOM-IN INSETS SHOW THE ESTIMATED AREAL DENSITY OF HSFs OVERLAIN ONTO A GRAYSCALE SEAFLOOR RENDERING AT 3-m PIXEL RESOLUTION. THE GRAYSCALE ZOOM-IN INSETS SHOW AUV CAMERA PHOTOMOSAICS OF HSFs.

4. THE BACKGROUND GRAYSCALE SEAFLOOR RENDERING IMAGE WAS DERIVED FROM AUV MBES DATA (BINNED AT 3 m) AND 3DX SEAFLOOR PICKS (BINNED AT 12.5 m).

5. PROPOSED AND REPORTED INFRASTRUCTURE AND LEASE BLOCK INFORMATION PROVIDED BY EXXONMOBIL.

SPHEROID:	WGS_1984	FLATTENING:	1/F=298.257223563
SEMI MAJOR AXIS:	a=6,378,137.00 m	SCALE FACTOR:	0.9996
PROJECTION:	TRANSVERSE MERCATOR	CENTRAL MERIDIAN:	-57°00'00"W
DATUM:	WGS 1984	LAT. ORIGIN:	00°00'00"
ZONE:	UTM ZONE 21 NORTH	FALSE EASTING:	500,000 m
GRID UNITS:	METERS	FALSE NORTHING:	0,000,000 m

SCALE = 1:65,000

0 500 1,000 2,000 3,000 4,000 5,000 6,000 7,000 8,000 Meters

ESTIMATED AREAL DENSITY OF HARD SEAFLOOR FEATURES WITHIN THE LIZA AND PAYARA AUV SURVEY AREAS

PAYARA AND LIZA FIELD DEVELOPMENT AREAS, OFFSHORE GUYANA

ESSO EXPLORATION AND PRODUCTION GUYANA LTD

CONTOUR INTERVAL: N/A	
DATUM: SEAFLOOR	
VELOCITY: N/A	
POSITIONING BY: SEE NOTE 1	DRAFTED BY: K. ROVANG & M.JOHN
INTERPRETED BY: M. JOHN & K. ROVANG	CHECKED BY: M.JOHN & K. J. CAMPBELL
DATE: 23 MAY 2019	GIS: PAYARA_Chart03_HSF_Density_v10_6
JOB NO.: 02.1803-1430	REVISION NO.:

CHART 3

EEPGL

MAP PREPARED BY:
FUGRO USA MARINE, INC
6100 HILLCROFT
HOUSTON, TEXAS 77081
PHONE: 713-369-5600
WWW.FUGRO.COM

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APPENDICES

A. SERVICE WARRANTY

B. PHOTOGRAPHIC ANALYSIS LOGS

B.1 PHOTOGRAPHIC POSITIONING LOG

B.2 PHOTOGRAPHIC INTERPRETATION LOG

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A. SERVICE WARRANTY

This report and the assessment carried out in connection with the report (together the "Services") were compiled and carried out by Fugro for Esso Exploration and Production Guyana Limited (the "Client") in accordance with the terms of a contract between Fugro and the Client. The Services were performed by Fugro with the skill and care ordinarily exercised by a reputable geological consultant at the time the Services were performed. Further, and in particular, the Services were performed by Fugro taking into account the limits of the scope of works authorized by the Client, the time scale involved, and the resources, including financial and manpower resources, agreed upon between Fugro and the Client.

Other than that, expressly contained in the contract and in paragraph 1 above, Fugro provides no other representation or warranty whether expressed or implied, in relation to the Services.

The Services were performed by Fugro exclusively for the purposes of the Client. Fugro is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless stated in the contract or expressly provided in writing, Fugro does not authorize, consent or condone any party other than the Client relying upon the Services. Should this report or any part of this report, or other details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and Fugro disclaims any liability to such party. Any such party would be advised to seek independent advice from a competent geological consultant and / or lawyer.

It is Fugro's understanding that this report is to be used for the purpose described in Section 1 - "Introduction" of this report. In particular, the report does not represent or constitute a basis for engineering design (design basis). That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, and/or should the Client's proposed development or use of the site change (including in particular any change in any design and/or specification relating to the proposed use or development of the site), this report may no longer be valid or appropriate and any further use of or reliance upon the report in those circumstances by the Client without Fugro's review and advice shall be at the Client's sole and own risk.

The passage of time may result in changes (whether anthropogenic or otherwise) in site conditions and changes in regulatory or other legal provisions, technology, methods of analysis or economic conditions that could render the report inaccurate or unreliable. If any such changes have taken place or after a period of 2 years from the date of this report or such other period as may be expressly stated in the report, the information, recommendations and conclusions contained in this report should not be relied upon without the written agreement of Fugro. In the absence of such written agreement of Fugro, reliance on the report after any such changes have occurred or after the period of 2 years has expired shall be at the Client's own and sole risk. Should Fugro agree to review the report after the period of 2 years has expired, Fugro shall be entitled to additional payment at the then-existing rates or such other terms as may be agreed upon between Fugro and the Client.

The observations, recommendations and conclusions in this report are based solely upon the Services that were provided pursuant to the contract between the Client and Fugro. Fugro is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services.

Where the Services have involved the use of any information provided by third parties or the Client and upon which Fugro was reasonably entitled to rely then the Services clearly are limited by the accuracy of such information. Unless otherwise stated, Fugro was not authorized and did not attempt to verify independently the accuracy or completeness of information, documentation or materials received from the Client or third parties, including laboratories and information services, during the performance of the services. Fugro is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to Fugro and including the doing of any independent investigation of the information provided to Fugro save as otherwise provided in terms of the contract between the Client and Fugro.

B. PHOTOGRAPHIC ANALYSIS LOGS

B.1 PHOTOGRAPHIC POSITIONING LOG

Geodetic Parameters: WGS84 UTM Zone 21N											
Date	Time	AUV Line	Photo Name	HSF Name	Latitude	Longitude	Easting [m]	Northing [m]	Depth [m MSL]	Altitude [m]	Survey Heading [°]
23/12/2018	03:13:11	3004	tf_1545527514_0000002523FN	3004_01	8.25585	-57.02046	497 746.6	912 582.2	2047.63	5.44	131.24
23/12/2018	03:14:07	3004	tf_1545527514_0000002578FN	3004_02	8.25526	-57.01976	497 823.3	912 517.9	2044.88	5.61	134.13
23/12/2018	03:14:13	3004	tf_1545527514_0000002584FN	3004_03	8.25520	-57.01969	497 831.5	912 510.6	2044.60	5.61	135.84
23/12/2018	03:15:02	3004	tf_1545527514_0000002632FN	3004_04	8.25468	-57.01909	497 897.8	912 453.6	2042.56	5.59	133.17
23/12/2018	03:15:25	3004	tf_1545527514_0000002655FN	3004_05	8.25443	-57.01881	497 928.8	912 425.5	2041.59	5.65	134.14
23/12/2018	03:15:29	3004	tf_1545527514_0000002659FN	3004_06	8.25439	-57.01876	497 934.3	912 420.7	2041.43	5.65	133.49
23/12/2018	03:15:32	3004	tf_1545527514_0000002662FN	3004_07	8.25435	-57.01872	497 938.5	912 417.2	2041.29	5.65	133.39
23/12/2018	03:15:39	3004	tf_1545527514_0000002669FN	3004_08	8.25428	-57.01863	497 948.3	912 408.9	2041.05	5.65	129.73
23/12/2018	03:16:09	3004	tf_1545527514_0000002698FN	3004_09	8.25398	-57.01825	497 990.1	912 376.3	2040.14	5.65	132.44
23/12/2018	03:16:30	3004	tf_1545527514_0000002719FN	3004_10	8.25376	-57.01798	498 019.8	912 351.7	2039.47	5.59	133.19
23/12/2018	04:00:07	3009	tf_1545527514_0000004420FN	3009_01	8.25436	-57.00280	499 691.2	912 417.6	2043.57	5.49	117.28
23/12/2018	04:00:16	3009	tf_1545527514_0000004429FN	3009_02	8.25429	-57.00266	499 706.9	912 410.4	2043.68	5.27	117.08
23/12/2018	04:00:40	3009	tf_1545527514_0000004452FN	3009_03	8.25411	-57.00231	499 745.3	912 389.9	2043.33	5.46	122.10
23/12/2018	04:01:02	3009	tf_1545527514_0000004474FN	3009_04	8.25393	-57.00199	499 780.3	912 370.0	2043.08	5.23	121.15
23/12/2018	04:01:10	3009	tf_1545527514_0000004482FN	3009_05	8.25386	-57.00188	499 793.0	912 362.9	2042.81	5.44	120.99
23/12/2018	04:01:57	3009	tf_1545527514_0000004528FN	3009_06	8.25349	-57.00121	499 866.4	912 322.2	2042.12	5.49	122.60
23/12/2018	04:02:12	3009	tf_1545527514_0000004543FN	3009_07	8.25337	-57.00100	499 890.3	912 308.5	2041.54	5.65	120.70
23/12/2018	04:03:13	3009	tf_1545527514_0000004603FN	3009_08	8.25293	-57.00010	499 988.9	912 260.2	2040.10	5.65	115.24
23/12/2018	04:04:05	3009	tf_1545527514_0000004655FN	3009_09	8.25257	-56.99932	500 074.8	912 219.5	2039.96	5.47	118.86
23/12/2018	04:05:19	3009	tf_1545527514_0000004727FN	3009_10	8.25201	-56.99827	500 190.8	912 158.2	2039.46	5.59	117.87
23/12/2018	06:49:43	3014	tf_1545527514_0000014027FN	3014_01	8.24981	-57.00630	499 306.2	911 914.4	2029.68	5.49	298.82
23/12/2018	06:50:08	3014	tf_1545527514_0000014051FN	3014_02	8.24997	-57.00663	499 269.9	911 933.1	2029.83	5.66	291.98
23/12/2018	06:50:30	3014	tf_1545527514_0000014073FN	3014_03	8.25012	-57.00696	499 233.7	911 949.1	2030.22	5.65	291.81
23/12/2018	06:50:45	3014	tf_1545527514_0000014088FN	3014_04	8.25022	-57.00718	499 208.9	911 960.3	2030.65	5.55	292.25
23/12/2018	06:51:19	3014	tf_1545527514_0000014121FN	3014_05	8.25046	-57.00768	499 154.6	911 986.7	2031.23	5.59	294.39
23/12/2018	06:51:51	3014	tf_1545527514_0000014153FN	3014_06	8.25070	-57.00815	499 102.2	912 012.9	2031.76	5.66	294.22
23/12/2018	06:51:54	3014	tf_1545527514_0000014156FN	3014_07	8.25072	-57.00820	499 097.3	912 015.4	2031.89	5.70	293.76

Geodetic Parameters: WGS84 UTM Zone 21N											
Date	Time	AUV Line	Photo Name	HSF Name	Latitude	Longitude	Easting [m]	Northing [m]	Depth [m MSL]	Altitude [m]	Survey Heading [°]
23/12/2018	06:52:51	3014	tf_1545527514_0000014212FN	3014_08	8.25115	-57.00901	499 007.2	912 063.5	2032.69	5.71	294.75
23/12/2018	06:53:36	3014	tf_1545527514_0000014256FN	3014_09	8.25148	-57.00967	498 935.4	912 099.4	2033.63	5.51	294.09
23/12/2018	06:53:48	3014	tf_1545527514_0000014268FN	3014_10	8.25158	-57.00984	498 916.2	912 110.0	2033.70	5.62	296.27
23/12/2018	05:51:10	3021	tf_1545527514_0000010594FN	3021_01	8.24653	-56.99982	500 020.3	911 552.2	2026.13	5.66	55.25
23/12/2018	05:51:14	3021	tf_1545527514_0000010598FN	3021_02	8.24657	-56.99976	500 026.8	911 556.4	2026.30	5.70	54.10
23/12/2018	05:52:03	3021	tf_1545527514_0000010646FN	3021_03	8.24703	-56.99910	500 099.1	911 608.0	2028.16	5.31	52.07
23/12/2018	05:52:13	3021	tf_1545527514_0000010656FN	3021_04	8.24713	-56.99897	500 113.9	911 618.8	2028.40	5.41	51.81
23/12/2018	05:52:48	3021	tf_1545527514_0000010690FN	3021_05	8.24745	-56.99850	500 164.9	911 654.5	2029.38	5.54	53.60
23/12/2018	05:53:10	3021	tf_1545527514_0000010712FN	3021_06	8.24766	-56.99820	500 198.1	911 677.4	2030.26	5.47	52.83
23/12/2018	05:53:46	3021	tf_1545527514_0000010747FN	3021_07	8.24799	-56.99772	500 251.1	911 713.3	2031.61	5.60	55.85
23/12/2018	05:54:27	3021	tf_1545527514_0000010788FN	3021_08	8.24836	-56.99715	500 313.8	911 754.3	2032.96	5.51	54.16
23/12/2018	05:55:07	3021	tf_1545527514_0000010827FN	3021_09	8.24872	-56.99662	500 372.8	911 794.0	2034.57	5.61	54.90
23/12/2018	05:56:01	3021	tf_1545527514_0000010881FN	3021_10	8.24919	-56.99586	500 456.0	911 846.9	2036.65	5.65	53.49
23/12/2018	04:43:27	3029	tf_1545527514_0000006587FN	3024_01	8.24667	-56.99280	500 793.1	911 567.9	2034.47	5.51	70.99
23/12/2018	04:44:00	3029	tf_1545527514_0000006619FN	3024_02	8.24682	-56.99227	500 851.7	911 583.9	2034.97	5.51	74.54
23/12/2018	04:44:20	3029	tf_1545527514_0000006639FN	3024_03	8.24690	-56.99194	500 887.2	911 592.8	2035.27	5.31	73.88
23/12/2018	04:45:43	3029	tf_1545527514_0000006721FN	3024_04	8.24725	-56.99063	501 031.7	911 631.6	2037.62	5.58	77.62
23/12/2018	04:46:01	3029	tf_1545527514_0000006739FN	3024_05	8.24731	-56.99034	501 063.5	911 639.0	2038.25	5.65	73.24
23/12/2018	04:46:44	3029	tf_1545527514_0000006781FN	3024_06	8.24749	-56.98967	501 137.8	911 658.1	2040.23	5.54	73.88
23/12/2018	04:47:11	3029	tf_1545527514_0000006808FN	3024_07	8.24760	-56.98924	501 185.4	911 671.0	2041.34	5.57	72.75
23/12/2018	04:47:45	3029	tf_1545527514_0000006841FN	3024_08	8.24775	-56.98871	501 243.6	911 687.2	2042.66	5.51	73.12
23/12/2018	04:48:12	3029	tf_1545527514_0000006868FN	3024_09	8.24787	-56.98827	501 291.3	911 700.3	2043.81	5.57	73.47
23/12/2018	04:48:21	3029	tf_1545527514_0000006877FN	3024_10	8.24791	-56.98813	501 307.3	911 704.6	2044.10	5.33	73.61
23/12/2018	07:18:00	3034	tf_1545527514_0000015700FN	3034_01	8.24601	-57.00735	499 190.8	911 494.8	2021.32	5.47	294.42
23/12/2018	07:18:09	3034	tf_1545527514_0000015709FN	3034_02	8.24607	-57.00748	499 176.6	911 501.7	2021.30	5.65	293.45
23/12/2018	07:18:41	3034	tf_1545527514_0000015741FN	3034_03	8.24629	-57.00796	499 123.8	911 525.8	2021.74	5.46	292.09
23/12/2018	07:19:55	3034	tf_1545527514_0000015814FN	3034_04	8.24683	-57.00904	499 004.1	911 585.0	2022.14	5.61	294.39
23/12/2018	07:20:07	3034	tf_1545527514_0000015825FN	3034_05	8.24691	-57.00921	498 986.1	911 593.9	2022.20	5.65	294.54
23/12/2018	07:20:23	3034	tf_1545527514_0000015841FN	3034_06	8.24703	-57.00944	498 960.3	911 607.6	2022.53	5.51	295.04
23/12/2018	07:20:40	3034	tf_1545527514_0000015858FN	3034_07	8.24716	-57.00969	498 932.4	911 621.5	2022.65	5.64	298.87
23/12/2018	07:20:54	3034	tf_1545527514_0000015872FN	3034_08	8.24727	-57.00989	498 910.3	911 634.3	2023.16	5.54	295.08

Geodetic Parameters: WGS84 UTM Zone 21N											
Date	Time	AUV Line	Photo Name	HSF Name	Latitude	Longitude	Easting [m]	Northing [m]	Depth [m MSL]	Altitude [m]	Survey Heading [º]
23/12/2018	07:21:39	3034	tf_1545527514_0000015916FN	3034_09	8.24759	-57.01055	498 838.1	911 669.8	2024.19	5.54	298.57
23/12/2018	07:21:54	3034	tf_1545527514_0000015931FN	3034_10	8.24772	-57.01076	498 814.5	911 683.5	2024.55	5.51	295.24
23/12/2018	08:02:34	3040	tf_1545527514_0000018337FN	3040_01	8.23925	-57.00807	499 110.7	910 747.5	2004.28	5.71	129.76
23/12/2018	08:03:18	3040	tf_1545527514_0000018381FN	3040_02	8.23875	-57.00757	499 166.7	910 692.4	2003.53	5.34	137.58
23/12/2018	08:03:33	3040	tf_1545527514_0000018395FN	3040_03	8.23858	-57.00741	499 184.1	910 673.8	2002.87	5.56	137.99
23/12/2018	08:04:20	3040	tf_1545527514_0000018442FN	3040_04	8.23802	-57.00687	499 243.4	910 611.7	2001.09	5.55	136.32
23/12/2018	08:05:07	3040	tf_1545527514_0000018488FN	3040_05	8.23747	-57.00634	499 301.6	910 550.8	2001.03	5.49	137.26
23/12/2018	08:05:14	3040	tf_1545527514_0000018495FN	3040_06	8.23739	-57.00626	499 310.4	910 541.5	2000.78	5.58	137.29
23/12/2018	08:05:28	3040	tf_1545527514_0000018509FN	3040_07	8.23722	-57.00610	499 328.1	910 523.0	2000.59	5.58	137.22
23/12/2018	08:06:06	3040	tf_1545527514_0000018546FN	3040_08	8.23678	-57.00568	499 374.9	910 474.0	2000.04	5.52	137.31
23/12/2018	08:07:00	3040	tf_1545527514_0000018600FN	3040_09	8.23613	-57.00506	499 443.1	910 402.6	1998.84	5.64	137.22
23/12/2018	08:07:22	3040	tf_1545527514_0000018621FN	3040_10	8.23587	-57.00482	499 468.9	910 374.2	1998.13	5.60	141.27
23/12/2018	08:38:46	3045	tf_1545527514_0000020479FN	3045_01	8.23317	-57.00626	499 310.7	910 075.1	1990.65	5.71	110.83
23/12/2018	08:38:56	3045	tf_1545527514_0000020489FN	3045_02	8.23311	-57.00611	499 327.4	910 068.8	1991.12	5.53	115.33
23/12/2018	08:39:37	3045	tf_1545527514_0000020530FN	3045_03	8.23281	-57.00550	499 393.8	910 035.2	1991.65	5.55	118.74
23/12/2018	08:39:54	3045	tf_1545527514_0000020546FN	3045_04	8.23269	-57.00527	499 420.0	910 022.4	1991.64	5.66	116.22
23/12/2018	08:40:39	3045	tf_1545527514_0000020591FN	3045_05	8.23239	-57.00459	499 495.0	909 988.8	1992.20	5.53	120.25
23/12/2018	08:41:47	3045	tf_1545527514_0000020658FN	3045_06	8.23189	-57.00359	499 604.2	909 933.4	1992.63	5.52	118.20
23/12/2018	08:41:50	3045	tf_1545527514_0000020661FN	3045_07	8.23186	-57.00355	499 609.1	909 931.0	1992.64	5.53	118.16
23/12/2018	08:42:30	3045	tf_1545527514_0000020700FN	3045_08	8.23157	-57.00297	499 672.7	909 898.9	1992.69	5.65	118.25
23/12/2018	08:42:31	3045	tf_1545527514_0000020701FN	3045_09	8.23157	-57.00296	499 674.3	909 898.1	1992.69	5.65	118.26
23/12/2018	08:42:53	3045	tf_1545527514_0000020723FN	3045_10	8.23140	-57.00263	499 710.1	909 879.8	1992.92	5.64	118.29

Notes:
AUV = autonomous underwater vehicle
HSF = hard seabed feature
MSL = Mean Sea Level

B.2 PHOTOGRAPHIC INTERPRETATION LOGS

B.2.1 HSF PHYSICAL CHARACTERISTICS

HSF Name	HSF Dimensions			Total Cover [%]	S	N	Porifera (indeterminate)		Porifera (massive)		Hexactinellida? (spherical)		Porifera (osculate)		Hexactinellida (*Poliopogon amadou*?)	
	Width [m]	Length [m]	Area [m^2]				%	#	%	#	%	#	%	#	%	#
3004_01	0.6	1.4	0.9	5	1	3	-	-	-	-	-	-	-	-	5	3
3004_02	1.0	1.6	1.7	5	1	1	-	-	-	-	-	-	-	-	5	1
3004_03	0.6	0.7	0.6	7	3	4	-	-	-	-	-	-	-	-	5	2
3004_04	1.4	2.0	2.0	20	3	7	5	1	-	-	-	-	-	-	10	5
3004_05	1.7	1.7	1.7	1	1	1	-	-	-	-	-	-	-	-	-	-
3004_06	1.0	1.0	0.6	5	1	1	-	-	-	-	-	-	-	-	5	1
3004_07	1.0	1.3	1.1	5	2	3	-	-	-	-	-	-	-	-	5	2
3004_08	1.1	1.6	1.3	10	2	2	-	-	-	-	5	1	-	-	5	1
3004_09	0.9	1.1	0.7	10	1	5	-	-	-	-	-	-	-	-	10	5
3004_10	0.9	1.7	1.0	11	2	4	-	-	-	-	-	-	-	-	10	3
3009_01	0.3	0.9	0.1	10	1	1	10	1	-	-	-	-	-	-	-	-
3009_02	1.3	1.8	1.8	0	-	-	-	-	-	-	-	-	-	-	-	-
3009_03	1.0	1.4	0.5	16	3	7	5	4	-	-	1	1	-	-	10	2
3009_04	0.7	1.4	0.7	15	3	13	5	10	-	-	-	-	-	-	5	2
3009_05	1.0	1.0	0.8	40	2	5	-	-	30	3	-	-	-	-	10	2
3009_06	0.4	0.9	0.3	5	2	2	5	1	-	-	-	-	-	-	-	-
3009_07	1.3	1.6	1.6	20	1	1	-	-	-	-	-	-	-	-	20	1
3009_08	1.4	1.7	1.0	25	2	10	5	3	-	-	-	-	-	-	20	7
3009_09	0.7	1.0	0.5	15	3	3	-	-	-	-	-	-	-	-	5	1
3009_10	1.0	1.3	1.1	10	2	4	-	-	-	-	5	1	-	-	5	3
3014_01	1.1	1.3	0.8	10	2	3	5	2	-	-	-	-	-	-	-	-
3014_02	0.9	1.0	0.4	10	1	1	-	-	-	-	-	-	-	-	10	1
3014_03	0.9	1.3	1.0	0	-	-	-	-	-	-	-	-	-	-	-	-
3014_04	1.1	1.7	0.9	0	-	-	-	-	-	-	-	-	-	-	-	-
3014_05	0.7	1.1	0.8	5	1	3	5	3	-	-	-	-	-	-	-	-
3014_06	0.9	1.4	0.9	30	2	6	20	4	-	-	-	-	-	-	10	2
3014_07	0.7	0.7	0.4	25	3	5	10	1	-	-	-	-	-	-	10	3
3014_08	1.1	1.3	0.9	11	3	5	5	3	-	-	-	-	-	-	5	1

HSF Name	HSF Dimensions			Total Cover [%]	S	N	Porifera (indeterminate)		Porifera (massive)		Hexactinellida? (spherical)		Porifera (osculate)		Hexactinellida (*Poliopogon amadou*?)	
	Width [m]	Length [m]	Area [m^2]				%	#	%	#	%	#	%	#	%	#
3014_09	1.0	1.3	0.7	1	1	1	-	-	-	-	-	-	-	-	-	-
3014_10	0.9	1.0	0.7	6	2	3	5	1	-	-	-	-	-	-	1	2
3021_01	0.4	0.7	0.3	45	3	10	20	4	-	-	5	3	-	-	-	-
3021_02	0.9	1.6	0.9	5	1	4	5	4	-	-	-	-	-	-	-	-
3021_03	0.6	0.7	0.3	10	1	3	-	-	-	-	-	-	-	-	10	3
3021_04	0.7	0.7	0.3	5	1	1	-	-	-	-	5	1	-	-	-	-
3021_05	1.0	1.1	0.8	10	2	2	-	-	-	-	5	1	-	-	5	1
3021_06	1.0	1.1	0.7	5	1	4	5	4	-	-	-	-	-	-	-	-
3021_07	1.6	2.8	2.2	21	4	6	10	3	-	-	1	1	-	-	5	1
3021_08	0.6	1.1	0.6	10	2	6	5	2	-	-	-	-	-	-	5	4
3021_09	1.1	1.2	1.1	25	2	8	5	2	-	-	-	-	-	-	20	6
3021_10	0.9	0.9	0.4	5	1	1	-	-	-	-	5	1	-	-	-	-
3024_01	2.8	1.5	2.2	10	2	11	5	5	-	-	-	-	-	-	5	6
3024_02	1.8	1.5	1.7	7	3	8	-	-	-	-	5	3	-	-	1	3
3024_03	2.6	2.3	3.7	7	3	9	1	2	-	-	-	-	-	-	5	5
3024_04	1.5	1.0	0.9	2	2	3	-	-	-	-	-	-	-	-	1	1
3024_05	1.1	1.1	0.6	2	2	5	1	3	-	-	-	-	-	-	1	2
3024_06	1.3	1.0	0.6	1	1	1	-	-	-	-	-	-	-	-	1	1
3024_07	1.3	1.4	0.8	3	3	3	-	-	-	-	-	-	-	-	1	1
3024_08	1.4	1.2	0.8	7	3	8	1	2	-	-	-	-	-	-	5	5
3024_09	1.7	1.4	0.6	6	2	2	1	1	-	-	-	-	-	-	-	-
3024_10	2.6	2.6	3.8	11	2	12	1	1	-	-	-	-	-	-	10	11
3034_01	1.2	1.7	1.1	10	2	4	5	1	-	-	-	-	-	-	-	-
3034_02	0.3	0.3	0.1	10	2	2	5	1	-	-	-	-	-	-	5	1
3034_03	1.1	1.7	1.6	5	1	3	-	-	-	-	-	-	-	-	5	3
3034_04	0.9	0.9	0.7	0	0	0	-	-	-	-	-	-	-	-	-	-
3034_05	0.4	0.8	0.6	20	1	1	-	-	-	-	-	-	-	-	-	-
3034_06	1.0	1.6	1.6	10	1	1	-	-	-	-	-	-	-	-	-	-
3034_07	1.7	1.8	1.9	15	3	4	5	2	-	-	-	-	-	-	5	1
3034_08	1.1	1.3	1.0	10	2	3	5	1	-	-	-	-	-	-	-	-
3034_09	0.7	0.6	0.3	10	2	2	5	1	-	-	5	1	-	-	-	-

HSF Name	HSF Dimensions			Total Cover [%]	S	N	Porifera (indeterminate)		Porifera (massive)		Hexactinellida? (spherical)		Porifera (osculate)		Hexactinellida (*Poliopogon amadou*?)	
	Width [m]	Length [m]	Area [m^2]				%	#	%	#	%	#	%	#	%	#
3034_10	1.4	1.7	1.6	15	3	5	5	2	-	-	-	-	-	-	5	2
3040_01	0.7	0.9	0.5	15	3	7	-	-	-	-	5	2	-	-	5	4
3040_02	1.7	1.7	1.6	16	4	7	-	-	5	1	-	-	-	-	5	4
3040_03	1.4	2.0	2.1	15	3	6	-	-	-	-	5	1	-	-	5	5
3040_04	0.8	1.1	0.8	10	1	1	-	-	10	1	-	-	-	-	-	-
3040_05	1.1	1.8	1.6	16	3	6	1	2	-	-	-	-	5	1	10	3
3040_06	0.6	1.1	0.4	25	2	5	-	-	-	-	-	-	-	-	20	4
3040_07	0.9	2.1	1.1	20	3	5	10	2	-	-	-	-	-	-	5	2
3040_08	1.5	1.6	1.7	10	1	4	-	-	-	-	-	-	-	-	10	4
3040_09	1.6	1.8	1.4	10	2	5	5	4	-	-	-	-	-	-	-	-
3040_10	0.9	1.1	0.7	10	2	4	5	1	-	-	-	-	-	-	5	3
3045_01	1.4	1.8	1.7	16	3	9	1	1	-	-	-	-	-	-	10	4
3045_02	2.0	1.8	2.1	17	4	12	5	1	-	-	-	-	-	-	1	2
3045_03	1.7	2.1	2.3	11	3	6	-	-	-	-	-	-	-	-	5	3
3045_04	1.0	1.2	0.8	5	1	6	5	6	-	-	-	-	-	-	-	-
3045_05	1.6	1.6	1.3	20	4	6	5	3	-	-	-	-	-	-	5	2
3045_06	1.2	2.3	1.9	21	3	6	-	-	-	-	-	-	-	-	10	4
3045_07	1.4	1.6	1.8	10	2	3	-	-	-	-	-	-	-	-	5	2
3045_08	1.8	2.8	3.2	10	1	17	-	-	-	-	-	-	-	-	10	17
3045_09	1.4	1.7	1.7	10	2	3	5	1	-	-	-	-	-	-	5	2
3045_10	1.1	1.6	1.6	25	4	9	5	1	-	-	-	-	-	-	10	6

Notes:
HSF = hard seabed feature
S = number of taxa
N = total faunal abundance

B.2.2 HSF BIOLOGICAL COMMUNITY CHARACTERISTICS

HSF Name	Crinoidea		Asteroidea		Brisingida (*Freyella* sp?)		Ophiuroidea (Ophionereidae?)		*Bathypathes* sp.		Indeterminate		Zoarcidae
	%	#	%	#	%	#	%	#	%	#	%	#	#
3004_01	-	-	-	-	-	-	-	-	-	-	-	-	-
3004_02	-	-	-	-	-	-	-	-	-	-	-	-	-
3004_03	1	1	1	1	-	-	-	-	-	-	-	-	-
3004_04	-	-	-	-	5	1	-	-	-	-	-	-	-
3004_05	-	-	-	-	-	-	1	1	-	-	-	-	-
3004_06	-	-	-	-	-	-	-	-	-	-	-	-	-
3004_07	-	-	-	-	-	-	-	-	-	-	-	-	1
3004_08	-	-	-	-	-	-	-	-	-	-	-	-	-
3004_09	-	-	-	-	-	-	-	-	-	-	-	-	-
3004_10	1	1	-	-	-	-	-	-	-	-	-	-	-
3009_01	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_02	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_03	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_04	-	-	-	-	5	1	-	-	-	-	-	-	-
3009_05	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_06	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_07	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_08	-	-	-	-	-	-	-	-	-	-	-	-	-
3009_09	-	-	5	1	5	1	-	-	-	-	-	-	-
3009_10	-	-	-	-	-	-	-	-	-	-	-	-	-
3014_01	-	-	-	-	5	1	-	-	-	-	-	-	-
3014_02	-	-	-	-	-	-	-	-	-	-	-	-	-
3014_03	-	-	-	-	-	-	-	-	-	-	-	-	-
3014_04	-	-	-	-	-	-	-	-	-	-	-	-	-
3014_05	-	-	-	-	-	-	-	-	-	-	-	-	-
3014_06	-	-	-	-	-	-	-	-	-	-	-	-	-
3014_07	-	-	-	-	5	1	-	-	-	-	-	-	-
3014_08	1	1	-	-	-	-	-	-	-	-	-	-	-
3014_09	-	-	-	-	-	-	1	1	-	-	-	-	-
3014_10	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_01	-	-	-	-	20	3	-	-	-	-	-	-	-

HSF Name	Crinoidea		Asteroidea		Brisingida (*Freyella* sp?)		Ophiuroidea (Ophionereidae?)		*Bathypathes* sp.		Indeterminate		Zoarcidae
	%	#	%	#	%	#	%	#	%	#	%	#	#
3021_02	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_03	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_04	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_05	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_06	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_07	-	-	5	1	-	-	-	-	-	-	-	-	-
3021_08	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_09	-	-	-	-	-	-	-	-	-	-	-	-	-
3021_10	-	-	-	-	-	-	-	-	-	-	-	-	-
3024_01	-	-	-	-	-	-	-	-	-	-	-	-	-
3024_02	-	-	-	-	-	-	1	2	-	-	-	-	-
3024_03	-	-	-	-	-	-	1	2	-	-	-	-	-
3024_04	-	-	1	2	-	-	-	-	-	-	-	-	-
3024_05	-	-	-	-	-	-	-	-	-	-	-	-	-
3024_06	-	-	-	-	-	-	-	-	-	-	-	-	-
3024_07	-	-	-	-	-	-	1	1	-	-	1	1	-
3024_08	-	-	-	-	-	-	1	1	-	-	-	-	-
3024_09	-	-	-	-	-	-	-	-	-	-	5	1	-
3024_10	-	-	-	-	-	-	-	-	-	-	-	-	-
3034_01	-	-	-	-	-	-	-	-	-	-	5	3	-
3034_02	-	-	-	-	-	-	-	-	-	-	-	-	-
3034_03	-	-	-	-	-	-	-	-	-	-	-	-	-
3034_04	-	-	-	-	-	-	-	-	-	-	-	-	-
3034_05	-	-	-	-	20	1	-	-	-	-	-	-	-
3034_06	-	-	-	-	-	-	-	-	-	-	10	1	-
3034_07	-	-	5	1	-	-	-	-	-	-	-	-	-
3034_08	-	-	-	-	-	-	-	-	-	-	5	2	-
3034_09	-	-	-	-	-	-	-	-	-	-	-	-	-
3034_10	-	-	-	-	-	-	-	-	-	-	5	1	-
3040_01	-	-	-	-	5	1	-	-	-	-	-	-	-
3040_02	-	-	-	-	5	1	1	1	-	-	-	-	-
3040_03	-	-	-	-	-	-	-	-	-	-	5	?1	-

HSF Name	Crinoidea		Asteroidea		Brisingida (*Freyella* sp?)		Ophiuroidea (Ophionereidae?)		*Bathypathes* sp.		Indeterminate		Zoarcidae
	%	#	%	#	%	#	%	#	%	#	%	#	#
3040_04	-	-	-	-	-	-	-	-	-	-	-	-	-
3040_05	-	-	-	-	-	-	-	-	-	-	-	-	-
3040_06	-	-	-	-	5	1	-	-	-	-	-	-	-
3040_07	-	-	-	-	5	1	-	-	-	-	-	-	-
3040_08	-	-	-	-	-	-	-	-	-	-	-	-	-
3040_09	-	-	-	-	5	1	-	-	-	-	-	-	-
3040_10	-	-	-	-	-	-	-	-	-	-	-	-	-
3045_01	-	-	-	-	-	-	-	-	-	-	5	4	-
3045_02	-	-	-	-	10	8	-	-	-	-	1	1	-
3045_03	1	1	-	-	-	-	-	-	-	-	5	2	-
3045_04	-	-	-	-	-	-	-	-	-	-	-	-	-
3045_05	-	-	-	-	5	1	-	-	-	-	5	1	-
3045_06	-	-	1	1	-	-	-	-	10	1	-	-	-
3045_07	-	-	-	-	-	-	-	-	-	-	5	1	-
3045_08	-	-	-	-	-	-	-	-	-	-	-	-	-
3045_09	-	-	-	-	-	-	-	-	-	-	-	-	-
3045_10	-	-	-	-	5	1	-	-	-	-	5	1	-

Notes:
HSF = hard seabed feature

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APPENDIX I

2018 Environmental Baseline Survey Report

Resubmitted without changes

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Environmental Baseline Survey and Habitat Assessment Report Payara Development

Offshore Guyana

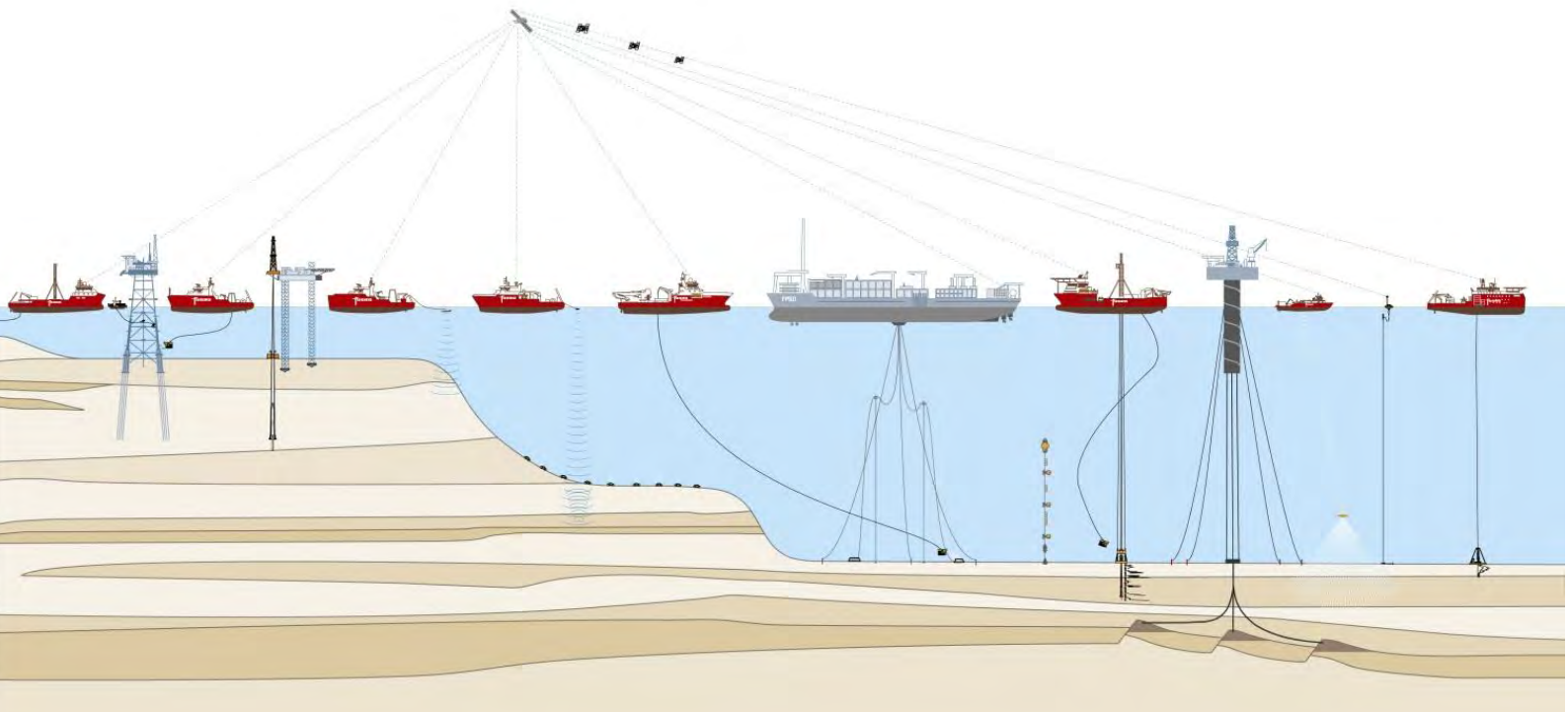
Fugro Document No.: 1803-1430-V8-EBS
6 March 2019

Esso Exploration and Production Guyana Limited

EEPGL

Volume 8

Final report



Environmental Baseline Survey and Habitat Assessment Report Payara Development

Offshore Guyana

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Volume 8

Final report

Prepared by:

Fugro GB Marine Limited
Trafalgar Wharf, Unit 16, Hamilton Road
Portchester, Portsmouth, PO6 4PX
United Kingdom
T +44 (0)2392 205 500
www.fugro.com

Prepared for:

Esso Exploration and Production Guyana Limited
c/o ExxonMobil Development Company
N2.3A.435
22777 Springwoods Village Parkway
Spring, Texas 77389
USA

EEPGL

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6 March 2019

Fugro GB Marine Limited
Trafalgar Wharf (Unit 16)
Hamilton Road
Portchester
Portsmouth, PO6 4PX
United Kingdom

T +44 (0)2392 205 500

Esso Exploration and Production Guyana Limited
c/o ExxonMobil Development Company
N2.3A.435
22777 Springwoods Village Parkway
Spring, Texas 77389
USA

Attention: Mr Patrick Lee
patrick.y.lee@exxonmobil.com

Environmental Baseline Survey and Habitat Assessment Report
Payara Development
Offshore Guyana

As a subcontractor to Fugro Canada Corp., Fugro GB Marine Limited has the pleasure of submitting the Environmental Baseline Survey and Habitat Assessment Report for the integrated site investigation programme within the Payara Deepwater Field, offshore Guyana. This report presents a summary of the survey operations and the preliminary results from the environmental survey. These results are subject to change after full interpretation and analysis undertaken in the office has been completed.

This work was carried out as authorised by Master Marine Survey Order A4000457, dated 16 August 2018 and under Master Marine Survey Agreement A1998840 and Marine Survey Sub agreement A2002836, both dated 14 February 2006 (contract reference Schedule H – Onshore Reporting, item 8.3). This report was prepared in general accordance with the Esso Exploration and Production Guyana Limited (EEPGL) project work scope, in accordance with Fugro proposal PL18-036 dated 8 June 2018, and as otherwise agreed with the EEPGL representative, Patrick Lee.

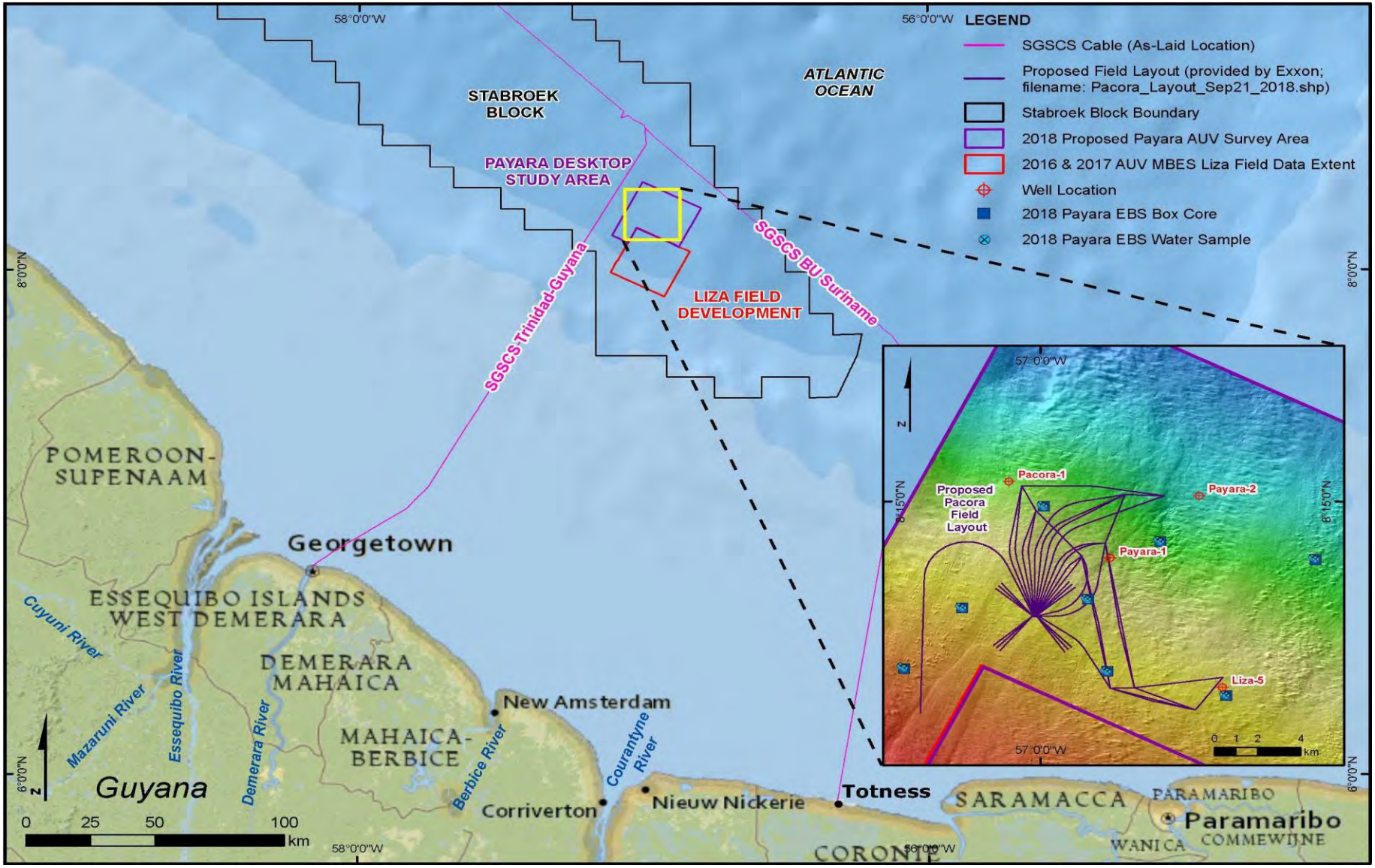
We hope that you find this report to your satisfaction; should you have any queries, please do not hesitate to contact us.

Yours faithfully
Fugro GB Marine Limited



J. Lusted
Ecology Group Survey Manager

Distribution: One electronic copy to **Mr Patrick Lee**



FRONTISPIECE

EXECUTIVE SUMMARY

Introduction

On the instruction of Esso Exploration and Production Guyana Limited (EEPGL), Fugro performed an integrated site investigation programme within the Payara deepwater field, offshore Guyana. The first phase of the site investigation comprised geotechnical sampling and an environmental baseline survey (EBS). Geophysical operations, comprising automated underwater vehicle (AUV) based multibeam echo sounder (MBES), sidescan sonar (SSS), and sub-bottom profiler (SBP) data collection, will be undertaken during the second phase of the programme.

Survey Strategy

Seabed video and still photographic data collection was performed at 13 locations to establish and identify the seabed habitats and epifaunal species within the survey area. Sediment box core sampling was performed at eight locations to establish the physico-chemical and biological properties of the sediment. Water quality was assessed through in situ collection of water column profiles and acquisition of water samples at eight locations.

Sediment Characterisation

Using the Wentworth (1922) sediment description, six stations were classified as ‘coarse silt’, with the remaining two being classified as ‘medium silt’ and ‘very fine sand’. The sediments were all classed as very poorly sorted and had a sediment composition consisting of mainly sand and fines content. Total organic carbon (TOC) concentrations displayed low variability across the survey area and values were low (≤ 0.36 %).

Sediment Hydrocarbons

The gas chromatographic profiles obtained from sediments collected from within the Payara survey area were typical of background sediments, displaying weathered low level petroleum and biogenic hydrocarbons and an associated unresolved complex mixture (UCM) commonly found in marine sediments.

The total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations were low across the survey area. The United States Environmental Protection Agency’s 16 priority PAH pollutants (US EPA 16 PAH) were below their respective effects range low (ERL) values at all stations.

Sediment Trace/Heavy Metals

The concentrations of metals (aqua regia digest) displayed low to high variability for all metal concentrations across the sediments (RSD ≤ 227 %). Metal concentrations were all below their respective ERL values at all stations, with the exception of arsenic and nickel. The arsenic ERL value was exceeded at two stations and the effects range median (ERM) value at one station. Nickel concentrations exceeded the ERL value at two stations. There is an increased likelihood of toxicity with regards to the benthic community when ERL and ERM values are exceeded, although the stations with ERL and ERM exceedances also contained a higher proportion of fines which are associated with increased concentrations of metals and no concurrent increase in toxicity.

Water Profiles

Water profiles showed a stratified water column, with a defined thermocline, halocline, pH boundary and oxygen boundary down to ca. 400 m, after which values remained relatively constant. Turbidity remained constant throughout the profile.

Total suspended solids (TSS) values across the Payara water samples showed no evidence of stratification, as the mean TSS vales for each depth were comparable. TOC content for all stations was below the minimum reporting value (MRV).

Water Hydrocarbons

Total hydrocarbon content (THC) concentrations across the survey area were below the MRV for all stations except for station EBSWS4 (Bottom). There were no clear spatial trends in concentrations of UCM or n-alkanes across the survey area and no clear relationship between concentrations of these analytes and depth. Total 2 to 6 ring PAH concentrations displayed moderate variability (RSD 33 %) between samples. Total US EPA 16 PAH concentrations and naphthalene, phenanthrene/anthracene and dibenzothiophene (NPD) (total and percentage) all displayed low variability (RSD ≤ 19 %). All US EPA 16 PAH values were below their respective ERL value where available.

Water Trace/Heavy Metals

The concentrations of metals in the water samples was generally low across the Payara survey area, with the majority of analyte concentrations below their respective MRV. The criterion continuous concentration (CCC) value was exceeded by mercury at one station. Zinc exceeded both the CCC and the criterion maximum concentration (CMC) value at three stations. No spatial or depth patterns were observed between metals concentrations in water samples at the Payara survey area.

Seabed Habitats

Analysis of the photographic data identified one biotope complex present within the Payara survey area, 'Western Atlantic abyssal benthic communities' (11.2122) (Institute of Terrestrial Ecology, 1996); the EUNIS (2012) biotope 'Deep-sea muddy sand' (A6.4) was also assigned in order to offer further description. No potentially sensitive habitats or species were identified in the current survey.

Macrofauna

The faunal community within the survey area was moderately diverse with a large number of taxa occurring in relatively low abundances. Annelids and arthropods were the most numerous taxa recorded, similar to the community recorded at the Liza field in 2016.

The most numerous taxa recorded in the survey area have been previously reported in the wider south Atlantic region. However, one arthropod individual classified as *Aspidoniscus* sp. A and three arthropod individuals classified as *Heteromesus* are considered as likely to be new records of these species.

Multivariate analysis demonstrated moderate to high variability across the survey area, potentially due to the relatively high number of taxa and the low number of individuals observed.

No meaningful correlations were observed between the macrofaunal community and the rest of the physico-chemical parameters sampled across the Payara Development survey area.

DOCUMENT ARRANGEMENT

Volume 1 AUV, EBS, and Geotechnical Sampling Operations Report
Volume 2 Digital Deliverables and Data Transmittal Report
Volume 3 Shallow Sampling Program - Geotechnical and Geohazards Field Report
Volume 4 Shallow Sampling Program - Environmental Baseline Field Report
Volume 5 AUV Geophysical Field Report
Volume 6 In Situ and Static Laboratory Test Data Results and Interpretation of Static Soil Properties Report
Volume 7 Geological Testing Interpretation Report
Volume 8 Environmental Baseline Survey and Habitat Assessment Report
Volume 9 AUV Geophysical Results and Interpretation Report

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ABBREVIATIONS

1-λ	Simpson's diversity index
AUV	Autonomous underwater vehicle
BC	Box core
CCC	Criterion continuous concentration
CEMP	Coordinated Environmental Monitoring Programme
CLUSTER	Hierarchical agglomerative clustering
CMC	Criterion maximum concentration
CPI	Carbon preference index
CTD	Conductivity temperature depth
CV-AFS	Cold vapour-atomic fluorescence spectroscopy
DCM	Dichloromethane
DDV	Dual van Veen
DNA	Biodiversity DNA analysis sample
DO	Dissolved oxygen
DTI	Department of Trade and Industry
EBS	Environmental baseline survey
EEPGL	Esso Exploration and Production Guyana Limited
EOL	End of line
ERL	Effects range low
ERM	Effects range median
EUNIS	European Nature Information System
FA/FB	Fauna sample/replicate A or B
FID	Flame ionisation detection
FTU	Formazin turbidity units
GC	Gas chromatography
GC-FID	Gas chromatography–flame ionisation detection
GC-MS	Gas chromatography-mass spectrometry
H'Log_2	Shannon-Wiener index
Hb	Brillouin's diversity index
ICP-MS	Inductively coupled plasma-mass spectrometry
ICP-OES	Inductively coupled plasma-optical emission spectroscopy
IDA	Industrial denatured alcohol
IHM	In house method
J	Pielou's evenness
JNCC	Joint Nature Conservation Committee
LAT	Lowest astronomical tide
LED	Light emitting diode
MBES	Multibeam echo sounder
MRV	Minimum reporting value
MSL	Mean Sea Level
MV	Motor vessel
nC_{12-36}	n-alkane range
NDIR	Nondispersive infrared
NL	No layering
NMBAQC	North east Atlantic marine biological analytical quality control scheme
NOAA	National Oceanic and Atmospheric Administration
NPD	Naphthalene, phenanthrene/anthracene and dibenzothiophene
NR	Not recorded

PAH	Polycyclic aromatic hydrocarbon
PC	Physico-chemical (sample)
Ph	Phytane
Pr	Pristane
PSU	Practical salinity unit
Pr/Ph	Ratio of pristane to phytane
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSA	Particle size analysis
PSD	Particle size distribution
RSD	Relative standard deviation
SBP	Sub-bottom profiler
SD	Standard deviation
SIMPROF	Similarity profiling
sM	Sandy mud
SOL	Start of line
SSS	Sidescan sonar
THC	Total hydrocarbon content
TOC	Total organic carbon
TSS	Total suspended solids
UCM	Unresolved complex mixture
UKAS	United Kingdom Accreditation Service
USBL	Ultra short baseline
US EPA	United States Environmental Protection Agency
US EPA 16	United States Environmental Protection Agency's 16 priority PAH pollutants
USNEL	United States Naval Electronics Laboratory
UTC	Coordinated universal time
UTM	Universal Transverse Mercator
WGS84	World Geodetic System 1984
WP	Water profile
WS	Water sample

1. INTRODUCTION

1.1 Background

On the instruction of Esso Exploration and Production Guyana Limited (EEPGL), Fugro performed an integrated site investigation programme in support of the Payara development, offshore Guyana. The first phase of the site investigation comprised geotechnical sampling and an environmental baseline survey (EBS). Geophysical operations, comprising automated underwater vehicle (AUV) based multibeam echo sounder (MBES), sidescan sonar (SSS), and sub-bottom profiler (SBP) data collection, will be undertaken during the second phase of the programme.

The survey was conducted onboard the MV Fugro Supporter during the survey period 14 September to 4 October 2018.

Appendix A outlines the guidelines for use of this report.

1.2 Scope of Work

The surveys were undertaken to establish the water column and sediment conditions encountered at the Payara development. The environmental survey was carried out to assess the biological and physico-chemical properties of the water column and seabed, to acquire sufficient environmental data to describe all habitats recorded within the survey area and to identify and delineate the extent of any potentially sensitive habitats or species.

1.3 Geodetic Parameters

All coordinates detailed in this report are referenced to WGS84 (World Geodetic System 1984) datum, Universal Transverse Mercator (UTM) Projection Zone 21 N. Table 1.1 provides the detailed geodetic and projection parameters.

Table 1.1: Project Geodetic Parameters

Global Positioning System Geodetic Parameters*	
Datum:	World Geodetic System 1984 (WGS84)
Spheroid:	World Geodetic System 1984
Semi major axis:	a = 6 378 137.000 m
Reciprocal flattening:	1/f = 298.257 223 563
Project Projection Parameters	
Grid Projection:	Universal Transverse Mercator (UTM), Northern Hemisphere
UTM Zone:	21 N
Central Meridian:	57° 00’ 00.0” West
Latitude of Origin:	00° 00′ 00″ North
False Easting:	500 000 m
False Northing:	0 m
Scale factor on Central Meridian:	0.9996
Units:	Metre
Notes: * = Fugro Starfix navigation software always uses WGS84 geodetic parameters as a primary datum for any geodetic calculations † = This is the right-hand coordinate frame rotation used by the Fugro Starfix navigation software	

1.4 Regional Standards and Comparable Studies

The Liza field EBS (Fugro, 2016) was used to provide regional comparison data. The Liza field survey was conducted in 2016 at a similar range of water depths to the samples collected in the current survey.

In the absence of regional standards specific to Guyana for physico-chemical data, internationally recognised environmental standards have been adopted. For results in sediments recorded above the minimum reporting value, comparison has been made to the National Oceanic and Atmospheric Administration (NOAA) effects range low (ERL) and effects range median (ERM) reference values (Buchman, 2008) where applicable. ERLs represent the low point (10th percentile) and ERMs represent the 50th percentile on a continuum of chemical concentrations over which adverse biological effects have been observed (O’ Connor, 2004). Water data were compared to the United States Environmental Protection Agency (US EPA) criterion continuous concentration (CCC) and criterion maximum concentration (CMC) values (US EPA, 2018), where available. Detrimental effects are rarely observed in biota when concentrations are below these values.

2. ENVIRONMENTAL SURVEY METHODS

2.1 Survey Strategy

The objectives of the EBS were to provide data to establish the baseline physico-chemical and biological characteristics of the seabed and water column environment, by undertaking water column and seabed sampling. Seabed photographic data were also collected to identify the habitats and epifaunal communities present within the survey area. Table 2.1 provides the locations, samples to be acquired and rationale for each location.

Table 2.1: Proposed Environmental Survey Sampling Stations, Payara Development

Geodetic Parameters: WGS84 UTM Zone 21N				
Station	**Easting [m]**	**Northing [m]**	**Rationale**	**Sample Acquisition**
Video Transects				
EBSDDV1	500 166.9	911 657.3	Client predetermined for site spatial coverage	Video and stills
EBSDDV2	505 560.5	909 795.3	Client predetermined for site spatial coverage	Video and stills
EBSDDV3	503 091.1	902 979.6	Client predetermined for site spatial coverage	Video and stills
EBSDDV4	508 613.5	901 724.2	Client predetermined for site spatial coverage	Video and stills
EBSDDV5	496 384.9	906 337.6	Client predetermined for site spatial coverage	Video and stills
EBSDDV6	502 198.9	906 781.5	Client predetermined for site spatial coverage	Video and stills
EBSDDV7	493 677.3	903 163.9	Client predetermined for site spatial coverage	Video and stills
EBSDDV8	512 754.4	908 877.2	Client predetermined for site spatial coverage	Video and stills
EBSDDV9	502 540.5	917 514.4	Ground-truthing geotechnical location	Video and stills
EBSDDV10	513 107.3	900 648.3	Ground-truthing geotechnical location	Video and stills
EBSDDV11	504 530.4	917 021.3	Ground-truthing geotechnical location	Video and stills
EBSDDV16	500 098.1	906 826.9	Ground-truthing geotechnical location	Video and stills
EBSDDV36	499 637.7	906 889.6	Ground-truthing geotechnical location	Video and stills
Sediment Sampling				
EBSBC1	500 166.9	911 657.3	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC2	505 560.5	909 795.3	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC3	503 091.1	902 979.6	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC4	508 613.5	901 724.2	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC5	496 384.9	906 337.6	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC6	502 198.9	906 781.5	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC7	493 677.3	903 163.9	Client predetermined for site spatial coverage	FA, FB, PC
EBSBC8	512 754.4	908 877.2	Client predetermined for site spatial coverage	FA, FB, PC
Water Sampling				
EBSWS1	500 166.9	911 657.3	Client predetermined for site spatial coverage	WS, WP
EBSWS2	505 560.5	909 795.3	Client predetermined for site spatial coverage	WS, WP
EBSWS3	503 091.1	902 979.6	Client predetermined for site spatial coverage	WS, WP
EBSWS4	508 613.5	901 724.2	Client predetermined for site spatial coverage	WS, WP
EBSWS5	496 384.9	906 337.6	Client predetermined for site spatial coverage	WS, WP
EBSWS6	502 198.9	906 781.5	Client predetermined for site spatial coverage	WS, WP
EBSWS7	493 677.3	903 163.9	Client predetermined for site spatial coverage	WS, WP
EBSWS8	512 745.5	908 877.2	Client predetermined for site spatial coverage	WS, WP

Notes:
FA/FB = Faunal samples A/B
WS = Water sample
DDV = Drop-down video
PC = Physico-chemical
WP = Water profile
BC = Box core

2.2 Survey Methods

Seabed photography was acquired using a Sonar Equipment Services deep-sea camera system mounted within a purpose built camera frame complete with one high resolution video camera, one stills camera, a separate strobe and four light emitting diode (LED) lights.

Seabed video footage was displayed on a computer monitor and recorded directly onto a hard drive. A video overlay was used to overlay a navigation string from an attached ultra short baseline (USBL) beacon, including the time, date, depth and location (easting and northing). The survey location and station number were also displayed (manually updated). The stills camera imagery was visible on a second window of the computer. Footage was viewed in real time via a co-axial cable, assisting in the control of the camera in the water. Two lasers were set up 17 cm apart to provide image scaling.

Seabed grab samples were primarily collected for analysis of physico-chemical and biological sediment characterisation; however, observations of the grab sample contents have been used to supplement the seabed video/photographic data in describing the benthic habitat where appropriate. Seabed samples were acquired using a United States Naval Electronics Laboratory (USNEL) 0.25 m^2 box corer equipped with a USBL beacon, within the agreed 50 m sampling accuracy.

Water profiles were acquired from both deployment and recovery from sea surface to near seabed using a Valeport Midas+ deepwater conductivity temperature depth (CTD) profiler recording depth, salinity, dissolved oxygen (DO), pH, turbidity and temperature. At each station, the initial drop had a clump weight, beacon, CTD and two 5 litre Niskin water samplers attached to the lifting wire at intervals coinciding with the bottom three sampling depths. The CTD profiles were acquired simultaneously with the collection of near-seabed (bottom) water samples. Mid-depth and near-surface samples were then acquired in two subsequent deployments of the Niskin sampler only.

Further detail can be found within the Payara development field report (Fugro, 2018a).

2.3 Analytical Strategy

The following list briefly describes the suites of analyses carried out. Further description of the methods used for the analyses are detailed in Appendix B.

- Sediment particle size distribution (PSD) analysis and characterisation including total organic carbon (TOC) (Section 4);
- Sediment total hydrocarbon content (THC) by gas chromatography–flame ionisation detection (GC-FID; Sections 5.2.1 and 5.2.2);
- Sediment 2 to 6 ring aromatic hydrocarbons, including the United States Environmental Protection Agency's (US EPA) 16 priority pollutants, by gas chromatography-mass spectrometry (GC-MS; Section 5.2.3);
- Sediment metals predominantly by an aqua regia acid digest and subsequent instrumental analysis. Arsenic, cadmium, chromium, copper, lead, nickel and zinc were analysed by inductively coupled plasma-mass spectrometry (ICP-MS). Aluminium, barium and iron were analysed by inductively coupled plasma-optical emission spectroscopy (ICP-OES). Mercury was analysed by cold vapour-atomic fluorescence spectroscopy (CV-AFS)) (Section 6);

- Water sample data were analysed for total suspended solids (TSS), TOC, hydrocarbons and metals content (Section 7);
- Habitats were classified using the 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (Institute of Terrestrial Ecology, 1996; Section 8);
- Macrofauna were identified and enumerated from two sample replicates at each station, 0.5 mm sieve (Section 9).

3. FIELD OPERATIONS

3.1 Seabed Sampling

Box corer sampling was successfully conducted at all of the proposed eight sediment stations. Table 3.1 summarises the samples acquired.

Table 3.1: Completed Environmental Survey Sampling Stations, Payara Development

Geodetic Parameters: WGS84 UTM Zone 21N					
Station	**Easting [m]**	**Northing [m]**	**Offset from Proposed [m]**	**Depth [m MSL]**	**Sample Acquisition**
EBSBC1	500 160.6	911 659.0	6.5	2074.6	FA, FB, DNA, PC
EBSBC2	505 554.4	909 799.9	7.6	2079.4	FA, FB, DNA, PC
EBSBC3	503 099.2	902 990.1	13.3	1917.7	FA, FB, DNA, PC
EBSBC4	508 609.3	901 723.1	4.3	1941.3	FA, FB, DNA, PC
EBSBC5	496 371.7	906 328.4	16.1	1907.9	FA, FB, DNA, PC
EBSBC6	502 203.2	906 793.7	12.9	1976.8	FA, FB, DNA, PC
EBSBC7	493 679.8	903 140.8	23.2	1817.5	FA, FB, DNA, PC
EBSBC8	512 761.0	908 871.0	9.1	2090.0	FA, FB, DNA, PC

Notes:
MSL = Mean Sea Level
FA/FB = Faunal sample A/B
DNA = Biodiversity DNA analysis sample
PC = Physico-chemical sediment sample
BC = Box core

3.2 Seabed Video/Photography

Photographic stills and video footage were successfully acquired at all of the proposed 13 drop-down camera stations. Table 3.2 summarises the samples acquired.

Table 3.2: Completed Environmental Survey Camera Transects, Payara Development

Geodetic Parameters: WGS84 UTM Zone 21N						
Station		**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
EBSDDV1	SOL	500 145.4	911 642.8	2036.7	49	11 min 25 sec 19 stills
	EOL	500 178.1	911 679.5	2035.9		
EBSDDV2	SOL	505 583.0	909 801.1	2079.8	47	37 min 22 sec 17 stills
	EOL	505 536.7	909 793.0	2077.8		
EBSDDV3.1	SOL	503 090.1	902 999.8	1916.2	10	2 min 56 sec 2 stills
	EOL	503 083.5	903 007.6	1915.1		
EBSDDV3.2	SOL	503 070.2	902 970.6	1914.6	44	10 min 31 sec 15 stills
	EOL	503 113.9	902 969.0	1915.6		
EBSDDV4	SOL	508 612.9	901 719.4	1936.6	20	6 min 0 sec 10 stills
	EOL	508 603.4	901 736.8	1939.1		
EBSDDV5	SOL	496 409.6	906 364.4	1907.9	49	31 min 24 sec 18 stills
	EOL	496 369.9	906 317.4	1905.7		
EBSDDV6	SOL	502 217.5	906 797.7	1976.8	44	18 min 9 sec 14 stills
	EOL	502 211.7	906 753.8	1974.6		

Geodetic Parameters: WGS84 UTM Zone 21N						
Station		**Easting [m]**	**Northing [m]**	**Depth [m BSL]**	**Length [m]**	**Data Acquisition**
EBSDDV7	SOL	493 696.8	903 154.4	1823.9	52	23 min 36 sec 18 stills
	EOL	493 648.1	903 171.4	1822.2		
EBSDDV8	SOL	512 796.8	908 871.3	2095.6	69	55 min 11 sec 26 stills
	EOL	512 729.7	908 887.5	2098.0		
EBSDDV9.1	SOL	502 533.2	917 524.3	2180.6	4	4 min 38 sec 5 stills
	EOL	502 537.5	917 524.6	2177.3		
EBSDDV9.2	SOL	502 537.2	917 521.3	2178.4	26	10 min 29 sec 12 stills
	EOL	502 548.4	917 498.1	2177.8		
EBSDDV10	SOL	513 127.3	900 667.5	1970.5	50	48 min 22 sec 28 stills
	EOL	513 087.7	900 637.4	1967.9		
EBSDDV11.1	SOL	504 516.0	917 028.3	2179.5	42	18 min 31 sec 16 stills
	EOL	504 551.2	917 005.5	2178.6		
EBSDDV11.2	SOL	504 535.9	917 022.4	2179.8	22	40 min 3 sec 17 stills
	EOL	504 517.1	917 011.6	2182.7		
EBSDDV16	SOL	500 123.4	906 809.1	1951.7	49	24 min 32 sec 19 stills
	EOL	500 075.7	906 819.9	1953.8		
EBSDDV36	SOL	499 672.2	906 888.2	1950.1	72	21 min 39 sec 19 stills
	EOL	499 600.0	906 892.8	1952.8		

Notes:
MSL = Mean Sea Level
SOL = Start of line
EOL = End of line
DDV = Drop-down video

3.3 Water Sampling and Profiling

Water sampling and profiling were successfully conducted at all of the proposed eight water sampling stations. Sample acquisition and coordinates are detailed in Table 3.3. Water profiles are displayed in Appendix F.

Table 3.3: Completed Environmental Water Sampling Stations, Payara Development

Geodetic Parameters: WGS84 UTM Zone 21N						
Station	**Easting [m]**	**Northing [m]**	**Sample Depth [m MSL]**			**Sample Acquisition**
			Top	**Mid**	**Bottom**	
EBSWS1	500 171.4	911 673.2	10.0	522.9	2015.7	WP, WS
EBSWS2	505 547.2	909 801.9	10.0	533.0	2055.6	WP, WS
EBSWS3	503 093.1	902 966.2	10.0	424.7	1896.7	WP, WS
EBSWS4	508 620.8	901 735.4	10.0	526.2	1917.0	WP, WS
EBSWS5	496 381.4	906 335.3	10.0	427.8	1894.0	WP, WS
EBSWS6	502 210.7	906 792.3	10.0	535.0	1955.0	WP, WS
EBSWS7	493 677.2	903 170.8	10.0	420.0	1802.3	WP, WS
EBSWS8	512 745.5	908 873.7	10.0	535.0	2074.0	WP, WS

Notes:
MSL = Mean Sea Level
WP = Water profile
WS = Water sample

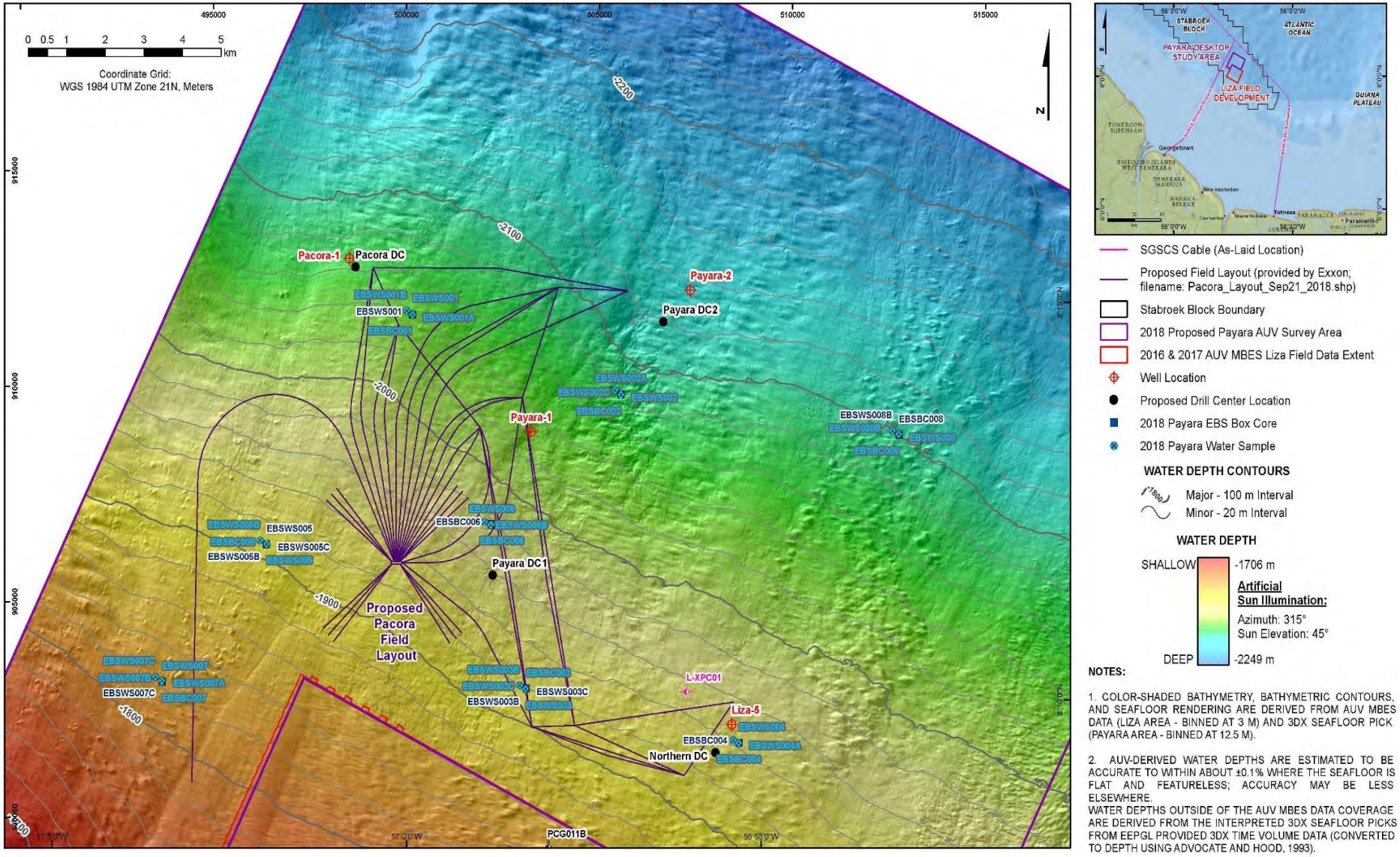


Figure 3.1: Completed environmental sampling locations overlaid on bathymetry, Payara development

4. SEDIMENT CHARACTERISATION

4.1 Introduction

Sediment samples were analysed for their PSD using a combination of two techniques; sieve analysis for all material retained by a 1 mm sieve followed by laser diffraction analysis of the finer material. The results of the particle size analysis were treated statistically to characterise the sediment type (Wentworth scale) and particle size homogeneity (sorting).

The proportion of TOC was determined by combustion and non-dispersive infrared detection following inorganic carbon removal.

Relative standard deviation (RSD) indicates the extent of variability in a dataset in relation to the mean value. The RSD value expresses the standard deviation as a percentage of the mean. For this report, RSD of less than 30 % will be considered low variability, 30 % to 70 % will be considered moderate variability and more than 70 % will be considered high variability.

Appendix B provides full details of the analytical techniques employed and Appendix D displays the histograms of particle size class summary for each station.

4.2 Results

Table 4.1 presents a summary of sediment characteristics, including granulometry and TOC across the Payara development survey area. Figure 4.1 presents the physical composition of the sediments at each station.

The sediments from the Payara development survey area had a mean particle size ranging from 29.3 µm to 74.8 µm, at stations EBSBC7 and EBSBC8 respectively, and a mean value of 49.9 µm. Interstation variation was moderate (RSD 31 %).

The sediment fractional composition was similar across all the Payara survey area stations (Table 4.1 and Figure 4.1). Sediments were predominantly composed of silt and sand, with low gravel content. The proportion of fines ranged from 34.6 % to 56.2 % at stations EBSBC8 and EBSBC7 respectively, with a mean value of 44.5 %. The range of fines values at the Payara survey area were lower than the mean value recorded at the Liza field (60.78 %; Fugro, 2016). Gravel content ranged from 0.00 % to 0.51 % at stations EBSBC4 and EBSBC5 respectively, with a mean value of 0.12 % which was comparable to that of the Liza field survey (0.11 %; Fugro, 2016). The variation across the survey area was high (RSD 143 %), influenced by the higher gravel content at station EBSBC5. Sand was generally the greatest constituent of the Payara sediments with values ranging from 43.8 % to 65.4 % at stations EBSBC7 and EBSBC8 respectively, with a mean value of 55.3 %. Interstation variation was low (RSD 14 %). The range of sand content values at the Payara survey area were all higher than the mean from the Liza field survey (39.11 %; Fugro, 2016). The sediments from the Payara survey area were described as coarse silt at all stations, with the exception of stations EBSBC7 and EBSBC8, which were described as medium silt and very fine sand, respectively.

Standard deviation of particle size (SD) indicates the degree of spread of individual size classes about the mean and provides the basis of a sorting index, in which low values of SD indicate sediments to be

fairly homogeneous (good sorting) while high values suggest a relatively large scatter of particle sizes about the mean (poor sorting). Values from the Payara survey sediments ranged from 3.04 phi to 3.24 phi at station EBSBC8 and EBSBC5 respectively, with a mean value of 3.11 phi. The sediments across the Payara survey area were all classed as very poorly sorted.

Skewness indicates the tendency of particle size classes to be skewed about the mean, either towards coarser sediment (negative skewness) or finer sediment (positive skewness). Values for the Payara sediments ranged from 0.027 phi to 0.797 phi at stations EBSBC7 and EBSBC8 respectively, with a mean value of 0.439 phi. Sediments ranged from symmetrical to fine skewed.

The TOC content was low across the Payara survey area, with values ranging from 0.27 % at station EBSBC1 to 0.36 % at station EBSBC5. The mean value was 0.31 % and interstation variation was low (RSD 9 %). The mean TOC value for the current survey was comparable to the mean from the Liza field survey (0.32 %; Fugro. 2016).

Table 4.1: Summary of Sediment Characteristics and Particle Size Distribution (PSD), Payara Development

Station	Mean [µm]*	Mean [phi]*	SD [phi]*	Skewness [phi]*	Wentworth Description†	Sorting‡	Fractional Composition			Fines		TOC [%]
							Gravel [%]	Sand [%]	Fines [%]	Silt [%]	Clay [%]	
EBSBC1	61.0	4.04	3.07	0.602	Coarse silt	Very poorly sorted	0.08	60.4	39.6	23.9	15.7	0.27
EBSBC2	46.8	4.42	3.13	0.414	Coarse silt	Very poorly sorted	0.05	54.6	45.3	26.8	18.5	0.29
EBSBC3	40.7	4.62	3.08	0.299	Coarse silt	Very poorly sorted	0.24	51.2	48.5	29.7	18.8	0.32
EBSBC4	60.4	4.05	3.08	0.663	Coarse silt	Very poorly sorted	0.00	61.8	38.2	21.4	16.8	0.31
EBSBC5	32.2	4.96	3.24	0.147	Coarse silt	Very poorly sorted	0.51	46.6	52.9	28.8	24.1	0.36
EBSBC6	54.2	4.21	3.16	0.559	Coarse silt	Very poorly sorted	0.06	58.9	41.0	22.8	18.3	0.29
EBSBC7	29.3	5.09	3.09	0.027	Medium silt	Very poorly sorted	0.01	43.8	56.2	33.7	22.5	0.34
EBSBC8	74.8	3.74	3.04	0.797	Very fine sand	Very poorly sorted	0.02	65.4	34.6	19.8	14.8	0.30
Minimum	**29.3**	**3.74**	**3.04**	**0.027**	**-**	**-**	**0.00**	**43.8**	**34.6**	**19.8**	**14.8**	**0.27**
Maximum	**74.8**	**5.09**	**3.24**	**0.797**	**-**	**-**	**0.51**	**65.4**	**56.2**	**33.7**	**24.1**	**0.36**
Mean	**49.9**	**4.39**	**3.11**	**0.439**	**-**	**-**	**0.12**	**55.3**	**44.5**	**25.9**	**18.7**	**0.31**
Standard Deviation	**15.6**	**0.473**	**0.061**	**0.266**	**-**	**-**	**0.175**	**7.63**	**7.54**	**4.73**	**3.19**	**0.029**
RSD [%]	**31**	**-**	**-**	**-**	**-**	**-**	**143**	**14**	**17**	**18**	**17**	**9**
Liza Field (Fugro, 2016)^												
Mean	**37.87**	**5.29**	**-**	**-**	**-**	**-**	**0.11**	**39.11**	**60.78**	**-**	**-**	**0.32**
RSD [%]	**99**	**25**	**-**	**-**	**-**	**-**	**418**	**56**	**36**	**-**	**-**	**78**

Notes:

Fines = silt and clay content
Silt = +4.0 to +8.0 ø units or 3.9 µm to 62.5 µm
Clay = +8.0 to +10.0 ø units or 0.98 µm to 3.9 µm
TOM = Total organic matter
TOC = Total organic carbon
RSD = Relative standard deviation
SD = Standard deviation
BC = Box core
* = Geometric/Logarithmic method of moments (Pettijohn et al., 1973; Gradistat statistics)
† = Wentworth description (Wentworth, 1922)
‡ = Sorting based on logarithmic Folk and Ward (1957) graphical measures (Gradistat statistics)
^ = Mean and relative standard deviation values estimated from a historical environmental survey in the neighbouring Liza field (Fugro, 2016)

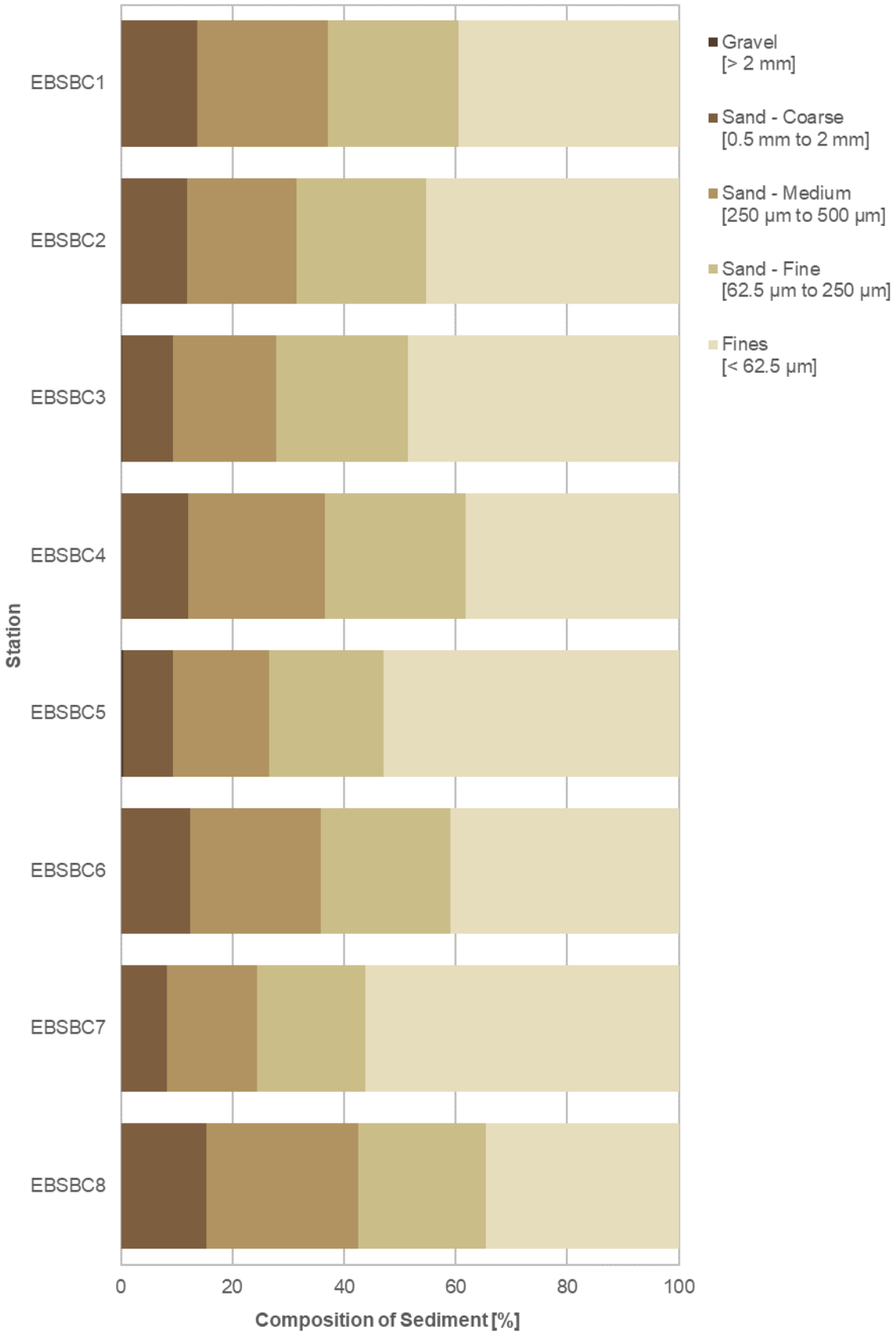


Figure 4.1: Sediment composition, Payara development

5. SEDIMENT HYDROCARBONS

5.1 Introduction

The sediment samples were analysed for hydrocarbon content including THC, total n-alkanes (nC_{12} to nC_{36}) and PAHs, specifically the United States Environmental Protection Agency's 16 priority PAH pollutants (US EPA 16 PAHs) and alkylated PAHs.

Samples were extracted by ultrasonication of wet sediments with mixed solvents. The sample extracts were then cleaned-up using absorption column chromatography. The extracts were analysed for THC, unresolved complex mixture (UCM), individual and total n-alkanes (nC_{12} to nC_{36} and the subsequent carbon preference index (CPI) using GC-FID. Aromatic hydrocarbons were analysed by GC-MS.

The total hydrocarbon material present was quantified using response factors calculated from the analysis of mixed oil standard solutions over an appropriate range. The UCM was determined by subtracting the area of all the resolved peaks from the total hydrocarbon area and applying the total hydrocarbon response factor. The concentration of individual n-alkanes present in the sediments was determined by measuring the response of each component (nC_{12} to nC_{36}) by GC-FID. Standard solutions containing an appropriate range and concentration of n-alkanes were run to calibrate the instrument and to acquire response factors for quantification purposes. Individual n-alkanes were quantified using a series of internal standards. A total n-alkane (nC_{12} to nC_{36}) value for each sediment sample was calculated by summing the concentrations of individual n-alkanes.

The distributions and concentrations of 2 to 6 ring PAHs within the samples were determined by GC-MS. Standard solutions containing an appropriate range and concentration of aromatic hydrocarbons were run to calibrate the instrument and acquire response factors for quantification purposes. Individual aromatic compounds were quantified using a series of deuterated internal standards. The total 2 to 6 ring PAH values for each sediment sample was calculated by summing the concentrations of individual aromatic compounds.

Appendix B provides full details of the analytical techniques employed.

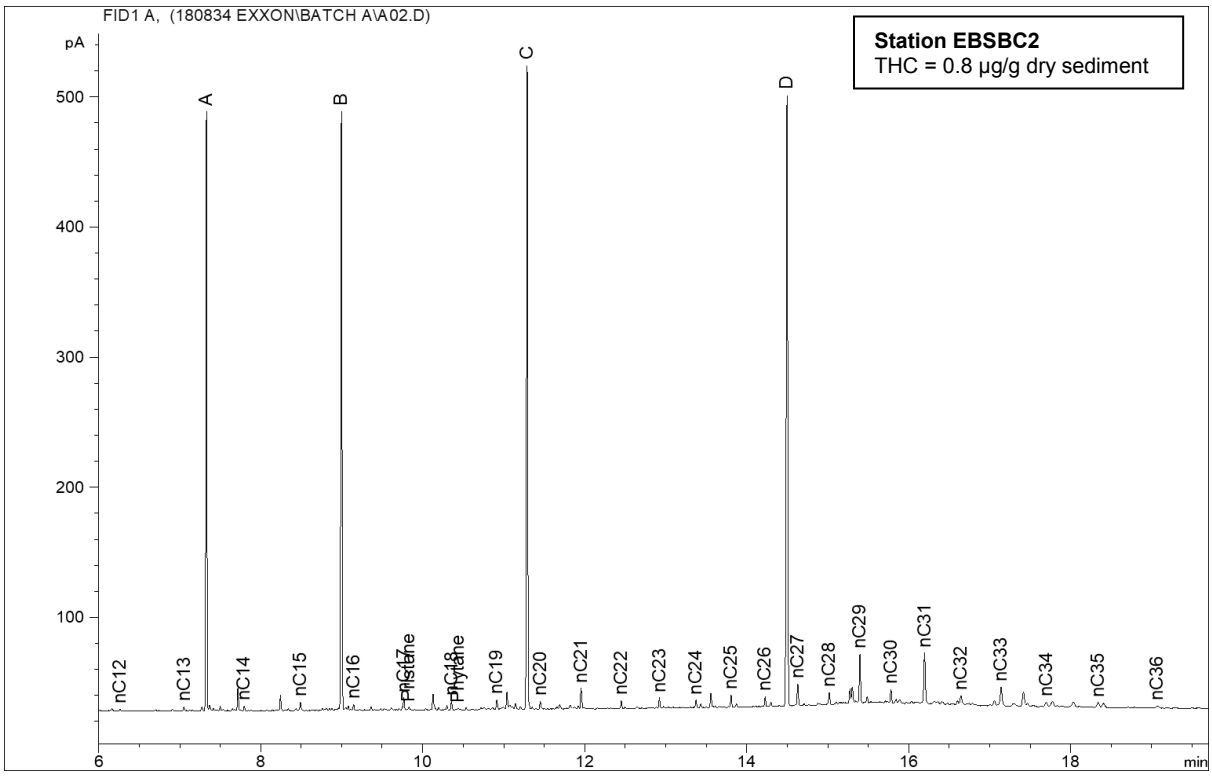
5.2 Results

5.2.1 Gas Chromatography–Flame Ionisation Detection (GC-FID) Hydrocarbon Profiles

A visual comparison of the GC-FID profiles can provide information on the potential origins of the hydrocarbons present in marine sediments samples. The GC-FID profiles illustrating the hydrocarbon components detected in each of the sediment samples are provided in Appendix E. To support more detailed discussions (Section 10.3) relating to the hydrocarbon components identified by GC-FID analysis of the sediments. Figure 5.1 displays an example gas chromatogram, representative of the grab samples across the Payara development survey area.

The GC-FID profiles obtained for all the sediment samples were broadly similar. The example chromatogram in Figure 5.1 is characterised by a very small 'hump' of unresolved material (UCM) peaking late in the chromatogram window and a homologous series of trace level resolved n-alkanes. There is a slight prevalence of the heavier odd number n-alkanes (nC_{27}, nC_{29}, nC_{31}), indicating trace

inputs of biogenic material from terrestrial run off. The GC-FID profiles for the Payara sediments are all characteristic of background sediments.



Notes:
THC = Total hydrocarbon content
A, B, C and D peaks refer to the internal standards added for quantification

Figure 5.1: Gas chromatographic profile for typical surface sediment, Payara development

5.2.2 Total Hydrocarbon and n-Alkanes (nC_{12} to nC_{36}) Content

Table 5.1 presents the concentrations of total hydrocarbons, UCM, total n-alkanes and CPI ratios (nC_{12} to nC_{36}) and pristane/phytane ratios reported from the surface sediment across the Payara survey area. Appendix E.2 presents individual n-alkane concentrations for the sediments analysed across the Payara survey area.

Total hydrocarbon content (THC) reported for the survey area ranged from 0.6 µg/g at four stations to 0.8 µg/g at station EBSBC2, with a mean concentration of 0.7 µg/g. Variation across all stations was low (RSD 11 %). The mean THC concentration across the survey area was lower than the mean of the Liza field (2.8 µg/g; Fugro, 2016)

The total n-alkane (nC_{12} to nC_{36}) concentration ranged from 0.06 µg/g at station EBSBC6 to 0.10 µg/g at station EBSBC2, with a mean concentration of 0.08 µg/g. Interstation variation was low (RSD 16 %). The mean n-alkane concentration across the survey area was lower than that from the Liza field survey (mean 0.27 µg/g; Fugro, 2016).

The CPI for the nC_{12} to nC_{36} n-alkanes ranged from 2.02 to 2.40 at stations EBSBC6 and EBSBC1 respectively, with a mean value of 2.22. Interstation variation was low (RSD 5 %) and the mean value for the Payara sediments was comparable to the mean from the Liza field survey (2.22; Fugro, 2016).

The pristane/phytane ratios ranged from 2.06 to 3.17 at stations EBSBC5 and EBSBC8 respectively, with a mean value of 2.42. Variation between stations was moderate across the survey area (RSD 17 %). The mean pristane/phytane ratio was higher than that of the Liza field (1.28; Fugro, 2016).

Table 5.1: Summary of Sediment Hydrocarbon Analysis, Payara Development

Station	THC*	UCM*	n-alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
EBSBC1	0.6	0.4	0.02	0.06	0.08	1.20	2.92	2.40	0.0006	0.0003	2.08
EBSBC2	0.8	0.5	0.02	0.08	0.10	1.20	2.59	2.20	0.0008	0.0004	2.13
EBSBC3	0.6	0.4	0.01	0.05	0.07	1.04	2.67	2.14	0.0006	0.0003	2.20
EBSBC4	0.7	0.4	0.02	0.07	0.09	1.09	2.84	2.30	0.0008	0.0003	2.76
EBSBC5	0.7	0.4	0.02	0.06	0.08	1.12	2.76	2.27	0.0006	0.0003	2.06
EBSBC6	0.6	0.4	0.02	0.05	0.06	1.18	2.45	2.02	0.0007	0.0002	2.71
EBSBC7	0.7	0.4	0.02	0.07	0.08	1.08	2.80	2.27	0.0008	0.0003	2.28
EBSBC8	0.6	0.4	0.02	0.06	0.07	1.13	2.66	2.17	0.0009	0.0003	3.17
Minimum	**0.6**	**0.4**	**0.01**	**0.05**	**0.06**	**1.04**	**2.45**	**2.02**	**0.0006**	**0.0002**	**2.06**
Maximum	**0.8**	**0.5**	**0.02**	**0.08**	**0.10**	**1.20**	**2.92**	**2.40**	**0.0009**	**0.0004**	**3.17**
Mean	**0.7**	**0.4**	**0.02**	**0.06**	**0.08**	**1.13**	**2.71**	**2.22**	**0.0007**	**0.0003**	**2.42**
Standard Deviation	**0.07**	**0.04**	**0.004**	**0.010**	**0.012**	**0.059**	**0.150**	**0.115**	**0.00012**	**0.00005**	**0.407**
RSD [%]	**11**	**9**	**19**	**17**	**16**	**5**	**6**	**5**	**16**	**18**	**17**
Liza Field (Fugro, 2016)†											
Mean	**2.8**	**1.8**	**0.06**	**0.21**	**0.27**	**1.29**	**2.62**	**2.22**	**0.002**	**0.003**	**1.28**
RSD [%]	**32**	**33**	**50**	**43**	**41**	**19**	**10**	**9**	**100**	**100**	**39**

Notes:
THC = Total hydrocarbon content
UCM = Unresolved complex mixture
CPI = Carbon preference index
Pr/Ph = Ratio of pristane to phytane
BC = Box core
RSD = Relative standard deviation
* = Concentrations expressed as µg/g of dry sediment
† = Mean and relative standard deviation values estimated from a historical environmental survey at the Liza field (Fugro, 2016)

5.2.3 Sediment Aromatic Hydrocarbon Content

The distribution and concentration of aromatic compounds in seabed sediments were analysed by GC-MS. The aromatic compounds quantified were the naphthalenes (2 ring aromatics), 3 to 6 ring PAHs and the dibenzothiophenes (sulphur containing heteroaromatics). Table 5.2 summarises the total concentrations of aromatic hydrocarbons, including the US EPA 16 PAH and NPD.

Appendix E.3 presents the individual aromatic hydrocarbon and their alkyl homologue concentrations across the Payara development survey area, with the US EPA 16 PAH concentrations presented in Appendix E3 including reference values where available. The distributions of aromatic hydrocarbons are displayed as three-dimensional plots for ease of interpretation in Appendix E.4.

Table 5.2 summarises the sediment aromatic hydrocarbon analysis. Total 2 to 6 ring PAH concentrations ranged from 0.002 µg/g at station EBSBC3 to 0.007 µg/g at station EBSBC2, with a mean concentration of 0.004 µg/g. Interstation variation was moderate (RSD 33%). The mean total 2 to 6 ring PAH concentrations concentration was below the mean from the Liza field survey (0.05 µg/g; Fugro, 2016). All values were below the NOAA ERL and ERM values (Buchman, 2008).

The proportion of petrogenically derived naphthalenes, phenanthrenes and dibenzothiophenes (NPD) to total 2 to 6 ring aromatic material ranged from not recorded at station EBSBC3 to 29 % at station EBSBC2. The mean value was 26 % and interstation variation was low (RSD 6 %).

The total US EPA 16 PAH concentrations displayed low variation between stations (RSD 17 %) and values ranged from 1.0 ng/g at stations EBSBC3 and EBSBC7 to 1.5 ng/g at stations EBSBC2 and EBSBC4. The mean concentration for the Payara sediments was 1.2 ng/g. All individual US EPA 16 PAHs were below their respective ERL and ERM values (Buchman, 2008) across the survey area (Appendix E.3).

Figure 5.2 displays the concentrations of total 2 to 6 ring PAHs in relation to THC values across the Payara survey area. In general, no clear correlation between THC and PAH content was evident, possibly reflecting the low hydrocarbon concentrations recorded across the survey area.

Table 5.2: Summary of Sediment Polycyclic Aromatic Hydrocarbons (PAHs) Analysis, Payara Development

Station	Total 2 to 6 Ring PAH*	Total US EPA 16 PAH†	NPD	
			Total*	[%]
EBSBC1	0.004	1.1	0.001	25
EBSBC2	0.007	1.5	0.002	29
EBSBC3	0.002	1.0	< 0.001	NR
EBSBC4	0.004	1.5	0.001	25
EBSBC5	0.004	1.3	0.001	25
EBSBC6	0.004	1.1	0.001	25
EBSBC7	0.004	1.0	0.001	25
EBSBC8	0.004	1.3	0.001	25
Minimum	**0.002**	**1.0**	**< 0.001**	**25**
Maximum	**0.007**	**1.5**	**0.002**	**29**
Mean	**0.004**	**1.2**	**0.001**	**26**
Standard Deviation	**0.0014**	**0.21**	**0.0003**	**1.5**
RSD [%]	**33**	**17**	**33**	**6**
Liza Field (Fugro, 2016)‡				
Mean	**0.048**	**-**	**0.016**	**33**
RSD [%]	**94**	**-**	**94**	**-**
Marine Sediment Assessment Criteria (Buchman, 2008)#				
ERL	**4.022**	**-**	**-**	**-**
ERM	**44.792**	**-**	**-**	**-**

Notes:
Total 2 to 6 ring PAH = Total 2 to 6 ring polycyclic aromatic hydrocarbons (PAH), including alkyl homologues
Total US EPA 16 PAH = Total United States Environmental Protection Agency's 16 (US EPA PAH) priority polycyclic aromatic hydrocarbons
BC = Box core
NR = Not recorded
ERL = Effects range low
ERM = Effects range median
Total NPD = Total naphthalene, phenanthrene/anthracene and dibenzothiophene
NPD [%] = Percentage of total 2 to 6 ring PAH concentration comprised of NPD
* = Concentrations expressed as µg/g of dry sediment
† = Concentrations expressed as ng/g of dry sediment
‡ = Mean and relative standard deviation values estimated from a survey in the neighbouring Liza field (Fugro, 2016)
= NOAA screening values for marine sediments (Buchman, 2008)

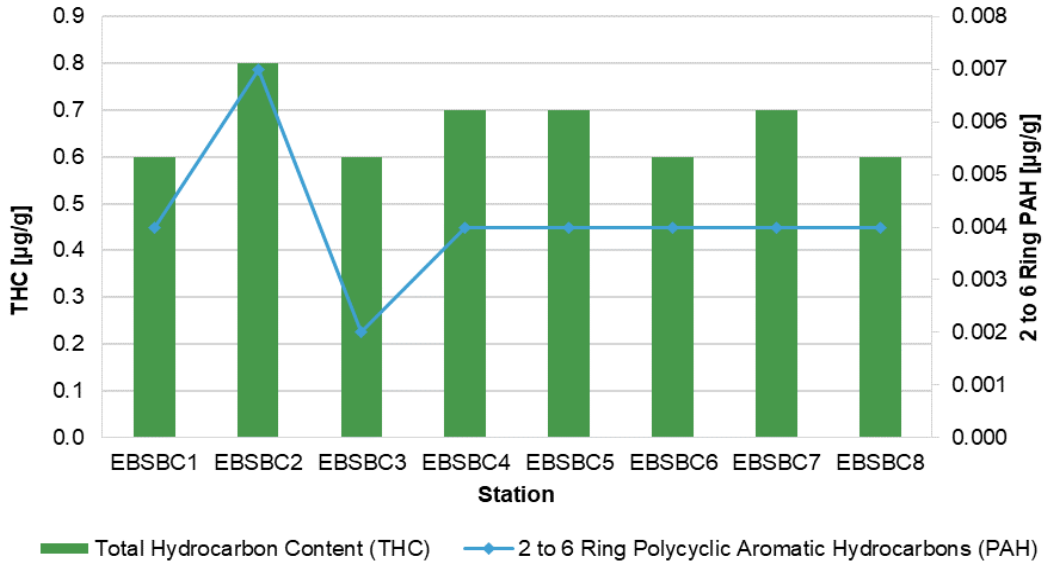


Figure 5.2: Comparison of sediment total hydrocarbon content (THC) and total 2 to 6 ring polycyclic aromatic hydrocarbon (PAH) concentrations, Payara development

6. SEDIMENT METALS

6.1 Introduction

Sediments collected from the survey area were analysed for selected elements: aluminium, arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium and zinc using ICP-MS, ICP-OES and CV-AFS.

The sediment samples were digested using aqua regia. This provides a strong partial digest, releasing into solution metals associated with the fines fraction within the sediments (but does not extract all trace elements associated with the coarse fraction). As macrofaunal communities can exhibit a preference for finer sediments, the concentrations of metals released by an aqua regia digest are typically considered indicative of those influencing biological interactions.

Once digested, the sediment samples underwent multi-element analysis by inductively coupled plasma-mass spectrometry (ICP-MS) or by inductively coupled plasma-optical emission spectroscopy (ICP-OES). These methods were used to analyse aluminium, arsenic, barium, cadmium, chromium, copper, iron, lead, nickel, selenium and zinc. Analysis of mercury was by cold vapour-atomic fluorescence spectroscopy (CV-AFS).

Appendix B provides full details of the analytical techniques employed.

6.2 Results

Table 6.1 summarises the concentrations of the extractable metals of biological interest in the sediment samples from the current survey following an aqua regia digest. The Liza field sediments were subjected to a hydrofluoric acid digest. This technique releases all metals from the sediment, including those bound within the sediment alumino-silicate matrix and typically not biologically available. Consequently, the two datasets are not directly comparable and the Liza field data is given in Table 6.1 for information only and is not used in the text as comparison data.

Metals concentrations across the survey area exhibited low to high variability (RSD 10 % to 227 %).

Sediment concentrations of arsenic ranged from 6.62 µg/g to 250 µg/g at stations EBSBC1 and EBSBC5 respectively. The mean concentration was 37.8 µg/g. Arsenic concentrations exceeded the NOAA ERL value (8.2 µg/g, Buchman, 2008) at stations EBSBC5 and EBSBC7 and the NOAA ERM value (70.0 µg/g; Buchman, 2008) at station EBSBC5. Interstation variability was high (RSD 227 %), influenced by the high arsenic concentration at station EBSBC5.

Barium concentrations across the survey area ranged from 132 µg/g at station EBSBC8 to 240 µg/g at station EBSBC2, with a mean concentration of 165 µg/g.

Cadmium concentrations were all below the MRV of 0.2 µg/g.

The concentrations of chromium ranged from 24.5 µg/g at station EBSBC8 to 38.9 µg/g at station EBSBC7, demonstrating low variability (RSD 17 %).

Mercury concentrations ranged from 0.0206 µg/g at station EBSBC8 to 0.0270 µg/g at station EBSBC7, with a mean concentration of 0.0236 µg/g. Interstation variation was low (RSD 10 %).

The concentration of nickel ranged from 16.8 µg/g at station EBSBC6 to 26.1 µg/g at station EBSBC7 with low variability (RSD 16 %). Two stations in the Payara development survey area exceeded the NOAA ERL value for nickel (20.9 µg/g; Buchman, 2008).

Lead concentrations across the survey area ranged from 10.4 µg/g to 14.7 µg/g at stations EBSBC8 and EBSBC7 respectively. The mean lead concentration was 12.3 µg/g and interstation variation was low (RSD 12 %).

The concentration of zinc ranged from 42.6 µg/g at station EBSBC8 to 112 µg/g at station EBSBC4 with moderate variability (RSD 37 %). The mean zinc concentration was 60.5 µg/g.

A comparison of metals across the survey area is shown in Figure 6.1. The highest metal concentrations were generally observed at station EBSBC7 and the lowest concentrations were generally recorded at station EBSBC8.

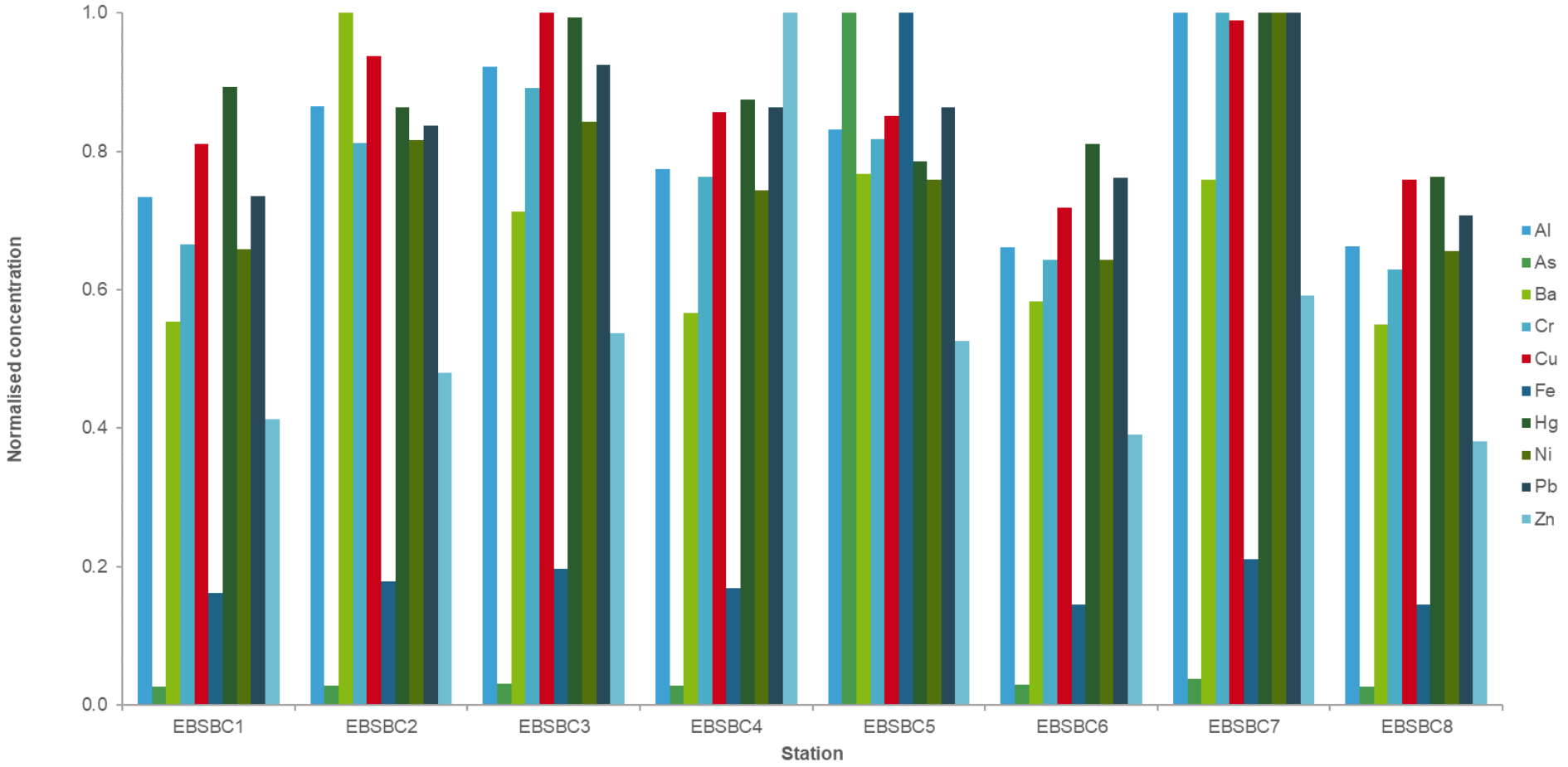
Table 6.1: Summary of Sediment Metals Analysis, Payara Development

Station	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Se	Zn
EBSBC1	33100	6.62	133	< 0.2	25.9	14.1	19800	0.0241	17.2	10.8	< 1	46.2
EBSBC2	39000	7.07	240	< 0.2	31.6	16.3	2900	0.0233	21.3	12.3	< 1	53.7
EBSBC3	41600	7.65	171	< 0.2	34.7	17.4	24100	0.0268	22.0	13.6	< 1	60.2
EBSBC4	34900	6.92	136	< 0.2	29.7	14.9	20700	0.0236	19.4	12.7	< 1	112
EBSBC5	37500	250	184	< 0.2	31.8	14.8	122000	0.0212	19.8	12.7	1.53	58.9
EBSBC6	29800	7.58	140	< 0.2	25.0	12.5	17700	0.0219	16.8	11.2	< 1	43.7
EBSBC7	45100	9.36	182	< 0.2	38.9	17.2	25800	0.0270	26.1	14.7	< 1	66.3
EBSBC8	29900	6.80	132	< 0.2	24.5	13.2	17700	0.0206	17.1	10.4	< 1	42.6
Minimum	**29800**	**6.62**	**132**	**< 0.2**	**24.5**	**12.5**	**17700**	**0.0206**	**16.8**	**10.4**	**< 1**	**42.6**
Maximum	**45100**	**250**	**240**	**< 0.2**	**38.9**	**17.4**	**122000**	**0.0270**	**26.1**	**14.7**	**1.53**	**112**
Mean	**36400**	**37.8**	**165**	**-**	**30.3**	**15.1**	**33700**	**0.0236**	**20.0**	**12.3**	**-**	**60.5**
Standard Deviation	**5470**	**85.8**	**37.6**	**-**	**5.05**	**1.80**	**35800**	**0.00238**	**3.16**	**1.46**	**-**	**22.5**
RSD [%]	**15**	**227**	**23**	**-**	**17**	**12**	**106**	**10**	**16**	**12**	**-**	**37**
Liza Field (Fugro, 2016)*												
Mean	**43432**	**11.59**	**175**	**0.120**	**36.1**	**20.2**	**30472**	**0.0285**	**27.0**	**15.5**	**0.230**	**69.7**
RSD [%]	**30**	**154**	**35**	**28**	**28**	**27**	**53**	**25**	**31**	**26**	**60**	**26**
Marine Sediment Assessment Criteria (Buchman, 2008)†												
ERL	**-**	**8.20**	**-**	**1.20**	**81.0**	**34.0**	**-**	**0.150**	**20.9**	**46.7**	**-**	**150**
ERM	**-**	**70.0**	**-**	**9.60**	**370**	**270**	**-**	**0.710**	**51.6**	**218**	**-**	**410**

Notes:
Concentrations expressed in µg/g dry sediment

Al = Aluminium As = Arsenic Ba = Barium Cd = Cadmium Cr = Chromium Cu = Copper Fe = Iron
Hg = Mercury Ni = Nickel Pb = Lead Se = Selenium Zn = Zinc
RSD = Relative standard deviation
ERL = Effects Range Low
ERM = Effects Range Median
BC = Box core
* = Mean and relative standard deviation values estimated from a historical environmental survey at the Liza field (Fugro, 2016) using a HF digest method
† = NOAA screening values for marine sediments (Buchman, 2008)

Key:	Below NOAA ERL	Above NOAA ERL	Above NOAA ERM



Notes:

Al = Aluminium As = Arsenic Ba = Barium Cr = Chromium Cu = Copper Fe = Iron Hg = Mercury Ni = Nickel
Pb = Lead Zn = Zinc

Figure 6.1: Relative (maximum normalised) elemental concentrations in sediments, Payara development

7. WATER SAMPLES

7.1 Introduction

Water column profiles were acquired at a total of eight stations in the Payara development area. Profiles were acquired from both deployment and recovery from sea surface to near seabed using a Valeport Midas+ deepwater conductivity temperature depth (CTD) profiler recording depth, salinity, dissolved oxygen (DO), pH, turbidity and temperature. Two profiles were acquired at each station, resulting in two downward and two upward datasets.

Seawater samples were collected at the eight sampling stations for the analysis of key indicators of water quality. Discrete water samples were collected at three depths; the surface (10 m), below the thermocline and 20 m above the seabed. Subsamples were analysed for TSS, TOC, hydrocarbon content and metals content.

Full details of methodologies are found in Appendix B.

7.2 Water Profiles

7.2.1 Results

Figure 7.1 shows an example (station EBSWS1) of the water column profiles for temperature salinity, conductivity, turbidity, dissolved oxygen saturation and pH. Results from all stations showed a stratified water column, with a defined thermocline, halocline, pH boundary and oxygen boundary, below which these parameters notably dropped. Turbidity returned similar values throughout the water column. The full set of results are presented in Table 7.1 and Appendix F.

7.2.1.1 Temperature

Temperatures across the survey area ranged from 3.55 °C to 29.3 °C, with a mean of 6.47 °C. The largest intrastation variability was reported at station EBSWS7 where temperatures of 3.69 °C were recorded near the seabed and 29.3 °C near the surface, with a temperature range of 25.6 °C. Intrastation variability range from 76 % to 81 %. A surface temperature of ca. 29 °C was recorded from the surface and decreased to ca. 7 °C by ca. 300 m at all stations.

7.2.1.2 Salinity

Salinity ranged from 34.6 PSU to 36.9 PSU, with a mean of 35.0 PSU. Intrastation variability at all stations was 1 %. A distinct halocline was observed to a depth of ca. 300 m, where after salinity remained constant at ca 35.0 PSU at all stations for the remainder of the water profile.

7.2.1.3 Conductivity

Conductivity ranged from 33.0 ms/cm to 58.6 ms/cm, with a mean value of 35.5 ms/cm. Intrastation variability was similar across the survey area, ranging from 14 % to 16 %. Values were ca. 58 ms/cm at surface level and decreased to ca. 35 ms/cm at approximately 400 m for all stations. A gradual decline from 35 ms/cm at 400 m to ca. 33 ms/cm at the lowest recorded depths in the profile was observed for all stations.

7.2.1.4 Turbidity

Turbidity values ranged from 0.644 FTU to 1.03 FTU across the survey area, with a mean value of 0.680 FTU. Turbidity values remained relatively constant throughout the water column, with values of ca. 0.7 FTU.

7.2.1.5 Dissolved Oxygen

Dissolved oxygen saturation ranged from 33.2 % to 105 %, with a mean of 49.1 %. Intrastation variability ranged from 24 % to 28 %. Dissolved oxygen saturations of ca. 106 % were recorded at the surface, decreasing to ca. 50 % by approximately 300 m at all stations. Concentrations then remained relatively constant to a depth of ca. 1000 m, where a slight increase was observed for the remainder of the profile.

7.2.1.6 pH

The pH values were alkaline throughout the Payara survey area and ranged from 7.60 to 8.43, with a mean of 7.77. Intrastation variation was low (RSD ≥ 3 %). pH values of ca. 8.40 were recorded at the surface to depths and decreased to ca. 7.60 by 600 m.

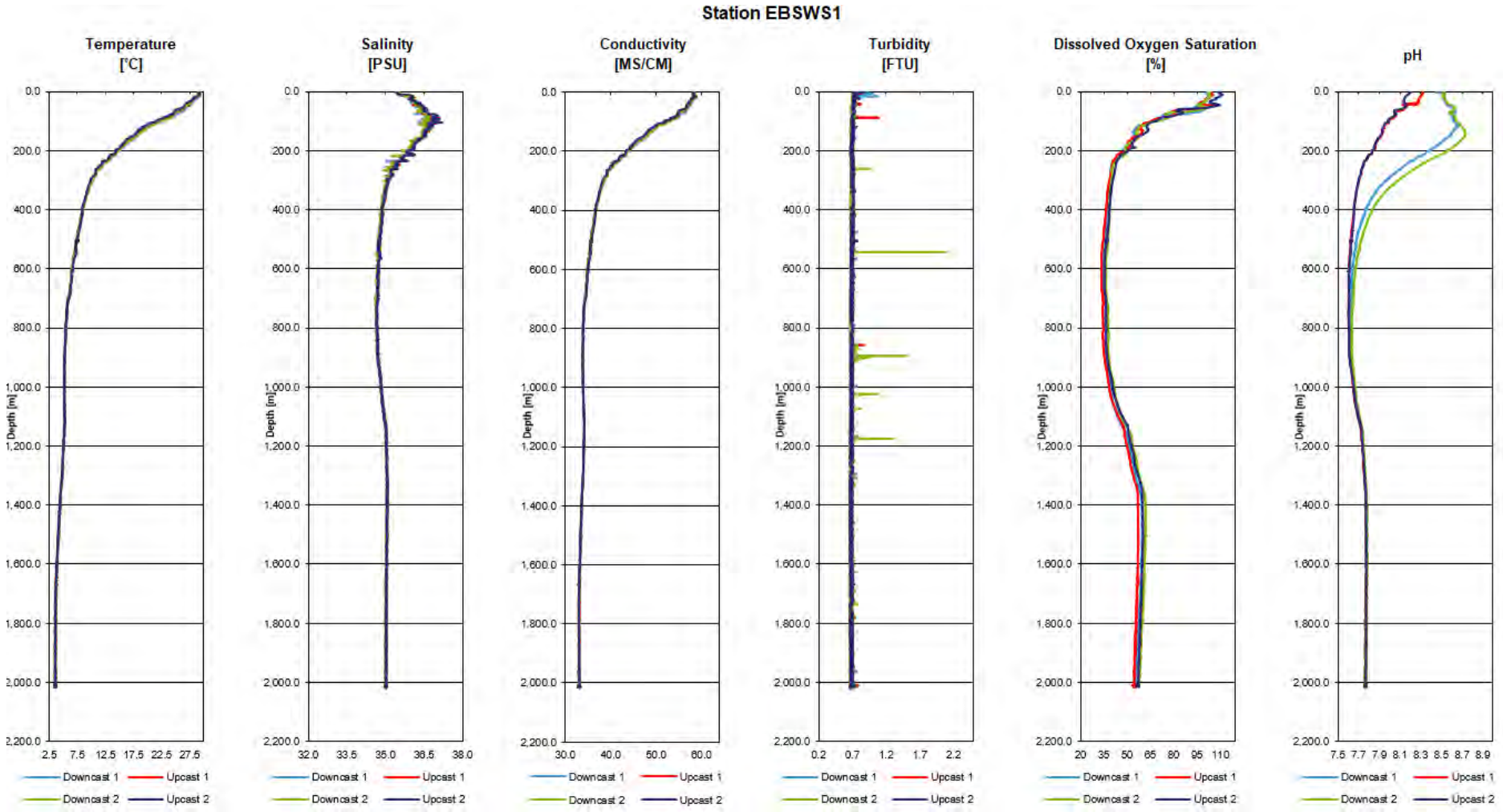


Figure 7.1: Water column profile at sampling station EBSWS1, Payara development

Table 7.1: Summary of Water Parameters Recorded by Water Column Profiles, Payara Development

Station		Depth [m]	Temperature [°C]	Salinity [PSU]	Conductivity [MS/CM]	DO Saturation [%]	pH	Turbidity [FTU Counts]
EBSWS1	Minimum	-	3.55	34.6	33.0	35.0	7.61	0.66
	Mean	-	29.2	37.0	58.8	106	8.48	1.29
	Maximum	2016	6.48	35.1	35.5	51.8	7.78	0.69
	Standard Deviation	-	5.24	0.393	5.32	13.2	0.179	0.026
	RSD		81	1	15	26	2	4
EBSWS2	Minimum	-	3.55	34.6	33.0	35.7	7.61	0.68
	Mean	-	29.3	36.9	58.7	106	8.48	1.64
	Maximum	2057	6.73	35.1	35.7	51.4	7.77	0.84
	Standard Deviation	-	5.28	0.405	5.36	13.3	0.184	0.100
	RSD		79	1	15	26	2	12
EBSWS3	Minimum	-	3.67	34.6	33.1	35.9	7.61	0.66
	Mean	-	29.3	37.0	58.6	107	8.43	1.04
	Maximum	1894	6.58	35.0	35.6	52.0	7.77	0.70
	Standard Deviation	-	4.94	0.384	5.02	13.0	0.168	0.022
	RSD		76	1	14	25	2	3
EBSWS4	Minimum	-	3.66	34.6	33.1	35.9	7.61	0.66
	Mean	-	29.2	37.1	58.6	107	8.43	1.03
	Maximum	1917	6.54	35.0	35.6	52.1	7.77	0.69
	Standard Deviation	-	4.94	0.393	5.02	13.0	0.169	0.020
	RSD		76	1	14	25	2	3
EBSWS5	Minimum	-	3.58	34.6	33.0	34.0	7.61	0.66
	Mean	-	29.2	37.0	58.7	107	8.45	1.74
	Maximum	1885	6.93	35.1	35.9	49.1	7.77	0.87
	Standard Deviation	-	5.21	0.423	5.34	13.6	0.177	0.142
	RSD		76	1	15	28	2	16
EBSWS6	Minimum	-		34.6	33.1	35.6	7.60	0.69
	Mean	-	29.3	37.0	58.7	106	8.45	1.75
	Maximum	1954	6.63	35.1	35.7	51.8	7.77	0.96
	Standard Deviation	-	5.20	0.412	5.29	13.0	0.172	0.188
	RSD		79	1	15	25	2	19
EBSWS7	Minimum	-	3.69	34.6	33.1	33.2	7.61	0.64
	Mean	-	29.3	37.0	58.8	105	8.58	1.05
	Maximum	1708	7.08	35.1	36.1	51.6	7.81	0.68
	Standard Deviation	-	5.86	0.400	6.00	14.5	0.223	0.023
	RSD		81	1	16	28	3	3
EBSWS8	Minimum	-	3.57	34.6	33.0	36.0	7.60	0.67
	Mean	-	29.2	37.0	58.7	106	8.43	1.07
	Maximum	2078	6.47	35.1	35.5	51.8	7.77	0.71
	Standard Deviation	-	4.95	0.390	5.01	12.6	0.167	0.022
	RSD		77	1	14	24	2	3

Notes:
Statistics calculated from four replicates
RSD = Relative standard deviation
WS = Water Sample

7.3 Total Suspended Solids (TSS) and Total Organic Carbon (TOC)

7.3.1 Introduction

Water samples from the Payara survey area were analysed by Kaizen LAB for TSS content and TOC content.

7.3.2 Results

TSS values across the Payara water samples showed little evidence of stratification, as the mean TSS values for each depth profile were comparable. Higher surface TSS values in comparison to other depth values were observed at stations EBSWS1 and EBSWS4. Station EBSWS6 had a higher mid depth TSS value compared to other depths at this station. Station EBSWS8 had a higher bottom depth TSS value in comparison to other water depths.

In surface seawater samples, TSS ranged from 22.9 mg/L at station EBSWS8 to 56.1 mg/L at station EBSWS1. In mid depth samples, concentrations ranged from 25.0 mg/L at station EBSWS1 to 58.6 mg/L at station EBSWS6. In the bottom depth samples, TSS concentrations ranged from 25.4 mg/L to 49.6 mg/L at stations EBSWS1 and EBSWS8 respectively. Interstation variability at each depth ranged from low to moderate (RSD 25 % to 36 %). The mean TSS values in the current survey were higher than those from the Liza field survey (Fugro, 2016) at comparable depths.

All TOC values were below the MRV of 0.5 mg/L and lower than the mean values from the Liza field survey (Fugro, 2016).

Table 7.2: Summary of Total Suspended Solids and Total Organic Carbon Content, Payara Development

Station	Total Suspended Solids [mg/L]			Total Organic Carbon [mgl/L]		
	Surface	Mid	Bottom	Surface	Mid	Bottom
EBSWS1	56.1	25.0	25.4	< 0.5	< 0.5	< 0.5
EBSWS2	27.1	27.0	29.1	< 0.5	< 0.5	< 0.5
EBSWS3	28.9	29.6	27.1	< 0.5	< 0.5	< 0.5
EBSWS4	48.9	28.4	29.1	< 0.5	< 0.5	< 0.5
EBSWS5	27.7	27.9	28.3	< 0.5	< 0.5	< 0.5
EBSWS6	31.4	58.6	38.3	< 0.5	< 0.5	< 0.5
EBSWS7	27.8	26.9	29.1	< 0.5	< 0.5	< 0.5
EBSWS8	22.9	26.0	49.6	< 0.5	< 0.5	< 0.5
Minimum	**22.9**	**25.0**	**25.4**	**< 0.5**	**< 0.5**	**< 0.5**
Maximum	**56.1**	**58.6**	**49.6**	**< 0.5**	**< 0.5**	**< 0.5**
Mean	**33.9**	**31.2**	**32.0**	**-**	**-**	**-**
Standard Deviation	**11.9**	**11.2**	**8.1**	**-**	**-**	**-**
RSD [%]	**35**	**36**	**25**	**-**	**-**	**-**
Liza Field (Fugro, 2016)						
Mean	**6.7**	**3.1**	**3.4**	**2.3**	**1.9**	**1.8**
RSD [%]	**63**	**42**	**47**	**35**	**42**	**28**

Notes:
RSD = Relative standard deviation
WS = Water sample

7.4 Hydrocarbons

7.4.1 Introduction

The water column samples were analysed for hydrocarbon content including THC, total n-alkanes (nC_{12} to nC_{36}) and PAHs, specifically the US EPA 16 PAHs and alkylated PAHs. Total hydrocarbon analysis is displayed in Table 7.3 and PAH content of water samples in Table 7.4.

7.4.2 Results

7.4.2.1 Total Hydrocarbon Content (THC)

THC concentrations were below the MRV of 10 µg/L at all stations with the exception of station EBSWS4 (Bottom), which had a concentration of 21.0 µg/L. The UCM concentrations displayed moderate variation (RSD 33 %), ranging from 1.9 µg/L at stations EBSWS8 (Bottom) and EBSWS6 (Mid) to 5.1 µg/L at stations EBSWS4 (Bottom) and EBSWS5 (Bottom). Total n-alkane concentrations (nC_{12-36}) ranged from 0.22 µg/L to 0.84 µg/L at stations EBSWS6 (Mid) and EBSWS7 (Surface) respectively. There was no clear spatial trend in concentrations of THC, UCM or n-alkanes across the survey area and no clear relationship between concentrations of these analytes and depth. The THC concentration that was > MRV was slightly higher than the mean of the Liza field survey (16.2 µg/L, Fugro, 2016).

The CPI ratio (nC_{12-36}) displayed moderate variation between stations (RSD 33 %). The pristane to phytane ratio displayed high variation (RSD 133 %), with values ranging from 0.68 to 15.3 at stations EBSWS7 (Surface) and EBSWS2 (Mid) respectively.

7.4.2.2 Polycyclic Aromatic Hydrocarbons (PAHs)

Total 2 to 6 ring PAH concentrations displayed moderate variability (RSD 33 %) between samples, ranging from 0.049 µg/L at station EBSWS7 (Mid) to 0.131 µg/L at station EBSWS2 (Bottom). The mean total 2 to 6 ring PAH concentration for the current survey was 0.076 µg/L, which was comparable to the mean concentration from the Liza field survey (0.075 µg/L; Fugro, 2016). Total US EPA 16 PAH concentrations, NPD (total and %) all displayed low variability (RSD ≤ 28 %).

Table 7.3: Summary of Water Column Hydrocarbon Analysis, Payara Development

Station	THC*	UCM*	n-alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
EBSWS1 (Surface)	< 10.0	2.4	0.35	0.28	0.63	2.50	2.08	2.30	0.0088	0.0051	2.58
EBSWS1 (Mid)	< 10.0	2.2	0.15	0.25	0.41	0.77	2.34	1.50	0.0074	0.0039	1.36
EBSWS1 (Bottom)	< 10.0	2.6	0.13	0.51	0.64	0.75	1.43	1.25	0.0131	0.0058	3.03
EBSWS2 (Surface)	< 10.0	3.7	0.36	0.28	0.64	3.10	2.19	2.64	0.0078	0.0049	1.10
EBSWS2 (Mid)	< 10.0	2.8	0.15	0.40	0.55	0.72	1.78	1.38	0.0033	0.0039	15.3
EBSWS2 (Bottom)	< 10.0	2.4	0.13	0.24	0.38	0.74	2.05	1.41	0.0073	0.0075	1.13
EBSWS3 (Surface)	< 10.0	2.3	0.24	0.20	0.45	2.64	2.32	2.49	0.0051	0.0075	2.33
EBSWS3 (Mid)	< 10.0	2.1	0.11	0.21	0.32	0.70	3.05	1.73	0.0096	0.0070	4.01
EBSWS3 (Bottom)	< 10.0	2.2	0.16	0.14	0.30	1.40	3.27	2.00	0.0041	0.0048	1.12
EBSWS4 (Surface)	< 10.0	2.6	0.39	0.19	0.58	3.58	2.96	3.36	0.0113	0.0066	1.33
EBSWS4 (Mid)	< 10.0	2.2	0.17	0.22	0.40	0.89	2.04	1.41	0.0068	0.0060	1.19
EBSWS4 (Bottom)	21.0	5.1	0.14	0.20	0.34	1.00	2.88	1.79	0.0050	0.0044	1.71
EBSWS5 (Surface)	< 10.0	3.1	0.23	0.20	0.44	3.10	0.89	1.65	0.0088	0.0051	1.72
EBSWS5 (Mid)	< 10.0	5.0	0.18	0.35	0.53	1.89	1.68	1.75	0.0074	0.0039	1.88
EBSWS5 (Bottom)	< 10.0	5.1	0.13	0.34	0.47	0.99	0.97	0.97	0.0131	0.0058	2.28
EBSWS6 (Surface)	< 10.0	2.2	0.22	0.18	0.40	2.18	4.46	2.92	0.0078	0.0049	1.59
EBSWS6 (Mid)	< 10.0	1.9	0.09	0.13	0.22	0.95	0.88	0.90	0.0033	0.0039	0.84
EBSWS6 (Bottom)	< 10.0	3.4	0.16	0.27	0.43	1.47	2.31	1.94	0.0073	0.0075	0.97
EBSWS7 (Surface)	< 10.0	3.3	0.31	0.53	0.84	3.74	1.49	2.01	0.0051	0.0075	0.68
EBSWS7 (Mid)	< 10.0	3.4	0.13	0.35	0.49	1.05	1.73	1.50	0.0096	0.0070	1.37
EBSWS7 (Bottom)	< 10.0	4.1	0.11	0.65	0.76	0.77	1.38	1.27	0.0041	0.0048	0.86
EBSWS8 (Surface)	< 10.0	3.5	0.29	0.25	0.54	3.25	1.98	2.56	0.0113	0.0066	1.72
EBSWS8 (Mid)	< 10.0	2.5	0.12	0.27	0.39	1.20	2.19	1.81	0.0068	0.0060	1.13
EBSWS8 (Bottom)	< 10.0	1.9	0.12	0.20	0.33	1.18	3.20	2.12	0.0050	0.0044	1.12
Minimum	**< 10.0**	**1.9**	**0.09**	**0.13**	**0.22**	**0.70**	**0.88**	**0.90**	**0.0033**	**0.0039**	**0.68**
Maximum	**21.0**	**5.1**	**0.39**	**0.65**	**0.84**	**3.74**	**4.46**	**3.36**	**0.0131**	**0.0075**	**15.3**
Mean	**-**	**3.0**	**0.19**	**0.29**	**0.48**	**1.69**	**2.15**	**1.86**	**0.0075**	**0.0056**	**2.18**
Standard Deviation	**-**	**0.996**	**0.088**	**0.128**	**0.149**	**1.03**	**0.847**	**0.611**	**0.00285**	**0.00128**	**2.90**
RSD [%]	**-**	**33**	**46**	**45**	**31**	**61**	**39**	**33**	**38**	**23**	**133**

Station	THC*	UCM*	n-alkanes*			CPI Ratio			Pristane*	Phytane*	Pr/Ph Ratio
			nC_{12-20}	nC_{21-36}	nC_{12-36}	nC_{12-20}	nC_{21-36}	nC_{12-36}			
Liza Field (Fugro, 2016)†											
Mean	**16.2**	**8.9**	**0.27**	**1.82**	**2.09**	**0.95**	**0.94**	**0.94**	**0.016**	**0.013**	**1.33**
RSD [%]	**40**	**56**	**26**	**168**	**148**	**31**	**8**	**9**	**31**	**43**	**38**

Notes:

THC = Total hydrocarbon content
UCM = Unresolved complex mixture
CPI = Carbon preference index
Pr/Ph = Ratio of pristane to phytane
WS = Water sample
RSD = Relative standard deviation
* = Concentrations expressed as µg/L
† = Mean and relative standard deviation values estimated from an environmental survey in the neighbouring Liza field (Fugro, 2016)

Table 7.4: Summary of Water Column Polycyclic Aromatic Hydrocarbons (PAHs) Analysis, Payara Development

Station	Total 2 to 6 Ring PAH*	Total US EPA16 PAH†	NPD	
			Total*	[%]
EBSWS1 (Surface)	0.065	5.5	0.026	40
EBSWS1 (Mid)	0.085	4.4	0.027	32
EBSWS1 (Bottom)	0.081	4.6	0.027	33
EBSWS2 (Surface)	0.105	4.5	0.032	30
EBSWS2 (Mid)	0.109	5.2	0.033	30
EBSWS2 (Bottom)	0.131	4.8	0.034	26
EBSWS3 (Surface)	0.081	3.6	0.027	33
EBSWS3 (Mid)	0.092	3.4	0.029	32
EBSWS3 (Bottom)	0.097	4.0	0.031	32
EBSWS4 (Surface)	0.109	4.5	0.032	29
EBSWS4 (Mid)	0.105	4.2	0.029	28
EBSWS4 (Bottom)	0.106	4.4	0.029	27
EBSWS5 (Surface)	0.055	4.3	0.022	40
EBSWS5 (Mid)	0.051	3.9	0.024	47
EBSWS5 (Bottom)	0.056	4.1	0.027	48
EBSWS6 (Surface)	0.055	3.9	0.023	42
EBSWS6 (Mid)	0.058	3.6	0.024	41
EBSWS6 (Bottom)	0.056	3.5	0.024	43
EBSWS7 (Surface)	0.054	3.5	0.023	43
EBSWS7 (Mid)	0.049	3.0	0.021	43
EBSWS7 (Bottom)	0.059	3.7	0.026	44
EBSWS8 (Surface)	0.054	3.9	0.025	46
EBSWS8 (Mid)	0.054	2.7	0.023	43
EBSWS8 (Bottom)	0.052	3.3	0.023	44
Minimum	**0.049**	**2.7**	**0.021**	**26**
Maximum	**0.131**	**5.5**	**0.034**	**48**
Mean	**0.076**	**4.0**	**0.027**	**37**
Standard Deviation	**0.0250**	**0.66**	**0.0037**	**7.1**
RSD [%]	**33**	**16**	**14**	**19**
Liza Field (Fugro, 2016)‡				
Mean	**0.075**	**9.5**	**0.037**	**51**
RSD [%]	**19**	**28**	**26**	**14**

Notes:
Total 2 to 6 ring PAH = Total 2 to 6 ring polycyclic aromatic hydrocarbons (PAH), including alkyl homologues
Total US EPA16 PAH = Total United States Environmental Protection Agency's 16 (US EPA PAH) priority polycyclic aromatic hydrocarbons
Total NPD = Total naphthalene, phenanthrene/anthracene and dibenzothiophene
NPD [%] = Percentage of total 2 to 6 ring PAH concentration comprised of NPD
WS = Water sample
* = Concentrations expressed as µg/L
† = Concentrations expressed as ng/L
‡ = Mean and relative standard deviation values estimated from an environmental survey in the neighbouring Liza field (Fugro, 2016)

7.5 Metals

7.5.1 Introduction

Water column samples collected from the Payara survey area were analysed for selected elements: aluminium, arsenic, barium, cadmium, chromium, copper, iron, lead, mercury, nickel, selenium, and zinc using ICP-MS and ICP-OES. Sample analysis was conducted by Kaizen LAB. Concentrations of metals in the water samples were compared to the US EPA criterion continuous concentration (CCC) and criterion maximum concentration (CMC) values (US EPA, 2018). Concentrations below these values are considered concentrations at which detrimental effects are rarely observed in biota.

7.5.2 Results

Arsenic concentrations ranged from 1.42 µg/L to 2.19 µg/L at stations EBSWS3 (Surface) and EBSWS7 (Surface) respectively. The mean concentration was 1.70 µg/L which was comparable to the mean from the Liza Field survey (1.43 µg/L; Fugro, 2016) and below the US EPA CCC value (36 µg/L; US EPA, 2018). Interstation variability was low (RSD 9 %). No patterns of arsenic concentrations with depth were observed.

Barium concentrations across the Payara survey area ranged from below the MRV of 10.0 µg/L for all stations except station EBSWS3 (Bottom), which had a concentration of 12.4 µg/L.

Cadmium concentrations were below the MRV of 0.6 µg/L and US EPA CCC value (7.9 µg/L; US EPA, 2018) for all stations.

The concentrations of chromium across the Payara survey area ranged from below the MRV of 10.0 µg/L for all stations except station EBSWS4 (Mid). The chromium concentration at this station was 222 µg/L, which was higher than the mean of the Liza Field (0.656 µg/L; Fugro, 2016).

Copper concentrations were all below the MRV of 12.0 µg/L and therefore it was not possible to make a comparison to the Liza Field survey mean (0.778 µg/L; Fugro, 2016), the US EPA CCC value (3.1 µg/L; US EPA, 2018) or the US EPA CMC value (4.8 µg/L).

Mercury concentrations ranged from below the MRV of 0.010 µg/g at most stations to 0.113 µg/g at station EBSWS3 (Mid). The US EPA CCC value (0.94 µg/L; Buchman, 2008) was exceeded at station EBSWS3 (Mid) but the US EPA CMC value (1.8 µg/L) was not exceeded at any station. No patterns of mercury concentrations with depth were observed.

Water column concentrations of nickel were all below the MRV of 4.00 µg/L and US EPA CCC value (8.2 µg/L; US EPA, 2018) for all stations.

Lead concentrations across the survey area ranged from below the MRV of 1.40 µg/L for all stations except station EBSWS1 (Bottom), which had a concentration of 1.42 µg/L. All lead concentrations were below the US EPA CCC value (8.1 µg/L; US EPA, 2018). The lead concentration that was above the MRV was higher than the mean lead concentration from the Liza field (0.144 µg/L; Fugro, 2016).

Selenium concentrations were below the MRV for all stations in the Payara development area. All concentrations were lower than the US EPA CCC value (71 µg/L; US EPA, 2018).

The concentrations of zinc ranged from below the MRV of 100 µg/L for the majority of stations to 173 µg/g at station EBSWS1 (Bottom). Three stations exceeded both the US EPA CCC value (81 µg/L; US EPA, 2018) and the US EPA CMC value (90 µg/L; US EPA, 2018). The zinc concentrations in the current survey area that were above the MRV were higher than the mean zinc concentration from the Liza field (6.42 µg/L; Fugro, 2016).

Table 7.5: Summary of Water Column Metals Analysis, Payara Development

Station	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Se	Zn
EBSWS1 (Surface)	< 80.0	1.79	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS1 (Mid)	< 80.0	1.60	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS1 (Bottom)	111	1.78	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.015	< 4.00	1.42	< 6.00	173
EBSWS2 (Surface)	< 80.0	1.68	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS2 (Mid)	82.5	1.83	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.011	< 4.00	< 1.40	< 6.00	< 100
EBSWS2 (Bottom)	< 80.0	1.68	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS3 (Surface)	< 80.0	1.42	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS3 (Mid)	< 80.0	1.73	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.113	< 4.00	< 1.40	< 6.00	< 100
EBSWS3 (Bottom)	< 80.0	1.67	12.4	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS4 (Surface)	< 80.0	1.80	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS4 (Mid)	< 80.0	1.66	< 10.0	< 0.600	222	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS4 (Bottom)	< 80.0	1.72	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.014	< 4.00	< 1.40	< 6.00	< 100
EBSWS5 (Surface)	< 80.0	1.49	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS5 (Mid)	< 80.0	1.63	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS5 (Bottom)	< 80.0	1.75	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS6 (Surface)	142	1.60	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	118
EBSWS6 (Mid)	112	1.85	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	126
EBSWS6 (Bottom)	< 80.0	1.69	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS7 (Surface)	< 80.0	2.19	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	< 0.010	< 4.00	< 1.40	< 6.00	< 100
EBSWS7 (Mid)	< 80.0	1.79	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.011	< 4.00	< 1.40	< 6.00	< 100
EBSWS7 (Bottom)	< 80.0	1.60	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.011	< 4.00	< 1.40	< 6.00	< 100
EBSWS8 (Surface)	< 80.0	1.57	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.014	< 4.00	< 1.40	< 6.00	< 100
EBSWS8 (Mid)	< 80.0	1.74	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.015	< 4.00	< 1.40	< 6.00	< 100
EBSWS8 (Bottom)	< 80.0	1.65	< 10.0	< 0.600	< 10.0	< 12.0	< 80.0	0.015	< 4.00	< 1.40	< 6.00	< 100
Minimum	**82.5**	**1.42**	**< 10.0**	**< 0.600**	**< 10.0**	**< 12.0**	**< 80.0**	**< 0.010**	**< 4.00**	**< 1.40**	**< 6.00**	**< 100**
Maximum	**142**	**2.19**	**12.4**	**< 0.600**	**222**	**< 12.0**	**< 80.0**	**0.113**	**< 4.00**	**1.42**	**< 6.00**	**173**
Mean	**-**	**1.70**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
Standard Deviation	**-**	**0.147**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
RSD [%]	**-**	**9**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**

Station	Al	As	Ba	Cd	Cr	Cu	Fe	Hg	Ni	Pb	Se	Zn
Liza Field (Fugro, 2016)*												
Mean	-	1.43	-	0.043	0.656	0.385	-	-	-	0.144	-	6.42
RSD [%]	-	13	-	23	16	58	-	-	-	93	-	103
US EPA Saltwater Quality Standards (US EPA, 2018)												
CCC	-	36	-	7.9	-	3.1	-	0.94	8.2	8.1	71	81
CMC	-	69	-	33	-	4.8	-	1.8	74	210	290	90

Notes:

Concentrations expressed in µg/L

Al = Aluminium; As = Arsenic; Ba = Barium; Cd = Cadmium; Cr = Chromium; Cu = Copper; Fe = Iron

Hg = Mercury; Ni = Nickel; Pb = Lead; Se = Selenium; Zn = Zinc

RSD = Relative standard deviation

WS = Water sample

CCC = Criterion continuous concentration

CMC = Criterion maximum concentration

US EPA = United States Environmental Protection Agency

* = Mean and relative standard deviation values estimated from a historical environmental survey at the Liza field (Fugro, 2016)

† = US Environmental Protection Agency (US EPA) 2018 national recommended water quality criteria (US EPA, 2018)

Key:	Below CCC Value	Above CCC Value	Above CMC Value

8. SEABED HABITATS

8.1 Introduction

To assess the habitats present within the survey area, detailed analysis of video and stills photography data were undertaken by experienced Fugro marine biologists/taxonomists. Video photography data were reviewed in conjunction with the still photographs, noting the locations of any observed change in sediment type and/or associated faunal community.

Appendix C provides the detailed video and photographic log. Appendix G provides detailed digital seabed stills photographs.

The 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (Institute of Terrestrial Ecology, 1996) has been used to broadly classify the observed seabed habitats. Due to a lack of more detailed habitat guidelines and background literature for South American marine habitats, the European Nature Information System (EUNIS) habitat classification (EUNIS, 2012) has also been used, which has comparable overarching descriptors of habitats. However, due to regionally different species in-depth biotope complex classifications cannot be applied.

8.2 Results

8.2.1 Seabed Habitats and Fauna

The seabed within the Payara survey area was predominantly homogenous, comprising of muddy sand with shell fragments and occasional small areas of hard substrate.

Analysis of the photographic data showed the Payara survey area to be comprised of one broad habitat, 'Western Atlantic abyssal benthic communities' (11.2122). This habitat encompasses benthic communities of abyssal plains and abyssal hills of Atlantic waters of South America north of about 42 °S, characteristic of the Western Atlantic province of the Atlantic abyssal region (Institute of Terrestrial Ecology, 1996). The equivalent EUNIS habitat was 'Deep-sea bed' (A6) which describes the sea bed beyond the continental shelf break generally over 200 m (EUNIS 2012).

The 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (Institute of Terrestrial Ecology, 1996) habitat classification system does not provide more detailed biotope descriptions below 'Western Atlantic abyssal benthic communities' habitat (11.2122). However, within the EUNIS habitat 'Deep-sea bed', one biotope complex was identified which provides a more detailed description of the sediments observed: 'Deep-sea muddy sand' (A6.4).

Table 8.1 summarises the assigned 'Biotopes/Ecosystems Nomenclature, Habitats of South America' (1996) and EUNIS (2012) habitat classification.

Table 8.1: Habitat Classifications, Payara Development

EUNIS (2012) Habitat Classification			Biotopes/Ecosystems Nomenclature, Habitats of South America' Classification (1996)
Environment Level 1	**Broad Habitat Level 2**	**Habitat Level 3**	
A Marine	A6 Deep-sea bed	A6.4 Deep-sea muddy sand	11.2122 Western Atlantic abyssal benthic communities
Notes: EUNIS = European Nature Information System			

Epifauna observed within the Payara survey area was sparse. The most frequently observed biota were sea cucumbers (*Benthodytes* sp.), particularly at stations EBSDDV1 and EBSDDV8 where aggregations were observed, and xenophyophores (Xenophyophoroidea). Brittlestars (Ophiuroidea), starfish (Asteroidea), anemones (Actiniaria), shrimp (Caridea) and were also observed in association with the soft sediment. Where the hard substrate was present a change in the species diversity was observed, with sponges (Porifera, including *Polymastia* sp.), starfish (Asteroidea, including Brisingidae), bryozoans (Bryozoa) and an increased abundance of shrimp (Caridea), anemones (Actiniaria) and brittlestars (Ophiuroidea).

Two fish were observed within the survey area: a tripod fish (Ipnopidae) observed at station EBSDDV7 and an unidentified fish (Pisces) observed at station EBSDDV36.

Figure 8.1 presents example photographs of the biotope and species observed within the Payara survey area.

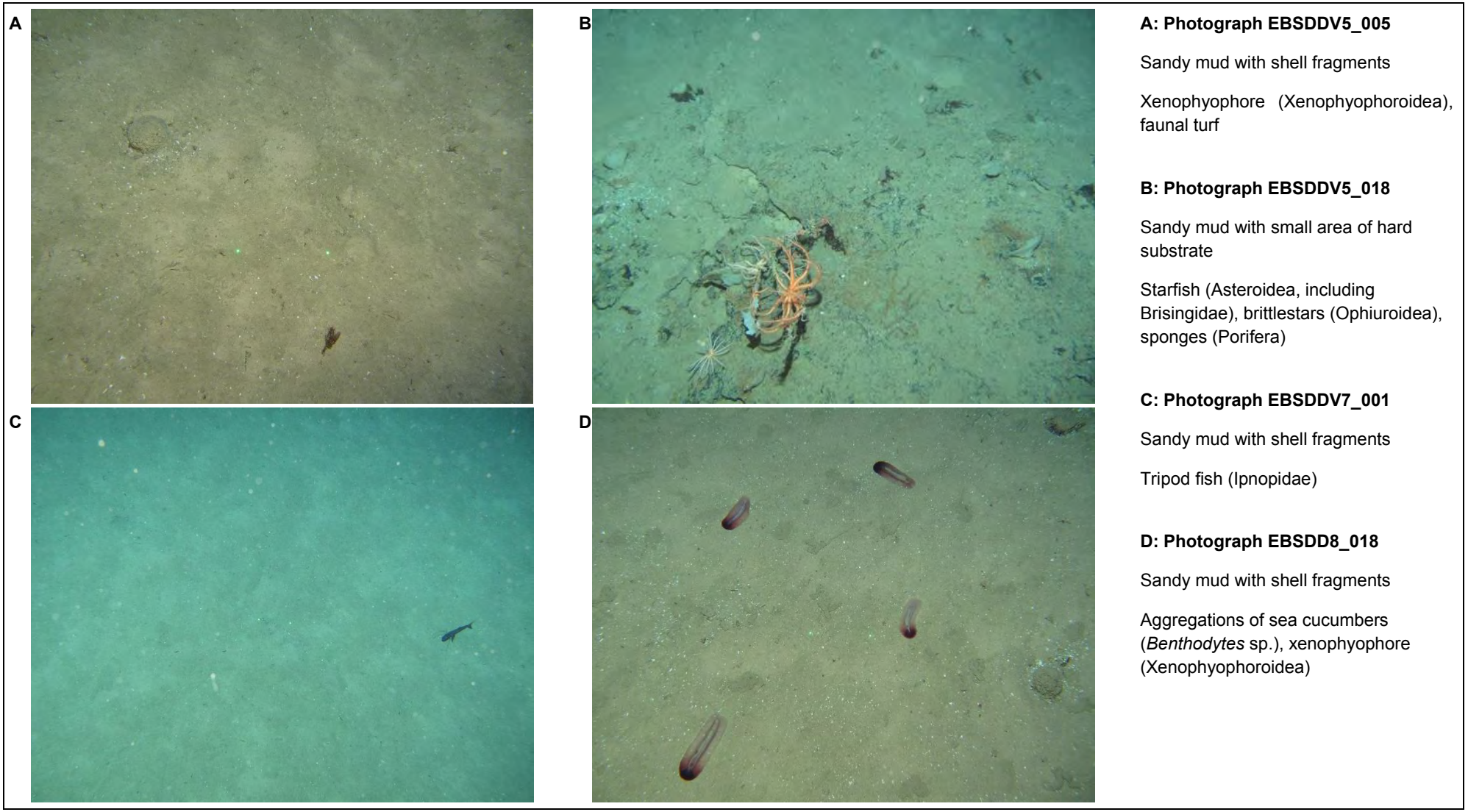


Figure 8.1: Example seabed sediment photographs, Payara development

9. SEDIMENT MACROFAUNA

9.1 Introduction

This section presents the results of the macrofaunal analysis of samples collected across the survey area. A total of eight stations were sampled for macrofaunal content using a United States Naval Electronics Laboratory (USNEL) 0.25 m^2 box corer. Each of the station samples was subsampled into two 0.1 m^2 macrofauna samples that were processed for analysis (FA and FB). Appendix B provides full details of the analytical techniques employed.

The sediment macrofauna is defined as those animals living in or on the seabed that are retained on a sieve mesh of 0.5 mm. Before any analysis was undertaken, the reported macrofaunal dataset underwent rationalisation to prevent spurious enhancement of community statistics and allow comparison to historical datasets. Some indeterminate species were also rationalised at a higher taxonomic level and merged to avoid losing the resolution of the dataset (i.e. individuals identified as Eulimidae and Eulimidae sp. A were merged and presented as Eulimidae). Analysis was completed with juveniles (i.e. *Glycera*), removed from the dataset as juveniles are not considered part of the permanent community. Any phyla considered colonial (i.e. Porifera), or pelagic (i.e. Chaetognatha) were also removed for this reason. Damaged specimens (i.e. Sipuncula) were also removed prior to analysis.

Following rationalisation, intrastation variability for the survey area varied from moderate to high, with stations ranging in average similarity between each of the two samples from 0 % (stations EBSBC4 and EBSBC5) to 44 % (station EBSBC2). The data from samples for each station were combined to obtain numbers of taxa and individuals per 0.2 m^2 for each station, as well as diversity indices. Individual sample data was combined in this manner to achieve a more accurate representation of the numbers of taxa and individuals present in a given area of the seabed. This is accepted practise in marine benthic monitoring.

The results of the macrofaunal analysis are presented in the form of figures and tables; the main features of the communities identified are highlighted in the text. A full list of taxa identified, and the number enumerated (individuals per 0.1 m^2) from the survey area are presented in Appendix G.

It should be noted that any statements on the macrofaunal community recorded in the current survey should be treated with caution, due to the low abundances observed.

9.2 Results

9.2.1 Phyletic Composition

Table 9.1 summarises the abundance of taxonomic groups identified across the survey area and Figures 9.1 and 9.2 display the data graphically.

A total of 90 taxa and 215 individuals were identified within grab samples from the survey area. Of these taxa, 12 were merged and presented as 6 taxa, and 25 were recorded as juveniles, pelagic, colonial or damaged. To avoid spurious enhancement of diversity indices the dataset was rationalised and these taxa were removed prior to statistical analysis (see Appendix G).

The rationalised data comprised 59 benthic taxa, of which 21 (35.6 %) were annelids, 23 (39.0 %) were arthropods, 10 (16.9 %) were molluscs, 2 (3.4 %) were echinoderms, whereas 3 (5.1 %) were other phyla. A total of 155 individual animals were identified in the rationalised data, of which 79 (51.0 %) were annelids, 47 (30.3 %) were arthropods, 14 (9.0 %) were molluscs, 4 (2.6 %) were echinoderms, whereas 11 (7.1 %) were other phyla. (Table 9.1).

Table 9.1: Taxonomic Groups, Payara Development

Taxonomic Group	Number of Taxa	Composition of Taxa [%]	Abundance	Composition of Individuals [%]
Annelida	21	35.6	79	51.0
Arthropoda	23	39.0	47	30.3
Mollusca	10	16.9	14	9.0
Echinodermata	2	3.4	4	2.6
Other phyla	3	5.1	11	7.1
Total	**59**	**100**	**155**	**100**
Notes: Other phyla included: Sipuncula Macrofaunal sample were processed through a 0.5 mm sieve				
Liza Field (Fugro, 2016)				
Taxonomic Group	**Number of Taxa**	**Composition of Taxa [%]**	**Abundance**	**Composition of Individuals [%]**
Annelida	66	40.0	216	42.7
Arthropoda	63	38.3	198	39.1
Mollusca	21	12.7	44	8.7
Echinodermata	5	3.0	8	1.6
Other phyla	10	6.0	40	7.9
Total	**165**	**100**	**506**	**100**
Notes: Other phyla included: Echiura, Nemertea and Cnidaria				

Figures 9.1 and 9.2 illustrate the phyletic composition of taxa and individuals for each station (per 0.2 m^2), respectively, facilitating spatial comparison and highlighting a number of dissimilarities between stations across the survey area.

When the proportion of taxa per phylum was considered, all stations were dominated by annelids except station EBSBC8, dominated by arthropods (Figures 9.1). An equal number of arthropod and annelid taxa was recorded in station EBSBC6. Molluscs were absent from stations EBSBC1 and EBSBC3, whereas echinoderms were absent from stations EBSBC1 to EBSBC4, EBSBC7 and EBSBC8. Other phyla were not recorded in station EBSBC3, EBSBC5, EBSBC7 and EBSBC8. Annelids and arthropods were noted to dominate the macrofaunal community in a previous survey carried out in 2016 at the Liza Field (Table 9.1; Fugro, 2016).

When the proportions of individuals per phylum were considered, a high variation was demonstrated between stations (Figure 9.2), possibly due to the very low numbers of individuals recorded.

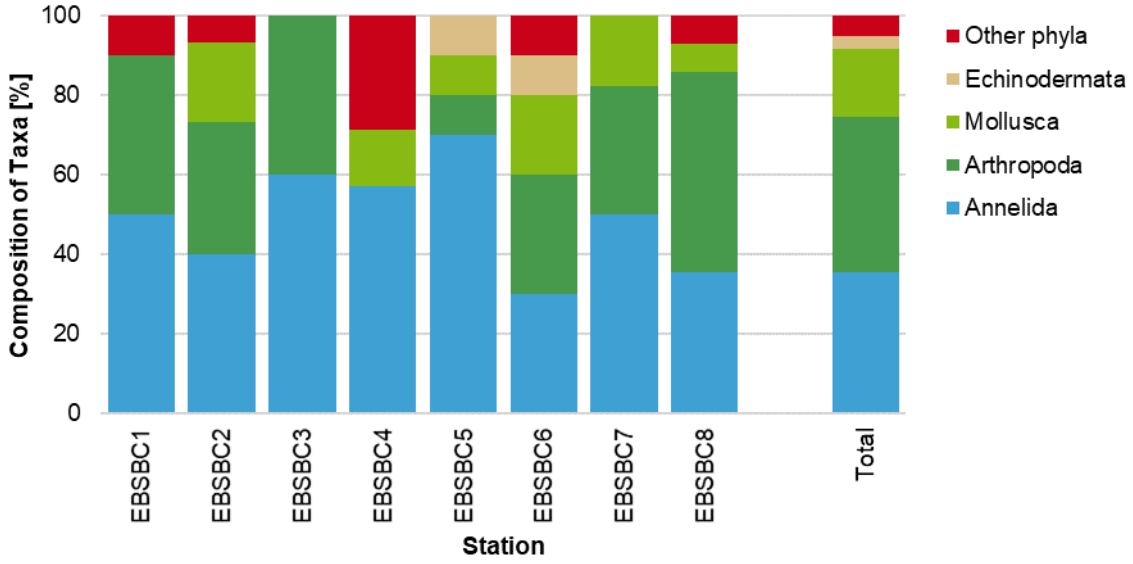


Figure 9.1: Phyletic composition of taxa, Payara development

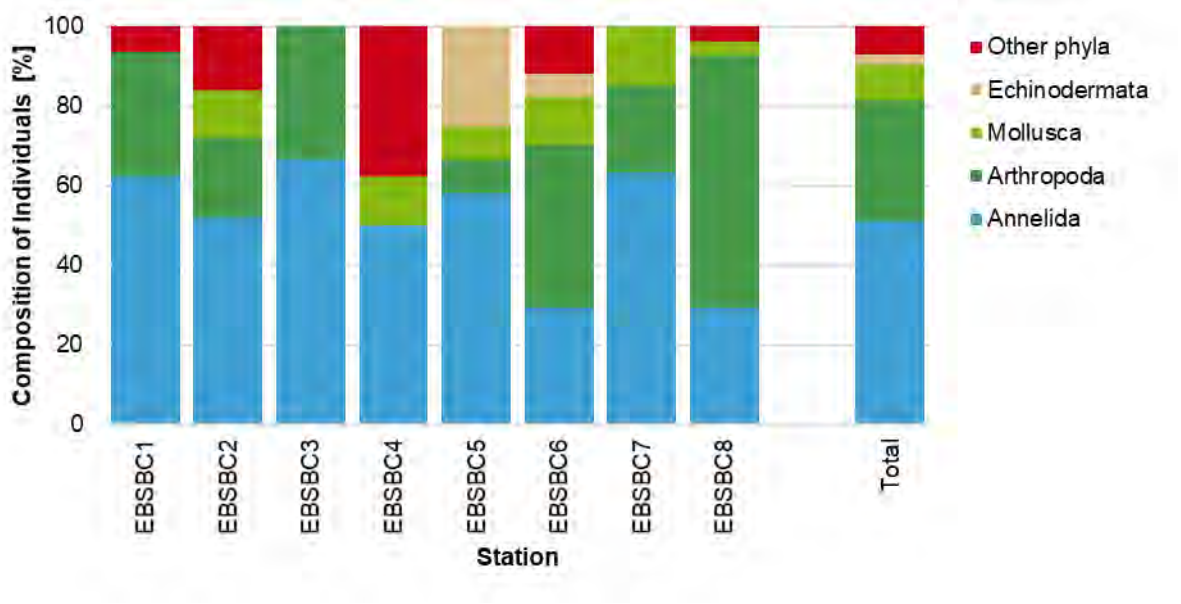


Figure 9.2: Phyletic composition of individuals, Payara development

9.2.2 Characteristic Taxa

Table 9.2 presents the dominant taxa within the survey area and Table 9.3 presents the top five most abundant taxa per station. By ranking the taxa recorded at each station in terms of density and summing the rank scores for all stations to assign an overall rank abundance and dominance for each taxon, it is possible to examine which species were consistently abundant as well as dominant throughout the survey area. The dominance rank is less susceptible to bias caused by species that occur in high densities in only a few of the samples analysed.

The top five most abundant taxa at each station were similar across the entire survey area and represented ≥ 36.6 % of the total abundance at each station (Table 9.3). Individuals of the polychaete

Spiophanes were the most dominant and abundant group present in all but two stations (stations EBSBC4 and EBSBC6). The annelid *Bathyglycinde profunda* was the second most dominant, but fourth most abundant taxon present in half of the stations (stations EBSBC1, EBSBC2, EBSBC6 and EBSBC7). The arthropod identified as Balanidae sp. A, was only present in station EBSBC8 and in high numbers, hence presented as the second most abundant taxon.

Notable differences were observed between the most abundant taxa per station sampled (Table 9.3). The annelid *Spiophanes* was the most abundant taxon in stations EBSBC1, EBSBC2 and EBSBC7. Annelid individuals identified as Oweniidae were the most abundant taxon in station EBSBC3, whereas the sipunculid *Aspidosiphon zinni* was the most abundant taxon in station EBSBC4. Echinoderms identified as Ophiuridae sp. A at station EBSBC5 and arthropods identified as Ampeliscidae at station EBSBC6, demonstrated the highest abundances. Two of the top ten most dominant taxa recorded in the current study, including *Spiophanes* and *Aspidosiphon zinni*, were also reported from the Lisa Field survey area (Fugro, 2016).

Table 9.2: Dominant Taxa by Rank Abundance and Dominance, Payara Development

Taxon	Rank Abundance	Mean Station Abundance [0.2 m^2]	Rank Dominance	Frequency [%]
Spiophanes	1	3	1	75.0
Bathyglycinde profunda	4	1	2	50.0
Oweniidae	3	1	3	62.5
Kirkegaardia	6	1	4	62.5
Paradoneis	8	1	5	25.0
Aspidosiphon zinni	4	1	6	50.0
Eulimidae	14	< 1	7	12.5
Paraonidae sp. A	14	< 1	7	12.5
Ampharetinae	14	< 1	7	12.5
Balanidae sp. A	2	1	10	12.5

Notes:
Rank abundance is calculated based on the total number of individuals across the survey area
Rank dominance is calculated based on frequency between stations across the survey area
Frequency = Percentage of the stations from which the taxa were recorded

Table 9.3: Top 5 Most Abundant Taxa at Each Station, Payara Development

Station EBSBC1	Ind [0.2 m^2]	Cum [%]	Station EBSBC2	Ind [0.2 m^2]	Cum [%]
Spiophanes	4	25.0	*Spiophanes*	8	32.0
Bathyglycinde profunda	3	43.8	*Aspidosiphon zinni*	4	48.0
Harpiniopsis (?) sp. B	2	56.3	*Bathyglycinde profunda*	1	52.0
Ampeliscidae	1	62.5	Oweniidae	1	56.0
Aspidosiphon zinni	1	68.8	Opheliidae	1	60.0
Station EBSBC3	**Ind [0.2 m^2]**	**Cum [%]**	**Station EBSBC4**	**Ind [0.2 m^2]**	**Cum [%]**
Oweniidae	3	33.3	*Aspidosiphon zinni*	2	25.0
Spiophanes	2	55.6	Oweniidae	1	37.5
Heteromesus	2	77.8	*Kirkegaardia*	1	50.0
Kirkegaardia	1	88.9	*Paradoneis*	1	62.5
Nannoniscidae sp. A	1	100	*Pristigloma*	1	75.0

Station EBSBC5	Ind [0.2 m^2]	Cum [%]	Station EBSBC6	Ind [0.2 m^2]	Cum [%]
Ophiuridae sp. A	3	25.0	Ampeliscidae	4	23.5
Kirkegaardia	1	33.3	*Kirkegaardia*	2	35.3
Spiophanes	1	41.7	*Bathyglycinde profunda*	2	47.1
Cirratulidae	1	50.0	SIPUNCULA sp. A	2	58.8
Capitellidae	1	58.3	Ischyroceridae	2	70.6
Station EBSBC7	**Ind [0.2 m^2]**	**Cum [%]**	**Station EBSBC8**	**Ind [0.2 m^2]**	**Cum [%]**
Spiophanes	4	9.8	Balanidae sp. A	10	37.0
Paradoneis	4	19.5	*Spiophanes*	4	51.9
Oweniidae	3	26.8	*Collettea*	2	59.3
Kirkegaardia	2	31.7	Oweniidae	1	63.0
Bathyglycinde profunda	2	36.6	Ampeliscidae	1	66.7

Notes:
Ind = Number of individuals of the taxa within the station (0.2 m^2)
Cum = Cumulative percentage of the individuals relative to the total number of individuals recorded within the station (0.2 m^2)

9.2.3 Species Accumulation and Richness Estimation

Figure 9.3 displays the species accumulation plot. This was generated using sample data (0.1 m^2) in PRIMER v6. The observed number of taxa obtained through repeated sampling (Sobs) were cumulatively plotted, as were richness estimates from repeated sampling as calculated by the Chao1, Chao2, Jacknife1 and Jacknife2 formulae. All displayed curves were smoothed (by random permutation of the data points) to aid interpretation.

The observed species accumulation curve had a relatively consistent slope. However, it did not appear close to reaching its asymptote, suggesting that a proportion of the macrofaunal community within the Payara Development survey area had not been fully detected by the sampling undertaken. Despite this, the richness estimators indicate that the survey area has partially been described, with estimates for the total macrofaunal diversity of the area ranging from 84 taxa (Chao 1) to 110 taxa (Jacknife 2), in comparison to the 59 taxa recorded. These estimates suggest that between 54 % and 70 % of the area's total faunal diversity has been detected by the sampling undertaken.

The initial spike in the Chao 2 richness estimator was likely due to little, or no, overlap in species composition within the first few stations causing on artificial overestimation in species count.

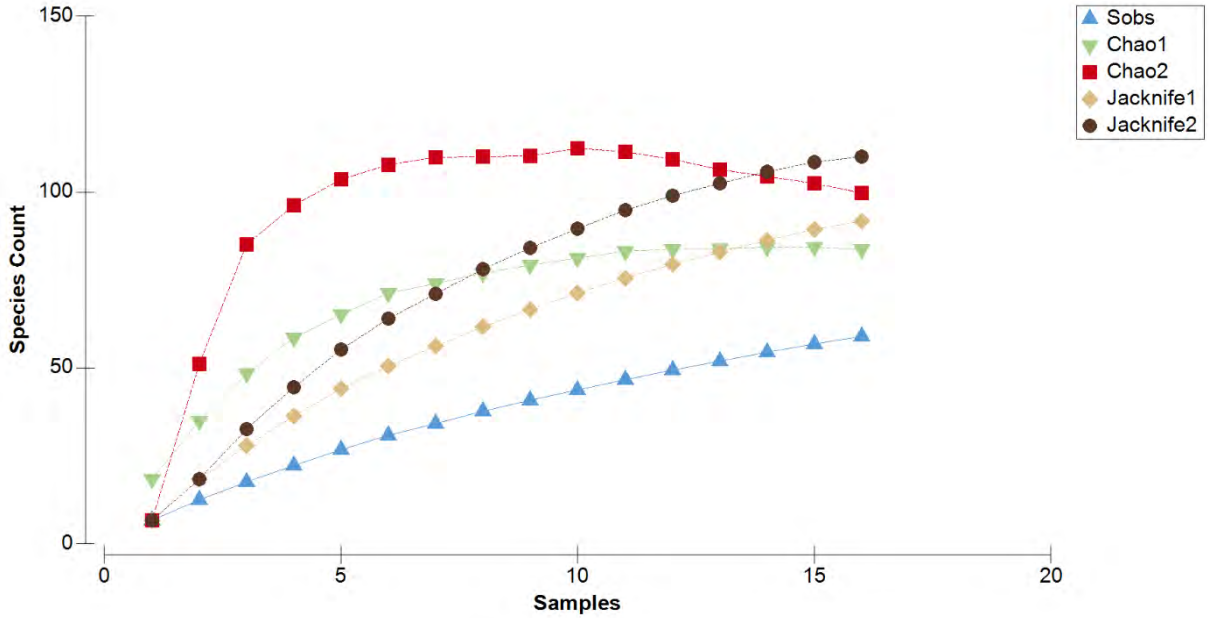


Figure 9.3: Species accumulation plot for sample data (0.1 m²), Payara development

9.2.4 Community Statistics

Table 9.4 presents the number of taxa and individuals identified from each station along with several commonly used diversity and evenness statistics.

The number of taxa per 0.2 m² ranged from 5 (station EBSBC3) to 28 (station EBSBC7), with a mean of 12 and moderate station variability (RSD 57 %). The number of individuals per 0.2 m² ranged from 8 (station EBSBC4) to 41 (station EBSBC7), with a mean of 19 and moderate interstation variability (RSD 57 %). The mean values of both the number of taxa and individuals recorded in the current survey were comparable to the respective values reported previously from the Lisa Field survey (Fugro, 2016).

Diversity was moderate across the survey area (Dauvin et al., 2012). The Shannon-Weiner diversity index ranged from 2.20 (station EBSBC3) to 4.61 (station EBSBC7), with a mean of 3.19. The Brillouin's index ranged from 1.07 (station EBSBC3) to 2.50 (station EBSBC7), with a mean of 1.62. Low variability was observed for both diversity indices (RSD 21 % and 26 %, respectively). Comparable mean values for diversity indices were recorded previously from the Lisa Field survey (Fugro, 2016).

Evenness was high across the survey area. The Pielou's evenness index (J), a measure of the distribution of individuals between taxa ranged from 0.828 (station EBSBC8) to 0.980 (station EBSBC4), with a mean of 0.926. The Simpson's index of dominance (expressed as $1 - \lambda$) ranged from 0.765 (station EBSBC3) to 0.952 (station EBSBC7), with a mean of 0.855. Low variability was observed for both indices (RSD 6 %, respectively). Comparable mean values for evenness were recorded previously from the Lisa field survey (Fugro, 2016).

Table 9.4: Macrofaunal Community Statistics (0.2 m^2), Payara Development

Station	Numbers		Diversity Indices		Evenness	
	Taxa	Individuals	Shannon-Wiener [$H'Log_2$]	Brillouin [Hb]	Pielou [J]	Simpson [1-λ]
EBSBC1	10	16	3.08	1.56	0.927	0.859
EBSBC2	15	25	3.36	1.77	0.861	0.851
EBSBC3	5	9	2.20	1.07	0.946	0.765
EBSBC4	7	8	2.75	1.24	0.980	0.844
EBSBC5	10	12	3.19	1.52	0.960	0.875
EBSBC6	10	17	3.15	1.62	0.947	0.872
EBSBC7	28	41	4.61	2.50	0.958	0.952
EBSBC8	14	27	3.15	1.69	0.828	0.820
Minimum	**5**	**8**	**2.20**	**1.07**	**0.828**	**0.765**
Maximum	**28**	**41**	**4.61**	**2.50**	**0.980**	**0.952**
Mean	**12**	**19**	**3.19**	**1.62**	**0.926**	**0.855**
Standard Deviation	**7**	**11**	**0.68**	**0.42**	**0.053**	**0.053**
RSD [%]	**57**	**57**	**21**	**26**	**6**	**6**
Liza Field (Fugro, 2016)*						
Mean	**14**	**20**	**2.42**	**-**	**0.95**	**0.94**
RSD [%]	**50**	**55**	**23**	**-**	**6**	**10**

Notes:
RSD = Relative standard deviation
* = Mean and relative standard deviation values estimated from an environmental survey in the neighbouring Liza field (Fugro, 2016). 0.2 m^2 stations processed through a 0.5 mm sieve

9.2.5 Investigation of Faunal Similarities

Univariate statistics can summarise large and complex datasets (see Appendix B.3) to a certain extent, however, multivariate techniques will condense a large data matrix to a much more manageable form and compare each variable with all others in the process. In doing so, subtle trends in the data may be elucidated.

Various multivariable techniques were applied to the survey area data to investigate such patterns of similarity within the macrobenthic community, which were then further considered with the results from the univariate analyses. Figure 9.4 presents the multivariate statistical analyses of the community: hierarchical agglomerative clustering (CLUSTER) from PRIMER.

9.2.5.1 Cluster Analysis

CLUSTER analysis groups stations according to their faunal similarity and the results are presented in the form of a dendrogram. Figure 9.4 presents the CLUSTER analysis dendrogram and demonstrates the pattern of similarity of square root transformed station data. The SIMPROF algorithm was used to identify statistically significant (P = 0.05) differences between stations. No significant splits were demonstrated.

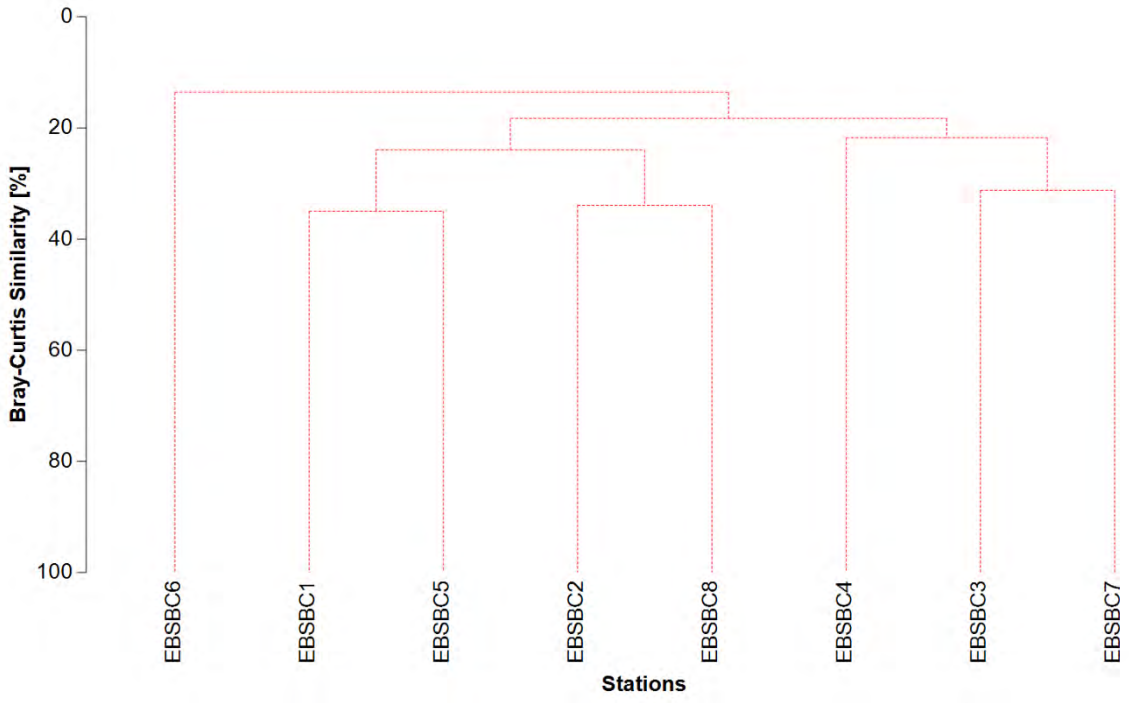


Figure 9.4: Classification by Bray-Curtis similarity for square root transformed macrofaunal abundance station (0.2 m^2) data, Payara development

The relationship between macrofauna communities and physical and chemical determinants will be discussed further in Section 10.

10. DISCUSSION

10.1 Introduction

The survey and analytical strategies were designed to provide a comprehensive baseline dataset of the biological and physico-chemical characteristics in the vicinity of the Payara development. An assessment of likely habitats and biotopes, with particular attention to environmentally sensitive habitats and species, was also conducted. The sampling plan included the collection of surface sediment from eight stations located in proximity to the proposed drill centres and wells for physico-chemical and biota analysis. The surface (0 cm to 2 cm) sediment samples collected (Section 3) were analysed for total TOC, hydrocarbons (including 2 to 6 ring aromatics) and heavy metal content. Selected physical characteristics were analysed using surface sediment samples of 0 cm to 5 cm. Macrofaunal analysis (> 0.5 mm) was carried out on duplicate 0.1 m^2 grab samples at each station. Water column samples were collected at three depths and analysed for TSS, TOC, hydrocarbons and metals content.

The previous sections of this report have presented the data generated from the analysis programme stated above with the aid of data tables and graphics. This discussion section will review the data with respect to regional comparison data from a previous survey at similar depths in the neighbouring Liza field development (Fugro, 2016). The data from this report were also compared to appropriate reference values (Buchman, 2008; US EPA, 2018) to determine whether the concentrations present in the sediments and water columns may potentially have a detrimental effect on the benthic communities in the Payara development survey area.

In addition to the comparison of the analytical data against available references, statistical correlations of the sediment parameters recorded with the chemical and biological determinants in the survey are summarised (for the main environmental parameters) in Appendix I. The statistical analysis chosen was the Spearman's rank correlation coefficient (Spearman, 1904), sometimes referred to as Spearman's rho. This coefficient is used to test the association between two reported values for statistical dependence. It is a measure of rank correlation, or the similarity of the orderings of the data when ranked by each of the values. Correlations can only suggest a relationship and do not prove a causal link between status of the chemical or physical nature of the seabed and the infaunal community composition. Correlations occur as both positive and negative: they are positive when both reported values increase or decrease in unison, whilst negative correlations indicate that as one value increases the other decreases and vice-versa. Commonly observed positive correlations would include such variables as THC and PAH whereas common negative correlations would typically include factors such as distance from oil and gas infrastructure and THC (i.e. the further from a platform, the lower the level of contamination observed).

Although correlations analysis indicated that some correlations were apparent between intrinsic physicochemical and biological parameters, the low variation demonstrated in the datasets summarised within the preceding sections of this report suggest that these are not true ecological correlations. Consequently, whilst they are included within Appendix I, they have not been discussed further.

10.2 Sediment Characterisation

The general physical and chemical characteristics of sediment particles have a significant effect on how other chemical components and biological species interact with seabed sediments. For example, the silt/clay fraction is known to adsorb petroleum hydrocarbons/heavy metals from seawater and through

this pathway, these chemicals become incorporated into the sediment system (Meyers and Quinn, 1973). Granulometry data can therefore be critical when interpreting chemical and biological data obtained in this type of benthic study. In addition, since waste discharges (such as drill cuttings) often possess significantly different physical characteristics from the natural sediments present in the area, such data may also provide some information on the spread of discharged material.

Regarding macrofaunal communities, the species distributions and community structure can be greatly influenced by the nature of the sediment, which represents the effects of a complex set of hydrological factors, such as water movement, turbulence and suspended load, at one particular point in time. Some animals have a behavioural preference for sediment of a particular grain size (Meadows, 1964; Gray, 1981), while this factor and organic matter content are closely associated with other properties of the sediment such as density, porosity, permeability, oxygenation and bacterial count (Buchanan, 1984), all of which affect animal functions such as locomotion, attachment, tube construction and feeding. Specifically, the proportion of fine (silt/clay) material often influences the distribution of macrofaunal communities.

The sediments at most stations within the Payara survey area demonstrated moderate interstation variability in mean diameter and low variability for the proportion of sand and fines, indicating the presence of mostly homogenous sediment. Station EBSBC8 had a slightly higher mean particle size than the remaining stations predominantly due to the higher proportion of sand recorded at this station.

Using the Folk (1954) sediment description in situ, the seabed was reported to comprise sand and shell fragments. This was supported in the laboratory by the Wentworth (1922) classification, describing sediments across the survey area as coarse silt, with the exception of stations EBSBC7 and EBSBC8, which were described as medium silt and very fine sand, respectively (Section 4). Sediments were described as very poorly sorted across the survey areas. All stations were dominated by the sand and silt fractions. The composition of sediments along the Guyana coast is influenced by riverine discharges from the Amazon basin, which are transported northwards via ocean currents (Eisma and Van der Marel, 1971). Secondary inputs are likely to be the discharge of sediments from the Essequibo-Demerara drainage basin (Nota, 1958). The quantity of gravel was highly variable across the Payara survey area, with the EBSBC5 site having a slightly higher gravel content when compared to the other stations. All stations were classified as the biotope complex ‘Western Atlantic abyssal benthic communities’ (11.2122; Table 8.1). This was further corroborated by the results of the PSD.

No spatial pattern for TOC was observed, with low TOC values across the survey area displaying low interstation variability. No correlations were observed between TOC and the macrofaunal indices, likely to be due to the low variability in TOC across the sediments and suggesting little influence of organic content on the occurrence and distribution of faunal communities across the Payara survey area. Weak positive correlations were observed between TOC and some metals concentrations which is expected as metals can bind to organic phases in sediments (Morillo et al., 2004).

10.3 Sediment Hydrocarbons

10.3.1 Total and Aliphatic Hydrocarbons

Marine sediments contain hydrocarbons derived from many sources that enter the marine environment via three general processes (Farrington and Meyer, 1975; Myers and Gunnerson, 1976): biosynthesis

(marine and land organisms biosynthesise hydrocarbons), geochemical processes (submarine and coastal/terrestrial oil-seeps) and anthropogenic sources (from accidental or intentional discharge of fossil fuel). The latter obviously includes hydrocarbon exploration, production and associated shipping; these and other sources of contaminants are assessed in the reports NSTF (1993) and OSPAR (2000; 2010).

Biosynthesised hydrocarbons are ubiquitous in the marine environment (Harada et al., 1995). Odd carbon number, long chain n-alkanes are widely distributed in the plant kingdom (Douglas and Eglinton, 1966; Eglinton et al., 1962) as components of cuticle waxes that are common to the surfaces of leaf, stem, flower and pollen and their presence in sediments is indicative of an input through run-off from adjacent land masses. Relatively high concentrations of nC_{29}, nC_{31} and nC_{33} are therefore a common feature of many marine sediments (Farrington et al., 1977).

Anthropogenic hydrocarbon inputs enter the marine environment from a number of sources. For example, from marine transportation, offshore oil production, coastal oil refineries, accidental shipping losses, industrial and municipal waste (which includes sewage and dredged spoils) with a significant contribution to the global budget entering via urban and river run-off, atmospheric deposition (from combustion sources; including PAHs) and natural seepages (e.g. Johnston, 1980; Dicks et al., 1987; NSTF, 1993; OSPAR, 2000, 2010).

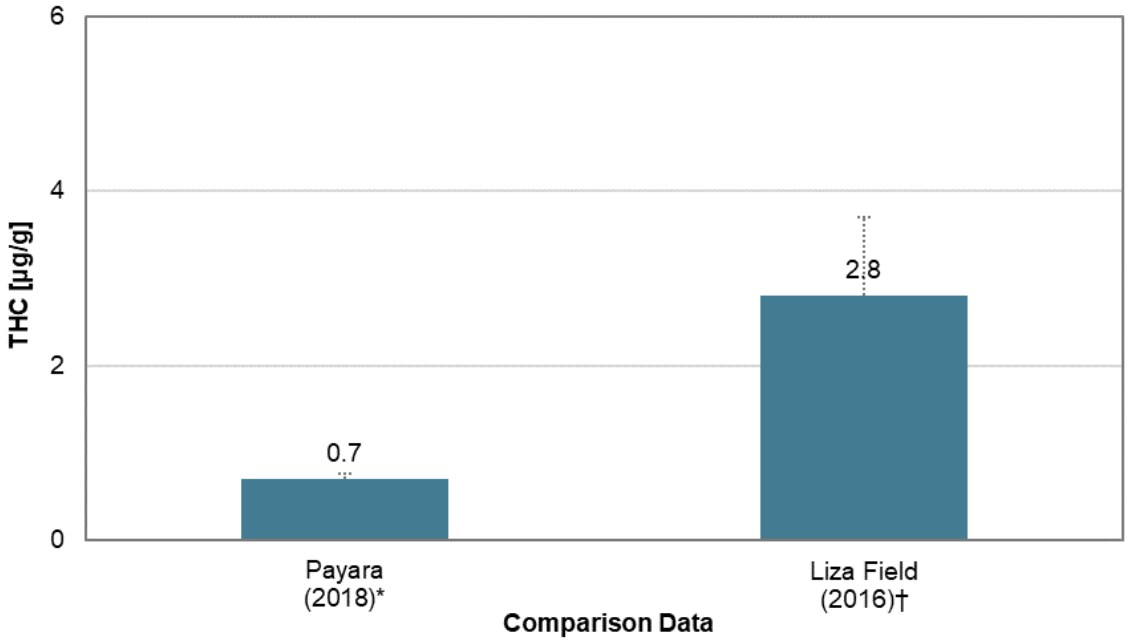
The gas chromatographic profiles in sediments collected within the survey area shared a common underlying hydrocarbon distribution. The chromatograms all contained a trace level homologous series of resolved n-alkanes from nC_{12} to nC_{36}. The profiles also contained a trace level unresolved 'hump' covering the nC_{19} to nC_{36} range. This feature is the UCM and is composed of a wide range of compounds, including cycloalkanes, which remain after substantial weathering and biodegradation of petrogenic hydrocarbons (Farrington et al., 1977). The presence of the UCM in the samples suggests some contribution to the sediments from petroleum hydrocarbon sources, which may be attributed to fossil fuel discharges from historic or current industrial activities in the marine environment (such as shipping or oil and gas development) or via terrestrial run-off. Evidence of terrestrial run off was observed through the slight prevalence of the n-alkanes nC_{29}, nC_{31} and nC_{33}, which as discussed previously are indicative of leaf cuticle waxes. The profiles observed at the Payara survey area indicate background sediments.

Total hydrocarbon content (THC) reported for the survey area displayed low variability (RSD 11 %) and all stations had concentrations lower than the mean recorded at the Liza field survey (mean 2.8 µg/g; Fugro, 2016; Figure 10.1). No spatial trends in THC were apparent with any variation between stations likely to be a result of natural small-scale heterogeneity in sediment characteristics and associated THC concentrations.

The ratio of odd to even carbon numbered normal alkanes is termed the carbon preference index (CPI) and has been calculated over various chain length ranges. Elevated ratios (i.e. those > 1.00) over the nC_{12} to nC_{36} carbon range are due to the domination of the odd-chain length n-alkanes (nC_{27} to nC_{33}) and are typically associated/observed with inputs from terrestrial run-off (leaf waxes, etc., discussed previously). The carbon preference index (CPI) for the nC_{12} to nC_{36} n-alkanes ranged from 2.02 to 2.40, with a mean value of 2.22, which was comparable to the mean of the Liza Field survey (2.22;

Fugro, 2016). Interstation variation was low (RSD 5 %). The CPI ratios of the Payara sediments highlight the influence of odd-chain length n-alkanes and biogenic material.

The isoprenoidal alkanes pristane (Pr) and phytane (Ph) were reported in low concentrations in each of the sediment samples analysed. These compounds are present in significant concentrations in crude oils (Berthou and Friocourt, 1981). They may also be biosynthesised (Gunkel and Gassmann, 1980) and pristane, a breakdown product of the phytol moiety of chlorophyll is widespread in the marine ecosystem, probably being derived from zooplankton. Phytane is generally absent or present in only relatively low levels in uncontaminated natural systems (Blumer and Snyder, 1965). The Pr/Ph ratios reported in the sediments ranged from 2.06 to 3.17 (mean 2.42; Table 5.1). These values would typically suggest that the higher proportion of the pristane present in the sediments was derived from non petrogenic sources.



Notes:
Error bars represent 95th percentile
THC = Total hydrocarbon content (expressed as µg/g dry sediment)
* = Mean of data collected from the Payara development survey area
† = Mean of data from the Liza field survey (Fugro, 2016)

Figure 10.1: Comparison of sediment total hydrocarbon content (THC) values with regional dataset, Payara development

10.3.2 Aromatic Hydrocarbons

PAHs and their alkyl homologues have been detected in a wide range of marine sediments (Laflamme and Hites, 1978; Neff, 1979; Youngblood and Blumer, 1975). These compounds consist of two or more fused benzene rings in linear, angular or cluster arrangements. Polycyclic aromatic hydrocarbons technically contain only carbon and hydrogen atoms. However, other atoms (e.g. nitrogen, sulphur and oxygen) may be readily substituted into the benzene ring to form heterocyclic compounds that are present in significant concentrations in petroleum and refined products.

Monitoring of aromatic hydrocarbon type and content is important due to the particularly toxic nature (mutagenic/carcinogenic) of several PAHs even at very low concentrations. The US EPA has identified 16 priority PAHs to be monitored (Keith, 2015) and the Coordinated Environmental Monitoring Programme (CEMP) specifies 9 PAHs of specific concern (OSPAR, 2014), which primarily reflect inputs from man-made combustion sources (further alkylated and parent compounds are normally studied because of the information they provide on PAH origin and fate). Many PAHs have long been recognised as universal environmental pollutants with the heavier molecular weight PAHs (mainly 4 to 6 ring PAH) generally being regarded as carcinogens and mutagens. Indeed, 11 of 40 PAHs ranging from 3 to 6 ring structures have been listed as being strongly carcinogenic or mutagenic with a further 10 listed as weakly carcinogenic or mutagenic (Edwards, 1983).

As previously stated, PAHs are widely spread in the environment (Butler et al., 1984) with natural sources occurring primarily through synthesis by plants (Sims and Overcash, 1983; Neff, 1979), related to natural seeps of petroleum (NRC, 1983; Kennicutt et al., 1988) and to formation during natural forest and prairie fires (Youngblood and Blumer, 1975; Wakeham et al., 1979). By far the greatest proportion of PAHs released into the environment are formed during fossil fuel combustion and man-made, forest and agricultural fires (Sims and Overcash, 1983; Edwards, 1983). Once released into the atmosphere PAHs may be carried long distances adsorbed to particulate material (e.g. soot and flyash; Windsor and Hites, 1979). Similarly, when deposited within the water environment PAHs may undergo further transport (e.g. by rivers or ocean currents) before final deposition in the sediments. Due to the low solubility and hydrophobic nature of PAHs, when deposited within the water column they tend to be adsorbed to suspended inorganic and organic particulate matter, which gradually settles out. Once deposited in the sediment PAHs are less susceptible to photochemical and biological degradation and may accumulate to relatively high concentrations.

Petroleum sources are rich in aromatic hydrocarbons, particularly 1 to 3 ring compounds (benzenes, naphthalenes and phenanthrenes); the levels of 4 to 6 ring compounds being relatively low. In addition, significant concentrations of organosulphur compounds (dibenzothiophenes) are normally present (Friocourt et al., 1982). The relative proportion of these compounds will vary between crude oils and refined petroleum.

The many possible origins of PAHs in marine sediments have been briefly discussed in this section. The source of the PAHs may be determined by investigation of the relative proportions of individual PAH concentrations (Neff, 1979; Garrigues et al., 1995; Budzinski et al., 1997) as well as examining the overall distributions of parent and alkylated PAHs present. Pyrogenically (or pyrolytic) derived PAHs signatures (i.e. forest fires, etc.) are dominated by higher molecular weight compounds (mainly 4 to 6 ring) and are predominantly unsubstituted. In contrast, PAH formed during the slow geological maturation of petroleum, are dominated by alkylated, low molecular weight (mainly 1 to 3 ring) compounds (Neff, 1979).

Most natural and anthropogenic contaminants have a higher affinity to fine particulate matter than coarse sediments, due to the increased adsorption capacity of organic matter and clay minerals. Natural sediment contaminant concentrations will be closely related to the distribution of fine grained material with the effects of other sources of contaminants, for example anthropogenic sources, at least partly

obscured by sediment characteristics (ICES, 2009; 2012). PAHs are lipophilic and bind strongly to organic matter in sediments (Davies, 2004).

The potential environmental effects of 2 to 6 ring PAH compounds present were assessed by comparisons with available comparable environmental data. The 2 to 6 ring PAH concentrations (individual and total) can be directly compared with the assigned ERL threshold (OSPAR, 2014) (Table 10.1 and Figure 10.2).

Table 10.1: Comparison of Polycyclic Aromatic Hydrocarbons (PAHs) with Regional and Reference Values, Payara Development

Parameter	Payara Development (2018) Mean	Liza Field (2016) Mean	NOAA ERL (Buchman, 2008)	NOAA ERM (Buchman, 2008)
Naphthalene	0.0002	0.001	**0.160**	**2.10**
C_1-naphthalene	< 0.001	0.001	-	-
C_2-naphthalene	< 0.001	0.002	-	-
Acenaphthylene	< 0.0001	0.0001	**0.044**	**0.640**
Acenaphthene	< 0.0001	0.0003	**0.016**	**0.500**
Fluorene	< 0.0001	0.0005	**0.019**	**0.540**
Phenanthrene	0.0002	0.003	**0.240**	**1.50**
C_1-phenanthrene	< 0.001	0.002	-	-
C_2-phenanthrene	< 0.001	0.003	-	-
Dibenzothiophene	< 0.001	0.001	-	-
C_1-dibenzothiophene	< 0.001	0.001	-	-
Anthracene	< 0.001	0.0006	**0.0853**	**1.10**
Fluoranthene	< 0.0001	0.0019	**0.600**	**5.10**
Pyrene	0.0001	0.0012	**0.665**	**2.60**
Benz(a)anthracene	< 0.0001	0.0006	**0.261**	**1.60**
Chrysene	0.0001	0.0009	**0.384**	**2.80**
Benzo(a)pyrene	< 0.0001	0.0004	**0.430**	**1.60**
Benzo(ghi)perylene	0.0001	0.0005	-	-
Indeno(1,2,3-cd)pyrene	0.0001	0.0004	-	-
Total Comparable 2 to 6 Ring PAH	**0.0018**	**0.048**	**4.022***	**44.792***

Notes:
ERL = Effects range low
ERM = Effects range median
Values expressed as µg/g dry sediment
* = Total 2 to 6 ring PAH concentration (Buchman, 2008)



Notes:
Log_{10} scale used to present data
Error bars represent 95th percentile
2 to 6 PAH = Total 2 to 6 ring PAH concentration (expressed as µg/g dry sediment)
* = Mean of data collected from the Payara development survey area
† = Mean of data collected from the Liza field survey area (Fugro, 2016)
ERL = Effects range low (Buchman, 2008)

Figure 10.2: Comparison of sediment 2 to 6 ring aromatic hydrocarbons concentrations with regional data set, Payara development

Total 2 to 6 ring PAH concentrations ranged from below the MRV of 0.002 µg/g to 0.007 µg/g, with a mean concentration of 0.004 µg/g (Table 5.2). The potential environmental effects of 2 to 6 ring PAH compounds present were assessed by comparisons with comparable environmental data. The 2 to 6 ring PAH concentrations (individual and total) can be compared with regional data from a neighbouring development (Tables 5.2 and 10.1; Fugro, 2016), along with the assigned NOAA ERL and ERM thresholds (Buchman, 2008) (Table 10.1 and Figure 10.2). For all the US EPA 16 compounds assessed, the mean concentrations reported within the Payara survey area were below the NOAA ERL and ERM threshold concentrations (Buchman, 2008). Consequently, it is unlikely that the PAH concentrations present in the Payara sediments would have a detrimental effect on the marine macrofaunal community.

Further information on the source(s) of PAH in the sediment may be obtained from a study of their alkyl homologue distributions (i.e. the degree of methyl, ethyl, substitution of the parent compounds). Pyrolytically derived PAHs are predominantly unalkylated whereas petrogenically derived PAH is formed at relatively low temperatures (< 150 °C) and contains mainly alkylated species. The distribution of parent 2 to 6 ring PAH compounds also reflects whether the source is petrogenic or pyrolytic. The concentration of PAHs was mostly below the MRV for the Payara sediments, so the origins of the PAHs cannot be assessed.

10.4 Sediment Metals

10.4.1 Heavy and Trace Metals

The analysis of samples for heavy metal content can provide further corroboration in conjunction with the physical characteristics and hydrocarbon content of marine sediments in assessing either the background levels or the dispersion of discharged material around offshore installations.

Metals and metalloids occur naturally in the marine environment and are widely distributed in both dissolved and sedimentary forms. Some are essential to marine life while others have no biological function and therefore are toxic to numerous organisms at certain levels (Paez-Osuna and Ruiz Fernandez, 1995; Boening, 1999). Metals can enter the environment via natural methods such as riverine transport, coastal discharges, geological weathering and atmospheric fallout (Brady et al., 2015). Other routes into marine sediments are from anthropogenic activities such as direct discharges from industrial activities.

Trace metal contaminants in the marine environment tend to form associations with the non-residual phases of mineral matter, such as iron and manganese oxides and hydroxides, metal sulphides, clays, organics and carbonates (Warren and Zimmerman, 1993; Dang et al., 2015; Wang et al., 2015). Non-residual trace metals are associated with more reactive and available sediment components through processes such as adsorption onto mineral surfaces and organic complexation. Metals associated with these more reactive phases are prone to various environmental interactions and transformations (physical, chemical and biological) potentially increasing their mobility and biological availability (Tessier et al., 1979; Warren and Zimmerman, 1993; Du Laing et al., 2009). Residual trace metals are defined as those which are part of the crystal structure of the component minerals and are generally unavailable to organisms (de Orte et al., 2018). Therefore, in monitoring trace metal contamination of the marine environment, it is important to distinguish the more mobile non-residual trace metals from the residual metals held tightly in the sediment lattice (Chester and Voutsinou, 1981), which are of comparatively lesser environmental significance because of their low reactivity and availability.

In this study, an analytical procedure involving the digestion of sediment in aqua regia was employed to analyse the elemental content of the sediments. The aqua regia digest releases for analysis the ‘non-residual’ heavy metals, which are not incorporated in the mineral matrix and are therefore potentially available for biological uptake.

The distribution of metals across the surveyed area indicated low to moderate variability (Table 6.1), with the exception of iron and arsenic which displayed high interstation variability (RSD 106 % and 227 %, respectively). The metals of biological interest were compared against their respective NOAA ERL and ERM values (Buchman, 2008). Arsenic concentrations exceeded the ERL value at two stations and the ERM value at one station. Nickel exceeded its ERL value at two stations. These metals could be, in part, introduced from contaminated terrestrial runoff from Guyana’s mining industry via the main riverine inputs to the Guyana basin (TDI Brooks, 2014). Arsenic is a known by-product of gold mining, which is a key industry in Guyana. Arsenic enriched sediments, possibly related to gold mining, were previously observed at the Liza field, with higher concentrations observed at the stations that were closest to land. Other potential sources of arsenic into the marine sediments are from geogenic sources, as arsenic is known to originate from arsenic bearing minerals such as arsenopyrite. The elevated

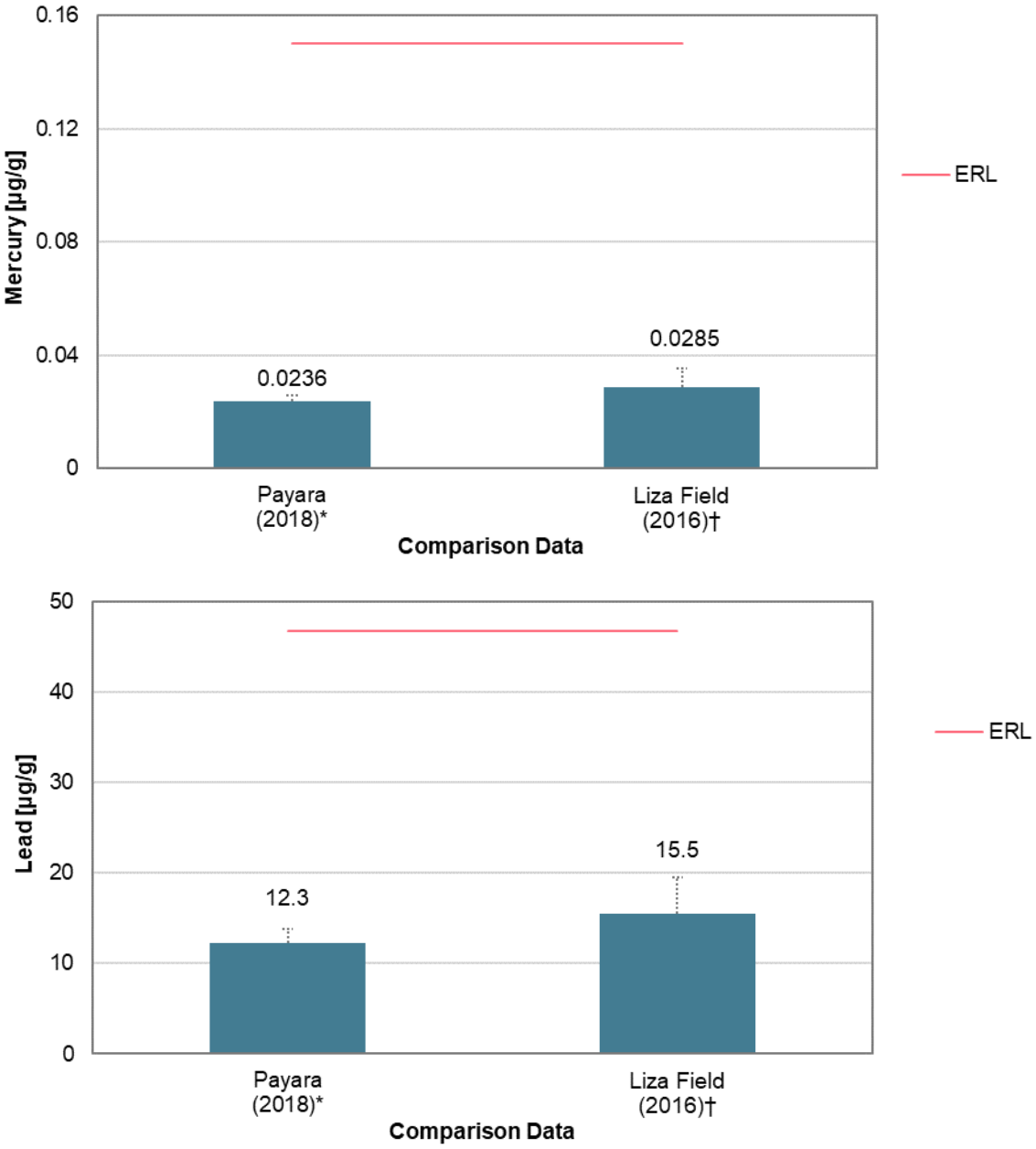
concentrations of arsenic in this survey coincide with higher concentrations of iron and such minerals can be transported to marine sediments from riverine discharges into the Atlantic.

If NOAA ERL and ERM values are exceeded, there is a higher probability that sediment quality will be impaired and impact the benthic community. However, no statistically significant correlations were observed between the metal concentrations and macrofaunal indices, suggesting that the concentrations of arsenic and nickel present in the Payara sediments are unlikely to influence sediment macrofauna. The stations with ERL and ERM exceedances also contained a higher proportion of fines, which are associated with increased concentrations of metals and no concurrent increase in toxicity. All other mean metal concentrations across the Payara sediments were below their ERL and ERM values (Table 10.2).

Table 10.2: Comparison of Sediment Metals Concentrations with Reference Values, Payara Development

Parameter	Payara Development (2018) Mean	NOAA ERL (Buchman, 2008)	NOAA ERM (Buchman, 2008)
Aqua Regia Digest			
Mercury	**0.0236**	**0.150**	**0.710**
Cadmium	**< 0.2**	**1.20**	**9.60**
Lead	**12.3**	**46.7**	**218**
Arsenic	**37.8**	**8.20**	**70.0**
Nickel	**20.0**	**20.9**	**51.6**
Chromium	**30.3**	**81.0**	**370**
Copper	**15.1**	**34.0**	**270**
Zinc	**60.5**	**150**	**410**

Notes:
ERL = Effects range low (Buchman, 2008)
ERM = Effects range medium (Buchman, 2008)
Values expressed as µg/g dry sediment



Notes:
Error bars represent 95th percentile
Concentrations expressed as µg/g dry sediment
ERL = Effects range low (Buchman, 2008)
* = Mean of data collected from the Payara development survey area
† = Mean of data collected from the Liza field survey area (Fugro, 2016)

Figure 10.3: Comparison of sediment mercury and lead concentrations (means) with regional datasets, Payara development

10.5 Water Samples

10.5.1 Water Profiles

At all eight water profiling stations, temperature, salinity and dissolved oxygen displayed a strong thermocline, halocline and oxygen boundary. Surface temperatures were reasonably similar between all stations and temperature decreased with water depth. Turbidity remained reasonably constant within

the water column for the entire length of all water profiles, this is likely because the survey area is located offshore in deepwater.

Salinity was generally lowest at the sea surface, likely to be influenced by precipitation and freshwater input from the Essequibo River in Guyana. The North Atlantic deepwater influences the water columns below 1000 m and is characterised as has having salinity of ca. 35 % and a temperature of ca 2 ºC (Tomczak and Godfrey, 2003). Similar properties are observed in all the water profiles below 1000 m in the Payara survey area.

The oxygen content of natural waters varies with temperature, salinity, turbulence, the photosynthetic activity of algae and plants, and atmospheric pressure. Biological respiration, including that related to decomposition processes, reduces dissolved oxygen concentrations. The solubility of oxygen decreases as temperature increases. Dissolved oxygen decreases with an increase in salinity. Dissolved oxygen saturation ranged from 33.2 % near the seabed to 106 % near the surface, demonstrating that surface waters within the survey area were at near oxygen saturation, at the time of survey, with no indication of oxygen depletion.

At all water sampling stations, the pH decreased slowly with increasing depth and all profiles were very similar between stations. The US EPA quote a normal range for seawater as pH 6.5 to 8.5 (US EPA, 2018) and the majority of seawater pH values for the current survey conform to this range.

10.5.2 Total Suspended Solids (TSS) and Total Organic Carbon (TOC) Content

Total suspended solids are important indicators of water quality and can be indicative of sediment transport and discharge from drilling activities. No evidence of stratification was present for the Payara water column samples, suggesting a well-mixed distribution of TSS throughout the water column. TSS values were noted to be considerably higher than the water column data from the Liza field survey (Fugro, 2016). There are large seasonal variations in suspended particulate matter and the current survey was conducted after the rainy season, potentially accounting for the higher suspended solids content due to increased riverine discharges from the Amazon River (Martinez, et al. 1999). TSS content in the Payara water column is likely to originate from the northward movement of suspended material from the Amazon River and other major rivers that discharge into the Atlantic (Pujos and Froidefond, 1995).

TOC consists of both dissolved and particulate organic carbon and can be an approximate indicator of productivity in marine waters where anthropogenic inputs are not present. TOC concentrations were below the MRV for all stations in the Payara development area and lower than concentrations recorded at the Liza field development. As concentrations at both sites are reported to be low, it is likely that they are representative of background concentrations.

10.5.3 Hydrocarbons

Hydrocarbon content can be used as an indicator of petrogenic inputs into water columns. This is because soluble fractions of hydrocarbons can partition between dissolved and particulate bound phases in the water column (Latimer and Zheng, 2003; Thibodeaux et al., 2011). Total hydrocarbon concentrations and polycyclic aromatic hydrocarbon (PAH) concentrations in seawater samples were generally considered to be at low levels across the Payara survey area and therefore considered to be

representative of background concentrations. The CPI ratios for suggest a domination of the odd-chain length n-alkanes, indicative of terrestrial inputs of leaf cuticular waxes. The majority of concentrations were lower than those recorded for the Liza field development (Fugro, 2016). No patterns were observed between hydrocarbon concentrations and depth in the Payara water samples.

10.5.4 Metals

Heavy and trace metal concentrations were low in most water samples, being close to or below their respective detection limits in the majority of samples across the Payara Development area. US EPA CCC values (US EPA, 2018) were exceeded for mercury at one station and zinc at three stations. US EPA CMC values (US EPA, 2018) were exceeded by zinc at three stations. Corresponding depth samples for the stations that exceeded CMC and CCC values were below the MRV, except for station EBSWS6 as both surface and mid depth samples exceeded both CCC and CMC values for Zinc. No patterns were observed between metals concentrations and depth in the Payara water samples.

The concentrations chromium at one station (EBSWS4 (Mid)) was considerably higher than the remaining stations, which were all below the MRV. The chromium concentrations at the corresponding bottom and surface samples at station EBSWS4 were below the MRV.

10.6 Seabed Habitats

Analysis of the photographic data identified one biotope complex present within the Payara survey area, 'Western Atlantic abyssal benthic communities' (11.2122) (Institute of Terrestrial Ecology, 1996), the EUNIS (2012) biotope 'Deep-sea muddy sand' (A6.4) was also assigned in order to offer further description. This broadly agrees with the PSD results which described the sediments from the Payara survey area as coarse silt at all stations, with the exception stations EBSBC7 and EBSBC8, which were described as medium silt and very fine sand, respectively. Overall biota was scarce, however one of the most abundant epifauna were sea cucumbers (*Benthodytes* sp.), with aggregations observed at stations EBSDDV1 and EBSDDV8. These sea cucumbers are a deep-sea holothurian known to be occur in abyssal ecosystems (Bisol et al., 1984). Xenophyophores (Xenophyophoroidea) were also one of the most common biota observed, which are known to be a major component of deep-sea communities in all oceans, particularly abyssal plains (Amon et al., 2016) and play a crucial role in deep-sea ecosystems (Gooday et al., 2017).

Areas where hard substrate was present an increase in the diversity of the fauna was observed, with sponges (Porifera, including *Polymastia* sp.), starfish (Asteroidea, including Brisingidae), bryozoans (Bryozoa) and an increased abundance of anemones (Actiniaria) and brittlestars (Ophiuroidea).

10.7 Macrofaunal Communities

Seabed sediments provide support, protection and the food source for many macrofaunal species. The sediment macrofauna, most of which are infaunal (living within the sediment), are therefore particularly vulnerable to external influences which alter the sediments' physical, chemical or biological nature. Such infaunal animals are largely sedentary and are thus unable to avoid unfavourable conditions. Each species has its own response and degree of sensitivity to changes in the physical and/or chemical environment and consequently the species composition and their relative abundance in a particular location provides a reflection of the health and condition of the immediate environment, both current and historical. The recognition that aquatic contaminant inputs may alter sediment characteristics, together

with the relative ease of obtaining quantitative samples from specific locations, has led to the widespread use of infaunal communities in monitoring the impact of disturbances to the marine environment over a long period of time.

The faunal community within the survey area was found to be relatively diverse and non-dominated with a large number of taxa occurring in relatively low abundances. Moderate to high variability was demonstrated across the survey area with polychaete worms and arthropods the most numerous taxa recorded.

Limited information exists on the deep-sea macrofaunal communities in offshore Guyana however a similar community was recorded at the Liza field in 2016 (Table 9.1; Fugro, 2016).

Overall, the macrofaunal community was moderate in diversity across the survey area (Dauvin et al., 2012), with low variability observed for both Shannon-Weiner and Brillouin's diversity indices (RSD 21 % and 26 %, respectively), again similar to that recorded at the Liza field in 2016.

All of the most abundant taxa recorded have been previously reported in the wider south Atlantic region. One arthropod individual recorded at station EBSBC8 and classified as *Aspidoniscus* sp. A, as well as three arthropod individuals recorded at stations EBSBC3 and EBSBC7 classified as *Heteromesus*, are considered as likely to be new records of these species. Only one species (arthropod *Aspidoniscus perplexus*) has been identified within the genus of *Aspidoniscus* and the one recorded in the current survey did not match with this description. *A. perplexus* has been recorded in the northern margin of the Colombian basin in the Caribbean Sea, in depths of approximately 3100 m (WoRMS, 2016). Three arthropod individuals classified as *Heteromesus* were also noted to be different to other species identified globally within the genus.

Multivariate analysis demonstrated that there were differences between the stations sampled across the survey area, however not statistically significant. Although differing macrofaunal communities appeared within the survey area (low to moderate similarity between intrastations), it is likely that the macrofauna comprised one broad community with some small-scale variation across the site.

No meaningful correlations were observed between the macrofaunal community and the physicochemical parameters sampled across the Payara Development survey area.

11. CONCLUSIONS

The aim of this report has been to evaluate the existing physical/chemical components in the marine environment within the survey area. A review of the environmental data in context with other cited studies from the region and estimated sediment and water effects threshold values (Buchman 2008; US EPA, 2018) was also undertaken. Environmental samples, along with video and stills photography were successfully collected at all eight proposed locations. This allowed potential water column and sediment conditions likely to be encountered during development to be established. Based on the overall assessment of the survey area, the following key conclusions can be stated:

The sediments across the Payara survey area were all classed as very poorly sorted and had a sediment composition consisting of mainly sand and fines content. Using the Wentworth (1922) sediment description, six stations were classified as ‘coarse silt’, with the remaining two being classified as ‘medium silt’ and ‘very fine sand’. TOC concentration displayed low variation across the survey area and values were low (≤ 0.36 %).

The gas chromatographic profiles obtained from sediments collected from within the Payara survey area were typical of background sediments, displaying weathered low-level petroleum and biogenic hydrocarbons and associated UCM, commonly found in marine sediments. The total 2 to 6 ring PAH concentrations were low across the survey area with the United States Environmental Protection Agency’s 16 priority PAH pollutants (US EPA 16 PAH) below their respective ERL values at all stations.

Metal concentrations in the Payara sediments exhibited low to high variability (RSD ≤ 227 %) and were all below their respective ERL values at all stations, with the exception of arsenic and nickel. Nickel concentrations exceeded the ERL value at two stations. The arsenic ERL value was exceeded at two stations and the ERM value at one station. There is an increased risk of negative effects on the benthic community when sediment metal concentrations exceed ERL and ERM values; however, the exceedances occurred in sediments which had a higher proportion of fines, which are associated with increased metals concentrations but no concurrent increase in toxicity.

Water profiles showed a stratified water column, with a defined thermocline, halocline and oxygen boundary down to ca. 400 m, after which values remained relatively constant. Turbidity remained constant throughout the profile.

The TOC content for the water samples was below the MRV for all stations. TSS values across the Payara water samples showed no evidence of stratification as the mean TSS values for each depth profiles were comparable.

Water sample THC concentrations across the survey were low and below the MRV for all stations with the exception of station EBSWS4 (Bottom). There were no clear spatial trends in concentrations of UCM or n-alkanes across the survey area and no clear relationship between concentrations of these analytes and depth. Total 2 to 6 ring PAH concentrations displayed moderate variability (RSD 33 %) between samples. Total US EPA 16 PAH concentrations and NPD (total and percentage) all displayed low variability (RSD < 19 %). All US EPA 16 PAH values were below their respective ERL value where available.

The metals content of the water samples was generally low across the Payara survey area, with the majority of analyte concentrations below their respective MRV. CCC values were exceeded by mercury at one station. Zinc exceeded both CCC and CMC values at three stations. No spatial or depth patterns were observed for the metals concentrations in the water samples at the Payara survey area.

Analysis of the photographic data identified one biotope complex present within the Payara survey area, 'Western Atlantic abyssal benthic communities' (11.2122) (Institute of Terrestrial Ecology, 1996), the EUNIS (2012) biotope 'Deep-sea muddy sand' (A6.4) was also assigned in order to offer further description. No potentially sensitive habitats or species were identified in the current survey.

The faunal community within the survey area was found to be relatively diverse and non-dominated with a large number of taxa occurring in relatively low abundances. Polychaete worms and arthropods were the most numerous taxa recorded, similar to the community recorded at the Liza field in 2016.

All of the most abundant taxa recorded have been previously reported in the wider south Atlantic region. However, one arthropod individual classified as *Aspidoniscus* sp. A and three arthropod individuals classified as *Heteromesus* are considered as likely to be new records of these species.

Univariate analysis demonstrated that macrofaunal diversity was moderate. Multivariate analysis demonstrated moderate to high variability across the survey area. However, the overall dissimilarities observed within the macrofaunal community are likely to be influenced, in part, by the low number of individuals observed.

No meaningful correlations were observed between the macrofaunal community and the rest of the physico-chemical parameters sampled across the Payara Development survey area.

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APPENDICES

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H. MACROFAUNAL ANALYSIS

I. CORRELATIONS - SEDIMENTS

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A. GUIDELINES ON USE OF REPORT

This report (the "Report") was prepared as part of the services (the "Services") provided by Fugro GB Marine Limited ("Fugro") for its client (the "Client") under terms of the relevant contract between the two parties (the "Contract"). The Services were performed by Fugro based on requirements of the Client set out in the Contract or otherwise made known by the Client to Fugro at the time.

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B. METHODOLOGIES

B.1 LABORATORY ANALYSIS -SEDIMENTS

B.1.1 Particle Size Analysis

Particle size analysis was conducted by Fugro GB Marine Limited.

B.1.1.1 Dry Sieve Analysis

Particle size distribution analysis was undertaken in accordance with FGBML in-house methods based on the National Marine Biological Association Quality Control scheme's (NMBAQC) best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis, and BS1377: Parts 1: 2016 and 2: 1990.

Representative material > 1 mm was split from the bulk subsample and oven dried before sieving through a series of sieves with apertures corresponding to 0.5 phi intervals between 63 mm and 1 mm as described by the Wentworth scale (Wentworth, 1922). The weight of the sediment fraction retained on each mesh was subsequently measured and recorded.

B.1.1.2 Laser Diffraction

Particle size distribution analysis was undertaken in accordance with FGBML in-house methods based on the National Marine Biological Associations Quality Control scheme's (NMBAQC) best practice guidance document – Particle Size Analysis (PSA) for Supporting Biological Analysis, and BS ISO 13320: 2009.

Representative material < 1 mm was removed from the bulk subsample for laser analysis, a minimum of three triplicate analyses (mixed samples) or one triplicate analyses (sands) were analysed using the laser sizer at 0.5 phi intervals between < 1 mm to < 3.9 µm. Laser diffraction was carried out using a Malvern Mastersizer 2000 with a Hydro 2000G dispersion unit.

B.1.2 Total Organic Carbon

Sediment samples were analysed for total organic carbon (TOC) by Exova Jones Environmental.

The dry, homogenised sample was treated with hydrochloric acid, then rinsed with deionised water to remove mineral carbon. The sample was then combusted in an Eltra TOC furnace/analyser in the presence of oxygen. Organic carbon was oxidised to CO_2 and measured by non-dispersive infrared analysis. This method does not quantify volatile organic carbon, which should be determined by another technique. The minimum reporting value (MRV) for this method was < 0.02 % w/w.

B.1.3 Hydrocarbon Analysis in Sediments

Hydrocarbon analysis of sediments was carried out by Fugro GB Marine Limited.

B.1.3.1 General Precautions

To effectively eliminate all possible sources of hydrocarbon contamination from the analysis the following precautionary measures were taken prior to sample work-up:

- All solvents were purchased as high purity grade. Each batch was checked for purity by concentrating approximately 400 mL down to a small volume (< 1 mL) and analysing by gas chromatography (GC);
- All water used was distilled through an all glass still and dichloromethane extracted to minimise contamination from plasticisers;
- All glassware was cleaned using an acid/base machine wash. The glassware was rinsed with acetone then finally with dichloromethane prior to use;
- Procedural blanks, replicate analyses and laboratory reference material were run with each batch.

B.1.3.2 Ultrasonication Extraction for Hydrocarbons in Sediment

Sediment samples were thawed, homogenised and accurately weighed into a 250 mL conical flask. A solution containing an appropriate amount of the following internal standards was added to each sample using a microsyringe.

Aliphatic Standards	Aromatic Standards
Heptamethylnonane	d_8 naphthalene
D_{34} Hexadecane	d_{10} acenaphthene
D_{42} Eicosane	d_{10} phenanthrene
Squalane	d_{10} pyrene
	d_{12} chrysene
	d_{12} perylene

Methanol (50 mL) and solvent were mixed with the sediment. Dichloromethane (DCM) (60 mL) was then added and the sample mixed again. The flasks were then capped with solvent cleaned aluminium foil and ultrasonicated for 30 minutes.

After being allowed to settle the solvent was decanted through a GF-C filter paper into a 1 litre separating funnel. The extract was then partitioned with 100 mL of DCM extracted distilled water and the DCM layer run-off into a clean 500 mL round-bottomed flask. The ultrasonic extraction was repeated a further two times using 50 mL DCM and 15 minutes of ultrasonication. Each time the filtered extract was partitioned with the remaining methanol/water in the separating funnel. The DCM extracts were bulked and reduced in volume to approximately 2 mL using a rotary evaporator, then further reduced to approximately 1 mL under a gentle stream of nitrogen prior to clean-up.

Correction factors for wet/dry sediments were obtained by drying a subsample of the homogenised sediment to constant weight at 105 °C.

B.1.3.3 Clean-up of Extracts by Column Chromatography

Removal of polar material, including lipids was carried out using a silica gel column. The silica gel used was 70 to 230 mesh which was heated at 400 °C for at least 4 hours to remove impurities and residual moisture and then stored at 200 °C prior to use. The sample extract was added to the silica gel column, containing 5 g of adsorbent and eluted with 35 mL of DCM/pentane (1:2). The eluant was reduced in volume using the evaporator to approximately 2 mL, with activated copper powder (for removal of free

sulphur), before being further reduced under a gentle stream of nitrogen to an appropriate volume and analysed by both gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS).

	Gas Chromatography [GC]	Gas Chromatography-Mass Spectrometry [GC-MS]
Instrument	HP 6890 Series GC with 7673 autoinjector	HP 7890 Series GC with autoinjector and 5977A MSD
Column	100 %-dimethylpolysiloxane bonded fused silica, 60 m, 0.25 µm film thickness, 0.32 mm internal diameter	(5 %phenyl)-methylpolysiloxane bonded fused silica, 60 m, 0.32 µm film thickness 0.25 mm internal diameter
Carrier Gas	Hydrogen (constant flow 3.5 mL /min)	Hydrogen (constant flow 1.4 mL/min)
Injector	On–column (2 µl injection)	Splitless, 280 °C, split flow 40 mL/min, vent time 1.5 min (1 µl injection)
Oven Temperature Programme	80 °C – 2 min 80 °C to 320 °C at 18 °C/min 320 °C – 13 min 320 °C to 350 °C at 30 °C/min	60 °C – 1 min 60 °C to 180 °C at 11 °C/min 180 °C to 260 °C at 6 °C/min 260 °C to 320 °C at 6 °C/min 330 °C – 7 min
Source/Detector Temperature	350 °C (FID)	230 °C
Electron Energy	-	70 eV
Selected Ion Monitoring (SIM)	-	9 groups - 6 ions per group
Dwell Time (per ion)	-	0.035 second

B.1.3.4 Total Hydrocarbons by Gas Chromatography–Flame Ionisation Detection (GC-FID)

The total hydrocarbon material present was quantified using response factors calculated from the analysis of mixed oil standard solutions over an appropriate range. The unresolved complex mixture (UCM) was determined by subtracting the area of all the resolved peaks from the total hydrocarbon area and applying the total hydrocarbon response factor.

B.1.3.5 n-Alkanes, Pristane and Phytane

Calibration was undertaken using a range of n-alkane standard solutions containing the even carbon number compounds between nC_{12} and nC_{36}, and a range of suitable internal standards. Individual response factors were calculated for each of the n-alkanes present in the calibration solution. Response factors for the non-calibrated n-alkanes (and pristane and phytane) were taken to be equivalent to closely eluting compounds.

The n-alkanes between nC_{12} and nC_{36} were reported, as were the ranges between nC_{12} and nC_{20} and nC_{21} to nC_{36}. Carbon preference index (CPI) values (the ratio of odd to even carbon numbered compounds) for the same ranges were also calculated. Pristane and phytane (and associated ratio) were also determined.

B.1.3.6 Polycyclic Aromatic Hydrocarbons (PAHs)

A full range of polycyclic aromatic hydrocarbons (PAHs) and alkylated PAH were quantified as specified by Department of Trade and Industry (DTI) regulations (DTI, 1993).

Calibration was undertaken using a range of PAH standard solutions, a number of alkylated PAH, dibenzothiophene and a range of suitable internal standards. Individual response factors were

calculated for each of the compounds present in the calibration solution. Response factors for the non-calibrated alkylated PAH were taken to be equivalent to closely related compounds. The MRV of individual PAHs is 0.1 ng/g and 1 ng/g dry weight for alkylated PAHs.

B.1.4 Heavy and Trace Metals in Sediments

Analysis of sediment metals content was conducted by the National Laboratory Service.

Sediment samples were air dried at 30 °C and then sieved to the required size fraction (2000 µm). Samples were subjected to an aqua regia microwave digestion, with the exception of selenium which underwent an aqua regia block digest under reflux. This acid mixture allows a partial dissolution of metals from most soil and sediment types which allows the bioavailable metals content to be analysed. Arsenic, cadmium, chromium, copper, lead, nickel and zinc were analysed by inductively coupled plasma-mass spectrometry (ICP-MS). Aluminium, barium, iron and selenium were analysed by inductively coupled plasma-optical emission spectrometry (ICP-OES).

Mercury content was determined by sieving the sample to < 2000 µm followed by a microwave assisted aqua regia digest, acidic stannous chloride reduction and determination by cold vapour-atomic fluorescence spectroscopy (CV-AFS).

B.1.5 Macrofaunal Analysis

Macrofauna analysis was carried out by Fugro GB Marine Limited benthic laboratories which are members of the National Marine Biological Analytical Quality Control Scheme (NMBAQC) scheme of external quality assurance.

On return to the laboratory, the samples were removed from formalin and washed through 0.5 mm mesh sieves. The material retained was then processed to remove fauna. The animals were separated by hand from the retained sediment by using a combination of stereo microscopes for the fine sediments and in white trays for any coarser material. Processed sediment is stored in phenoxetol (2 %) or returned to the original formalin.

Following extraction, the animals were identified and enumerated by specialist taxonomists. Identification was to species level where possible. Specimens which, due to their immaturity, damage incurred during processing or lack of suitable taxonomic literature, cannot be identified to species level are identified at higher taxonomic levels as appropriate. After identification, samples were stored in 70 % industrial denatured alcohol (IDA) or a mixture of 70 % ethanol/1 % propylene glycol/29 % water. A minimum of 10 % of samples within the project were re-analysed (for extraction, species identification, enumeration and data entry) as per NMBAQC quality control guidelines (Worsfold, 2010). For biomass, identified macrofauna were blot dried and weighed at species/phyla level then returned to storage container.

Species abundances were entered on file in a spreadsheet package or the Unicorn database, both of which store and sort entries into taxonomic order and provide output files for numerical analysis. Nomenclature follows that given on the World Register of Marine Species (http://www.marinespecies.org/). The taxonomic order is based on Species Directory codes (Howson and Picton, 1997) to give an idea of ‘evolutionary rank’. Once all the entries had been checked, the

resulting quantitative data were subjected to various statistical techniques to investigate community structure. All quantitative analyses were performed on species abundances pooled from the two replicates at each station, thus the sample size was 0.2 m^2 at all stations.

Prior to statistical analysis, the macrofaunal abundance data was manipulated to avoid spurious enhancement of community statistics. This involved the removal of all epibenthic taxa (e.g. Ostracods) and juvenile specimens, as they are not considered to be a permanent part of the community. Some indeterminate species were also rationalised at a higher taxonomic level with another taxon in the same genus to maintain these data in the dataset (e.g. *Echinocardium cordatum* with *Echinocardium* (dam.) and *Callianassa subterranea* with *Callianassidae* (dam.).

B.1.6 Sampling and Analysis Requirements – Sediments

Analyte	Volume per Sample [g]	Sample Container	Fixative/Storage	Analysing Laboratory	Method Code	Method Description	Accreditation	LOD	Holding Time
Al	200	Ziplock bags (double bagged)	Freeze	NLS	IHM 1043	ICP-OES	UKAS	20 µg/g	30 days
As					IHM 1041	ICP-MS		1 µg/g	
Ba					IHM 1043	ICP-OES		0.4 µg/g	
Cd					IHM 1041	ICP-MS		0.2 µg/g	
Cr					IHM 1041	ICP-MS	UKAS	2 µg/g	30 days
Cu					IHM 1041	ICP-MS		1 µg/g	
Fe					IHM 1043	ICP-OES		20 µg/g	
Ni					IHM 1041	ICP-MS		1 µg/g	
Pb					IHM 1041	ICP-MS		2 µg/g	
Zn					IHM 1041	ICP-MS		2.5 µg/g	
Se					IHM 914	ICP-OES		1 µg/g	
Hg					IHM 1042	CV-AFS	UKAS	0.01 µg/g	30 days
TOC	10	Ziplock bags	Freeze	Exova Jones	TM21/PM24	Combustion with NDIR	UKAS	0.02 %	30 days
PSD	200	Ziplock bags (double bagged)	Freeze	Fugro	BS1377: 1990 Parts 1-3/ BS13320:2009	Dry sieving/ laser diffraction	UKAS	0.01 %	5 years
THC	200	Amber glass	Freeze	Fugro	IHM	GC-FID	-	0.5 µg/g	181 days
n-Alkanes					IHM	GC-FID	-	0.5 ng/g	
PAH (EPA 16/alkylated)					IHM	GC-MS	-	0.1/1 ng/g	
Benthic macrofauna (0.5 mm)	Variable	1 L/5 L bucket	Formalin, ambient	Fugro	IHM	Microscopy	UKAS	NA	Indefinite

Notes:

Al = Aluminium; As = Arsenic; Ba = Barium; Cd = Cadmium; Cr = Chromium; Cu = Copper
Fe = Iron; Hg = Mercury; Ni = Nickel; Pb = Lead; Se = Selenium; Zn = Zinc
TOC = Total organic carbon; PSD = Particle size distribution
THC = Total hydrocarbon content; IHM = In house method
PAH = Polycyclic aromatic hydrocarbons; NA = Not applicable
GC-FID = Gas chromatography–flame ionisation detection; GC-MS = Gas chromatography-mass spectrometry
ICP-OES = Inductively coupled plasma-optical emission spectroscopy; ICP-MS = Inductively coupled plasma-mass spectrometry
CV-AFS = Cold vapour-atomic fluorescence spectroscopy; UKAS = United Kingdom Accreditation Service

B.2 LABORATORY ANALYSIS - WATERS

B.2.1 Total Suspended Solids (TSS)

Analysis of water samples for TSS content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 2540 D. Samples were filtered through a glass-fibre filter, which was then dried to a constant weight at 103 ºC to 105 ºC. The increase in the weight of the filter is representative of the TSS content of the water samples.

B.2.2 Total Organic Carbon (TOC)

Analysis of water samples for TOC content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 5310 C. Organic carbon is oxidised to CO_2 by persulfate in the presence of heat or ultraviolet light and the CO_2 is measured.

B.2.3 Hydrocarbon Analysis

Analysis of water samples for hydrocarbon content was conducted by Fugro GB Marine Limited using the methods described in Section B1.3, although the following procedure was used in place of B.1.3.2:

B.2.3.1 Liquid-liquid Extraction Procedure

Water samples were thawed, weighed and poured into a 1 litre separating funnel. The empty sample bottle was then weighed. A solution containing an appropriate amount of the following internal standards was added to each sample using a microsyringe.

Aliphatic Standards	Aromatic Standards
Heptamethylnonane	d_8 naphthalene
D_{34} Hexadecane	d_{10} acenaphthene
D_{42} Eicosane	d_{10} phenanthrene
Squalane	d_{10} pyrene
	d_{12} chrysene
	d_{12} perylene

Approximately 50 mL of DCM was used to rinse the sample bottle and this was then poured into the separating funnel containing the sample and internal standard. The separating funnel was shaken thoroughly for approximately 30 seconds and the DCM layer run-off through a 100 mm diameter filter funnel containing a GF-C filter paper approximately half-filed with granular sodium sulphate into a clean 500 mL round-bottomed flask. This was repeated a further two times. The sodium sulphate in the filter funnel was then rinsed three times with approximately 30 mL of DCM.

The contents of the round-bottomed flask were then reduced in volume to approximately 2 mL using a rotary evaporator. The extract was transferred quantitatively into an 8 mL screw top vial, evaporated to approximately 1 mL under a gentle stream of nitrogen and approximately 2 mL of pentane was added to the vials. The clean-up and analysis procedures were then followed as for the sediment samples.

B.2.4 Metals

Analysis of water samples for metals content was conducted by Kaizen LAB, Trinidad in accordance with standard method SMEWW 3030 F, SMEWW 3120 B. Samples were digested on a hot plate with the addition of concentrated nitric acid, then hydrochloric acid and water were added, and the sample was heated prior to adjusting the volume to 100 mL and analysing by ICP-OES.

B.2.5 Sampling and Analysis Requirements – Waters

Analyte	Volume per Sample [mL]	Sample Container	Fixative/Storage	Analysing Lab	Method Code	Method Description	Accreditation	MRV	Holding Time
Al	500	Plastic bottle	Nitric acid, refrigerate	Kaizen LAB	SMEWW 3030 F, 3120 B	ICP-OES	TT labs	80 µg/L	6 months
As								4 µg/L	
Ba								10 µg/L	
Cd								0.6 µg/L	
Cr								10 µg/L	
Cu								12 µg/L	
Fe								80 µg/L	
Ni								4 µg/L	
Pb								1.4 µg/L	
Se								6 µg/L	
Zn								100 µg/L	
Hg								0.01 µg/L	30 days
TOC	2 × 40	Glass vials	Dihydrogen phosphate, refrigerate	Kaizen LAB	SMEWW 5310 C	Persulfate Ultraviolet/ Heated Persulfate Oxidation Method	TT labs	0.5 mg/L	7 days
TSS	1000	Plastic bottle	Refrigerate	Kaizen LAB	SMEWW 2540 D	Filtration, Gravimetry (dried at 103 ˚C to 105 ˚C)	TT labs	3.75 mg/L	7 days
THC	1000	Amber Glass	Freeze	Fugro	IHM	GC-FID	-	10 µg/L	152 days
n-Alkanes					IHM	GC-FID	-	0.1 ng/L	
PAH (EPA 16/alkylated)					IHM	GC-MS	-	0.1/1 ng/L	
Spare	1000	Plastic bottle	Freeze	Fugro (spare)	NA	NA	NA	NA	NA

Notes:

Al = Aluminium; As = Arsenic; Ba = Barium; Cd = Cadmium; Cr = Chromium; Cu = Copper
Fe = Iron; Hg = Mercury; Ni = Nickel; Pb = Lead; Se = Selenium; Zn = Zinc
TOC = Total organic carbon; THC = Total hydrocarbon content
IHM = In house method; PAH = Polycyclic aromatic hydrocarbon
NA = Not applicable; GC-FID = Gas chromatography–flame ionisation detection
GC-MS = Gas chromatography-mass spectrometry; ICP-OES = Inductively coupled plasma-optical emission spectroscopy

B.3 STATISTICAL ANALYSIS

B.3.1 Correlations

Depth, crude granulometric data, chemical data and univariate indices of community structure were correlated using Spearman's Rank Correlation Coefficient. This is calculated as follows:

$$\rho = \frac{\sum(x - \overline{x})\,(y - \overline{y})}{\sqrt{\sum(x - \overline{x})^2 \sum(y - \overline{y})^2}}$$

Where x and y are ranked vales for each variable.

The resultant test statistic (ρ) will range from -1 to 1, with -1 indicating a very strong negative correlation, 0 no correlation and 1 a very strong positive correlation. Significance levels were assigned from tabulated values for a two-tail test at 5 % and 1 % based on Fowler et al. (2013).

B.3.2 Univariate and Multivariate Analysis of Macrofauna Data

B.3.2.1 Primary Variables and Diversity Indices

A range of primary variables and derived indices were calculated that attempt to quantify the species richness, evenness and a combination of both. The primary variables (number of individuals and species) and diversity indices (Shannon-Wiener diversity, Brillouin's diversity, Simpson's diversity and Pielou's evenness) were calculated for both the samples and the pooled replicates for each station using the PRIMER v6 DIVERSE procedure.

Shannon Wiener Index (H' or more specifically H'Log$_2$)

The Shannon-Wiener index (or Shannon-Wiener information function) is essentially a measure of how difficult it would be to predict correctly the species of the next individual collected from the community under study. It is a measure of uncertainty and was originally developed to assess the information content of codes. Information content is a measure of uncertainty, so that the larger the value of the index, the greater the uncertainty. It is usually expressed as:

$$= -\sum_i P_i \, \mathrm{Log}(P_i)$$

Where pi is the proportion of the ith species. For practical application, the formula can be expanded to:

$$H_s = C\left(\log_{10} N - \frac{1}{N}\sum n_i \log_{10} n_i\right)$$

Where N = total number of individuals
ni = number of individuals of ith species
C = conversion factor $\log_{10} - \log_2$.

Two components of diversity are combined in the Shannon-Wiener index. These are species richness (i.e. numbers of species) and the equitability or evenness of distribution of individuals among the species. A greater number of species increases the index value as does more even distribution of

individuals amongst species. Theoretically, the Shannon-Wiener index should only be used on random samples drawn from a large community in which the total number of species is known. This is, of course, not usually possible and so the use of the index is always a compromise.

Simpsons (1-λ)

Simpson's index of diversity is derived from probability theory. It is simply a measure of the probability of picking two individuals from a community at random that are different species. The index is calculated from:

$$D = 1 - \sum_{i=1}^{s} (p_i)^2$$

Where pi is the proportion of the ith species. An expanded and more practicable formula is:

$$D = 1 - \sum \frac{n_i(n_i - 1)}{N(N - 1)}$$

Where ni = number of individuals of ith species
N = total number of individuals.

Simpson's index assigns relatively little weight to rare species, and more weight to the common ones. It ranges in value from 0 (low diversity) to a maximum of (1 to 1/s) where s = the number of species.

Brillouin's Index (Hb)

This index, like that of Shannon-Wiener, is concerned with information content. However, unlike the Shannon-Wiener index, which provides an estimate of the community diversity, Brillouin's index provides the actual diversity of the fully censused sample. It is not a statistical estimate but an actual measurement of the diversity of the sample unit. The formula, displayed below, contains factorials that can involve very large numbers in computation. In the past, this has been a serious drawback to the use of the index by practical ecologists. This is no longer the case with the advent of personal computers capable of high speed calculations.

The formula for Brillouin's index is:

$$H_b = \frac{1}{N} \log_e \frac{N!}{N_1! N_2! \ldots N_s!}$$

Where N = total number of individuals
Ni = number of individuals of the ith species
S = total number of species in the collection.

As the index provides the exact diversity of the sample, it is most appropriate in surveys where it is not possible to define the limits of the population. Since this is nearly always the case when dealing with benthic communities, Brillouin's index has much to commend it in offshore pollution monitoring studies.

Pielou's Equitability (J)

Equitability refers to the evenness with which individuals are distributed amongst species. Equitability is clearly a component of species diversity and certainly enters into diversity indices such as H'Log$_2$, Hb, and λ.

Equitability can be assessed in several ways, the most commonly used approach being to calculate the theoretical diversity for a given species abundance list if all the species were equal in abundance. The equitability of the sample can then be defined as the ratio of the actual diversity to the theoretical maximum.

This is usually done using the Shannon-Wiener index (H'Log$_2$)

If all species are equally represented, then the equation can be written:

$$H'(max) = -S\left(\frac{1}{s} log2 \frac{1}{s}\right) = log_s S$$

The equitability ratio is therefore:

$$J = \frac{H_s}{log_2 S}$$

Where J = equitability measure (Pielou)
H' = calculated Shannon-Wiener diversity
S = total number of species.

Heip (1974) has suggested a modified form of Pielou's J that is essentially the antilog of H' divided by the antilog of H(max). To prevent equitability values at the extreme end of the range becoming nonsensical Heip took the precaution of subtracting 1 from the enumerator and denominator so that his index becomes:

$$Eh = \frac{2^H - 1}{s - 1}$$

Where 2H = the antilog of H'
S = the number of species

The advantage of this measure is that it appears to provide more realistic equitability values in absolute terms; however, there is a curvilinear relationship between Eh and H' making it difficult to compare ranges of equitability. Although used by Government Laboratories, Heip's measure is not widely used elsewhere.

B.3.2.2 Multivariate Analysis

Macrofauna abundance data was analysed by multivariate techniques using the statistical package PRIMER v6. Approaches followed those outlined in Clarke and Gorley (2006). The main techniques used to interrogate the data are detailed below.

Pre-treatment and Transformations: prior to analysis data typically undergo transformation to down weight the effect of dominant data components in determining inter-sample similarities. These transformations vary in their effect through: no transform; square root (√); fourth root/double square root (√√); logarithmic, and; reduction to presence/absence. At the former end of the spectrum (no transform) all attention is focused on the dominant components of the dataset, and at the latter end (reduction to presence/absence) equal weighting is applied to all components (Clarke and Gorley, 2006). Macrofauna data is generally fourth root transformed for multivariate analysis. However, due to the small numbers of individuals in each taxon, square root transformation was used in this instance as detailed within the report.

Similarity Matrices: a triangular similarity matrix was produced from the square root transformed data, by calculating the similarity between every pair of replicate samples. The Bray-Curtis similarity coefficient was used for macrofaunal data (Bray and Curtis, 1957). This similarity measure is considered the most suitable as it maintains independence of joint absence (i.e. will not infer similarity between samples based on the absence of a certain parameter in them).

Hierarchical Agglomerative Clustering (CLUSTER) and Similarity Profile Testing (SIMPROF): the CLUSTER programme uses the similarity matrix to successively fuse samples into groups and groups into clusters according to their level of similarity. The end point of this process is a single cluster containing all the samples, which is displayed by means of a dendrogram with similarity displayed on one axis and samples on the other. Similarity profile permutation tests (SIMPROF) were also performed, to look for evidence of genuine statistically significant clusters, in samples that are a-priori unstructured (i.e. with no prior statistical design). By combining this significance testing with the CLUSTER function, dendrograms are produced indicating those clusters that are statistically significant.

Correlations with Environmental Variables: if more than one benthic assemblage was present in the macrofaunal data (i.e. there was structuring in the data), attempts were made to match the variation with reported environmental variables. This process can help identify relationships between the physical or chemical environment and the benthic communities present.

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C. LOGS

C.1 SURVEY LOG

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
14/09/18	16:41	EBSDDV7	Video	SOL	1	1823.9	493 677.3	903 163.9	493 696.8	903 154.4	21.7	
14/09/18	16:43	EBSDDV7	Still	EBSDDV7_001	2	1820.0	493 677.3	903 163.9	493 698.8	903 153.2	24.0	
14/09/18	16:45	EBSDDV7	Still	EBSDDV7_002	3	1819.5	493 677.3	903 163.9	493 700.9	903 155.2	25.1	
14/09/18	16:46	EBSDDV7	Still	EBSDDV7_003	4	1823.7	493 677.3	903 163.9	493 692.8	903 159.0	16.3	
14/09/18	16:47	EBSDDV7	Still	EBSDDV7_004	5	1820.8	493 677.3	903 163.9	493 690.5	903 161.3	13.4	
14/09/18	16:50	EBSDDV7	Still	EBSDDV7_005	6	1820.4	493 677.3	903 163.9	493 688.3	903 156.5	13.2	
14/09/18	16:51	EBSDDV7	Still	EBSDDV7_006	7	1821.8	493 677.3	903 163.9	493 681.5	903 153.2	11.6	
14/09/18	16:53	EBSDDV7	Still	EBSDDV7_007	8	1821.6	493 677.3	903 163.9	493 677.6	903 153.5	10.5	
14/09/18	16:55	EBSDDV7	Still	EBSDDV7_008	9	1821.9	493 677.3	903 163.9	493 680.8	903 163.0	3.6	
14/09/18	16:57	EBSDDV7	Still	EBSDDV7_009	10	1823.4	493 677.3	903 163.9	493 670.8	903 161.3	7.0	
14/09/18	16:58	EBSDDV7	Still	EBSDDV7_010	11	1823.3	493 677.3	903 163.9	493 673.4	903 160.6	5.1	
14/09/18	16:59	EBSDDV7	Still	EBSDDV7_011	12	1823.8	493 677.3	903 163.9	493 669.9	903 156.1	10.8	
14/09/18	17:03	EBSDDV7	Still	EBSDDV7_012	13	1820.0	493 677.3	903 163.9	493 664.0	903 151.1	18.5	
14/09/18	17:04	EBSDDV7	Still	EBSDDV7_013	14	1821.4	493 677.3	903 163.9	493 652.7	903 161.3	24.8	
14/09/18	17:04	EBSDDV7	Still	EBSDDV7_014	14	1821.4	493 677.3	903 163.9	493 652.7	903 161.3	24.8	
14/09/18	17:05	EBSDDV7	Still	EBSDDV7_015	15	1820.5	493 677.3	903 163.9	493 669.7	903 176.3	14.5	
14/09/18	17:06	EBSDDV7	Still	EBSDDV7_016	16	1821.3	493 677.3	903 163.9	493 650.3	903 168.0	27.3	
14/09/18	17:07	EBSDDV7	Still	EBSDDV7_017	17	1820.2	493 677.3	903 163.9	493 648.9	903 172.0	29.6	
14/09/18	17:07	EBSDDV7	Video	EOL	18	1822.2	493 677.3	903 163.9	493 648.1	903 171.4	30.2	
14/09/18	20:55	EBSDDV5	Video	SOL	19	1907.9	496 384.9	906 337.6	496 409.6	906 364.4	36.4	
14/09/18	21:06	EBSDDV5	Still	EBSDDV5_001	20	1907.4	496 384.9	906 337.6	496 398.0	906 361.4	27.2	
14/09/18	21:09	EBSDDV5	Still	EBSDDV5_002	21	1906.6	496 384.9	906 337.6	496 397.0	906 356.1	22.1	
14/09/18	21:10	EBSDDV5	Still	EBSDDV5_003	22	1906.4	496 384.9	906 337.6	496 389.0	906 352.1	15.1	
14/09/18	21:11	EBSDDV5	Still	EBSDDV5_004	23	1907.8	496 384.9	906 337.6	496 388.4	906 351.7	14.5	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
14/09/18	21:12	EBSDDV5	Still	EBSDDV5_005	24	1907.8	496 384.9	906 337.6	496 385.8	906 352.6	15.0	
14/09/18	21:14	EBSDDV5	Still	EBSDDV5_006	25	1906.6	496 384.9	906 337.6	496 385.5	906 350.2	12.6	
14/09/18	21:16	EBSDDV5	Still	EBSDDV5_007	26	1905.7	496 384.9	906 337.6	496 384.0	906 342.7	5.2	
14/09/18	21:17	EBSDDV5	Still	EBSDDV5_008	27	1906.5	496 384.9	906 337.6	496 380.4	906 343.3	7.2	
14/09/18	21:18	EBSDDV5	Still	EBSDDV5_009	28	1908.4	496 384.9	906 337.6	496 376.3	906 340.6	9.0	
14/09/18	21:18	EBSDDV5	Still	EBSDDV5_010	No fix	-	496 384.9	906 337.6	-	-		
14/09/18	21:19	EBSDDV5	Still	EBSDDV5_011	30	1906.6	496 384.9	906 337.6	496 377.3	906 336.7	7.6	
14/09/18	21:20	EBSDDV5	Still	EBSDDV5_012	31	1905.7	496 384.9	906 337.6	496 377.8	906 333.1	8.3	
14/09/18	21:20	EBSDDV5	Still	EBSDDV5_013	32	1905.8	496 384.9	906 337.6	496 373.5	906 336.9	11.4	
14/09/18	21:22	EBSDDV5	Still	EBSDDV5_014	33	1905.5	496 384.9	906 337.6	496 372.4	906 329.6	14.9	
14/09/18	21:23	EBSDDV5	Still	EBSDDV5_015	34	1904.4	496 384.9	906 337.6	496 375.6	906 321.3	18.7	
14/09/18	21:24	EBSDDV5	Still	EBSDDV5_016	35	1906.5	496 384.9	906 337.6	496 369.6	906 323.9	20.5	
14/09/18	21:25	EBSDDV5	Still	EBSDDV5_017	36	1905.0	496 384.9	906 337.6	496 365.1	906 320.1	26.4	
14/09/18	21:26	EBSDDV5	Still	EBSDDV5_018	37	1905.1	496 384.9	906 337.6	496 366.9	906 317.7	26.8	
14/09/18	21:26	EBSDDV5	Video	EOL	38	1905.7	496 384.9	906 337.6	496 369.9	906 317.4	25.1	
15/09/18	01:14	EBSDDV1	Video	SOL	39	2036.7	500 166.9	911 657.3	500 145.4	911 642.8	25.9	
15/09/18	01:14	EBSDDV1	Still	EBSDDV1_001	40	2035.9	500 166.9	911 657.3	500 144.7	911 643.5	26.1	
15/09/18	01:15	EBSDDV1	Still	EBSDDV1_002	41	2034.8	500 166.9	911 657.3	500 145.8	911 648.8	22.7	
15/09/18	01:16	EBSDDV1	Still	EBSDDV1_003	42	2034.4	500 166.9	911 657.3	500 149.4	911 648.1	19.7	
15/09/18	01:17	EBSDDV1	Still	EBSDDV1_004	43	2035.0	500 166.9	911 657.3	500 150.8	911 648.9	18.1	
15/09/18	01:18	EBSDDV1	Still	EBSDDV1_005	44	2035.5	500 166.9	911 657.3	500 148.4	911 652.0	19.2	
15/09/18	01:19	EBSDDV1	Still	EBSDDV1_006	45	2034.5	500 166.9	911 657.3	500 147.9	911 654.6	19.2	
15/09/18	01:19	EBSDDV1	Still	EBSDDV1_007	46	2034.2	500 166.9	911 657.3	500 156.2	911 653.9	11.2	
15/09/18	01:20	EBSDDV1	Still	EBSDDV1_008	47	2035.9	500 166.9	911 657.3	500 152.6	911 660.9	14.8	
15/09/18	01:21	EBSDDV1	Still	EBSDDV1_009	48	2035.0	500 166.9	911 657.3	500 157.8	911 649.8	11.8	
15/09/18	01:21	EBSDDV1	Still	EBSDDV1_010	49	2036.8	500 166.9	911 657.3	500 154.6	911 657.0	12.3	
15/09/18	01:22	EBSDDV1	Still	EBSDDV1_011	50	2036.5	500 166.9	911 657.3	500 156.3	911 649.1	13.4	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
15/09/18	01:23	EBSDDV1	Still	EBSDDV1_012	51	2037.6	500 166.9	911 657.3	500 166.8	911 660.4	3.2	
15/09/18	01:24	EBSDDV1	Still	EBSDDV1_013	52	2033.9	500 166.9	911 657.3	500 167.0	911 665.7	8.4	
15/09/18	01:24	EBSDDV1	Still	EBSDDV1_014	53	2034.6	500 166.9	911 657.3	500 163.2	911 666.9	10.4	
15/09/18	01:25	EBSDDV1	Still	EBSDDV1_015	54	2036.1	500 166.9	911 657.3	500 161.8	911 669.3	13.1	
15/09/18	01:27	EBSDDV1	Still	EBSDDV1_016	55	2035.7	500 166.9	911 657.3	500 166.9	911 673.5	16.2	
15/09/18	01:28	EBSDDV1	Still	EBSDDV1_017	56	2034.8	500 166.9	911 657.3	500 167.8	911 674.3	17.1	
15/09/18	01:29	EBSDDV1	Still	EBSDDV1_018	57	2034.6	500 166.9	911 657.3	500 172.4	911 669.7	13.6	
15/09/18	01:30	EBSDDV1	Still	EBSDDV1_019	58	2035.2	500 166.9	911 657.3	500 180.4	911 675.6	22.8	
15/09/18	01:30	EBSDDV1	Video	EOL	59	2035.9	500 166.9	911 657.3	500 178.1	911 679.5	24.9	
15/09/18	05:43	EBSDDV9	Video	SOL	60	2180.6	502 540.5	917 514.4	502 533.2	917 524.3	12.3	
15/09/18	05:44	EBSDDV9	Still	EBSDDV9_001	61	2180.8	502 540.5	917 514.4	502 537.7	917 530.5	16.4	
15/09/18	05:44	EBSDDV9	Still	EBSDDV9_002	62	2179.3	502 540.5	917 514.4	502 535.8	917 529.9	16.3	
15/09/18	05:45	EBSDDV9	Still	EBSDDV9_003	63	2179.0	502 540.5	917 514.4	502 531.7	917 523.9	13.0	
15/09/18	05:46	EBSDDV9	Still	EBSDDV9_004	64	2179.4	502 540.5	917 514.4	502 536.0	917 525.7	12.2	
15/09/18	05:47	EBSDDV9	Still	EBSDDV9_005	65	2178.5	502 540.5	917 514.4	502 537.5	917 523.9	10.0	
15/09/18	05:47	EBSDDV9	Video	EOL	66	2177.3	502 540.5	917 514.4	502 537.5	917 524.6	10.6	Loss of colour
15/09/18	05:50	EBSDDV9	Video	SOL	67	2178.4	502 540.5	917 514.4	502 537.2	917 521.3	7.7	Resume line
15/09/18	05:52	EBSDDV9	Still	EBSDDV9_006	68	2177.9	502 540.5	917 514.4	502 542.6	917 515.2	2.2	
15/09/18	05:53	EBSDDV9	Still	EBSDDV9_007	69	2178.1	502 540.5	917 514.4	502 542.8	917 513.4	2.5	
15/09/18	05:53	EBSDDV9	Still	EBSDDV9_008	70	2178.9	502 540.5	917 514.4	502 542.7	917 514.0	2.2	
15/09/18	05:54	EBSDDV9	Still	EBSDDV9_009	71	2178.7	502 540.5	917 514.4	502 549.4	917 512.2	9.1	
15/09/18	05:55	EBSDDV9	Still	EBSDDV9_010	72	2178.9	502 540.5	917 514.4	502 544.2	917 513.5	3.8	
15/09/18	05:55	EBSDDV9	Still	EBSDDV9_011	73	2179.1	502 540.5	917 514.4	502 545.3	917 513.3	4.9	
15/09/18	05:56	EBSDDV9	Still	EBSDDV9_012	74	2178.8	502 540.5	917 514.4	502 545.5	917 513.4	5.1	
15/09/18	05:57	EBSDDV9	Still	EBSDDV9_013	75	2179.5	502 540.5	917 514.4	502 547.1	917 507.6	9.4	
15/09/18	05:58	EBSDDV9	Still	EBSDDV9_014	76	2178.4	502 540.5	917 514.4	502 548.6	917 507.7	10.5	
15/09/18	05:59	EBSDDV9	Still	EBSDDV9_015	77	2180.0	502 540.5	917 514.4	502 550.1	917 506.2	12.6	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
15/09/18	05:59	EBSDDV9	Still	EBSDDV9_016	78	2179.0	502 540.5	917 514.4	502 548.1	917 502.6	14.0	
15/09/18	06:01	EBSDDV9	Still	EBSDDV9_017	79	2179.1	502 540.5	917 514.4	502 548.5	917 503.0	13.9	
15/09/18	06:01	EBSDDV9	Video	EOL	80	2177.8	502 540.5	917 514.4	502 548.4	917 498.1	18.1	
15/09/18	10:32	EBSDDV11	Video	SOL	82	2179.5	504 530.4	917 021.3	504 516.0	917 028.3	15.9	
15/09/18	10:33	EBSDDV11	Still	EBSDDV11_001	83	2179.4	504 530.4	917 021.3	504 516.0	917 028.7	16.1	
15/09/18	10:34	EBSDDV11	Still	EBSDDV11_002	84	2180.4	504 530.4	917 021.3	504 511.3	917 025.7	19.5	
15/09/18	10:35	EBSDDV11	Still	EBSDDV11_003	85	2178.4	504 530.4	917 021.3	504 519.2	917 024.0	11.5	
15/09/18	10:36	EBSDDV11	Still	EBSDDV11_004	86	2180.7	504 530.4	917 021.3	504 521.8	917 022.4	8.6	
15/09/18	10:36	EBSDDV11	Still	EBSDDV11_005	87	2180.2	504 530.4	917 021.3	504 516.8	917 024.4	13.9	
15/09/18	10:37	EBSDDV11	Still	EBSDDV11_006	88	2181.6	504 530.4	917 021.3	504 518.6	917 021.4	11.7	
15/09/18	10:37	EBSDDV11	Still	EBSDDV11_007	89	2179.8	504 530.4	917 021.3	504 519.9	917 027.0	11.9	
15/09/18	10:38	EBSDDV11	Still	EBSDDV11_008	90	2179.8	504 530.4	917 021.3	504 527.4	917 023.2	3.6	
15/09/18	10:39	EBSDDV11	Still	EBSDDV11_009	91	2179.2	504 530.4	917 021.3	504 535.7	917 022.2	5.5	
15/09/18	10:40	EBSDDV11	Still	EBSDDV11_010	92	2179.8	504 530.4	917 021.3	504 527.0	917 020.3	3.5	
15/09/18	10:41	EBSDDV11	Still	EBSDDV11_011	93	2179.1	504 530.4	917 021.3	504 529.8	917 020.2	1.2	
15/09/18	10:42	EBSDDV11	Still	EBSDDV11_012	94	2181.0	504 530.4	917 021.3	504 532.9	917 021.3	2.5	
15/09/18	10:44	EBSDDV11	Still	EBSDDV11_013	95	2181.2	504 530.4	917 021.3	504 537.1	917 018.8	7.2	
15/09/18	10:46	EBSDDV11	Still	EBSDDV11_014	96	2178.7	504 530.4	917 021.3	504 537.6	917 020.5	7.3	
15/09/18	10:47	EBSDDV11	Still	EBSDDV11_015	97	2181.3	504 530.4	917 021.3	504 543.7	917 012.4	16.0	
15/09/18	10:48	EBSDDV11	Still	EBSDDV11_016	98	2180.1	504 530.4	917 021.3	504 545.1	917 012.9	16.9	
15/09/18	10:51	EBSDDV11	Video	EOL	99	2178.6	504 530.4	917 021.3	504 551.2	917 005.5	26.1	Resumed transect
15/09/18	13:02	EBSDDV11	Video	SOL	100	2179.8	504 530.4	917 021.3	504 535.9	917 022.4	5.6	
15/09/18	13:02	EBSDDV11	Still	EBSDDV11_017	101	2181.6	504 530.4	917 021.3	504 538.4	917 027.5	10.2	
15/09/18	13:06	EBSDDV11	Still	EBSDDV11_018	102	2179.5	504 530.4	917 021.3	504 541.9	917 030.5	14.7	
15/09/18	13:07	EBSDDV11	Still	EBSDDV11_019	103	2180.9	504 530.4	917 021.3	504 543.9	917 021.7	13.6	
15/09/18	13:08	EBSDDV11	Still	EBSDDV11_020	104	2180.4	504 530.4	917 021.3	504 550.5	917 025.1	20.5	
15/09/18	13:09	EBSDDV11	Still	EBSDDV11_021	105	2180.5	504 530.4	917 021.3	504 548.2	917 024.9	18.2	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
15/09/18	13:10	EBSDDV11	Still	EBSDDV11_022	106	2179.5	504 530.4	917 021.3	504 545.5	917 026.0	15.9	
15/09/18	13:11	EBSDDV11	Still	EBSDDV11_023	107	2181.2	504 530.4	917 021.3	504 552.0	917 017.4	22.0	
15/09/18	13:13	EBSDDV11	Still	EBSDDV11_024	108	2180.7	504 530.4	917 021.3	504 551.7	917 018.4	21.5	
15/09/18	13:13	EBSDDV11	Still	EBSDDV11_025	109	2180.8	504 530.4	917 021.3	504 556.0	917 018.0	25.9	
15/09/18	13:14	EBSDDV11	Still	EBSDDV11_026	110	2180.6	504 530.4	917 021.3	504 554.6	917 012.2	25.9	
15/09/18	13:15	EBSDDV11	Still	EBSDDV11_027	111	2181.1	504 530.4	917 021.3	504 554.0	917 010.7	25.9	
15/09/18	13:16	EBSDDV11	Still	EBSDDV11_028	112	2181.6	504 530.4	917 021.3	504 554.0	917 012.2	25.3	
15/09/18	13:36	EBSDDV11	Still	EBSDDV11_029	113	2182.0	504 530.4	917 021.3	504 523.7	916 999.3	23.0	
15/09/18	13:39	EBSDDV11	Still	EBSDDV11_030	114	2180.4	504 530.4	917 021.3	504 524.9	917 000.6	21.4	
15/09/18	13:41	EBSDDV11	Still	EBSDDV11_031	115	2181.6	504 530.4	917 021.3	504 519.7	917 007.3	17.6	
15/09/18	13:42	EBSDDV11	Still	EBSDDV11_032	116	2182.1	504 530.4	917 021.3	504 515.3	917 008.9	19.5	
15/09/18	13:42	EBSDDV11	Still	EBSDDV11_033	117	2182.4	504 530.4	917 021.3	504 515.2	917 010.8	18.5	
15/09/18	13:42	EBSDDV11	Video	EOL	118	2182.7	504 530.4	917 021.3	504 517.1	917 011.6	16.4	
15/09/18	18:55	EBSDDV2	Video	SOL	119	2079.8	505 560.5	909 795.3	505 583.0	909 801.1	23.2	
15/09/18	18:56	EBSDDV2	Still	EBSDDV2_001	120	2079.5	505 560.5	909 795.3	505 587.2	909 801.8	27.5	
15/09/18	18:58	EBSDDV2	Still	EBSDDV2_002	121	2079.0	505 560.5	909 795.3	505 581.9	909 801.6	22.3	
15/09/18	18:59	EBSDDV2	Still	EBSDDV2_003	122	2080.0	505 560.5	909 795.3	505 579.5	909 803.3	20.7	
15/09/18	19:07	EBSDDV2	Still	EBSDDV2_004	123	2080.3	505 560.5	909 795.3	505 578.8	909 803.6	20.1	
15/09/18	19:08	EBSDDV2	Still	EBSDDV2_005	124	2078.1	505 560.5	909 795.3	505 584.1	909 792.9	23.8	
15/09/18	19:10	EBSDDV2	Still	EBSDDV2_006	125	2078.6	505 560.5	909 795.3	505 577.4	909 795.6	17.0	
15/09/18	19:12	EBSDDV2	Still	EBSDDV2_007	126	2078.1	505 560.5	909 795.3	505 577.3	909 795.0	16.8	
15/09/18	19:13	EBSDDV2	Still	EBSDDV2_008	127	2080.9	505 560.5	909 795.3	505 568.8	909 797.3	8.6	
15/09/18	19:16	EBSDDV2	Still	EBSDDV2_009	128	2079.1	505 560.5	909 795.3	505 568.3	909 797.0	8.0	
15/09/18	19:18	EBSDDV2	Still	EBSDDV2_010	129	2079.3	505 560.5	909 795.3	505 565.5	909 792.0	6.0	
15/09/18	19:18	EBSDDV2	Still	EBSDDV2_011	130	2080.2	505 560.5	909 795.3	505 565.0	909 790.7	6.5	
15/09/18	19:20	EBSDDV2	Still	EBSDDV2_012	131	2081.1	505 560.5	909 795.3	505 557.9	909 790.1	5.8	
15/09/18	19:24	EBSDDV2	Still	EBSDDV2_013	132	2080.6	505 560.5	909 795.3	505 551.4	909 789.5	10.7	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
15/09/18	19:26	EBSDDV2	Still	EBSDDV2_014	133	2080.8	505 560.5	909 795.3	505 549.0	909 789.7	12.8	
15/09/18	19:28	EBSDDV2	Still	EBSDDV2_015	134	2078.4	505 560.5	909 795.3	505 546.5	909 791.9	14.4	
15/09/18	19:28	EBSDDV2	Still	EBSDDV2_016	135	2077.3	505 560.5	909 795.3	505 545.9	909 787.2	16.7	
15/09/18	19:29	EBSDDV2	Still	EBSDDV2_017	136	2078.9	505 560.5	909 795.3	505 545.0	909 789.9	16.4	
15/09/18	19:32	EBSDDV2	Video	EOL	137	2077.8	505 560.5	909 795.3	505 536.7	909 793.0	23.9	
15/09/18	23:07	EBSDDV6	Video	SOL	138	1976.8	502 198.9	906 781.5	502 217.5	906 797.7	24.7	
15/09/18	23:08	EBSDDV6	Still	EBSDDV6_001	139	1973.9	502 198.9	906 781.5	502 223.2	906 793.9	27.3	
15/09/18	23:10	EBSDDV6	Still	EBSDDV6_002	140	1974.3	502 198.9	906 781.5	502 218.3	906 794.1	23.1	
15/09/18	23:11	EBSDDV6	Still	EBSDDV6_003	141	1974.9	502 198.9	906 781.5	502 220.5	906 788.4	22.7	
15/09/18	23:13	EBSDDV6	Still	EBSDDV6_004	142	1974.6	502 198.9	906 781.5	502 214.0	906 781.6	15.1	
15/09/18	23:14	EBSDDV6	Still	EBSDDV6_005	143	1975.7	502 198.9	906 781.5	502 216.8	906 779.5	18.0	
15/09/18	23:16	EBSDDV6	Still	EBSDDV6_006	144	1976.3	502 198.9	906 781.5	502 211.9	906 774.0	15.0	
15/09/18	23:17	EBSDDV6	Still	EBSDDV6_007	145	1975.7	502 198.9	906 781.5	502 212.5	906 771.3	17.0	
15/09/18	23:18	EBSDDV6	Still	EBSDDV6_008	146	1976.2	502 198.9	906 781.5	502 211.8	906 771.1	16.5	
15/09/18	23:19	EBSDDV6	Still	EBSDDV6_009	147	1974.5	502 198.9	906 781.5	502 208.0	906 780.1	9.2	
15/09/18	23:20	EBSDDV6	Still	EBSDDV6_010	148	1976.4	502 198.9	906 781.5	502 208.6	906 776.8	10.8	
15/09/18	23:20	EBSDDV6	Still	EBSDDV6_011	149	1973.6	502 198.9	906 781.5	502 209.3	906 772.8	13.5	
15/09/18	23:22	EBSDDV6	Still	EBSDDV6_012	150	1972.7	502 198.9	906 781.5	502 210.2	906 765.0	20.0	
15/09/18	23:23	EBSDDV6	Still	EBSDDV6_013	151	1977.5	502 198.9	906 781.5	502 203.9	906 760.3	21.8	
15/09/18	23:24	EBSDDV6	Still	EBSDDV6_014	152	1977.4	502 198.9	906 781.5	502 205.8	906 758.9	23.6	
15/09/18	23:25	EBSDDV6	Video	EOL	153	1974.6	502 198.9	906 781.5	502 211.7	906 753.8	30.5	
16/09/18	04:10	EBSDDV3	Video	SOL	154	1916.2	503 091.1	902 979.6	503 090.1	902 999.8	20.2	
16/09/18	04:11	EBSDDV3	Still	EBSDDV3_001	155	1916.5	503 091.1	902 979.6	503 089.9	903 005.5	25.9	
16/09/18	04:11	EBSDDV3	Still	EBSDDV3_002	156	1919.4	503 091.1	902 979.6	503 083.3	903 004.2	25.8	
16/09/18	04:14	EBSDDV3	Video	EOL	157	1915.1	503 091.1	902 979.6	503 083.5	903 007.6	29.0	
16/09/18	04:42	EBSDDV3	Video	SOL	158	1914.6	503 091.1	902 979.6	503 070.2	902 970.6	22.7	
16/09/18	04:45	EBSDDV3	Still	EBSDDV3_003	159	1913.7	503 091.1	902 979.6	503 081.6	902 970.5	13.2	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
16/09/18	04:45	EBSDDV3	Still	EBSDDV3_004	160	1915.6	503 091.1	902 979.6	503 077.1	902 970.7	16.6	
16/09/18	04:45	EBSDDV3	Still	EBSDDV3_005	161	1913.5	503 091.1	902 979.6	503 080.6	902 967.9	15.7	
16/09/18	04:45	EBSDDV3	Still	EBSDDV3_006	162	1913.0	503 091.1	902 979.6	503 086.7	902 970.8	9.9	
16/09/18	04:46	EBSDDV3	Still	EBSDDV3_007	163	1912.5	503 091.1	902 979.6	503 085.4	902 971.8	9.7	
16/09/18	04:47	EBSDDV3	Still	EBSDDV3_008	164	1915.4	503 091.1	902 979.6	503 085.4	902 971.2	10.1	
16/09/18	04:47	EBSDDV3	Still	EBSDDV3_009	165	1915.5	503 091.1	902 979.6	503 091.0	902 967.2	12.4	
16/09/18	04:48	EBSDDV3	Still	EBSDDV3_010	166	1913.2	503 091.1	902 979.6	503 088.4	902 969.3	10.6	
16/09/18	04:48	EBSDDV3	Still	EBSDDV3_011	167	1914.1	503 091.1	902 979.6	503 086.6	902 964.8	15.5	
16/09/18	04:48	EBSDDV3	Still	EBSDDV3_012	168	1915.1	503 091.1	902 979.6	503 096.4	902 970.5	10.5	
16/09/18	04:49	EBSDDV3	Still	EBSDDV3_013	169	1913.7	503 091.1	902 979.6	503 097.5	902 972.9	9.3	
16/09/18	04:49	EBSDDV3	Still	EBSDDV3_014	170	1914.7	503 091.1	902 979.6	503 100.4	902 974.5	10.6	
16/09/18	04:50	EBSDDV3	Still	EBSDDV3_015	171	1913.4	503 091.1	902 979.6	503 105.0	902 971.6	16.0	
16/09/18	04:50	EBSDDV3	Still	EBSDDV3_016	172	1913.3	503 091.1	902 979.6	503 102.6	902 966.3	17.6	
16/09/18	04:51	EBSDDV3	Still	EBSDDV3_017	173	1915.8	503 091.1	902 979.6	503 109.4	902 971.1	20.2	
16/09/18	04:53	EBSDDV3	Video	EOL	174	1915.6	503 091.1	902 979.6	503 113.9	902 969.0	25.1	
16/09/18	09:21	EBSDDV4	Video	SOL	175	1936.6	508 613.5	901 724.2	508 612.9	901 719.4	4.9	
16/09/18	09:21	EBSDDV4	Still	EBSDDV4_001	176	1937.0	508 613.5	901 724.2	508 613.7	901 721.7	2.5	
16/09/18	09:22	EBSDDV4	Still	EBSDDV4_002	177	1937.3	508 613.5	901 724.2	508 609.1	901 724.3	4.3	
16/09/18	09:22	EBSDDV4	Still	EBSDDV4_003	178	1940.4	508 613.5	901 724.2	508 607.2	901 724.7	6.3	
16/09/18	09:23	EBSDDV4	Still	EBSDDV4_004	179	1937.3	508 613.5	901 724.2	508 608.6	901 725.0	4.9	
16/09/18	09:23	EBSDDV4	Still	EBSDDV4_005	180	1938.2	508 613.5	901 724.2	508 607.6	901 725.9	6.1	
16/09/18	09:24	EBSDDV4	Still	EBSDDV4_006	181	1939.0	508 613.5	901 724.2	508 606.4	901 732.3	10.8	
16/09/18	09:24	EBSDDV4	Still	EBSDDV4_007	182	1938.0	508 613.5	901 724.2	508 600.4	901 734.7	16.8	
16/09/18	09:25	EBSDDV4	Still	EBSDDV4_008	183	1941.3	508 613.5	901 724.2	508 599.0	901 732.6	16.8	
16/09/18	09:25	EBSDDV4	Still	EBSDDV4_009	184	1938.4	508 613.5	901 724.2	508 605.9	901 733.9	12.2	
16/09/18	09:26	EBSDDV4	Still	EBSDDV4_010	185	1939.7	508 613.5	901 724.2	508 600.9	901 740.3	20.4	
16/09/18	09:27	EBSDDV4	Video	EOL	186	1939.1	508 613.5	901 724.2	508 603.4	901 736.8	16.2	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
16/09/18	13:16	EBSDDV10	Video	SOL	187	1970.5	513 107.3	900 648.3	513 127.3	900 667.5	27.7	
16/09/18	13:21	EBSDDV10	Still	EBSDDV10_001	188	1969.1	513 107.3	900 648.3	513 128.1	900 666.7	27.7	
16/09/18	13:22	EBSDDV10	Still	EBSDDV10_002	189	1970.0	513 107.3	900 648.3	513 125.7	900 668.1	27.0	
16/09/18	13:24	EBSDDV10	Still	EBSDDV10_003	190	1972.3	513 107.3	900 648.3	513 124.0	900 665.4	23.9	
16/09/18	13:24	EBSDDV10	Still	EBSDDV10_004	191	1972.0	513 107.3	900 648.3	513 123.2	900 663.9	22.3	
16/09/18	13:27	EBSDDV10	Still	EBSDDV10_005	192	1970.4	513 107.3	900 648.3	513 121.0	900 661.3	18.8	
16/09/18	13:27	EBSDDV10	Still	EBSDDV10_006	193	1969.7	513 107.3	900 648.3	513 125.8	900 658.5	21.1	
16/09/18	13:29	EBSDDV10	Still	EBSDDV10_007	194	1971.3	513 107.3	900 648.3	513 122.7	900 659.4	18.9	
16/09/18	13:30	EBSDDV10	Still	EBSDDV10_008	195	1970.5	513 107.3	900 648.3	513 120.4	900 652.8	13.9	
16/09/18	13:32	EBSDDV10	Still	EBSDDV10_009	196	1970.0	513 107.3	900 648.3	513 119.9	900 648.7	12.5	
16/09/18	13:33	EBSDDV10	Still	EBSDDV10_010	197	1968.5	513 107.3	900 648.3	513 116.5	900 645.5	9.5	
16/09/18	13:33	EBSDDV10	Still	EBSDDV10_011	198	1970.3	513 107.3	900 648.3	513 117.0	900 646.9	9.8	
16/09/18	13:35	EBSDDV10	Still	EBSDDV10_012	199	1970.0	513 107.3	900 648.3	513 113.9	900 648.6	6.5	
16/09/18	13:36	EBSDDV10	Still	EBSDDV10_013	200	1968.7	513 107.3	900 648.3	513 114.7	900 640.6	10.6	
16/09/18	13:38	EBSDDV10	Still	EBSDDV10_014	201	1967.8	513 107.3	900 648.3	513 118.0	900 643.4	11.7	
16/09/18	13:39	EBSDDV10	Still	EBSDDV10_015	202	1970.1	513 107.3	900 648.3	513 113.6	900 641.7	9.1	
16/09/18	13:40	EBSDDV10	Still	EBSDDV10_016	203	1970.0	513 107.3	900 648.3	513 110.0	900 641.4	7.3	
16/09/18	13:43	EBSDDV10	Still	EBSDDV10_017	204	1971.0	513 107.3	900 648.3	513 105.1	900 636.2	12.3	
16/09/18	13:44	EBSDDV10	Still	EBSDDV10_018	205	1969.7	513 107.3	900 648.3	513 107.5	900 640.0	8.3	
16/09/18	13:47	EBSDDV10	Still	EBSDDV10_019	206	1970.6	513 107.3	900 648.3	513 101.7	900 636.7	13.0	
16/09/18	13:47	EBSDDV10	Still	EBSDDV10_020	207	1970.7	513 107.3	900 648.3	513 097.0	900 636.0	16.0	
16/09/18	13:51	EBSDDV10	Still	EBSDDV10_021	208	1969.2	513 107.3	900 648.3	513 069.4	900 606.6	56.3	
16/09/18	13:51	EBSDDV10	Still	EBSDDV10_022	209	1969.1	513 107.3	900 648.3	513 100.4	900 630.5	19.1	
16/09/18	13:52	EBSDDV10	Still	EBSDDV10_023	210	1971.9	513 107.3	900 648.3	513 098.7	900 631.1	19.3	
16/09/18	13:52	EBSDDV10	Still	EBSDDV10_024	211	1969.2	513 107.3	900 648.3	513 098.3	900 630.4	20.0	
16/09/18	13:53	EBSDDV10	Still	EBSDDV10_025	212	1970.5	513 107.3	900 648.3	513 095.7	900 631.9	20.1	
16/09/18	13:58	EBSDDV10	Still	EBSDDV10_026	213	1967.9	513 107.3	900 648.3	513 094.6	900 630.0	22.3	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
16/09/18	14:01	EBSDDV10	Still	EBSDDV10_027	214	1967.9	513 107.3	900 648.3	513 092.0	900 632.3	22.2	
16/09/18	14:04	EBSDDV10	Still	EBSDDV10_028	215	1967.9	513 107.3	900 648.3	513 090.0	900 633.1	23.0	
16/09/18	14:04	EBSDDV10	Video	EOL	216	1967.9	513 107.3	900 648.3	513 087.7	900 637.4	22.4	
16/09/18	20:33	EBSDDV8	Video	SOL	217	2095.6	512 754.4	908 877.2	512 796.8	908 871.3	42.9	
16/09/18	20:39	EBSDDV8	Still	EBSDDV8_002	218	2097.9	512 754.4	908 877.2	512 790.2	908 872.5	36.2	
16/09/18	20:45	EBSDDV8	Still	EBSDDV8_003	219	2098.9	512 754.4	908 877.2	512 787.2	908 877.0	32.8	
16/09/18	20:47	EBSDDV8	Still	EBSDDV8_004	220	2099.0	512 754.4	908 877.2	512 776.8	908 873.0	22.8	
16/09/18	20:49	EBSDDV8	Still	EBSDDV8_005	221	2098.1	512 754.4	908 877.2	512 779.4	908 875.5	25.1	
16/09/18	20:50	EBSDDV8	Still	EBSDDV8_006	222	2096.1	512 754.4	908 877.2	512 776.0	908 876.8	21.6	
16/09/18	20:51	EBSDDV8	Still	EBSDDV8_007	223	2097.2	512 754.4	908 877.2	512 778.4	908 873.7	24.3	
16/09/18	20:56	EBSDDV8	Still	EBSDDV8_008	224	2097.4	512 754.4	908 877.2	512 776.5	908 876.7	22.1	
16/09/18	20:58	EBSDDV8	Still	EBSDDV8_009	225	2098.9	512 754.4	908 877.2	512 769.7	908 875.6	15.4	
16/09/18	20:58	EBSDDV8	Still	EBSDDV8_010	226	2099.0	512 754.4	908 877.2	512 766.9	908 878.9	12.6	
16/09/18	21:01	EBSDDV8	Still	EBSDDV8_011	227	2097.3	512 754.4	908 877.2	512 763.8	908 877.7	9.5	
16/09/18	21:04	EBSDDV8	Still	EBSDDV8_012	228	2099.7	512 754.4	908 877.2	512 758.9	908 876.5	4.6	
16/09/18	21:05	EBSDDV8	Still	EBSDDV8_013	229	2098.7	512 754.4	908 877.2	512 757.6	908 883.5	7.0	
16/09/18	21:08	EBSDDV8	Still	EBSDDV8_014	230	2098.5	512 754.4	908 877.2	512 761.9	908 878.9	7.7	
16/09/18	21:10	EBSDDV8	Still	EBSDDV8_015	231	2098.7	512 754.4	908 877.2	512 749.4	908 879.7	5.6	
16/09/18	21:12	EBSDDV8	Still	EBSDDV8_016	232	2096.3	512 754.4	908 877.2	512 751.1	908 875.7	3.6	
16/09/18	21:13	EBSDDV8	Still	EBSDDV8_017	233	2098.3	512 754.4	908 877.2	512 755.1	908 884.0	6.8	
16/09/18	21:14	EBSDDV8	Still	EBSDDV8_018	234	2097.6	512 754.4	908 877.2	512 750.6	908 878.7	4.0	
16/09/18	21:16	EBSDDV8	Still	EBSDDV8_019	235	2097.0	512 754.4	908 877.2	512 749.6	908 884.1	8.3	
16/09/18	21:18	EBSDDV8	Still	EBSDDV8_020	236	2095.9	512 754.4	908 877.2	512 743.1	908 881.1	11.9	
16/09/18	21:18	EBSDDV8	Still	EBSDDV8_021	237	2095.7	512 754.4	908 877.2	512 747.0	908 883.5	9.7	
16/09/18	21:20	EBSDDV8	Still	EBSDDV8_022	238	2096.1	512 754.4	908 877.2	512 747.7	908 882.0	8.2	
16/09/18	21:21	EBSDDV8	Still	EBSDDV8_023	239	2098.3	512 754.4	908 877.2	512 740.8	908 882.5	14.5	
16/09/18	21:22	EBSDDV8	Still	EBSDDV8_024	240	2097.3	512 754.4	908 877.2	512 744.7	908 883.9	11.8	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
16/09/18	21:26	EBSDDV8	Still	EBSDDV8_025	241	2097.2	512 754.4	908 877.2	512 736.2	908 883.1	19.1	
16/09/18	21:28	EBSDDV8	Still	EBSDDV8_026	242	2098.6	512 754.4	908 877.2	512 729.3	908 886.5	26.7	
16/09/18	21:28	EBSDDV8	Video	EOL	243	2098.0	512 754.4	908 877.2	512 729.7	908 887.5	26.7	
17/09/18	10:48	EBSBC8	BC	FA, FB, PC	-	2090.0	512 754.4	908 877.2	512 761.0	908 871.0	9.1	
21/09/18	11:57	EBSWS7	WS	Bottom	-	1802.4	493 677.3	903 163.9	493 674.6	903 147.5	16.6	1st attempt
21/09/18	15:39	EBSWS7	WS	Bottom	-	1802.8	493 677.3	903 163.9	493 678.5	903 177.4	13.5	2nd attempt
21/09/18	17:31	EBSWS7	WS	Bottom	-	1802.3	493 677.3	903 163.9	493 677.2	903 170.8	6.9	3rd attempt
21/09/18	18:35	EBSWS7	WS	Middle	-	420.0	493 677.3	903 163.9	493 501.1	903 261.7	201.5	
21/09/18	19:10	EBSWS7	WS	Surface	-	10.0	493 677.3	903 163.9	493 671.9	903 167.2	6.3	
21/09/18	21:48	EBSWS5	WS	Bottom	-	1894.0	496 384.9	906 337.6	496 381.4	906 335.3	4.2	
22/09/18	00:13	EBSWS5	WP	Profile	-	1902.0	496 384.9	906 337.6	496 375.8	906 334.6	9.6	CTD 15 m off seabed
22/09/18	00:41	EBSWS5	WS	Middle	-	427.8	496 384.9	906 337.6	496 210.8	906 421.9	193.4	
22/09/18	02:17	EBSWS5	WS	Surface	-	10.0	496 384.9	906 337.6	496 384.8	906 338.3	0.7	
22/09/18	05:35	EBSWS1	WS	Bottom	-	2015.7	500 166.9	911 657.3	500 171.4	911 673.2	16.6	
22/09/18	08:01	EBSWS1	WP	Profile	-	2014.0	500 166.9	911 657.3	500 151.3	911 654.0	16.0	CTD 15 m off seabed
22/09/18	08:27	EBSWS1	WS	Middle	-	522.9	500 166.9	911 657.3	500 006.1	911 751.9	186.6	
22/09/18	09:12	EBSWS1	WS	Surface	-	10.0	500 166.9	911 657.3	500 164.0	911 658.7	3.2	
22/09/18	11:31	EBSWS2	WS	Bottom	-	2055.6	505 560.5	909 795.3	505 547.2	909 801.9	14.8	
22/09/18	14:09	EBSWS2	WP	Profile	-	2056.0	505 560.5	909 795.3	505 562.2	909 813.8	18.6	CTD 15 m off seabed
22/09/18	14:46	EBSWS2	WS	Middle	-	533.0	505 560.5	909 795.3	505 402.2	909 903.7	191.8	
22/09/18	15:39	EBSWS2	WS	Surface	-	10.0	505 560.5	909 795.3	505 558.2	909 799.8	5.0	
22/09/18	15:45	EBSWS2	WS	Surface	-	10.0	505 560.5	909 795.3	505 559.9	909 798.5	3.3	
22/09/18	18:28	EBSWS6	WP	Bottom	-	1955.0	502 198.9	906 781.5	502 210.7	906 792.3	16.1	
22/09/18	20:47	EBSWS6	WS	Profile	-	1970.0	502 198.9	906 781.5	502 187.5	906 773.6	13.9	CTD 15 m off seabed
22/09/18	21:30	EBSWS6	WS	Middle	-	535.0	502 198.9	906 781.5	502 025.4	906 848.7	186.1	
22/09/18	22:30	EBSWS6	WS	Surface	-	10.0	502 198.9	906 781.5	502 190.3	906 783.8	8.9	
23/09/18	00:59	EBSWS3	WS	Bottom	-	1896.7	503 091.1	902 979.6	503 093.1	902 966.2	13.6	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
23/09/18	03:00	EBSWS3	WP	Profile	-	1896.4	503 091.1	902 979.6	503 092.5	902 990.7	11.2	CTD 15 m off seabed
23/09/18	03:25	EBSWS3	WS	Middle	-	424.7	503 091.1	902 979.6	502 935.3	903 059.6	175.2	
23/09/18	04:14	EBSWS3	WS	Surface	-	10.0	503 091.1	902 979.6	503 088.2	902 981.4	3.5	
23/09/18	06:50	EBSWS4	WS	Bottom	-	1917.0	508 613.5	901 724.2	508 620.8	901 735.4	13.4	
23/09/18	08:43	EBSWS4	WP	Profile	-	1918.4	508 613.5	901 724.2	508 604.3	901 733.5	13.0	CTD 15 m off seabed
23/09/18	09:07	EBSWS4	WS	Middle	-	526.2	508 613.5	901 724.2	508 470.2	901 785.1	155.6	
23/09/18	19:51	EBSWS4	WS	Surface	-	10.0	508 613.5	901 724.2	508 607.0	901 725.6	6.7	
23/09/18	12:32	EBSWS8	WS	Bottom	-	2074.0	512 754.4	908 877.2	512 745.5	908 873.7	9.5	
23/09/18	15:04	EBSWS8	WP	Profile	-	2073.0	512 754.4	908 877.2	512 750.6	908 884.7	8.4	CTD 15 m off seabed
23/09/18	15:40	EBSWS8	WS	Middle	-	535.0	512 754.4	908 877.2	512 589.0	908 966.5	187.9	
23/09/18	16:51	EBSWS8	WS	Surface	-	10.0	512 754.4	908 877.2	512 753.0	908 879.9	3.0	
25/09/18	16:40	EBSDDV36	Video	SOL	244	1950.1	499 637.7	906 889.6	499 672.2	906 888.2	34.4	
25/09/18	16:42	EBSDDV36	Still	EBSDDV36_001	245	1950.2	499 637.7	906 889.6	499 668.0	906 888.1	30.3	
25/09/18	16:42	EBSDDV36	Still	EBSDDV36_002	246	1950.0	499 637.7	906 889.6	499 669.1	906 889.9	31.4	
25/09/18	16:44	EBSDDV36	Still	EBSDDV36_003	247	1950.6	499 637.7	906 889.6	499 662.1	906 892.7	24.5	
25/09/18	16:46	EBSDDV36	Still	EBSDDV36_004	248	1950.5	499 637.7	906 889.6	499 656.9	906 892.0	19.3	
25/09/18	16:47	EBSDDV36	Still	EBSDDV36_005	249	1951.8	499 637.7	906 889.6	499 654.1	906 895.3	17.3	
25/09/18	16:49	EBSDDV36	Still	EBSDDV36_006	250	1949.6	499 637.7	906 889.6	499 653.1	906 892.7	15.6	
25/09/18	16:50	EBSDDV36	Still	EBSDDV36_007	No fix	1951.9	499 637.7	906 889.6	499 635.3	906 891.6	3.1	
25/09/18	16:51	EBSDDV36	Still	EBSDDV36_008	252	1951.0	499 637.7	906 889.6	499 638.0	906 886.4	3.2	
25/09/18	16:52	EBSDDV36	Still	EBSDDV36_009	253	1948.6	499 637.7	906 889.6	499 644.2	906 888.6	6.5	
25/09/18	16:53	EBSDDV36	Still	EBSDDV36_010	254	1950.0	499 637.7	906 889.6	499 638.7	906 891.2	1.8	
25/09/18	16:54	EBSDDV36	Still	EBSDDV36_011	255	1948.4	499 637.7	906 889.6	499 642.1	906 894.1	6.2	
25/09/18	16:54	EBSDDV36	Still	EBSDDV36_012	256	1948.3	499 637.7	906 889.6	499 640.8	906 894.4	5.7	
25/09/18	16:56	EBSDDV36	Still	EBSDDV36_013	257	1947.9	499 637.7	906 889.6	499 632.4	906 894.6	7.3	
25/09/18	16:57	EBSDDV36	Still	EBSDDV36_014	258	1948.4	499 637.7	906 889.6	499 629.7	906 891.6	8.3	
25/09/18	16:58	EBSDDV36	Still	EBSDDV36_015	259	1949.3	499 637.7	906 889.6	499 624.5	906 894.7	14.2	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
25/09/18	16:58	EBSDDV36	Still	EBSDDV36_016	260	1948.2	499 637.7	906 889.6	499 625.8	906 890.2	12.0	
25/09/18	17:00	EBSDDV36	Still	EBSDDV36_017	261	1949.1	499 637.7	906 889.6	499 616.5	906 894.8	21.9	
25/09/18	17:01	EBSDDV36	Still	EBSDDV36_018	262	1949.4	499 637.7	906 889.6	499 614.7	906 896.5	24.1	
25/09/18	17:01	EBSDDV36	Still	EBSDDV36_019	263	1949.9	499 637.7	906 889.6	499 605.7	906 888.6	32.1	
25/09/18	17:01	EBSDDV36	Video	EOL	264	1952.8	499 637.7	906 889.6	499 600.0	906 892.8	37.9	
25/09/18	20:58	EBSDDV16	Video	SOL	265	1951.7	500 098.1	906 826.9	500 123.4	906 809.1	30.9	
25/09/18	21:06	EBSDDV16	Still	EBSDDV16_001	266	1952.1	500 098.1	906 826.9	500 106.8	906 813.7	15.8	
25/09/18	21:06	EBSDDV16	Still	EBSDDV16_002	267	1953.9	500 098.1	906 826.9	500 106.0	906 815.3	14.0	
25/09/18	21:08	EBSDDV16	Still	EBSDDV16_003	268	1952.3	500 098.1	906 826.9	500 106.8	906 816.1	13.8	
25/09/18	21:09	EBSDDV16	Still	EBSDDV16_004	269	1951.7	500 098.1	906 826.9	500 099.7	906 819.0	8.0	
25/09/18	21:10	EBSDDV16	Still	EBSDDV16_005	270	1952.5	500 098.1	906 826.9	500 092.6	906 816.0	12.2	
25/09/18	21:11	EBSDDV16	Still	EBSDDV16_006	271	1953.6	500 098.1	906 826.9	500 095.9	906 814.8	12.3	
25/09/18	21:12	EBSDDV16	Still	EBSDDV16_007	272	1951.8	500 098.1	906 826.9	500 095.3	906 817.1	10.2	
25/09/18	21:14	EBSDDV16	Still	EBSDDV16_008	273	1950.2	500 098.1	906 826.9	500 100.3	906 810.1	16.9	
25/09/18	21:15	EBSDDV16	Still	EBSDDV16_009	274	1950.7	500 098.1	906 826.9	500 095.2	906 813.1	14.1	
25/09/18	21:16	EBSDDV16	Still	EBSDDV16_010	275	1950.9	500 098.1	906 826.9	500 093.5	906 817.6	10.3	
25/09/18	21:16	EBSDDV16	Still	EBSDDV16_011	276	1952.8	500 098.1	906 826.9	500 085.6	906 815.7	16.7	
25/09/18	21:17	EBSDDV16	Still	EBSDDV16_012	277	1951.1	500 098.1	906 826.9	500 085.6	906 813.3	18.4	
25/09/18	21:18	EBSDDV16	Still	EBSDDV16_013	278	1952.4	500 098.1	906 826.9	500 086.5	906 816.8	15.3	
25/09/18	21:18	EBSDDV16	Still	EBSDDV16_014	279	1952.3	500 098.1	906 826.9	500 084.3	906 816.0	17.6	
25/09/18	21:19	EBSDDV16	Still	EBSDDV16_015	280	1950.5	500 098.1	906 826.9	500 086.5	906 816.8	15.4	
25/09/18	21:19	EBSDDV16	Still	EBSDDV16_016	281	1953.1	500 098.1	906 826.9	500 079.1	906 818.7	20.7	
25/09/18	21:20	EBSDDV16	Still	EBSDDV16_017	282	1952.3	500 098.1	906 826.9	500 078.2	906 818.2	21.7	
25/09/18	21:21	EBSDDV16	Still	EBSDDV16_018	283	1952.0	500 098.1	906 826.9	500 076.6	906 818.0	23.3	
25/09/18	21:22	EBSDDV16	Still	EBSDDV16_019	284	1952.2	500 098.1	906 826.9	500 078.8	906 823.3	19.6	
25/09/18	21:23	EBSDDV16	Video	EOL	285	1953.8	500 098.1	906 826.9	500 075.7	906 819.9	23.5	
02/10/18	12:31	EBSBC4	BC	FA, FB, PC	-	1941.3	508 613.5	901 724.2	508 609.3	901 723.1	4.3	

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E												
Date	Time [UTC-4]	Station	Type	Sample Rep/ Still No.	Fix No.	Water Depth [m MSL]	Proposed Location		Actual Location		Offset [m]	Notes
							Easting [m]	Northing [m]	Easting [m]	Northing [m]		
03/10/18	02:26	EBSBC3	BC	FA, FB, PC	-	1917.7	503 091.1	902 979.6	503 099.2	902 990.1	13.2	
03/10/18	05:06	EBSBC6	BC	FA, FB, PC	-	1976.8	502 198.9	906 781.5	502 203.2	906 793.7	13.0	
03/10/18	07:27	EBSBC2	BC	FA, FB, PC	-	2079.4	505 560.5	909 795.3	505 554.4	909 799.9	7.6	
04/10/18	01:22	EBSBC1	BC	FA, FB, PC	-	2074.6	500 166.9	911 657.3	500 160.6	911 659.0	6.5	
04/10/18	04:21	EBSBC5	BC	FA, FB, PC	-	1907.9	496 384.9	906 337.6	496 371.7	906 328.4	16.1	
04/10/18	06:42	EBSBC7	BC	FA, FB, PC	-	1817.5	493 677.3	903 163.9	493 679.8	903 140.8	23.2	

Notes:
UTC = Universal coordinated time
MSL = Mean Sea Level
BC = Box core
WS = Water sample
WP = Water profile
PC = Physico-chemical sample
FA/FB = Faunal sample A/B
SOL = Start of line
EOL = End of line

C.2 GRAB LOG

Date	Time [UTC-4]	Station	Sample Rep	Sample Depth [cm]	Temp [˚C]	Redox [mV]	pH	Sediment Description (including stratigraphy)				Comments (fauna, smell, bioturbation, debris)
								Depth [cm]	Sediment Type	Sediment Description	Colour (Munsell)	
17/09/18	06:06	EBSBC8	FA/FB/PC	21	24.8	138	8.31	NL	sM	Mud with coarse sand and shell fragments	10YR/5/1	
					16.8	135	8.31					
					20.9	142	8.28					
02/10/18	12:31	EBSBC4	FA/FB/PC	28	21.6	140	8.56	NL	sM	Mud with coarse sand and shell fragments	10YR/5/3	Anthropogenic debris (rusted metal pieces)
					20.4	146	8.55					
					15.6	142	8.52					
03/10/18	02:26	EBSBC3	FA/FB/PC	21	21.6	140	8.56	NL	sM	Mud with coarse sand and shell fragments	10YR/5/3	
					20.4	146	8.55					
					15.6	142	8.52					
03/10/18	05:06	EBSBC6	FA/FB/PC	25	25.0	204	8.54	NL	sM	Mud with coarse sand and shell fragments	10YR/5/3	
					23.1	189	8.50					
					20.1	186	8.47					
03/10/18	07:28	EBSBC2	FA/FB/PC	21	26.4	126	8.97	NL	sM	Mud with coarse sand and shell fragments	10YR/5/3	
					23.0	120	8.95					
					21.2	122	8.91					
04/10/18	01:22	EBSBC1	FA/FB/PC	34	25.7	99	8.81	NL	sM	Mud with coarse sand and shell fragments	10YR/5/3	
					24.1	98	8.80					
					22.4	95	8.76					
04/10/18	04:21	EBSBC5	FA/FB/PC	22	21.6	126	8.81	NL	sM	Mud with coarse sand and shell fragments. Some consolidated material	10YR/5/3	Three crinoids, and some sponges. Wood debris?
					19.9	105	8.80					
					18.9	107	8.78					
04/10/18	06:42	EBSBC7	FA/FB/PC	25	26.4	130	8.91	NL	sM	Mud with coarse sand and shell fragments	10YR/5/3	
					24.7	127	8.90					
					19.9	114	8.87					

Notes:
UTC = Coordinated Universal Time
NL = No layering
PC = Physico-chemical sample
sM = Sandy mud
FA/FB = Faunal sample A/B

C.3 VIDEO AND PHOTOGRAPHIC LOG

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E										
Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna / Bioturbation / Debris
					Easting [m]	Northing [m]				
15/09/2018	EBSDDV1	EBSDDV1	SOL	01:14:13	500 145.4	911 642.8	49	19	Muddy sand with shell fragments	Aggregations of sea cucumbers *(Benthodytes* sp.), shrimp (Caridea), brittlestar (Ophiuroidea)
			EOL	01:25:37	500 178.1	911 679.5				
15/09/2018	EBSDDV2	EBSDDV2	SOL	18:55:45	505 583.0	909 801.1	47	17	Muddy sand with shell fragments	Sea cucumbers (*Benthodytes* sp.), shrimp (Caridea), starfish (Asteroidea), anemone (Actiniaria), xenophyophores (Xenophyophoroidea)
			EOL	19:33:06	505 536.7	909 793.0				
16/09/2018	EBSDDV3	EBSDDV3.1	SOL	04:10:38	503 090.1	902 999.8	10	17	Muddy sand with shell fragments	No fauna observed
			EOL	04:13:33	503 083.5	903 007.6				
		EBSDDV3.2	SOL	04:44:13	503 070.2	902 970.6	44		Muddy sand with shell fragments	Starfish (Asteroidea), anemone (Actiniaria)
			EOL	04:54:43	503 113.9	902 969.0				
16/09/2018	EBSDDV4	EBSDDV4	SOL	09:21:33	508 612.9	901 719.4	20	10	Muddy sand with shell fragments	No fauna observed
			EOL	09:27:51	508 603.4	901 736.8				
14/09/2018	EBSDDV5	EBSDDV5	SOL	20:54:59	496 409.6	906 364.4	62	18	Muddy sand, with occasional small areas of hard substrate	Sea cucumbers (*Benthodytes* sp.), brittlestars (Ophiuroidea), sponges (Porifera), anemones (Actiniaria) and starfish (Asteroidea, including Brisingidae), faunal turf (Bryozoa and Hydrozoa)
			EOL	21:26:22	496 369.9	906 317.4				
15/09/2018	EBSDDV6	EBSDDV6	SOL	23:07:28	502 217.5	906 797.7	44	14	Muddy sand, with occasional small areas of hard substrate	Sponges (Porifera), starfish (Asteroidea including Brisingidae), shrimp (Caridea), brittlestar (Ophiuroidea) and faunal turf.
			EOL	23:25:36	502 211.7	906 753.8				
14/09/2018	EBSDDV7	EBSDDV7.1	SOL	16:44:01	493 697.7	903 154.2	11	18	Muddy sand, with occasional small areas of hard substrate	Sea cucumbers *(Benthodytes* sp.)
			EOL	16:48:51	493 687.2	903 158.7				
		EBSDDV7.2	SOL	16:48:57	493 696.8	903 154.4	52		Muddy sand, with occasional small areas of hard substrate	Shrimp (Caridea), sea cucumbers (*Benthodytes* sp.), brittlestars (Ophiuroidea), sponge (Porifera), tripod fish (Ipnopidae) .
			EOL	17:07:39	493 648.1	903 171.4				

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E										
Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna / Bioturbation / Debris
					Easting [m]	Northing [m]				
16/09/2018	EBSDDV8	EBSDDV8	SOL	20:33:46	512 796.8	908 871.3	69	26	Muddy sand with shell fragments	Aggregations of sea cucumbers (*Benthodytes* sp.), brittlestars (Ophiuroidea), starfish (Asteroidea), xenophyophores (Xenophyophoroidea), faecal casts
			EOL	21:28:54	512 729.7	908 887.5				
15/09/2018	EBSDDV9	EBSDDV9.1	SOL	05:43:14	502 533.2	917 524.3	4	17	Muddy sand with shell fragments	Sea cucumbers (*Benthodytes* sp.)
			EOL	05:47:49	502 537.5	917 524.6				
		EBSDDV9.2	SOL	05:50:47	502 537.2	917 521.3	26		Muddy sand with shell fragments	Sea cucumbers (*Benthodytes* sp.)
			EOL	06:01:12	502 548.4	917 498.1				
16/09/2018	EBSDDV10	EBSDDV10	SOL	13:16:29	513 127.3	900 667.5	50	28	Muddy sand with shell fragments	Starfish (Asteroidea), large shrimp/prawn (Caridea), anemones (Actiniaria), xenophyophores (Xenophyophoroidea)
			EOL	14:04:49	513 087.7	900 637.4				
15/09/2018	EBSDDV11	EBSDDV11.1	SOL	10:32:39	504 516.0	917 028.3	42	33	Muddy sand with shell fragments	Brittlestar (Ophiuroidea)
			EOL	10:51:07	504 551.2	917 005.5				
		EBSDDV11.2	SOL	13:02:37	504 535.9	917 022.4	22		Muddy sand with shell fragments	Sea cucumbers (*Benthodytes* sp.)
			EOL	13:42:38	504 517.1	917 011.6				
25/09/2018	EBSDDV16	EBSDDV16	SOL	20:58:38	500 123.4	906 809.1	49	19	Muddy sand with shell fragments	Sea cucumbers (*Benthodytes* sp.), brittlestars (Ophiuroidea), crinoids (Crinoidea), starfish (Asteroidea including Brisingidae), xenophyophores (Xenophyophoroidea), stalked crinoid (Isocrinida), Bryozoans, faunal turf
			EOL	21:23:07	500 075.7	906 819.9				

Geodetic Parameters: Geodetic Parameters: ED50, UTM Zone 31N, 3°E										
Date	Transect/ Station	Video File	Point on Line	Time [UTC]	Video Coordinates		Length [m]	Still Nos.	Sediment Description	Fauna / Bioturbation / Debris
					Easting [m]	Northing [m]				
25/09/2018	EBSDDV36	EBSDDV36	SOL	16:40:31	499 672.2	906 888.2	72	19	Muddy sand, with occasional small areas of hard substrate	Sea cucumbers (*Benthodytes* sp.), xenophyophores (Xenophyophoroidea), starfish (Asteroidea), unidentified fish (Pisces), brittlestars (Ophiuroidea), anemones (Actiniaria), pencil urchin (Cidaridae), shrimp (Caridea), sponges (Porifera including *Polymastia* sp.), faecal casts
			EOL	17:02:09	499 600.0	906 892.8				

Notes:
UTC = Coordinated Universal Time
SOL = Start of line
EOL = End of line

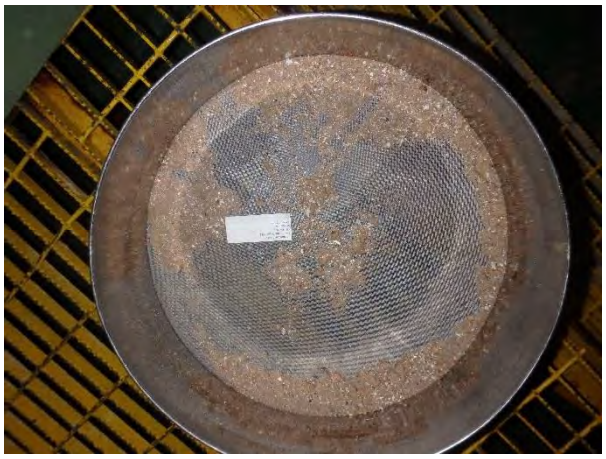
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D. SEDIMENT PARTICLE SIZE AND GRAB SAMPLE PHOTOGRAPHS

STATION EBSBC1



Easting: 500 160.6 mE **Depth:** 2074.6 m MSL
Northing: 911 659.0 mN **Sediment Type:** Slightly gravelly muddy sand



Easting: 500 160.6 mE **Depth:** 2074.6 m MSL
Northing: 911 659.0 mN **Sediment Type:** Slightly gravelly muddy sand



Easting: 500 160.6 mE **Depth:** 2074.6 m MSL
Northing: 911 659.0 mN **Sediment Type:** Slightly gravelly muddy sand

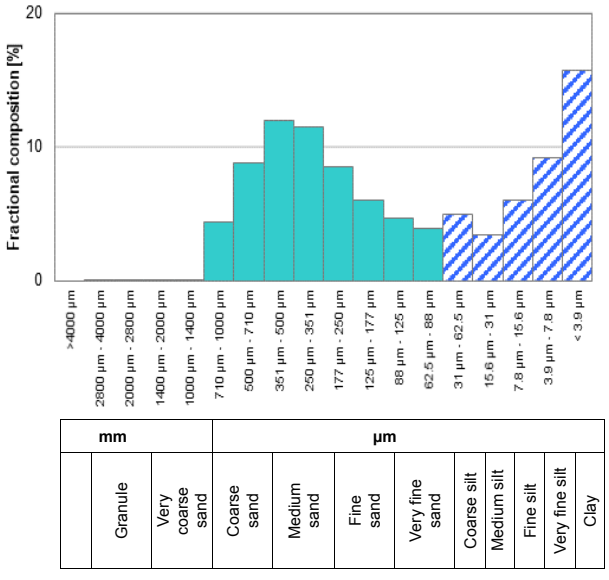
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.01	0.01
2000	-1.00	0.07	0.08
1400	-0.49	0.15	0.23
1000	0.00	0.13	0.35
707	0.49	4.46	4.82
500	1.00	8.87	13.7
354	1.51	12.0	25.7
250	2.00	11.5	37.2
177	2.50	8.58	45.7
125	3.00	6.03	51.8
88.0	3.51	4.74	56.5
62.5	4.00	3.93	60.4
31.2	5.01	5.02	65.4
15.6	6.00	3.50	68.9
7.81	7.00	6.09	75.0
3.91	8.00	9.25	84.3
< 3.91	> 8.00	15.7	100
Total		**100**	**100**

STATISTICS

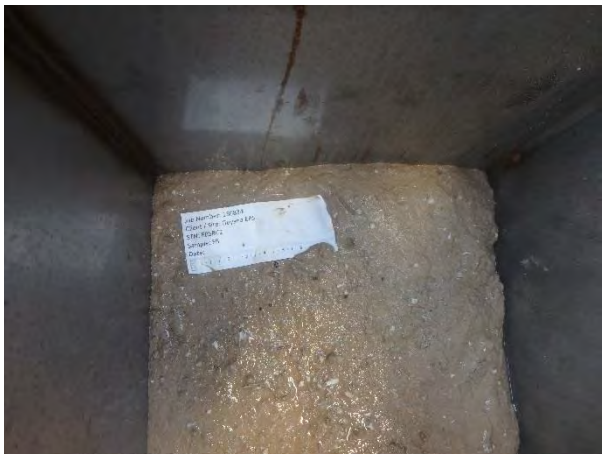
Sorting	3.07	Very poorly sorted
Skewness	0.602	Fine skewed
Mean [µm]	61.0	Coarse silt
Mean [phi]	4.04	
Gravel [%]	0.08	Slightly gravelly muddy sand
Sand [%]	60.4	
Mud [%]	39.6	

PARTICLE SIZE DISTRIBUTION



mm			µm							
	Granule	Very coarse sand	Coarse sand	Medium sand	Fine sand	Very fine sand	Coarse silt	Medium silt	Fine silt	Very fine silt	Clay

STATION EBSBC2



Easting: 505 554.4mE
Depth: 2079.4 m MSL
Northing: 909 799.9 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 505 554.4mE
Depth: 2079.4 m MSL
Northing: 909 799.9 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 505 554.4mE
Depth: 2079.4 m MSL
Northing: 909 799.9 mN
Sediment Type: Slightly gravelly muddy sand

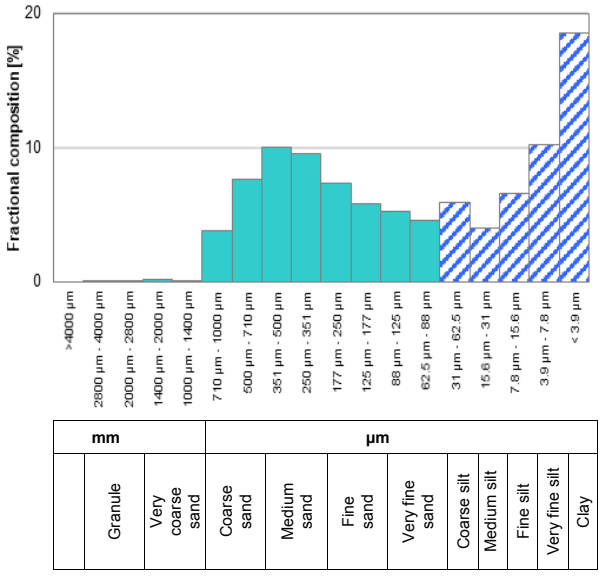
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.03	0.03
2000	-1.00	0.03	0.05
1400	-0.49	0.19	0.25
1000	0.00	0.11	0.36
707	0.49	3.87	4.23
500	1.00	7.65	11.9
354	1.51	10.1	22.0
250	2.00	9.54	31.5
177	2.50	7.40	38.9
125	3.00	5.88	44.8
88.0	3.51	5.26	50.1
62.5	4.00	4.59	54.7
31.2	5.01	5.94	60.6
15.6	6.00	4.04	64.6
7.81	7.00	6.58	71.2
3.91	8.00	10.3	81.5
< 3.91	> 8.00	18.5	100
Total		**100**	**100**

STATISTICS

Sorting	3.13	Very poorly sorted
Skewness	0.414	Symmetrical
Mean [µm]	46.8	Coarse silt
Mean [phi]	4.42	
Gravel [%]	0.05	Slightly gravelly muddy sand
Sand [%]	54.6	
Mud [%]	45.3	

PARTICLE SIZE DISTRIBUTION



STATION EBSBC3



Easting: 503 099.2 mE
Depth: 1917.7 m MSL
Northing: 902 990.1 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 503 099.2 mE
Depth: 1917.7 m MSL
Northing: 902 990.1 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 503 099.2 mE
Depth: 1917.7 m MSL
Northing: 902 990.1 mN
Sediment Type: Slightly gravelly muddy sand

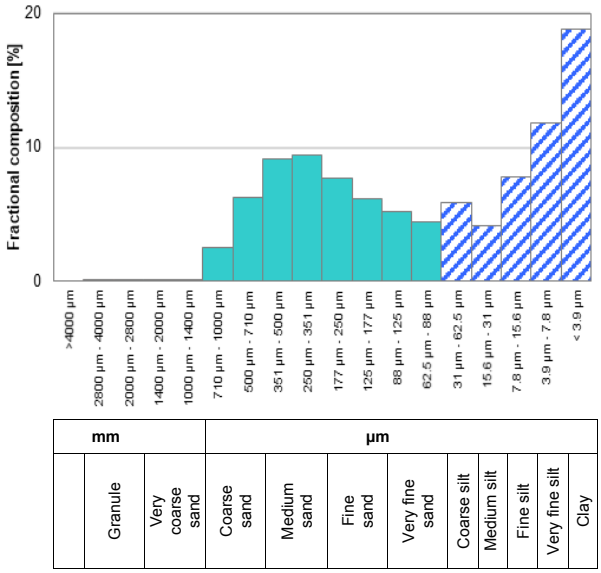
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.09	0.09
2000	-1.00	0.15	0.24
1400	-0.49	0.15	0.39
1000	0.00	0.11	0.50
707	0.49	2.57	3.07
500	1.00	6.25	9.32
354	1.51	9.13	18.5
250	2.00	9.39	27.8
177	2.50	7.75	35.6
125	3.00	6.15	41.7
88.0	3.51	5.25	47.0
62.5	4.00	4.49	51.5
31.2	5.01	5.89	57.4
15.6	6.00	4.21	61.6
7.81	7.00	7.78	69.4
3.91	8.00	11.8	81.2
< 3.91	> 8.00	18.8	100
Total		**100**	**100**

STATISTICS

Sorting	3.08	Very poorly sorted
Skewness	0.299	Symmetrical
Mean [µm]	40.7	Coarse silt
Mean [phi]	4.62	
Gravel [%]	0.24	Slightly gravelly muddy sand
Sand [%]	51.2	
Mud [%]	48.5	

PARTICLE SIZE DISTRIBUTION



STATION EBSBC4



Easting: 508 609.3mE **Depth:** 1941.3 m MSL
Northing: 901 723.1 mN **Sediment Type:** Muddy sand



Easting: 508 609.3mE **Depth:** 1941.3 m MSL
Northing: 901 723.1 mN **Sediment Type:** Muddy sand



Easting: 508 609.3mE **Depth:** 1941.3 m MSL
Northing: 901 723.1 mN **Sediment Type:** Muddy sand

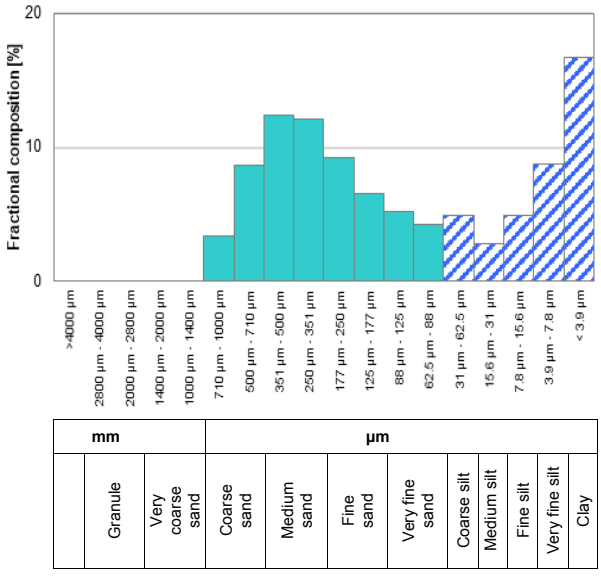
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.00	0.00
1400	-0.49	0.00	0.00
1000	0.00	0.00	0.00
707	0.49	3.43	3.43
500	1.00	8.66	12.1
354	1.51	12.4	24.5
250	2.00	12.1	36.6
177	2.50	9.22	45.8
125	3.00	6.60	52.4
88.0	3.51	5.20	57.6
62.5	4.00	4.22	61.8
31.2	5.01	4.97	66.8
15.6	6.00	2.78	69.6
7.81	7.00	4.97	74.5
3.91	8.00	8.72	83.2
< 3.91	> 8.00	16.8	100
Total		**100**	**100**

STATISTICS

Sorting	3.08	Very poorly sorted
Skewness	0.663	Fine skewed
Mean [µm]	60.4	Coarse silt
Mean [phi]	4.05	
Gravel [%]	0.00	Muddy sand
Sand [%]	61.8	
Mud [%]	38.2	

PARTICLE SIZE DISTRIBUTION



STATION EBSBC5



Easting: 496 371.7 mE
Depth: 1907.9 m MSL
Northing: 906 328.4 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 496 371.7 mE
Depth: 1907.9 m MSL
Northing: 906 328.4 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 496 371.7 mE
Depth: 1907.9 m MSL
Northing: 906 328.4 mN
Sediment Type: Slightly gravelly muddy sand

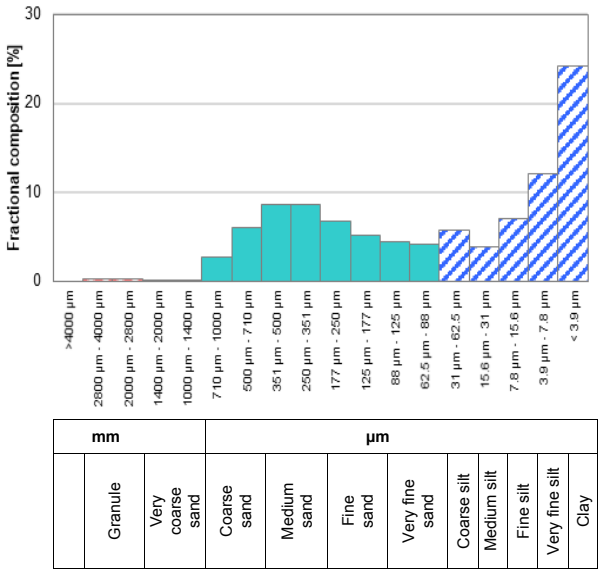
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.26	0.26
2000	-1.00	0.26	0.51
1400	-0.49	0.03	0.54
1000	0.00	0.05	0.60
707	0.49	2.72	3.32
500	1.00	5.99	9.31
354	1.51	8.63	17.9
250	2.00	8.67	26.6
177	2.50	6.79	33.4
125	3.00	5.12	38.5
88.0	3.51	4.47	43.0
62.5	4.00	4.12	47.1
31.2	5.01	5.72	52.8
15.6	6.00	3.87	56.7
7.81	7.00	7.04	63.8
3.91	8.00	12.1	75.9
< 3.91	> 8.00	24.1	100
Total		**100**	**100**

STATISTICS

Sorting	3.24	Very poorly sorted
Skewness	0.147	Symmetrical
Mean [µm]	32.2	Coarse silt
Mean [phi]	4.96	
Gravel [%]	0.51	Slightly gravelly muddy sand
Sand [%]	46.6	
Mud [%]	52.9	

PARTICLE SIZE DISTRIBUTION



STATION EBSBC6



Easting: 502 203.2 mE
Depth: 1976.8 m MSL
Northing: 906 793.7 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 502 203.2 mE
Depth: 1976.8 m MSL
Northing: 906 793.7 mN
Sediment Type: Slightly gravelly muddy sand



Easting: 502 203.2 mE
Depth: 1976.8 m MSL
Northing: 906 793.7 mN
Sediment Type: Slightly gravelly muddy sand

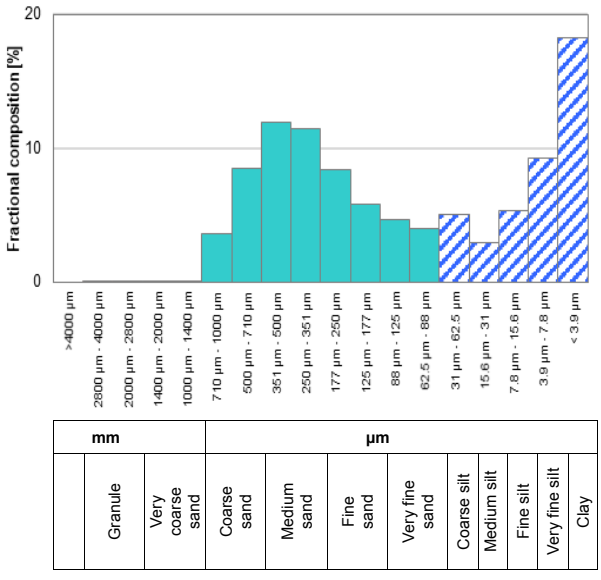
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.01	0.01
2000	-1.00	0.05	0.06
1400	-0.49	0.07	0.13
1000	0.00	0.04	0.17
707	0.49	3.67	3.83
500	1.00	8.49	12.3
354	1.51	12.0	24.3
250	2.00	11.5	35.8
177	2.50	8.48	44.3
125	3.00	5.86	50.2
88.0	3.51	4.72	54.9
62.5	4.00	4.07	59.0
31.2	5.01	5.13	64.1
15.6	6.00	2.99	67.1
7.81	7.00	5.35	72.4
3.91	8.00	9.30	81.7
< 3.91	> 8.00	18.3	100
Total		**100**	**100**

STATISTICS

Sorting	3.16	Very poorly sorted
Skewness	0.559	Fine skewed
Mean [µm]	54.2	Coarse silt
Mean [phi]	4.21	
Gravel [%]	0.06	Slightly gravelly muddy sand
Sand [%]	58.9	
Mud [%]	41.0	

PARTICLE SIZE DISTRIBUTION



STATION EBSBC7



Easting: 493 679.8 mE
Northing: 903 140.8 mN
Depth: 1817.5 m MSL
Sediment Type: Slightly gravelly muddy sand



Easting: 493 679.8 mE
Northing: 903 140.8 mN
Depth: 1817.5 m MSL
Sediment Type: Slightly gravelly muddy sand



Easting: 493 679.8 mE
Northing: 903 140.8 mN
Depth: 1817.5 m MSL
Sediment Type: Slightly gravelly muddy sand

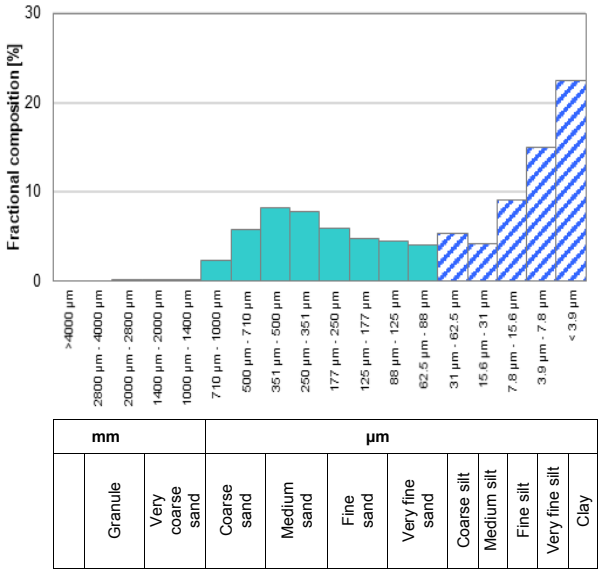
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.01	0.01
1400	-0.49	0.03	0.04
1000	0.00	0.04	0.08
707	0.49	2.40	2.48
500	1.00	5.76	8.23
354	1.51	8.23	16.5
250	2.00	7.90	24.4
177	2.50	6.02	30.4
125	3.00	4.81	35.2
88.0	3.51	4.51	39.7
62.5	4.00	4.11	43.8
31.2	5.01	5.33	49.1
15.6	6.00	4.23	53.4
7.81	7.00	9.19	62.6
3.91	8.00	15.0	77.5
< 3.91	> 8.00	22.5	100
Total		**100**	**100**

STATISTICS

Sorting	3.09	Very poorly sorted
Skewness	0.027	Symmetrical
Mean [µm]	29.3	Medium silt
Mean [phi]	5.09	
Gravel [%]	0.01	Slightly gravelly muddy sand
Sand [%]	43.8	
Mud [%]	56.2	

PARTICLE SIZE DISTRIBUTION



STATION EBSBC8



Easting: 512 761.0 mE
Northing: 908 871.0 mN
Depth: 2090.0 m MSL
Sediment Type: Slightly gravelly muddy sand



Easting: 512 761.0 mE
Northing: 908 871.0 mN
Depth: 2090.0 m MSL
Sediment Type: Slightly gravelly muddy sand



Easting: 512 761.0 mE
Northing: 908 871.0 mN
Depth: 2090.0 m MSL
Sediment Type: Slightly gravelly muddy sand

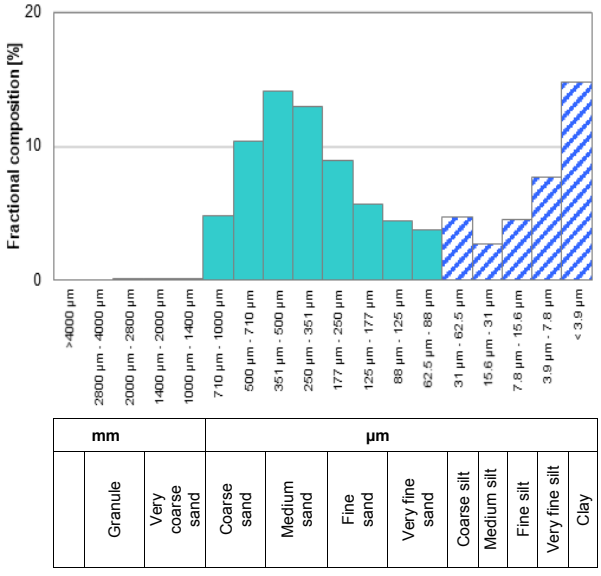
FRACTIONAL DATA

Aperture [µm]	Aperture [phi]	Fractional [%]	Cumulative [%]
4000	-2.00	0.00	0.00
2800	-1.49	0.00	0.00
2000	-1.00	0.02	0.02
1400	-0.49	0.08	0.11
1000	0.00	0.06	0.17
707	0.49	4.81	4.97
500	1.00	10.4	15.4
354	1.51	14.1	29.5
250	2.00	13.0	42.5
177	2.50	8.95	51.4
125	3.00	5.73	57.1
88.0	3.51	4.44	61.6
62.5	4.00	3.82	65.4
31.2	5.01	4.75	70.2
15.6	6.00	2.69	72.9
7.81	7.00	4.57	77.4
3.91	8.00	7.75	85.2
< 3.91	> 8.00	14.8	100
Total		**100**	**100**

STATISTICS

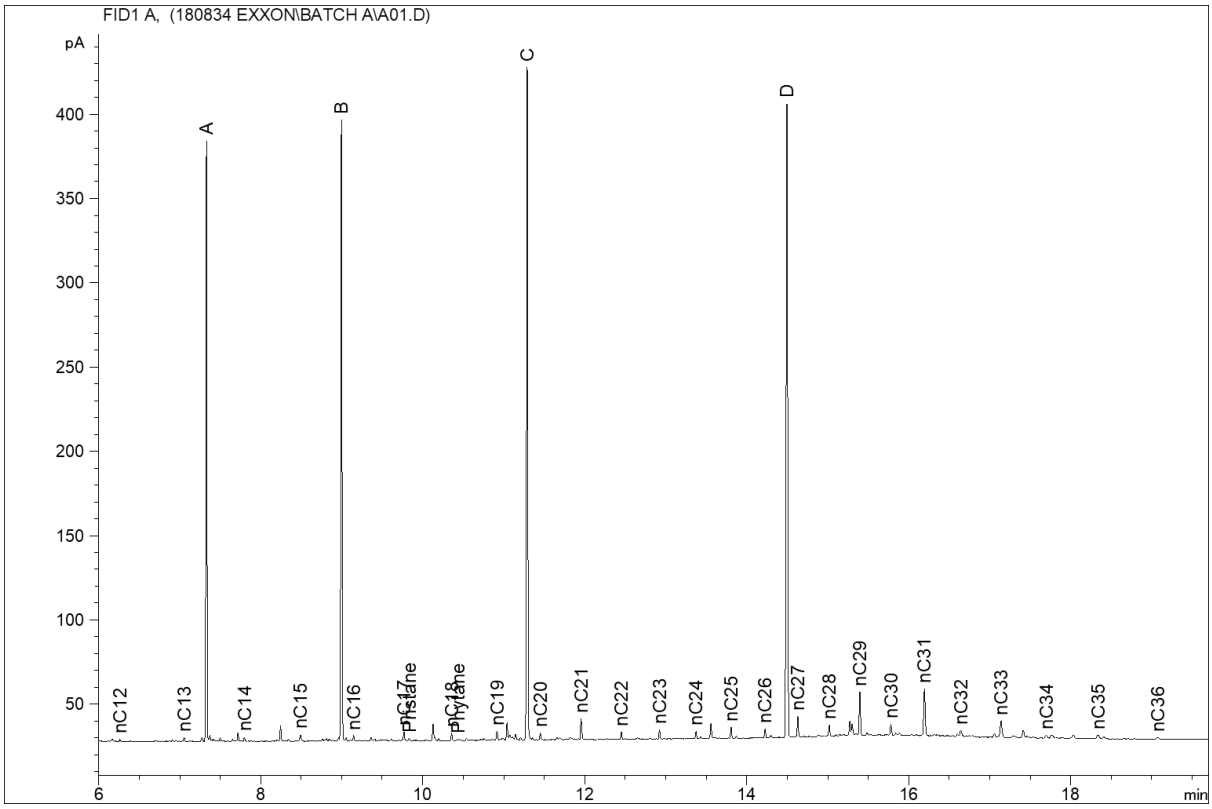
Sorting	3.04	Very poorly sorted
Skewness	0.797	Fine skewed
Mean [µm]	74.8	Very fine sand
Mean [phi]	3.74	
Gravel [%]	0.02	Slightly gravelly muddy sand
Sand [%]	65.4	
Mud [%]	34.6	

PARTICLE SIZE DISTRIBUTION

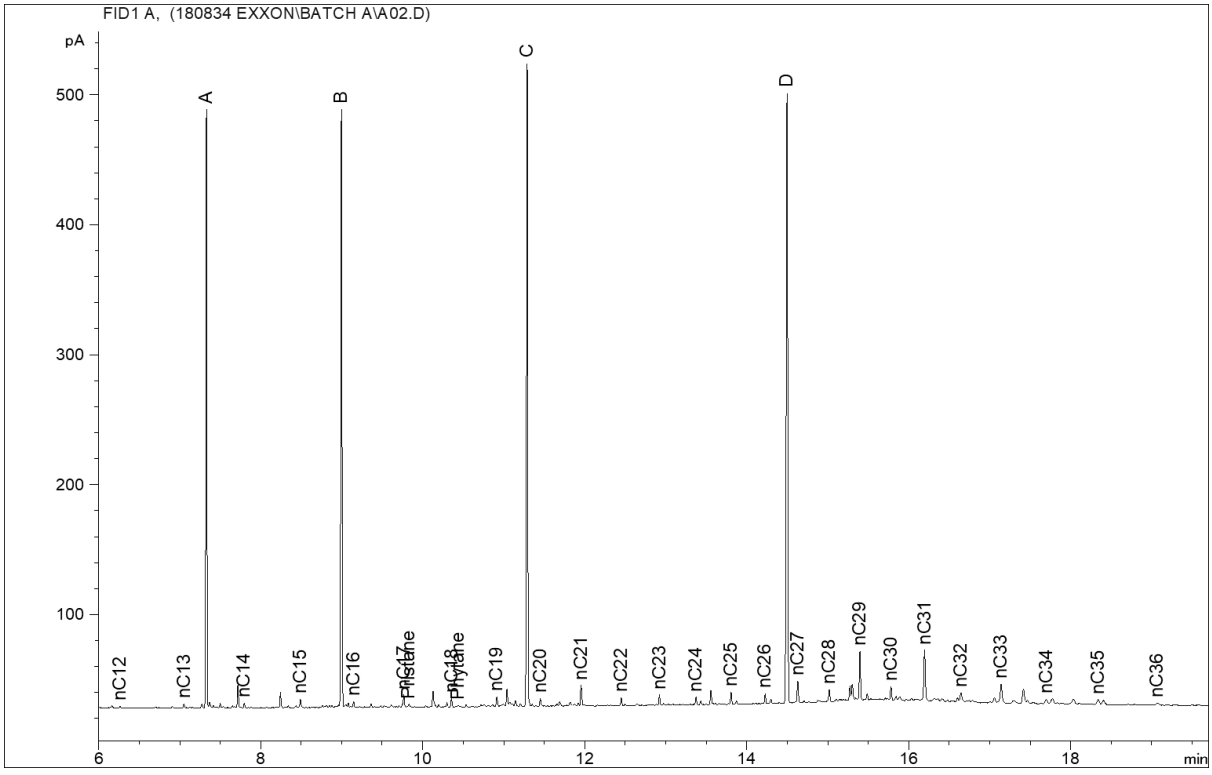


E. SEDIMENT HYDROCARBON ANALYSIS

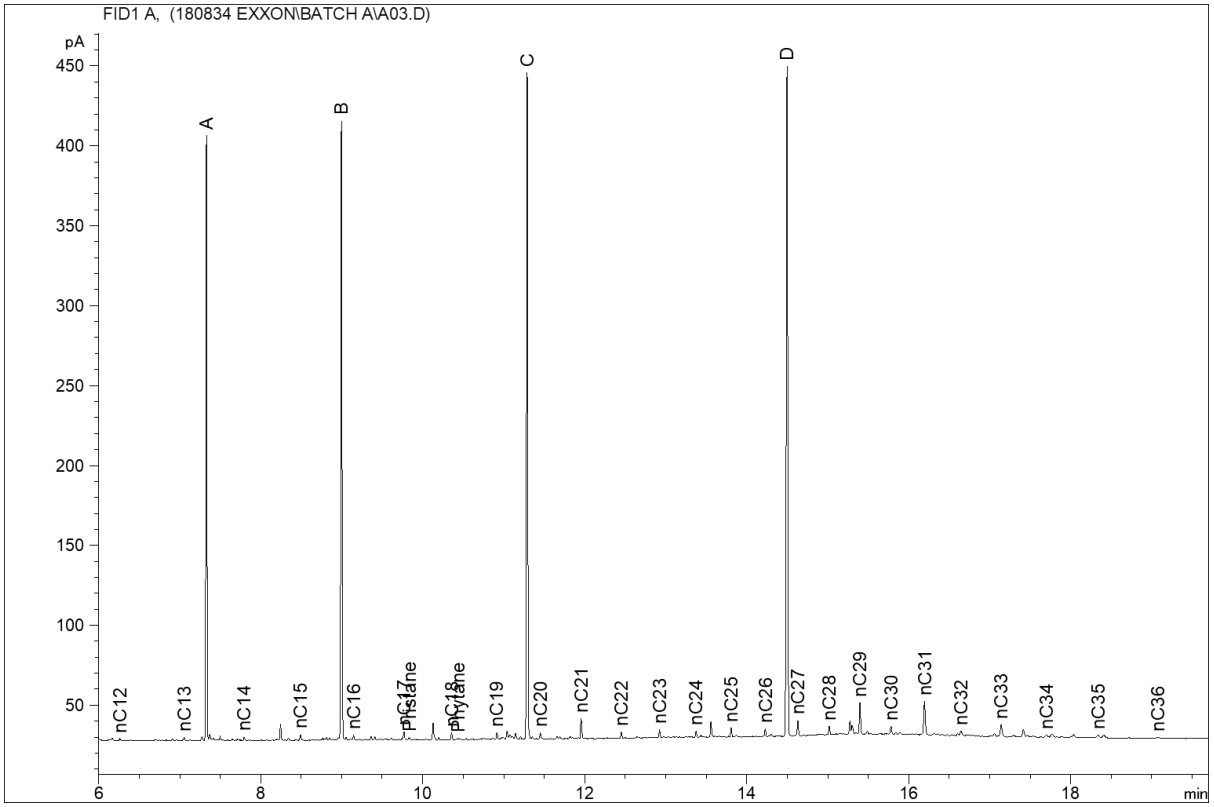
E.1 GAS CHROMATOGRAPHY TRACES



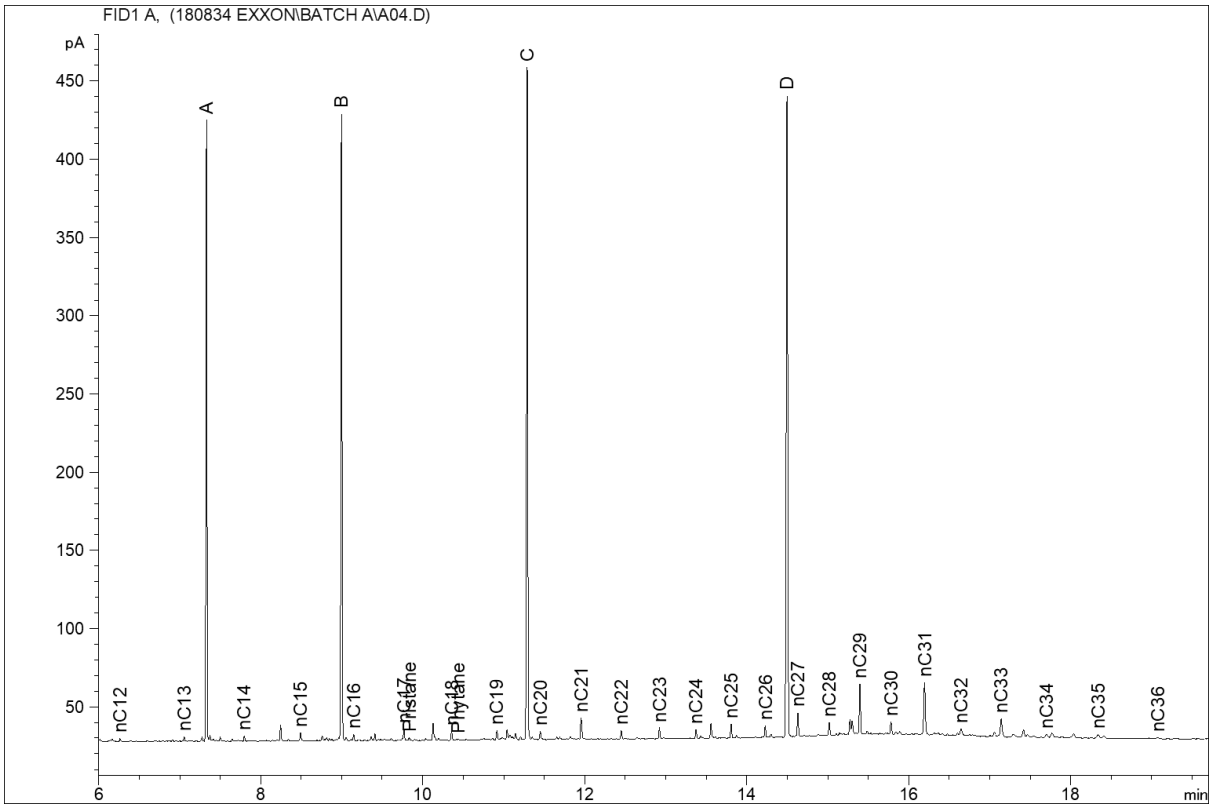
Station EBSBC1



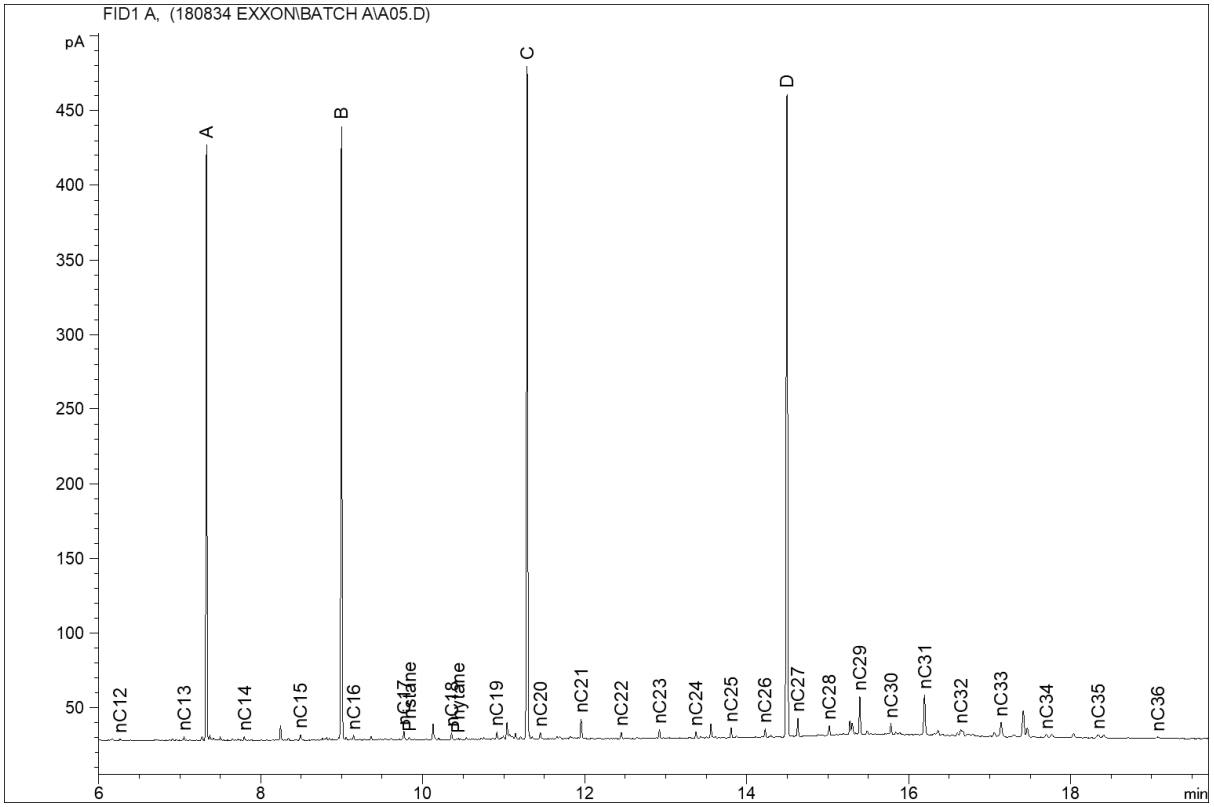
Station EBSBC2



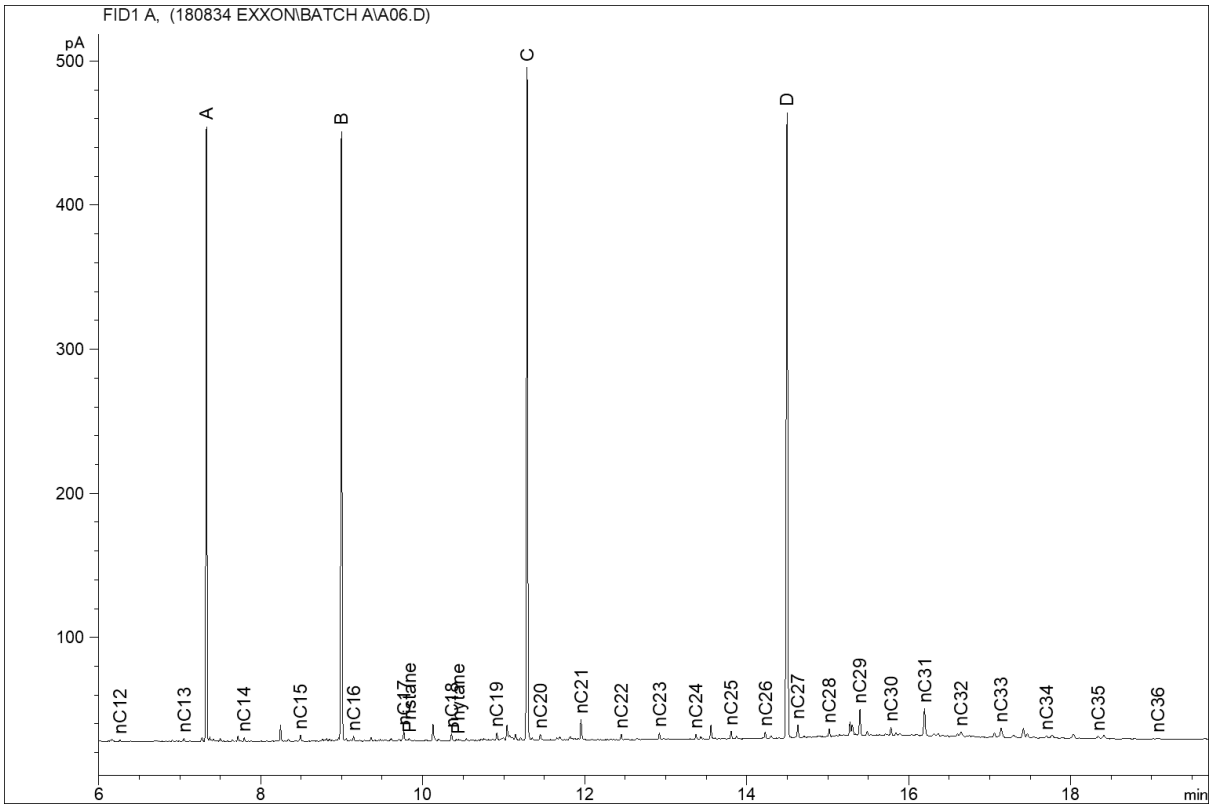
Station EBSBC3



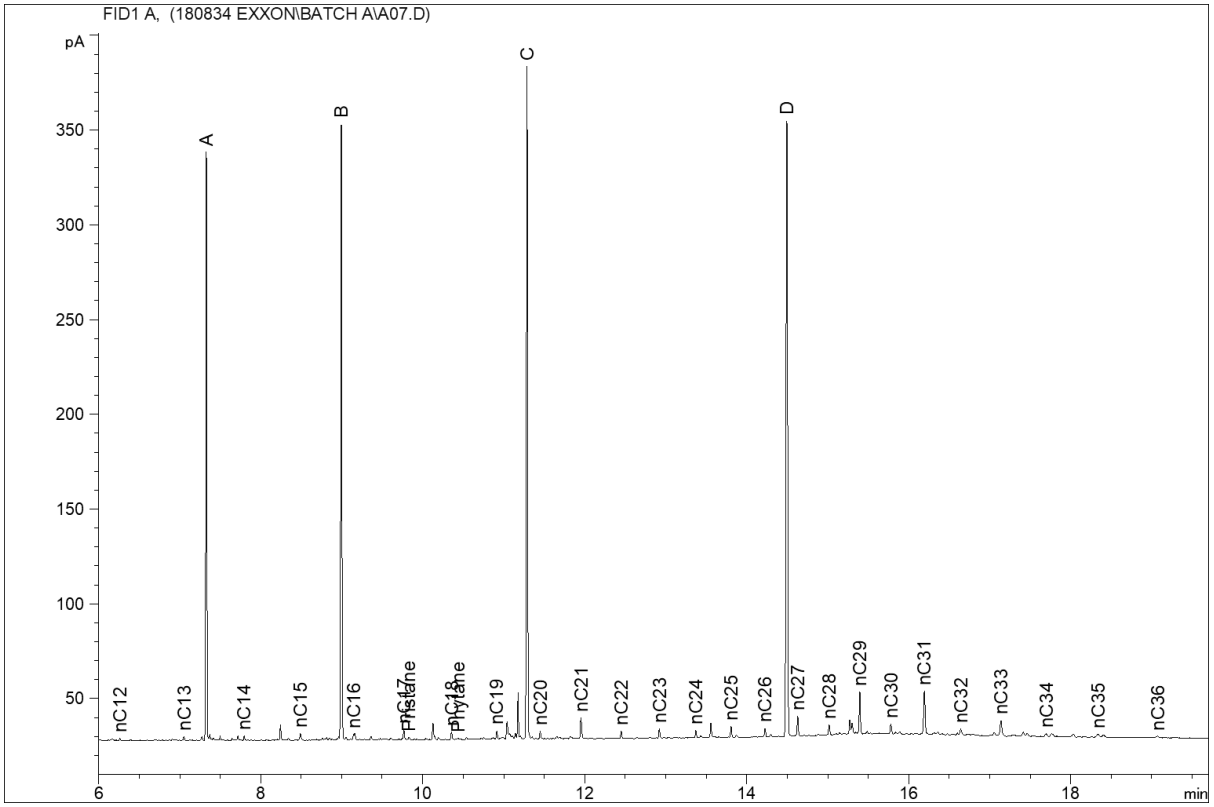
Station EBSBC4



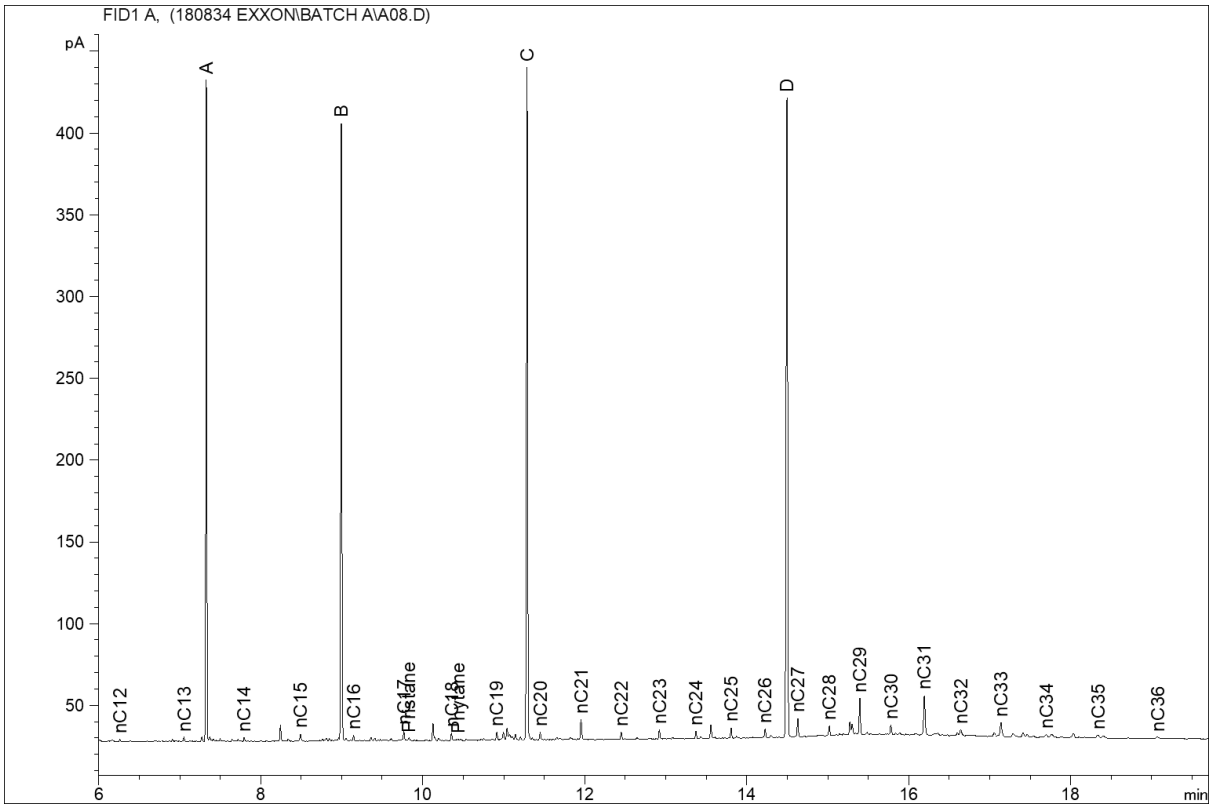
Station EBSBC5



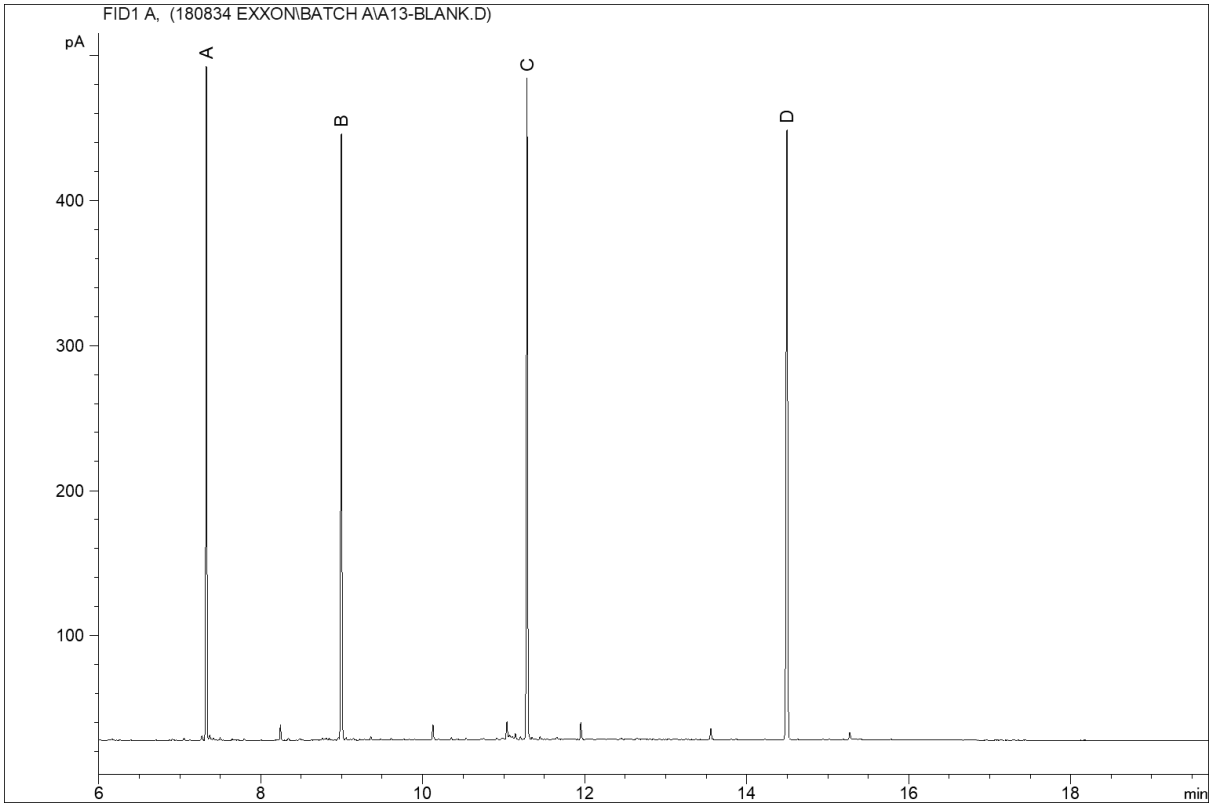
Station EBSBC6



Station EBSBC7



Station EBSBC8


FID1 A, (180834 EXXON\BATCH A\A13-BLANK.D)
pA
400
300
200
100
A
B
C
D
6
8
10
12
14
16
18
min

Blank

E.2 N-ALKANE CONCENTRATIONS

E.2.1 Sediment Samples

n-Alkane [ng/g]	Station No.							
	EBSBC1	EBSBC2	EBSBC3	EBSBC4	EBSBC5	EBSBC6	EBSBC7	EBSBC8
nC_{12}	0.5	0.6	0.5	0.7	0.6	0.4	0.6	0.6
nC_{13}	1.1	1.2	0.9	1.2	1.1	0.9	1.1	1.1
nC_{14}	1.1	1.5	1.0	1.2	1.1	1.0	1.2	1.1
nC_{15}	2.2	2.6	1.6	2.3	2.1	2.0	2.2	2.3
nC_{16}	1.5	1.8	1.5	1.8	1.6	1.5	1.7	1.6
nC_{17}	2.5	3.9	2.3	3.1	2.7	3.0	2.9	2.7
nC_{18}	2.0	2.7	2.0	2.6	2.2	2.2	2.3	2.2
nC_{19}	2.7	2.9	2.2	2.6	2.4	2.4	2.5	2.4
nC_{20}	1.9	2.2	1.7	2.2	2.1	1.8	2.2	2.1
nC_{21}	1.9	2.4	1.7	2.9	2.1	2.0	2.6	1.9
nC_{22}	1.9	2.2	1.7	2.0	2.0	1.6	2.0	1.8
nC_{23}	2.2	2.7	2.0	2.6	2.4	1.8	2.5	2.3
nC_{24}	1.7	2.1	1.6	2.1	1.8	1.4	1.9	1.9
nC_{25}	2.8	3.4	2.3	3.5	3.0	2.2	3.0	2.8
nC_{26}	2.2	2.6	2.0	2.8	2.2	1.8	2.4	2.2
nC_{27}	5.1	6.2	4.0	5.9	5.1	3.9	5.3	4.9
nC_{28}	2.7	3.4	2.2	3.3	3.0	2.1	2.8	2.5
nC_{29}	11.4	13.4	8.6	12.6	11.1	7.9	11.5	9.9
nC_{30}	3.2	4.3	2.6	3.7	3.3	2.6	3.2	2.9
nC_{31}	14.9	18.3	12.1	16.8	15.2	10.5	16.0	13.3
nC_{32}	2.0	3.7	2.2	2.8	2.4	2.5	2.5	2.4
nC_{33}	6.8	9.5	5.3	7.3	6.8	4.8	6.9	5.7
nC_{34}	1.4	2.3	1.0	1.4	1.5	1.2	1.5	1.2
nC_{35}	2.0	2.5	1.4	1.7	1.9	1.2	1.9	1.7
nC_{36}	1.0	1.8	0.8	0.6	1.0	0.8	1.3	1.0
Total n-alkane [µg/g]	**0.079**	**0.100**	**0.065**	**0.090**	**0.081**	**0.064**	**0.084**	**0.074**
Pristane [ng/g]	0.6	0.8	0.6	0.8	0.6	0.7	0.8	0.9
Phytane [ng/g]	0.3	0.4	0.3	0.3	0.3	0.2	0.3	0.3

Note:
Individual n-alkane, pristane and phytane concentrations expressed as ng/g of dry sediment
Total n-alkane concentrations expressed as µg/g of dry sediment
BC = Box core

E.2.2 Water Samples

n-Alkane [ng/L]	Station											
	EBSWS1 (Surface)	EBSWS1 (Mid)	EBSWS1 (Bottom)	EBSWS2 (Surface)	EBSWS2 (Mid)	EBSWS2 (Bottom)	EBSWS3 (Surface)	EBSWS3 (Mid)	EBSWS3 (Bottom)	EBSWS4 (Surface)	EBSWS4 (Mid)	EBSWS4 (Bottom)
nC_{12}	10.1	10.8	7.6	8.7	11.6	6.2	5.1	6.3	10.4	11.1	8.0	7.8
nC_{13}	24.6	20.8	19.0	20.2	28.0	16.2	16.2	13.5	18.1	15.6	18.5	22.1
nC_{14}	28.7	24.2	21.3	27.9	26.7	17.2	16.8	17.5	19.2	19.9	22.3	21.2
nC_{15}	119	12.8	13.6	130	13.2	13.2	76.5	10.2	59.4	129	36.2	30.9
nC_{16}	22.4	17.3	19.6	21.2	27.3	20.0	20.9	15.4	12.1	20.6	22.8	13.1
nC_{17}	96.1	20.9	13.2	108	10.1	14.7	76.9	12.5	9.1	153	17.4	8.7
nC_{18}	20.8	20.0	15.1	18.2	12.1	17.5	12.3	15.3	14.9	14.7	17.7	14.3
nC_{19}	7.6	12.5	9.1	11.3	12.7	12.4	7.9	9.5	9.0	9.1	8.7	9.0
nC_{20}	17.1	14.8	9.6	10.7	10.7	15.8	12.1	11.1	11.8	19.3	20.3	14.1
nC_{21}	96.1	94.6	94.4	111	110	100	86.9	100	84.4	97.3	90.8	96.0
nC_{22}	5.0	3.0	4.2	8.7	1.9	3.3	2.5	4.1	3.7	5.2	3.6	6.3
nC_{23}	3.7	2.8	5.5	2.6	6.2	4.4	5.0	4.9	2.3	3.1	4.7	4.8
nC_{24}	2.2	2.5	7.2	5.2	3.3	8.0	4.8	4.0	4.4	4.8	3.9	6.6
nC_{25}	2.7	3.5	8.2	4.6	5.3	5.4	4.8	6.0	2.5	3.1	3.9	6.9
nC_{26}	3.9	4.3	11.7	6.5	7.9	9.9	4.0	6.2	2.5	3.9	5.1	8.2
nC_{27}	12.5	8.7	25.5	22.1	24.1	1.5	1.9	15.8	3.1	5.7	4.0	16.3
nC_{28}	9.0	11.9	25.8	13.6	16.3	10.6	6.5	10.0	3.4	7.5	9.6	7.6
nC_{29}	15.5	12.1	34.0	9.4	15.1	12.7	8.2	6.4	1.8	9.2	9.8	8.6
nC_{30}	21.3	15.5	45.3	12.8	22.1	12.3	12.7	10.1	6.5	8.1	12.7	6.3
nC_{31}	27.8	22.9	53.0	12.4	29.5	14.1	12.4	6.4	7.3	10.5	14.5	4.7
nC_{32}	22.3	17.7	54.4	13.8	32.4	14.2	15.6	5.9	6.3	10.6	13.0	5.4
nC_{33}	23.7	20.4	49.9	18.3	38.0	13.8	16.5	10.1	3.5	7.5	13.0	4.7
nC_{34}	20.3	14.2	40.3	20.2	32.1	13.5	10.0	7.0	3.3	5.8	19.0	5.1
nC_{35}	6.8	13.0	29.0	12.8	28.3	11.4	5.2	5.6	2.0	5.9	10.4	3.1
nC_{36}	6.9	7.1	20.6	7.5	27.9	7.8	4.6	3.7	2.7	2.3	7.0	4.8
Total n-alkane [µg/L]	**0.626**	**0.408**	**0.637**	**0.637**	**0.553**	**0.376**	**0.447**	**0.318**	**0.304**	**0.583**	**0.397**	**0.336**
Pristane [ng/L]	5.8	8.1	13.7	6.7	18.2	3.3	6.8	10.4	5.4	9.9	6.3	7.7
Phytane [ng/L]	2.3	5.9	4.5	6.0	1.2	2.9	2.9	2.6	4.9	7.4	5.3	4.5

Notes:
Individual n-alkane, pristane and phytane concentrations expressed as ng/L
Total n-alkane concentrations expressed as µg/L
WS = Water sample

	Station											
n-Alkane [ng/L]	**EBSWS5 (Surface)**	**EBSWS5 (Mid)**	**EBSWS5 (Bottom)**	**EBSWS6 (Surface)**	**EBSWS6 (Mid)**	**EBSWS6 (Bottom)**	**EBSWS7 (Surface)**	**EBSWS7 (Mid)**	**EBSWS7 (Bottom)**	**EBSWS8 (Surface)**	**EBSWS8 (Mid)**	**EBSWS8 (Bottom)**
nC_{12}	3.0	6.1	4.1	6.7	3.2	5.7	7.4	5.2	5.6	5.2	6.2	5.8
nC_{13}	12.9	12.6	9.7	10.5	8.7	13.5	13.7	10.6	10.6	10.6	9.4	10.6
nC_{14}	13.5	15.9	16.1	15.8	10.7	16.0	15.4	16.6	15.7	17.2	13.5	10.6
nC_{15}	61.8	69.7	26.6	77.8	14.7	54.6	109	33.6	19.5	118	32.0	36.1
nC_{16}	12.4	11.2	11.0	15.0	8.9	9.0	13.6	10.4	13.5	12.9	6.1	11.2
nC_{17}	89.1	25.4	19.0	52.8	6.8	16.0	108	9.6	9.8	84.3	10.8	10.5
nC_{18}	14.0	13.5	16.4	17.3	12.6	18.2	12.4	16.7	12.2	15.8	12.0	11.1
nC_{19}	12.8	10.1	11.6	10.5	14.9	10.8	10.6	14.9	7.6	11.2	11.2	9.4
nC_{20}	14.1	15.6	20.0	14.9	12.2	15.6	15.7	16.8	14.7	17.6	15.1	17.6
nC_{21}	8.6	105	9.2	112	8.4	111	117	99.4	124	116	105	112
nC_{22}	5.7	6.7	10.1	2.3	5.0	7.7	5.8	5.0	9.2	6.3	7.3	5.4
nC_{23}	5.6	6.1	8.6	3.4	6.6	9.4	7.9	8.2	9.7	6.1	6.5	6.7
nC_{24}	6.4	6.2	9.3	3.1	5.6	9.6	7.2	6.5	12.0	26.1	5.6	6.1
nC_{25}	4.0	3.8	9.4	4.3	6.4	9.4	5.5	6.3	13.6	5.4	3.8	5.7
nC_{26}	5.4	7.1	12.6	5.5	6.2	10.6	11.7	10.9	20.7	5.9	3.5	7.2
nC_{27}	6.5	7.7	13.7	5.8	6.7	11.0	15.2	10.5	24.2	7.4	11.0	9.2
nC_{28}	12.1	14.7	21.7	4.8	10.0	12.9	29.9	17.0	43.7	9.0	12.5	8.6
nC_{29}	12.0	13.5	26.8	3.0	8.9	11.1	35.9	20.9	47.1	5.7	15.4	4.7
nC_{30}	17.3	21.8	30.9	7.0	8.9	11.4	45.6	23.9	56.2	11.2	19.5	3.7
nC_{31}	23.8	35.1	42.2	11.1	8.0	17.6	56.6	29.2	67.0	7.5	20.4	7.1
nC_{32}	25.0	33.0	37.8	6.3	9.6	11.7	48.8	24.0	61.4	9.7	20.6	4.5
nC_{33}	20.9	28.2	34.6	6.3	7.7	12.2	44.7	33.3	55.8	8.7	15.6	6.5
nC_{34}	24.2	25.6	31.9	3.0	10.5	9.4	38.3	25.9	37.0	8.9	9.0	10.0
nC_{35}	14.4	20.2	20.4	3.4	6.1	7.1	33.8	15.3	33.5	6.8	10.7	3.8
nC_{36}	12.3	15.3	16.7	1.3	11.1	8.5	25.9	15.8	31.0	5.7	7.8	3.0
Total n-alkane [µg/L]	**0.438**	**0.530**	**0.470**	**0.404**	**0.218**	**0.430**	**0.835**	**0.486**	**0.755**	**0.539**	**0.390**	**0.327**
Pristane [ng/L]	8.8	7.4	13.1	7.8	3.3	7.3	5.1	9.6	4.1	11.3	6.8	5.0
Phytane [ng/L]	5.1	3.9	5.8	4.9	3.9	7.5	7.5	7.0	4.8	6.6	6.0	4.4

Notes:
Individual n-alkane, pristane and phytane concentrations expressed as ng/L
Total n-alkane concentrations expressed as µg/L
WS = Water sample

E.3 AROMATIC HYDROCARBON CONCENTRATIONS

E.3.1 Sediment Samples

E.3.1.1 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/g]	Station								NOAA ERL (Buchman, 2008)	NOAA ERM (Buchman, 2008)
	EBSBC1	EBSBC2	EBSBC3	EBSBC4	EBSBC5	EBSBC6	EBSBC7	EBSBC8		
Naphthalene	0.1	0.1	0.1	0.4	0.1	0.1	0.1	0.3	**160**	**2100**
Acenaphthylene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**44**	**640**
Acenaphthene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**16**	**500**
Fluorene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**19**	**540**
Phenanthrene	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	**240**	**1500**
Anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**85.3**	**1100**
Fluoranthene	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	**600**	**5100**
Pyrene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	**665**	**2600**
Benzo(a)anthracene	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	**261**	**1600**
Chrysene	0.1	0.2	0.1	0.2	0.1	0.1	0.1	0.1	**384**	**2800**
Benzo(b)fluoranthene	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.3	-	-
Benzo(k)fluoranthene	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-	-
Benzo(a)pyrene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**430**	**1600**
Indeno(123cd)pyrene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-
Benzo(ghi)perylene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-	-
Dibenzo(ah)anthracene	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	**63.4**	**260**
Total US EPA 16	**1.1**	**1.5**	**1.0**	**1.5**	**1.3**	**1.1**	**1.0**	**1.3**	-	-

Notes:
Concentrations expressed as ng/g dry sediment
BC = Box core
ERL = Effects range low
ERM = Effects range median

Key:	Below ERL	Above ERL	Above ERM

E.3.1.2 Total 2 to 6 Ring PAH concentrations

PAH	Station							
	EBSBC1	EBSBC2	EBSBC3	EBSBC4	EBSBC5	EBSBC6	EBSBC7	EBSBC8
Naphthalene (128)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 128	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 128	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_3 128	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_4 128	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 128	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**
Phenanthrene/anthracene (178)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 178	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 178	1	1	< 1	1	1	1	1	1
C_3 178	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 178	**1**	**2**	**< 1**	**1**	**1**	**1**	**1**	**1**
Dibenzothiophene (184)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_3 184	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 184	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**
Fluoranthene/pyrene (202)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 202	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 202	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_3 202	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 202	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**
Benzanthracenes/ benzphenanthrenes (228)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 228	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 228	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 228	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**
m/z 252*	3	4	2	3	3	3	3	3
C_1 252	< 1	1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 252	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 252*	**3**	**5**	**2**	**3**	**3**	**3**	**3**	**3**
m/z 276†	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 276	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_2 276	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
TOTAL 276†	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**	**< 1**
NPD‡	**1**	**2**	**< 1**	**1**	**1**	**1**	**1**	**1**
% NPD	**25**	**29**	**NR**	**25**	**25**	**25**	**25**	**25**
Total 2 to 6 ring PAH	**4**	**7**	**2**	**4**	**4**	**4**	**4**	**4**

Notes:
BC = Box core
Concentrations expressed as ng/g dry sediment
NR = Not recorded
* = m/z 252 - benzfluoranthenes/benzpyrenes/perylene
† = m/z 276 - anthanthrene/indenopyrenes/benzperylenes
‡ = NPD - naphthalenes, phenanthrenes and dibenzothiophenes (totals)

E.3.2 Water Samples

E.3.2.1 United States Environmental Protection Agency (US EPA) 16 Polycyclic Aromatic Hydrocarbon (PAH) Concentrations

PAH [ng/L]	Station												NOAA Chronic Value (Buchman, 2008)
	EBSWS1 (Surface)	EBSWS1 (Mid)	EBSWS1 (Bottom)	EBSWS2 (Surface)	EBSWS2 (Mid)	EBSWS2 (Bottom)	EBSWS3 (Surface)	EBSWS3 (Mid)	EBSWS3 (Bottom)	EBSWS4 (Surface)	EBSWS4 (Mid)	EBSWS4 (Bottom)	
Naphthalene	2.2	1.7	1.9	1.9	2.2	1.9	1.4	1.5	1.8	1.6	1.5	1.5	**1400**
Acenaphthylene	0.2	0.1	0.1	< 0.1	0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	-
Acenaphthene	0.2	0.3	0.3	0.3	0.4	0.2	0.2	0.2	0.3	0.3	0.2	0.3	**40000**
Fluorene	0.3	0.3	0.3	0.3	0.5	0.3	0.2	0.2	0.2	0.2	0.3	0.3	-
Phenanthrene	0.7	0.6	0.7	0.7	0.7	0.7	0.6	0.6	0.5	0.7	0.6	0.7	**4600**
Anthracene	0.1	0.1	0.1	0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	0.1	0.1	0.1	-
Fluoranthene	0.2	0.1	0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.2	0.1	0.2	**11000**
Pyrene	0.3	0.2	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.4	0.4	0.2	-
Benzo(a)anthracene	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.2	0.3	0.3	0.4	0.2	-
Chrysene	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-
Benzo(b)fluoranthene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	0.1	0.1	-
Benzo(k)fluoranthene	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	-
Benzo(a)pyrene	0.1	0.1	0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	0.2	0.1	0.2	-
Indeno(123cd)pyrene	0.2	0.1	< 0.1	0.1	0.1	0.2	< 0.1	< 0.1	0.1	0.1	0.1	0.1	-
Benzo(ghi)perylene	0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	0.1	< 0.1	0.1	< 0.1	0.1	-
Dibenzo(ah)anthrace	0.2	0.1	0.1	0.1	0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	0.1	-
Total US EPA 16	**5.5**	**4.4**	**4.6**	**4.5**	**5.2**	**4.8**	**3.6**	**3.4**	**4.0**	**4.5**	**4.2**	**4.4**	-

PAH [ng/L]	Station												NOAA Chronic Value (Buchman, 2008)
	EBSWS5 (Surface)	EBSWS5 (Mid)	EBSWS5 (Bottom)	EBSWS6 (Surface)	EBSWS6 (Mid)	EBSWS6 (Bottom)	EBSWS7 (Surface)	EBSWS7 (Mid)	EBSWS7 (Bottom)	EBSWS8 (Surface)	EBSWS8 (Mid)	EBSWS8 (Bottom)	
Naphthalene	1.5	1.5	1.8	1.5	1.6	1.4	1.6	1.3	1.4	1.6	1.2	1.6	**1400**
Acenaphthylene	0.1	0.1	0.1	0.1	0.1	0.1	< 0.1	0.1	0.1	0.1	< 0.1	0.1	-
Acenaphthene	0.2	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.2	0.3	**40000**
Fluorene	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.3	0.3	0.3	0.2	0.2	-
Phenanthrene	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.5	0.6	0.7	0.5	0.6	**4600**
Anthracene	0.1	0.1	0.1	< 0.1	0.1	0.1	0.1	< 0.1	< 0.1	0.1	0.1	< 0.1	-
Fluoranthene	0.2	0.2	0.2	0.2	0.1	0.2	0.1	0.1	0.2	0.1	0.1	0.1	**11000**
Pyrene	0.3	0.5	0.3	0.3	0.3	0.2	0.3	0.2	0.3	0.3	0.2	0.2	-
Benzo(a)anthracene	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.2	0.2	-
Chrysene	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-
Benzo(b)fluoranthene	0.1	0.1	0.1	0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	-
Benzo(k)fluoranthene	0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-
Benzo(a)pyrene	0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	-
Indeno(123cd)pyrene	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	-
Benzo(ghi)perylene	0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	-
Dibenzo(ah)anthrace	0.1	< 0.1	< 0.1	0.1	< 0.1	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.1	< 0.1	-
Total US EPA 16	**4.3**	**3.9**	**4.1**	**3.9**	**3.6**	**3.5**	**3.5**	**3.0**	**3.7**	**3.9**	**2.7**	**3.3**	-

Notes:
Concentrations expressed as ng/L
PAH = Polycyclic aromatic hydrocarbon
US EPA 16 = United States Environmental Protection Agency's 16 priority polycyclic aromatic hydrocarbons
WS = Water sample

Key:	Below Chronic Value	Above Chronic Value

E.3.2.2 Total 2 to 6 Ring PAHs

PAH [ng/l of Water]	Station																							
	EBSWS1 (Surface)	EBSWS1 (Mid)	EBSWS1 (Bottom)	EBSWS2 (Surface)	EBSWS2 (Mid)	EBSWS2 (Bottom)	EBSWS3 (Surface)	EBSWS3 (Mid)	EBSWS3 (Bottom)	EBSWS4 (Surface)	EBSWS4 (Mid)	EBSWS4 (Bottom)	EBSWS5 (Surface)	EBSWS5 (Mid)	EBSWS5 (Bottom)	EBSWS6 (Surface)	EBSWS6 (Mid)	EBSWS6 (Bottom)	EBSWS7 (Surface)	EBSWS7 (Mid)	EBSWS7 (Bottom)	EBSWS8 (Surface)	EBSWS8 (Mid)	EBSWS8 (Bottom)
Naphthalene (128)	2	2	2	2	2	2	1	2	2	2	2	2	1	2	2	1	2	1	2	1	1	2	1	2
C_1 128	3	3	3	3	3	3	2	3	3	3	2	2	1	1	1	1	1	1	1	1	1	1	1	1
C_2 128	3	4	3	4	6	5	3	4	4	5	4	4	5	6	7	5	5	5	5	4	5	5	6	6
C_3 128	6	6	6	8	7	8	7	7	9	8	7	8	4	3	4	4	4	4	4	4	5	4	4	4
C_4 128	3	3	3	4	4	5	4	3	4	4	4	3	2	2	3	2	2	3	2	2	3	3	3	2
TOTAL 128	**17**	**18**	**17**	**21**	**22**	**23**	**17**	**19**	**22**	**22**	**19**	**19**	**13**	**14**	**17**	**13**	**14**	**14**	**14**	**12**	**15**	**15**	**15**	**15**
Phenanthrene/anthracene (178)	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_1 178	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_2 178	2	2	2	3	3	3	3	2	2	2	2	2	2	2	2	2	2	3	2	2	3	3	2	2
C_3 178	2	3	3	3	3	3	2	3	2	3	3	3	2	3	3	3	3	3	3	3	3	3	2	2
TOTAL 178	**6**	**7**	**7**	**8**	**8**	**8**	**7**	**7**	**6**	**7**	**7**	**7**	**6**	**7**	**7**	**7**	**7**	**8**	**7**	**7**	**8**	**8**	**6**	**6**
Dibenzothiophene (184)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 184	1	< 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	< 1	< 1	< 1	1	< 1	< 1	< 1
C_2 184	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_3 184	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
TOTAL 184	**3**	**2**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**3**	**2**	**2**	**2**	**3**	**2**	**2**	**2**
Fluoranthene/pyrene (202)	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
C_1 202	< 1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	< 1	1
C_2 202	1	1	1	2	1	2	1	1	1	1	1	2	1	< 1	1	1	1	1	1	1	1	1	1	1
C_3 202	2	2	2	2	3	2	1	2	1	2	2	2	2	2	2	1	2	2	2	1	2	2	2	2
TOTAL 202	**3**	**4**	**4**	**5**	**5**	**5**	**3**	**4**	**3**	**4**	**4**	**5**	**4**	**3**	**4**	**3**	**4**	**4**	**4**	**3**	**4**	**4**	**3**	**4**

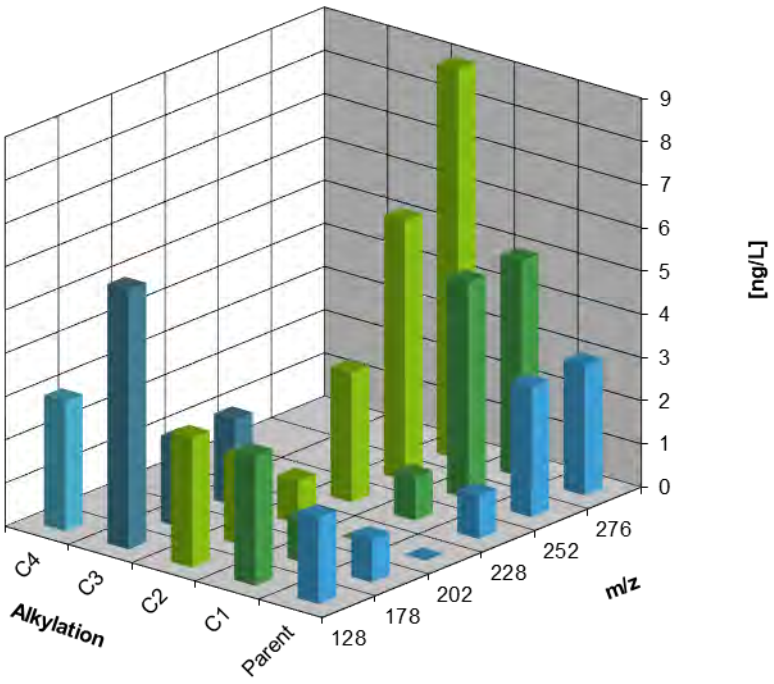
PAH [ng/l of Water]	Station																							
	EBSWS1 (Surface)	EBSWS1 (Mid)	EBSWS1 (Bottom)	EBSWS2 (Surface)	EBSWS2 (Mid)	EBSWS2 (Bottom)	EBSWS3 (Surface)	EBSWS3 (Mid)	EBSWS3 (Bottom)	EBSWS4 (Surface)	EBSWS4 (Mid)	EBSWS4 (Bottom)	EBSWS5 (Surface)	EBSWS5 (Mid)	EBSWS5 (Bottom)	EBSWS6 (Surface)	EBSWS6 (Mid)	EBSWS6 (Bottom)	EBSWS7 (Surface)	EBSWS7 (Mid)	EBSWS7 (Bottom)	EBSWS8 (Surface)	EBSWS8 (Mid)	EBSWS8 (Bottom)
Benzanthracenes/benzphenanthrenes (228)	1	1	1	1	1	2	1	1	2	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_1 228	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
C_2 228	3	3	3	4	4	3	3	4	5	6	5	7	2	2	2	3	2	2	2	2	3	2	2	2
TOTAL 228	**5**	**5**	**6**	**6**	**6**	**6**	**5**	**6**	**8**	**9**	**7**	**9**	**4**	**4**	**4**	**5**	**4**	**4**	**4**	**4**	**5**	**4**	**4**	**4**
m/z 252	3	3	3	5	4	5	3	4	3	5	6	6	2	2	2	2	2	2	2	2	2	2	2	2
C_1 252	5	5	3	5	8	13	7	9	6	9	8	7	4	3	3	4	3	4	3	4	4	4	3	3
C_2 252	6	14	12	15	16	23	10	13	15	17	17	12	6	5	5	6	6	5	5	4	5	4	5	6
TOTAL 252	**14**	**22**	**18**	**25**	**28**	**41**	**20**	**26**	**24**	**31**	**31**	**25**	**12**	**10**	**10**	**12**	**11**	**11**	**10**	**10**	**11**	**10**	**10**	**11**
m/z 276	3	3	3	4	6	8	3	4	5	5	6	5	2	2	1	1	2	2	2	2	1	1	2	1
C_1 276	5	9	9	12	12	13	8	10	10	11	11	14	3	2	4	4	5	4	4	4	5	4	6	3
C_2 276	9	15	14	21	19	24	15	13	16	17	17	19	8	6	6	7	8	7	7	5	7	6	6	6
TOTAL 276	**17**	**27**	**26**	**37**	**37**	**45**	**26**	**27**	**31**	**33**	**34**	**38**	**13**	**10**	**11**	**12**	**15**	**13**	**13**	**11**	**13**	**11**	**14**	**10**
NPD	**26**	**27**	**27**	**32**	**33**	**34**	**27**	**29**	**31**	**32**	**29**	**29**	**22**	**24**	**27**	**23**	**24**	**24**	**23**	**21**	**26**	**25**	**23**	**23**
% NPD	**40**	**32**	**33**	**30**	**30**	**26**	**33**	**32**	**32**	**29**	**28**	**27**	**40**	**47**	**48**	**42**	**41**	**43**	**43**	**43**	**44**	**46**	**43**	**44**
Total 2 to 6 ring PAH	**65**	**85**	**81**	**105**	**109**	**131**	**81**	**92**	**97**	**109**	**105**	**106**	**55**	**51**	**56**	**55**	**58**	**56**	**54**	**49**	**59**	**54**	**54**	**52**

Notes:
Concentrations expressed as ng/L
WS = Water sample
* = m/z 252 - benzfluoranthenes/benzpyrenes/perylene
† = m/z 276 - anthanthrene/indenopyrenes/benzperylenes
‡ = NPD - naphthalenes, phenanthrenes and dibenzothiophenes (totals)

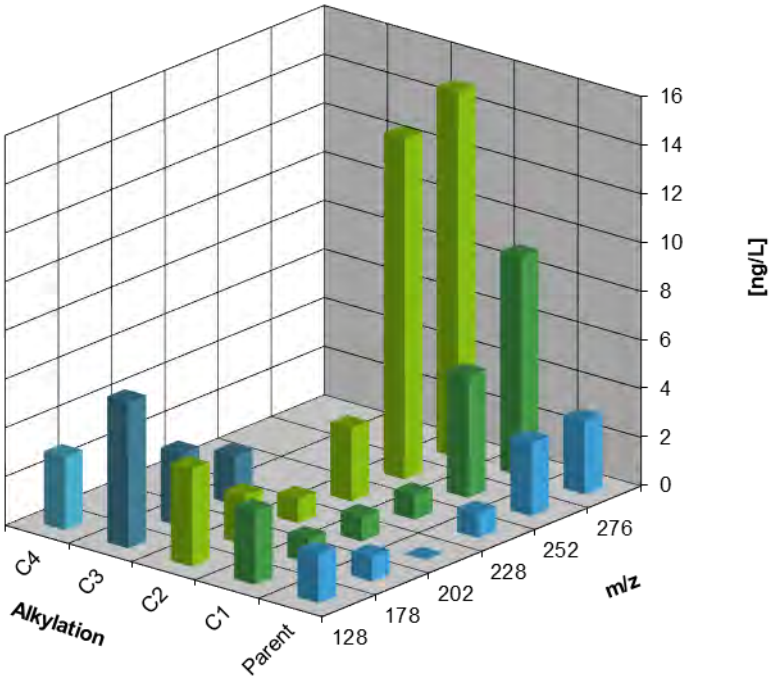
E.4 DISTRIBUTION OF AROMATIC HYDROCARBONS - WATERS

The layout of the three-dimensional plots are as follows:

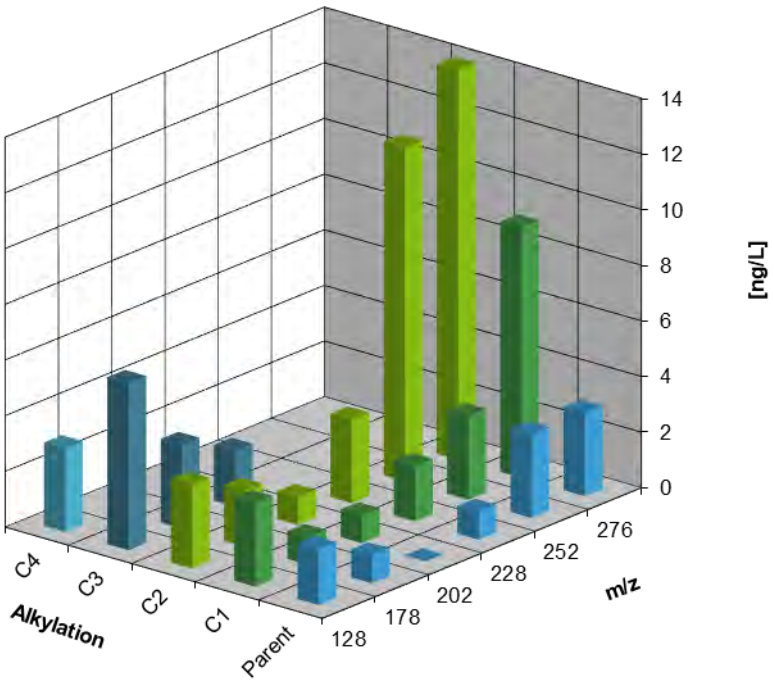
- Naphthalenes (molecular mass 128, 142, 156, 170, 184);
- Phenanthrenes/anthracenes (molecular mass 178, 192, 206, 220);
- Fluoranthenes/pyrenes (molecular mass 202, 216, 230, 244);
- Chrysene/benzanthracenes (molecular mass 228, 242, 256);
- Benzfluoranthenes/benzpyrenes/perylenes (molecular mass 252, 266, 280);
- Anthanthrenes/indenopyrenes/benzoperylenes (molecular mass 276, 290, 304).



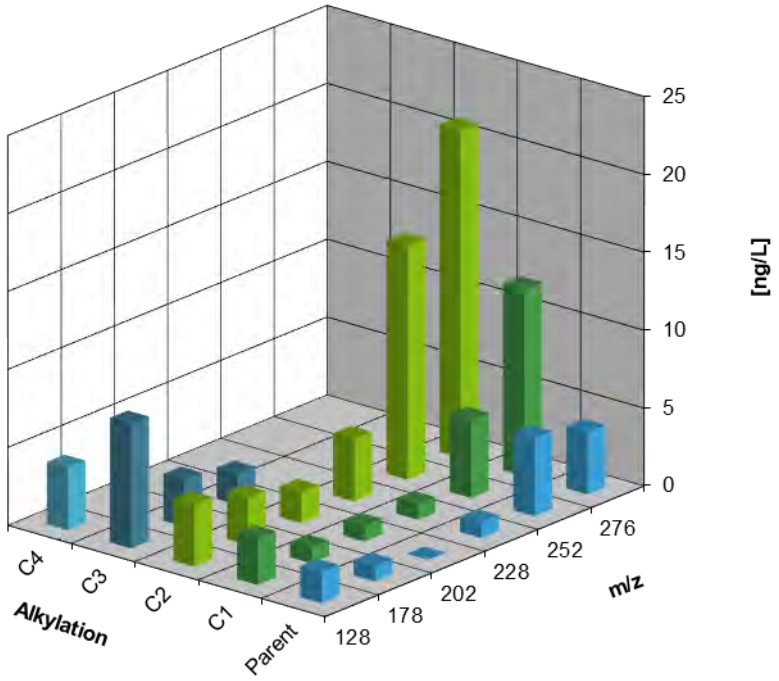
Station EBSWS1 (Surface)



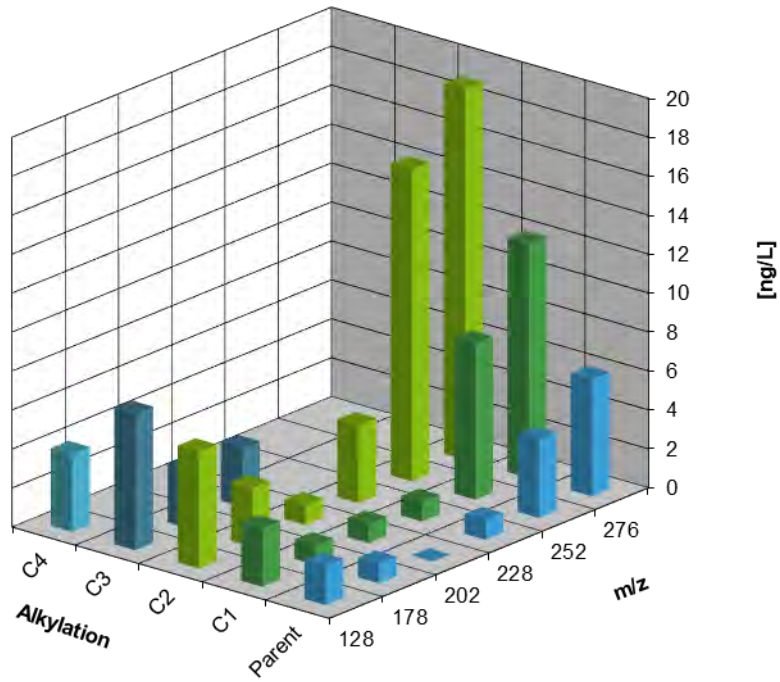
Station EBSWS1 (Mid)



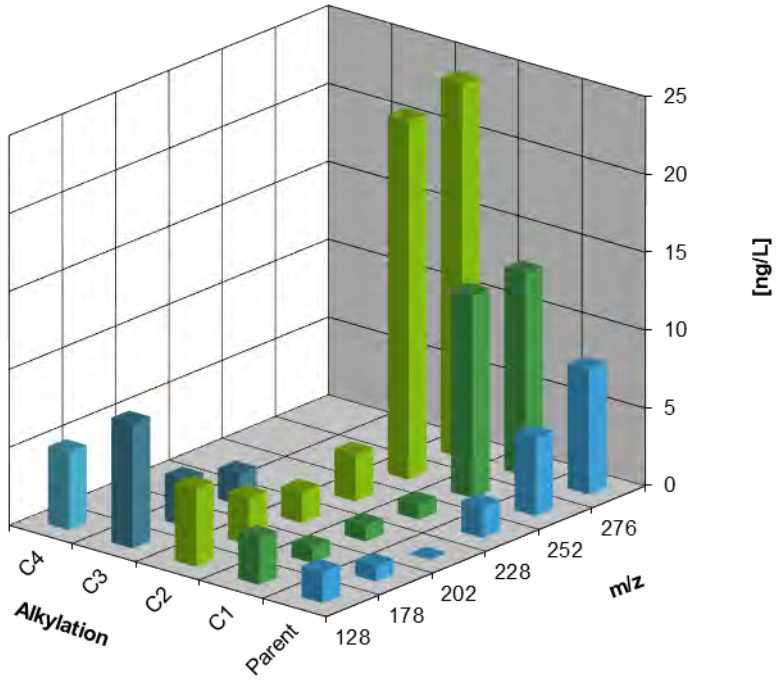
Station EBSWS1 (Bottom)



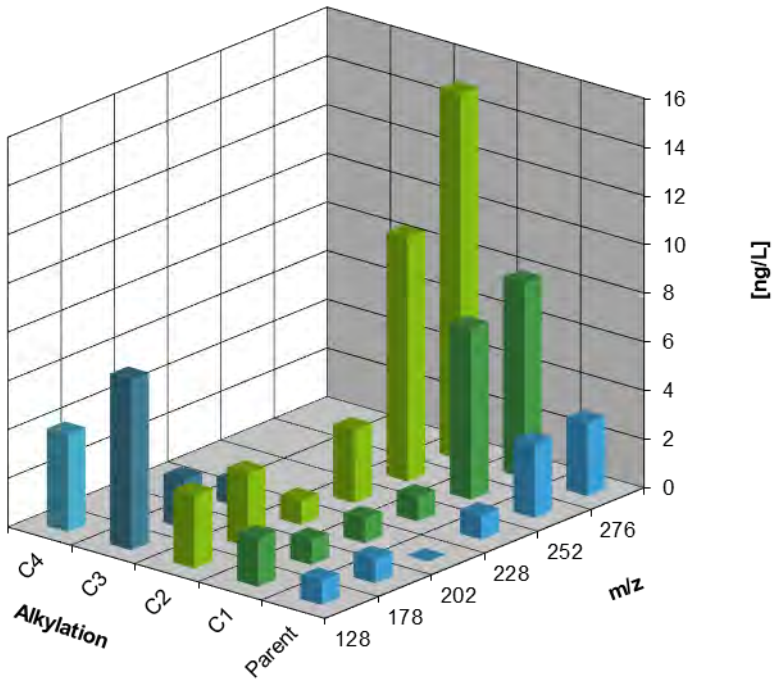
Station EBSWS2 (Surface)



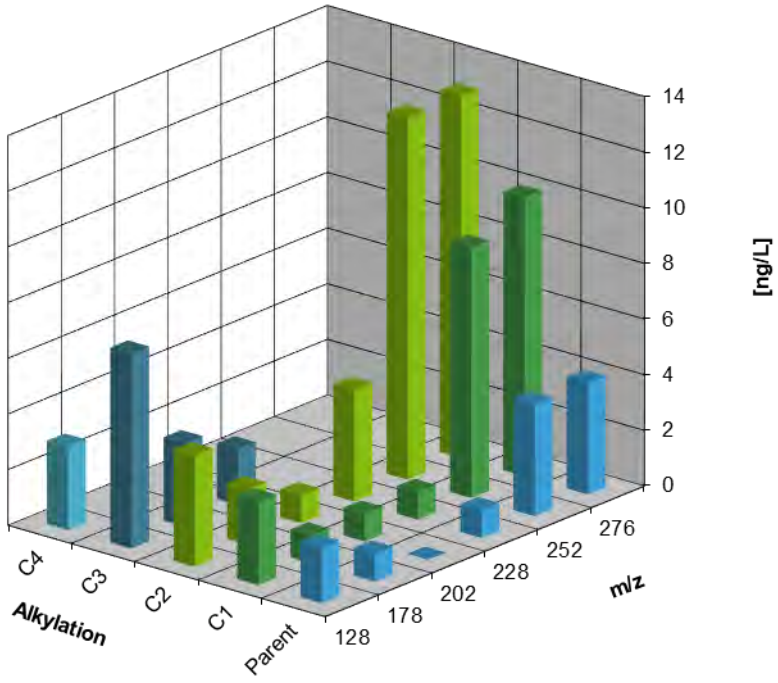
Station EBSWS2 (Mid)



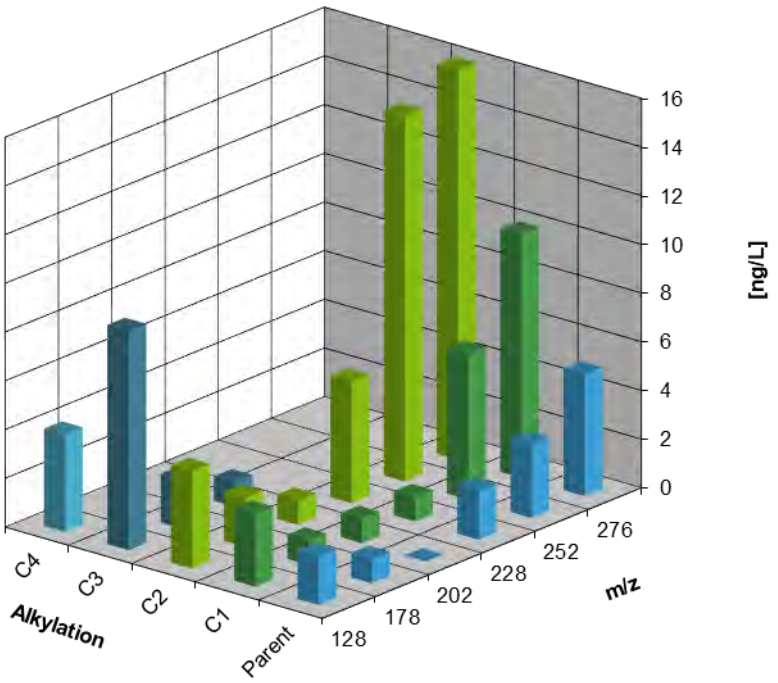
Station EBSWS2 (Bottom)



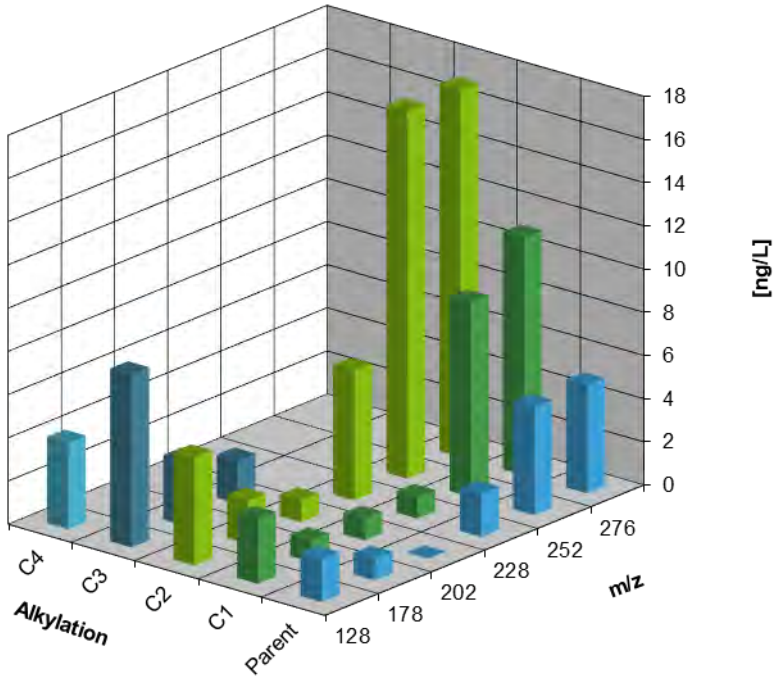
Station EBSWS3 (Surface)



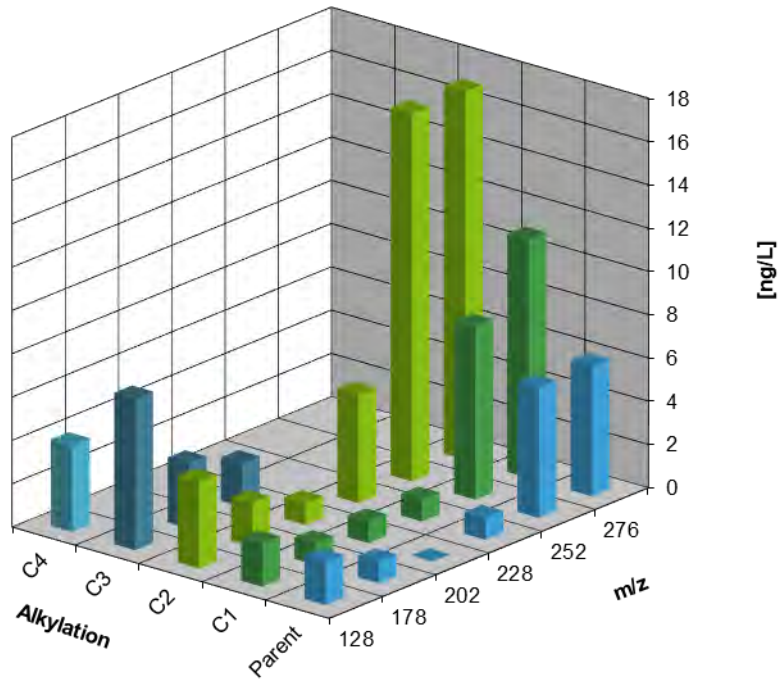
Station EBSWS3 (Mid)



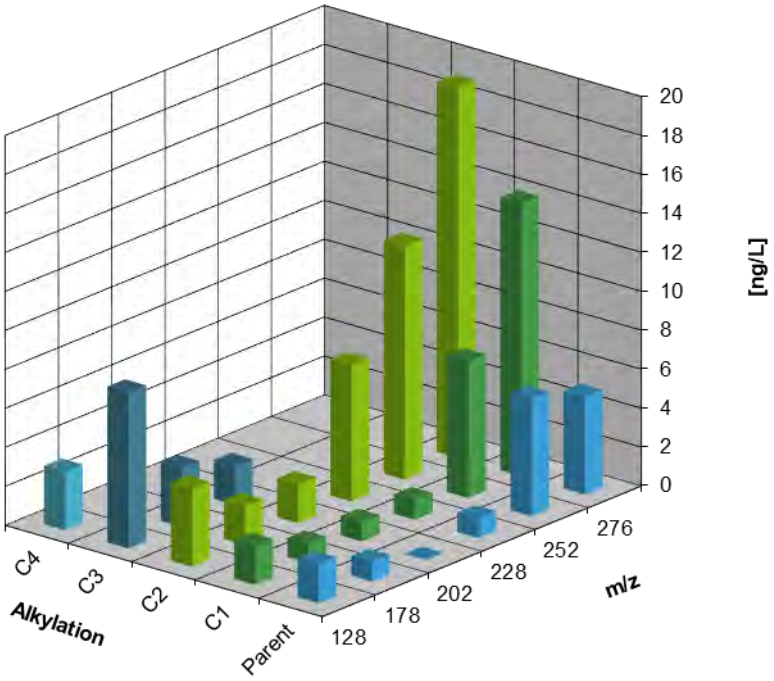
Station EBSWS3 (Bottom)



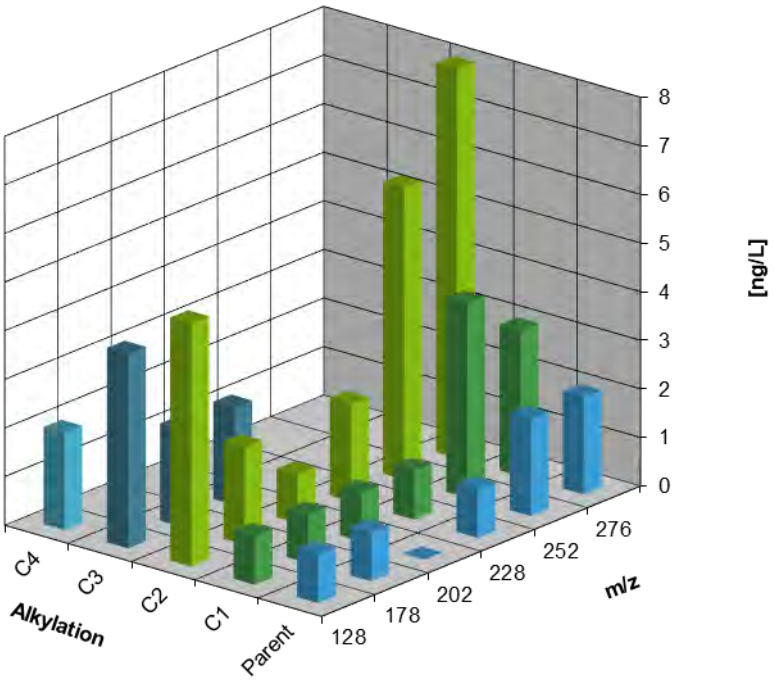
Station EBSWS4 (Surface)



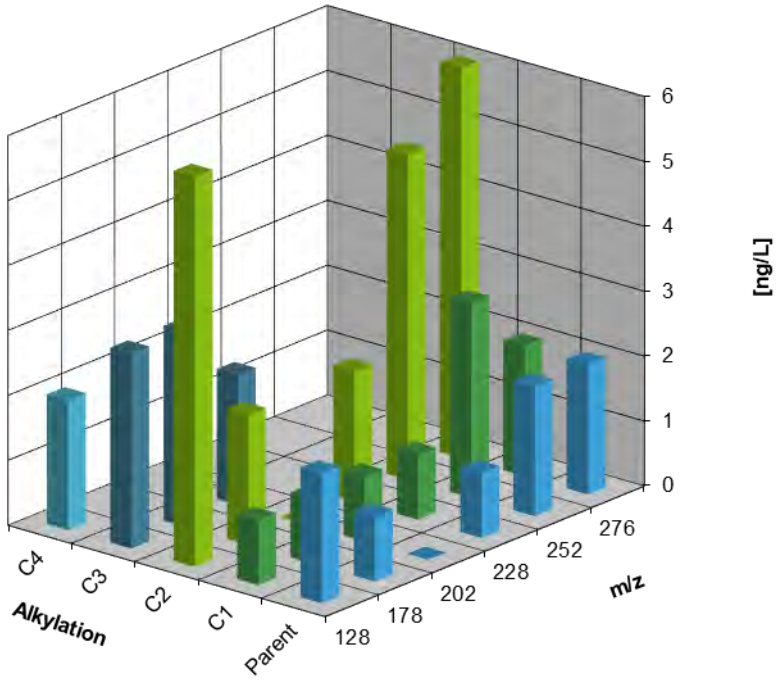
Station EBSWS4 (Mid)



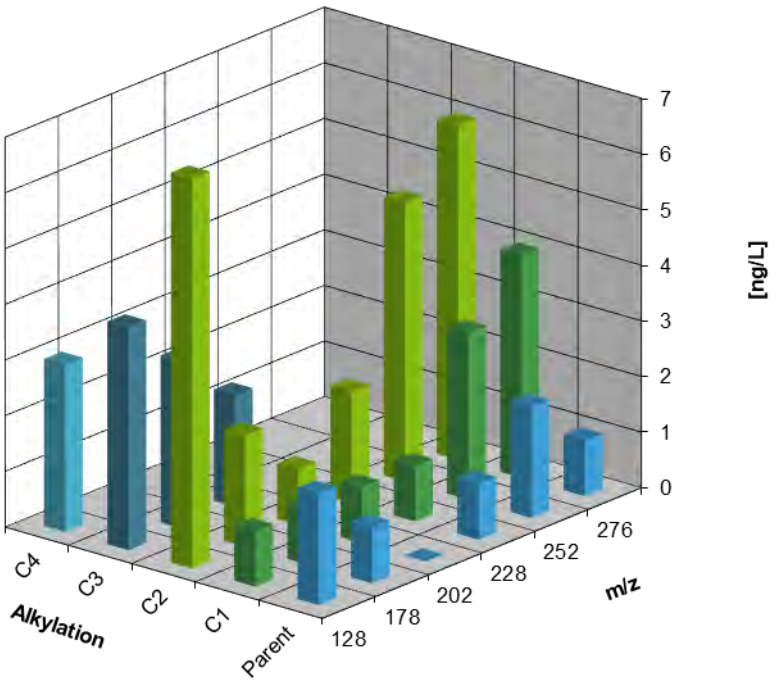
Station EBSWS4 (Bottom)



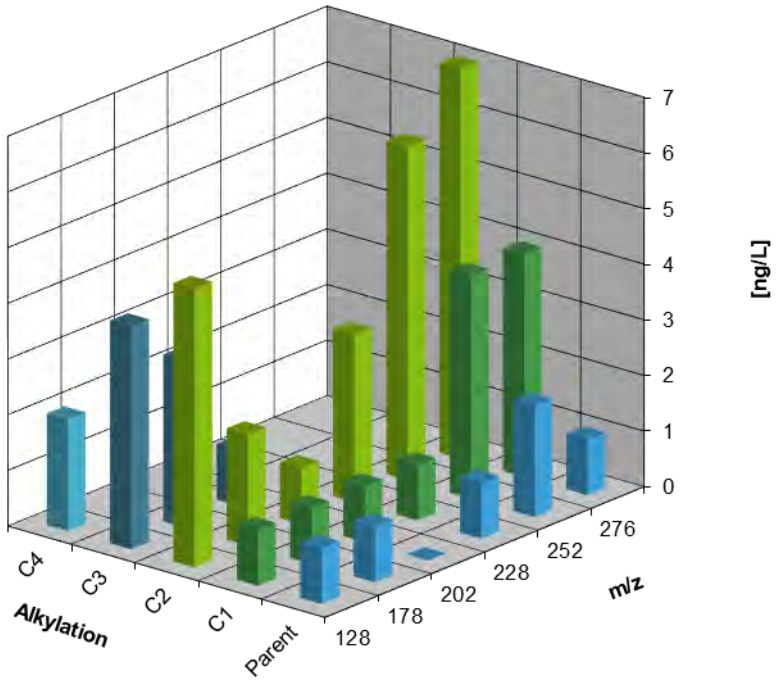
Station EBSWS5 (Surface)



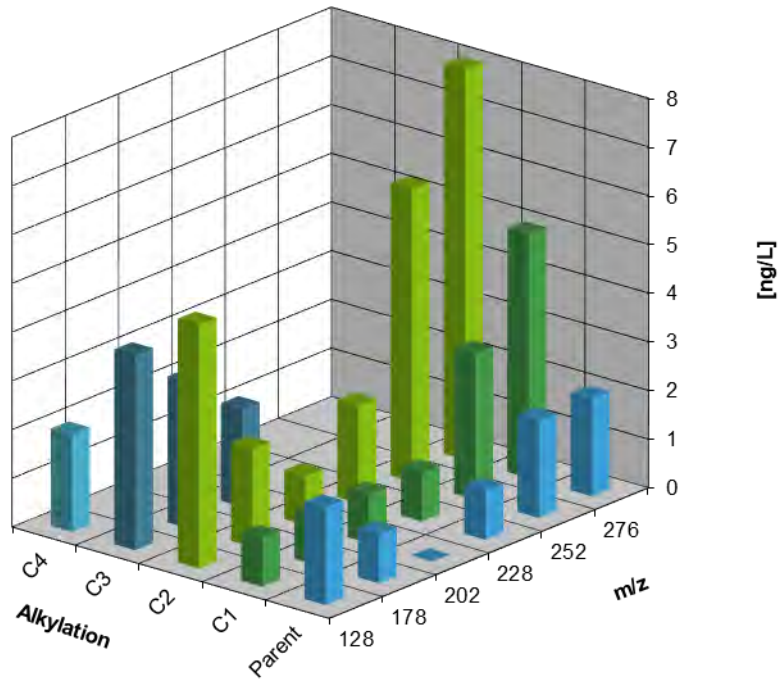
Station EBSWS5 (Mid)



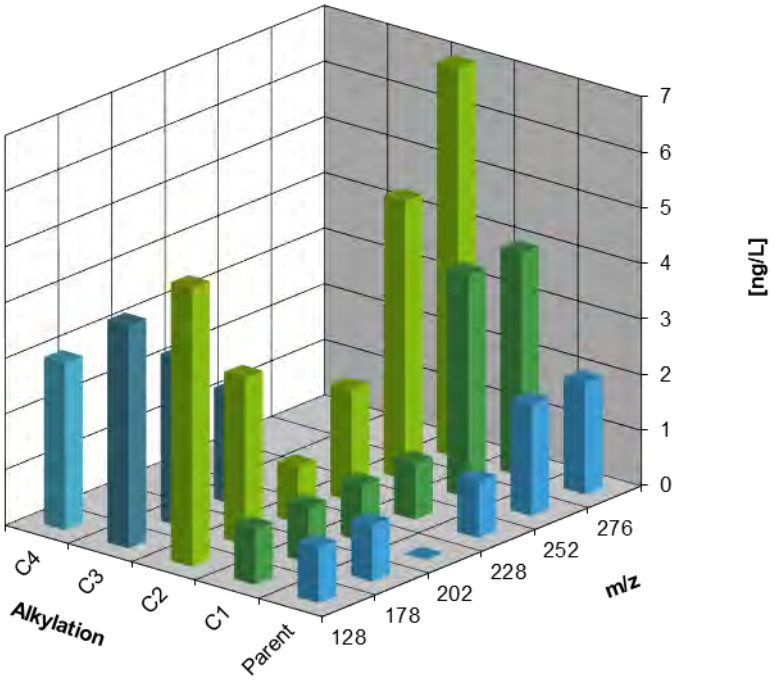
Station EBSWS5 (Bottom)



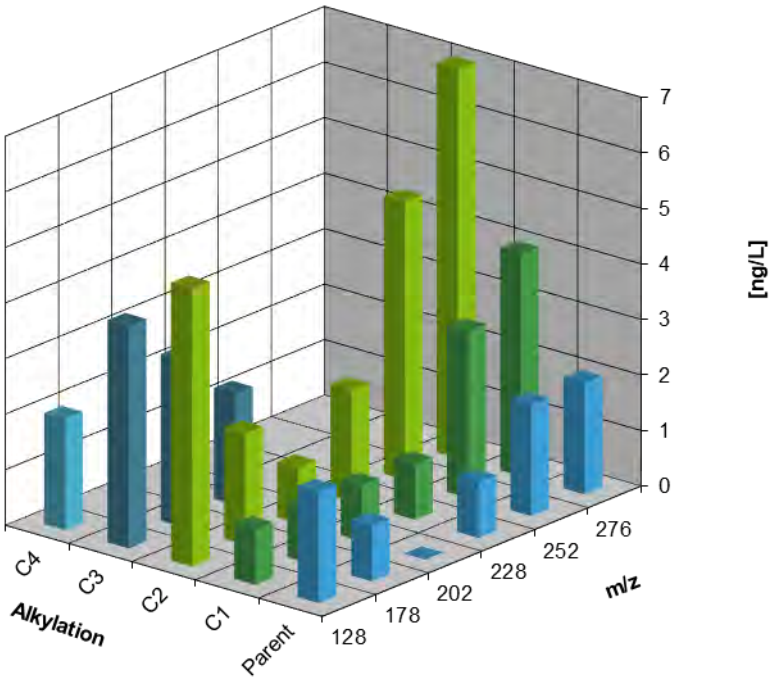
Station EBSWS6 (Surface)



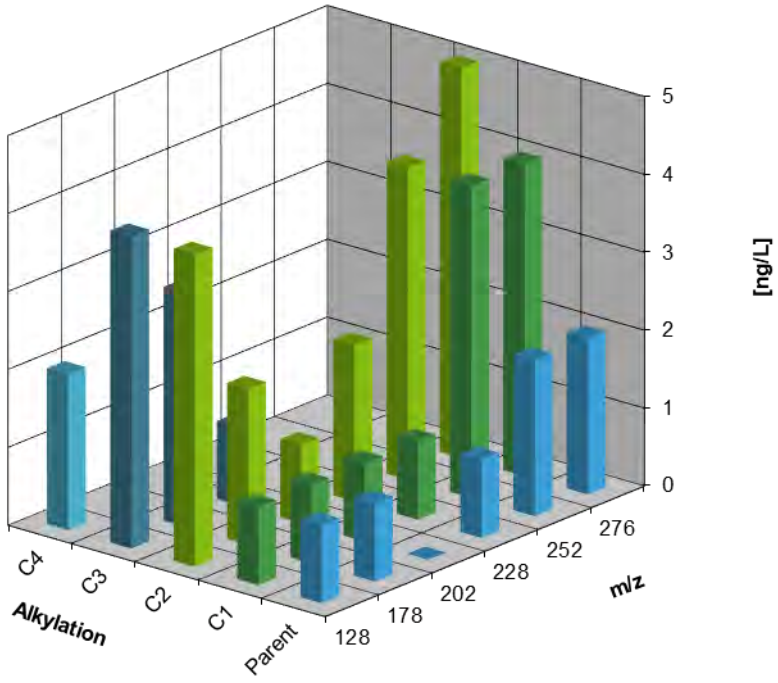
Station EBSWS6 (Mid)



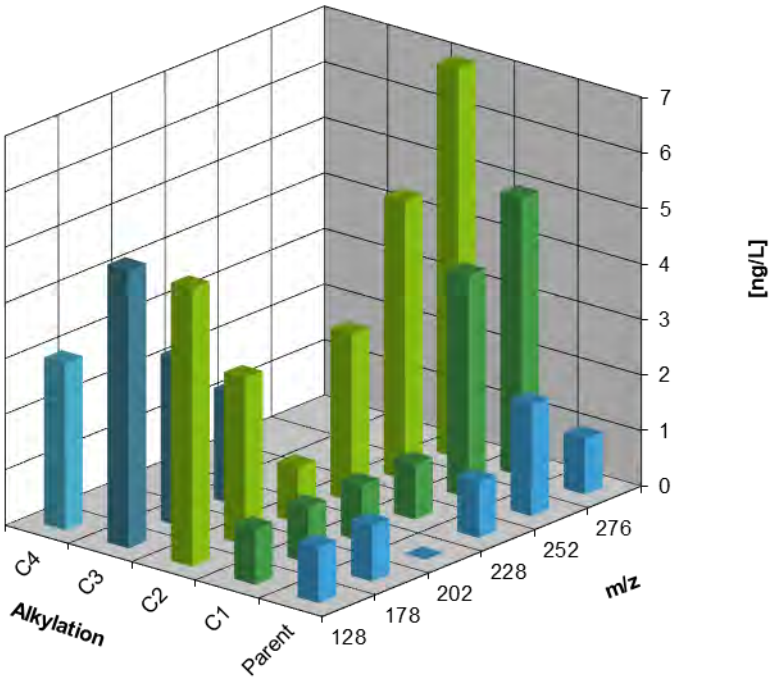
Station EBSWS6 (Bottom)



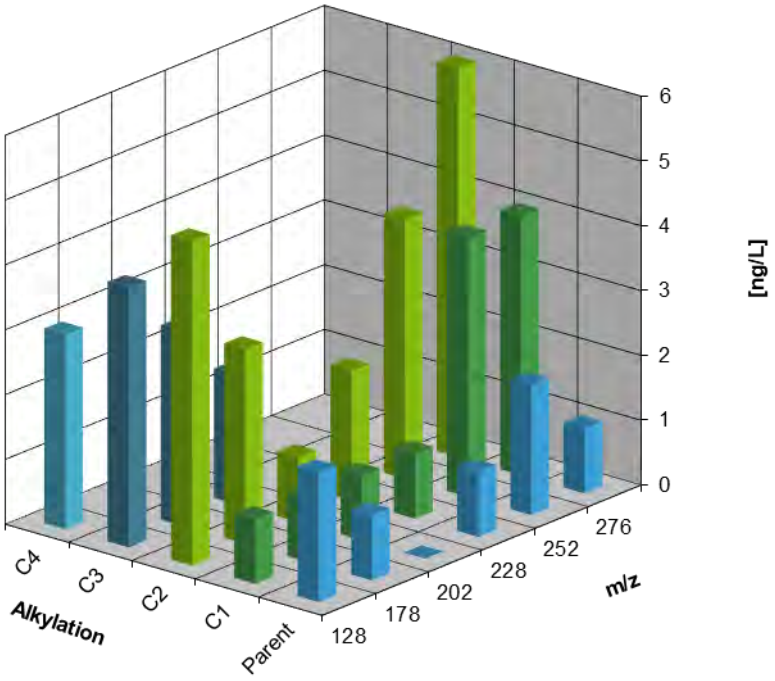
Station EBSWS7 (Surface)



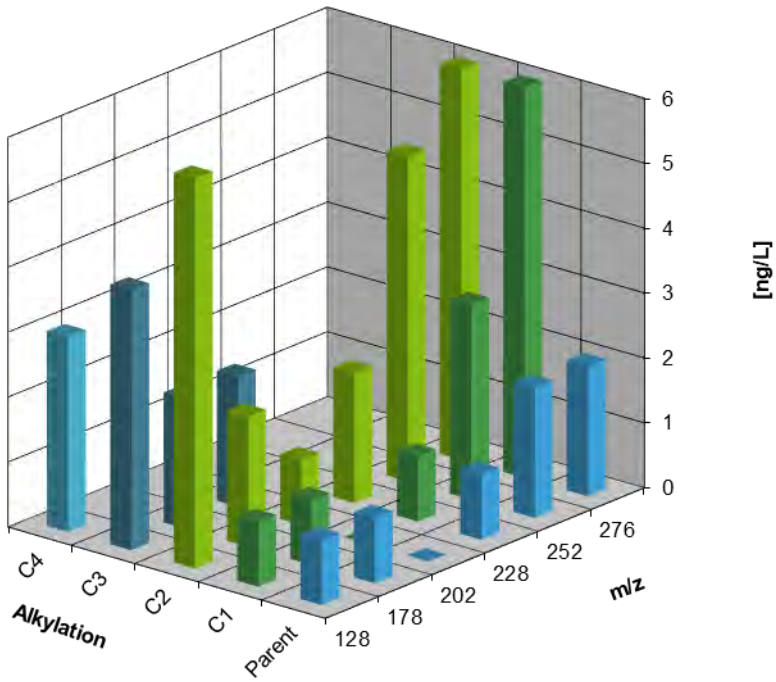
Station EBSWS7 (Mid)



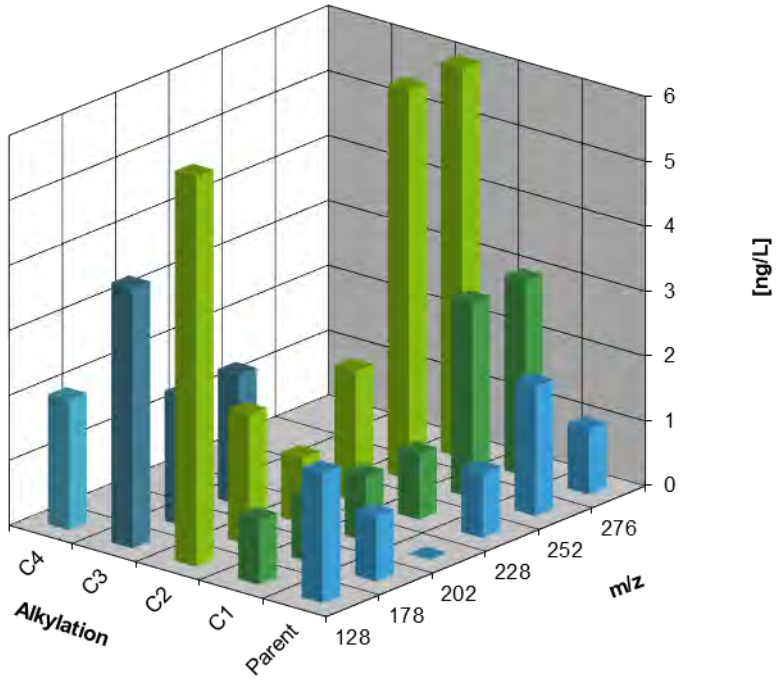
Station EBSWS7 (Bottom)



Station EBSWS8 (Surface)



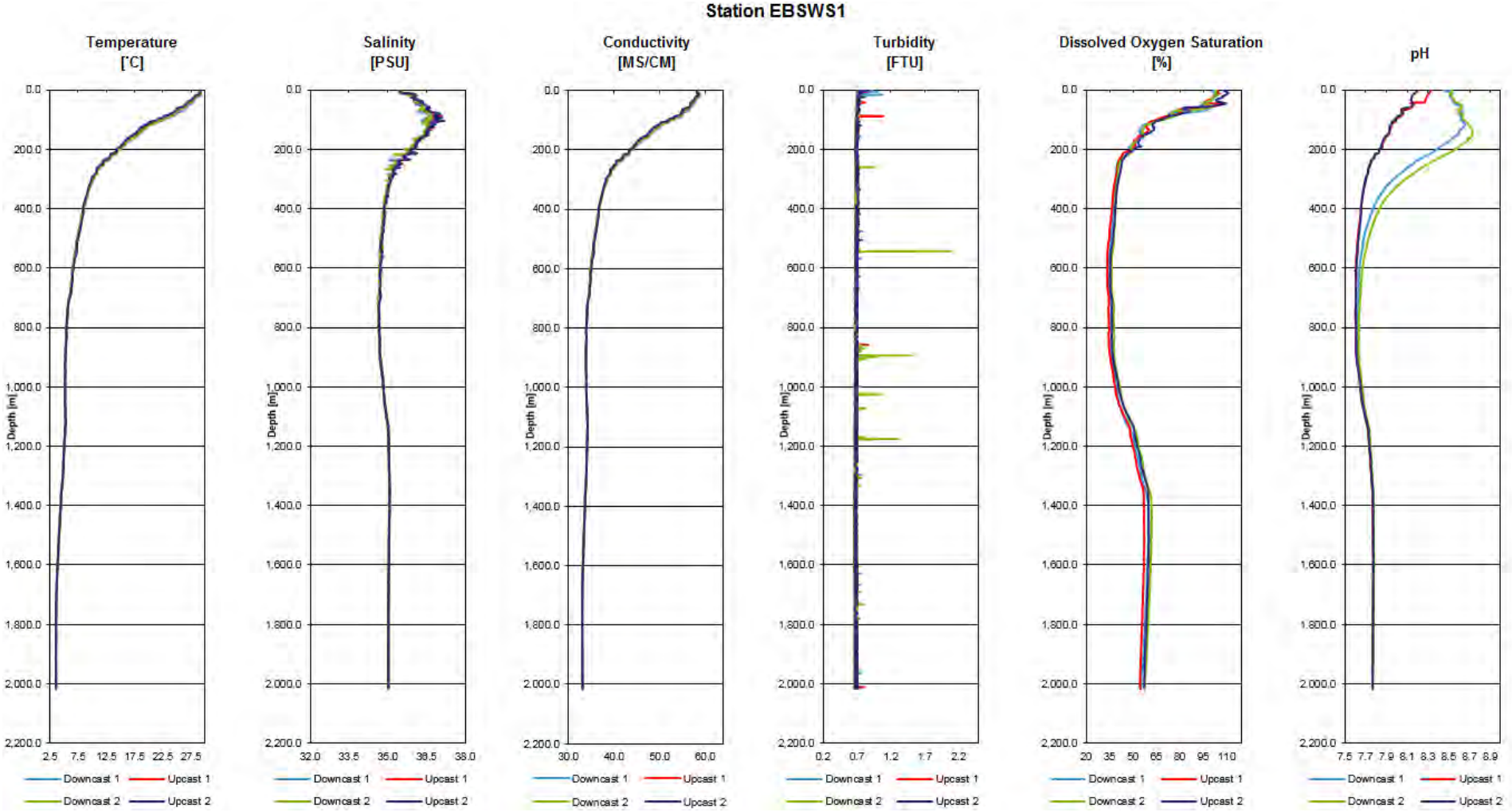
Station EBSWS8 (Mid)

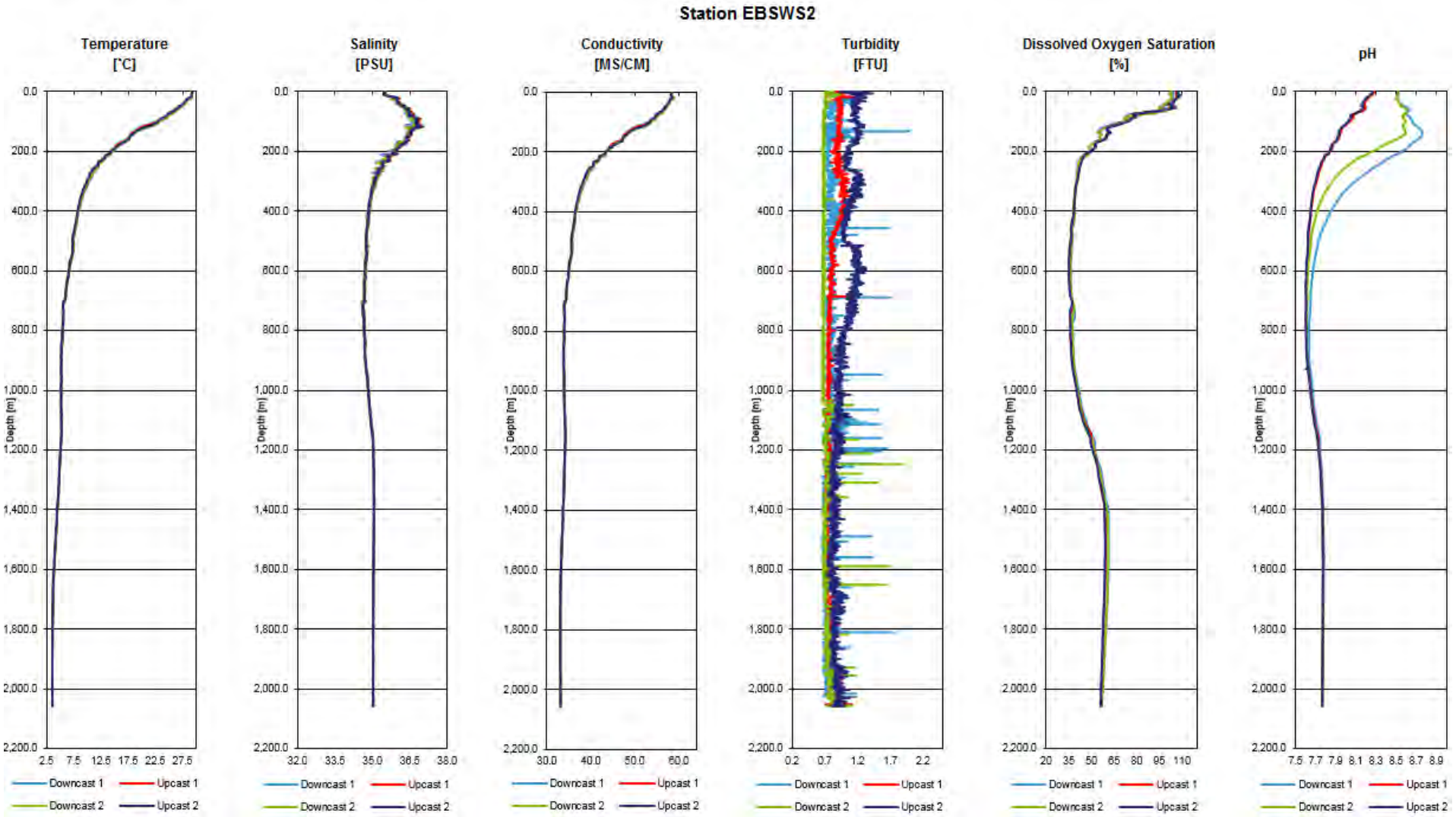


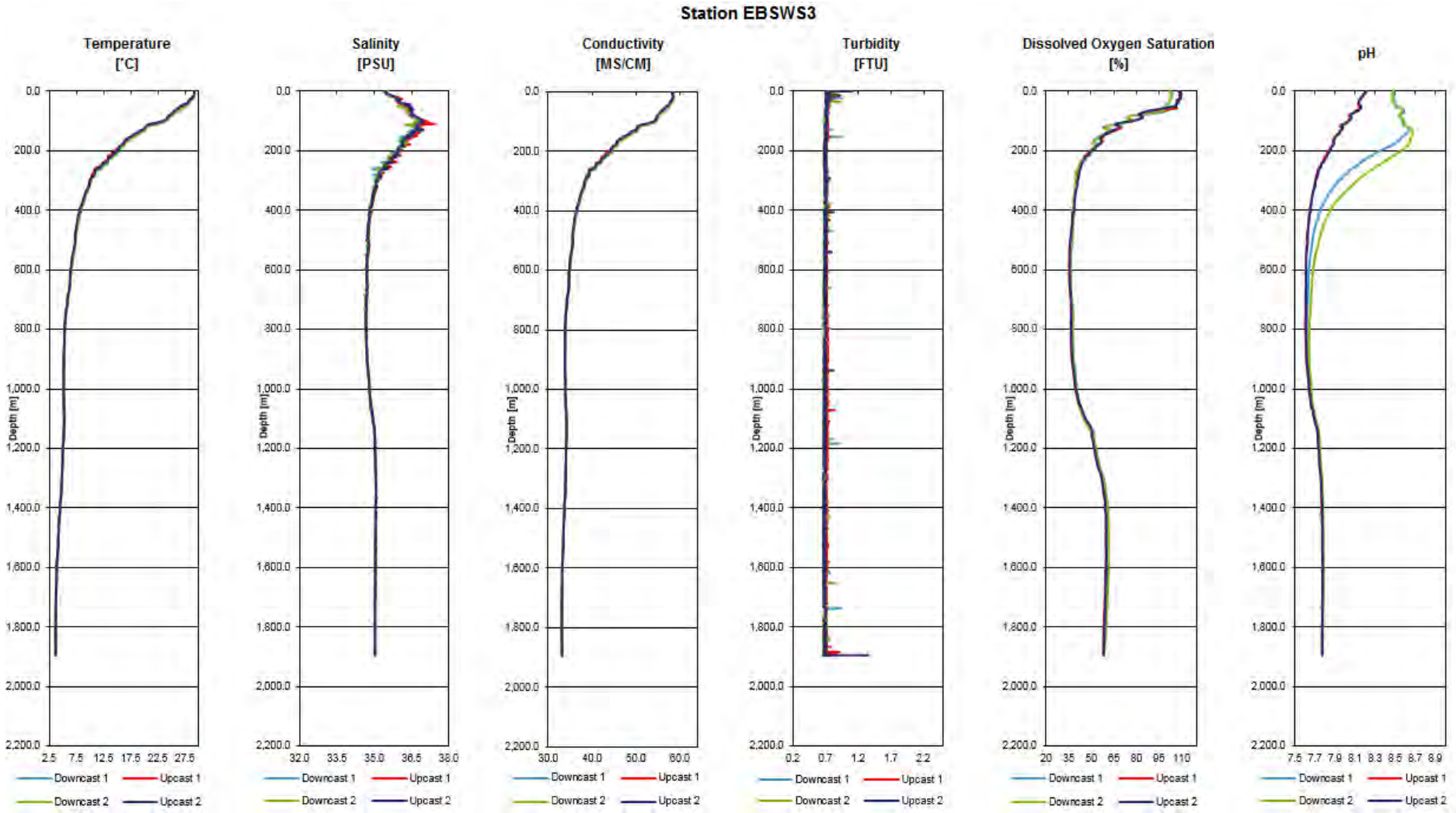
Station EBSWS8 (Bottom)

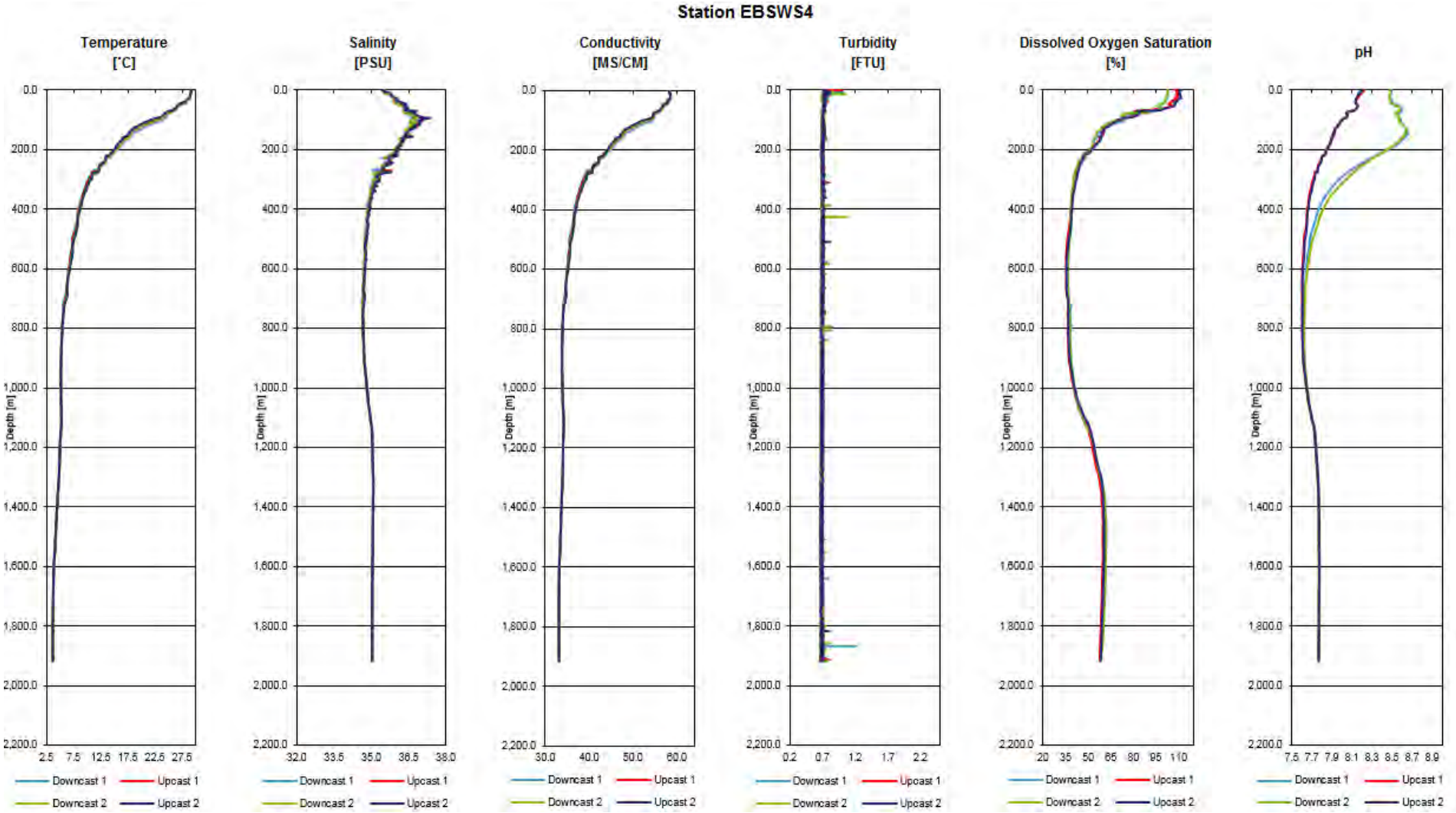
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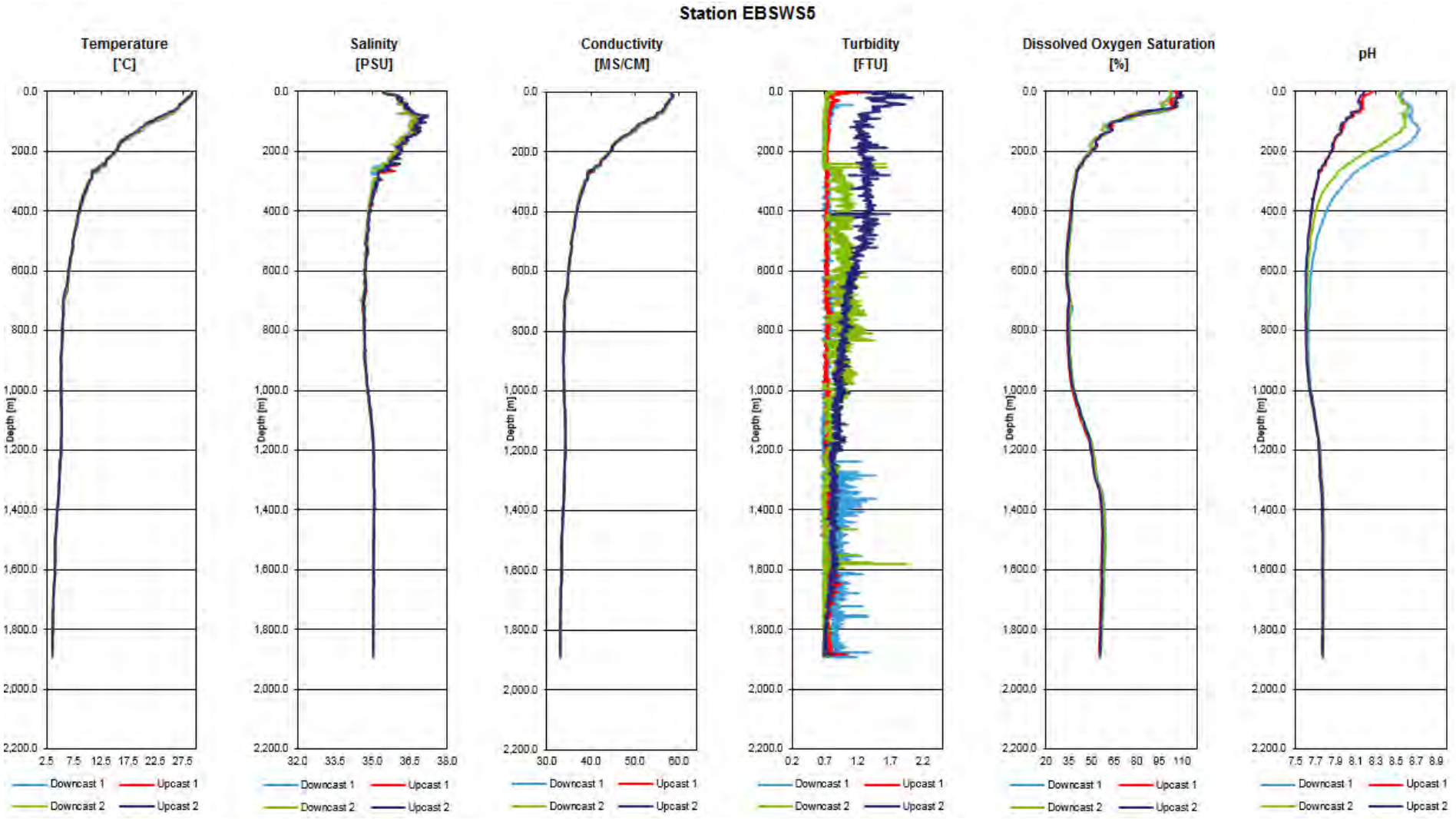
F. WATER PROFILES

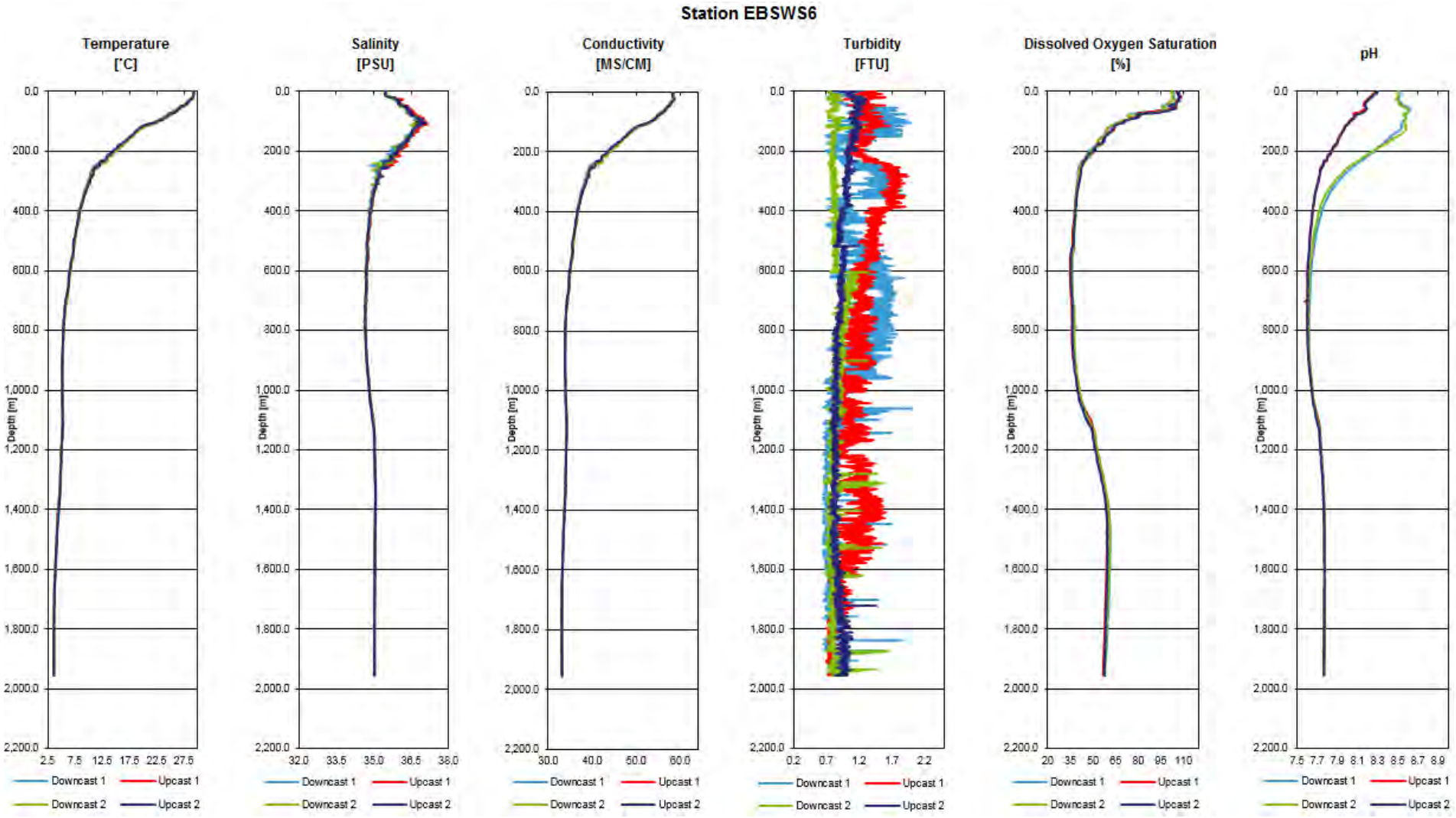


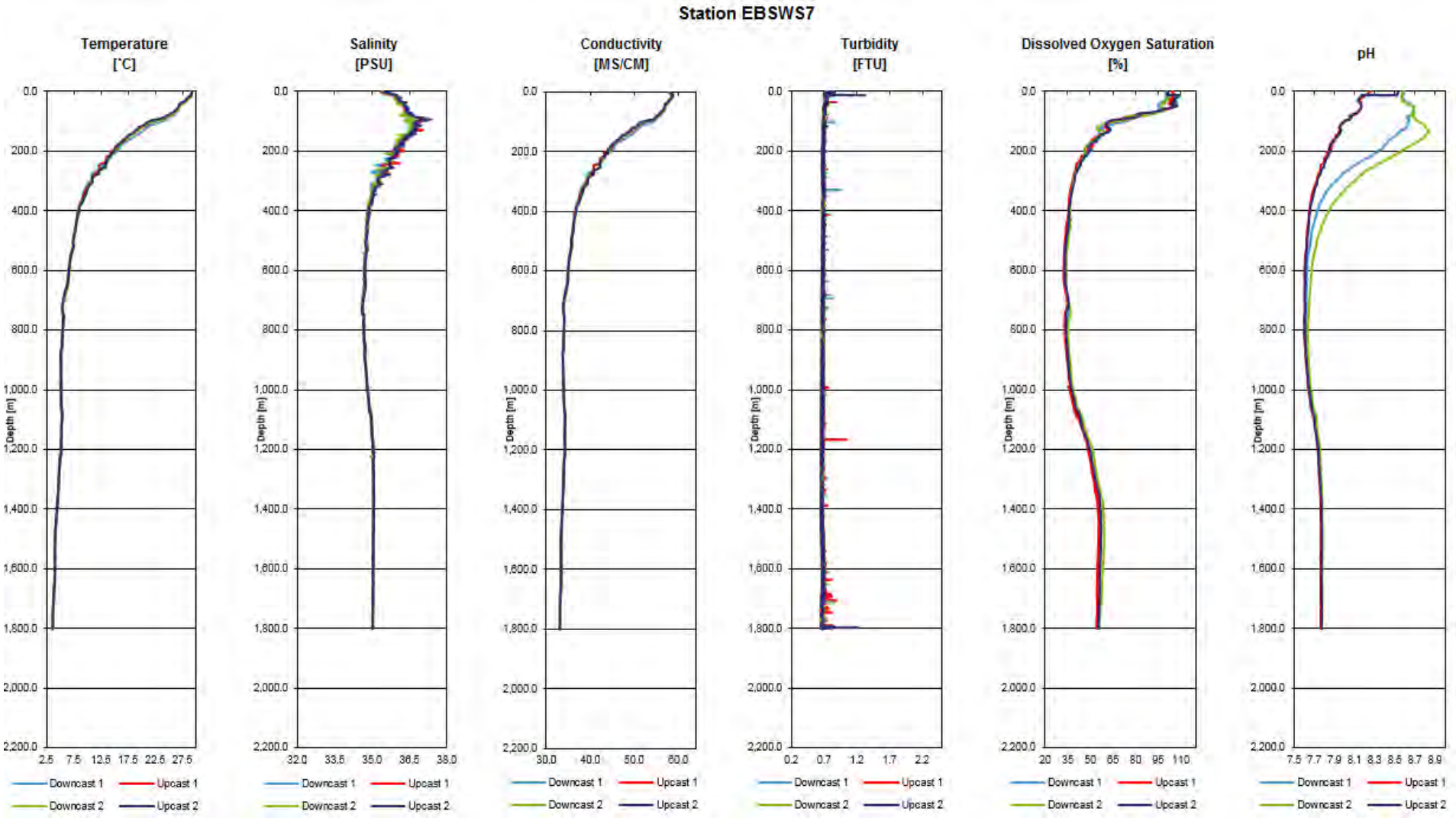

Station EBSWS2
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
2,000.0
2,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2

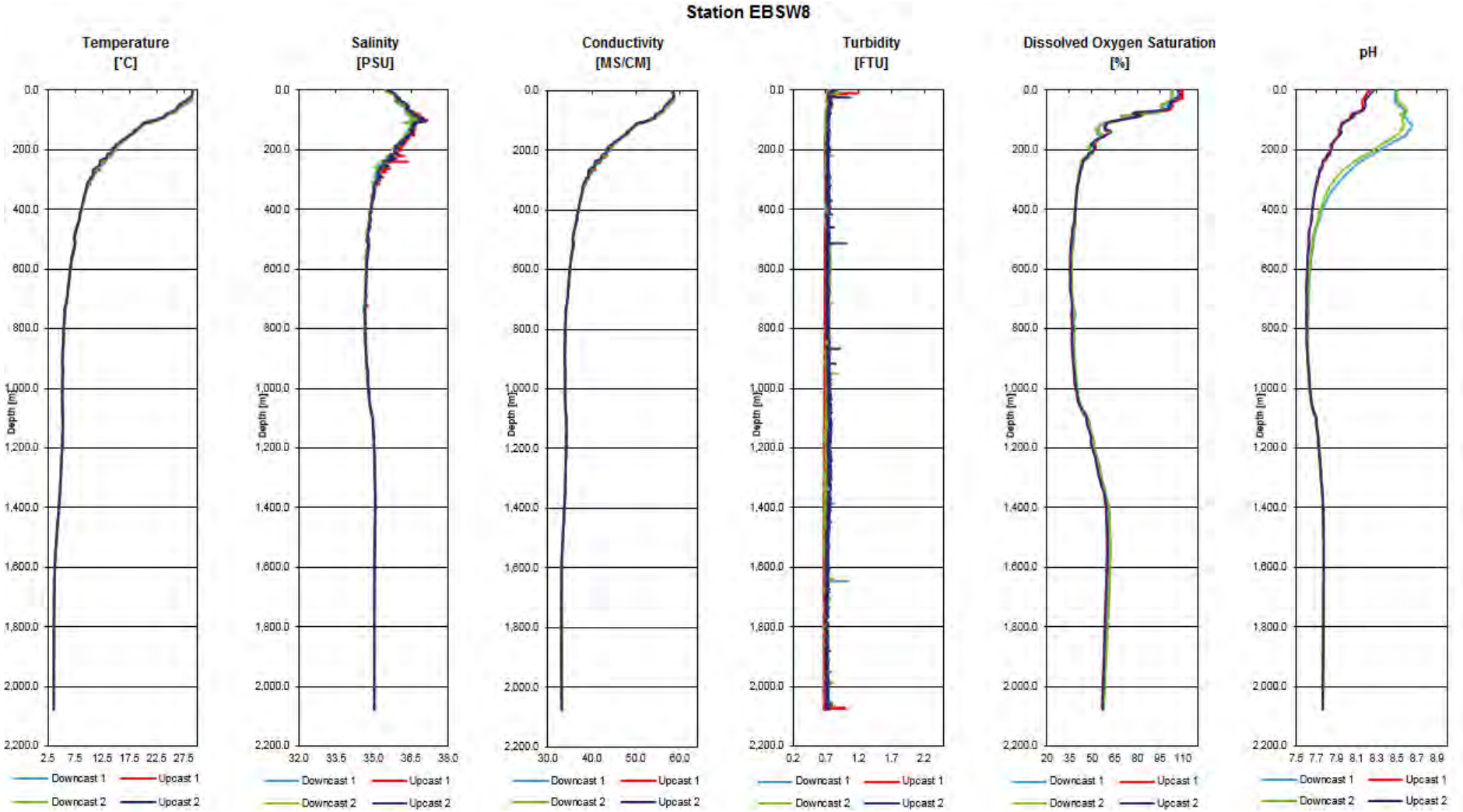

Station EBSWS3
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
2,000.0
2,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSWS4
Temperature
[°C]
Salinity
[PSU]
Conductivity
[MS/CM]
Turbidity
[FTU]
Dissolved Oxygen Saturation
[%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
2,000.0
2,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSWS5
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
2,000.0
2,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2

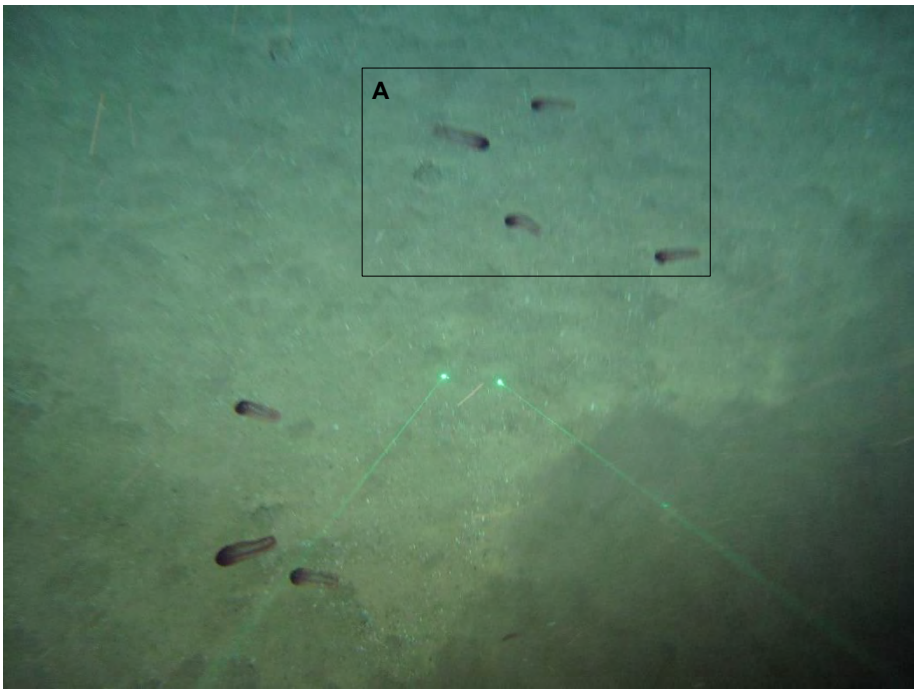

Station EBSWS6
Temperature
[°C]
Salinity
[PSU]
Conductivity
[MS/CM]
Turbidity
[FTU]
Dissolved Oxygen Saturation
[%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
2,000.0
2,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSWS7
Temperature
[°C]
Salinity
[PSU]
Conductivity
[MS/CM]
Turbidity
[FTU]
Dissolved Oxygen Saturation
[%]
pH
Depth [m]
0.0
200.0
400.0
600.0
800.0
1,000.0
1,200.0
1,400.0
1,600.0
1,800.0
2,000.0
2,200.0
2.5 7.5 12.5 17.5 22.5 27.5
32.0 33.5 35.0 36.5 38.0
30.0 40.0 50.0 60.0
0.2 0.7 1.2 1.7 2.2
20 35 50 65 80 95 110
7.5 7.7 7.9 8.1 8.3 8.5 8.7 8.9
Downcast 1
Upcast 1
Downcast 2
Upcast 2


Station EBSW8
Temperature [°C]
Salinity [PSU]
Conductivity [MS/CM]
Turbidity [FTU]
Dissolved Oxygen Saturation [%]
pH
Depth [m]
Downcast 1
Upcast 1
Downcast 2
Upcast 2

G. SEABED PHOTOGRAPHS

STATION EBSDDV1

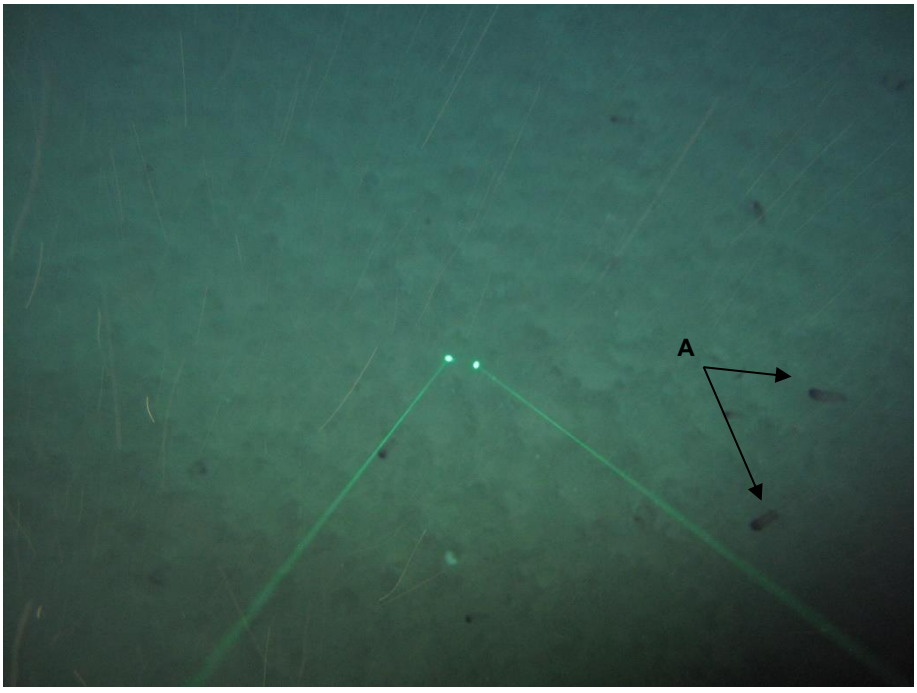


Photograph:
EBSDDV1_001

Easting: 500 144.7 mE
Northing: 911 643.5mN
Depth: 2035.9 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Sea cucumbers (*Benthodytes* sp.)



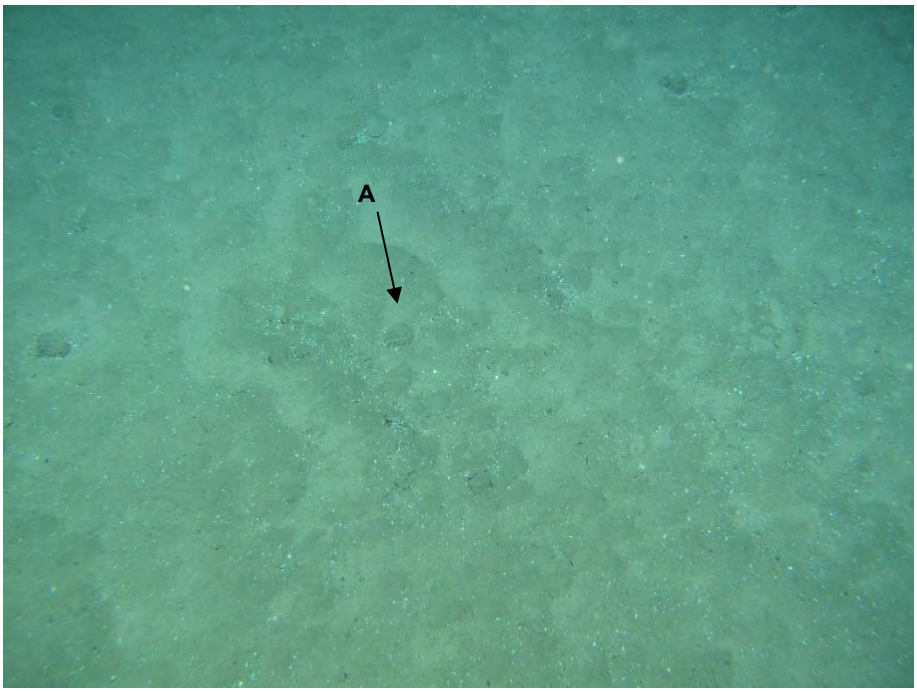
Photograph:
EBSDDV1_018

Easting: 500 172.4 mE
Northing: 911 669.7 mN
Depth: 2034.6 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Sea cucumbers (*Benthodytes* sp.)

STATION EBSDDV2

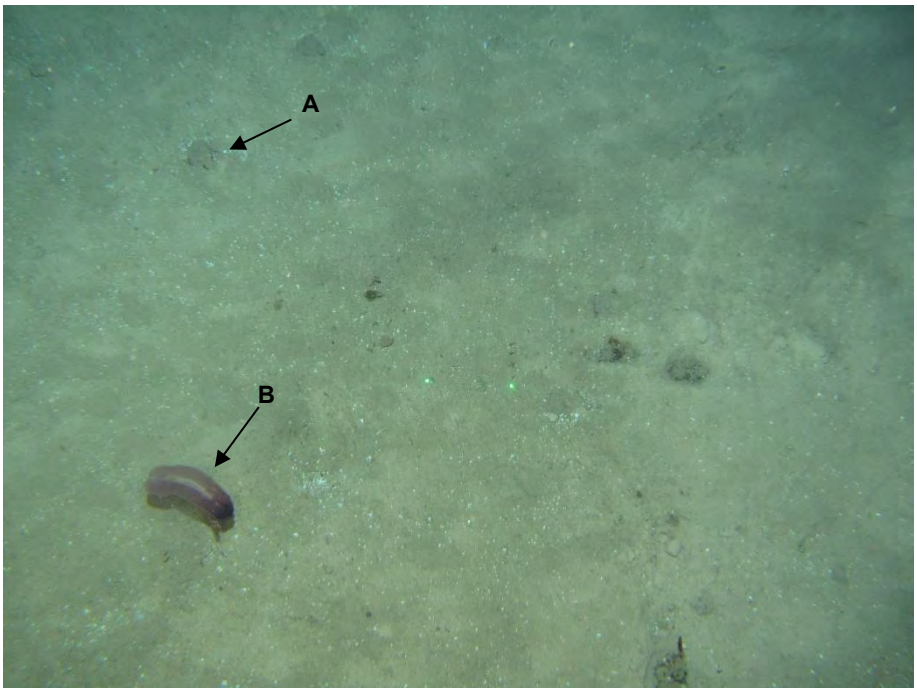


Photograph:
EBSDDV2_002

Easting: 505 581.9 mE
Northing: 909 801.6 mN
Depth: 2079.0 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Xenophyophore (Xenophyophoroidea)



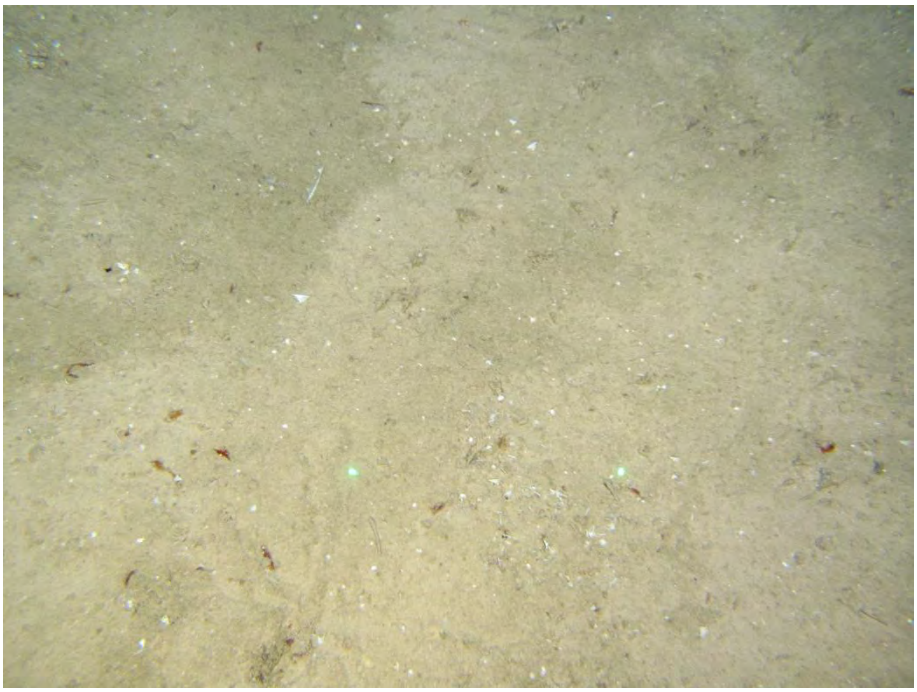
Photograph:
EBSDDV2_012

Easting: 505 557.9 mE
Northing: 909 790.1 mN
Depth: 2081.1 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Xenophyophore (Xenophyophoroidea)
B: Sea cucumber (*Benthodytes* sp.)

STATION EBSDDV3

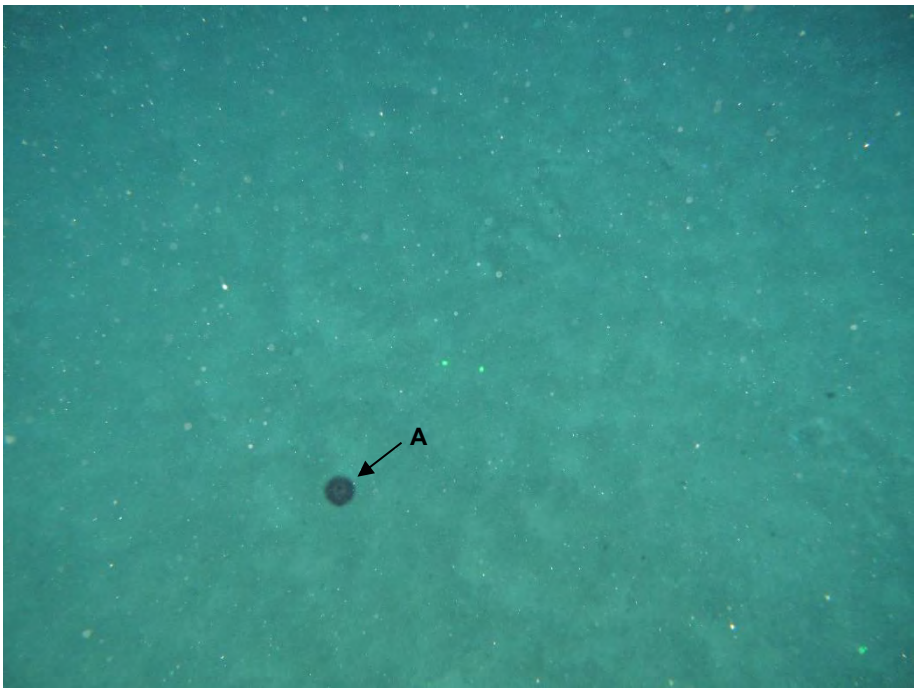


Photograph:
EBSDDV3_002

Easting: 503 083.3 mE
Northing: 903 004.2 mN
Depth: 1919.4 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
No fauna visible



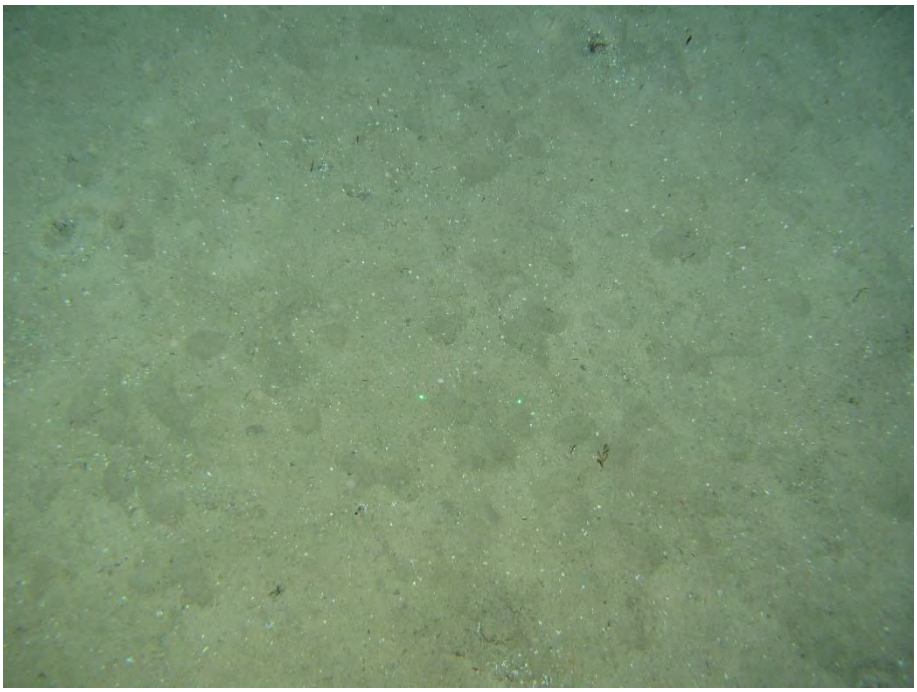
Photograph:
EBSDDV3_012

Easting: 503 096.4 mE
Northing: 902 970.5 mN
Depth: 1915.1 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Anemone (Actiniaria)

STATION EBSDDV4

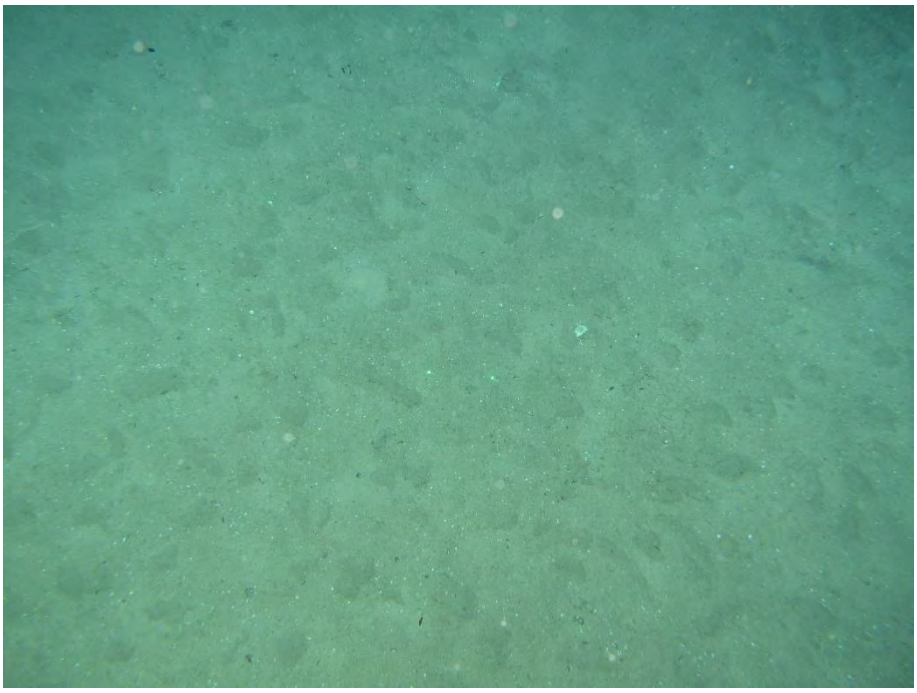


Photograph:
EBSDDV4_002

Easting: 508 609.1 mE
Northing: 901 724.3 mN
Depth: 1937.3 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
No fauna visible



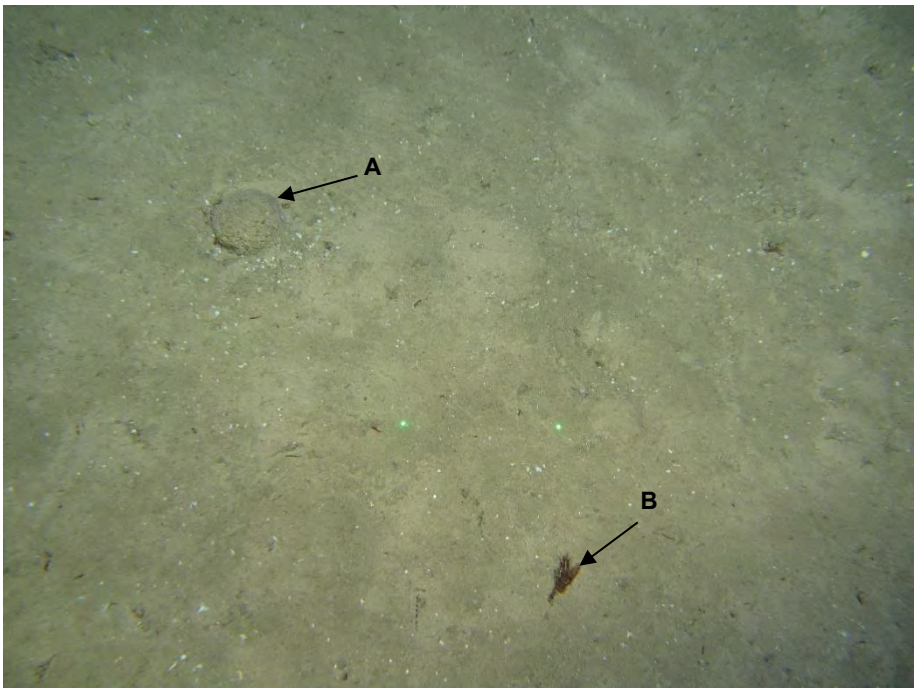
Photograph:
EBSDDV4_009

Easting: 508 605.9 mE
Northing: 901 733.9 mN
Depth: 1938.4 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
No fauna visible

STATION EBSDDV5

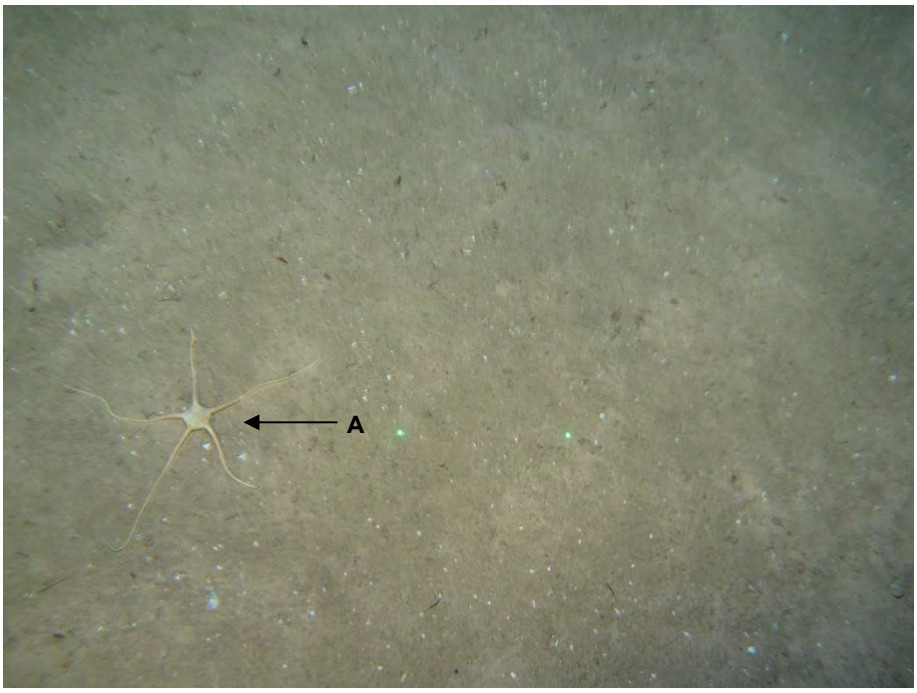


Photograph:
EBSDDV5_005

Easting: 496 385.8 mE
Northing: 906 352.6 mN
Depth: 1907.8 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Xenophyophore (Xenophyophoroidea)
B: Faunal turf



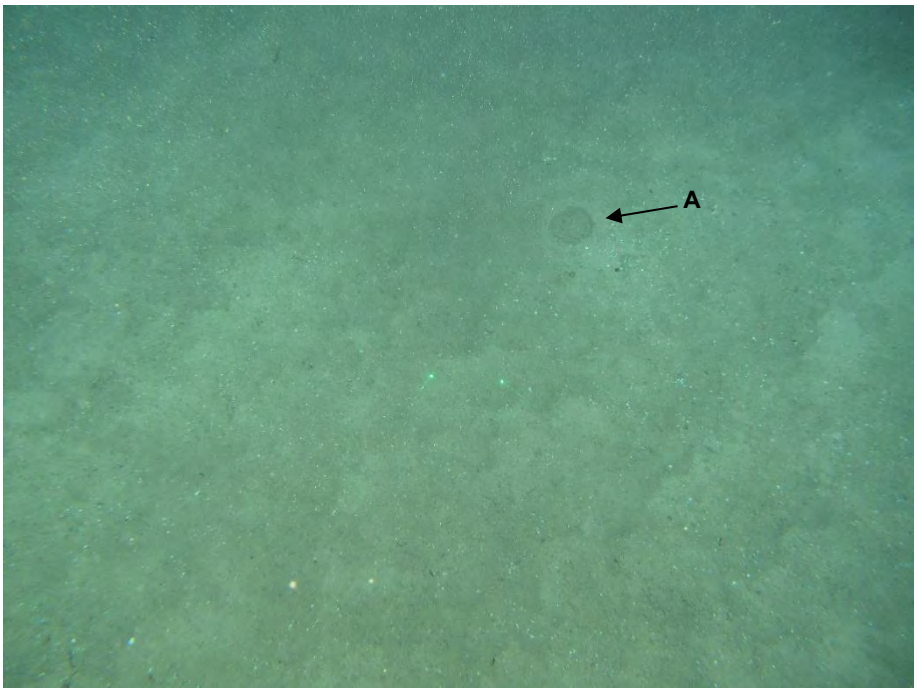
Photograph:
EBSDDV5_012

Easting: 496 377.8 mE
Northing: 906 333.1 mN
Depth: 1905.7 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Brittlestar (Ophiuroidea)

STATION EBSDDV6

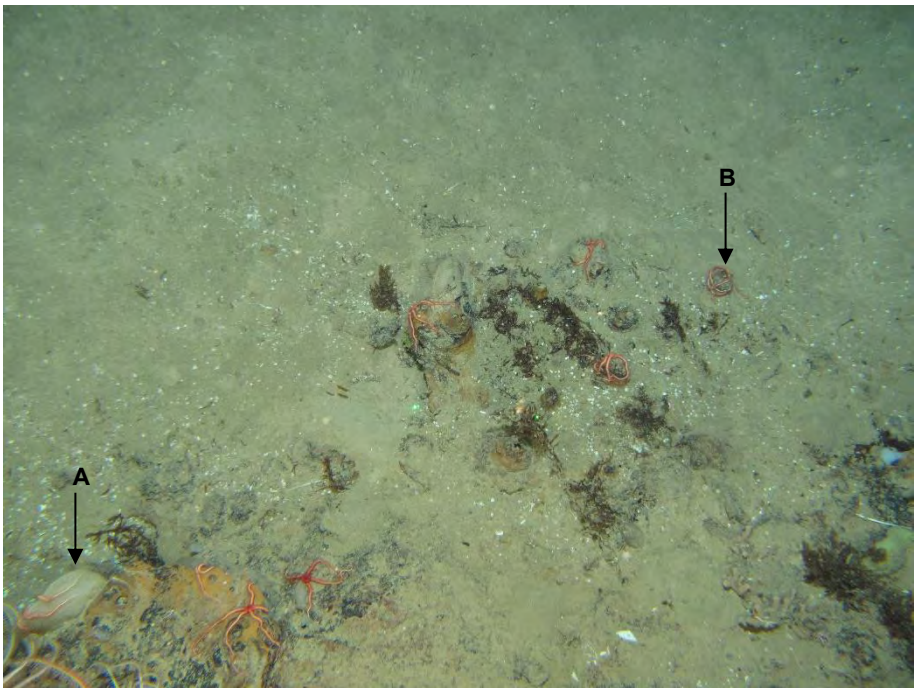


Photograph:
EBSDDV6_004

Easting: 502 214.0 mE
Northing: 906 781.6 mN
Depth: 1974.6 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Xenophyophore (Xenophyophoroidea)



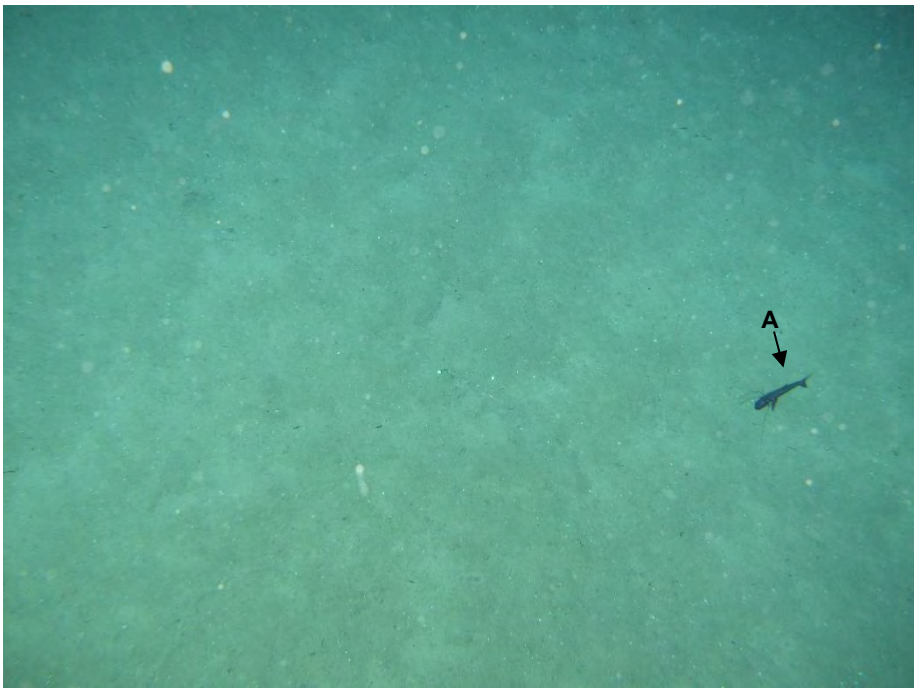
Photograph:
EBSDDV6_010

Easting: 502 208.6 mE
Northing: 906 776.8 mN
Depth: 1976.4 m MSL

Sediment Type:
Muddy sand with shell fragments and area of hard substrate.

Fauna:
A: Sponge (Porifera)
B: Brittlestar (Ophiuroidea)

STATION EBSDDV7



Photograph:
EBSDDV7_001

Easting: 493 698.8 mE
Northing: 903 153.2 mN
Depth: 1820.0 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Tripod fish (Ipnopidae)



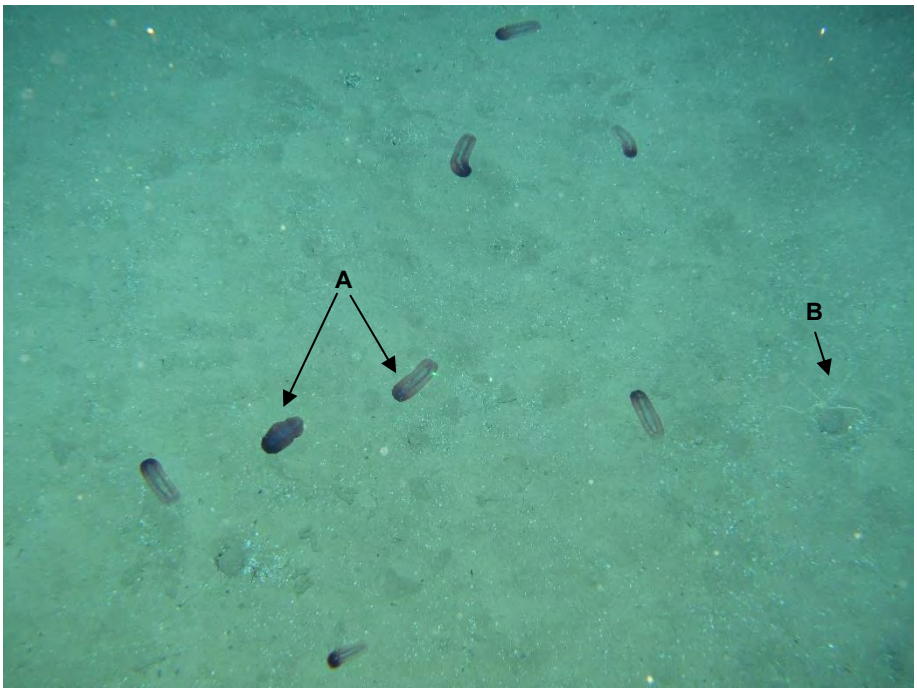
Photograph:
EBSDDV7_010

Easting: 493 673.4 mE
Northing: 903 160.6 mN
Depth: 1823.3 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
No fauna visible

STATION EBSDDV8

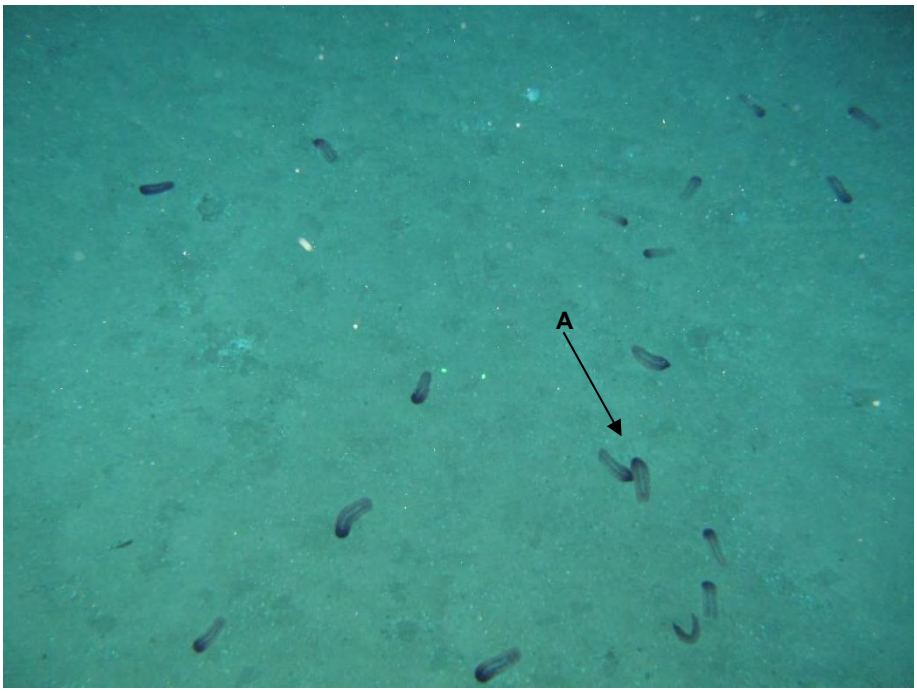


Photograph:
EBSDDV8_003

Easting: 512 787.2 mE
Northing: 908 877.0 mN
Depth: 2098.9 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Aggregations of sea cucumbers (*Benthodytes* sp.)
B: Brittlestar (Ophiuroidea)



Photograph:
EBSDDV8_010

Easting: 512 766.9 mE
Northing: 908 878.9 mN
Depth: 2099.0 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Aggregations of sea cucumbers (*Benthodytes* sp.)

STATION EBSDDV9



Photograph:
EBSDDV9_001

Easting: 502 537.7 mE
Northing: 917 530.5 mN
Depth: 2180.8 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
No fauna visible



Photograph:
EBSDDV9_005

Easting: 502 537.5 mE
Northing: 917 523.9 mN
Depth: 2178.5 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Sea cucumbers (*Benthodytes* sp.)

STATION EBSDDV10

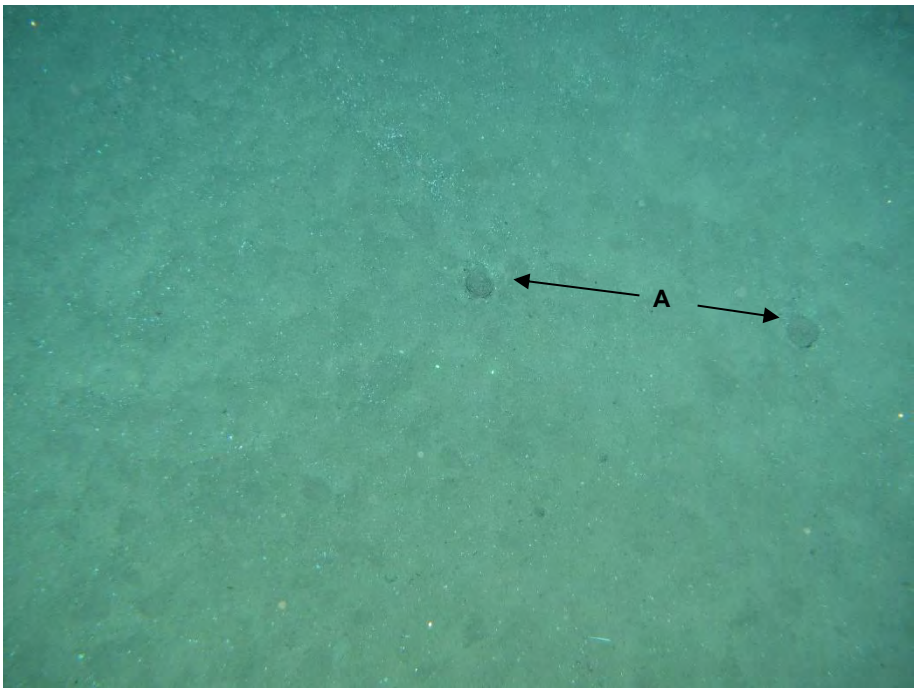


Photograph:
EBSDDV10_003

Easting: 513 124.0 mE
Northing: 900 665. mN
Depth: 1972.3 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Anemone (Actiniaria)



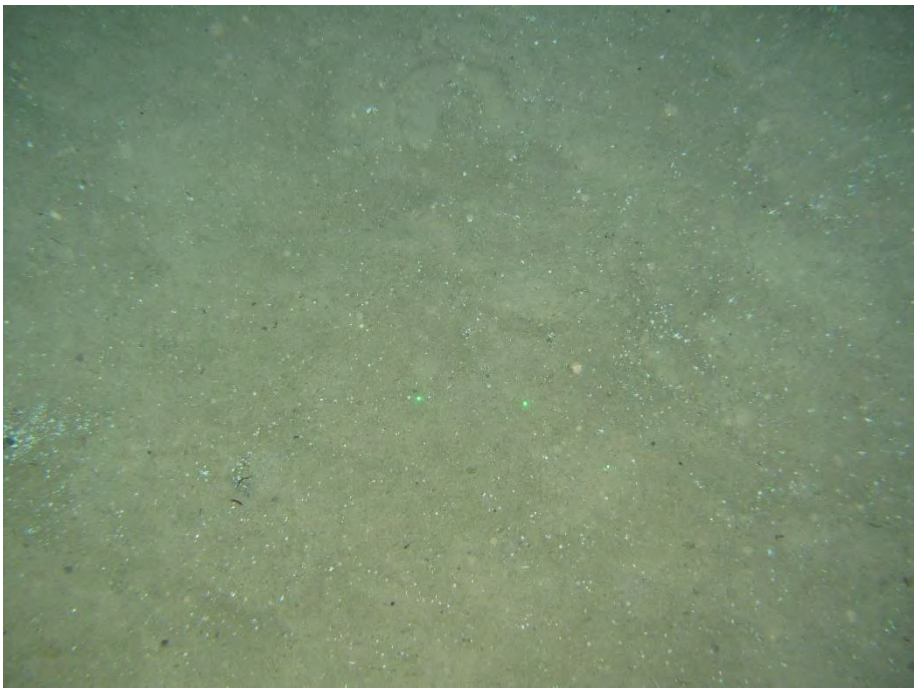
Photograph:
EBSDDV10_028

Easting: 513 090.0 mE
Northing: 900 633.1 mN
Depth: 1967.9 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Xenophyophore (Xenophyophoroidea)

STATION EBSDDV11



Photograph:
EBSDDV11_023

Easting: 504 552.0 mE
Northing: 917 017.4 mN
Depth: 2181.2m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
No fauna visible



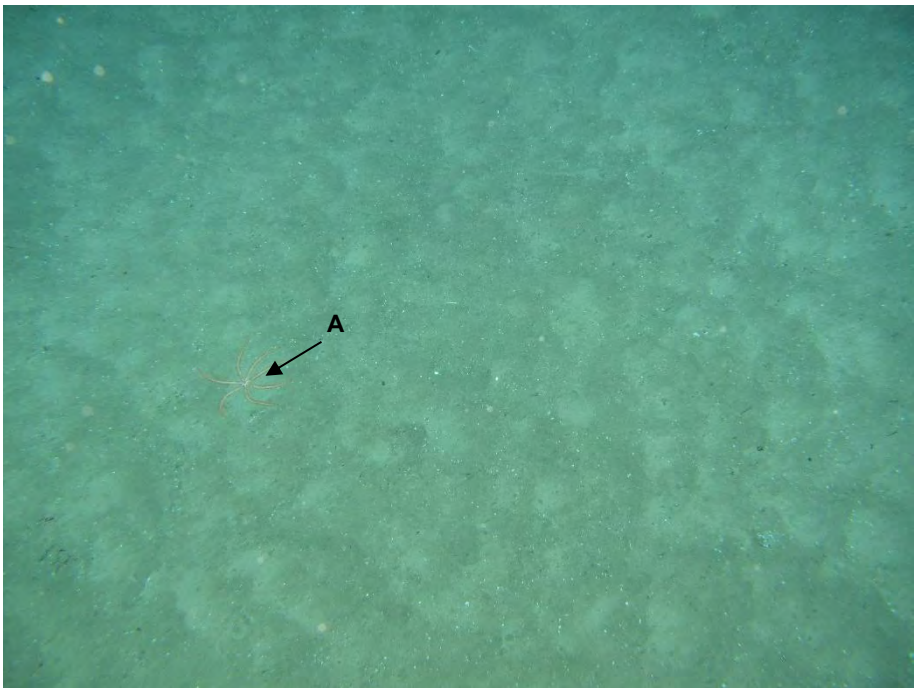
Photograph:
EBSDDV11_030

Easting: 504 524.9 mE
Northing: 917 000.6 mN
Depth: 2180.4 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Sea cucumber (*Benthodytes* sp.)

STATION EBSDDV16

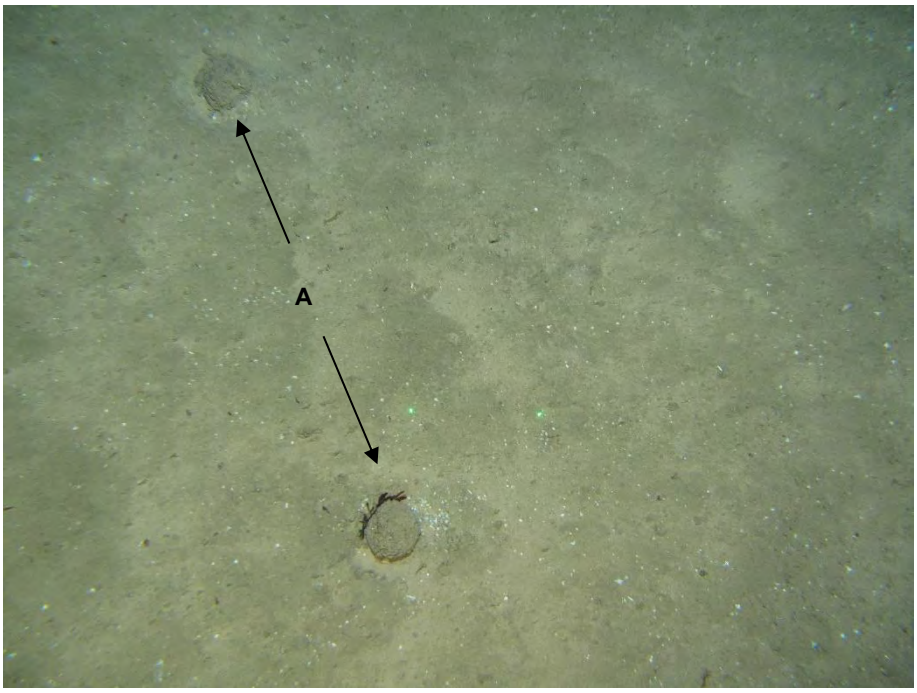


Photograph:
EBSDDV16_004

Easting: 500 099.7 mE
Northing: 906 819 mN
Depth: 1951.7 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Crinoid (Crinoidea)



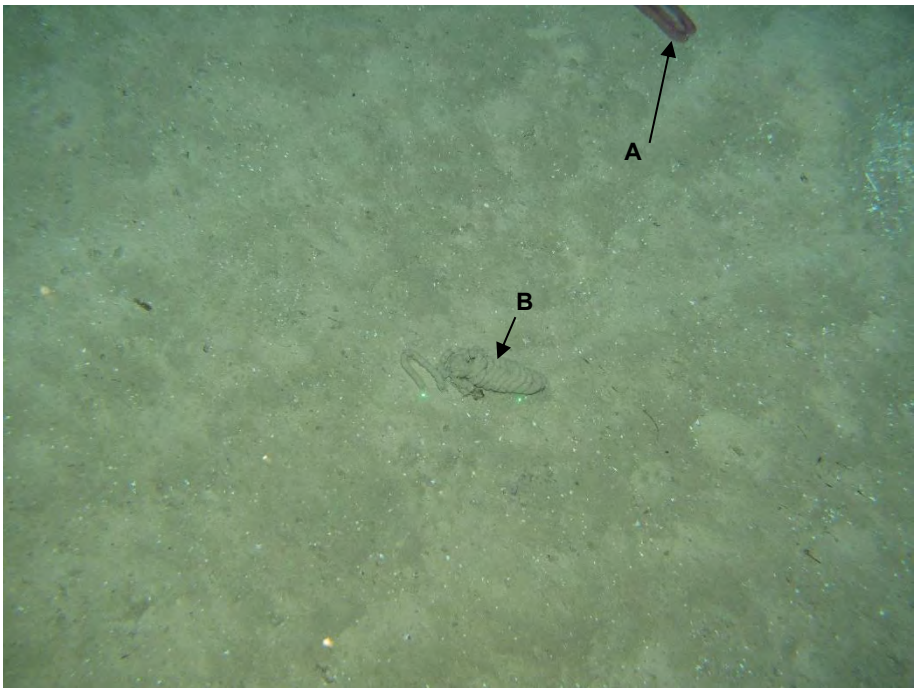
Photograph:
EBSDDV16_019

Easting: 500 078.8 mE
Northing: 906 823.3 mN
Depth: 1952.2 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Xenophyophore (Xenophyophoroidea)

STATION EBSDDV36

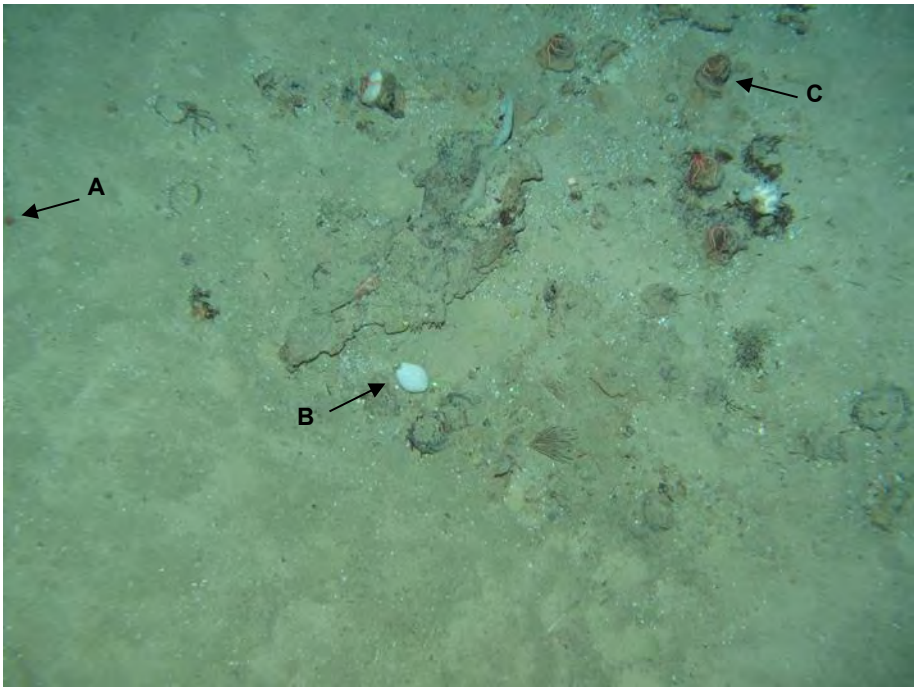


Photograph:
EBSDDV36_007

Easting: 499 635.3 mE
Northing: 906 891.6 mN
Depth: 1951.9 m MSL

Sediment Type:
Muddy sand with shell fragments

Fauna:
A: Sea cucumber (*Benthodytes* sp.)
B: Faecal casts



Photograph:
EBSDDV36_015

Easting: 499 624.5 mE
Northing: 906 894.7 mN
Depth: 1949.3 m MSL

Sediment Type:
Muddy sand with shell fragments and area of hard substrate.

Fauna:
A: Pencil urchin (Cidaridae)
B: Sponge (Porifera)
C: Brittlestar (Ophiuroidea)

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H. MACROFAUNAL ANALYSIS

Kingdom	Phylum	Class	Order	Family	Genus	Subgenus	Species	Taxon	Aphia ID	Authority	EBSB C1 FA	EBSB C1 FB	EBSB C2 FA	EBSB C2 FB	EBSB C3 FA	EBSB C3 FB	EBSB C4 FA	EBSB C4 FB
								SIPUNCULA										
Animalia	Sipuncula							SIPUNCULA sp. A	1268	-								
Animalia	Sipuncula	Phascolosomatidea	Phascolosomatida	Phascolosomatidae	*Apionsoma*			*Apionsoma*	136027	Sluiter, 1902								1
Animalia	Sipuncula	Phascolosomatidea	Aspidosiphonida	Aspidosiphonidae	*Aspidosiphon*	*Akrikos*	*zinni*	*Aspidosiphon zinni*	136039	Cutler, 1969		1	2	2				2
								ANNELIDA										
Animalia	Annelida	Polychaeta	Phyllodocida	Pholoidae	*Pholoe*		*anoculata*	*Pholoe anoculata*	154921	Hartman, 1965								
Animalia	Annelida	Polychaeta	Phyllodocida	Goniadidae	*Bathyglycinde*		*profunda*	*Bathyglycinde profunda*	240611	(Hartman & Fauchald, 1971)	3			1				
Animalia	Annelida	Polychaeta	Phyllodocida	Goniadidae	*Goniada*			*Goniada*	129300	Audouin & H Milne Edwards, 1833							1	
Animalia	Annelida	Polychaeta	Amphinomida	Amphinomidae	*Paramphinome*		*posterobranchiata*	*Paramphinome posterobranchiata*	767303	Barroso & Paiva, 2008		1						
Animalia	Annelida	Polychaeta	Eunicida	Lumbrineridae	*Augeneria*			*Augeneria*	129332	Monro, 1930								
Animalia	Annelida	Polychaeta		Paraonidae				Paraonidae sp. A	903	Cerruti, 1909								
Animalia	Annelida	Polychaeta		Paraonidae	*Aricidea*			*Aricidea*	129430	Webster, 1879		1						
Animalia	Annelida	Polychaeta		Paraonidae	*Paradoneis*			*Paradoneis*	129433	Hartman, 1965								1
Animalia	Annelida	Polychaeta	Spionida	Spionidae	*Spiophanes*			*Spiophanes*	129626	Grube, 1860	1	3	3	5	1	1		
Animalia	Annelida	Polychaeta	Spionida	Longosomatidae	*Heterospio*			*Heterospio*	129325	Ehlers, 1874	1							
Animalia	Annelida	Polychaeta		Chaetopteridae	*Spiochaetopterus*			*Spiochaetopterus*	129233	M Sars, 1856								
Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae				Cirratulidae	919	Ryckholt, 1851			1					
Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*Kirkegaardia*			*Kirkegaardia*	884676	Blake, 2016						1		1
Animalia	Annelida	Polychaeta	Terebellida	Flabelligeridae	*Pherusa*			*Pherusa*		Oken, 1807								
Animalia	Annelida	Polychaeta		Capitellidae				Capitellidae	921	**Grube, 1862**			**1**					
Animalia	Annelida	Polychaeta		Maldanidae				Maldanidae	923	Malmgren, 1867								
Animalia	Annelida	Polychaeta		Opheliidae				Opheliidae	924	**Malmgren, 1867**				**1**				
Animalia	Annelida	Polychaeta		Scalibregmatidae				Scalibregmatidae sp. A	925	Malmgren, 1867								
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae	975	**Rioja, 1917**			**1**			**3**	**1**	
Animalia	Annelida	Polychaeta	Terebellida	Ampharetidae				Ampharetinae	152252	Malmgren, 1866								
Animalia	Annelida	Clitellata	Enchytraeida	Enchytraeidae				Enchytraeidae	2038	Vejdovský, 1879								
								ARTHROPODA										
Animalia	Arthropoda	Hexanauplia	Scalpelliformes	Scalpellidae				Scalpellidae	106055	Pilsbry, 1907		1						
Animalia	Arthropoda	Hexanauplia	Sessilia	Balanidae				Balanidae sp. A	106057	Leach, 1817								
Animalia	Arthropoda	Malacostraca	Amphipoda	Phoxocephalidae	*Harpiniopsis*			*Harpiniopsis* (?) sp. A	101717	Stephensen, 1925								
Animalia	Arthropoda	Malacostraca	Amphipoda	Phoxocephalidae	*Harpiniopsis*			*Harpiniopsis* (?) sp. B	101717	Stephensen, 1925	1	1						
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae				Ampeliscidae	101364	**Krøyer, 1842**	**1**							
Animalia	Arthropoda	Malacostraca	Amphipoda	Ischyroceridae				Ischyroceridae	101389	Stebbing, 1899								
Animalia	Arthropoda	Malacostraca	Isopoda	Leptanthuridae				Leptanthuridae	148628	Poore, 2001		1						
Animalia	Arthropoda	Malacostraca	Isopoda	Haploniscidae	*Aspidoniscus*			*Aspidoniscus* sp. A	248462	Menzies & Schultz, 1968								
Animalia	Arthropoda	Malacostraca	Isopoda	Ischnomesidae	*Heteromesus*			*Heteromesus*	118357	Richardson, 1908					2			
Animalia	Arthropoda	Malacostraca	Isopoda	Nannoniscidae				Nannoniscidae sp. A	118265	Hansen, 1916					1			
Animalia	Arthropoda	Malacostraca	Isopoda	Nannoniscidae				Nannoniscidae sp. B	118265	Hansen, 1916								
Animalia	Arthropoda	Malacostraca	Isopoda	Desmosomatidae	*Eugerdella*			*Eugerdella* (?)	118324	Kussakin, 1965								
Animalia	Arthropoda	Malacostraca	Isopoda	Macrostylidae	*Macrostylis*			*Macrostylis*	118371	G.O. Sars, 1864								

Kingdom	Phylum	Class	Order	Family	Genus	Subgenus	Species	Taxon	Aphia ID	Authority	EBSB C1 FA	EBSB C1 FB	EBSB C2 FA	EBSB C2 FB	EBSB C3 FA	EBSB C3 FB	EBSB C4 FA	EBSB C4 FB
Animalia	Arthropoda	Malacostraca	Tanaidacea					TANAIDOMORPHA sp. A	136152	Sieg, 1980								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Paratanaoidea incertae sedis	*Parafilitanais*			*Parafilitanais*	246987	Kudinova-Pasternak, 1989								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Colletteidae	*Collettea*			*Collettea*	136208	Lang, 1973								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Agathotanaidae	*Agathotanais*			*Agathotanais*	136222	Hansen, 1913				1				
Animalia	Arthropoda	Malacostraca	Tanaidacea	Agathotanaidae	*Paragathotanais*			*Paragathotanais*	136224	Lang, 1971				1				
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae	*Peraeospinosus*			*Peraeospinosus*	136255	Sieg, 1986			1					
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae	*Torquella*			*Torquella*	247875	Blazewicz-Paszkowycz, 2007								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Neotanaidae	*Neotanais*			*Neotanais*	136204	Beddard, 1886								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Apseudidae	*Glabroapseudes*			*Glabroapseudes*	246931	Guerrero-Kommritz & Heard, 2003				1				
Animalia	Arthropoda	Malacostraca	Cumacea	Diastylidae	*Leptostylis*			*Leptostylis*	110403	G.O. Sars, 1869				1				
								MOLLUSCA										
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae	135	**Philippi, 1853**								
Animalia	Mollusca	Scaphopoda	Dentaliida	Dentaliidae	*Graptacme*			*Graptacme* (?)	343648	Pilsbry & Sharp, 1897								
Animalia	Mollusca	Bivalvia						BIVALVIA sp. A	105	Linnaeus, 1758								
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*			*Pristigloma*	138375	**Dall, 1900**							**1**	
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae	*Brevinucula*		*verrillii*	*Brevinucula verrillii*	140580	(Dall, 1886)								
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae	*Ennucula*			*Ennucula*	138261	Iredale, 1931			1					
Animalia	Mollusca	Bivalvia	Nuculanida	Nuculanidae				Ledellinae sp. A	510729	Allen & Sanders, 1982								
Animalia	Mollusca	Bivalvia	Nuculanida	Nuculanidae	*Ledella*		*pustulosa*	Ledella pustulosa	182796	(Jeffreys, 1876)				1				
Animalia	Mollusca	Bivalvia	Nuculanida	Yoldiidae	*Yoldiella*			*Yoldiella* sp. A	138673	A. E. Verrill & Bush, 1897			1					
Animalia	Mollusca	Bivalvia	Nuculanida	Yoldiidae	*Yoldiella*			*Yoldiella* sp. B	138673	A. E. Verrill & Bush, 1897								
								ECHINODERMATA										
Animalia	Echinodermata	Crinoidea						CRINOIDEA	123081	-								
Animalia	Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae				Ophiuridae sp. A	123200	Müller & Troschel, 1840								
								Number of Taxa			**5**	**7**	**8**	**9**	**3**	**3**	**3**	**4**
								Number of Individuals			**7**	**9**	**11**	**14**	**4**	**5**	**3**	**5**
The following taxa were merged for analysis																		
								ANNELIDA										
Animalia	Annelida	Polychaeta		Capitellidae				Capitellidae	921	**Grube, 1862**			**1**					
Animalia	Annelida	Polychaeta		Capitellidae				Capitellidae (dam.)	921	Grube, 1862								
Animalia	Annelida	Polychaeta		Capitellidae	*Notomastus*			*Notomastus*	129220	M. Sars, 1851			1					
Animalia	Annelida	Polychaeta		Opheliidae				Opheliidae	924	**Malmgren, 1867**				**1**				
Animalia	Annelida	Polychaeta		Opheliidae				Opheliidae (dam.)	924	Malmgren, 1867				1				
Animalia	Annelida	Polychaeta		Opheliidae	*Ophelina*		*abranchiata*	*Ophelina abranchiata* (?)	130499	Støp-Bowitz, 1948								
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae	975	**Rioja, 1917**			**1**			**3**	**1**	
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae (dam.)	975	Rioja, 1917			1			3	1	
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae	*Myriochele*			*Myriochele (Myrioglobula)*	129426	Malmgren, 1867								
								ARTHROPODA										
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae				Ampeliscidae	101364	**Krøyer, 1842**	**1**							
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae				Ampeliscidae (dam.)	101364	Krøyer, 1842	1							
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	*Byblis*			*Byblis*	101446	Boeck, 1871								
								MOLLUSCA										

Kingdom	Phylum	Class	Order	Family	Genus	Subgenus	Species	Taxon	Aphia ID	Authority	EBSB C1 FA	EBSB C1 FB	EBSB C2 FA	EBSB C2 FB	EBSB C3 FA	EBSB C3 FB	EBSB C4 FA	EBSB C4 FB
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae	135	**Philippi, 1853**								
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae	135	Philippi, 1853								
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae sp. A	135	Philippi, 1853								
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*			*Pristigloma*	138375	**Dall, 1900**							**1**	
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*			*Pristigloma* (dam.)	138375	Dall, 1900								
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*		*alba*	*Pristigloma alba*	156977	Sanders & Allen, 1973							1	
								Number of Taxa			**1**	**0**	**2**	**1**	**0**	**1**	**2**	**0**
								Number of Individuals			**1**	**0**	**2**	**1**	**0**	**3**	**2**	**0**
The following taxa were merged for analysis																		
								Colonial										
Animalia	Porifera							PORIFERA	558	Grant, 1836		P						
								STOLONIFERA		Thomson & Simpson, 1909								
								Damaged										
Animalia	Sipuncula							SIPUNCULA (dam.)	1268	-		1						
Animalia	Annelida	Polychaeta						POLYCHAETA (dam.)	883	Grube, 1850			1					1
Animalia	Arthropoda	Malacostraca	Amphipoda					AMPHIPODA (dam.)	1135	Latreille, 1816			1		1			
Animalia	Arthropoda	Malacostraca	Isopoda					ISOPODA (dam.)	1131	Latreille, 1817								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae				Typhlotanaidae (dam.)	136165	Sieg, 1984								
Animalia	Mollusca	Bivalvia						BIVALVIA (dam.)	105	Linnaeus, 1758								
								Juvenile										
Animalia	Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera*			*Glycera* (juv.)	129296	Lamarck, 1818		1						
Animalia	Annelida	Polychaeta	Eunicida	Onuphidae				Onuphidae (juv.)	965	Kinberg, 1865	1							
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae (juv.)	975	Rioja, 1917								
Animalia	Arthropoda	Hexanauplia						CIRRIPEDIA (juv.)	1082	Burmeister, 1834								
Animalia	Arthropoda	Malacostraca	Isopoda	Leptanthuridae				Leptanthuridae (juv.)	148628	Poore, 2001				1				
Animalia	Arthropoda	Malacostraca	Tanaidacea					TANAIDACEA (juv.)	1133	Dana, 1849								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae				Typhlotanaidae (juv.)	136165	Sieg, 1984				1				
Animalia	Arthropoda	Malacostraca	Tanaidacea	Sphyrapodidae				Sphyrapodidae (juv.)	246702	Gutu, 1980								
Animalia	Mollusca	Bivalvia						BIVALVIA (juv.)	105	Linnaeus, 1758								
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae				Nuculidae (juv.)	204	Gray, 1824			1					
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae	*Ennucula*			*Ennucula* (juv.)	138261	Iredale, 1931								
Animalia	Mollusca	Bivalvia	Nuculanida	Nuculanidae				Nuculanidae (juv.)	205	H. Adams & A. Adams, 1858 (1854)		1	2					
Animalia	Echinodermata	Crinoidea						CRINOIDEA (juv.)	123081	-								
Animalia	Echinodermata	Ophiuroidea						OPHIUROIDEA (juv.)	123084	Gray, 1840		1						
Animalia	Echinodermata	Holothuroidea						HOLOTHUROIDEA (juv.)	123083	-				1				
Animalia	Chordata	Ascidiacea						ASCIDIACEA (juv.)	1839	Blainville, 1824	2							
								Pelagic										
Animalia	Chaetognatha							CHAETOGNATHA (dam.)	2081	-						1		
								Number of Taxa			**2**	**5**	**4**	**3**	**1**	**1**	**0**	**1**
								Number of Individuals			**3**	**4**	**5**	**3**	**1**	**1**	**0**	**1**

Kingdom	Phylum	Class	Order	Family	Genus	Subgenus	Species	Taxon	Aphia ID	Authority	EBSB C5 FA	EBSB C5 FB	EBSB C6 FA	EBSB C6 FB	EBSB C7 FA	EBSB C7 FB	EBSB CA FA	EBSB C8 FB
								SIPUNCULA										
Animalia	Sipuncula							SIPUNCULA sp. A	1268	-			2					
Animalia	Sipuncula	Phascolosomatidea	Phascolosomatida	Phascolosomatidae	*Apionsoma*			*Apionsoma*	136027	Sluiter, 1902								
Animalia	Sipuncula	Phascolosomatidea	Aspidosiphonida	Aspidosiphonidae	*Aspidosiphon*	*Akrikos*	*zinni*	*Aspidosiphon zinni*	136039	Cutler, 1969								1
								ANNELIDA										
Animalia	Annelida	Polychaeta	Phyllodocida	Pholoidae	*Pholoe*		*anoculata*	*Pholoe anoculata*	154921	Hartman, 1965		1						
Animalia	Annelida	Polychaeta	Phyllodocida	Goniadidae	*Bathyglycinde*		*profunda*	*Bathyglycinde profunda*	240611	(Hartman & Fauchald, 1971)			2			2		
Animalia	Annelida	Polychaeta	Phyllodocida	Goniadidae	*Goniada*			*Goniada*	129300	Audouin & H Milne Edwards, 1833								
Animalia	Annelida	Polychaeta	Amphinomida	Amphinomidae	*Paramphinome*		*posterobranchiata*	*Paramphinome posterobranchiata*	767303	Barroso & Paiva, 2008		1						
Animalia	Annelida	Polychaeta	Eunicida	Lumbrineridae	*Augeneria*			*Augeneria*	129332	Monro, 1930				1				
Animalia	Annelida	Polychaeta		Paraonidae				Paraonidae sp. A	903	Cerruti, 1909						2		
Animalia	Annelida	Polychaeta		Paraonidae	*Aricidea*			*Aricidea*	129430	Webster, 1879						1		
Animalia	Annelida	Polychaeta		Paraonidae	*Paradoneis*			*Paradoneis*	129433	Hartman, 1965					1	3		
Animalia	Annelida	Polychaeta	Spionida	Spionidae	*Spiophanes*			*Spiophanes*	129626	Grube, 1860		1			3	1	4	
Animalia	Annelida	Polychaeta	Spionida	Longosomatidae	*Heterospio*			*Heterospio*	129325	Ehlers, 1874		1						
Animalia	Annelida	Polychaeta		Chaetopteridae	*Spiochaetopterus*			*Spiochaetopterus*	129233	M Sars, 1856					1			
Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae				Cirratulidae	919	Ryckholt, 1851		1						1
Animalia	Annelida	Polychaeta	Terebellida	Cirratulidae	*Kirkegaardia*			*Kirkegaardia*	884676	Blake, 2016		1		2	1	1		
Animalia	Annelida	Polychaeta	Terebellida	Flabelligeridae	*Pherusa*			*Pherusa*		Oken, 1807					1			
Animalia	Annelida	Polychaeta		Capitellidae				Capitellidae	921	**Grube, 1862**		**1**						
Animalia	Annelida	Polychaeta		Maldanidae				Maldanidae	923	Malmgren, 1867						1		
Animalia	Annelida	Polychaeta		Opheliidae				Opheliidae	924	**Malmgren, 1867**					**1**		**1**	
Animalia	Annelida	Polychaeta		Scalibregmatidae				Scalibregmatidae sp. A	925	Malmgren, 1867					1			
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae	975	**Rioja, 1917**					**3**		**1**	
Animalia	Annelida	Polychaeta	Terebellida	Ampharetidae				Ampharetinae	152252	Malmgren, 1866						2		
Animalia	Annelida	Clitellata	Enchytraeida	Enchytraeidae				Enchytraeidae	2038	Vejdovský, 1879						1		1
								ARTHROPODA										
Animalia	Arthropoda	Hexanauplia	Scalpelliformes	Scalpellidae				Scalpellidae	106055	Pilsbry, 1907		1						
Animalia	Arthropoda	Hexanauplia	Sessilia	Balanidae				Balanidae sp. A	106057	Leach, 1817							8	2
Animalia	Arthropoda	Malacostraca	Amphipoda	Phoxocephalidae	*Harpiniopsis*			*Harpiniopsis* (?) sp. A	101717	Stephensen, 1925						1		
Animalia	Arthropoda	Malacostraca	Amphipoda	Phoxocephalidae	*Harpiniopsis*			*Harpiniopsis* (?) sp. B	101717	Stephensen, 1925								
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae				Ampeliscidae	101364	**Krøyer, 1842**			**2**	**2**		**1**	**1**	
Animalia	Arthropoda	Malacostraca	Amphipoda	Ischyroceridae				Ischyroceridae	101389	Stebbing, 1899			2					
Animalia	Arthropoda	Malacostraca	Isopoda	Leptanthuridae				Leptanthuridae	148628	Poore, 2001						1		
Animalia	Arthropoda	Malacostraca	Isopoda	Haploniscidae	*Aspidoniscus*			*Aspidoniscus* sp. A	248462	Menzies & Schultz, 1968							1	
Animalia	Arthropoda	Malacostraca	Isopoda	Ischnomesidae	*Heteromesus*			*Heteromesus*	118357	Richardson, 1908					1			
Animalia	Arthropoda	Malacostraca	Isopoda	Nannoniscidae				Nannoniscidae sp. A	118265	Hansen, 1916					1			
Animalia	Arthropoda	Malacostraca	Isopoda	Nannoniscidae				Nannoniscidae sp. B	118265	Hansen, 1916					1			
Animalia	Arthropoda	Malacostraca	Isopoda	Desmosomatidae	*Eugerdella*			*Eugerdella* (?)	118324	Kussakin, 1965								1
Animalia	Arthropoda	Malacostraca	Isopoda	Macrostylidae	*Macrostylis*			*Macrostylis*	118371	G.O. Sars, 1864					1			
Animalia	Arthropoda	Malacostraca	Tanaidacea					TANAIDOMORPHA sp. A	136152	Sieg, 1980						1		
Animalia	Arthropoda	Malacostraca	Tanaidacea	Paratanaoidea incertae sedis	*Parafilitanais*			*Parafilitanais*	246987	Kudinova-Pasternak, 1989								1
Animalia	Arthropoda	Malacostraca	Tanaidacea	Colletteidae	*Collettea*			*Collettea*	136208	Lang, 1973			1					2

Kingdom	Phylum	Class	Order	Family	Genus	Subgenus	Species	Taxon	Aphia ID	Authority	EBSB C5 FA	EBSB C5 FB	EBSB C6 FA	EBSB C6 FB	EBSB C7 FA	EBSB C7 FB	EBSB CA FA	EBSB C8 FB
Animalia	Arthropoda	Malacostraca	Tanaidacea	Agathotanaidae	*Agathotanais*			*Agathotanais*	136222	Hansen, 1913								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Agathotanaidae	*Paragathotanais*			*Paragathotanais*	136224	Lang, 1971								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae	*Peraeospinosus*			*Peraeospinosus*	136255	Sieg, 1986								
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae	*Torquella*			*Torquella*	247875	Blazewicz-Paszkowycz, 2007					1			
Animalia	Arthropoda	Malacostraca	Tanaidacea	Neotanaidae	*Neotanais*			*Neotanais*	136204	Beddard, 1886								1
Animalia	Arthropoda	Malacostraca	Tanaidacea	Apseudidae	*Glabroapseudes*			*Glabroapseudes*	246931	Guerrero-Kommritz & Heard, 2003								
Animalia	Arthropoda	Malacostraca	Cumacea	Diastylidae	*Leptostylis*			*Leptostylis*	110403	G.O. Sars, 1869								
								MOLLUSCA										
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae	135	**Philippi, 1853**					**2**			
Animalia	Mollusca	Scaphopoda	Dentaliida	Dentaliidae	*Graptacme*			*Graptacme* (?)	343648	Pilsbry & Sharp, 1897							1	
Animalia	Mollusca	Bivalvia						BIVALVIA sp. A	105	Linnaeus, 1758					1			
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*			*Pristigloma*	138375	**Dall, 1900**			**1**					
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae	*Brevinucula*		*verrillii*	*Brevinucula verrillii*	140580	(Dall, 1886)					1			
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae	*Ennucula*			*Ennucula*	138261	Iredale, 1931		1						
Animalia	Mollusca	Bivalvia	Nuculanida	Nuculanidae				Ledellinae sp. A	510729	Allen & Sanders, 1982					1			
Animalia	Mollusca	Bivalvia	Nuculanida	Nuculanidae	*Ledella*		*pustulosa*	*Ledella pustulosa*	182796	(Jeffreys, 1876)					1			
Animalia	Mollusca	Bivalvia	Nuculanida	Yoldiidae	*Yoldiella*			*Yoldiella* sp. A	138673	A. E. Verrill & Bush, 1897								
Animalia	Mollusca	Bivalvia	Nuculanida	Yoldiidae	*Yoldiella*			*Yoldiella* sp. B	138673	A. E. Verrill & Bush, 1897			1					
								ECHINODERMATA										
Animalia	Echinodermata	Crinoidea						CRINOIDEA	123081	-			1					
Animalia	Echinodermata	Ophiuroidea	Ophiurida	Ophiuridae				Ophiuridae sp. A	123200	Müller & Troschel, 1840	3							
								Number of Taxa			**1**	**9**	**8**	**3**	**18**	**13**	**7**	**8**
								Number of Individuals			**3**	**9**	**12**	**5**	**23**	**18**	**17**	**10**
The following taxa were merged for analysis																		
								ANNELIDA										
Animalia	Annelida	Polychaeta		Capitellidae				Capitellidae	921	**Grube, 1862**		**1**						
Animalia	Annelida	Polychaeta		Capitellidae				Capitellidae (dam.)	921	Grube, 1862		1						
Animalia	Annelida	Polychaeta		Capitellidae	*Notomastus*			*Notomastus*	129220	M. Sars, 1851								
Animalia	Annelida	Polychaeta		Opheliidae				Opheliidae	924	**Malmgren, 1867**					**1**		**1**	
Animalia	Annelida	Polychaeta		Opheliidae				Opheliidae (dam.)	924	Malmgren, 1867							1	
Animalia	Annelida	Polychaeta		Opheliidae	*Ophelina*		*abranchiata*	*Ophelina abranchiata* (?)	130499	Støp-Bowitz, 1948					1			
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae	975	**Rioja, 1917**					**3**		**1**	
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae (dam.)	975	Rioja, 1917					1		1	
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae	*Myriochele*			*Myriochele (Myrioglobula)*	129426	Malmgren, 1867					2			
								ARTHROPODA										
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae				Ampeliscidae	101364	**Krøyer, 1842**			**2**	**2**		**1**	**1**	
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae				Ampeliscidae (dam.)	101364	Krøyer, 1842			2	1				
Animalia	Arthropoda	Malacostraca	Amphipoda	Ampeliscidae	*Byblis*			*Byblis*	101446	Boeck, 1871				1		1	1	
								MOLLUSCA										
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae	135	**Philippi, 1853**					**2**			
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae	135	Philippi, 1853					1			
Animalia	Mollusca	Gastropoda	Littorinimorpha	Eulimidae				Eulimidae sp. A	135	Philippi, 1853					1			
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*			*Pristigloma*	138375	**Dall, 1900**			**1**					

Kingdom	Phylum	Class	Order	Family	Genus	Subgenus	Species	Taxon	Aphia ID	Authority	EBSB C5 FA	EBSB C5 FB	EBSB C6 FA	EBSB C6 FB	EBSB C7 FA	EBSB C7 FB	EBSB CA FA	EBSB C8 FB
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*			*Pristigloma* (dam.)	138375	Dall, 1900			1					
Animalia	Mollusca	Bivalvia	Nuculanida	Sareptidae	*Pristigloma*		*alba*	*Pristigloma alba*	156977	Sanders & Allen, 1973								
								Number of Taxa			**0**	**1**	**2**	**1**	**3**	**1**	**3**	**0**
								Number of Individuals			**0**	**1**	**3**	**2**	**6**	**1**	**3**	**0**
The following taxa were removed from the analysis																		
								Colonial										
Animalia	Porifera							PORIFERA	558	Grant, 1836	P							
								STOLONIFERA		Thomson & Simpson, 1909	P							
								Damaged										
Animalia	Sipuncula							SIPUNCULA (dam.)	1268	-							1	
Animalia	Annelida	Polychaeta						POLYCHAETA (dam.)	883	Grube, 1850				1	1	1		
Animalia	Arthropoda	Malacostraca	Amphipoda					AMPHIPODA (dam.)	1135	Latreille, 1816						1		
Animalia	Arthropoda	Malacostraca	Isopoda					ISOPODA (dam.)	1131	Latreille, 1817						1		
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae				Typhlotanaidae (dam.)	136165	Sieg, 1984					1			
Animalia	Mollusca	Bivalvia						BIVALVIA (dam.)	105	Linnaeus, 1758		1						
								Juvenile										
Animalia	Annelida	Polychaeta	Phyllodocida	Glyceridae	*Glycera*			*Glycera* (juv.)	129296	Lamarck, 1818						1		
Animalia	Annelida	Polychaeta	Eunicida	Onuphidae				Onuphidae (juv.)	965	Kinberg, 1865								
Animalia	Annelida	Polychaeta	Sabellida	Oweniidae				Oweniidae (juv.)	975	Rioja, 1917						1		
Animalia	Arthropoda	Hexanauplia						CIRRIPEDIA (juv.)	1082	Burmeister, 1834							9	2
Animalia	Arthropoda	Malacostraca	Isopoda	Leptanthuridae				Leptanthuridae (juv.)	148628	Poore, 2001								
Animalia	Arthropoda	Malacostraca	Tanaidacea					TANAIDACEA (juv.)	1133	Dana, 1849				1				
Animalia	Arthropoda	Malacostraca	Tanaidacea	Typhlotanaidae				Typhlotanaidae (juv.)	136165	Sieg, 1984						1		
Animalia	Arthropoda	Malacostraca	Tanaidacea	Sphyrapodidae				Sphyrapodidae (juv.)	246702	Gutu, 1980				1				
Animalia	Mollusca	Bivalvia						BIVALVIA (juv.)	105	Linnaeus, 1758	1	1					1	
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae				Nuculidae (juv.)	204	Gray, 1824					1	1	2	1
Animalia	Mollusca	Bivalvia	Nuculida	Nuculidae	*Ennucula*			*Ennucula* (juv.)	138261	Iredale, 1931	1							
Animalia	Mollusca	Bivalvia	Nuculanida	Nuculanidae				Nuculanidae (juv.)	205	H. Adams & A. Adams, 1858 (1854)			2		1	2	2	
Animalia	Echinodermata	Crinoidea						CRINOIDEA (juv.)	123081	-			1					
Animalia	Echinodermata	Ophiuroidea						OPHIUROIDEA (juv.)	123084	Gray, 1840								
Animalia	Echinodermata	Holothuroidea						HOLOTHUROIDEA (juv.)	123083	-						1		
Animalia	Chordata	Ascidiacea						ASCIDIACEA (juv.)	1839	Blainville, 1824								
								Pelagic										
Animalia	Chaetognatha							CHAETOGNATHA (dam.)	2081	-								
								Number of Taxa			**4**	**2**	**2**	**3**	**4**	**9**	**5**	**2**
								Number of Individuals			**2**	**2**	**3**	**3**	**4**	**10**	**15**	**3**

I. CORRELATIONS - SEDIMENTS

	PSD Mean [µm]	PSD Mean [phi]	SD [phi]	Skew [phi]	Silt [%]	Clay [%]	Gravel [%]	Sand [%]	Fines [%]	TOC [%]	THC [µg/g]	UCM [µg/g]	nC_{12-36} [µg/g]	CPI (nC_{12-36})	Pr [µg/g]	Ph [µg/g]	Pr/Ph Ratio	2 - 6 Ring PAH [ng/g]	% NPD	Al [µg/g]	As [µg/g]	Ba [µg/g]	Cr [µg/g]	Cu [µg/g]	Fe [µg/g]	Hg [µg/g]	Ni [µg/g]	Pb [µg/g]	Zn [µg/g]	Taxa	individuals	Shannon-Wiener [H'Log^2]	Brillouin [Hb]	Pielou [J]	Simpson [1-λ]
PSD Mean [µm]																																		
PSD Mean [phi]	-1.00																																	
SD [phi]	-0.68	0.68																																
Skew [phi]	0.98	-0.98	-0.65																															
Silt [%]	-0.90	0.90	0.42	-0.95																														
Clay [%]	-0.98	0.98	0.75	-0.95	0.86																													
Gravel [%]	-0.24	0.24	0.34	-0.36	0.36	0.38																												
Sand [%]	0.98	-0.98	-0.65	1.00	-0.95	-0.95	-0.36																											
Fines [%]	-0.98	0.98	0.65	-1.00	0.95	0.95	0.36	-1.00																										
TOC [%]	-0.71	0.71	0.34	-0.61	0.53	0.73	0.08	-0.61	0.61																									
THC [µg/g]	-0.48	0.48	0.49	-0.39	0.30	0.48	-0.30	-0.39	0.39	0.31																								
UCM [µg/g]	-0.08	0.08	0.25	-0.08	0.08	0.08	-0.08	-0.08	0.08	-0.33	0.63																							
nC_{12-36} [µg/g]	-0.14	0.14	0.09	-0.09	0.12	0.14	-0.32	-0.09	0.09	0.01	0.85	0.60																						
CPI (nC_{12-36})	0.08	-0.08	-0.22	0.06	0.02	-0.08	-0.19	0.06	-0.06	0.00	0.34	-0.08	0.68																					
Pr [µg/g]	0.30	-0.30	-0.30	0.40	-0.45	-0.40	-0.85	0.40	-0.40	-0.08	0.27	0.26	0.18	-0.10																				
Ph [µg/g]	-0.11	0.11	-0.11	-0.11	0.22	0.11	-0.11	-0.11	0.11	0.00	0.66	0.76	0.79	0.33	0.23																			
Pr/Ph Ratio	0.45	-0.45	-0.44	0.57	-0.60	-0.55	-0.74	0.57	-0.57	-0.08	-0.26	-0.25	-0.32	-0.34	0.75	-0.33																		
2 - 6 Ring PAH [ng/g]	0.11	-0.11	0.27	0.11	-0.22	-0.11	-0.33	0.11	-0.11	-0.38	0.66	0.76	0.62	0.22	0.46	0.50	-0.11																	
% NPD	0.11	-0.11	0.27	0.11	-0.22	-0.11	-0.33	0.11	-0.11	-0.38	0.66	0.76	0.62	0.22	0.46	0.50	-0.11	1.00																
Al [µg/g]	-0.79	0.79	0.18	-0.76	0.86	0.71	0.00	-0.76	0.76	0.59	0.53	0.25	0.43	0.16	-0.10	0.55	-0.36	-0.11	-0.11															
As [µg/g]	-0.93	0.93	0.75	-0.88	0.74	0.95	0.33	-0.88	0.88	0.80	0.34	-0.08	-0.10	-0.28	-0.30	-0.11	-0.33	-0.22	-0.22	0.57														
Ba [µg/g]	-0.83	0.83	0.79	-0.81	0.71	0.86	0.26	-0.81	0.81	0.41	0.73	0.58	0.42	-0.11	-0.20	0.44	-0.57	0.33	0.33	0.67	0.74													
Cr [µg/g]	-0.90	0.90	0.37	-0.88	0.93	0.86	0.14	-0.88	0.88	0.68	0.48	0.08	0.32	0.14	-0.30	0.33	-0.45	-0.22	-0.22	0.95	0.74	0.71												
Cu [µg/g]	-0.64	0.64	0.04	-0.60	0.74	0.57	-0.05	-0.60	0.60	0.49	0.44	0.25	0.42	0.11	-0.10	0.55	-0.24	-0.22	-0.22	0.95	0.43	0.55	0.88											
Fe [µg/g]	-0.63	0.63	0.23	-0.61	0.60	0.66	0.26	-0.61	0.61	0.84	0.09	-0.58	-0.01	0.33	-0.45	-0.16	-0.34	-0.55	-0.55	0.51	0.66	0.23	0.68	0.42										
Hg [µg/g]	-0.43	0.43	-0.14	-0.45	0.64	0.29	-0.14	-0.45	0.45	0.11	0.07	-0.08	0.20	0.29	-0.25	0.11	-0.17	-0.33	-0.33	0.67	0.14	0.17	0.67	0.71	0.36									
Ni [µg/g]	-0.79	0.79	0.18	-0.76	0.86	0.71	0.00	-0.76	0.76	0.59	0.53	0.25	0.43	0.16	-0.10	0.55	-0.36	-0.11	-0.11	1.00	0.57	0.67	0.95	0.95	0.51	0.67								
Pb [µg/g]	-0.86	0.86	0.38	-0.78	0.79	0.80	-0.04	-0.78	0.78	0.75	0.43	-0.08	0.22	0.07	-0.20	0.11	-0.19	-0.33	-0.33	0.85	0.75	0.60	0.93	0.83	0.71	0.66	0.85							
Zn [µg/g]	-0.57	0.57	0.17	-0.45	0.50	0.52	-0.26	-0.45	0.45	0.60	0.52	-0.08	0.50	0.41	-0.10	0.22	-0.10	-0.22	-0.22	0.71	0.43	0.38	0.76	0.76	0.63	0.64	0.71	0.87						
Taxa	-0.17	0.17	0.11	-0.22	0.15	0.07	-0.37	-0.22	0.22	-0.06	0.41	0.42	0.24	0.05	0.56	0.34	0.02	0.67	0.67	0.17	0.05	0.27	0.05	-0.05	-0.25	-0.07	0.17	-0.10	-0.24					
Individuals	-0.07	0.07	-0.04	-0.14	0.10	-0.05	-0.31	-0.14	0.14	-0.13	0.08	0.25	-0.11	-0.20	0.55	0.11	0.19	0.44	0.44	0.05	0.00	0.07	-0.07	-0.14	-0.31	-0.07	0.05	-0.19	-0.43	0.93				
Shannon-Wiener [H'Log^2]	-0.47	0.47	0.49	-0.49	0.34	0.42	-0.17	-0.49	0.49	0.19	0.59	0.41	0.28	0.02	0.35	0.27	-0.19	0.66	0.66	0.28	0.40	0.56	0.25	0.01	-0.01	-0.12	0.28	0.12	-0.08	0.91	0.77			
Brillouin [Hb]	-0.10	0.10	0.08	-0.14	0.07	-0.02	-0.43	-0.14	0.14	-0.19	0.31	0.41	0.14	-0.06	0.60	0.22	0.14	0.65	0.65	0.07	-0.02	0.19	-0.05	-0.12	-0.37	-0.05	0.07	-0.16	-0.31	0.98	0.95	0.85		
Pielou [J]	-0.48	0.48	0.48	-0.36	0.24	0.50	-0.10	-0.36	0.36	0.59	0.33	-0.41	0.18	0.32	-0.25	-0.33	-0.07	-0.22	-0.22	0.21	0.52	0.24	0.43	0.19	0.69	0.24	0.21	0.63	0.74	-0.34	-0.50	-0.05	-0.38	
Simpson [1-λ]	-0.52	0.52	0.62	-0.57	0.40	0.50	0.05	-0.57	0.57	0.22	0.34	-0.08	0.11	0.28	-0.15	-0.22	-0.38	0.33	0.33	0.12	0.48	0.40	0.29	-0.14	0.36	0.10	0.12	0.24	0.10	0.51	0.38	0.72	0.48	0.43

Notes:
Correlations based on n = 8
Significance — P = 0.05 at 0.738; P = 0.01 at 0.881; P = 0.05 at -0.738; P = 0.01 at 0.881; NS = not significant (< 0.65 and >– 0.65)

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APPENDIX J

Water Quality Modeling Report

Submitted with changes

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Esso Exploration and Production Guyana Limited

Water Quality Modeling Report

Payara Development Project

July 2019

Project No.: 0484443

The business of sustainability

ERM

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Signature Page

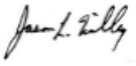
July 2019

Water Quality Modeling Report

Payara Development Project



Shwet Prakash
Partner



Jason Willey
Project Manager



Todd Hall, P.E.
Partner-in-Charge

ERM Guyana, Inc.
210 New Market Street
Georgetown, Guyana

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Acronyms and Abbreviations

Name	Description
ºC	degrees Celsius
°F	degrees Fahrenheit
2-D	two-dimensional
3-D	three-dimensional
bbl	barrel
BOD_5	5-day biochemical oxygen demand
BPD	barrels per day
CFU	colony-forming units
cm	centimeter
cm/s	centimeters per second
CORMIX	Cornell Mixing Zone Expert System
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental Impact Assessment
ERM	Environmental Resources Management
FPSO	Floating Production, Storage, and Offloading (vessel)
g/m^2	grams per square meter
GEBCO	General Bathymetric Chart of the Oceans
GEMSS	Generalized Environmental Modelling System for Surfacewaters
GIFT	Generalized Integrated Fate and Transport
GLLVHT	Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport
HYCOM	HYbrid Coordinate Ocean Model
kBPD	thousand barrels per day
km^2	square kilometers
m	meter
m^2	square meters
m/s	meters per second
MARPOL 73/78	International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978
mg/L	milligrams per liter
mi^2	square miles
mm	millimeter
NA	not applicable

Name	Description
NADF	non-aqueous drilling fluid
ppg	pounds per gallon
ppm	parts per million
SRU	Sulfate Removal Unit
SURF	subsea, umbilicals, risers, and flowlines
TSS	total suspended solids
USEPA	U.S. Environmental Protection Agency
UTM	Universal Transverse Mercator
WBM	water-based mud

1. INTRODUCTION

1.1 Purpose

In support of an Environmental Impact Assessment (EIA) for the proposed Payara Development Project (Project), Esso Exploration and Production Guyana Limited (EEPGL) commissioned Environmental Resources Management (ERM) to perform modeling of discharges into the marine environment related to planned drilling and oil production in the Stabroek Petroleum Prospecting License Area offshore Guyana (Stabroek Block; Figure 1-1). This modeling included simulations of drill cuttings and mud deposition and discharges of cooling water, sulfate removal and potable water process brines, produced water, and hydrotest fluid. Additionally, modeling was performed for a potential unplanned event comprising the hypothetical release of untreated black water from the Project's proposed floating production, storage and offloading (FPSO) vessel.

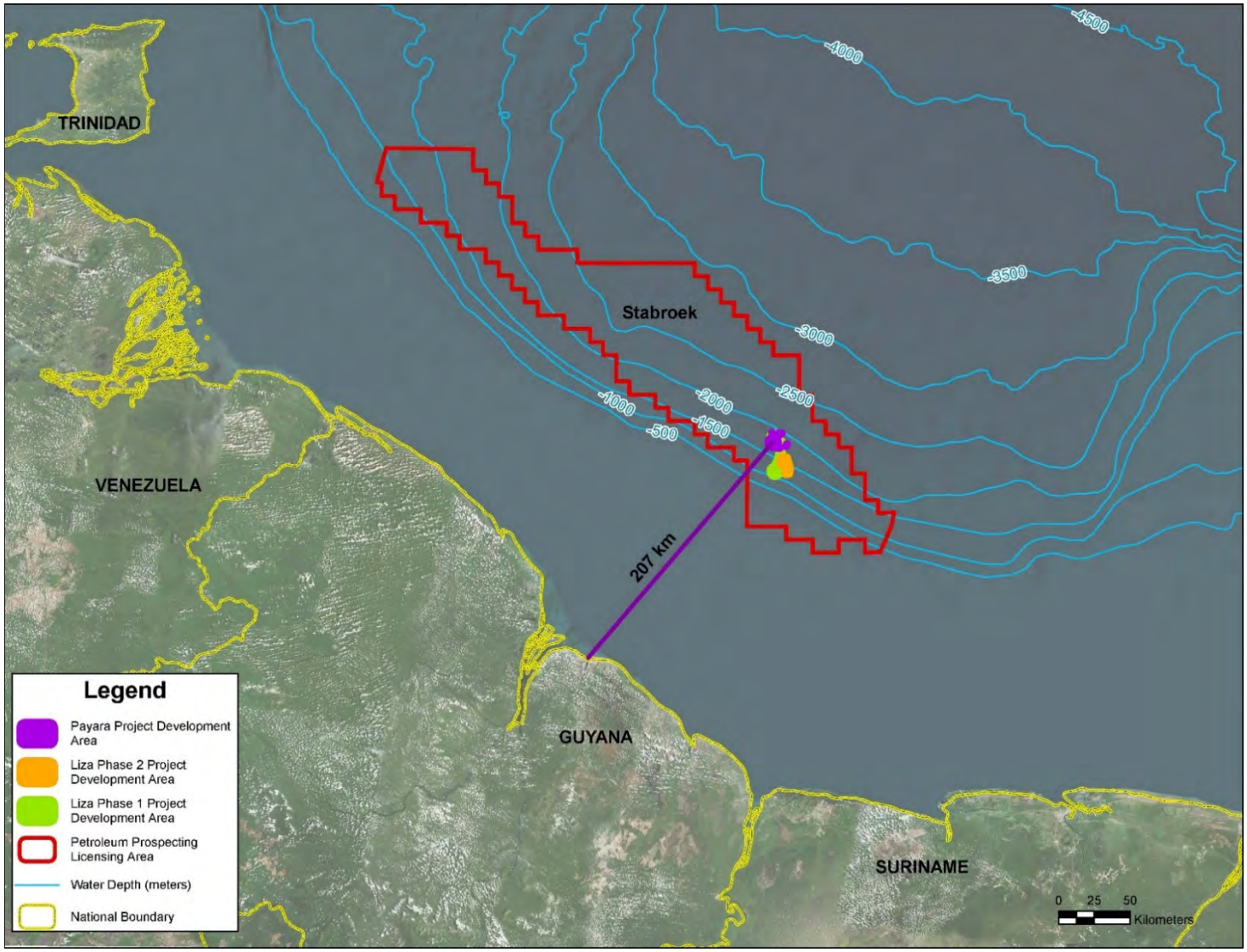
1.2 Scope of Work and Report Organization

This technical report describes the modeling study performed to facilitate assessment of the potential impacts from planned offshore releases and one unplanned offshore release. Section 2 describes modeling performed for planned discharges related to drilling operations; Section 3 describes modeling performed for planned discharges related to production operations, as well as modeling performed for an unplanned release of untreated wastewater (black water) from the Project FPSO. Because the planned activities of the Project will overlap with the planned activities of other nearby EEPGL projects, Sections 4 and 5 describe modeling performed for the combined (cumulative) activities of the Project along with the Liza Phase 1 and Phase 2 Development Projects.

Computational models were used to estimate the fate and transport of Project-related discharges. Input data for the modeling were selected based on review of available Project design information, review of oceanographic data from the Project Development Area vicinity, and use of conservative assumptions where data were not available.

A separate report describing modeling conducted for unplanned oil spill scenarios is provided as an attachment to the Oil Spill Response Plan prepared in support of EEPGL's offshore activities in Guyana.

Figure 1-1: Location of the Payara Project Development Area within the Stabroek Block



km = kilometer

2. DRILL CUTTINGS AND MUD DEPOSITION MODELING

2.1 Approach

In this study, the discharge of drill cuttings is evaluated. It is assumed that there will be a direct discharge (i.e., near the seabed) of cuttings with water-based drilling fluids during drilling of the riserless open-hole section at each well and, for all other well sections, a discharge near the sea surface of cuttings with a small fraction of adhered residual base oil from material removed in the lower well sections after treatment on the FPSO.

Modeling was performed to predict the following as a result of cuttings discharge:

- The total suspended solids (TSS) concentrations in the water column;
- The seabed accumulation (thickness) of the adhered muds and drill cuttings over an area of seafloor (the footprint); and
- The mass of hydrocarbons settled upon the seafloor.

2.1.1 Scenario Design

Released material will pass vertically through the water column because cuttings and muds are denser than the receiving water. Released material will also migrate horizontally due to advection by local and regional currents. The dispersion of cuttings and muds is fundamentally a three-dimensional (3-D) phenomenon requiring 3-D hydrodynamic fate and transport modeling.

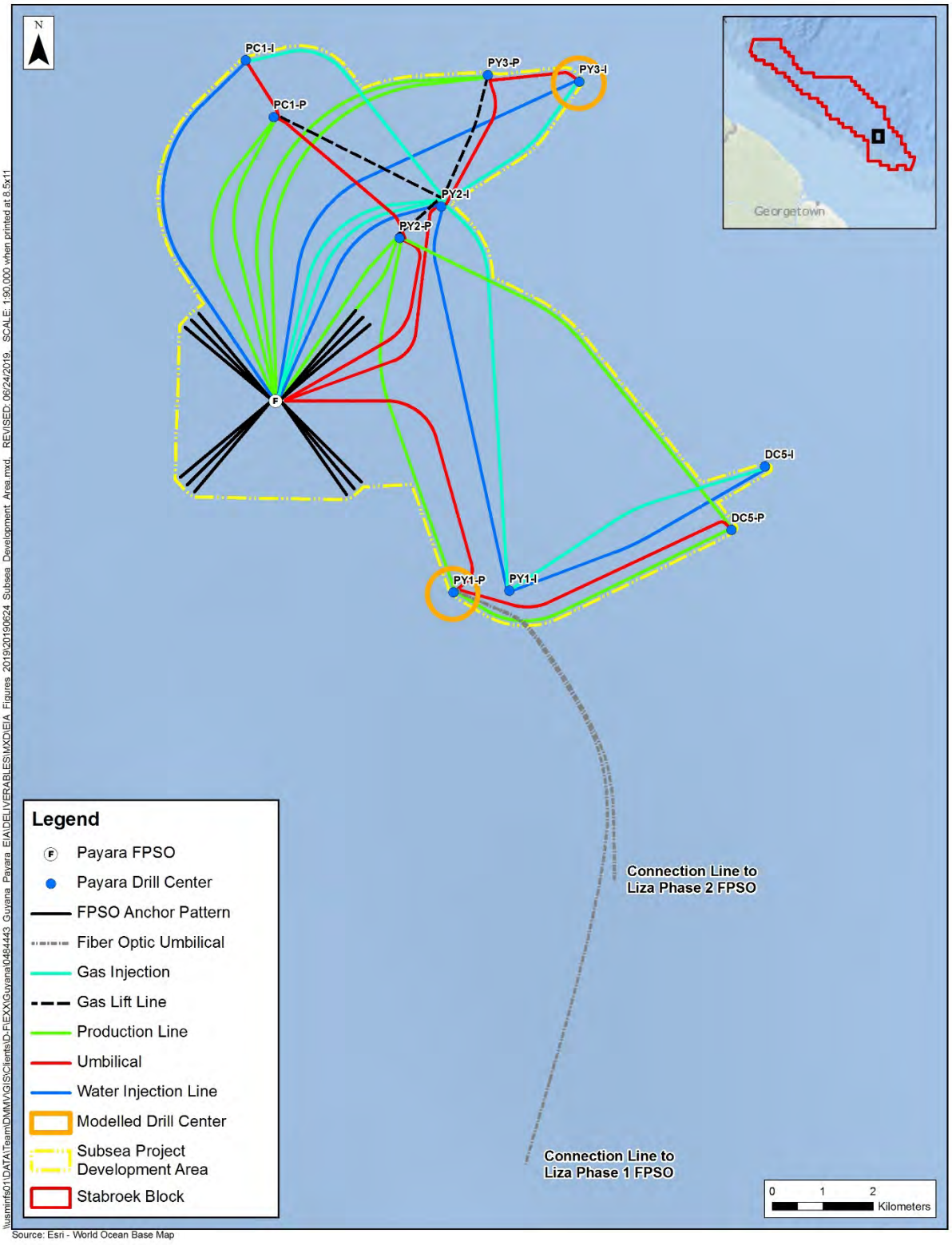
For modeling purposes, two drill center locations were selected at extreme ends of the range of water depths across the Project drill centers (see Figure 2-1). Location PY1-P represents a production well cluster at drill center PY1-P and location PY3-I represents an injection well cluster at drill center PY3-I. Coordinates of the main drill centers and the depths of water at these locations are presented in Table 2-1.

Table 2-1: Modeled Well Locations and Water Depths

Well Location	Longitude	Latitude	X Coordinate in UTM 21N (meters)	Y Coordinate in UTM 21N (meters)	Water Depth (meters)
PY1-P	-56.970533	8.161038	503,246	902,101	1,900
PY3-I	-56.947871	8.252458	505,741	912,208	2,119

UTM = Universal Transverse Mercator

Figure 2-1: Locations of Planned Drill Centers in the Payara Subsea Project Development Area



2.1.1.1 Location PY1-P

For modeling purposes, it is assumed that a cluster of four wells will be drilled within <20 meters (65.6 feet) of the drill center at PY1-P. Each well will consist of five sections. At each of these well locations, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with water-based muds (WBM) to a depth of 1,539 meters (5,049.2 feet) below the mud line. The subsequent three sections - with hole diameters sizes 44.5 centimeters (17.5 inches), 31.1 centimeters (12.25 inches), and 24.1 centimeters (9.5 inches) - will be drilled with non-aqueous drilling fluid (NADF) until a total depth of approximately 6,083 meters (19,957 feet) below the mud line is reached. Details of these sections are presented in Table 2-2. The discharge pipe from the drill platform will release treated cuttings from Sections 3 through 5 at a depth of 11 meters (36 feet) below mean sea level.

Table 2-2: Well Profile at Location PY1-P

Section	Diameter (inches)	Section Length (meters)	Modeled Cuttings Discharge Duration (days)
Section 1—Structural (Top Hole, Jet)	36	120	0.5
Section 2—Conductor	28	1,419	1.6
Section 3—Surface	17 ½	946	3.5
Section 4—Production	12 ¼	2,554	8.1
Section 5—Open	9 ½	1,044	6.8

2.1.1.2 Location PY3-I

For modeling purposes, it is assumed that a cluster of four wells will be drilled within <20 meters (65.6 feet) of the drill center at PY3-I. Each well will consist of five sections. At each of these well locations, the top hole (Section 1) and conductor (Section 2) will be jetted and drilled with WBM to a depth of 1,539 meters (5,049.2 feet) below the mud line. The subsequent three sections—with hole diameters sizes 44.5 centimeters (17.5 inches), 31.1 centimeters (12.25 inches), and 24.1 centimeters (9.5 inches)—will be drilled with NADF until a total depth of approximately 6,049 meters (19,845.9 feet) below the mud line is reached. Details of these sections are presented in Table 2-3. The discharge pipe from the drill platform will release treated cuttings from Section 3 through 5 at a depth of 11 meters (36.1 feet) below mean sea level.

Table 2-3: Well Profile at Location PY3-I

Section	Diameter (inches)	Section Length (meters)	Modeled Cuttings Discharge Duration (days)
Section 1—Structural (Top Hole, Jet)	36	120	0.5
Section 2—Conductor	28	1,292	1.6
Section 3—Surface	17 ½	930	3.5
Section 4—Production	12 ¼	2,664	8.1
Section 5—Open	9 ½	1,034	6.8

2.1.1.3 Model Scenarios

The model simulations for drill cuttings included three scenarios at each drill center location. These are described below.

Scenario 1

Scenario 1 evaluated the impacts from sequentially jetting and drilling two top-hole sections (Sections 1 and 2) at each of the four well locations at PY1-P and PY3-I. This represents the most likely maximum number of top holes (eight; four wells and two top-hole sections each) that will be drilled sequentially at any time from a drill center (PY1-P or PY3-I) within a 30-day time period (the time period relevant for the 5 centimeters (2 inches) per month deposition standard used). Table 2-2 and Table 2-3 show that the actual drilling duration based on continuous drilling are 0.5 days and 1.6 days for Section 1 and Section 2 respectively. However, from an operational standpoint, the total duration of the jetting/drilling of these top-hole sections (Section 1 and 2) will each take approximately 1 week, considering breaks and labor shifts. In addition, jetting/drilling of any top-hole section (Sections 1 and 2) will be followed by at least a 4-day rest period prior to starting the jetting/drilling of the next top-hole. Considering these breaks and rest periods, in addition to the actual drilling/jetting period, this results in a total operational period of 40 days for all four locations, with two top-hole sections at each location.

The resting/break period of 4 days between the sections and wells will allow releases to settle without initiation of a new release from a subsequent well. For conservativeness in the model, the model simulations assumed only a 1-day resting/break period, while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of 40 days to a total of 19 days. The modeled drilling schedule is shown in Table 2-4.

Table 2-4: Scenario 1 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 1	0.5
Break	1
Well 1—Section 2	1.6
Break	1
Well 2—Section 1	0.5
Break	1
Well 2—Section 2	1.6
Break	1
Well 3—Section 1	0.5
Break	1
Well 3—Section 2	1.6
Break	1
Well 4—Section 1	0.5
Break	1
Well 4—Section 2	1.6
Additional Modeled Period for Particle Settling	3.6
Total Simulation Days	**19**

Scenario 2

Scenario 2 evaluated the sequential jetting and drilling of two top-hole sections (Sections 1 and 2) at two of the well locations (PY1-P and PY3-I) followed by the change-out of the drill ship to NADF drilling and the drilling of Sections 3 and 4 at the second well location for which top-hole sections were drilled. This represents the most likely maximum number of top holes (two wells with two top-hole sections each) and bottom holes (one well with two bottom-hole sections) that will be drilled sequentially at any time from a drill center (PY-P or PY3-I) within a 30-day time period (the time period relevant for the 5 centimeters (2 inches) per month deposition standard used). Table 2-2 and Table 2-3 show that the actual drilling

duration based on continuous drilling are 0.5 days and 1.6 days for Section 1 and Section 2 respectively. Actual drilling duration based on continuous drilling is 3.5 days for Section 3 and 8.1 days for Section 4. However, from an operational standpoint, the total duration of the jetting/drilling operation of these top-hole sections (Section 1 or 2) will take approximately 1 week, considering breaks and labor shifts. Once the top-hole sections of the second well have been drilled (approximately 7 days), WBM drilling equipment will be changed to NADF equipment over a rest period of approximately 7 days. Following this change out, Sections 3 and 4 of the second well will be drilled over a period of approximately 15 days. Considering these breaks and rest periods, in addition to actual drilling/jetting period, this results in a total operation period of approximately 40 days.

The resting/break period of 4 to 7 days between the sections and wells will allow all releases to settle without any new release starting from the subsequent section. For conservativeness in the model, the model simulations only assumed a 1-day resting/break period, while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of 40 days to a total of 21.5 days. The modeled drilling schedule is shown in Table 2-5.

Table 2-5: Scenario 2 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 1	0.5
Break	1
Well 1—Section 2	1.6
Break	1
Well 2—Section 1	0.5
Break	1
Well 2—Section 2	1.6
Break	1
Well 2—Section 3	3.5
Break	1
Well 2—Section 4	8.1
Additional Modeled Period for Particle Settling	0.7
Total Simulation Days	**21.5**

Scenario 3

Scenario 3 assesses hydrocarbon deposition from topside discharges of treated drill cuttings with adhered oil from sequentially drilling three bottom-hole sections (Sections 3, 4, and 5) at each of four well locations at a drill center. Table 2-2 and Table 2-3 show that the actual drilling duration based on continuous drilling are 3.5 days, 8.1 days, and 6.8 days for Section 3, 4, and 5, respectively. However, from an operational standpoint, the drilling of Sections 3 to 5 of the a well will be drilled over a period of approximately 25 days, followed by a period of approximately 14 days before beginning drilling of Sections 3 to 5 of a subsequent well. The drilling of Sections 3 to 5 of the subsequent well will require another approximately 25 days to complete, followed by a period of approximately 14 days before drilling the next well's bottom-hole sections. Drilling of the third and fourth wells will take another approximately 64 days. In total, it is estimated that this drilling operation will take approximately 140 days.

The resting/break period ranging from 4 to 7 days to multiple weeks between the sections and wells will allow all releases to settle without any new release initiating. For conservativeness in the model, the model simulations only assumed a 1-day resting/break period while preserving the actual continuous drilling duration. This conservative assumption significantly compresses the overall drilling schedule from a total of more than 140 days to a total of 87 days. The modeled drilling schedule is shown in Table 2-6.

Table 2-6: Scenario 3 Simulation Schedule

Drilling Action	Duration (days)
Well 1—Section 3	3.5
Break	1
Well 1—Section 4	8.1
Break	1
Well 1—Section 5	6.8
Break	1
Well 2—Section 3	3.5
Break	1
Well 2—Section 4	8.1
Break	1
Well 2—Section 5	6.8
Break	1
Well 3—Section 3	3.5
Break	1
Well 3—Section 4	8.1
Break	1
Well 3—Section 5	6.8
Break	1
Well 4—Section 3	3.5
Break	1
Well 4—Section 4	8.1
Break	1
Well 4—Section 5	6.8
Additional Modeled Period for Particle Settling	2.4
Total Simulation Days	**87**

2.1.1.4 Particle Grids

Three model grids were used: a particle grid, a depositional grid, and a concentration grid. The movement of the discharged cuttings and muds using Lagrangian particles was computed within the particle grid (Figure 2-2). This particle grid is a square approximately 50 kilometers (31 miles) on each side, with each cell approximately 50 meters (164 feet) by 50 meters (164 feet). Each grid cell contains an interpolated depth value derived from the bathymetry data described in Section 2.1.3.1. Particles are free to move horizontally and vertically within this grid's domain, independently of the grid, except for movement past the grid boundaries representing the seafloor (as defined by the bathymetry) and shorelines.

For computation of the deposition on the seafloor, the model used a smaller, more finely spaced two-dimensional (2-D) depositional grid, with each grid centered on a drill center. The depositional grid is a square approximately 20 kilometers (12.4 miles) on each side. Cell sizes vary in size from 10 meters (32.8 feet) by 10 meters (32.8 feet) near the center to 100 meters (328 feet) by 100 meters (328 feet) at the edge of the grid. Figure 2-3 shows the (more tightly spaced) portion of the depositional grid in the vicinity of the FPSO.

The concentration grid, used for computation of TSS concentrations in the water column, is 3-D, with the same horizontal dimensions as the depositional grid. Vertically, the cells are 10 meters (32.8 feet) thick at the surface and bottom regions, where the maximum suspended solids are predicted to occur. The cell thicknesses expand in size towards the middle of the water column region.

A summary of the dimensions of these grids is presented in Table 2-7.

Figure 2-2: Particle Grid

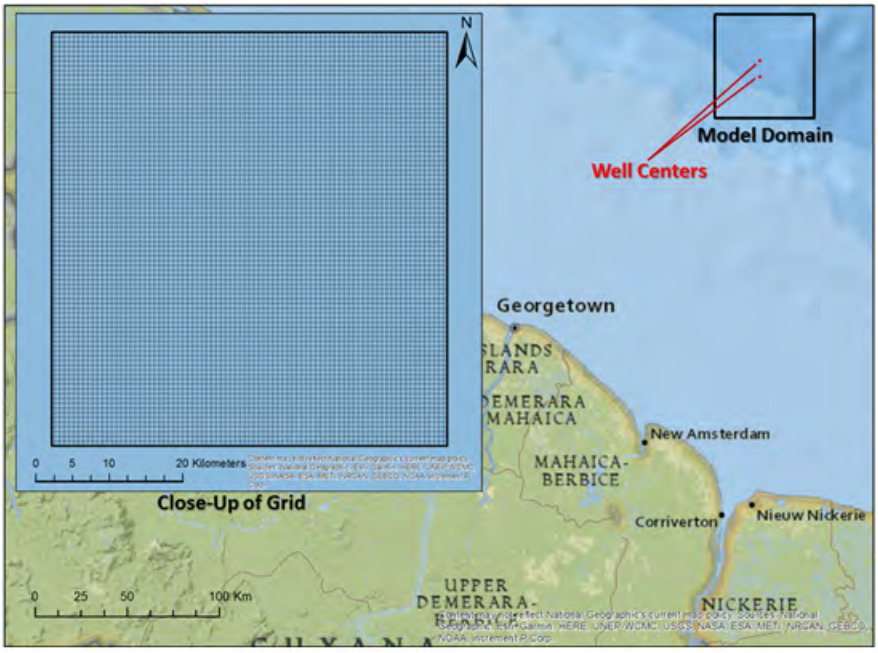


Figure 2-3: Depositional and Concentration Grid

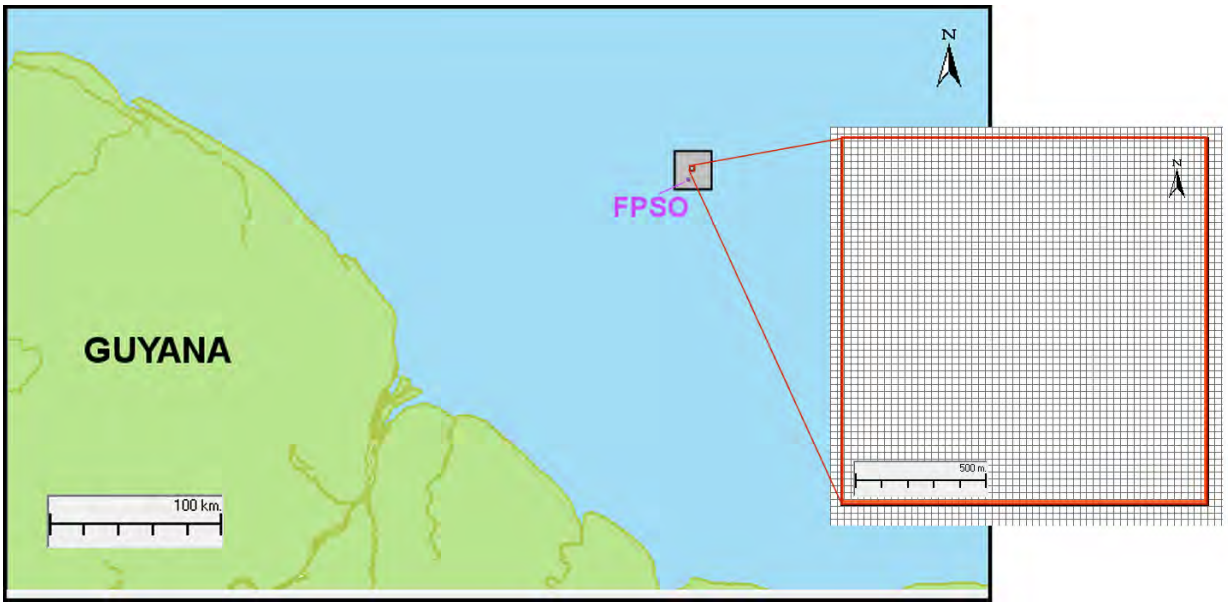


Table 2-7: Grid Dimensions

Grid	Horizontal Dimensions (meters)	Vertical Dimensions
Particle grid	50 x 50	NA
Depositional grid	Variable—smallest 10 x 10 at center	NA
Concentration grid	Variable—smallest 10 x 10 at center	Variable—smallest 10 meters at top and bottom

NA = not applicable

2.1.2 Drill Cuttings and Mud Deposition Software

The modeling was performed using the software package GEMSS® (Generalized Environmental Modelling System for Surfacewaters) and its drill cuttings and muds discharge module, GIFT (Generalized Integrated Fate and Transport) (Kolluru and Spaulding 1993; Kolluru, et al. 1998; Fichera and Kolluru 2007; Fichera et al. 2013; Prakash and Kolluru 2014). GIFT can simulate the fate of dissolved and particulate material discharged from a range of sources, including drill cuttings and muds and produced water. This 3-D particle-based model uses Lagrangian algorithms in conjunction with currents, specified mass load rates, release times and locations, particle sizes, settling velocities, and shear stress values. The modeling methodology is based on a deterministic mode of simulation. In deterministic, single event simulations, the starting date and current speed and direction at each time step are chosen from a database of properties in the selected periods.

Drill cuttings and muds were modeled as particles. Movement in the vertical direction resulted in the settling and deposition of cuttings on the seabed. The deposition, based on particle size distribution and the intensity of release, results in the predicted accumulation of drill cuttings on the seabed.

Modeling data inputs included:

- Drill section sizes and schedule;
- Drilling mud types;
- Cuttings and mud grain size distribution;
- Mud and cuttings densities; and
- Mud and cuttings release rates, durations, and discharge depths.

2.1.3 Environmental Data

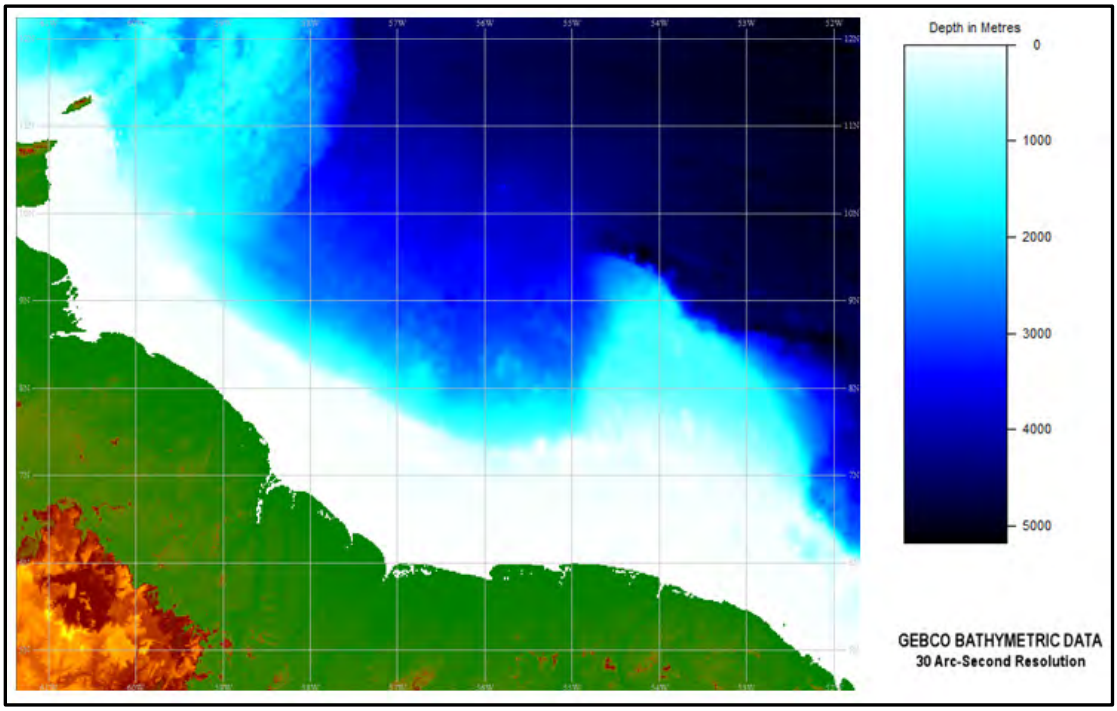
Model inputs were assembled and formatted for use with GIFT. The environmental data used by the model included bathymetry, ocean current, water temperature, and salinity data. Spatially and temporally varying oceanic data were collected to characterize the area in which the discharges will occur and determine appropriate simulation periods to represent the range of potential results (see Project EIA Section 6.4.2, Existing Conditions—Marine Water Quality).

2.1.3.1 Bathymetry

The primary spatial dataset is the bathymetric data, used to describe the depth and shape of the seafloor. Bathymetric data are used to develop the lower boundary of the modeling grids. The General Bathymetric Chart of the Oceans (GEBCO), a publicly available source, was used to extract seafloor bathymetry at the study site (IOC et al. 2003). The database used for this study is the GEBCO_08 Grid, which has a 30-arc-second resolution. GEBCO bathymetry offshore of Guyana is shown in Figure 2-4.

A polyline shapefile of the Guyana coastline was used as a boundary in the model domain between land and water. The coastline boundary was obtained from Esri's World Boundaries and Places Alternate product.

Figure 2-4: GEBCO Bathymetry Data Offshore Guyana



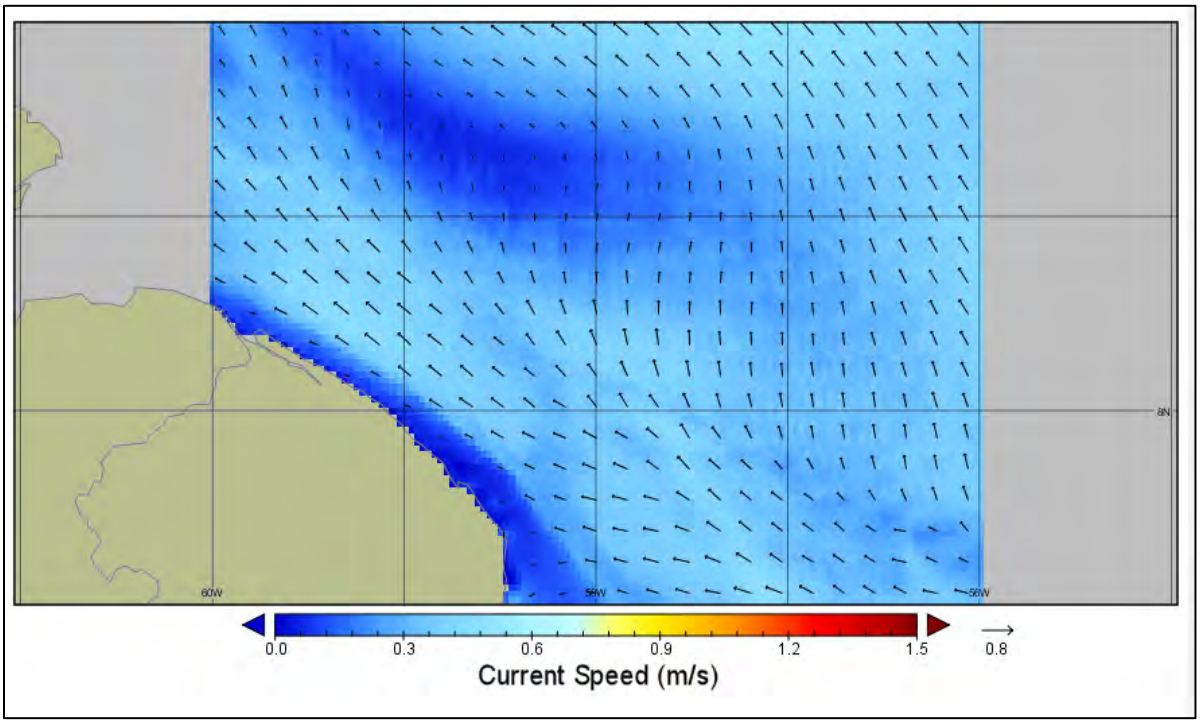
2.1.3.2 Time Varying Data: Ocean Current, Temperature, and Salinity Data

The time-varying data used for the drill cuttings deposition modeling included ocean current speed and direction, water temperature, and salinity. Deposition modeling requires time-varying currents on a 3-D grid. Hourly depth-varying and spatially varying currents were obtained from ExxonMobil Upstream Research Company using the SAT-OCEAN model combined with currents from the HYbrid Coordinate Ocean Model (HYCOM) global ocean circulation hindcast model. Currents were obtained every three hours from 2005 through 2014. The model extended from 56ºW to 58ºW longitude and 7ºN to 11ºN latitude over 128 by 128 grid cells and 22 depth bins at 0-, 5-, 10-, 20-, 30-, 40-, 50-, 75-, 100-, 125-, 150-, 200-, 300-, 400-, 500-, 1,000-, 1,500-, 2,000-, 2,500-, 3,000-, 3,500-, and 4,000-meter (0-, 16.4-, 32.8-, 65.6-, 98.4-, 131.2-, 164-, 246.1-, 328.1-, 410.1-, 492.1-, 656.2-, 984.3-, 1,312.3-, 1,640.4-, 3,280.8-, 4,921.3-, 6,561.7-, 8,202.1-, 9,842.5-, 11,482.9-, and 13,123.4-foot) depths. Depth-varying temperature and salinity values were obtained directly from HYCOM model output.

Monthly averaged, depth-averaged current speeds were computed across the 2005 to 2014 period of record. Through a statistical analysis of these current speeds at the well locations, the months with the minimum and maximum average current speeds were determined. Modeling was performed assuming drill cuttings deposition occurs starting on the first day of these 2 months: March 2006 (maximum speed) and August 2013 (minimum speed). Simulations performed during these 2 months will provide the extremes of the full range of depositional patterns (i.e., from a larger and thinner footprint when the current speeds are highest to a smaller and thicker footprint when the current speeds are lowest).

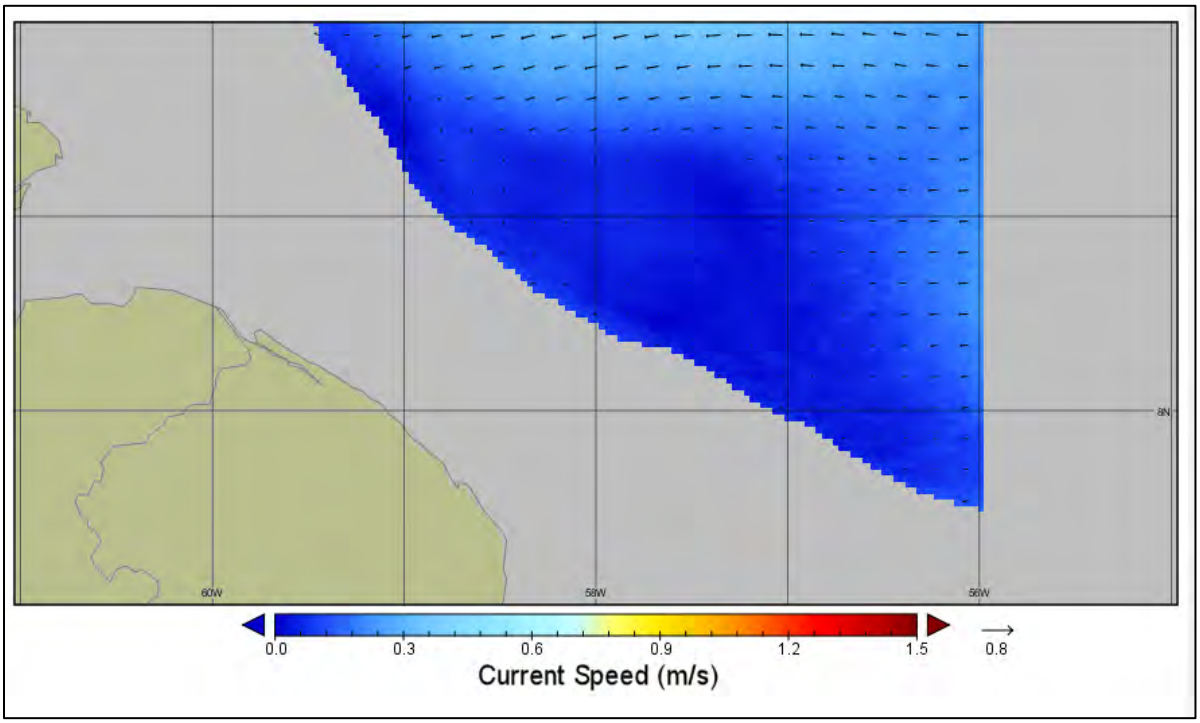
Example current vector plots for March 2006 and August 2013 are shown below in Figure 2-5 and Figure 2-7 (showing current speeds and directions at the sea surface) and in Figure 2-6 and Figure 2-8 (showing current speeds and directions at a depth of 1,000 meters [3,280.8 feet]).

Figure 2-5: Example Current Vector Diagram, 1 March 2006 (Surface)



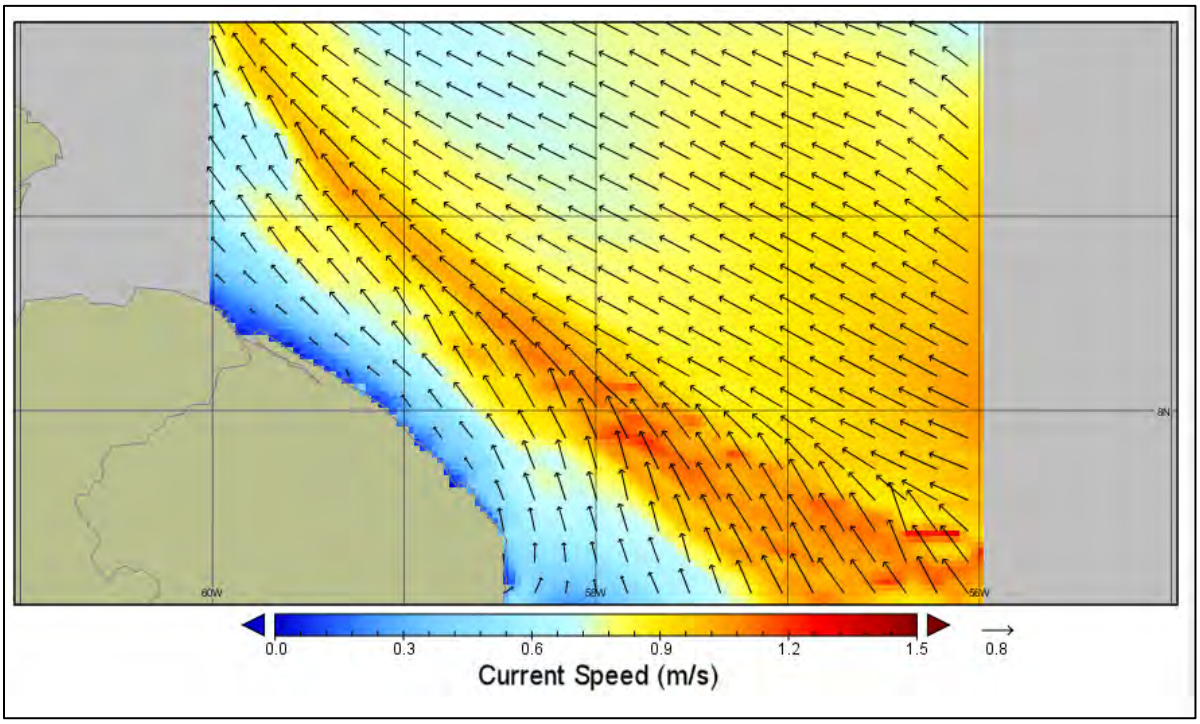
m/s = meters per second

Figure 2-6: Example Current Vector Diagram, 1 March 2006 (1,000-meter Depth)



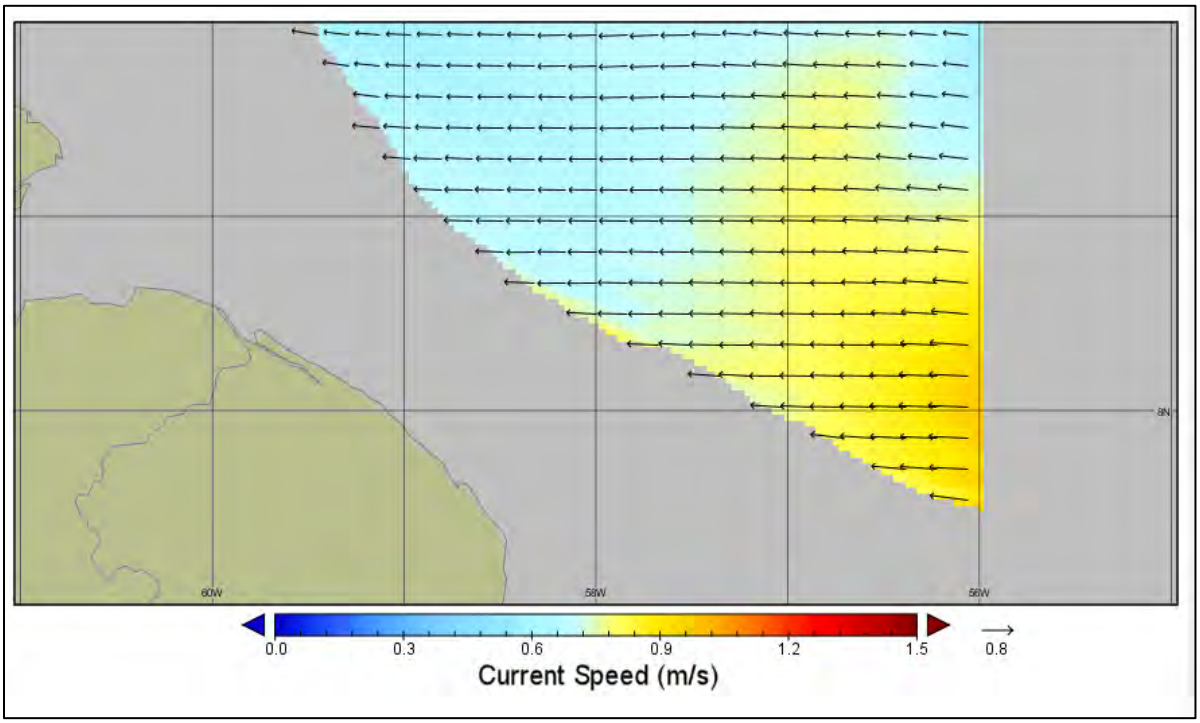
m/s = meters per second

Figure 2-7: Example Current Vector Diagram, 1 August 2013 (Surface)



m/s = meters per second

Figure 2-8: Example Current Vector Diagram, 1 August 2013 (1,000-meter Depth)



m/s = meters per second

2.1.3.3 Drill Cuttings and Mud Volumes and Properties

Estimated quantities of drill cuttings and fluids to be discharged during drilling are provided for locations PY1-P and PY3-I in Table 2-8 and Table 2-9, respectively. The estimated times to drill each section were provided by EEPGL. For the top-hole sections (Sections 1 and 2), only WBM is expected to be used and cuttings will be discharged at the seafloor. For Sections 3 through 5, the cuttings with a small percentage of adhered non-aqueous muds will be discharged at a depth of 11 meters (36.1 feet) below sea level. No non-aqueous drilling muds will be directly discharged (i.e., before treatment). Solids control and cuttings drying equipment will be installed on the drill ships to process and reduce the percentage of NADF retained on cuttings, such that NADF retained on discharged cuttings will not exceed 6.9 percent (by mass) on average. Accordingly, the modeling assumed an NADF content of 6.9 percent by mass for all discharged cuttings.

Table 2-8: Discharge Description for Location PY1-P

Hole Diameter (inches)	Volume of Cuttings Discharged (bbl)	Volume of Drilling Fluid to be Discharged (bbl)	Type of Drilling Fluid	Modeled Cuttings Discharge Duration (days)
36	496	668	WBM	0.5
26	4,077	9,729	WBM	1.6
17 ½	894	143	NADF	3.5
12 ¼	1,256	201	NADF	8.1
9 ½	309	49	NADF	6.8
TOTAL	**7,032**	**10,790**	**-**	**20.5**

bbl = barrel

Table 2-9: Discharge Description for Location PY3-I

Hole Diameter (inches)	Volume of Cuttings Discharged (bbl)	Volume of Drilling Fluid to be Discharged (bbl)	Type of Drilling Fluid	Modeled Cuttings Discharge Duration (days)
36	533	668	WBM	0.5
26	3,713	9,729	WBM	1.6
17 ½	879	141	NADF	3.5
12 ¼	1,310	210	NADF	8.1
9 ½	306	49	NADF	6.8
TOTAL	**6,740**	**10,796**	**-**	**20.5**

bbl = barrel

2.1.3.4 Cuttings and Mud Properties

The grain size properties of the drill cuttings and muds were provided by EEPGL. The distribution of particle sizes and associated fall velocities used in this study are listed in Table 2-10 for cuttings discharged from Section 1 and 2, in Table 2-11 for WBM, and in Table 2-12 for treated cuttings with NADF discharged from Sections 3 through 5. Cuttings density was assumed to be 2.6 kilograms per liter. The WBM density was assumed to be 11 pounds per gallon (ppg). The density of NADF was reported by EEPGL to range between 9 and 13.2 ppg; 9 ppg was used as a conservative assumption, since it would result in slower settling and a larger footprint of deposition.

Table 2-10: Properties of Cuttings for Well Sections 1 and 2 (Water-Based Fluid)

Estimated Diameter (cm)	Mass Fraction (Wt %)	Fall Velocity (cm/s)
0.00005	2	0.00003
0.0001	3	0.0001
0.0002	5	0.0003
0.0006	10	0.0046
0.0007	10	0.0695
0.0059	20	0.4460
0.0363	20	1.8300
0.1350	10	6.9300
0.3730	10	14.3000
0.6680	5	19.8000
0.9510	3	23.4000
1.2200	2	26.1000

cm = centimeter; cm/s = centimeters per second

Table 2-11: WBM Grain-Size Distribution

Estimated Diameter (cm)	Mass Fraction (Wt %)	Fall Velocity (cm/s)
0.0005	7	0.0027
0.0007	8	0.0061
0.0011	5	0.0148
0.0015	10	0.0300
0.0018	13.3	0.0434
0.0020	13.3	0.0511
0.0007	19.2	0.0640
0.0008	19.2	0.0823

Estimated Diameter (cm)	Mass Fraction (Wt %)	Fall Velocity (cm/s)
0.0058	4	0.4270
0.0250	1	1.1200

cm = centimeter; cm/s = centimeters per second

Table 2-12: Properties of Treated Cuttings for Well Sections 3 through 5 (with Adhered NADF)

Estimated Diameter (cm)	Mass Fraction (Wt %)	Fall Velocity (cm/s)
0.001	43	0.02
0.01	1.01	0.20
0.04	4.99	2.00
0.16	5.55	8.00
0.36	7.99	14.00
0.62	10.99	19.00
0.83	13.01	21.99
1.00	6.81	23.99
1.32	3.69	26.99
1.89	2.47	30.97
Note a	0.49	124.97

cm = centimeter; cm/s = centimeters per second
[a] Fall velocity outside the range of available correlations; size computed internally by GIFT model. Fall velocities were based on experiments. These velocities were directly used in the GIFT model to estimate settlement. Estimated diameter sizes are only for reference and do not affect GIFT computations.

2.2 Simulations

Modeling was performed for 12 simulations: for each of three scenario at each of the two modeled locations (PY1-P and PY3-I), at each of the minimum and maximum ambient current scenarios determined by the monthly averaged, depth-averaged currents analysis (see Table 2-13).

Table 2-13: Drill Cuttings and Fluid Deposition Simulations

Drill Center	Scenario	Parameter(s) Evaluated	Ambient Current Scenario
PY1-P	1	Depositional Thickness Bottom TSS	Minimum Monthly Average
			Maximum Monthly Average
	2	Depositional Thickness Bottom TSS Surface TSS	Minimum Monthly Average
			Maximum Monthly Average
	3	Hydrocarbon Mass Deposition	Minimum Monthly Average
			Maximum Monthly Average
PY3-I	1	Depositional Thickness Bottom TSS	Minimum Monthly Average
			Maximum Monthly Average
	2	Depositional Thickness Bottom TSS Surface TSS	Minimum Monthly Average
			Maximum Monthly Average
	3	Hydrocarbon Mass Deposition	Minimum Monthly Average
			Maximum Monthly Average

Because Scenario 1 results in only bottom discharges from the sequential jetting/drilling of the top-hole sections of four wells, the simulations include predicted cuttings depositional thickness on the seabed on a 2-D basis and TSS concentrations in the water column on a 3-D basis. Scenario 2 drilling results in both bottom and surface discharges. Consequently, depositional thickness as well as surface and bottom TSS concentrations were evaluated. Scenario 3 evaluated the sequential drilling of bottom holes (Sections 3 through 5) for four wells, which represents the worst case for hydrocarbon deposition (from the perspective of temporal overlap) resulting from surface discharges of treated drill cuttings. For this scenario, the mass of deposited hydrocarbons on a 2-D basis was evaluated.

2.2.1 Cuttings Depositional Thickness

Burial by drilling muds and cuttings may cause physical impacts on benthic communities on the seabed. The potential severity of burial impacts depends on the sensitivity of the benthic organism, the thickness of deposition, the amount of oxygen-depleting material, and the duration of the burial. Thickness thresholds vary by species and sediment impermeability. A suggested threshold deposition rate of 5 centimeters (2 inches) per month is recommended based on Ellis and Heim (1985) and MarLIN (2011). Smaller threshold values as low as 1 millimeter (0.04 inches) have been reported (e.g., Smit et al. 2006); however, they are associated with instantaneous burials on benthic species, not gradual smothering effects. Accordingly, for the purpose of modeling, results are presented in terms of the lateral extent of deposition exceeding 5 centimeters (2 inches) in thickness. Simulations were designed with consideration to the temporal aspect of the threshold.

2.2.2 Total Suspended Solids

Increases in TSS concentrations in the water column will occur due to discharges of drill cuttings and mud. The highest concentration increases will occur at the point of discharge (i.e., at the seafloor for top sections of the well and near the sea surface for subsequent sections of the well), and will decrease over time and distance as the TSS plume dissipates and settles. Larger particles will settle out more quickly than finer particles, such that smaller particles may stay suspended longer and travel laterally further than larger particles. As such, elevated TSS concentrations may form in regions where tiny suspended particles linger in a cloud and mix with particles from subsequent discharges.

Impacts on marine organisms related to elevated TSS may occur if light penetration in photic zones is impeded significantly for long periods of time (reducing the ability of plants and phytoplankton to photosynthesize). Increases in TSS may also decrease water clarity and clog fish gills. A commonly used guidance value for TSS from effluent discharges in the marine environment recommended by MARPOL 73/78[1] is 35 milligrams per liter (mg/L) (IMO 2006). Accordingly, for the purpose of modeling, results are presented in terms of the lateral area with TSS concentrations exceeding 35 mg/L.

2.3 Mass of Oil Deposition

Cuttings containing NADF will be treated through the FPSO onboard systems (shakers and dryers). The non-aqueous base fluid portion of the NADF that remains will be reduced to no more than 6.9 percent base fluid retention on cuttings (average, by mass). These hydrocarbons, once settled to the seafloor, can degrade over time, and may enter the pore water within the sediments or become dissolved in the water column, depending on each specific hydrocarbon's tendency to remain partitioned to the solids.

[1] International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978

2.4 Results

The results of the modeling are illustrated in the following sections as contour plots. The plots presented indicate the location of the drill cuttings release point. Results are presented for each of the following parameters for the appropriate scenarios:

- Cuttings deposition thickness at the end of the simulation;
- Maximum TSS concentration in the water column at any time in the simulation (at the surface and at the bottom, representing the surface and seabed discharges, respectively); and
- Mass of hydrocarbons per unit area deposited on the seafloor.

As discussed above, the following threshold criteria were applied for the purpose of reporting results:

- Criterion 1—Cuttings deposition rate less than 5 centimeters (2 inches) per month; and
- Criterion 2—Recommended TSS concentrations no greater than 35 mg/L.

There are no available criteria applicable for the mass of hydrocarbons deposited on the seafloor.

2.4.1 Cuttings Depositional Thickness

2.4.1.1 Scenario 1

When the first two (top-hole) sections of a well are jetted and drilled (prior to the installation of a riser), cuttings and WBMs are discharged directly to the seabed, resulting in a mound of material deposited closely around the well. The material discharged at the seabed is mostly deposited in the area directly adjacent to each wellhead and results in the thick layers of deposited material.

Figure 2-9 through Figure 2-12 present the depositional thickness for Scenario 1 for drill centers PY1-P and PY3-I. Higher thicknesses are concentrated around the drill center at the well clusters, but some discrete patches of depositional thicknesses greater than 1 millimeter (0.04 inch) are also present at some distance from these wells. For PY3-I, the small regions exceeding 1 millimeter (0.04 inch) thickness were all within a 0.2-kilometer (0.1-mile) radius from the drill center. For PY1-P, the small regions exceeding 1-millimeter (0.04-inch) thickness were all within a 0.5-kilometer (0.3-mile) radius from the drill center.

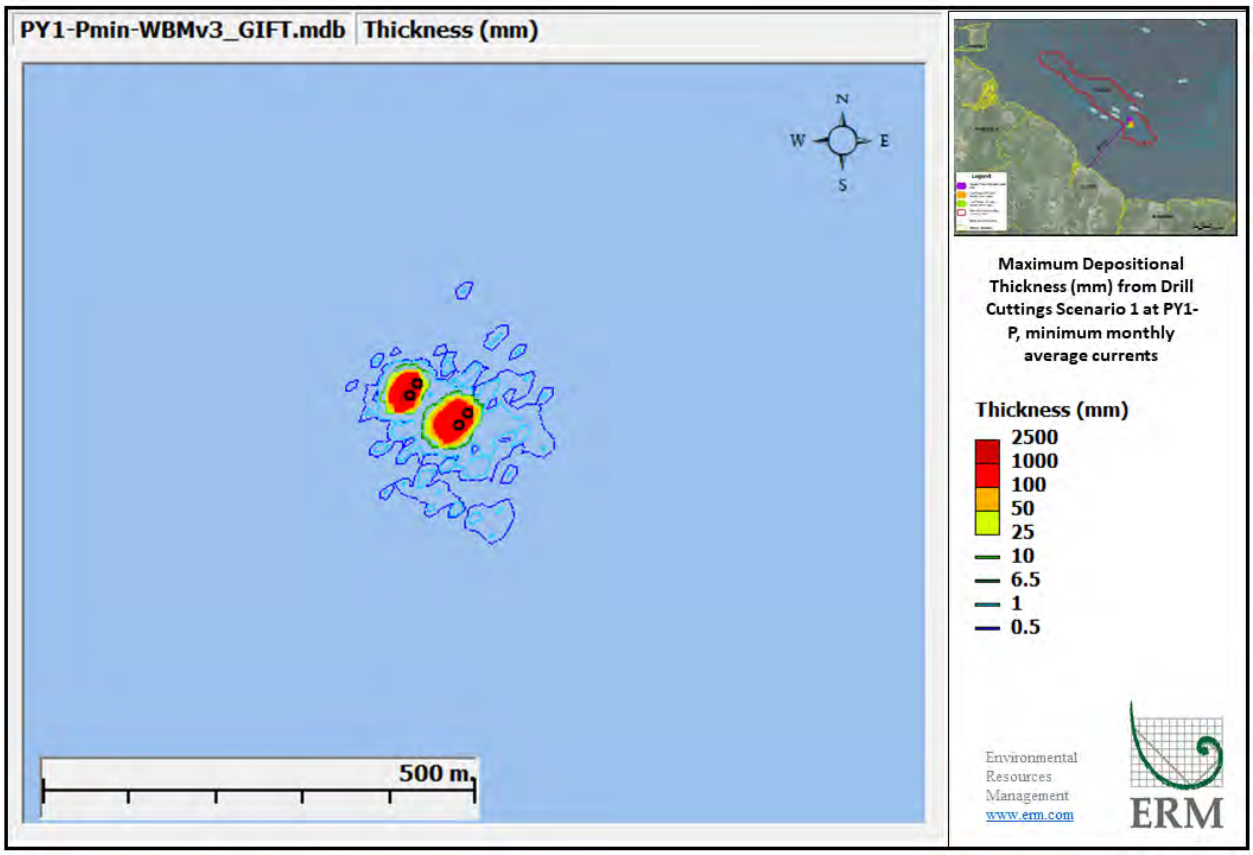
In all simulations, a small region surrounding the well clusters at the drill centers exceeds the depositional thickness threshold value of 5 centimeters (2 inches). There are two deposition mounds with an approximate lateral extent of 60 meters (164 feet) where the thicknesses exceed this threshold. The maximum depositional thicknesses and areas exceeding the threshold value of 5 centimeters (2 inches) for Scenario 1 are presented in Table 2-14. For drill center PY1-P, the maximum depositional thickness was approximately 239 centimeters (94.1 inches) under the maximum currents simulation. For drill center PY3-I, the maximum depositional thickness was approximately 256 centimeters (100.8 inches) under the maximum currents simulation. It is noted that these are conservatively high estimates, as slope failures (i.e., collapse of the depositional mound) and resuspension of the particles by ocean currents are likely to reduce the height of the deposited materials over time.

Table 2-14: Summary of Results—Cuttings Depositional Thickness: Scenario 1

Simulation	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm threshold
PY1-P Scenario 1 Minimum Currents	185.7	3,571
PY1-P Scenario 1 Maximum Currents	238.8	2,874
PY3-I Scenario 1 Minimum Currents	214.2	2,932
PY3-I Scenario 1 Maximum Currents	255.5	2,739

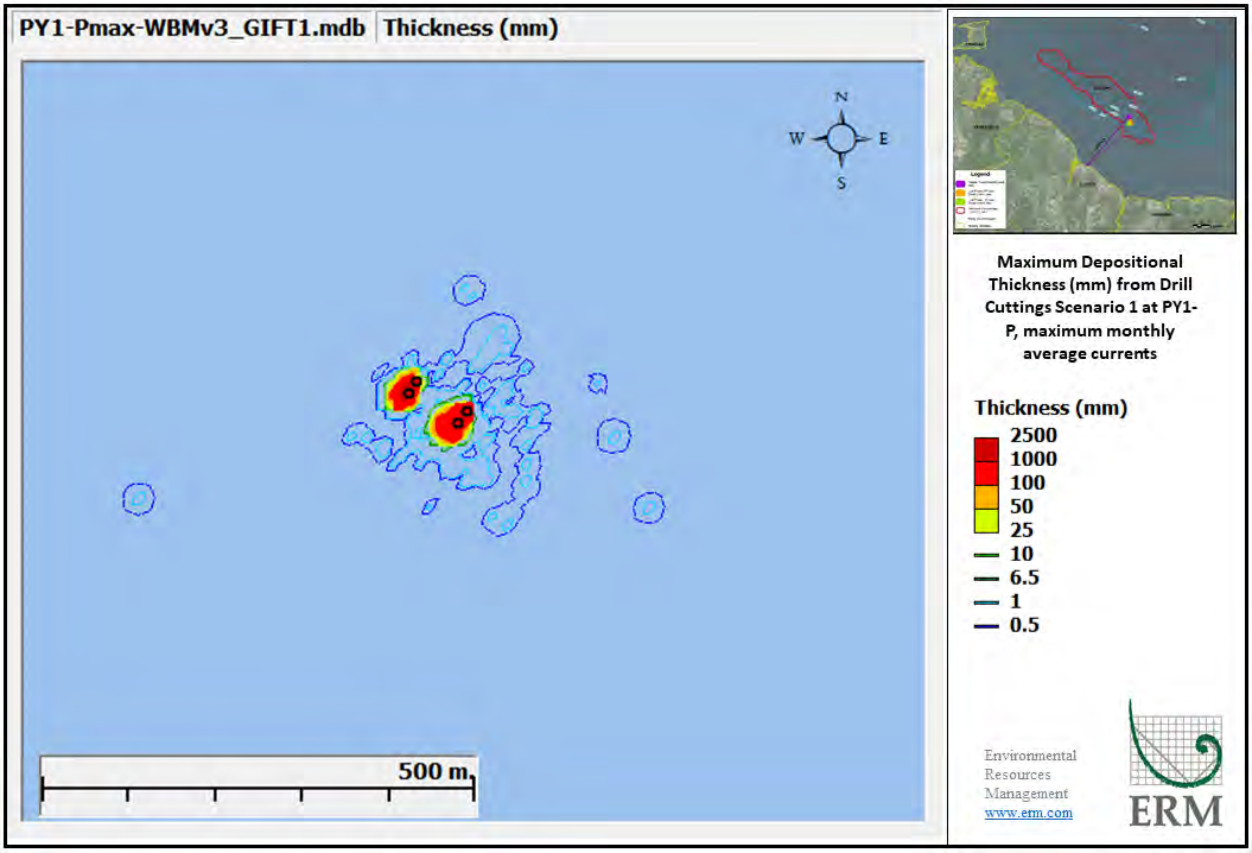
cm = centimeter; m^2 = square meters

Figure 2-9: Maximum Depositional Thickness—Scenario 1 PY1-P: Minimum Currents



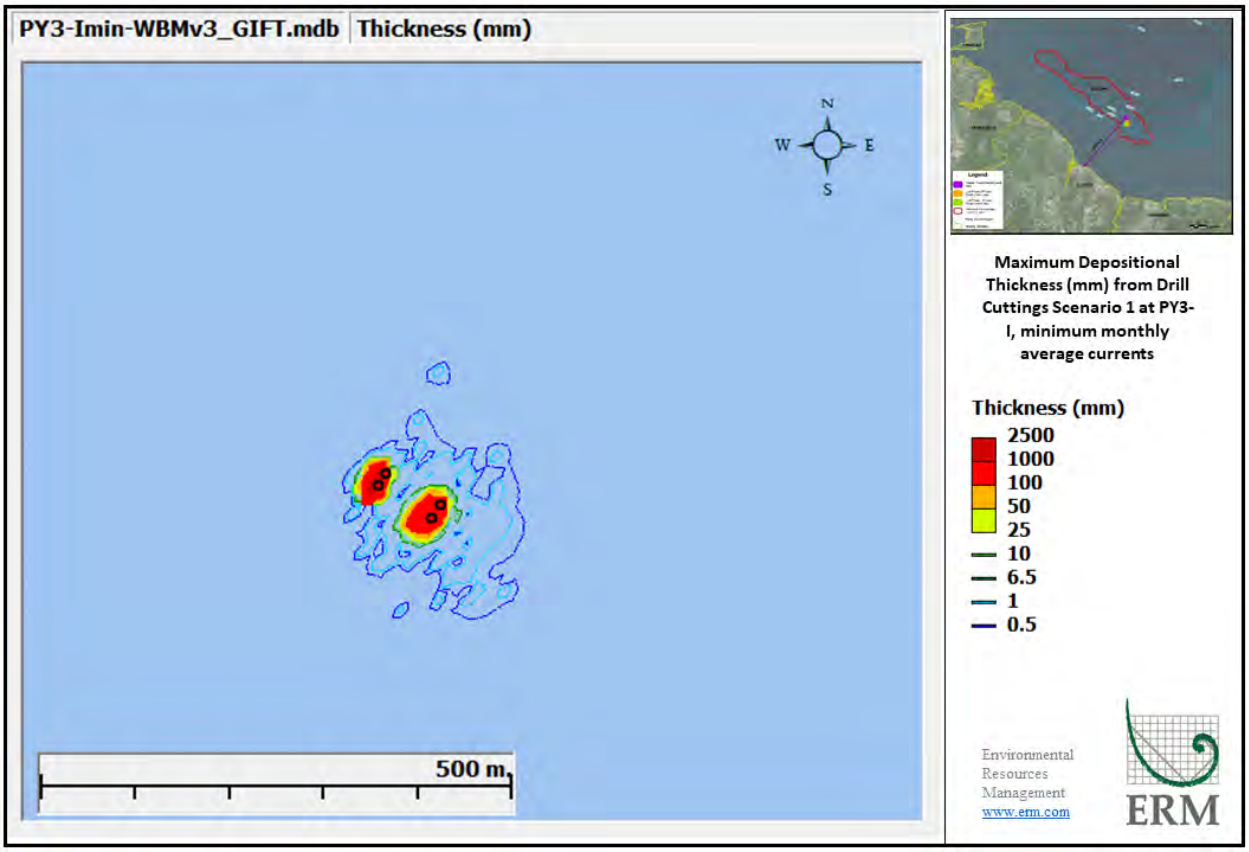
mm = millimeter

Figure 2-10: Maximum Depositional Thickness—Scenario 1 PY1-P: Maximum Currents



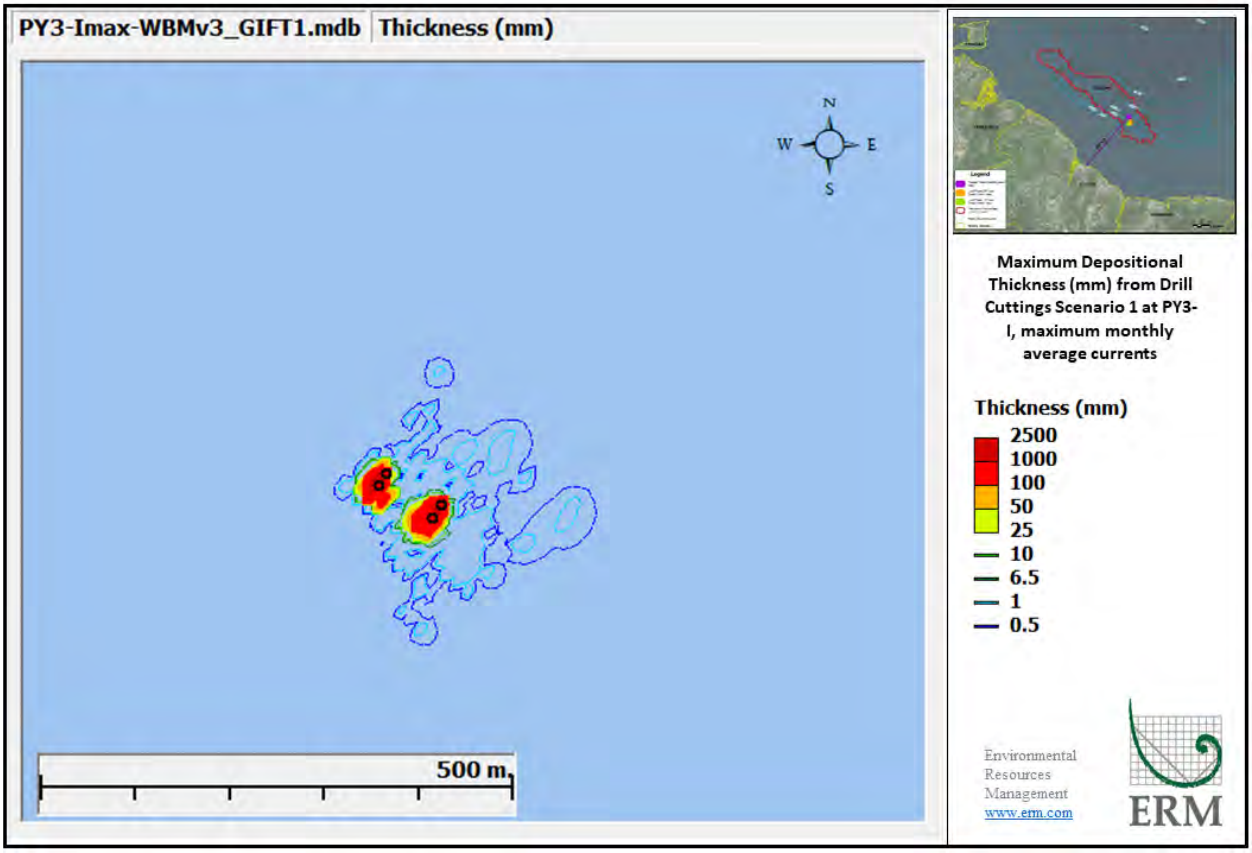
mm = millimeter

Figure 2-11: Maximum Depositional Thickness—Scenario 1 PY3-I: Minimum Currents



mm = millimeter

Figure 2-12: Maximum Depositional Thickness—Scenario 1 PY3-I: Maximum Currents



mm = millimeter

2.4.1.2 Scenario 2

Figure 2-13 through Figure 2-16 present the depositional thickness for Scenario 2 for drill centers PY1-P and PY3-I. For both PY1-P and PY3-I, higher thicknesses are concentrated around the well cluster associated with the drill center, but discrete patches of depositional thicknesses greater than 1 millimeter (0.04 inch) thickness are also present within a 0.2-kilometer (0.1-mile) radius of the drill centers. In all simulations, a small region close to the drill centers exceeded the depositional thickness threshold value of 5 centimeters (2 inches). There is one deposition mound with an approximate lateral extent of 60 meters (164 feet) where the thicknesses exceed this threshold.

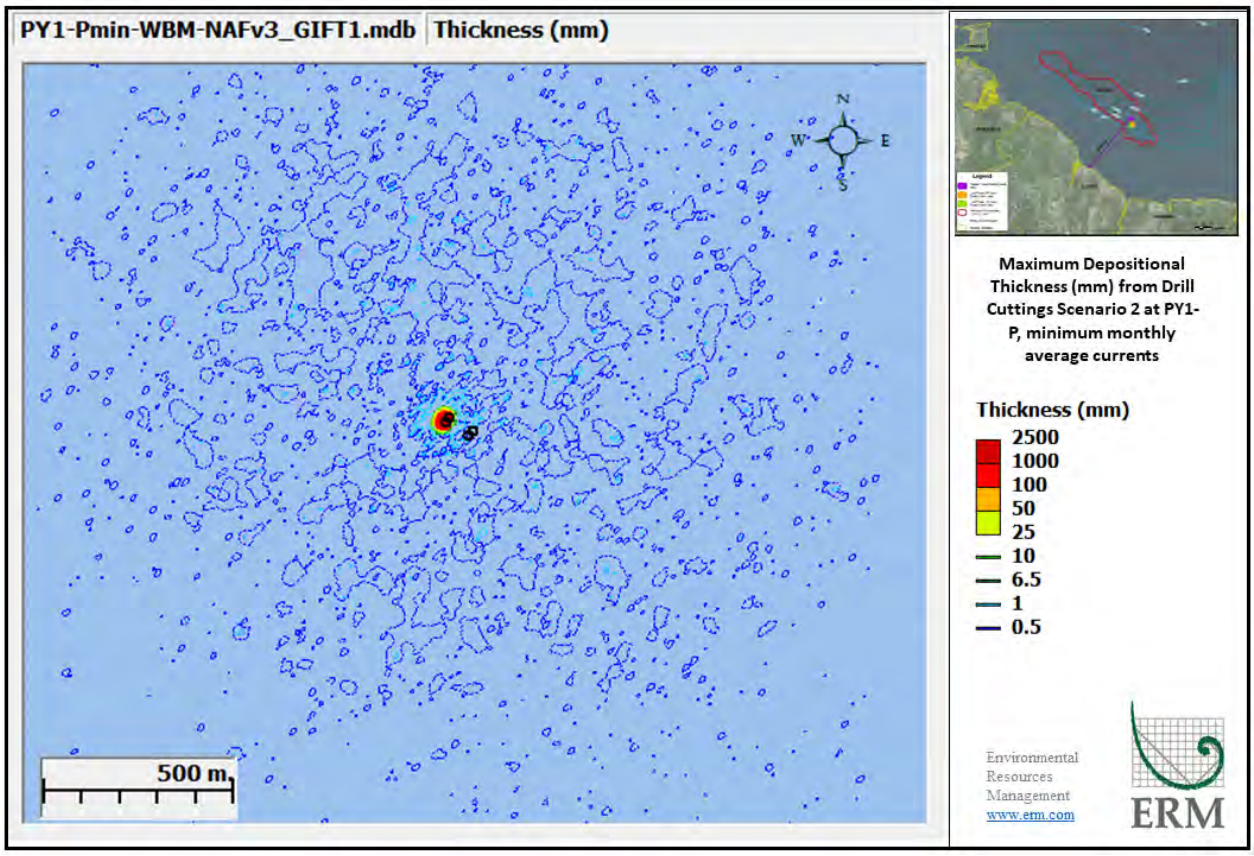
The maximum depositional thicknesses and areas exceeding the threshold value of 5 centimeters (2 inches) for Scenario 2 are presented in Table 2-15. For drill center PY1-P, the maximum depositional thickness was approximately 178 centimeters (70 inches) under the maximum current simulation. For drill center PY3-I, the maximum depositional thickness was approximately 179 centimeters (70.5 inches) under the maximum current simulation. It is noted that these are conservatively high estimates, as slope failures (i.e., collapse of the depositional mound) and resuspension of the particles by ocean currents are likely to reduce the height of the deposited materials over time.

Table 2-15: Summary of Results—Cuttings Depositional Thickness: Scenario 2

Simulation	Maximum Depositional Thickness (cm)	Area (m^2) with Thickness > 5 cm threshold
PY1-P Scenario 2 Minimum Currents	116.8	1,976
PY1-P Scenario 2 Maximum Currents	178.3	1,636
PY3-I Scenario 2 Minimum Currents	138.2	1,663
PY3-I Scenario 2 Maximum Currents	179.1	1,455

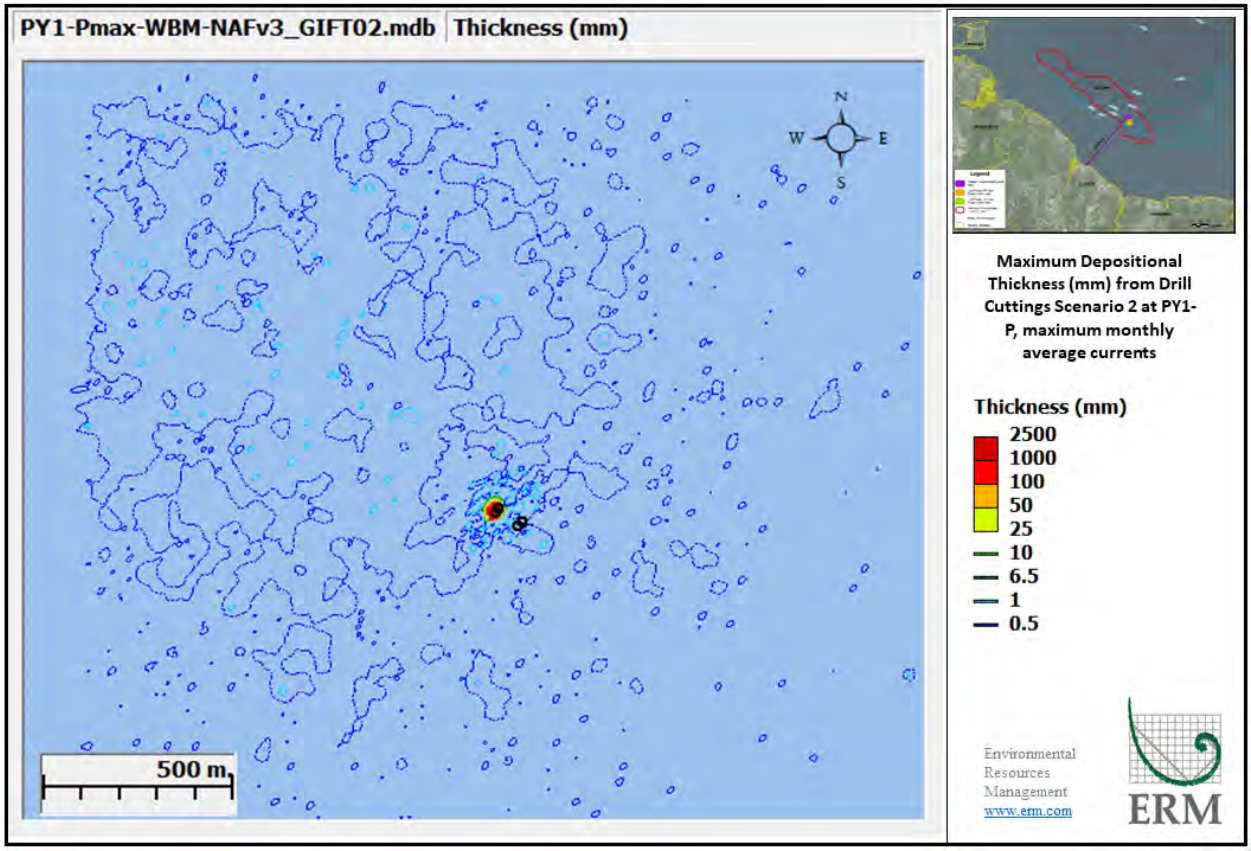
cm = centimeter; m^2 = square meters

Figure 2-13: Maximum Depositional Thickness—Scenario 2 PY1-P: Minimum Currents



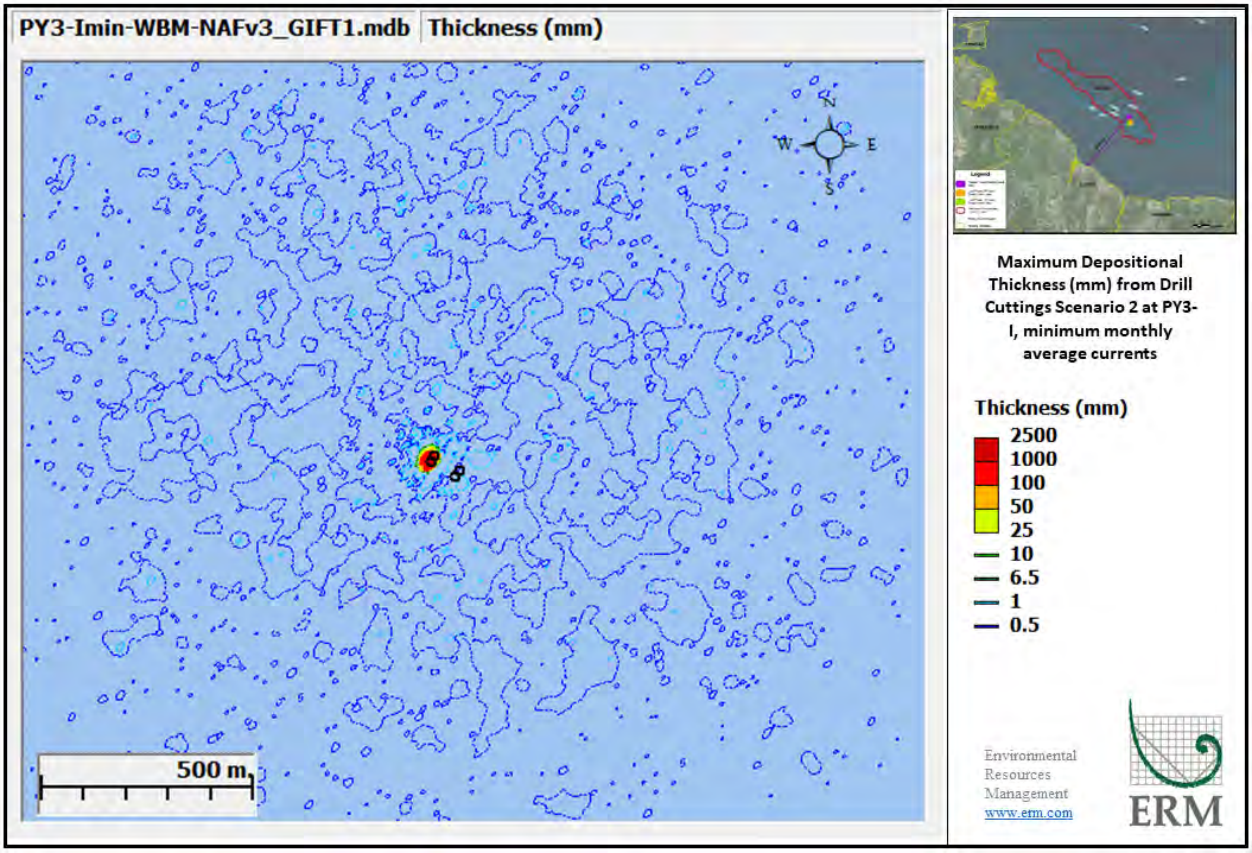
mm = millimeter

Figure 2-14: Maximum Depositional Thickness—Scenario 2 PY1-P: Maximum Currents



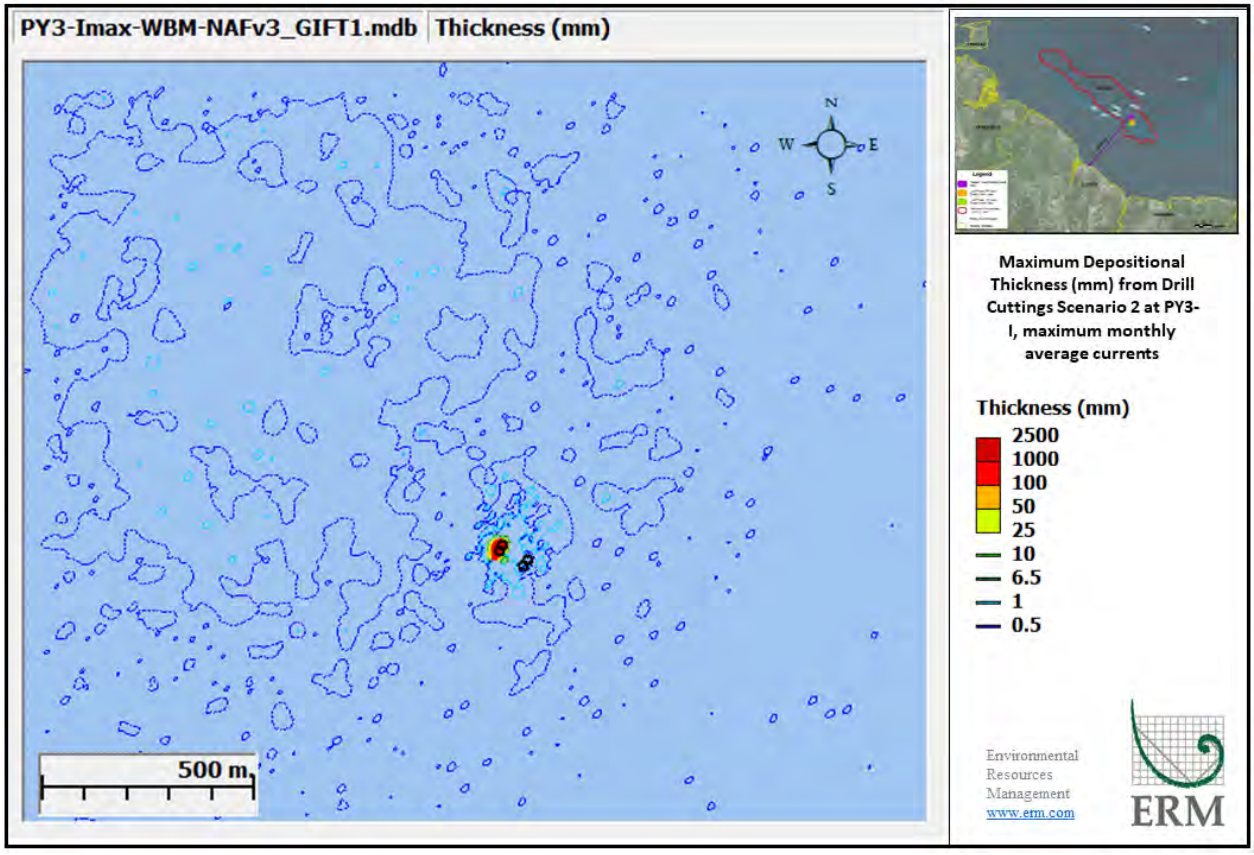
mm = millimeter

Figure 2-15: Maximum Depositional Thickness—Scenario 2 PY3-I: Minimum Currents



mm = millimeter

Figure 2-16: Maximum Depositional Thickness—Scenario 2 PY3-I: Maximum Currents



mm = millimeter

2.4.2 Total Suspended Solids

2.4.2.1 Scenario 1

Figure 2-17 through Figure 2-20 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated TSS concentration occurs at the seabed. A separate "maximum" event was captured for near-seabed concentrations (correlating with direct discharge at the seabed).

Table 2-16 summarizes the maximum predicted surface and bottom TSS concentrations modeled and the lateral areas with TSS concentrations exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center.

Table 2-16: Total Suspended Solids Summary—Scenario 1

Simulation	Maximum TSS (mg/L)		Area (km²) with TSS >35 mg/L Threshold	
	Surface	Bottom	Surface	Bottom
Scenario 1: PY1-P Minimum Currents	NA	42,796	NA	0.362
Scenario 1: PY1-P Maximum Currents	NA	36,859	NA	0.621
Scenario 1: PY3-I Minimum Currents	NA	51,120	NA	0.170
Scenario 1: PY3-I Maximum Currents	NA	51,164	NA	1.339

NA = not applicable

At the PY1-P drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 36,859 mg/L under maximum monthly averaged currents to 42,796 mg/L under minimum monthly averaged currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.362 square kilometers (km^2) (0.1 square miles [mi^2]) under minimum currents and 0.621 km^2 (0.2 mi^2) under maximum- currents.

At the PY3-I drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 51,120 mg/L under minimum currents to 51,164 mg/L under maximum currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.170 km^2 (0.07 mi^2) under minimum currents and 1.339 km^2 (0.52 mi^2) under maximum currents.

Figure 2-17: Maximum TSS Concentrations at the Bottom—Scenario 1 PY1-P: Minimum Currents

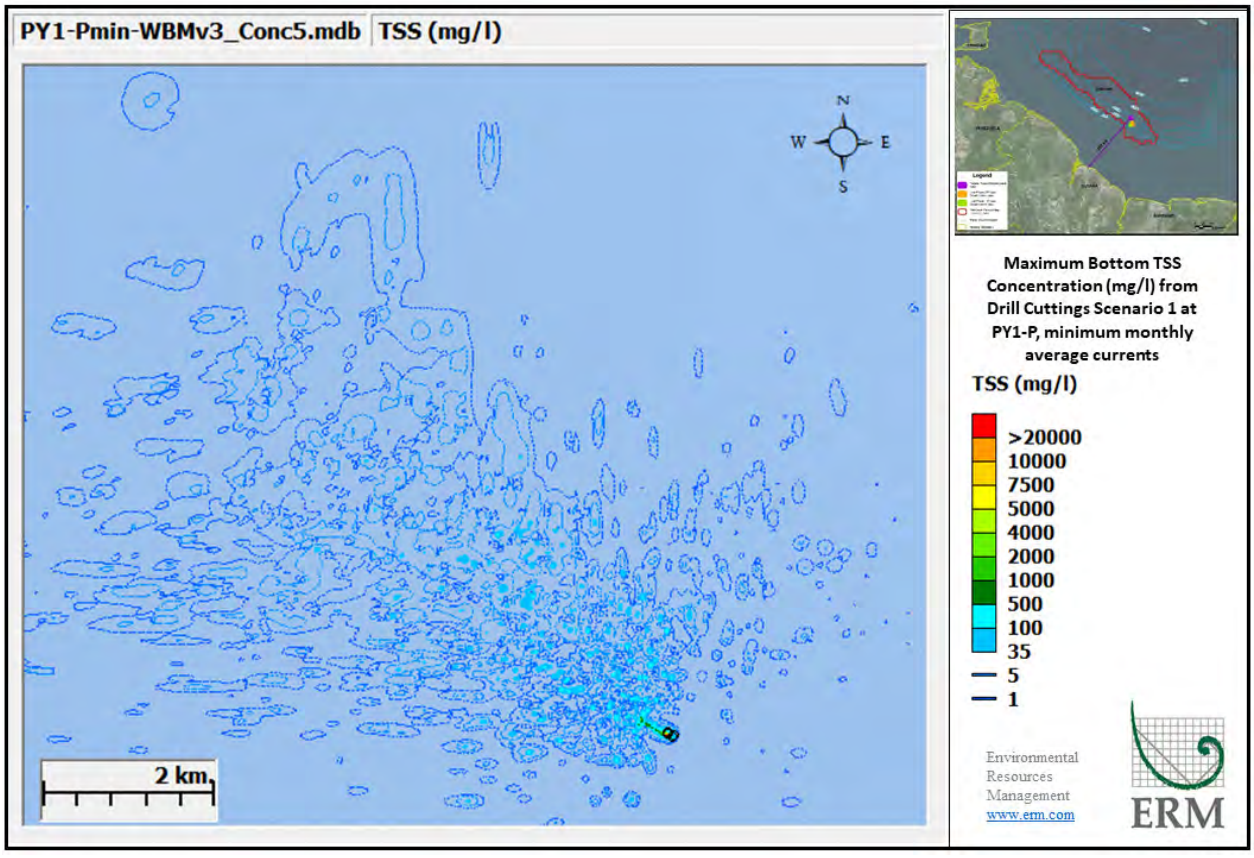


Figure 2-18: Maximum TSS Concentrations at the Bottom— Scenario 1 PY1-P: Maximum Currents

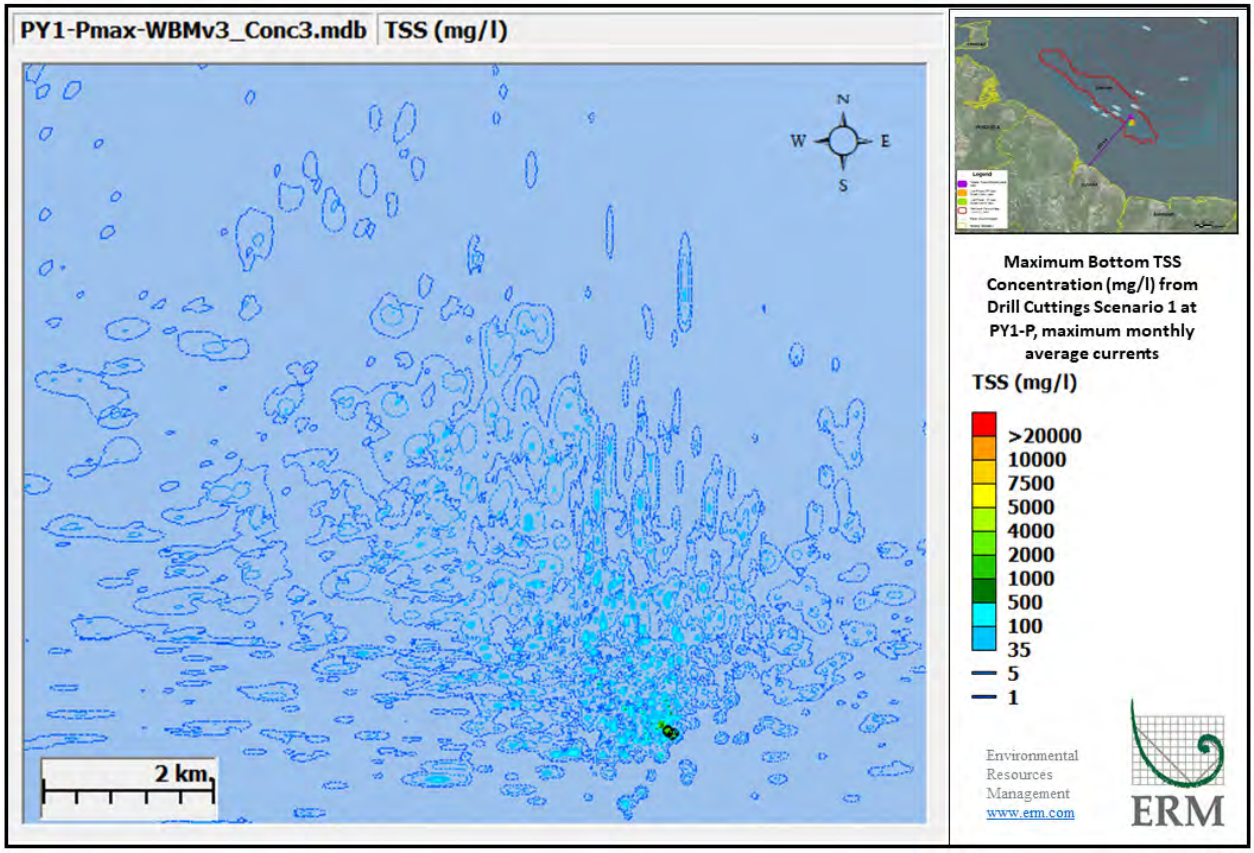


Figure 2-19: Maximum TSS Concentrations at the Bottom—Scenario 1 PY3-I: Minimum Currents

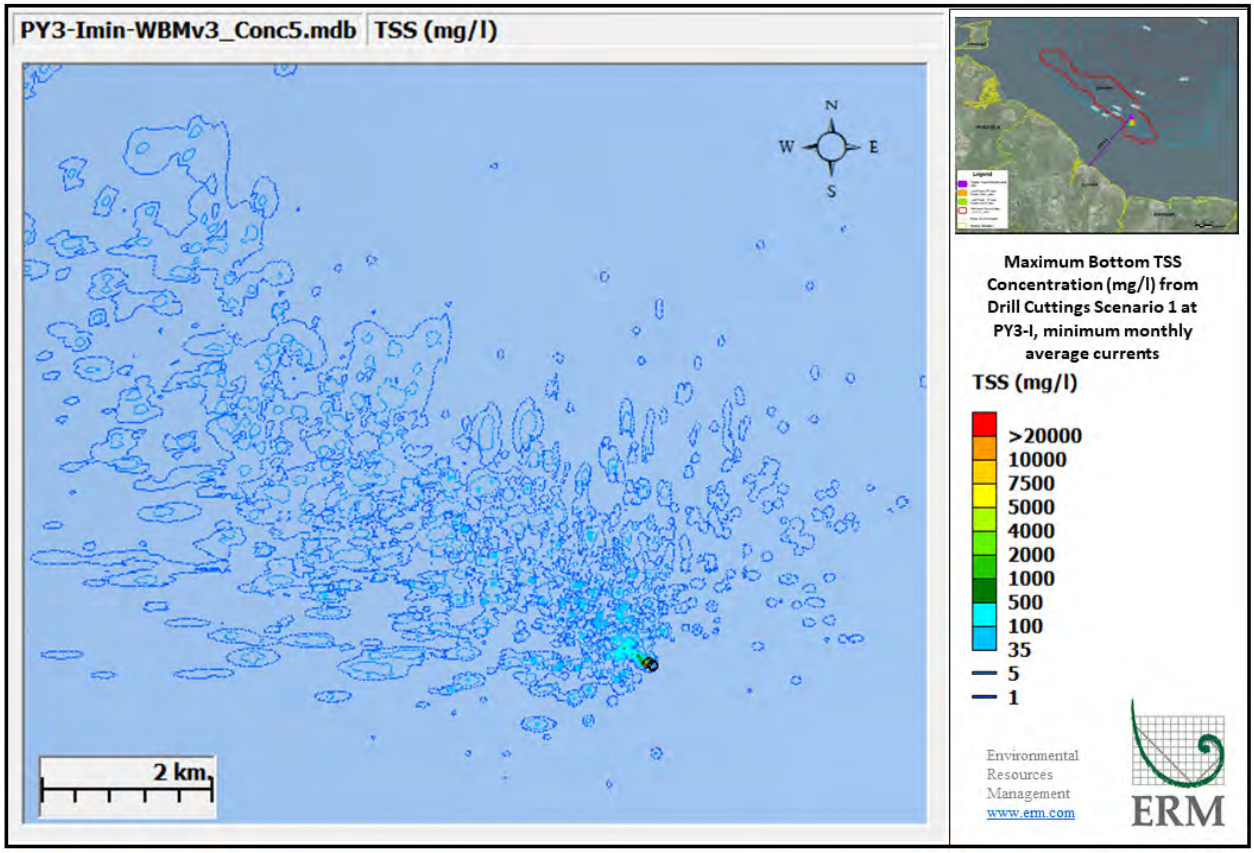
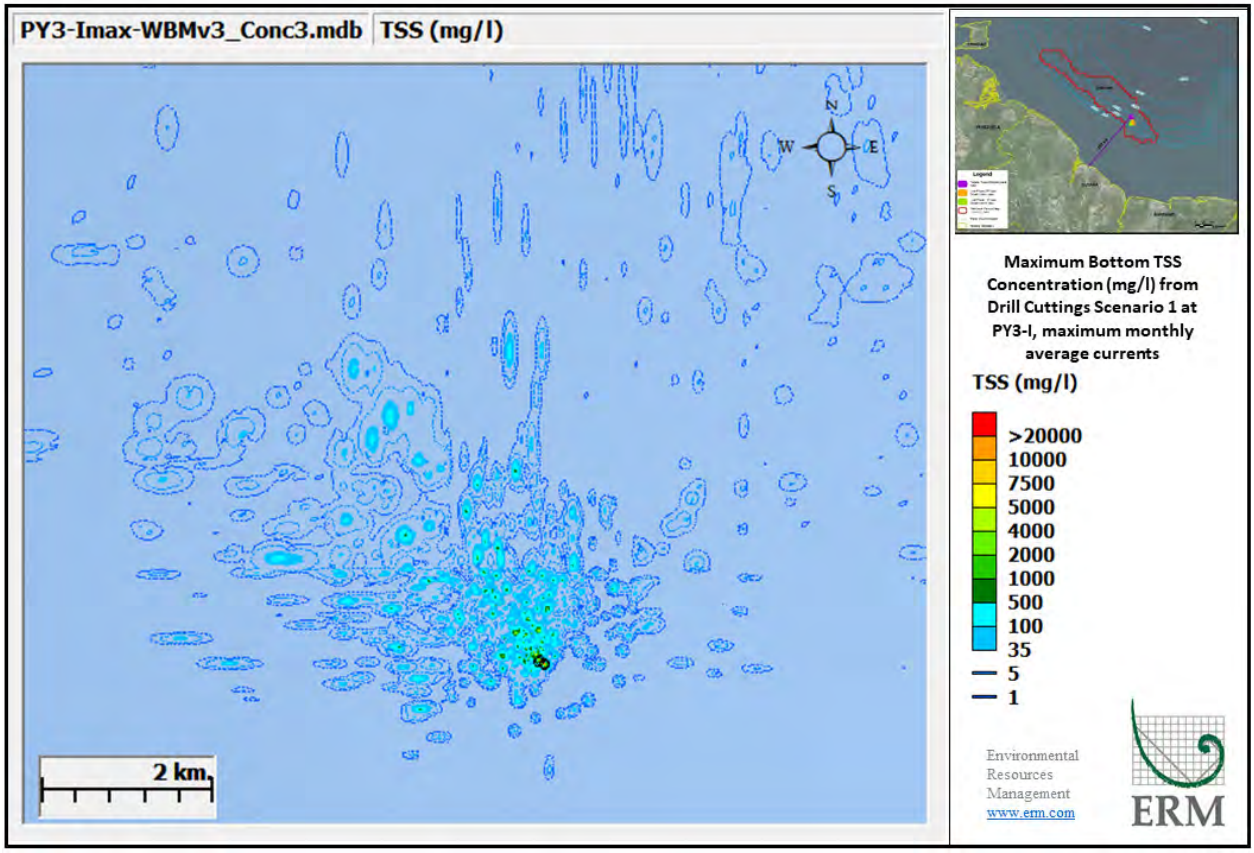


Figure 2-20: Maximum TSS Concentrations at the Bottom—Scenario 1 PY3-I: Maximum Currents



2.4.2.2 Scenario 2

Figure 2-21 through Figure 2-24 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated TSS concentration occurs at the seabed. Figure 2-25 through Figure 2-28 present the predicted TSS concentrations added above ambient levels at the time when the maximum Project-generated TSS concentration occurs from surface discharges. A separate "maximum" event was captured for near-seabed and surface concentrations.

At the PY1-P drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 18,520 mg/L under minimum currents to 26,149 mg/L under maximum monthly averaged currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.160 km^2 (0.1 mi^2) under maximum currents and 0.288 km^2 (0.1 mi^2) under minimum currents. For surface discharges, the maximum TSS concentration added above ambient ranged from 23.6 mg/L under minimum currents to 52.8 mg/L under maximum currents. The maximum area of TSS exceeding the 35 mg/L threshold was 0.0065 km^2 (0.003 mi^2) under maximum currents. The threshold was not exceeded under the minimum currents.

At the PY3-I drill center, the maximum TSS concentration added above ambient as a result of seabed discharges ranged from 12,711 mg/L under minimum currents to 45,302 mg/L under maximum currents. The maximum area with TSS exceeding the 35 mg/L threshold was 0.202 km^2 (0.1 mi^2) under maximum currents and 0.259 km^2 (0.1 mi^2) under minimum currents. For surface discharges, the maximum TSS concentration added above ambient ranged from 23.7 mg/L under minimum currents to 52.4 mg/L under

maximum currents. The maximum area of TSS exceeding the 35 mg/L threshold was 0.0065 km^2 (0.003 mi^2) under maximum currents. The threshold was not exceeded under the minimum currents.

Note that on the following figures, the estimated maximum TSS concentrations may be slightly offset from the discharge location as the simulation's floating small particles suspended in the water column may concentrate together at various locations. Larger particles do not remain suspended but quickly settle to the seafloor.

Table 2-17 summarizes the maximum predicted surface and bottom TSS concentrations modeled and the lateral areas with TSS concentrations exceeding the 35 mg/L threshold under minimum and maximum current conditions at each drill center.

Table 2-17: Total Suspended Solids Summary—Scenario 2

Simulation	Maximum TSS (mg/L)		Area (km^2) with TSS >35 mg/L Threshold	
	Surface	Bottom	Surface	Bottom
Scenario 2: PY1-P Minimum Currents	23.65	18,520	0.288	0
Scenario 2: PY1-P Maximum Currents	52.78	26,149	0.160	0.0065
Scenario 2: PY3-I Minimum Currents	23.73	12,711	0.259	0
Scenario 2: PY3-I Maximum Currents	52.42	45,302	0.202	0.0065

NA = not applicable

Figure 2-21: Maximum TSS Concentrations at the Bottom—Scenario 2 PY1-P: Minimum Currents

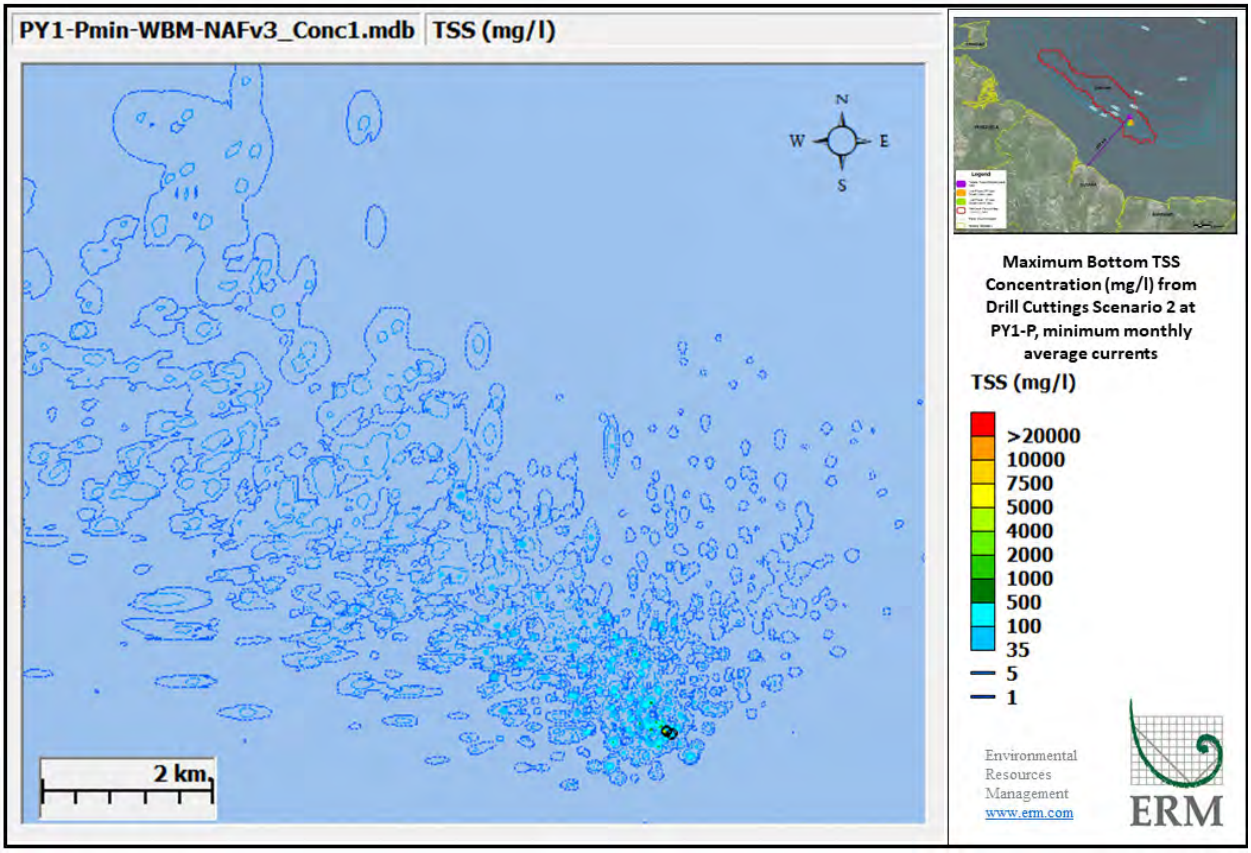


Figure 2-22: Maximum TSS Concentrations at the Bottom—Scenario 2 PY1-P: Maximum Currents

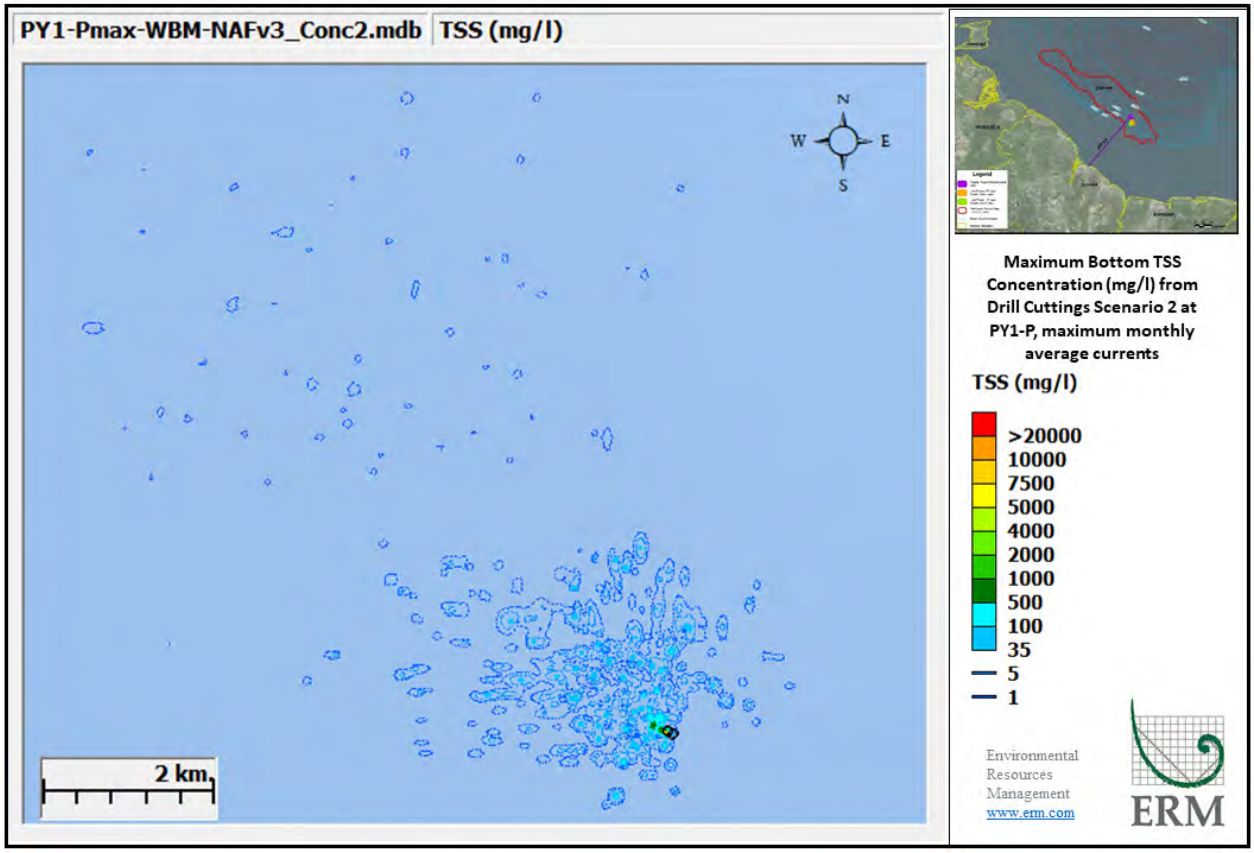


Figure 2-23: Maximum TSS Concentrations at the Bottom—Scenario 2 PY3-I: Minimum Currents

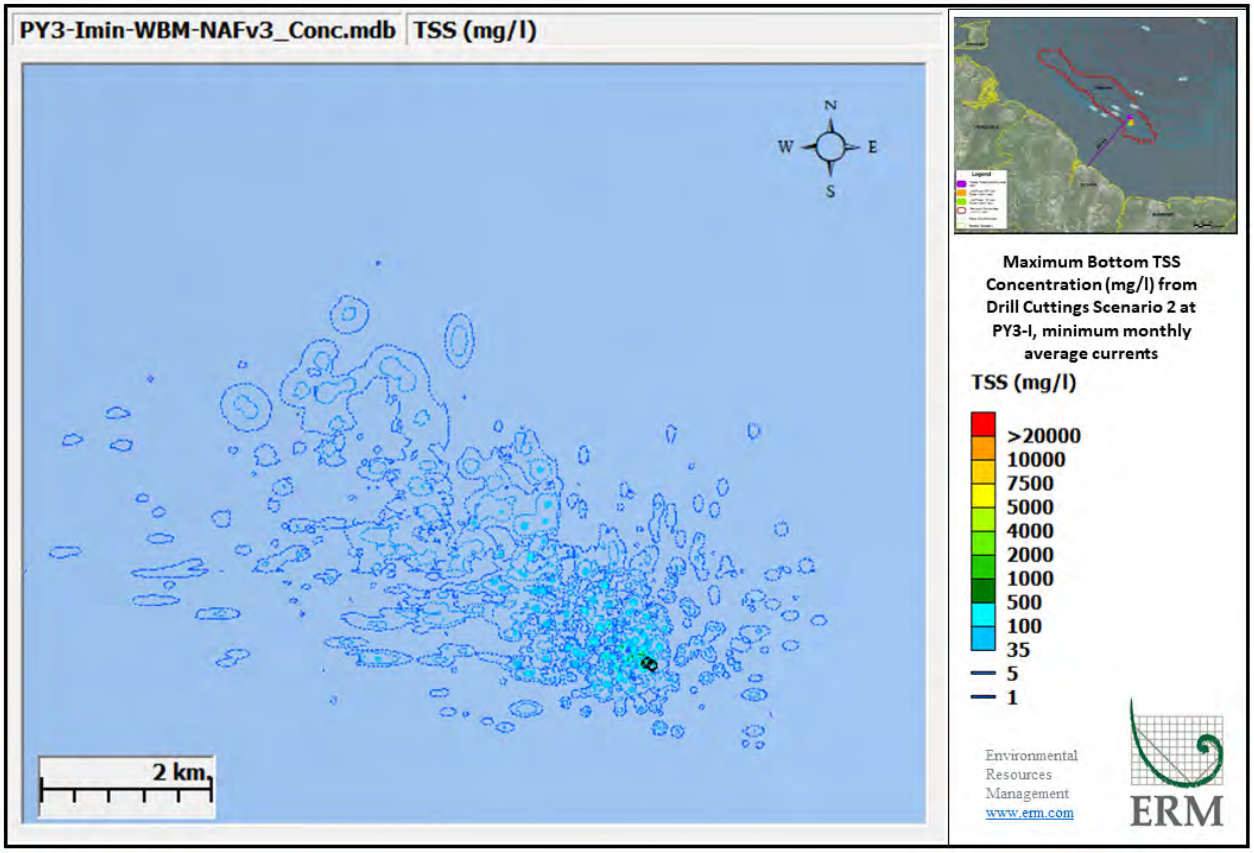


Figure 2-24: Maximum TSS Concentrations at the Bottom—Scenario 2 PY3-I: Maximum Currents

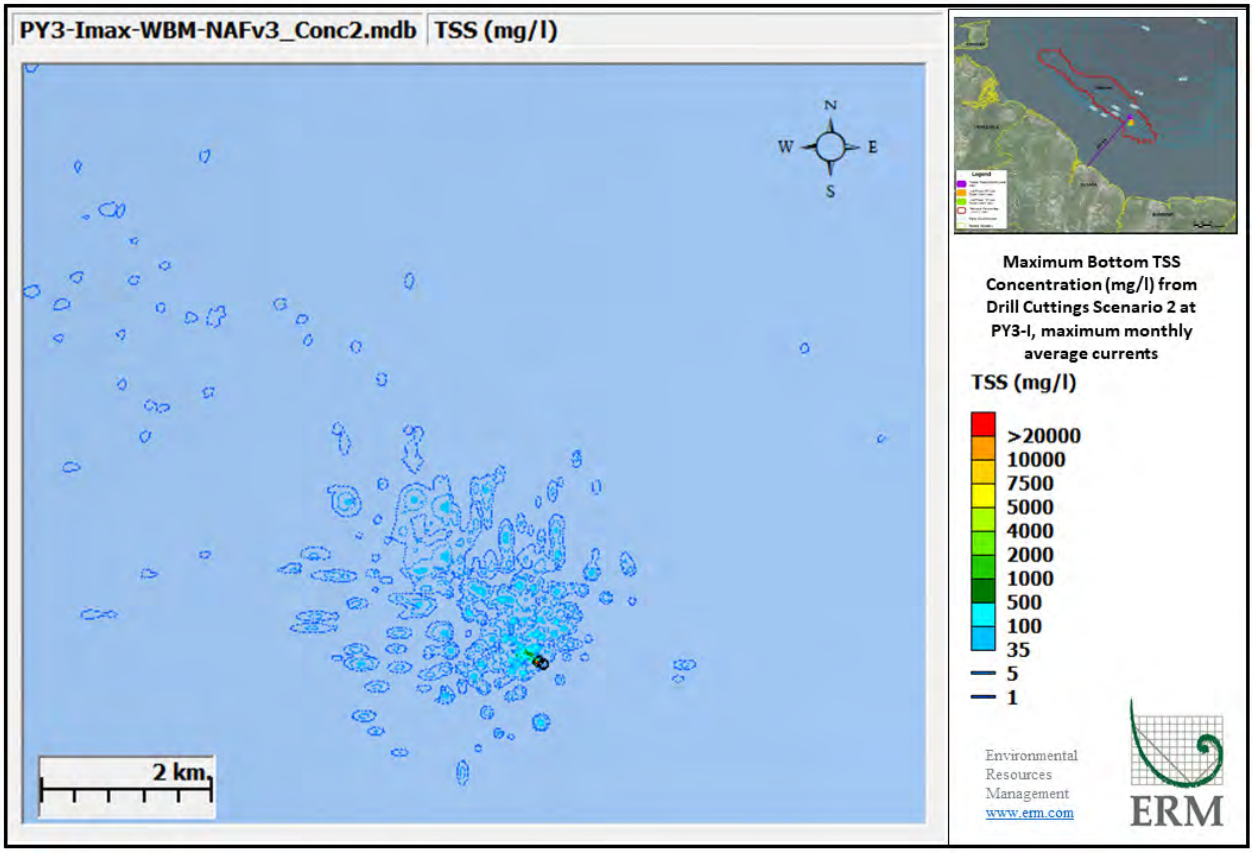


Figure 2-25: Maximum TSS Concentrations at the Surface—Scenario 2 PY1-P: Minimum Currents

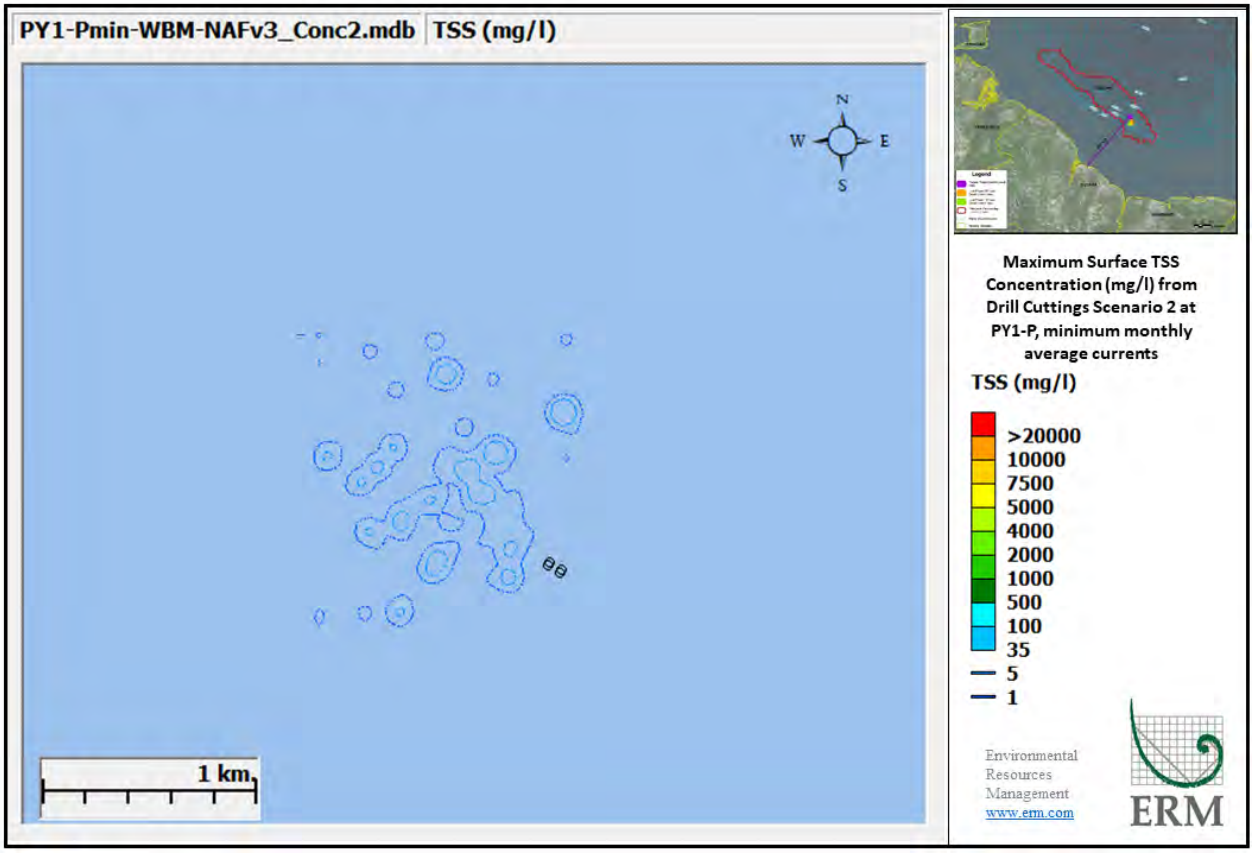


Figure 2-26: Maximum TSS Concentrations at the Surface—Scenario 2 PY1-P: Maximum Currents

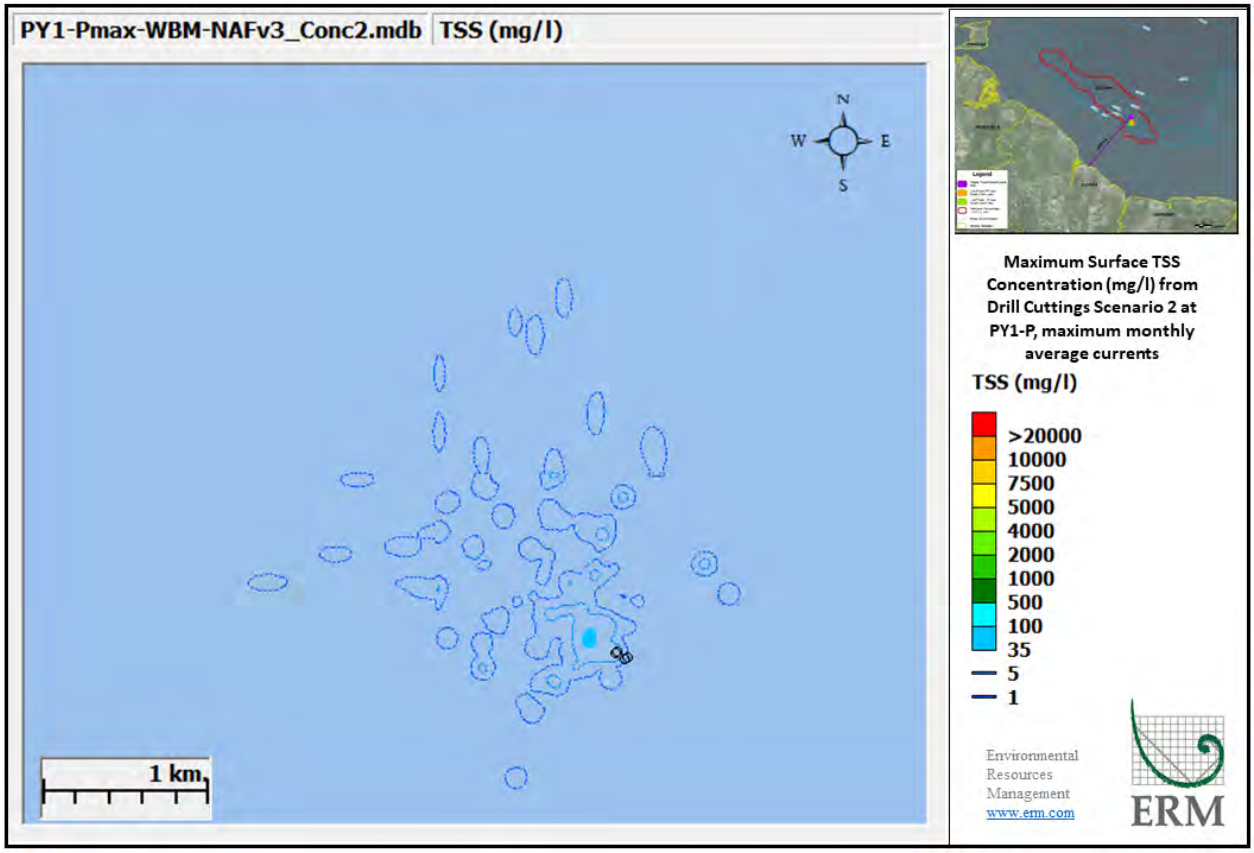


Figure 2-27: Maximum TSS Concentrations at the Surface—Scenario 2 PY3-I: Minimum Currents

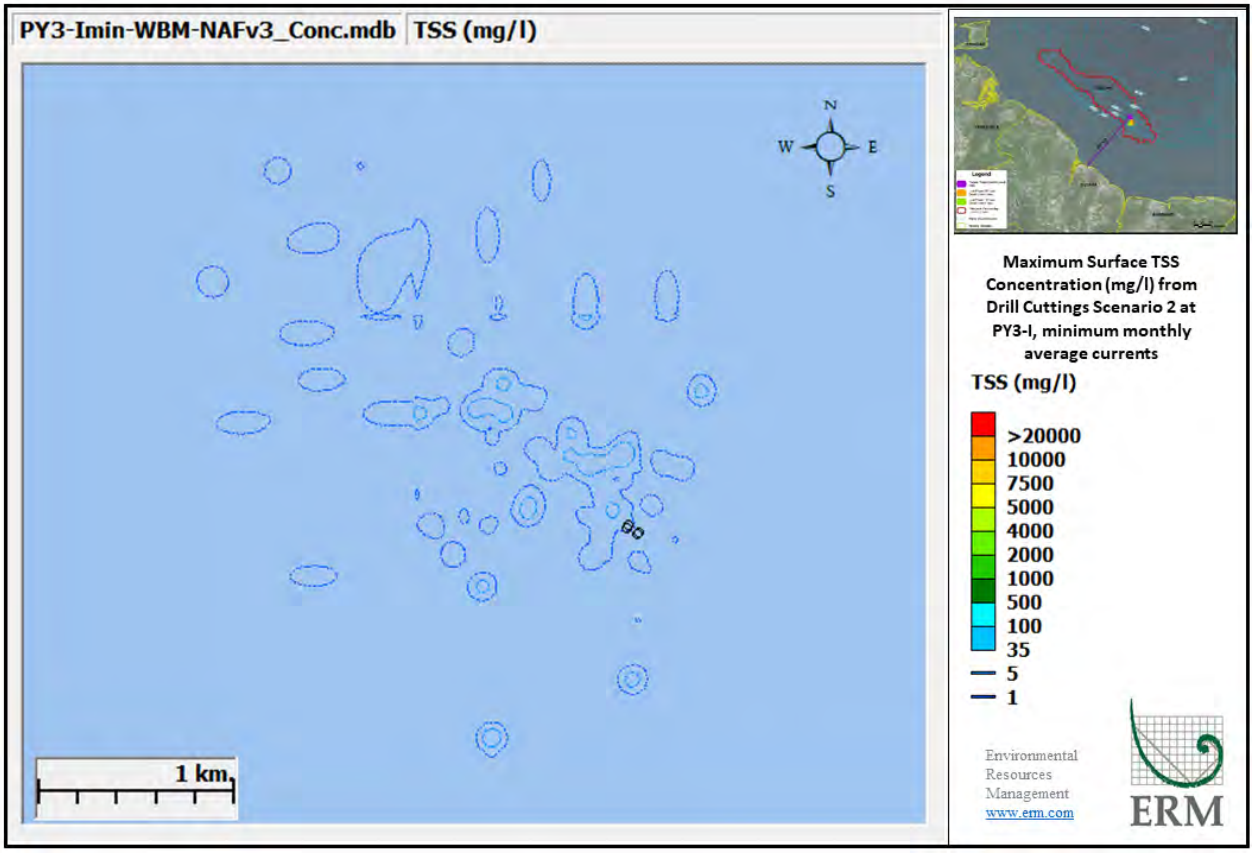
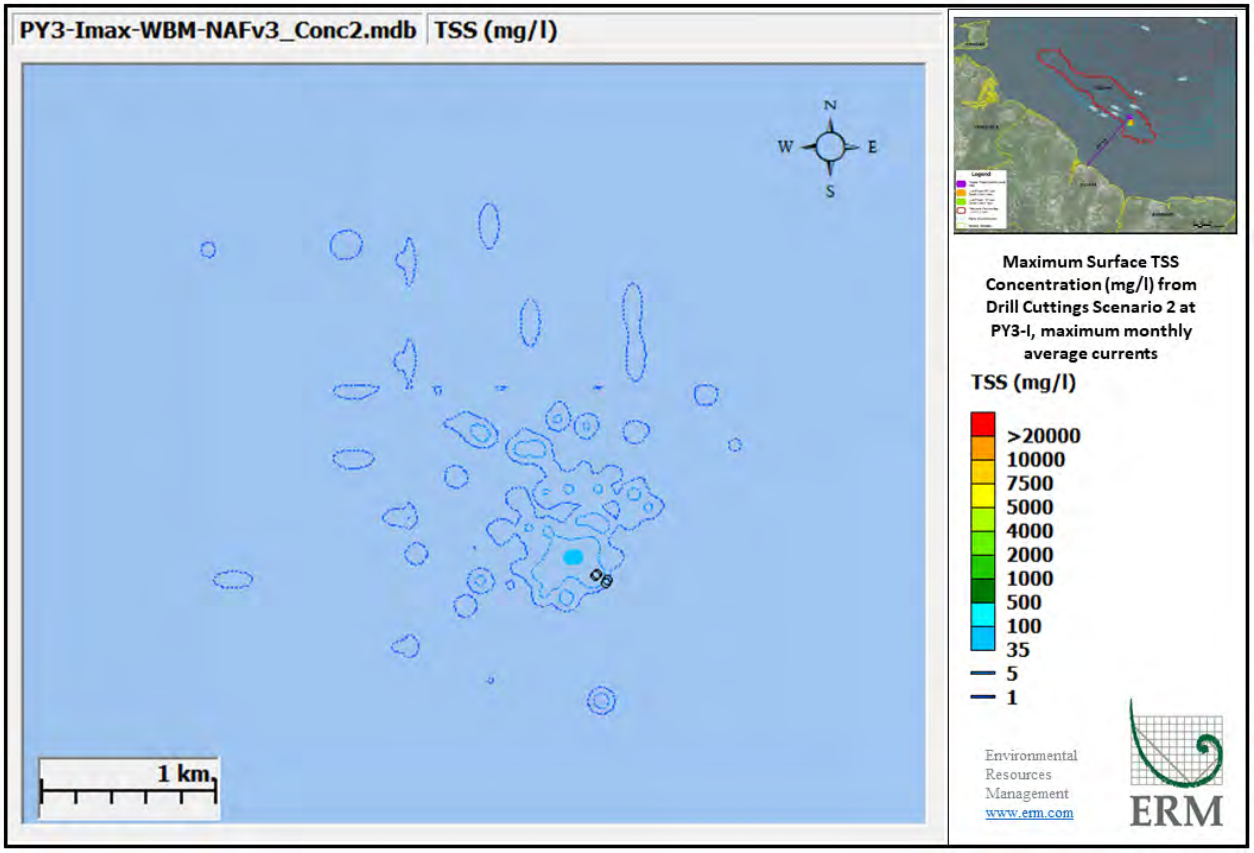


Figure 2-28: Maximum TSS Concentrations at the Surface—Scenario 2 PY3-I: Maximum Currents



2.4.3 Mass of Oil Deposited on the Seabed

Figure 2-29 through Figure 2-32 present the predicted hydrocarbon deposition on the seabed based on the statistical summary identifying the maximum hydrocarbon deposition occurring on the ocean floor during the entire simulation period. At the end of the simulation period (87 days), non-aqueous base fluid adhered to the cuttings settled primarily within an approximately 3-kilometer (1.9-mile) radius of the drill center for all four simulations.

For drill center PY1-P, the maximum hydrocarbon deposition under the minimum monthly averaged current scenario was 952.8 grams per square meter (g/m²) and was 897.7 g/m² under the maximum monthly averaged current scenario.

For drill center PY3-I, the maximum hydrocarbon deposition under the minimum monthly averaged current scenario was 901.9 g/m² and was 689.0 g/m² under the maximum monthly averaged current scenario.

Figure 2-29: Total Deposited Adhered Oil—Scenario 3 PY1-P: Minimum Currents

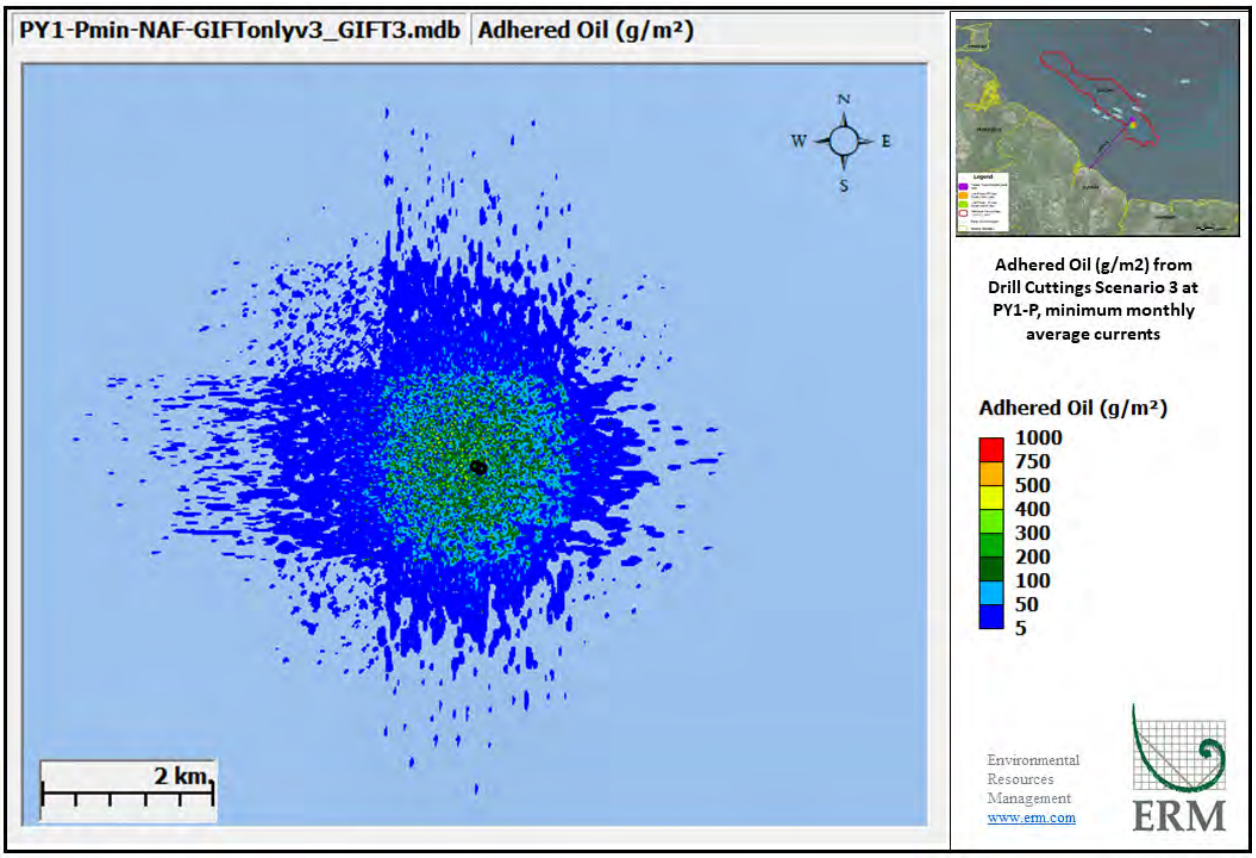


Figure 2-30: Total Deposited Adhered Oil—Scenario 3 PY1-P: Maximum Currents

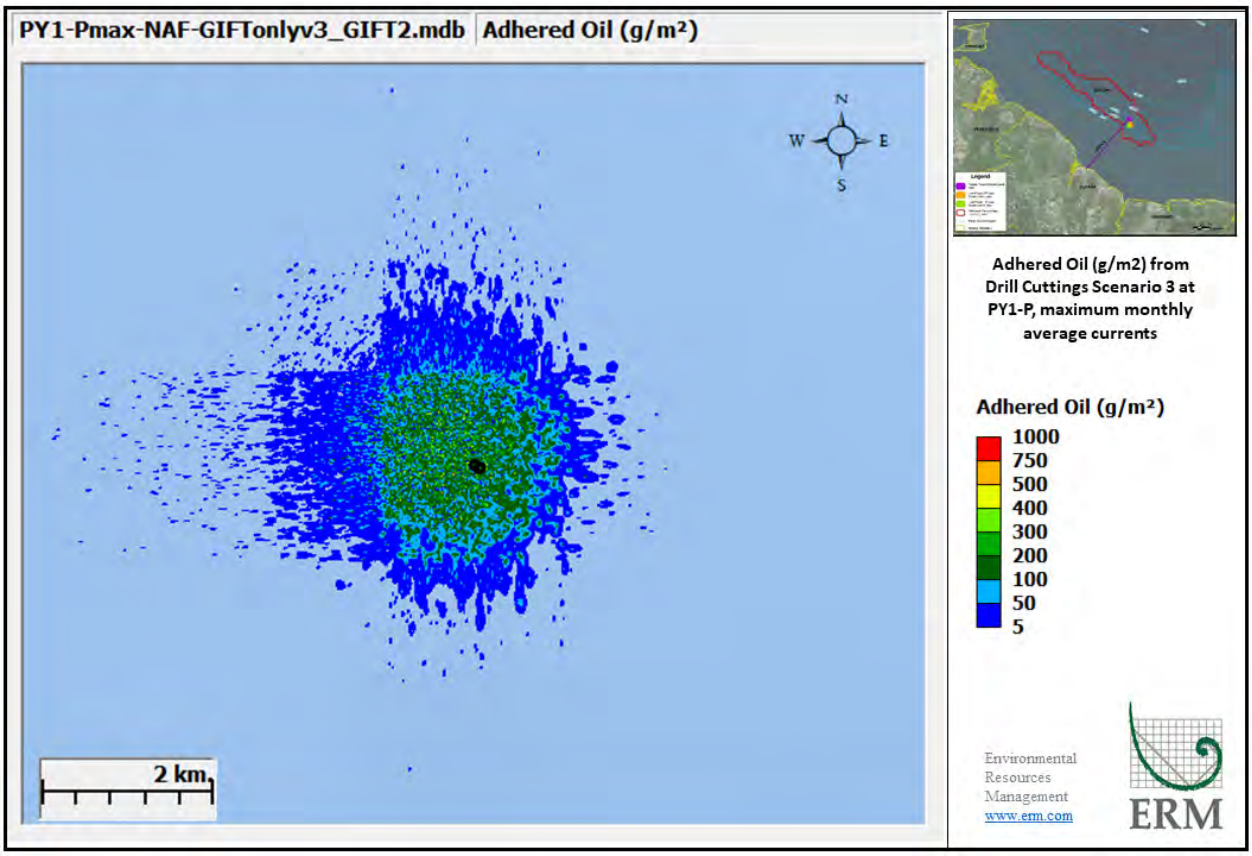


Figure 2-31: Total Deposited Adhered Oil—Scenario 3 PY3-I: Minimum Currents

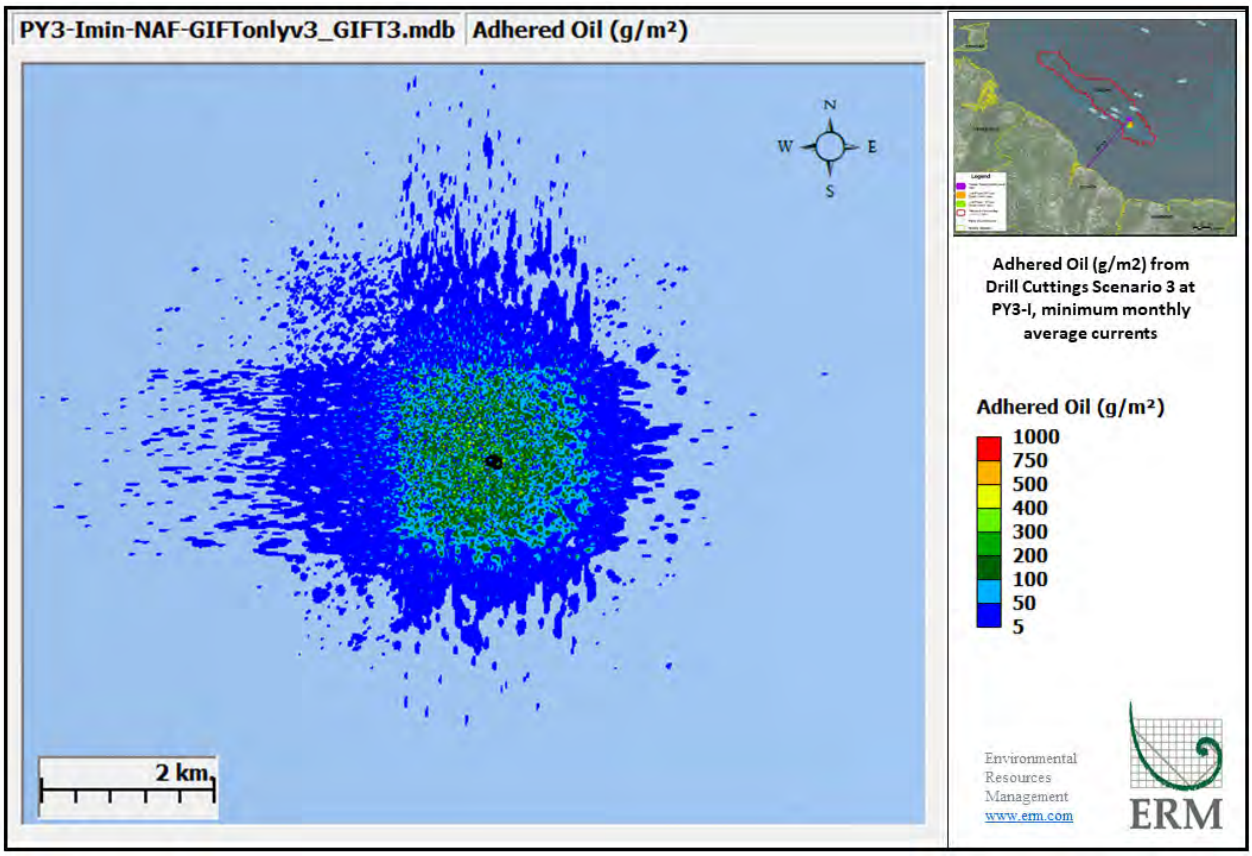


Figure 2-32: Total Deposited Adhered Oil—Scenario 3 PY3-I: Maximum Currents

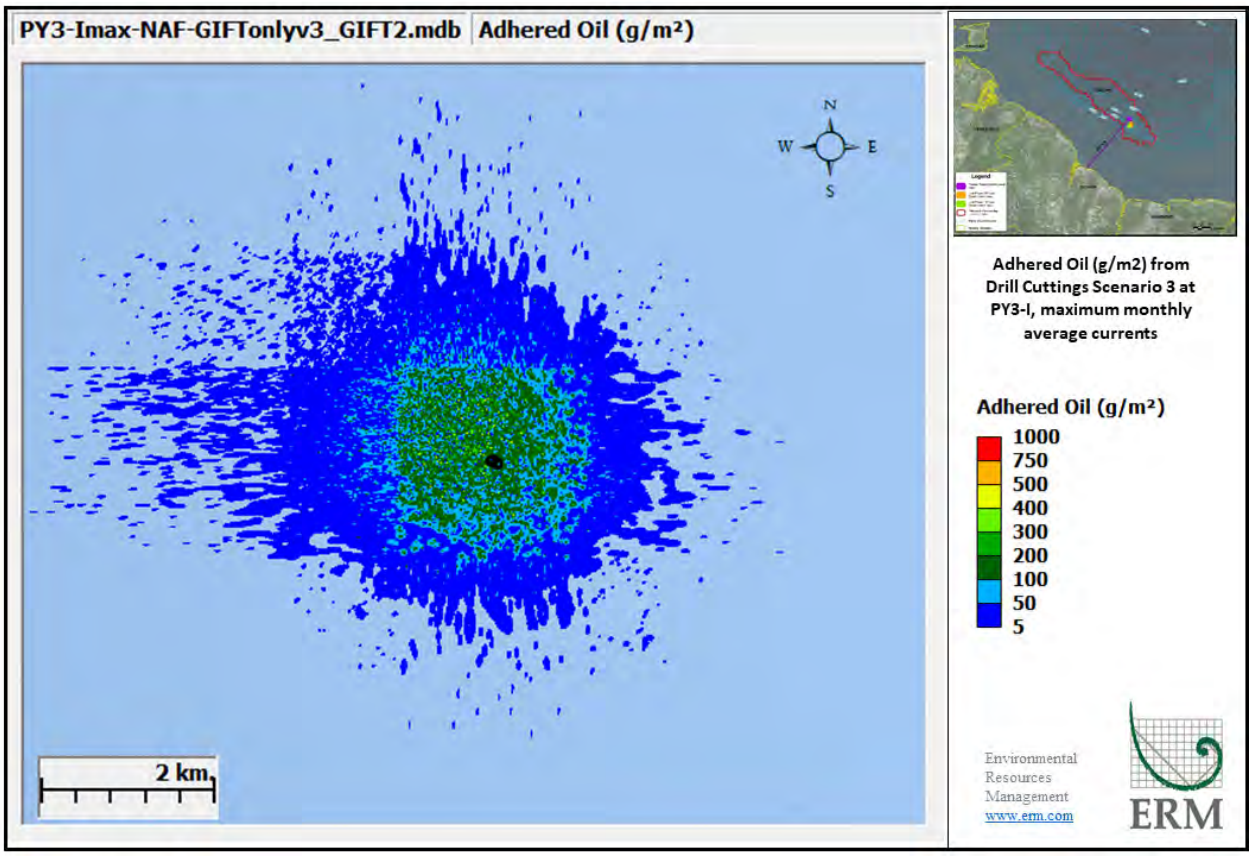


Table 2-18 summarizes the maximum hydrocarbon deposition modeled at any point for the scenario and the area with hydrocarbon deposition exceeding 5 g/m^2 under minimum and maximum current conditions at each drill center.

Table 2-18: Hydrocarbon Deposition Summary

Simulation	Maximum Hydrocarbon Deposition (g/m²)
Scenario 3: PY1-P Minimum Currents	952.8
Scenario 3: PY1-P Maximum Currents	897.7
Scenario 3: PY3-I Minimum Currents	901.9
Scenario 3: PY1-I Maximum Currents	689

2.5 Conclusions

Drill cuttings deposition modeling was performed using GEMSS® and its drill cuttings and muds deposition module, GIFT. Twelve simulations were modeled, representing two drill centers (PY1-P and PY3-I) and three drilling scenarios under two ambient current conditions (minimum and maximum monthly averaged, depth-averaged current speeds over a 10-year period of record).

Output from the drill cutting modeling included estimations of the lateral distribution of deposited cuttings thickness on the seafloor, the maximum increase in TSS concentrations above ambient conditions, and the lateral distribution of mass of hydrocarbons adhered to cuttings deposited on the seafloor. The results of the modeling are shown below in Table 2-19.

Table 2-19: Model Results Summary

Simulation	Maximum Depositional Thickness (cm)	Area (m²) with Thickness >5 cm Threshold	Maximum TSS (mg/L) Bottom/ Surface	Area (km²) with TSS >35 mg/L Threshold Bottom/ Surface	Maximum Adhered Oil Deposition (g/m²)
Scenario 1—PY1-P Minimum Currents	185.7	3,571	42,796	0.362	NA
Scenario 1—PY1-P Maximum Currents	238.8	2,874	36,859	0.621	NA
Scenario 1—PY3-I Minimum Currents	214.2	2,932	51,120	0.170	NA
Scenario 1—PY3-I Maximum Currents	255.5	2,739	51,164	1.339	NA
Scenario 2—PY1-P Minimum Currents	116.8	1,976	18,520/ 23.6	0.288/0	NA
Scenario 2—PY1-P Maximum Currents	178.3	1,636	26,149/ 52.8	0.160/0.0065	NA
Scenario 2—PY3-I Minimum Currents	138.2	1,663	12,711/ 23.7	0.259/0	NA
Scenario 2—PY3-I Maximum Currents	179.1	1,455	45,302/ 52.4	0.202/0.0065	NA
Scenario 3—PY1-P Minimum Currents	NA	NA	NA	NA	952.8
Scenario 3—PY1-P Maximum Currents	NA	NA	NA	NA	897.7
Scenario 3—PY3-I Minimum Currents	NA	NA	NA	NA	901.9
Scenario 3—PY3-I Maximum Currents	NA	NA	NA	NA	689

cm = centimeter; NA = not applicable

In all simulations, a small region close to the drill centers exceeded the depositional thickness threshold value of 5 centimeters (2 inches). The lateral extent of the deposition mound where thicknesses exceed this threshold was approximately 60 meters (164 feet). The bulk of the depositional mound results from the cuttings and muds discharged during the jetting and drilling of the two top-hole sections. The maximum increase in TSS concentration above ambient conditions in the bottom of the water column is predicted to be as much as 51,164 mg/L at the point of release; however, these concentrations will occur at water depths below the photic zone, in areas where photosynthesis inhibition is not a concern. At the surface, where photosynthesis inhibition is more of a concern, TSS concentration increases above ambient from discharges were predicted to be below the 35 mg/L threshold for minimum current conditions. For maximum current conditions, the maximum TSS concentration increases above ambient in the shallow water column is 52.8 mg/L. Hydrocarbon deposition on the seafloor had a maximum predicted value of 952.8 g/m².

Variations in the current speeds are the primary cause for the variations in the model results provided. In general, scenarios with minimum currents have higher maximum areas of deposition greater than the 5-centimeter (2-inch) threshold and higher bottom TSS concentrations compared to the scenarios with maximum currents. Slower currents allow for a less dispersed settling and therefore a more laterally concentrated deposition and more concentrated TSS.

Similar to the depositional thickness, scenarios with minimum currents have higher maximum hydrocarbon deposition compared to scenarios with maximum currents. Slower currents allow for a more laterally concentrated deposition of hydrocarbon-containing cuttings.

3. OFFSHORE DISCHARGES MODELING

3.1 Approach

The Project will have several planned discharges to water associated with subsea, umbilicals, risers, and flowlines (SURF) and FPSO commissioning activities as well as FPSO production operations. These discharges, based on the preliminary Project design information, are listed in Table 3-1.

Table 3-1: Summary of Commissioning- and Production-Related Discharges

Type of Discharge and Effluent Characteristics	Expected Discharge Volume/Rate
Ballast Water (FPSO initial deballasting)	≤550,000 bbl total
Hydrostatic Test Water ■ Biocide: ≤500 ppm ■ Oxygen scavenger ≤100 ppm ■ Corrosion inhibitor ≤200 ppm	65,000 bbl (total volume for all flowlines and risers, occurring throughout SURF commissioning phase)
Gas Injection Line Commissioning Fluids ■ Hydrate inhibitor (e.g., methanol or ethylene glycol)	1,400 bbl total
Produced Water ■ Oil and Grease ■ Temperature (55°C at point of discharge) ■ Residual production and water treatment chemicals ■ Scale Inhibitor ≤100 ppm ■ Corrosion Inhibitor ≤200 ppm	≤300,000 BPD
Cooling Water ■ Hypochlorite: ≤5 ppm ■ Temperature (50°C at point of discharge)	≤1,600,000 BPD
Sulfate Removal and Potable Water Processing Brines ■ Hypochlorite: ≤1 ppm ■ Electrolyte: ≤1 ppm ■ Biocide: ≤5 ppm ■ Oxygen Scavenger: ≤10 ppm ■ Scale Inhibitor: ≤5 ppm	≤265,000 BPD
Subsea Hydraulic Fluid Discharge ■ Water soluble, low-toxicity	≤5 BPD
FPSO Bilge Water	1,800 BPD
Inert Gas Generator Cooling Water	Negligible
FPSO Slop Tank Water	Negligible
Miscellaneous Discharges including Boiler Blowdown, Desalinization Blowdown, Lab Sink Drainage	<10 BPD
Tanker Ballast Water	Maximum 1,200,000 bbl total (at each tanker crude loading)
Blowout Preventer System and Subsea Blowout Preventer Testing Water-Soluble Low-Toxicity Hydraulic Fluid	30 bbl every 2 weeks
Gray Water	250 BPD
Black Water (sewage)	70 BPD
Food Preparation Wastes	<40 BPD

°C = degrees Celsius; bbl = barrel; BPD = barrels per day; ppm = parts per million

Cooling water, produced water, and brines from the Sulfate Removal Unit (SRU) and freshwater reverse osmosis system (all associated with the production operations stage) are the main operational discharges that are significant enough to require an assessment of the extent of the discharge plume. Although the discharge of hydrotest water and commissioning fluids will occur over only a short time period during the

SURF installation and commissioning stage, they were also included in the offshore discharge modeling as a conservative measure. Additionally, a scenario simulating a failure in the sewage treatment plant requiring all black water to bypass the macerator (and assuming it also bypasses the holding tank) and be discharged directly overboard via an emergency outfall was considered. The constituents considered from these discharges are listed in Table 3-2.

Table 3-2: Operational and Maintenance Offshore Discharges and their Constituents Modeled

Discharge	Modeled Constituents
Cooling Water	■ Temperature ■ Residual chlorine
Produced Water	■ Temperature ■ Oil and grease ■ Residual production and water treatment chemicals (e.g., scale and corrosion inhibitors)
Sulfate Removal and Potable Water Processing Brines	■ Hypochlorite ■ Electrolyte ■ Biocide ■ Oxygen scavenger ■ Scale inhibitor
Hydrotest Water	■ Biocides ■ Oxygen scavenger ■ Corrosion inhibitor
Gas Injection Line Commissioning Fluid	■ Hydrate inhibitor (e.g., methanol or ethylene glycol)
Black Water	■ TSS ■ BOD_5 ■ Coliform bacteria

BOD_5 = 5-day biochemical oxygen demand

As the standards applicable to marine discharges are typically applied at the edge of the mixing zone, modeling of the near-field mixing zone is necessary. The model used for the mixing zone calculations is the U.S. Environmental Protection Agency's (USEPA) Cornell Mixing Zone Expert System (CORMIX) dilution model. CORMIX is a design tool routinely used by regulatory agencies to estimate the size and configuration of proposed and existing mixing zones resulting from wastewater discharges. CORMIX is primarily a near-field model (i.e., it applies to the region adjacent to the discharge structure in which the wastewater plume is recognizable as separate from the ambient water and its trajectory is dominated by the discharge rate, effluent density, and geometry of the discharge structure).

The CORMIX calculation is based on defining the various hydraulic zones the effluent plume traverses in the receiving waterbody, then applying an analytical solution or empirical relationship to compute the plume trajectory and dilution rate in each zone. Each of these analytical solutions and empirical relationships has been validated by the developers and other researchers against laboratory and field studies. CORMIX has been applied to many cases (http://www.cormix.info) and is recognized by the USEPA and other national regulatory agencies as an appropriate model for computing trajectories, dilution rates, and mixing zone dimensions.

To represent the short-term nature of the discharge for the untreated black water discharge scenario, the 3-D hydrodynamic and water quality model GEMSS was used. Unlike CORMIX, the GEMSS model is capable of simulating temporally and spatially varying conditions.

3.2 Scenario Selection

Understanding the mixing characteristics of the various discharges and assessing compliance with applicable regulatory standards requires an understanding of the properties of the receiving (ambient) water. The properties of the ambient water, in combination with the discharge port configuration (pipe or diffuser), control the near-field mixing and dilution of the discharge. Properties of the ambient water relevant to the current analysis include current velocity, temperature, and salinity. While the ambient current velocity (and its strength relative to the discharge/exit velocity) determines the level of initial mixing, temperature and salinity influence the behavior of the discharge plume and its relative configuration due to density differences (i.e., buoyancy effects). Significant density differences between the discharge and ambient water will impede mixing. Balancing that effect, significant differences between discharge velocity and ambient current increase entrainment of the ambient water into the discharge plume, resulting in rapid mixing.

3.2.1 Discharge Velocity

Discharge velocity is directly related to the pipe diameter used for the various effluent streams. Smaller pipe diameters result in higher exit velocities, facilitating increased mixing. However, engineering constraints may require a minimum pipe diameter. As is typically the case for an EIA, details are not yet available for all aspects of the Project discharge design. However, detailed design information is available for the Liza Phase 1 Development Project and ERM is working with the design engineers for the Liza Phase 2 Development Project; accordingly, where appropriate, design values from these projects were used for the analysis for the Payara Project. If smaller discharge pipe diameters are used for the Payara Project, the discharge will result in increased mixing and smaller plumes. A larger pipe diameter was also evaluated for some scenarios to confirm that the plume under a larger pipe will continue to meet the targeted environmental guidelines. The pipe configurations considered for the discharge streams modeled are listed in Table 3-3.

Table 3-3: Pipe Diameters Considered for Offshore Discharges

Type of Discharge	Pipe Diameter (inches)	Vertical Location Relative to Sea Level
Produced Water	12.5	2 m above water surface
Cooling Water	22.6 and 45.2	2 m above water surface
Sulfate Removal and Potable Water Process Brines	12	2 m above water surface
Hydrostatic Test Water	2 and 6	Seafloor
Hydrate Control Fluid	2 and 6	Seafloor
Black Water	8	1 m below water surface

m = meter

3.2.2 Discharge Properties

Discharge rates for the various operational discharges were based on the preliminary design (see Table 3-1). For modeling of hydrotesting discharges, SURF volumes were also based on preliminary design information. The discharge rates and SURF volumes reflect conservative (high) estimates. Anticipated constituent concentrations and temperatures in discharge streams were also based on preliminary design. The selected discharge rates and constituent concentrations are shown in Table 3-4.

Table 3-4: Modeled Discharge Properties

Type of Discharge	Modeled Discharge Rate	Modeled Parameter Values
Produced Water	300,000 BPD (conservative)	■ Temperature: 55°C (131°F) ■ Oil and Grease: 42 mg/L (daily maximum) ■ Residual production and water treatment chemicals (100 ppm scale inhibitor and 200 ppm corrosion inhibitor used as examples)
Cooling Water	1,600,000 BPD	■ Temperature: 50°C (122°F) ■ Hypochlorite: ≤5 ppm
Sulfate Removal and Potable Water Processing Brines	265,000 BPD	■ Hypochlorite: ≤1 ppm ■ Electrolyte: ≤1 ppm ■ Biocide: ≤5 ppm ■ Oxygen scavenger: ≤10 ppm ■ Scale inhibitor: ≤5 ppm
Hydrostatic Test Water	65,000 bbl (total volume for all flowlines and risers, occurring across approximately 1 year)	■ Biocide: 500 ppm ■ Oxygen scavenger: 100 ppm ■ Corrosion inhibitor: 200 ppm
Hydrate Control Fluid	2,500 bbl (may be as low as 1,400 bbl)	■ Concentrated methanol or ethylene glycol
Black Water	3,200 gallons per day [a]	■ TSS: 650 mg/L ■ BOD_5: 350 mg/L ■ Coliform: 10,000,000 CFU/100 ml

°C = degrees Celsius; °F = degrees Fahrenheit; bbl = barrel; BOD_5 = 5-day biochemical oxygen demand; BPD = barrels per day; CFU = colony-forming units; ml = milliliter; ppm = parts per million
[a] Based on design capacity for black water (70 BPD) with 160 persons on board; 10 percent contingency factor applied.

3.2.3 Ambient Currents

Ambient current velocities for the region were available from ExxonMobil Upstream Research Company using the SAT-OCEAN model and analyzed in order to select appropriate values for the specific locations for the discharges at the FPSO location. Although the operational discharges will occur near the surface, the hydrotesting and hydrate control fluid releases will occur near the seabed. Therefore, the ambient current velocities were analyzed to select appropriate values depending on the discharge being modeled.

Ambient current velocities were analyzed for the period of January 2005 to December 2014. A frequency distribution analysis was performed to evaluate the magnitude and exceedance percentages for current velocities. The ambient current velocities selected for modeling consisted of bounding cases (5 percent and 95 percent) and typical (50 percent). The frequency distributions for the two depths are shown in Figure 3-1 and Figure 3-2. The selected current velocities are shown in Table 3-5.

The use of a frequency distribution for selection of current velocities helps determine bounding cases for extreme ambient currents. The period of record is 10 years, which is sufficient to represent ambient conditions. Conditions outside of the ones observed during this 10-year period are expected to occur infrequently and, if they do occur, to not be sustained for long durations. Dynamics of the discharge plume under these unlikely conditions will therefore be rare and will quickly return to typical conditions due to the transitional nature of the currents. Furthermore, the model selected for analysis (CORMIX) has inherent conservativeness built in. It is thus reasonable to assume that the choice of bounding cases (5 percent and 95 percent) from the 10 years of record provides adequate representation of the likely discharge plumes that would predominate.

Figure 3-1: Cumulative Frequency Distribution for Current Velocities at FPSO Location (near surface)

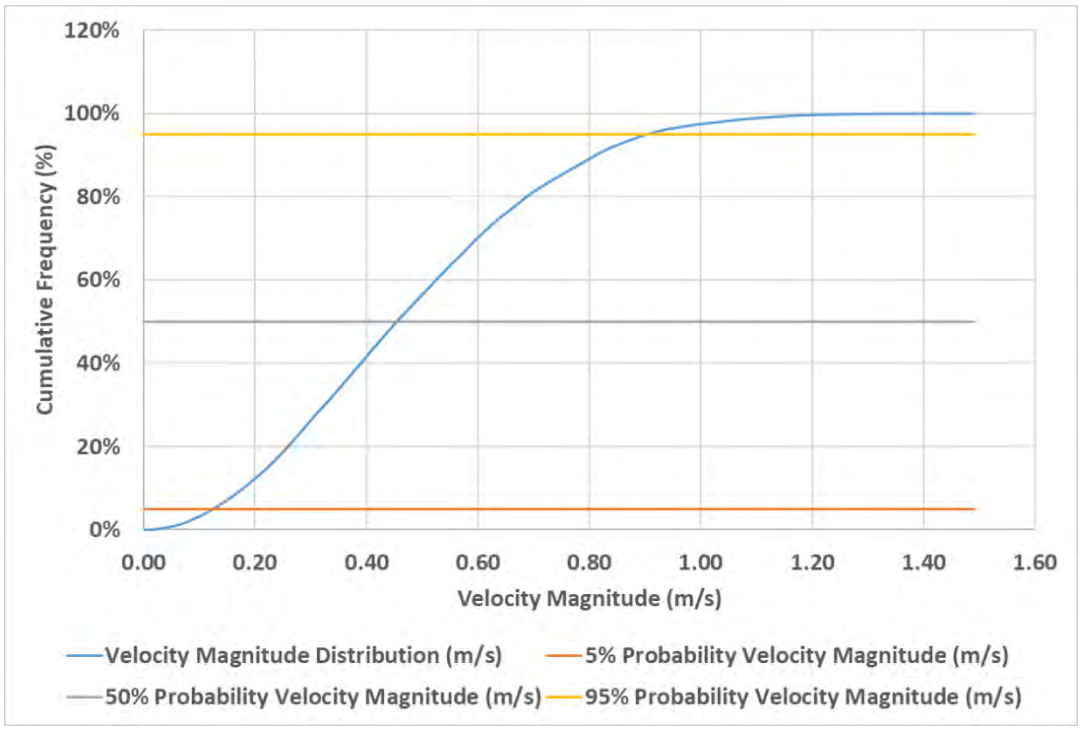


Figure 3-2: Cumulative Frequency Distribution for Current Velocities at FPSO Location (near seabed)

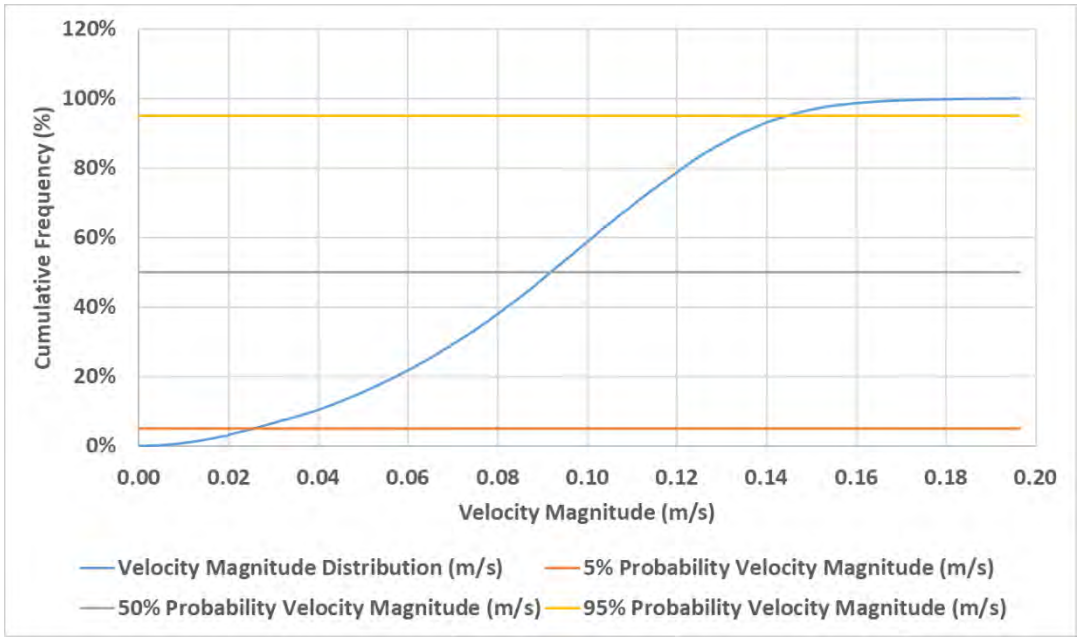


Table 3-5: Selected Ambient Current Velocities (meters/second)

Cumulative Frequency	Surface	Seabed
Low (5%)	0.12	0.03
Typical (50%)	0.45	0.09
High (95%)	0.90	0.14

3.2.4 Ambient Temperatures

An analysis of ambient temperatures for the FPSO location was conducted based on data available from the HYCOM model. Since the ambient temperatures do not vary significantly within the Stabroek Block, only the FPSO location was considered. The temperature data are available for January 2004 to December 2016. A frequency distribution analysis was completed to evaluate the temperatures and exceedance percentages. Selected ambient temperatures consisted of two bounding cases (1 percent and 99 percent) and a typical case (50 percent). Only the cooling water discharge, whose plume is influenced by the ambient temperatures and releases a large amount of water, was considered for the bounding cases and all remaining discharges were run for the typical case. The frequency distribution is shown in Figure 3-3 and the selected temperatures are shown in Table 3-6. For discharges released near the seafloor (hydrostatic test discharge), a single value of temperature at 4.5 degrees Celsius (ºC) (40.1°Fahrenheit [°F]) was used, as the temperature values near the seafloor do not vary considerably with time and space.

Figure 3-3: Cumulative Frequency Distribution for Temperatures at FPSO Location (near surface)

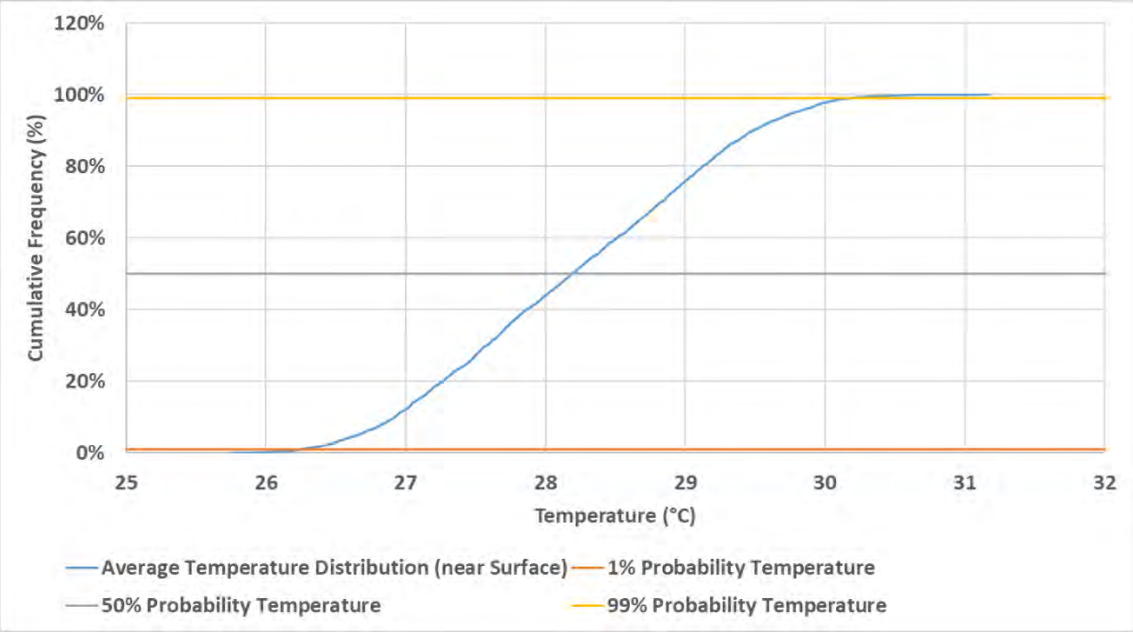


Table 3-6: Selected Ambient Near-Surface Temperatures (°C)

Cumulative Frequency	FPSO
Low (1%)	26.25
Typical (50%)	28.19
High (99%)	30.18

3.2.5 Scenarios

A combination of the discharges, ambient properties (currents and temperatures) and discharge velocities (pipe diameters) were used to develop a comprehensive list of scenarios for simulation with CORMIX (Table 3-7). All potential pipe diameters listed in Table 3-3 were used to model these scenarios.

Table 3-7: List of Modeled Scenarios

No	Discharge	Scenario Name	Ambient Currents	Ambient Temperature	Location
1	Cooling Water—Thermal	T Sc. 01	Low (5%)	High (99%)	FPSO; 2 m above water surface
		T Sc. 02	Typical (50%)	High (99%)	FPSO; 2 m above water surface
		T Sc. 03	High (95%)	High (99%)	FPSO; 2 m above water surface
		T Sc. 04	Low (5%)	Low (1%)	FPSO; 2 m above water surface
		T Sc. 05	Typical (50%)	Low (1%)	FPSO; 2 m above water surface
		T Sc. 06	High (95%)	Low (1%)	FPSO; 2 m above water surface
2	Cooling Water—Hypochlorite	C Sc. 01	Low (5%)	High (99%)	FPSO; 2 m above water surface
		C Sc. 02	Typical (50%)	High (99%)	FPSO; 2 m above water surface
		C Sc. 03	High (95%)	High (99%)	FPSO; 2 m above water surface
		C Sc. 04	Low (5%)	Low (1%)	FPSO; 2 m above water surface
		C Sc. 05	Typical (50%)	Low (1%)	FPSO; 2 m above water surface
		C Sc. 06	High (95%)	Low (1%)	FPSO; 2 m above water surface
3	Sulfate Removal and Potable Water Processing Brines	W Sc. 01	Low (5%)	Typical (50%)	FPSO; 2 m above water surface
		W Sc. 02	Typical (50%)	Typical (50%)	FPSO; 2 m above water surface
		W Sc. 03	High (95%)	Typical (50%)	FPSO; 2 m above water surface
4	Produced Water	P Sc. 01	Low (5%)	Typical (50%)	FPSO; 2 m above water surface
		P Sc. 02	Typical (50%)	Typical (50%)	FPSO; 2 m above water surface
		P Sc. 03	High (95%)	Typical (50%)	FPSO; 2 m above water surface
5	Hydrostatic Test Water	H Sc. 01	Low (5%)	4.5°C	FPSO; seafloor
		H Sc. 02	Typical (50%)	4.5°C	FPSO; seafloor
		H Sc. 03	High (95%)	4.5°C	FPSO; seafloor
6	Hydrate Control Fluid—Methanol	Methanol Sc01 2in	Low (5%)	4.5°C	FPSO; seafloor
		Methanol Sc03 2in	High (95%)	4.5°C	FPSO; seafloor
		Methanol Sc01 6in	Low (5%)	4.5°C	FPSO; seafloor
		Methanol Sc03 6in	High (95%)	4.5°C	FPSO; seafloor
7	Hydrate Control Fluid—Ethylene glycol	MEG Sc01 2in	Low (5%)	4.5°C	FPSO; seafloor
		MEG Sc03 2in	High (95%)	4.5°C	FPSO; seafloor
		MEG Sc01 6in	Low (5%)	4.5°C	FPSO; seafloor
		MEG Sc03 6in	High (95%)	4.5°C	FPSO; seafloor

m = meter

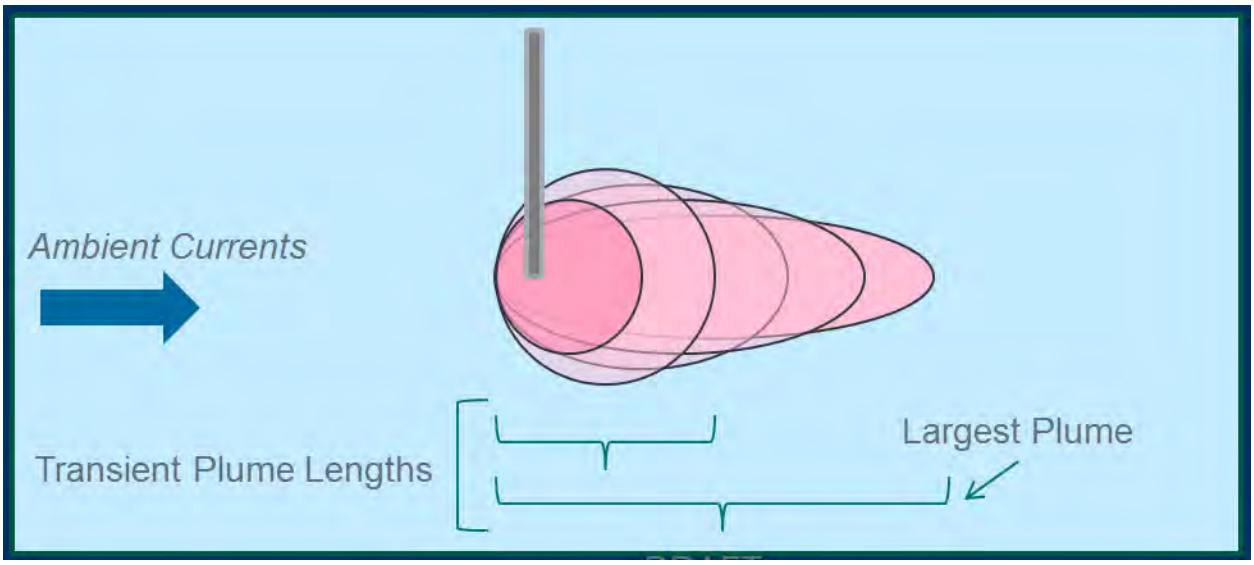
3.3 Standards and Thresholds

The cooling water discharges are typically regulated regionally with consideration of native aquatic species. These standards are more stringent in coastal and inland waters due to the presence of sensitive aquatic receptors and the limited area available for mixing. In offshore waters, such standards are usually absent. For this study, an internationally recognized thermal standard of 3°C maximum

temperature change at 100 meters (328.1 feet) from the point of discharge was used. Hypochlorite, added to cooling water to avoid biofouling, is either regulated as an end of pipe concentration or at the end of a mixing zone (100 meters [328.1 feet] in this case). However, the residual chlorine from the hypochlorite only poses risk to aquatic species if they are exposed to elevated concentrations for extended periods of time (72 to 96 hours). Although not technically applicable to a cooling water discharge, the International Maritime Organization's *2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plant*s recommends that when chlorine is used as a disinfectant, the best technical practice is used to keep the disinfectant residual in the effluent below 0.5 mg/L (IMO 2012).

The scenarios designed in this study are highly conservative (i.e., they assume extended periods of time during which ambient conditions—primarily currents, salinity and temperature – persist). This approach assumes a static plume, which, in reality, will be transient in extent and configuration. For instance, the small ambient currents (5 percent bounding condition) will only exist for a short duration, as these currents only exist for 5 percent of the total time. In actuality, the currents will increase and decrease and the resulting plume will disperse more rapidly than the model predicts. Figure 3-4 shows a schematic of such a transient plume, where the extent and dilution continues to change as ambient currents decrease or increase. When modeling slower ambient current velocities (5 percent bounding condition), the analysis will predict a more concentrated plume. However, this plume will exist for only a short duration, as velocities will change (increase), increasing dilution. Furthermore, the directionality of these currents will change the orientation of this transient plume, resulting in regions around the discharge that are only exposed to increased concentrations (or temperatures) for short durations.

Figure 3-4: Transient Discharge Plume from Various Offshore Releases



Discharges such as produced water, hydrotest or sulfate removal, and potable water processing brines are not subject to any regulatory standards for ambient water quality. The total concentration of oil and grease at the end of pipe is regulated by MARPOL standards at a maximum monthly average of 29 mg/L and a daily maximum of 42 mg/L. The USEPA compliance guidance document for the Gulf of Mexico (Final NPDES[2] General Permit for New and Existing Sources and New Discharges in the Offshore Subcategory of the Oil and Gas Extraction Category for the Western Portion of the Outer Continental Shelf of the Gulf of Mexico [GMG290000]) requires treatment chemicals such as biocides, corrosion

[2] National Pollutant Discharge Elimination System

inhibitors, or other chemicals used to prevent corrosion or fouling of piping or equipment to be limited by the following constraints (USEPA 2017):

- The maximum concentration and any other conditions specified in the USEPA product registration labelling; or
- The maximum manufacturer's recommended concentration; or
- 500 mg/L.

At the time of the study, no manufacturers' recommended limits are available for constituents within the SRU processing brines, produced water, or hydrotest water. It is noted that the maximum concentrations of any treatment chemicals in the discharge streams will be less than 500 mg/L.

With respect to the emergency black water discharge scenario, the International Maritime Organization's *2012 Guidelines on Implementation of Effluent Standards and Performance Tests for Sewage Treatment Plants* recommends the following standards for effluent discharge (IMO 2012):

- TSS should not exceed 35 mg/L.
- BOD_5 (5-day biochemical oxygen demand) should not exceed 25 mg/L.
- Thermotolerant coliforms should not exceed 100 colony-forming units (CFUs) per 100 milliliters.

Since no ambient water-quality standards exist or are applicable to the various offshore discharge streams except for the cooling water discharge, only percentage dilution values are reported at a reference distance of 100 meters (328.1 feet).

3.4 Results

Each CORMIX simulation codes its results in a prediction (*.prd) file that consists of the plume centerline coordinates (0,0,0 at the discharge location), dilution (S) and concentrations. For thermal discharge (cooling water), concentration refers to the temperature rise above ambient and includes heat loss from the surface. For all other constituents, the dilution value does not include any decay and, therefore, represents a conservative (high) result. Inclusion of a decay term would result in a smaller plume. Since the concentrations are always the highest at the plume centerline, the results discussed here are shown as centerline concentrations at a particular distance directly down current from the discharge.

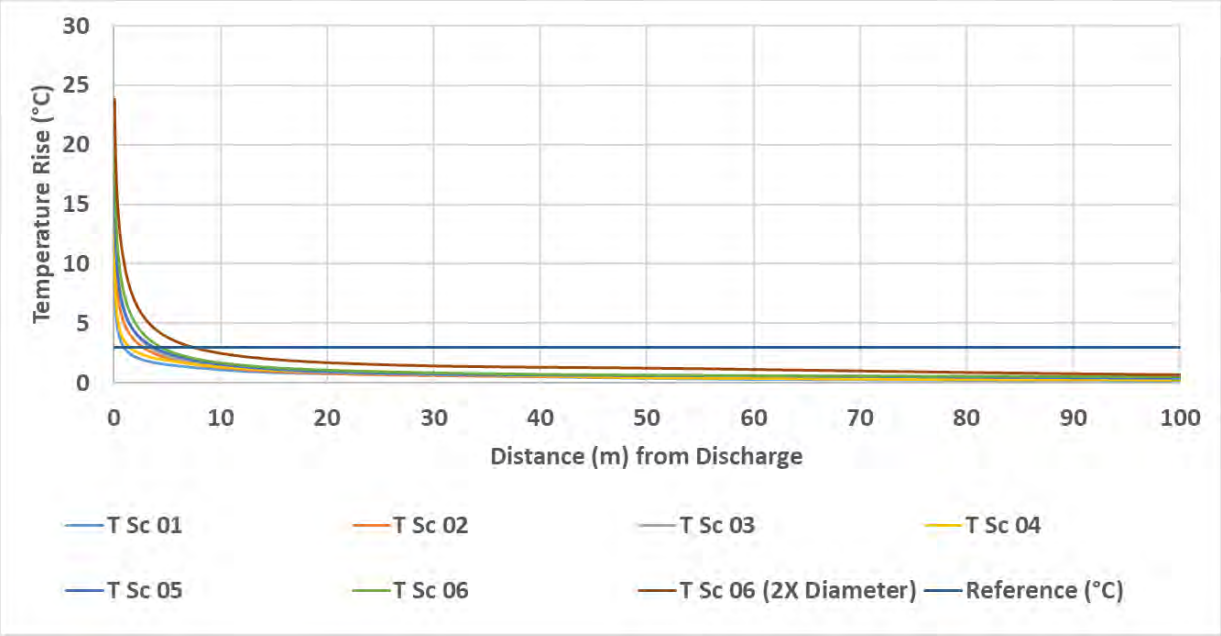
3.4.1 Cooling Water

The design of the cooling water discharge structure, at this early stage of the Project, is not finalized. However, information from the Liza Phase 1 and 2 Development Projects are available that can be used as reference since these FPSOs will have similar overall design themes to that of the Payara Project. The design will only consider pipe configurations that allow compliance with the thermal standard of temperature rise within 100 meters (328.1 feet) of the discharge to be less than 3°C. The Liza Phase 1 and Liza Phase 2 Project designs were based on this requirement and, as such, provide a good basis for use in the Payara Project. Furthermore, the Payara Project discharge rate is the same as that of the Liza Phase 2 Project, and thus the pipe diameter remains the same. Key to these design elements is the release of the discharge above the water surface, which results in significant gravitational acceleration and thus significant mixing at the point of entry into the ambient water. Two ambient temperatures (1 percent and 99 percent) were selected for simulation because different ambient temperatures will influence the plume behavior and the effluent temperature rise.

Based on the initial assessments, T Sc. 06 (low ambient temperature and high ambient currents) was found to result in the longest thermal plume. This scenario was then re-run for a pipe diameter twice the size used for the Liza Phase 1 Project. Even with the diameter doubled (4 times the area), the thermal

plume complied with the reference standard of 3°C within 10 meters (32.8 feet). Figure 3-5 shows the temperature rise diminishing with distance from the discharge, showing compliance with 3°C within 10 meters (32.8 feet) from the discharge for all scenarios.

Figure 3-5: Temperature Rise Above Ambient Versus Distance Downstream for All Scenarios



Compliance with the thermal discharge standard requires sufficient mixing within the immediate vicinity of the discharge. The pipe configurations designed to ensure compliance for thermal standards will therefore result in adequate mixing for the hypochlorite discharge as well. Since the thermal mixing at 100 meters (328.1 feet) results in the reduction of concentrations by a factor of at least 6.60 (19.82°C / 3°C), the residual chlorine concentrations resulting from hypochlorite addition will reduce by at least the same factor. For the scenarios considered here, the worst case (lowest mixing) scenario (T Sc. 06 with 2X diameter) results in a dilution factor of 32.1 (=23.8°C / 0.72°C). This means that for this same scenario, for a hypochlorite dosing of 5 parts per million (ppm), hypochlorite concentrations will be 0.11 ppm at 100 meters (328.1 feet). As noted earlier, these concentrations represent conservative estimates (i.e., peak values) and will be transient in nature.

3.4.2 Produced Water

Produced water is characterized by an elevated temperature, and concentrations of oil and grease and residual production and water treatment chemicals. Scale inhibitor and corrosion inhibitor were modeled at discharge concentrations of 100 ppm and 200 ppm, respectively, as examples of residual production chemicals that may exist as constituents in the produced water discharge. The pipe configuration (diameter and location) were assumed to be the same as used for Liza Phase 2 Project. Of the constituents of concern in produced water, only oil and grease end-of-pipe concentrations are regulated under MARPOL. The applicable standard is a maximum monthly average of 29 mg/L and a daily maximum of 42 mg/L, measured at the end of pipe. These standards are applied prior to the release of produced water. The daily maximum value of 42 mg/L was therefore used as the discharge concentration for this analysis. The thermal standard applied to cooling water (less than 3°C temperature rise within 100 meters [328.1 feet] of the discharge) also applies to produced water. No ambient water quality standards exist for the other constituents.

Concentrations of oil and grease, scale inhibitor and corrosion inhibitor are shown for the three scenarios (see Table 3-7) in Figure 3-6, Figure 3-7, and Figure 3-8, respectively. Oil and grease concentration decreases to less than 0.57 mg/L within 100 meters (328.1 feet) while scale inhibitor and corrosion inhibitor drop to less than 1.36 ppm and 2.72 ppm, respectively, within 100 meters (328.1 feet). The same level of mixing is expected for temperature rise, as seen in Figure 3-9, where the temperature rise drops to less than 0.40°C within 100 meters (328.1 feet).

Figure 3-6: Concentration of Oil and Grease (mg/L) with Distance (meters) from the Discharge for the Three Scenarios Modeled

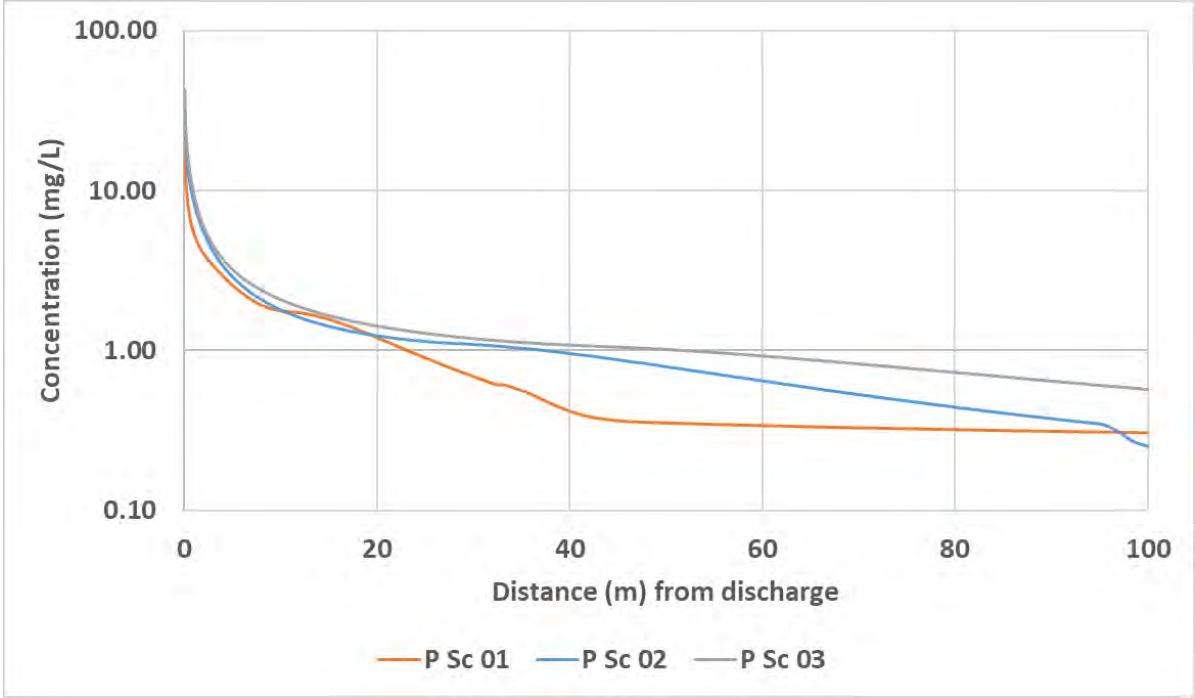


Figure 3-7: Concentration of Scale Inhibitor (ppm) with Distance (meters) from the Discharge for the Three Scenarios Modeled

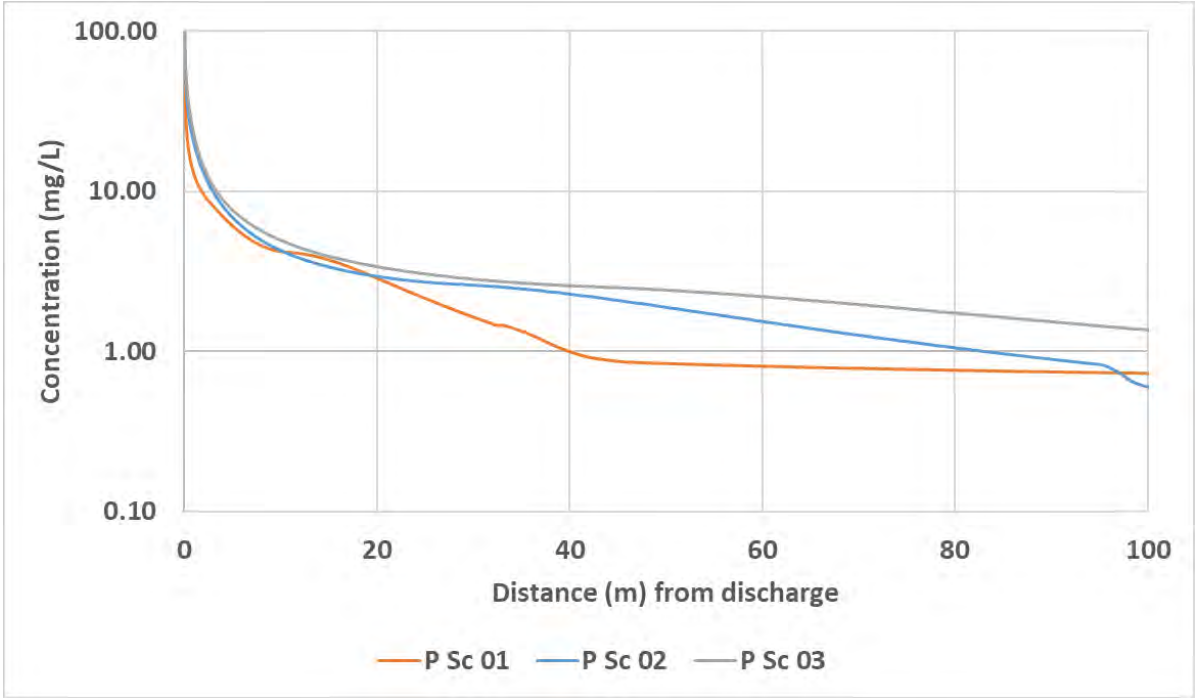


Figure 3-8: Concentration of Corrosion Inhibitor (ppm) with Distance (meters) from the Discharge for the Three Scenarios Modeled

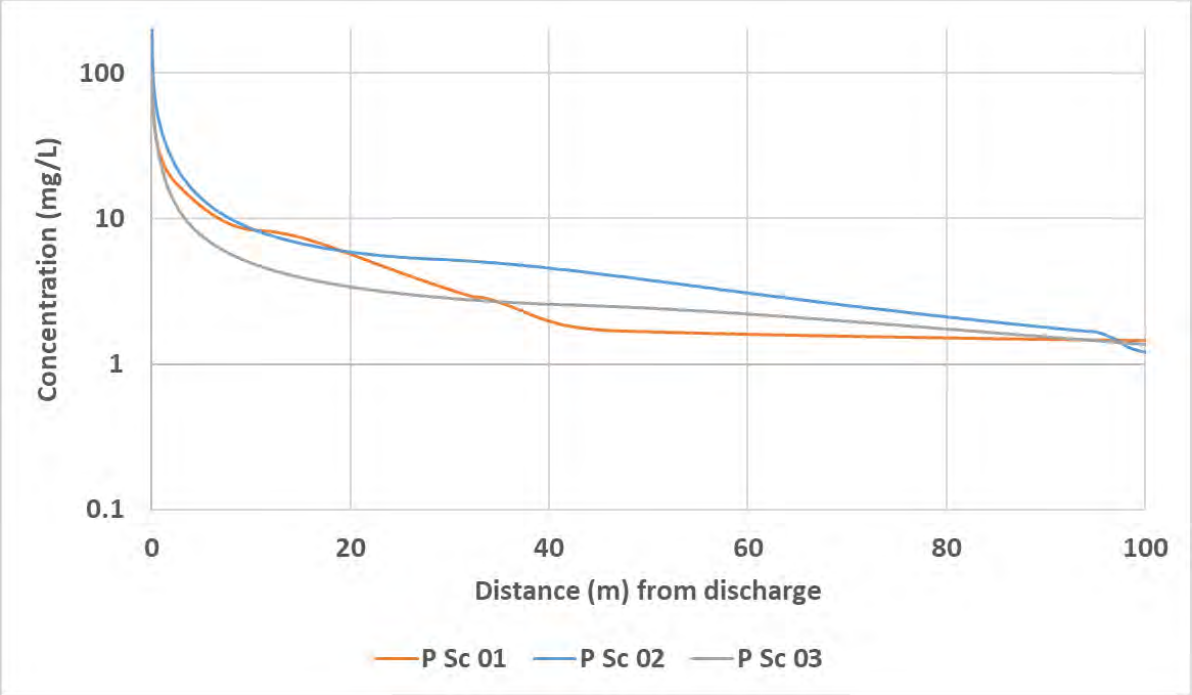
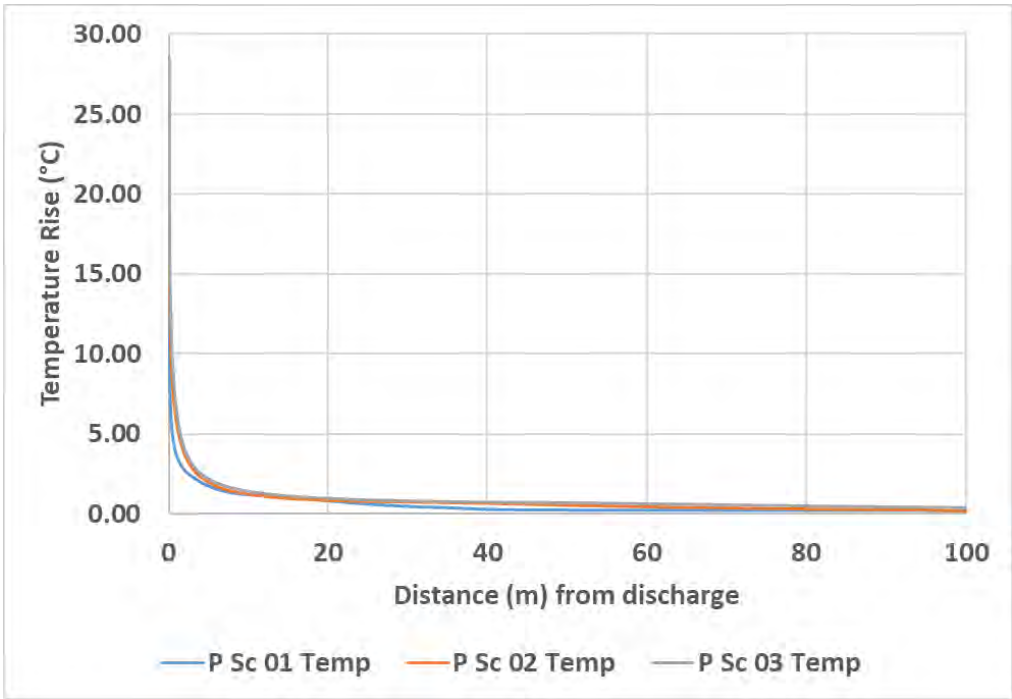


Figure 3-9: Temperature Rise with Distance (meters) from the Discharge for the Three Scenarios Modeled

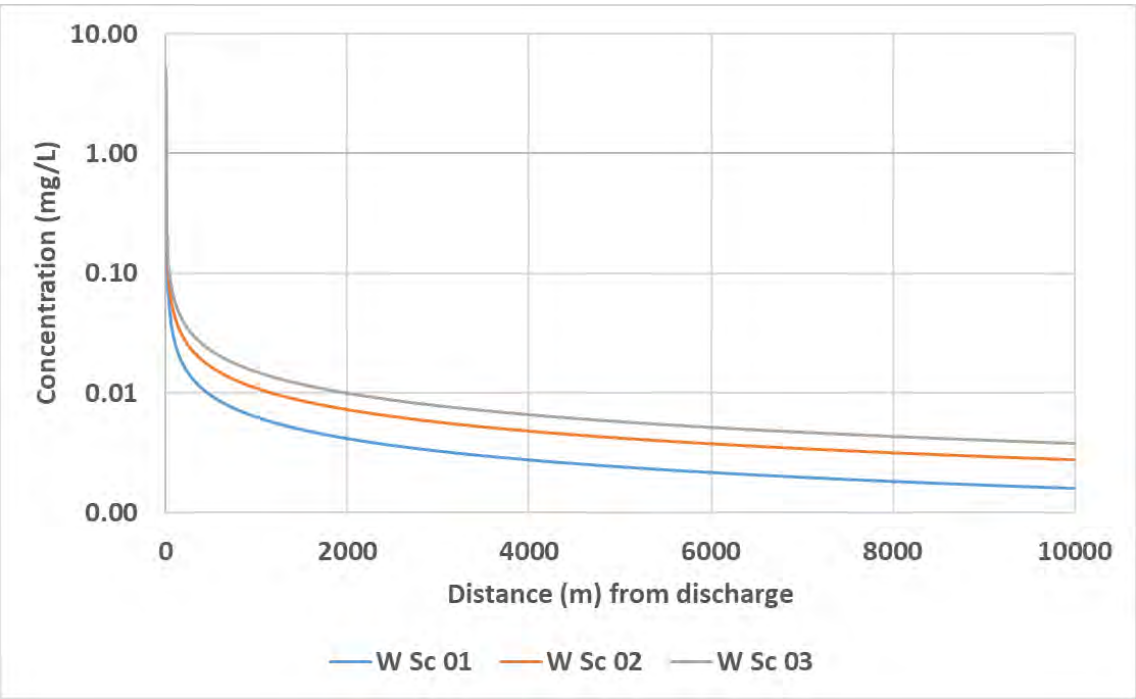


3.4.3 Sulfate Removal and Potable Water Processing Brines

This discharge stream consists of a combination of processing brines from the SRU and freshwater reverse osmosis system. The main constituents are hypochlorite, electrolytes, biocides, oxygen scavenger, and scale inhibitor. No ambient water quality standards exist for any of these constituents. It was assumed that the discharge pipe will not exceed a diameter of 30.5 centimeters (12 inches), and that the stream will be released at least 2 meters (6.6 feet) above the water surface. Any pipe of smaller diameter will result in increased mixing and a smaller plume.

The predicted biocide concentrations for the three scenarios modeled (see Table 3-7) are shown in Figure 3-10. The biocide concentration decreases to 0.11 mg/L within 100 meters and 0.015 mg/L within 1,000 meters (3,280.8 feet) (99.7 percent reduction) for the worst-case scenario (high ambient currents). All other constituents will follow the same mixing pattern and experience the same percent reduction.

Figure 3-10: Concentration of Biocide (ppm) with Distance (meters) from the Discharge for the Three Scenarios Modeled

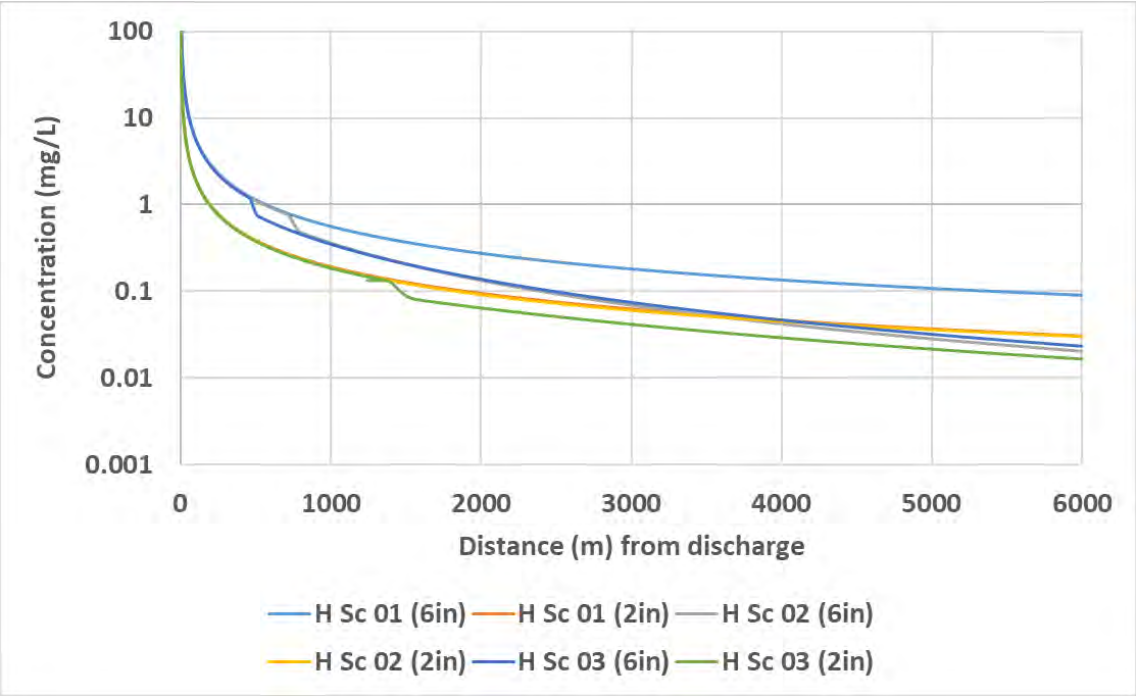


3.4.4 Hydrostatic Test Water

Hydrotesting will be conducted routinely for various pipeline and risers. All pipeline and riser volumes were considered for this analysis and the largest single release was selected for modeling. It was assumed that once testing is complete, the total volume will be released within 60 minutes. Since the pipelines and risers are of different diameters, all three scenarios were run for pipe diameters of 5.1 centimeters (2 inches) and 15.2 centimeters (6 inches). Results for all three scenarios showing reduction in biocide concentration with the bounding pipe diameter cases are shown in Figure 3-11. For the worst case (H Sc. 01 with 15.2-centimeter [6-inch] pipe), biocide decreases to 5.74 ppm within 100 meters (328.1 feet) of the discharge.

The other constituents (oxygen scavenger and corrosion inhibitor) will follow the same mixing pattern and experience the same percent reduction.

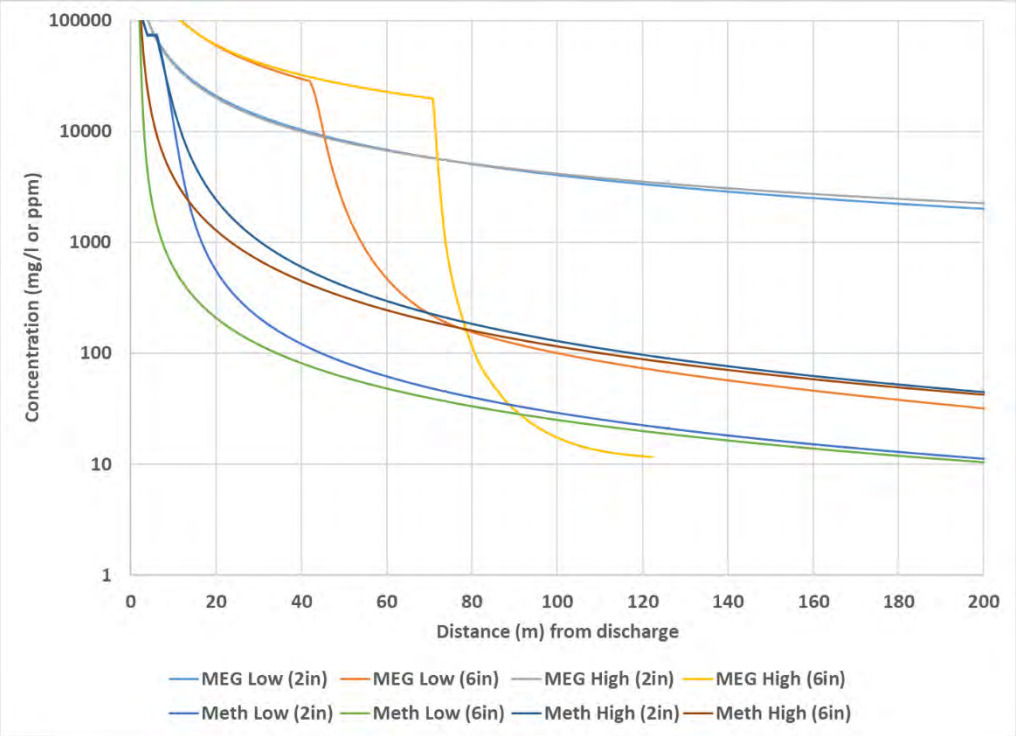
Figure 3-11: Concentration of Biocide (ppm) with Distance (meters) from the Discharge for the Three Scenarios and Two Pipe Diameters



3.4.5 Gas Injection Line Commissioning Fluids

As part of the gas injection line commissioning, a hydrate control fluid (concentrated methanol or ethylene glycol) will be discharged at the seafloor. The most probable volume for the hydrate control fluid will be 1,400 barrels (bbl), but a very conservative value of 2,500 bbl was assumed for the modeling analysis. Since the pipelines and risers are of different diameters, all three scenarios were run for pipe diameters of 5.1 centimeters (2 inches) and 15.2 centimeters (6 inches). Figure 3-12 shows the results for both methanol and ethylene glycol under the low and high ambient currents and 5.1-centimeter (2-inch) and 15.2-centimeter (6-inch) pipe diameters.

Figure 3-12: Concentration of Methanol or MEG (ppm) with Distance (meters) from the Discharge for the Low and High Currents and 2-inch and 6-inch Pipe Diameters



3.4.6 Black Water

An emergency scenario where an upset occurs for the onboard black water treatment system was considered. Under this emergency scenario, it was assumed that untreated black water from accommodations and the clinic would bypass the macerator and the sewage holding tank and be discharged directly overboard through an emergency outfall. The FPSO is designed for a maximum of 160 persons on board, with a black water design capacity of 70 barrels per day. Applying a contingency factor of 10 percent resulted in the modeled sewage generation and emergency discharge rate of 3,200 gallons per day.

The untreated black water experiences instant mixing once it enters the ambient water. Although the constituents (BOD_5, TSS, and coliform) are released at high concentrations, immediate mixing and dilution results in steep declines in concentrations with distance. Due to the selected model resolution, this steep decline cannot be captured visually on the model results representation. The highest concentrations can only be reported as volume-averaged within the first modeled grid cell, which covers a volume of 200 cubic meters (10 meters x 10 meters x 2 meters), although higher peak concentrations will exist within this cell (<10 meters).

Figure 3-13 shows the modeled maximum BOD_5 concentration across the model domain. As shown on the figure, there is no region in the modeling domain with a predicted BOD_5 concentration above 25 mg/L. Figure 3-14 shows the modeled maximum concentrations of TSS across the model domain. As shown on the figure, there is no region in the modeling domain with a predicted TSS concentration above 35 mg/L. Figure 3-15 shows the modeled maximum concentrations of coliform across the model domain. As shown on the figure, there is no region in the modeling domain with a predicted coliform concentration above

100 CFU per 100 milliliters. Further analysis of modeling results indicates that by 3 hours after the cessation of the discharge, the coliform concentration drops to less than 1 CFU per 100 milliliters.

Figure 3-13: Modeled Maximum Concentration of BOD_5 from an Untreated Black Water Discharge

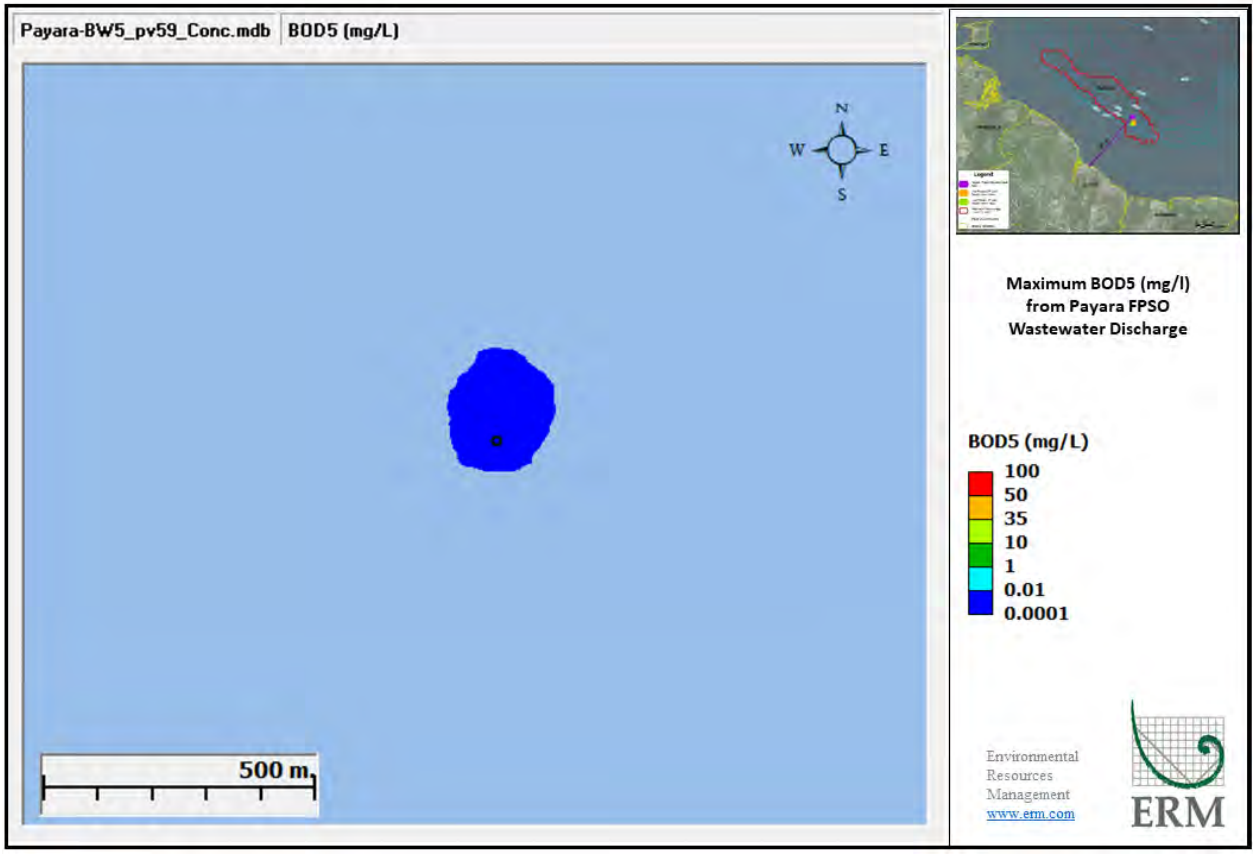


Figure 3-14: Modeled Maximum Concentration of TSS from an Untreated Black Water Discharge

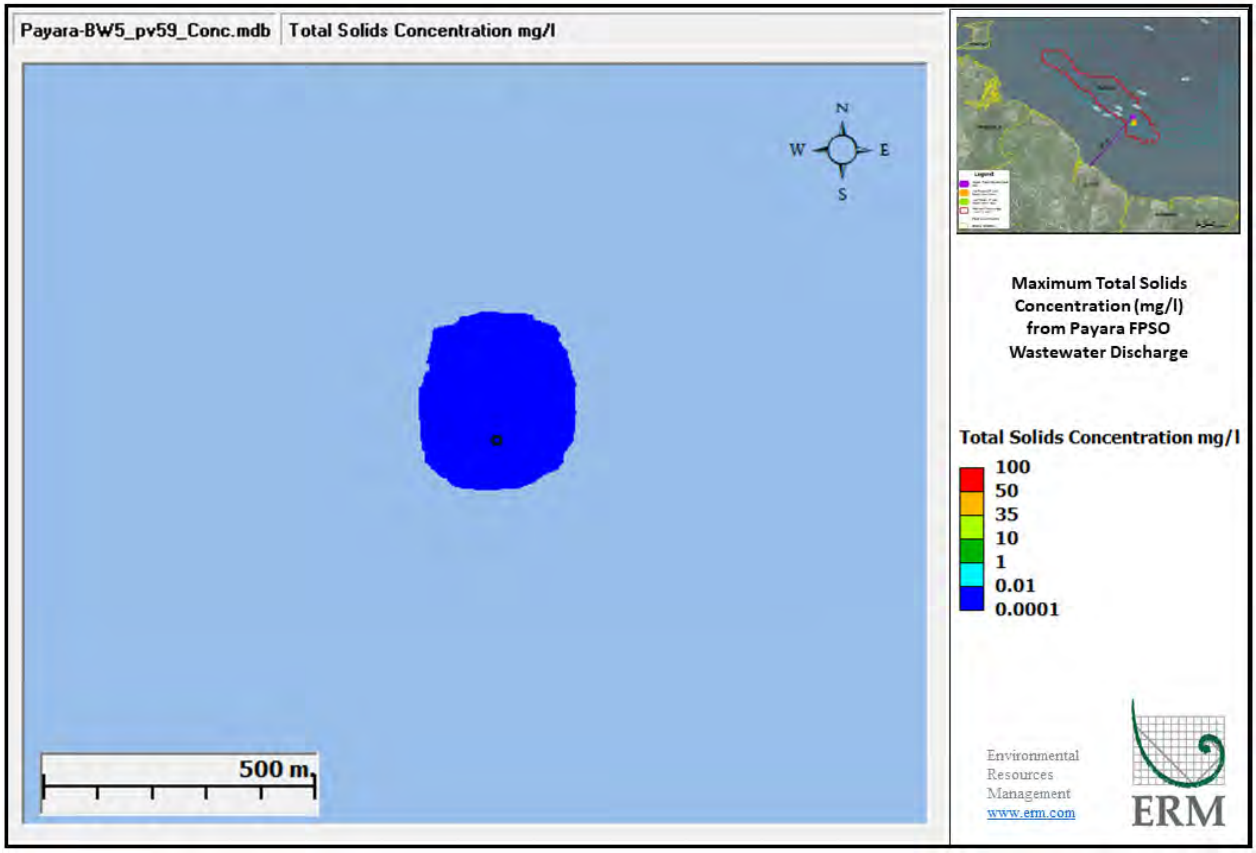
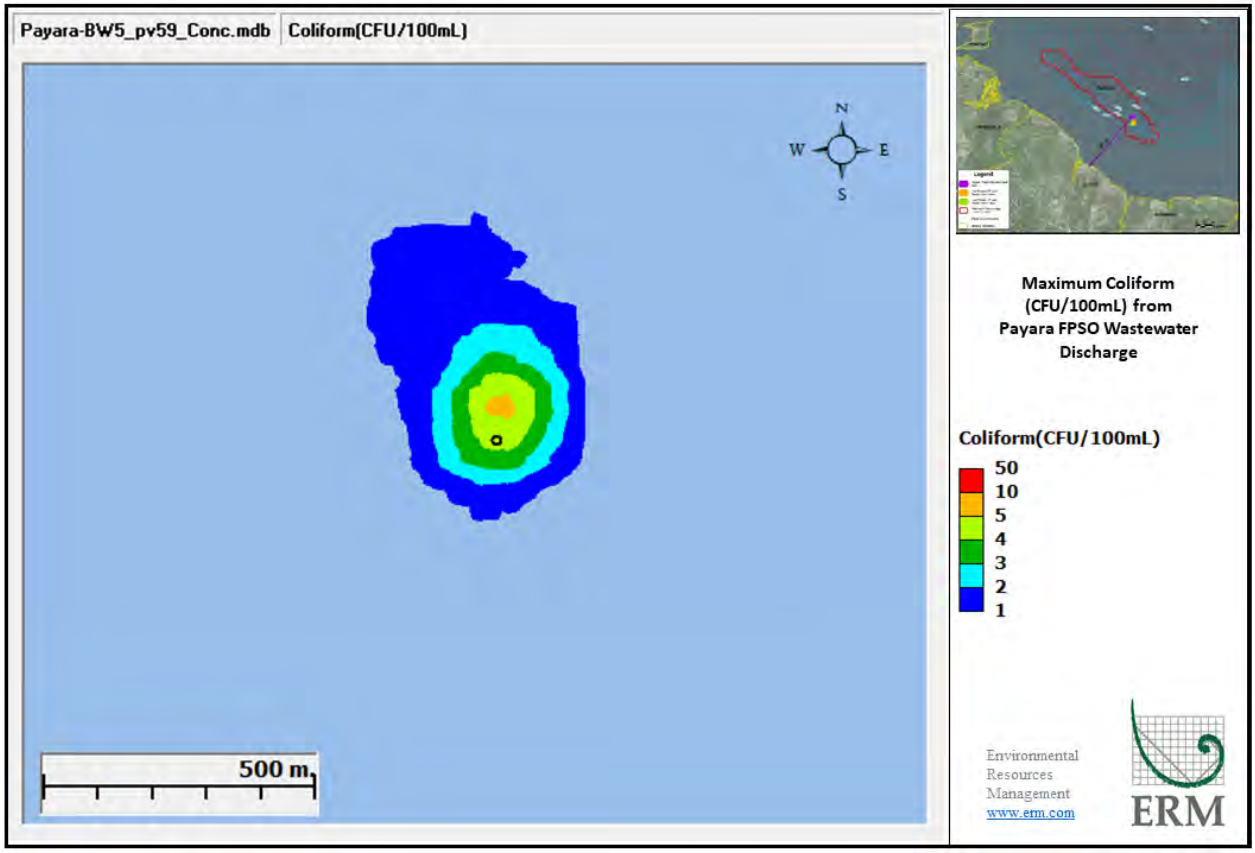


Figure 3-15: Modeled Maximum Concentration of Coliform Bacteria from an Untreated Black Water Discharge



3.5 Conclusions

Various operational and maintenance discharges and activities were modeled to estimate the extent of the associated discharge plumes. Extreme conditions and maximum expected discharge rates and concentrations were considered in this conservative analysis. The only relevant regulatory standard related to ambient water quality is for the thermal discharges: temperature rises within 100 meters (328.1 feet) of the discharge point are recommended to be less than 3°C. Since the Project is in a preliminary design phase, design specifications for the various discharge ports were not available. To address this lack of specific information, conservative estimates of the largest feasible pipe diameter were made, and modeling simulations were used to confirm that these upper-bound diameters will allow the standard to be met.

CORMIX, a near-field mixing zone model approved by USEPA, was used to simulate the size and configuration of the mixing zones of the various discharges (aside from the untreated black water discharge). It was found that even under upper-bound conditions discharge plumes were relatively small and subject to rapid mixing within the first 100 meters (328.1 feet). Although only thermal discharges are subject to regulatory limits, the reference distance of 100 meters (328.1 feet) is used for reporting purposes for all the discharges to demonstrate the rapid mixing that the discharge plumes experience. Table 3-8 summarizes the results of the modeling study for the planned offshore discharges.

Additionally, based on modeling of an untreated black water discharge using the GEMSS model, maximum concentrations of BOD_5, TSS, and coliform remain below the thresholds of 25 mg/L, 35 mg/L, and 100 CFU per 100 milliliters, respectively.

Table 3-8: Summary of Results of Modeling for Planned Offshore Discharges and Concentrations at 100-meter Reference Distance

No.	Discharge	Scenario Name	Discharge Concentration	Concentrations at 100 Meters [a]
1	Cooling Water—Thermal	Worst Case	Temperature: 50°C	Temperature Rise: <3°C
2	Cooling Water—Hypochlorite	Worst Case	Residual Chlorine: 5 ppm	Residual Chlorine: 0.11 ppm
3	Sulfate Removal and Potable Water Processing Brines [b]	W Sc. 01	Hypochlorite: 5 ppm Electrolyte: 1 ppm Biocide: 5 ppm Oxygen Scavenger: 10 ppm Scale Inhibitor: 5 ppm	Hypochlorite: 0.025 ppm Electrolyte: 0.005 ppm Biocide: 0.025 ppm Oxygen Scavenger: 0.05 ppm Scale Inhibitor: 0.025 ppm
		W Sc. 02	Hypochlorite: 5 ppm Electrolyte: 1 ppm Biocide: 5 ppm Oxygen Scavenger: 10 ppm Scale Inhibitor: 5 ppm	Hypochlorite: 0.042 ppm Electrolyte: 0.008 ppm Biocide: 0.042 ppm Oxygen Scavenger: 0.084 ppm Scale Inhibitor: 0.042 ppm
		W Sc. 03	Hypochlorite: 5 ppm Electrolyte: 1 ppm Biocide: 5 ppm Oxygen Scavenger: 10 ppm Scale Inhibitor: 5 ppm	Hypochlorite: 0.055 ppm Electrolyte: 0.011 ppm Biocide: 0.055 ppm Oxygen Scavenger: 0.11 ppm Scale Inhibitor: 0.055 ppm
4	Produced Water	P Sc. 01	Temperature: 55°C Oil and Grease: 42 mg/L Scale Inhibitor: 100 ppm Corrosion Inhibitor: 200 ppm	Temperature Rise: <3°C Oil and Grease: 0.30 mg/L Scale Inhibitor: 0.72 ppm Corrosion Inhibitor: 1.44 ppm
		P Sc. 02	Temperature: 55°C Oil and Grease: 42 mg/L Scale Inhibitor: 100 ppm Corrosion Inhibitor: 200 ppm	Temperature Rise: <3°C Oil and Grease: 0.21 mg/L Scale Inhibitor: 0.49 ppm Corrosion Inhibitor: 0.99 ppm
		P Sc. 03	Temperature: 55°C Oil and Grease: 42 mg/L Scale Inhibitor: 100 ppm Corrosion Inhibitor: 200 ppm	Temperature Rise: <3°C Oil and Grease: 0.57 mg/L Scale Inhibitor: 1.36 ppm Corrosion Inhibitor: 2.72 ppm
5	Hydrotest	H Sc. 01	Biocide (6-inch pipe): 500 ppm Biocide (2-inch pipe): 500 ppm	Biocide (6-inch pipe): 5.74 ppm Biocide (2-inch pipe): 1.92 ppm
		H Sc. 02	Biocide (6-inch pipe): 500 ppm Biocide (2-inch pipe): 500 ppm	Biocide (6-inch pipe): 5.72 ppm Biocide (2-inch pipe): 1.92 ppm
		H Sc. 03	Biocide (6-inch pipe): 500 ppm Biocide (2-inch pipe): 500 ppm	Biocide (6-inch pipe): 5.68 ppm Biocide (2-inch pipe): 1.93 ppm

No.	Discharge	Scenario Name	Discharge Concentration	Concentrations at 100 Meters [a]
6	Hydrate Control Fluid	Methanol Low 2in	Methanol (2-inch pipe): pure chemical at 800 kg/m^3	Methanol (2-inch pipe): 28.98 ppm
		Methanol High 2in	Methanol (2-inch pipe): pure chemical at 800 kg/m^3	Methanol (2-inch pipe): 128.87 ppm
		Methanol Low 6in	Methanol (6-inch pipe): pure chemical at 800 kg/m^3	Methanol (6-inch pipe): 25.03 ppm
		Methanol High 6in	Methanol (6-inch pipe): pure chemical at 800 kg/m^3	Methanol (6-inch pipe): 114.91 ppm
		MEG Low 2in	MEG (2-inch pipe): pure chemical at 1,115 kg/m^3	MEG (2-inch pipe): 4,044 ppm
		MEG High 2in	MEG (2-inch pipe): pure chemical at 1,115 kg/m^3	MEG (2-inch pipe): 4,165 ppm
		MEG Low 6in	MEG (6-inch pipe): pure chemical at 1,115 kg/m^3	MEG (6-inch pipe): 148 ppm
		MEG High 6in	MEG (6-inch pipe): pure chemical at 1,115 kg/m^3	MEG (6-inch pipe): 15.04 ppm

[a] Except for the thermal discharge (temperature rise), no standards exist for any discharge constituents. The distance of 100 meters (328.1 feet) is used as a widely accepted reference distance and should not be interpreted as a criterion for regulatory compliance.

4. CUMULATIVE IMPACTS: OFFSHORE DISCHARGES

The Payara Project will initiate after the Liza Phase 1 and Liza Phase 2 Projects, and activities for the three Projects will therefore overlap in time. Although the Payara Project's FPSO will be approximately 20 kilometers (12.4 miles) away from the Liza Phase 1 Project FPSO and 22 kilometers (13.7 miles) away from the Liza Phase 2 Project FPSO, modeling was conducted to assess whether there is a potential for cumulative impacts on water quality due to simultaneous offshore discharges from the respective developments. The CORMIX model considered to evaluate individual discharges is limited in its ability to appropriately include other local or regional discharges, and the resulting plume interactions. To address this limitation, and to appropriately quantify cumulative impacts from the three FPSOs, a separate 3-D hydrodynamic and water quality model was applied. The GEMSS model is capable of simulating temporally and spatially varying conditions, and can incorporate any number of discharges into one single model simulation. This section describes the use, application, and results of the GEMSS model for the cumulative impact analysis.

4.1 GEMSS

GEMSS is an integrated system of 3-D hydrodynamic and transport modules embedded in a geographic information and environmental data system. GEMSS is in the public domain and has been used by the U.S. Bureau of Reclamation, Washington State Department of Ecology, Norwegian Institute of Water Research, Royal Institute of Sweden, and other international organizations.

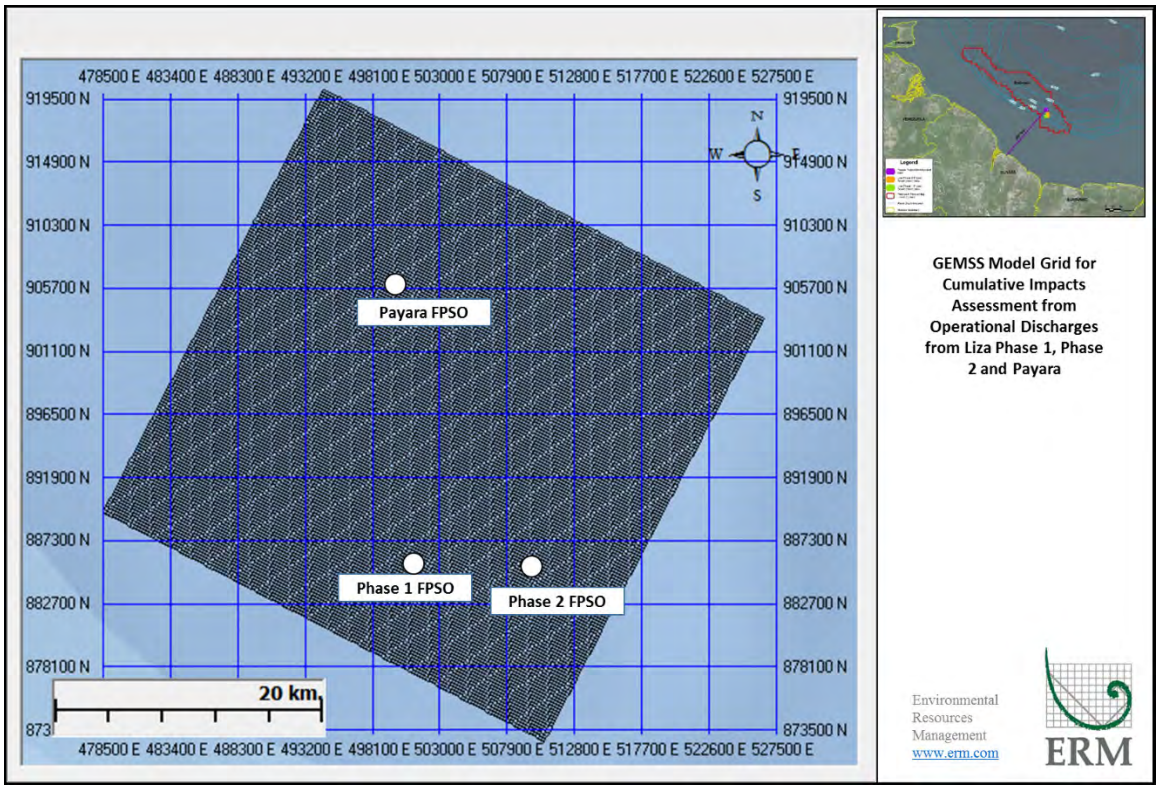
The theoretical basis of the hydrodynamic kernel of GEMSS is the 3-D Generalized, Longitudinal-Lateral-Vertical Hydrodynamic and Transport (GLLVHT) model, which was first presented in Edinger and Buchak (1980) and subsequently in Edinger and Buchak (1985). The GLLVHT computation has been peer reviewed and published (Edinger and Buchak 1995; Edinger et al. 1994 and 1997; Edinger and Kolluru 1999). The kernel is an extension of the well-known longitudinal-vertical transport model written by Buchak and Edinger (1984) that forms the hydrodynamic and transport basis of the United States Army Corps of Engineers' water quality model CE-QUAL-W2 (U.S. Army Engineer Waterways Experiment Station 1986). Improvements to the transport model, construction of the constituent modules, incorporation of supporting software tools, GIS interoperability, visualization tools, graphical user interface, and post-processors have been developed by Kolluru et al. (1998; 1999; 2003) and Kolluru and Fichera (2003).

GEMSS and its component modules have met agency approval among federal and state governments within the United States. GEMSS has also been approved by regulatory agencies in the Bahamas, Qatar, India, Australia, Canada, and other countries.

4.2 Model Domain

A 3-D model such as GEMSS requires specification of a model domain that defines the boundaries of the region of interest. Based on the CORMIX modeling assessment, the region of interest around each of the FPSO discharges is very small due to the small sizes of the plumes. However, for the cumulative impact assessment, it is important to have a model domain that covers the region, including all operational discharges (i.e., all three FPSOs). The model domain, therefore, was selected as a region that would cover the three FPSOs and have sufficient region beyond these FPSOs to allow discharge plume spreading. The model domain, including the model computational grid and the locations of the FPSOs, is shown in Figure 4-1. The selected model domain is large enough to accommodate all operational discharges from the three FPSOs to assess cumulative impacts within a single model simulation.

Figure 4-1: Cumulative Impact Assessment Model Domain and Computational Grid



4.3 Model Setup

As discussed in Section 3, there are several discharges from each FPSO. All of these discharges were included within a single GEMSS model simulation. Inclusion of all of these discharges for all three FPSOs affords the ability to perform a cumulative impact assessment by determining the extent of overall discharge plumes. The main constituent of concern was the temperature rise above ambient, as there is thermal load associated with cooling water streams and produced water discharge from these FPSOs. There is potential for overlap of the thermal discharge plume near each FPSO, as the two plumes from cooling water and produced water may theoretically interact, and the combined plumes from individual FPSOs may experience further overlap. Although the individual assessments of the discharges performed in Section 3 show relatively small extents for these plumes, the lower values (<3ºC temperature rise) may combine to reach levels above 3ºC temperature rise. Both cooling water and produced water discharges were included in the model. Furthermore, the sulfate removal and potable water process brines discharges release relatively large amounts of water, and thus were also included in the model.

The model was configured such that the boundaries of the model computation grid received available time-varying temperature and salinity data from the HYCOM model and available time-varying water surface elevations from the SAT-OCEAN model. These data provide the necessary input for the GEMSS model to perform hydrodynamic and transport computations within the model computational domain. Each of the discharges was specified to the details available as shown in Table 4-1.

Table 4-1: List of Discharges and their Characteristics included in the GEMSS Model for Cumulative Impact Assessment

Offshore Discharge	Liza Phase 1 FPSO	Liza Phase 2 and Payara FPSO
Cooling Water		
Flow (kBPD)	227	1,600
Temperature, ºC	50	50
Produced Water		
Flow (kBPD)	114	300
Temperature, ºC	55	55
Oil and Grease (mg/L)	42	42
Sulfate Removal and Potable Water Processing Brines		
Flow (kBPD)	100	265
Hypochlorite (ppm)	1	1

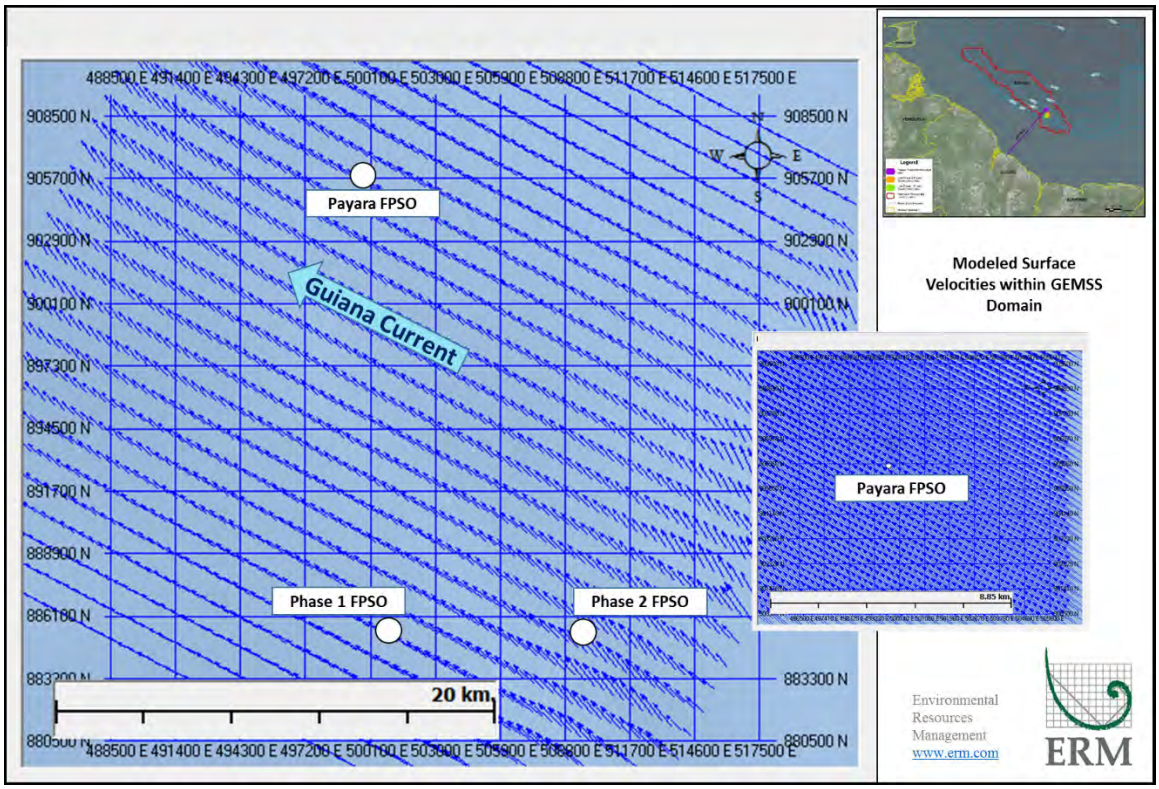
kBPD = thousand barrels per day

The model was run for a period of 28 days, which included a period of 7 days for model "spin-up." Model spin-up is defined as a time during which the computational model ramps up from stagnant condition to realistic conditions as forced by the conditions specified at the boundaries. All model results were summarized statistically to obtain worst conditions (i.e., maximum concentrations during the entire model simulation period).

4.4 Model Results

The model, under conditions specified through the boundaries, provided results that consisted of currents, water surface elevations, temperature, salinity, temperature rise above ambient, oil and grease concentration, hypochlorite concentration, and concentration of a dye constituent. Dye constituent was included in the model simulation such that concentrations of additional constituents, if needed, could be estimated by scaling the dye concentrations to the discharge values. The modeled currents were consistent with the known circulation pattern in the region (see Section 6.4.2.1, Oceanographic Conditions, of the Payara EIA). The results show a strong Guiana Current toward the northwest (see Figure 4-2).

Figure 4-2: Snapshot of Modeled Hydrodynamics within the GEMSS Model Domain



Note: The three groups of white dots denote the locations of the three FPSOs. Main image shows lower resolution and inset shows full resolution to demonstrate overall circulation patterns and strength.

4.4.1 Temperature Rise

As noted earlier, the key constituent of concern is the temperature rise above ambient. The reference standard of no more than 3ºC above ambient beyond 100 meters was used to evaluate if any region within the entire computational domain (outside of the 100-meter (328.2-foot) distance from each FPSO discharge) was predicted to experience a temperature rise above 3ºC. To evaluate if such a condition exists, the statistical maxima of the temperature rises above ambient were computed during the entire model simulation period. Note that the map showing the statistical maxima (Figure 4-3) only shows the maximum values, but this does not mean these maximum values occurred at the same time. Different maximum values at different locations could have occurred at different times during the simulation period. However, they can still be evaluated within a single map to evaluate the potential of any region reaching the maximum temperature rise above ambient.

Figure 4-3 shows the maximum temperature rise above ambient across the model domain. The color scale uses a hybrid approach, where all temperature-rise iso-lines below 3ºC are unfilled, and all temperature-rise iso-lines above 3ºC are filled with a designated color. As shown on the map, there is no region in the modeling domain with a predicted temperature rise above 3ºC. The blue iso-lines that extend between the two FPSOs denote a 0.05ºC temperature rise. Individual snapshots (representing actual predicted conditions across the domain at a given time) show the plumes much smaller than what is shown below; Figure 4-4 shows four such snapshots. Based on these results, it is clear that no thermal plume overlapping occurs and that all three FPSOs operating concurrently will result in conditions that adhere to the <3ºC temperature rise beyond 100 meters (328.1 feet) reference standard.

Figure 4-3: Modeled Maximum Temperature Rise above Ambient when All Discharges (all three FPSOs with Cooling Water and Produced Water) are Operational

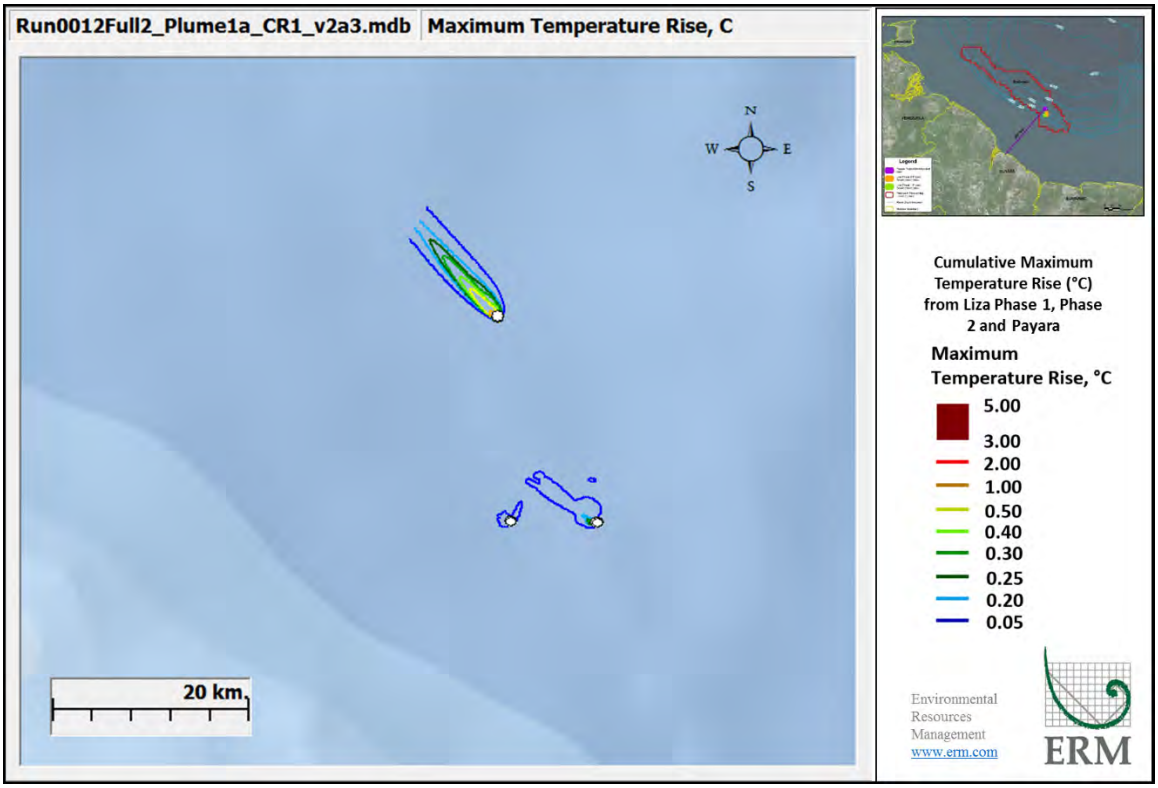
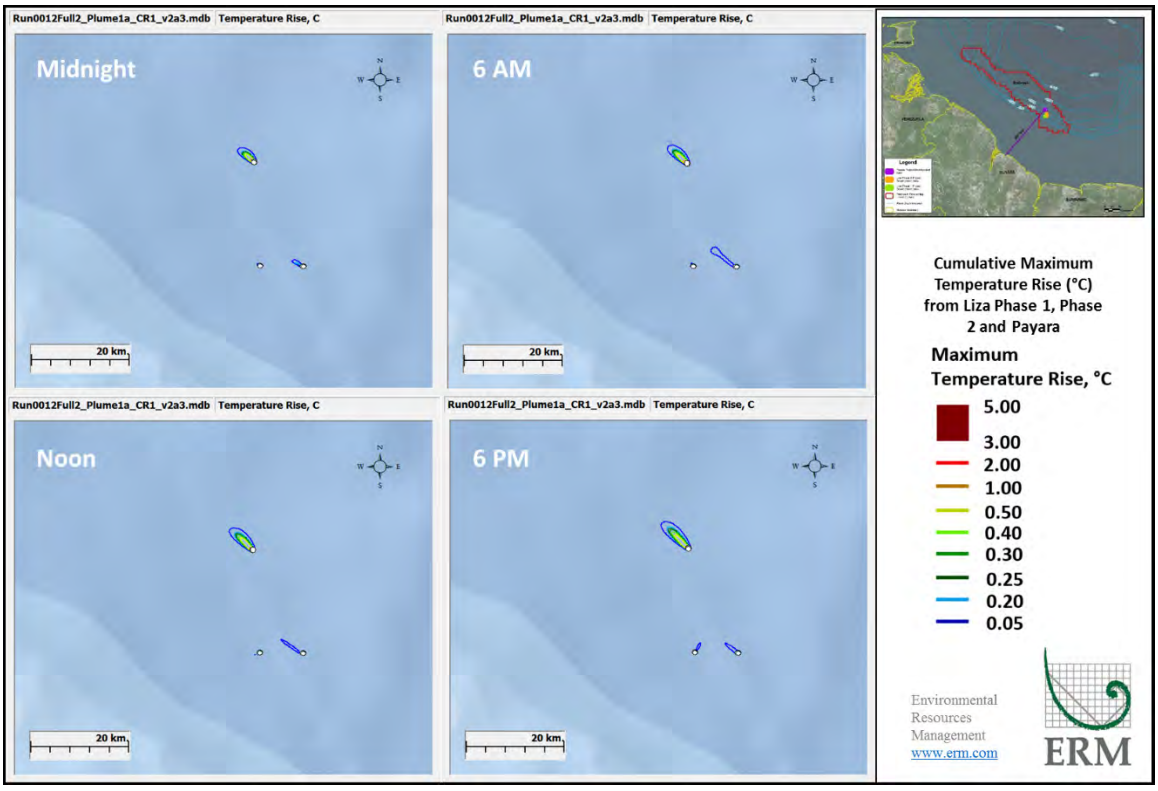


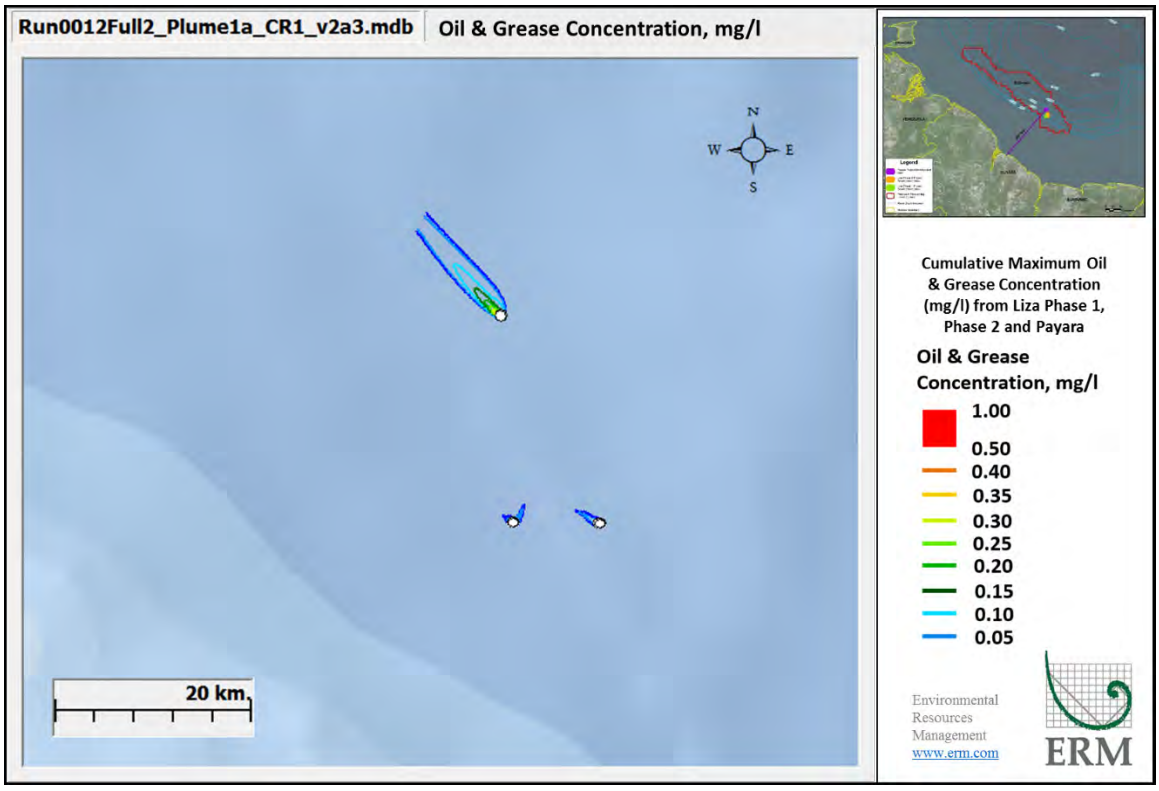
Figure 4-4: Modeled Time-Varying Temperature Rise above Ambient at Different Times (Every 6 Hours) during a Day



4.4.2 Oil and Grease

Oil and grease is a constituent within the produced water limited at a daily maximum discharge value of 42 mg/L. Similar to the temperature rise above ambient, oil and grease concentrations experience rapid dilution and mixing, with no overlap between the discharges of the three FPSOs. Figure 4-5 shows the modeled maximum concentration of oil and grease in the model domain. The closest of the outermost iso-lines extending from each FPSO (0.04 mg/L) are more than 5 kilometers (3.1 miles) apart.

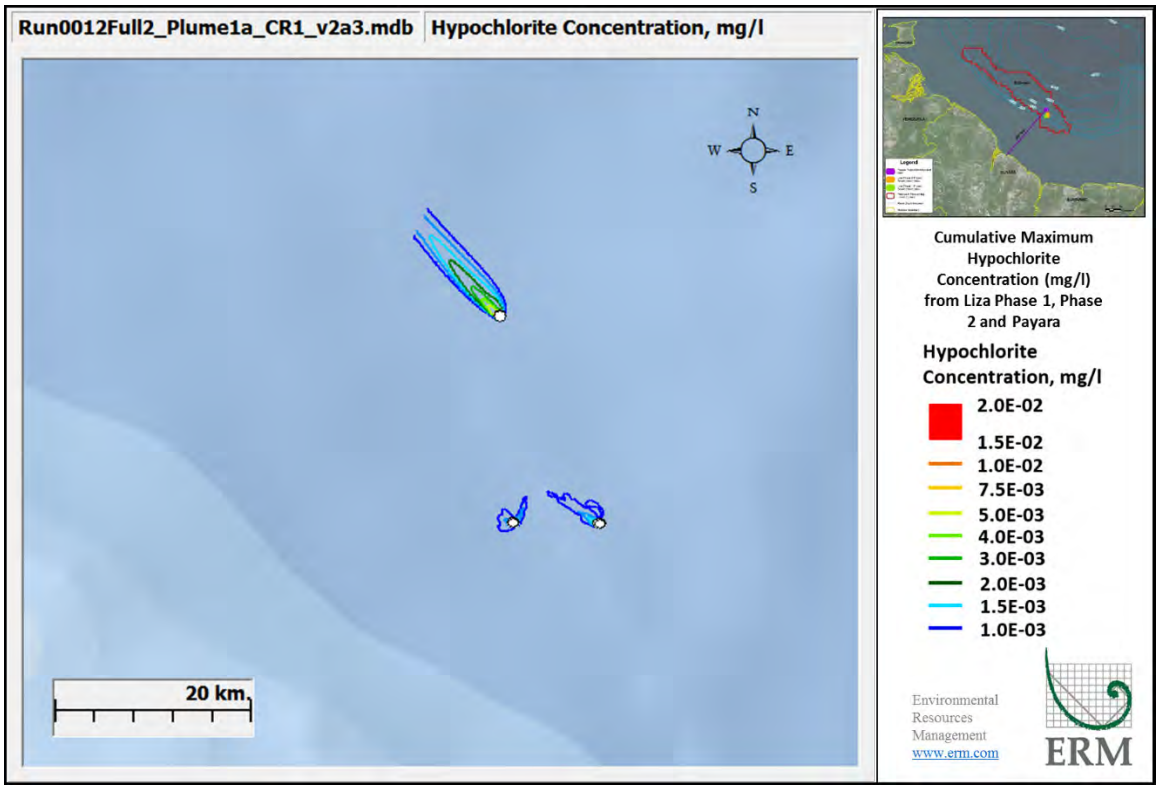
Figure 4-5: Modeled Maximum Oil and Grease Concentrations from Produced Water Streams of all three FPSOs



4.4.3 Hypochlorite

Hypochlorite is a constituent included in both cooling water and sulfate removal and potable water processing brines discharge. As noted earlier, there are no standards for hypochlorite in offshore waters. Similar to temperature rise and oil and grease, hypochlorite experiences rapid dilution and mixing once discharged. Figure 4-6 shows the maximum-modeled concentrations of hypochlorite during operation of all three FPSOs. The color scale is chosen to show the modeled plume and its potential to overlap. The color scale range is 0.0005 ppm to 0.02 ppm and even at these low values, there is no plume overlap.

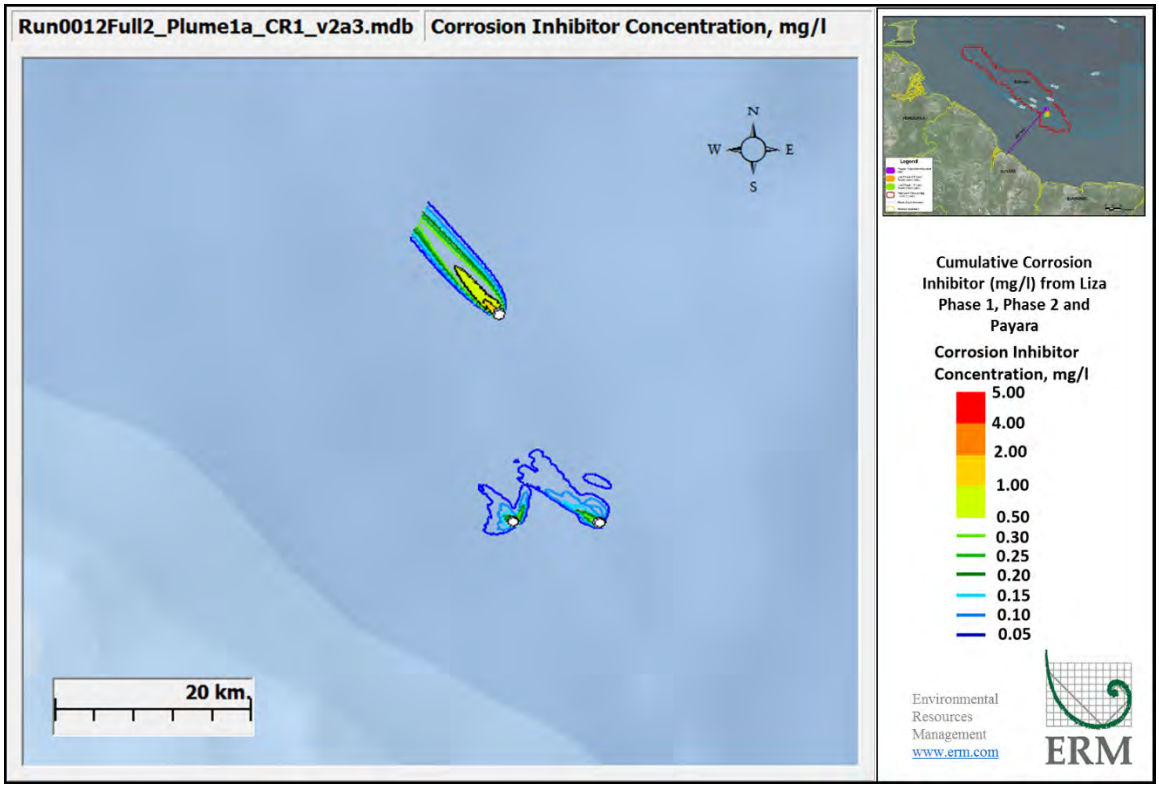
Figure 4-6: Modeled Maximum Concentrations of Hypochlorite during Operation of all three FPSOs



4.4.4 Other Chemicals

In addition to temperature rise, oil and grease, and hypochlorite, the various discharge streams include other production chemicals such as corrosion inhibitor and scale inhibitor. None of these constituents have any regulatory standards and experience similar rapid mixing and dilution as the other constituents described above. The plumes rarely overlap, even at extremely low concentrations. An example of modeled maximum concentrations for corrosion inhibitor is shown in Figure 4-7, where only the lowest iso-lines in the color scale (0.05 ppm) show minimal overlap.

Figure 4-7: Modeled Maximum Concentrations of Corrosion Inhibitor



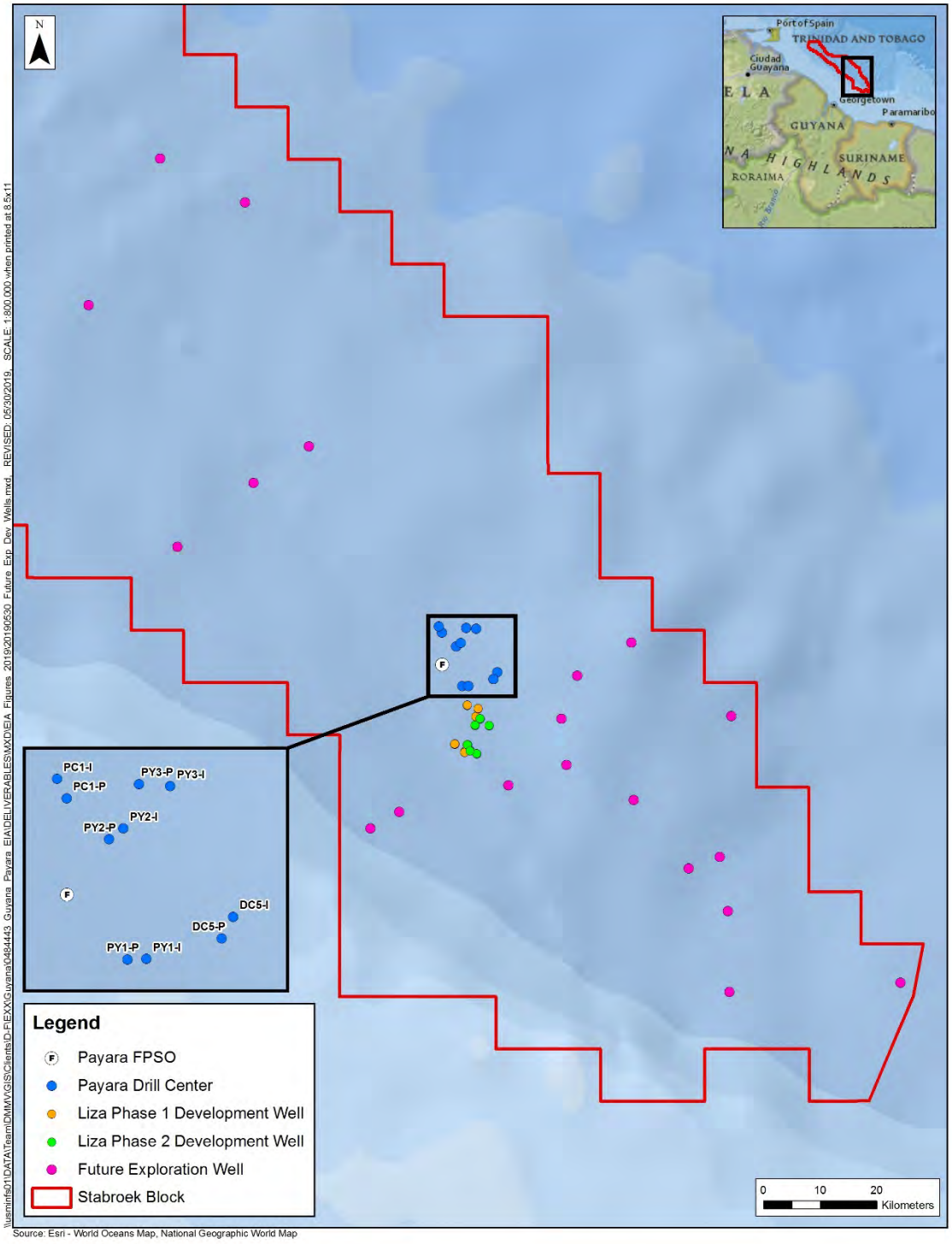
5. CUMULATIVE IMPACTS: DRILLING OPERATIONS

Similar to the offshore discharge, drilling operations for the Payara Project may occur simultaneously with drilling for other EEPGL development projects as well as EEPGL exploration drilling in the Stabroek Block. Although the footprint of drill cuttings deposition from drilling operations and the extent of associated TSS plumes is very limited, and typically located within close proximity of the drilling locations, an assessment was performed to evaluate the potential for cumulative impacts (overlap) from simultaneous drilling activities.

Figure 5-1 shows the preliminary locations of future exploration wells for which EEPGL has submitted an Environmental Management Plan to the Guyana Environmental Protection Agency in support of a request for EPA's authorization. Figure 5-1 also shows the Project development well locations, and the development well locations for the Liza Phase 1 and Liza Phase 2 Projects. As shown in Figure 5-2, the closest proposed exploration well to a Project development well is the well labelled "I," which is 13.9 kilometers (8.6 miles) away from the nearest Project development well. Results of the drill cuttings modeling (See Section 2) show that this distance of 13.9 kilometers (8.6 miles) far exceeds the distance that a drill cuttings deposition footprint and TSS plume extend from a well. Similarly, the closest Liza Phase 1 or Liza Phase 2 development well to a Project development well is a Liza Phase 1 well (LIZ_2P4), which is approximately 3.3 kilometers (2.1 miles) away from the nearest Project development well. This distance also is significantly larger than the distance a drill cuttings deposition footprint or TSS plume extends from a well.

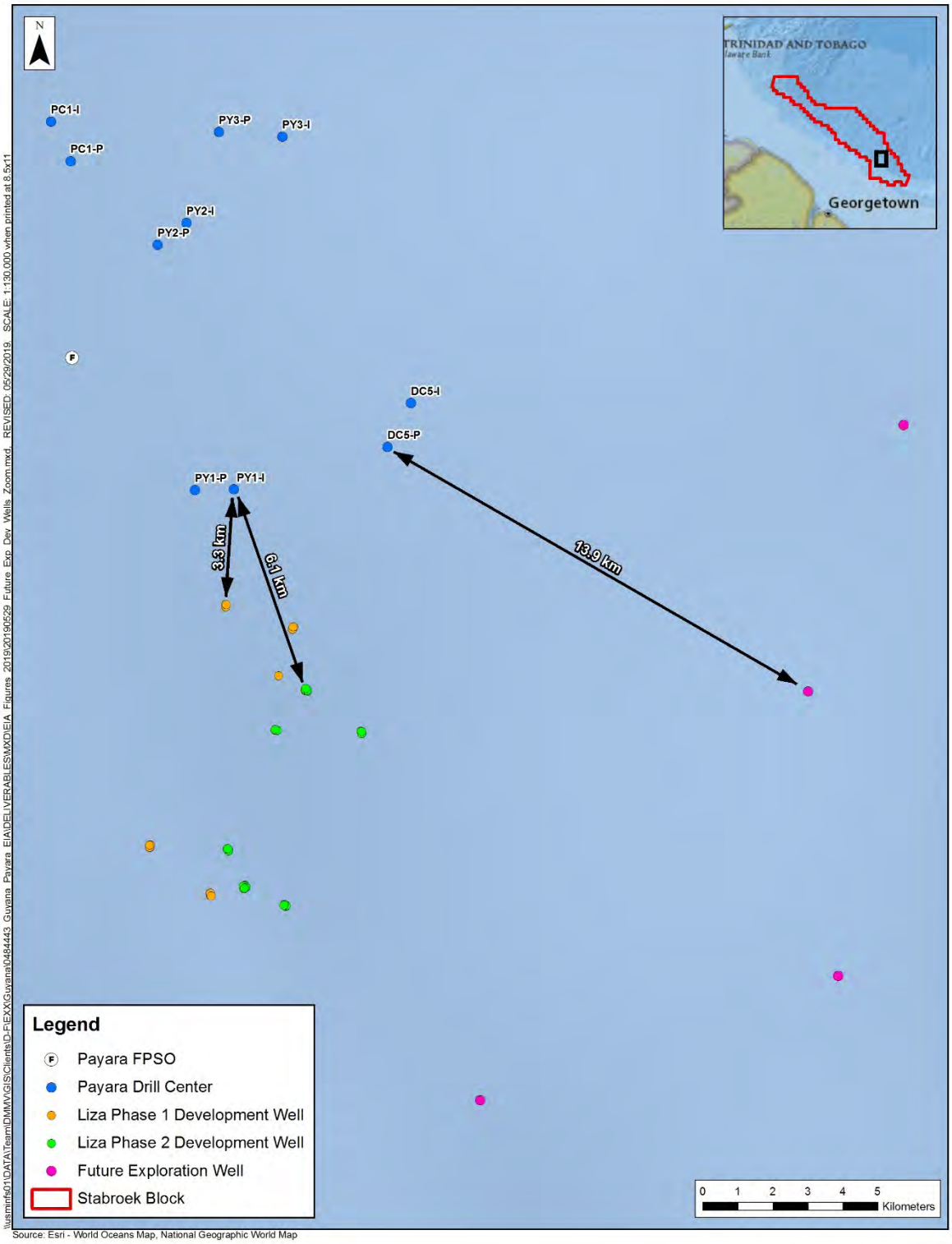
Furthermore, temporal behavior should also be considered in evaluation of the cumulative impacts. The threshold of sedimentation is 5 centimeters (2 inches) of deposition over a period of 30 days. Any additional drilling operation in a nearby location would have to produce additional sedimentation within the 30 days that exceeds 5 centimeters (2 inches). It is not likely that two wells closer than 1 kilometer (0.6 miles) would be drilled within a 30-day period. Similarly, the TSS plume is transient and will continue to move under the ambient currents with potential for any overlap with a nearby well unlikely.

Figure 5-1: Locations of Proposed Exploration Wells Compared to Existing and Proposed Locations of Development Wells (Liza Phase 1, Liza Phase 2, and Payara)



km = kilometer

Figure 5-2: Distances from Payara Development Wells Locations to the Closest Proposed Exploration Well and Liza Phase 1 or Liza Phase 2 Development Well Locations



6. CONCLUSIONS

Spatially and time-varying modeling of cumulative impacts due to multiple discharges from each FPSO was performed using the GEMSS model. The modeling included the major operational discharges and assessed the potential for plumes from the three FPSOs to overlap and result in cumulative impacts. As shown in Figure 4-3, Figure 4-5, Figure 4-6, and Figure 4-7, none of the constituent plumes that were included in the assessment (see Table 3-4) showed overlaps (considering relatively small outer limits).

The only constituent with a reference standard (<3ºC above ambient at 100 meters [328.1 feet]) is temperature rise. As discussed in Project EIA Section 6.4.3.3, Characterization of Impacts—Changes to Water Quality and Temperature, the significance of potential impacts on water quality from constituent concentrations and temperature rise was determined to be **Negligible** based on modeling from a single (Payara) FPSO. As shown above, modeling of all three FPSOs operating, with each FPSO discharging both produced water and cooling water (both of which add a thermal load), predicted no overlap in plumes. In the case of temperature rise, the outer edge of the plumes from each FPSO was defined as a temperature rise of 0.05ºC (see Figure 4-3). Accordingly, based on the fact that plumes of **Negligible** significance are not expected to overlap during simultaneous FPSO operations, it was concluded that the significance of cumulative impacts on water quality from simultaneous operation of the Liza Phase 1, Liza Phase 2, and Payara FPSOs is also considered **Negligible**.

The extent of the drill cuttings deposition footprint and associated TSS plume from any drilling operations, the minimum distance required between two drill ships operating simultaneously, and the spacing between Project wells and proposed exploration or other development wells suggest that there is no potential for overlap in either the drill cuttings deposition footprint or the TSS plume. Accordingly, it can be concluded that the significance of cumulative impacts on sediments and water quality as a result of drilling for Liza Phase 1, Liza Phase 2, exploration drilling, and the Payara Project is **Negligible**.

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APPENDIX K

IUCN-Listed Coastal and Marine Species Known From Guyana with Red List Status Classified as Data Deficient

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Table K-1: IUCN-Listed Coastal and Marine Species Known From Guyana with Red List Status Classified as Data Deficient

Scientific Name	Common Name
Mammals	
Globicephala macrorhynchus	Short-finned Pilot Whale
Kogia breviceps	Pygmy Sperm Whale
Kogia sima	Dwarf Sperm Whale
Mesoplodon densirostris	Blainville's Beaked Whale
Balaenoptera brydei	Bryde's Whale
Sotalia guianensis	Guiana Dolphin
Pseudorca crassidens	False Killer Whale
Orcinus orca	Killer Whale
Feresa attenuata	Pygmy Killer Whale
Delphinus capensis	Long-beaked Common Dolphin
Fishes	
Ancylopsetta kumperae	Four-eyed Flounder
Breviraja nigriventralis	Blackbelly Skate
Carcharhinus porosus	Smalltail Shark
Dasyatis americana	Southern Stingray
Dactylobatus clarkii	Hookskate
Elops smithi	Malacho
Echeneis naucrates	Live Sharksucker
Fenestraja plutonia	Pluto Skate
Genyatremus luteus	Torroto grunt
Ginglymostoma cirratum	Nurse Shark
Gymnura micrura	Smooth Butterfly Ray
Hexanchus nakamurai	Bigeyed Sixgill Shark
Himantura schmardae	Chupare Stingray
Holothuria arenicola	Sea cucumber
Hypanus guttatus	Longnose Stingray
Lonchurus elegans	Blackfin Croaker
Mugil liza	Lebranche mullet
Myliobatis freminvillii	Bullnose Ray
Myliobatis goodei	Southern Eagle Ray
Panulirus argus	Caribbean Spiny Lobster
Panulirus laevicauda	Smoothtail Spiny Lobster
Rhizoprionodon lalandii	Brazilian Sharpnose Shark
Sciades passany	Passany Sea Catfish
Sphyrna media	Scoophead Shark
Scyllarides delfosi	Three-spot Slipper Lobster
Tetrapturus georgii	Roundscale Spearfish
Torpedo nobiliana	Great Torpedo Ray

Source: International Union for Conservation of Nature. 2019. 2019 Red List of Threatened Species Version 2019.1. Accessed: May 2019. Retrieved from: http://www.iucnredlist.org/

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APPENDIX L

Marine Bird Survey Reports

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ERM

180 Admiral Cochran Drive Suite 400
Annapolis, Maryland 21401

Telephone: +1 (410) 266 0006
Fax: +1 (410) 266 6894

www.erm.com

Memo

To	Jena Lococo, Kari Ehmling
From	Julia Tims
Date	20 October 2018
Reference	Year 2 Marine Bird Study—Survey 1
Subject	Interim Report

1 Introduction

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), ERM conducted three marine bird surveys, collectively referred to herein as Survey 1, in the Stabroek Block and surrounding waters offshore Guyana in September and October 2018. These surveys are the first of a series of five surveys to be conducted as part of EEPGL's Year 2 Marine Bird Study. This study is a continuation of the Year 1 Marine Bird Study conducted pursuant to a condition of the Environmental Permit for the Liza Phase 1 Development Project. The Year 2 Marine Bird Study is an elective study commissioned by EEPGL and is not being conducted pursuant to any regulatory requirement.

This memo summarizes the results and highlights the key findings of the three marine bird surveys comprising Survey 1. ERM will prepare a full report detailing the results of all Year 2 surveys and comparing results across surveys in late 2019 after completion of the Year 2 Marine Bird Study surveys.

2 Survey Approach and Methods

Three marine bird survey events were conducted in the Stabroek Block and surrounding waters and in the area between the Stabroek Block and the Guyana coast in September and October 2018. International and Guyanese bird specialists were stationed on moving or stationary vessels during the surveys. The three surveys included the following:

- Survey 1a was a mobile survey of the Stabroek and Canje Blocks and the area between Georgetown and the Stabroek Block, and was conducted from the *Chouest Sable* geotechnical survey vessel. Dr. Jeffrey McCrary, an international specialist, conducted the survey from 15 September to 26 September 2018.
- Survey 1b was a mobile survey within the Stabroek Block and the area between Georgetown and the Stabroek Block, and was conducted from the *Sea Service* survey vessel. Dr. Jeffrey McCrary, an international specialist, conducted the survey from 1 October through 6 October 2018.
- Survey 1c was a stationary survey within the Stabroek Block from the *Noble Bob Douglas* drill ship, which is stationed near EEPGL's Liza 1 well, approximately 108 nautical miles northeast of

Georgetown. Dr. Brian O'Shea, an international expert, and Garey Sway, a Guyanese bird surveyor, conducted the survey from 17 September 2018 to 1 October 2018.

During each survey, one or two observers were stationed on the vessel's top deck (Noble Bob Douglas) or the forward bridge (Chouest Sable and Sea Service). To minimize observer fatigue and eyestrain caused by continuous observation, observers conducted 30-minute surveys, each followed by a 15- or 30-minute break, between the hours of 05:30 and 17:30. During each survey, the observer(s) continuously scanned the ocean surrounding the vessel to locate and identify any birds present. The surveyors noted the locations of birds relative to the vessel (general direction or, when possible, compass heading), along with their estimated distance from the vessel (greater or less than 300 meters [984.3 feet]) and direction of movement. Observers directed their scans away from the sun's glare so scans focused to the west during the morning and to the east during the afternoon. Whenever possible, observers collected GPS points at the location of sightings and photographed birds for documentation and, in some cases, species identification or confirmation. At the beginning of each survey, observers noted sky condition, wind strength, intensity of swells, density of whitecaps (which tended to impede visibility of birds near the water surface), and bow direction. Observers recorded data electronically in Microsoft Excel using a data-entry template developed for this survey by ERM and the specialist team that is compatible with EEPGL's Geographic Information System (GIS) platform (Attachment 1). In addition to the survey data, surveyors also recorded incidental observations of birds (i.e., birds observed outside of the survey periods).

Figure 1 depicts the locations of the three surveys. Portions of the mobile survey transit routes that were traversed at night were not surveyed.

3 Results Summary

3.1 Survey 1a

Survey 1a was performed aboard the *Chouest Sable*, which transited between Georgetown, Guyana, and the Liza and Canje fields within the Stabroek and Canje Blocks from 15 September to 26 September 2018. This survey covered 10 full days, during which a single observer conducted 99 30-minute surveys. These surveys yielded 415 individual birds classified into 32 species and 5 other taxa designations. Of these, 15 were Nearctic-Neotropical migrant landbirds or shorebirds that were migrating south *en route* to their wintering areas; the remainder were non-migrating landbirds observed on or very near the shoreline or nearshore and pelagic seabirds actively foraging in the offshore survey area or commuting between offshore foraging sites (e.g., schooling fish). The majority of the birds observed (283 individuals, including the 177 Feral Rock Pigeon observed leaving the port) occurred in four surveys conducted in the nearshore environment within 5 kilometers (3.1 miles) of the John Fernandes Port. The dominant marine bird species observed was Magnificent Frigatebird (*Fregata magnificens*). The observer recorded birds in 40 of the 99 surveys (40 percent). Incidental observations yielded 50 more individuals, bringing the total number of individual birds observed to 465 and the total number of species observed to 35 (Table 1).

Overall bird diversity was relatively high compared with Year 1 surveys and the other two fall 2018 surveys and the survey documented a notable number and assemblage of migrating landbirds and coastal species, particularly swallows and wading birds (i.e., herons, egrets, etc.), respectively. The survey also documented two unexpected species: (1) a single Eurasian Collared Dove (*Streptopelia*

decaocto), a non-native, non-migratory species that is rapidly expanding in population size and geographic range and, to date, has not been documented in Guyana; and (2) a single Homing Pigeon (*Columba livia domestica*) with identification rings.

Table 1: Bird Species Observed from the *Chouest Sable*, 15 to 26 September 2018.

Common Name	Species	Category	Number of Individuals Observed during Surveys and Incidental Observations
Feral Rock Pigeon	*Columba livia*	Non-migratory landbird	177
Black Tern	*Chlidonias niger*	Nearshore marine	46
Magnificent Frigatebird	*Fregata magnificens*	Marine	42
Laughing Gull	*Sula leucogaster*	Nearshore marine	36
Black-bellied Plover	*Pluvialis squatarola*	Migrant	25
Red-footed Booby	*Sula sula*	Marine	24
Barn Swallow	*Hirundo rustica*	Migrant	23
Snowy Egret	*Egretta thula*	Nearshore marine	16
Sandpiper species	Scolopacidae sp.	Marine	6
Cattle Egret	*Bubulcus ibis*	Nearshore marine	6
Least Tern	*Sternula antillarum*	Nearshore marine	6
Sandwich Tern	*Thalasseus sandvicensis*	Nearshore marine	4
Bulwer's Petrel	*Bulweria bulwerii*	Marine	4
Ruddy Ground-Dove	*Columbina talpacoti*	Migrant	4
Masked Booby	*Sula dactylatra*	Marine	4
Tricolored Heron	*Egretta tricolor*	Nearshore marine	3
Barolo Shearwater	*Buffinus baroli*	Marine	3
White-winged Swallow	*Tachycineta albiventer*	Migrant	3
Great Kiskadee	*Pitangus sulphuratus*	Migrant	3
Brown Pelican	*Pelecanus occidentalis*	Nearshore marine	2
Little Blue Heron	*Egretta caerulea*	Nearshore marine	2
Brown Noddy	*Anous stolidus*	Marine	2
Tern species	Laridae sp.	Nearshore marine	2
Shearwater species	Procellaridae sp.	Marine	2
Royal Tern	*Sterna maxima*	Marine	2
Gray-breasted Martin	*Progne chalybea*	Migrant	2
Cave Swallow	*Petrochelidon fulva*	Migrant	2
Lesser Kiskadee	*Pitangus lector*	Migrant	2
Tropical Kingbird	*Tyrannus melancholicus*	Migrant	2
Great Shearwater	*Ardenna gravis*	Marine	1
Short-tailed Swift	*Chaetura brachyura*	Migrant	1
Homing Pigeon	*Columba livia domestica*	Non-migratory landbird	1
Eurasian Collared Pigeon	*Streptopelia decaocto*	Non-migratory landbird [a]	1
Brown Booby	*Sula leucogaster*	Marine	1
Swallow species	Hirundinidae *sp.*	Migrant	1
Snail Kite	*Rostrhamus sociabilis*	Migrant	1

Common Name	Species	Category	Number of Individuals Observed during Surveys and Incidental Observations
House Wren	*Troglodytes aedon*	Non-migratory landbird	1
Bank Swallow	*Riparia riparia*	Migrant	1
Bobolink	*Dolichonyx oryzivorus*	Migrant	1

[a] Non-native, invasive species

3.2 Survey 1b

Survey 1b was performed aboard the *Sea Service*, which transited between Georgetown, Guyana, and the Stabroek Block from 1 October through 6 October 2018. This survey covered five full days, during which a single observer conducted 47 30-minute surveys. These surveys yielded 330 individual birds classified into 13 species and three other taxa designations (Table 2). Of these 16 taxa, five were Neartic-Neotropical migrant landbirds or shorebirds and the remainder were nearshore and pelagic seabirds actively foraging in the survey area or commuting between offshore foraging areas. The diversity of marine bird species was low and the dominant marine bird observed was Magnificent Frigatebird. The surveyor also recorded 76 incidental bird observations, bringing the total number of individual birds observed to 406. The observer recorded birds in 25 of the 47 surveys (53 percent).

Table 2: Bird Species Observed from the *Sea Service*, 1 to 6 October 2018.

Common Name	Species	Category	Number of Individuals Observed during Surveys and Incidental Observations
Common Tern	*Sterna hirundo*	Nearshore marine	190
Tern species	Laridae sp.	Nearshore marine	82
Laughing Gull	*Sula leucogaster*	Nearshore marine	64
Magnificent Frigatebird	*Fregata magnificens*	Marine	20
Barn Swallow	*Hirundo rustica*	Migrant	17
Sandpiper species	Scolopacidae sp.	Migrant	7
Least Tern	*Sternula antillarum*	Nearshore marine	5
Royal Tern	*Sterna maxima*	Nearshore marine	4
Sandwich Tern	*Thalasseus sandvicensis*	Nearshore marine	4
Least Sandpiper	*Calidris minutilla*	Migrant	2
Roseate Tern	*Sterna dougalli*	Nearshore marine	2
Masked Booby	*Sula dactylatra*	Marine	2
Bridled Tern	*Onychoprion anaethetus*	Nearshore marine	2
Swallow species	Hirundininae sp.	Migrant	2
Brown Booby	*Sula leucogaster*	Marine	1
Ruddy Turnstone	*Arenaria interpres*	Migrant	1
Unidentified Tern or Tropicbird species	Laridae or Phaethontidae	Marine	1

3.3 Survey 1c

Survey 1c was performed aboard the *Noble Bob Douglas*, a stationary vessel positioned in the Stabroek Block. The survey took place from 17 September 2018 to 1 October 2018 and yielded 159.75 observer-hours over 13 full days and two partial days, during which time two observers conducted 176 30-minute surveys. In addition, both observers spent an average of 95 minutes per day on the top deck during breaks between surveys, during which they recorded incidental bird sightings.

Observers recorded birds on 74 of the 176 surveys (42 percent). The surveys and incidental observations yielded 155 individual birds classified into 12 species and four other taxa designations (Table 3). Of the taxa recorded, half were Neartic-Neotropical migrant landbirds or shorebirds and the remainder were nearshore and pelagic seabirds actively foraging in the survey area or commuting between offshore foraging areas. The dominant marine bird observed was Masked Booby (*Sula dactylatra*). The diversity of marine species was low: most marine birds detected on the survey were boobies (*Sula* spp.).

Table 3: Bird Species Observed from the *Noble Bob Douglas*, 17 September to 1 October 2018

Common Name	Species	Category	Number of Individuals Observed during Surveys and Incidental Observations
Barn Swallow	*Hirundo rustica*	Migrant	44
Masked Booby	*Sula dactylatra*	Marine	31
Red-footed Booby	*Sula sula*	Marine	19
Semipalmated Sandpiper	*Calidris pusilla*	Migrant	16
Cliff Swallow	*Petrochelidon pyrrhonota*	Migrant	6
Lesser Yellowlegs	*Tringa flavipes*	Migrant	5
Magnificent Frigatebird	*Fregata magnificens*	Nearshore marine	3
Ruddy Turnstone	*Arenaria interpres*	Migrant	3
Little Blue Heron	*Egretta caerulea*	Migrant	3
Sandpiper species	Scolopacidae sp.	Migrant	3
Laughing Gull	*Leucophaeus atricilla*	Nearshore marine	2
Small Shearwater species	*Puffinus* sp.	Marine	2
Brown Booby	*Sula leucogaster*	Marine	2
Purple Martin	*Progne subis*	Migrant	1
Gull/tern species	Laridae sp.	Nearshore marine	1
Large shearwater species	*Ardenna/Calonectris* sp.	Marine	1

4 Discussion

A preliminary comparison of these results with those of the Year 1 Marine Bird Study, including the fall 2017 survey that was conducted during approximately the same period as these surveys, indicates a similar species assemblage across years, with some exceptions, including the preponderance of migratory swallow species and migratory shorebird species (i.e., sandpipers,

plovers, etc.) recorded during the fall 2018 surveys. Another notable result of the fall 2018 surveys is that Leach's Storm-Petrel (*Oceanodroma leucorhoa)*, one of the most commonly observed species in the spring 2018 survey, was not observed during any of the three fall 2018 surveys. A potential explanation for this is that this species may be an early migrant and so had already passed through the region by mid-September when the fall 2018 surveys began.

On 26 and 27 September, during Survey 1c, Tropical Storm Kirk passed from east to west approximately 320 nautical miles north of the *Noble Bob Douglas*. The storm's passing coincided with a shift in the direction of prevailing winds (from northeast to south), a notable lessening of wind speed, and a calming of the sea surface. This period had the highest abundance of birds observed during this survey, suggesting that offshore bird observations are strongly influenced by weather events independent of other factors (e.g., position and season).

Without exception, migratory species were observed flying either south or southwest, toward land. Movements of seabirds did not show any strong directionality indicating migration or seasonal dispersal from breeding areas, although the general trend in movement observed during all three surveys was toward the north and west of the survey vessel location. This suggests that seabirds were likely responding to short-term local fluctuations in food supply rather than undertaking migratory or post-breeding dispersal movements.

The survey vessels themselves, particularly the stationary *Noble Bob Douglas*, were used by at least four species of birds (Barn and Cliff Swallows and Masked and Red-footed Boobies). Swallows often rested on and around the helipad of the Noble Bob Douglas and on the bridge of the *Chouest Sable*. On one occasion, a Cliff Swallow was observed resting on a lower deck of the *Noble Bob Douglas* after nightfall.

The fall 2018 surveys were unique in that two simultaneous surveys within the Stabroek Block occurred in September, one aboard a stationary vessel (*Noble Bob Douglas*) and another aboard a transiting vessel (*Chouest Sable*). Observations between the two simultaneous surveys were similar and the numbers and species composition of migrants were similar, indicating that on certain days, large-scale movements of certain migratory species (particularly swallows and shorebirds) were taking place over a substantial area of ocean north of Guyana. A key difference between the two surveys was the diversity and abundance of pelagic seabirds observed: the mobile survey aboard the *Chouest Sable* recorded a higher abundance of pelagic seabirds throughout the survey and reported several species of pelagic seabirds not recorded on the stationary *Noble Bob Douglas*. It is possible that the mobile vessel was more of an attractant to pelagic seabirds than the stationary vessel. In addition, pelagic seabirds often fly low and close to the water surface and are therefore unlikely to be observed with any frequency from a stationary point high above the water's surface such as on the *Noble Bob Douglas*. Therefore, the low diversity and abundance of pelagic seabird species observed from the *Noble Bob Douglas* may not be representative of the actual number and species assemblage of pelagic seabirds in the Stabroek Block.

The ability to conduct simultaneous surveys aboard these distinctly different vessels confirmed that migrating species are moving across a broad front within and likely far beyond the Stabroek Block. It also identified benefits and limitations of the stationary survey. On the stationary survey, observers were stationed on a deck high above (over 100 meters [328.1 feet] above) the water surface and had an exceptionally clear view of the horizon in almost all directions. This proved excellent for

surveying migrating birds that fly near observer height or higher. Conversely, observers on the *Noble Bob Douglas* noted that they had limited visibility of birds that flew close to the water surface, particularly those that flew close to the water and near the vessel. The data indicate that more seabirds were attracted to the moving vessels compared to the stationary one and the large transit area covered by the moving vessel probably increased the likelihood of observing birds. These factors likely led to the higher bird abundance and diversity observed on the two mobile surveys compared with the stationary survey, as opposed to any real differences in species assemblage and abundance of birds within different portions of the Stabroek Block.

5 Next Steps

The next marine bird survey will be conducted in January or February 2019 based on vessel availability. ERM will coordinate with EEPGL on vessel availability as soon as vessel schedules for 2019 are available.

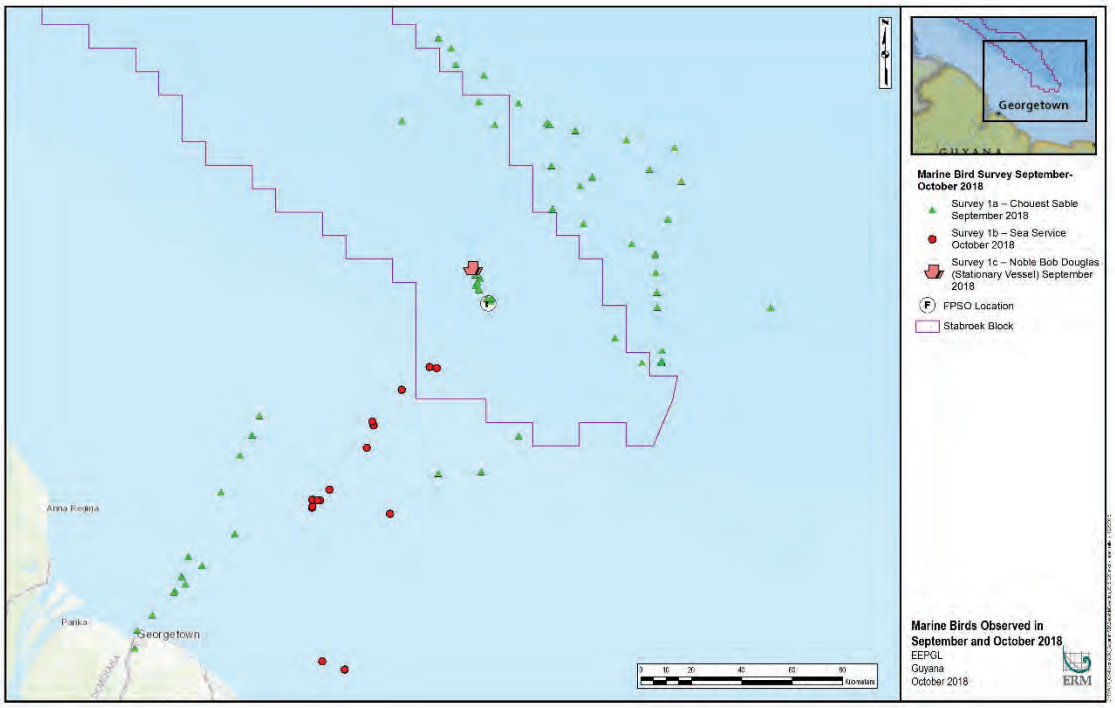
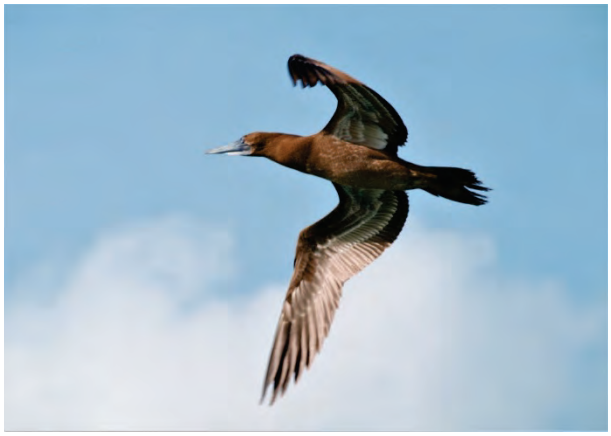


Figure 1: Survey Locations and Bird Sightings for the Fall 2018 Surveys

PHOTOGRAPHIC LOG



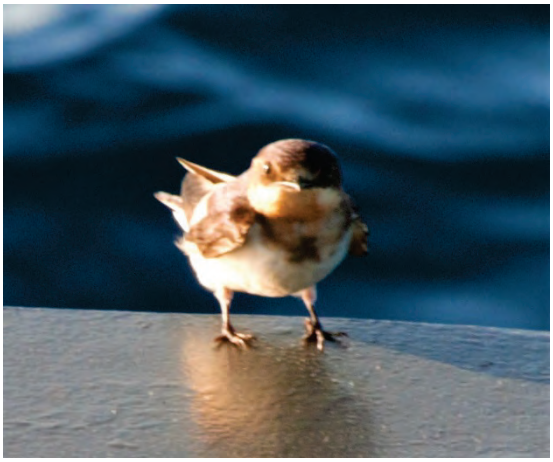
Photograph 1: Ruddy Turnstone Observed from the *Sea Service* 5 October 2018



Photograph 2: Brown Booby Observed from the *Sea Service* 5 October 2018



Photograph 3: Laughing Gulls Observed from the *Sea Service* 5 October 2018



Photograph 4: Barn Swallow Resting on the *Sea Service* 2 October 2018



Photograph 5: Red-footed Booby Resting on a Light on the *Chouest Sable*



Photograph 6: Scolopacidae (probable White-rumped Sandpiper) on board the *Chouest Sable* 15 September 2018



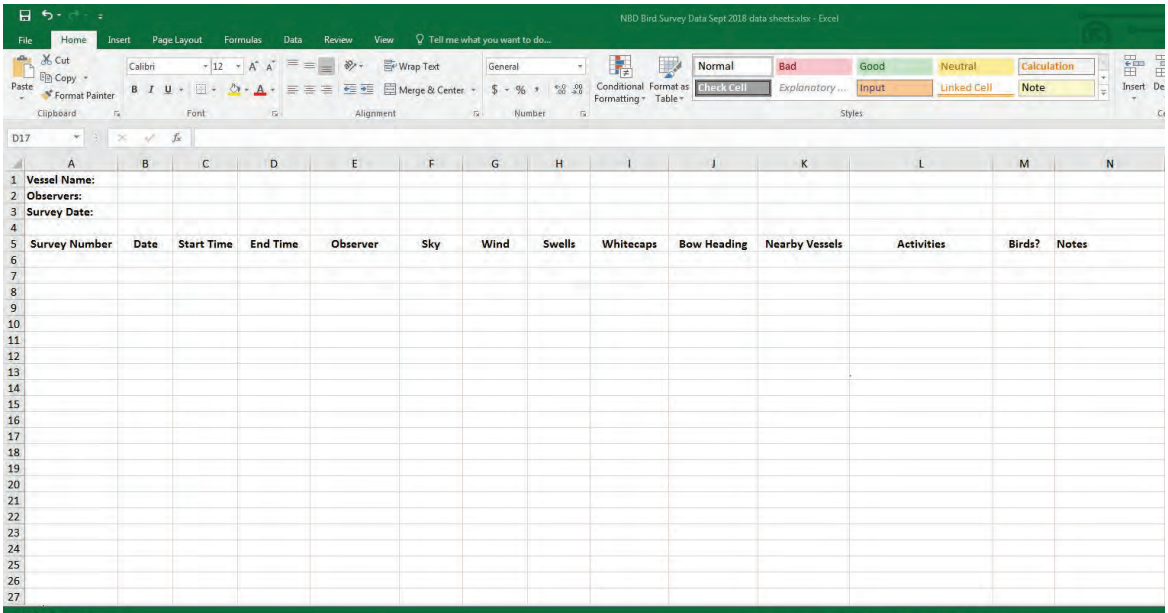
Photograph 7: Homing Pigeon on the *Chouest Sable* 17 September 2018

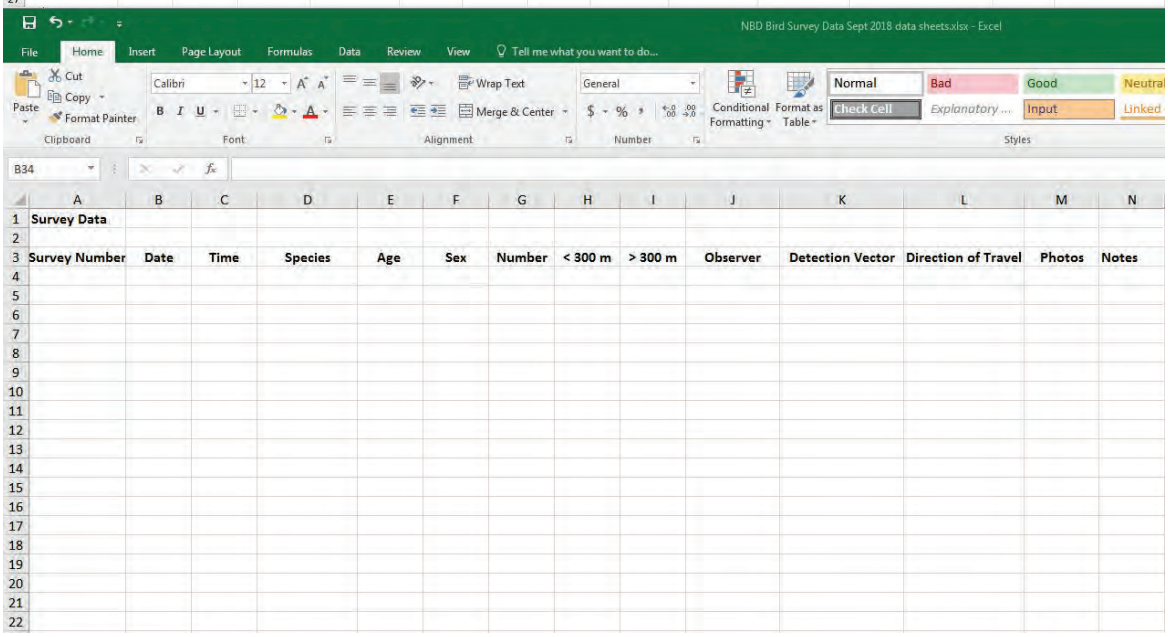


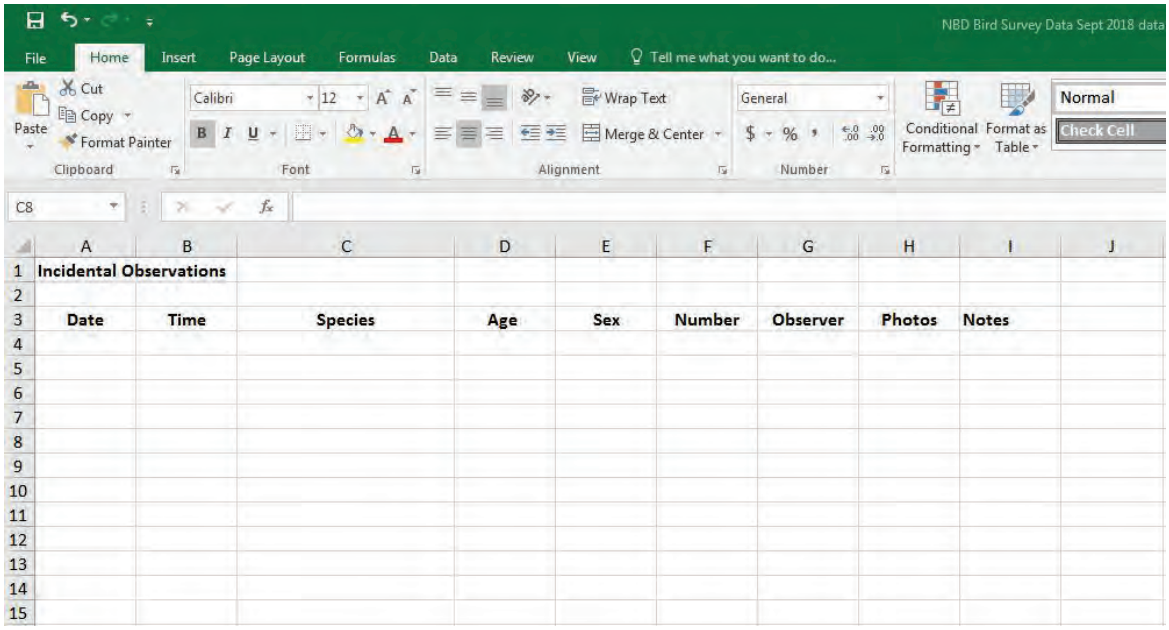
Photograph 8: Masked Booby on the *Chouest Sable* 17 September 2018

ATTACHMENT 1 DATA ENTRY TEMPLATES

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NBD Bird Survey Data Sept 2018 data sheets.xlsx - Excel
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ERM

180 Admiral Cochran Drive Suite 400
Annapolis, Maryland 21401

Telephone: +1 (410) 266 0006
Fax: +1 (410) 266 6894

www.erm.com

Memo

To	Jena Lococo, Kari Ehmling
From	Julia Tims, Jeffrey McCrary
Date	5 March 2019
Reference	Year 2 Marine Bird Study—Survey 2
Subject	Interim Report

1 Introduction

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), ERM conducted a marine bird survey in the Stabroek Block offshore Guyana in January and February 2019, hereafter referred to as the Winter 2019 survey. This survey was the second of a series of five surveys to be conducted as part of EEPGL's Year 2 Marine Bird Study. This study is a continuation of the Year 1 Marine Bird Study conducted pursuant to a condition of the Environmental Permit for the Liza Phase 1 Development Project. The Year 2 Marine Bird Study is an elective study commissioned by EEPGL and is not being conducted pursuant to any regulatory requirement.

This memo summarizes the results and highlights the key findings of the Winter 2019 survey. In late 2019, after completion of the Year 2 Marine Bird Study surveys, ERM will prepare a full report detailing the results of all Year 2 surveys and will compare results across surveys.

2 Survey Approach and Methods

The Winter 2019 survey was a stationary survey within the Stabroek Block from the *Noble Tom Madden* drill ship, which was stationed approximately 60 kilometers southeast of the planned location of EEPGL's Liza Phase 1 floating production, storage, and offloading vessel (FPSO) (Figure 1). Dr. Jeffrey McCrary, an international bird specialist who led prior EEPGL-commissioned marine bird surveys, conducted the survey from 28 January to 4 February 2019.

During the survey, Dr. McCrary was stationed on the Noble Tom Madden's top deck, located just above the captain's bridge and beneath the helicopter landing pad. The survey station provided an excellent viewscape for the bird survey, with clear views toward the bow and either flank of the ship, the sky, and the surrounding waters. Visibility toward the stern was limited due to the presence of infrastructure including the drilling scaffolding. The surveyor's viewpoint from this survey station was varied to maximize the opportunity to observe birds, taking into account the sun's position, wind direction, and vessel orientation.

This survey applied the protocol established for EEPGL's Year 1 Marine Bird Study and the first survey for the Year 2 Marine Bird Study, which involved recording all birds observed during 30-minute observation periods, each followed by a 15- or 30-minute break, between the hours of 05:30 and 17:30. During each observation period, the observer continuously scanned the vessel and the

ocean surrounding the vessel to locate and identify any birds present. The observer noted the locations of birds relative to the vessel (general direction or, when possible, compass heading), along with their estimated distance from the observer (greater or fewer than 300 meters [984.3 feet]) and direction of movement. Whenever possible, the observer took photographs of birds for documentation and, in some cases, for species identification or confirmation. At the beginning of each 30-minute observation period, the observer noted sky condition, wind strength, intensity of swells, density of whitecaps (which tend to impede visibility of birds near the water surface), and bow direction. The observer recorded and maintained all data in Microsoft Excel using a data-entry template developed for this survey by ERM and the specialist team (Attachment 1).

This seven-day survey included 70 diurnal (daytime) and two nocturnal observation periods encompassing 2,160 minutes or 36 hours of survey time. In addition to data recorded during the observation periods, the observer also recorded incidental observations of birds (i.e., birds observed outside of the observation periods).

3 Results Summary

This survey documented 102 bird sightings of seven species[1] during the 70 diurnal observation periods (Table 3-1). The survey documented birds during 56 of the diurnal observation periods (81 percent). The two nocturnal surveys yielded zero bird observations. Six additional incidental observations of birds were recorded during the seven-day survey. All of the species observed are seabirds, some of which are wintering in the region and others that are vagrants or permanent residents in the region. It is important to note that roughly half of the 102 bird observations recorded during this survey most likely involved only two individual birds that were observed repeatedly over the course of the survey - a single Brown Noddy and a single Great Black-backed Gull - both of which were reported to be roosting on the drill ship. The survey documented breeding interactions, including courtship activity, among boobies and Magnificent Frigatebirds.

Table 1: Bird Species Observed from the *Noble Tom Madden*, 28 January through 4 February 2019

Common Name	Species	Category	Number of Bird Sightings during Surveys and Incidental Observations
Great Black-backed Gull	*Larus marinus*	Marine, vagrant	34[1]
Magnificent Frigatebird	*Fregata magnificens*	Marine, year-round	26
Masked Booby	*Sula dactylatra*	Marine, year-round	21
Brown Noddy	*Anous stolidus*	Marine, year-round	18[1]
Pomarine Jaeger	*Stercorarius pomarinus*	Marine, migrant	5

[1] An eighth species, Great Skua (*Stercorarius skua*), may have been observed but the identification could not be confirmed. It is more likely that this sighting was of a Pomarine Jaeger and it was recorded as such. Both species have been documented in the region during winter, but the Pomarine Jaeger is much more common.

Common Name	Species	Category	Number of Bird Sightings during Surveys and Incidental Observations
Red-footed Booby	*Sula sula*	Marine, year-round	2
Sooty Shearwater	*Ardenna grisea*	Marine, migrant	2

[1] Sightings of this species were likely of one individual sighted multiple times.

4 Discussion

In contrast to the prior Year 1 and fall 2018 marine bird surveys, the assemblage of birds observed during the Winter 2019 survey included no land birds or North American migrants. This conforms to ERM's expectation that such birds would not be present offshore or would only be present at very low numbers outside of the spring and fall migration periods. The lack of migrating birds during this survey period resulted in the presence of fewer species and individuals compared with prior surveys, all of which were conducted during the spring or fall migration periods. All of the birds documented during this survey are considered true seabirds and can endure long periods away from land (e.g., when not nesting) by resting on the water or while airborne.

All but one of the species observed during this survey are previously known to occur in Guyana. The new country record for Guyana documented in this survey is the Great Black-backed Gull. Prior to this survey, there are no records that document the presence of the Great Black-backed Gull in Guyana (www.ebird.org; Braun et al. 2007). This species has been reported in Colombia, Venezuela, and French Guiana, so the species was expected to occur in Guyana despite the lack of formal records. As stated above, it is likely that all sightings of this species during this survey were the same individual, a likely first-winter bird (i.e., first winter post-hatching). The crew of the *Noble Tom Madden* reported that this bird perched on the stern of the vessel on multiple occasions.

Most of the species documented in this survey occur in the region year-round. Two are migrants that nest in the Southern Hemisphere and migrate to the Northern Hemisphere during the austral winter: the Pomarine Jaeger and the Sooty Shearwater. The Pomarine Jaeger is known to spend the winter months offshore Guyana and the surrounding region and the Sooty Shearwater is considered an occasional vagrant in Guyana (www.ebird.org; Braun et al. 2007). The Year 1 Marine Bird Study and the first survey of the Year 2 Marine Bird Study did not document Sooty Shearwater; however, the species is known to occur in Guyana based on historical records and RPS survey data collected by Protected Species Observers aboard some EEPGL-commissioned vessels.

The remaining birds sighted during this survey included four different species: Masked Booby, Red-footed Booby, Brown Noddy, and Magnificent Frigatebird, all of which nest in the Caribbean and are present in offshore Guyana waters year-round. Nesting activities for these species in the region typically start in January or February. The boobies observed in this survey were often found in pairs, and one pair of Masked Boobies exhibited breeding behavior. All observations of Brown Noddy during this survey were likely of the same individual, given individual particularities of the left wing (i.e., broken flight feathers). Ship crew confirmed sighting this bird roosting on the stern of the ship.

In contrast to prior surveys, this survey did not document any petrels or storm-petrels. All prior sightings of these species occurred offshore and were recorded during surveys from moving vessels. No petrels nor storm-petrels were sighted from this or the prior stationary survey conducted

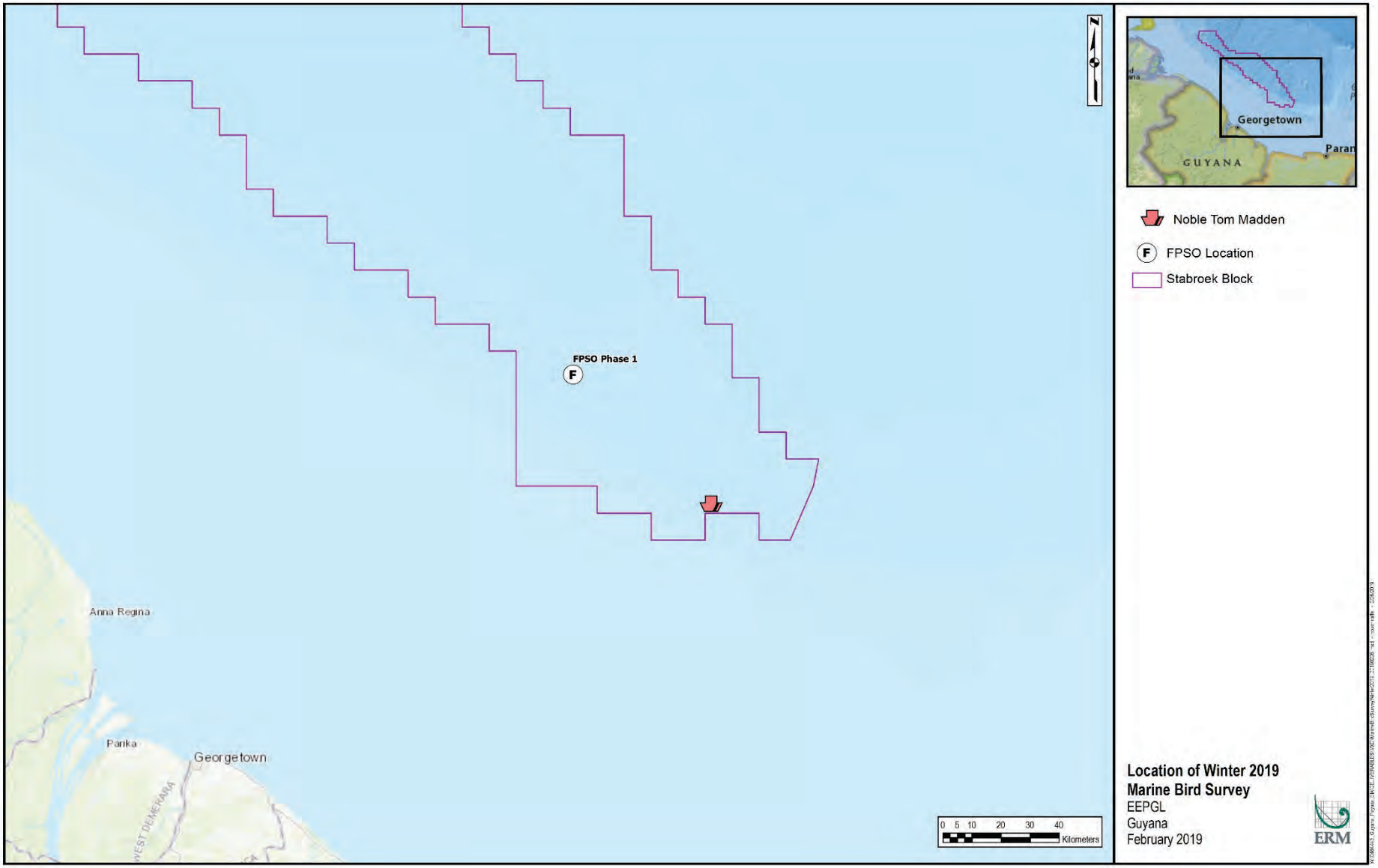
from the Noble Bob Douglas in fall 2018. It is unclear at this time if the type of survey vessel (stationary vs. mobile) affected the detection probability of this bird group. Future surveys in 2019 should shed light on this.

The results from the Winter 2019 survey complement prior EEPGL-commissioned marine bird surveys by adding new species to the registry for the Stabroek Block and the country, and contribute to a significant knowledge gap regarding offshore Guyana bird use during winter. The survey also demonstrates how the infrastructure added to the area may result in changes in bird behavior, including roosting on the vessels and other infrastructure for extended periods, even during the non-migratory season.

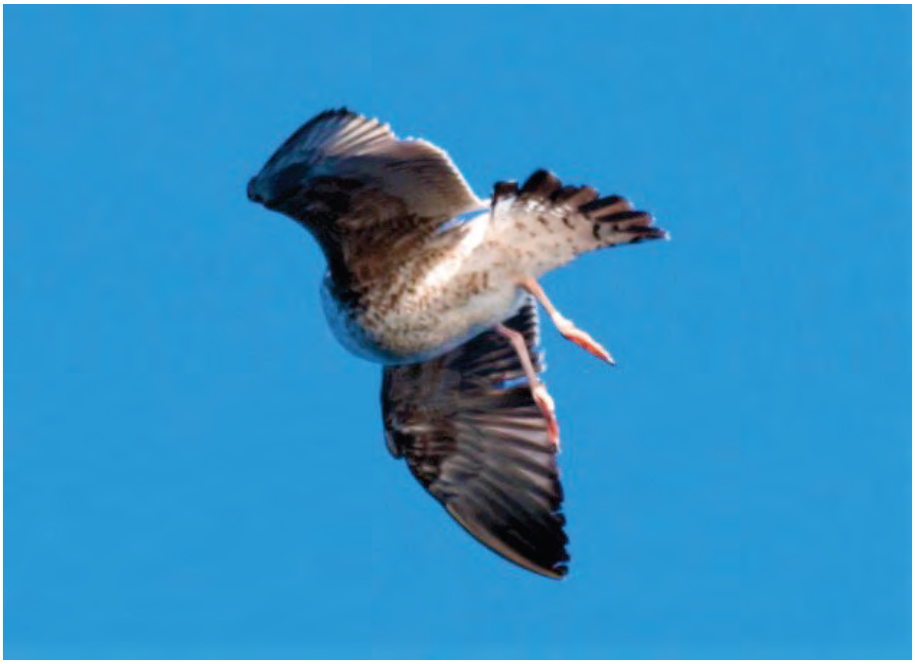
5 Next Steps

The next marine bird survey will be conducted in April 2019 based on vessel availability. ERM will continue to coordinate with EEPGL on vessel availability in order to schedule the next survey.

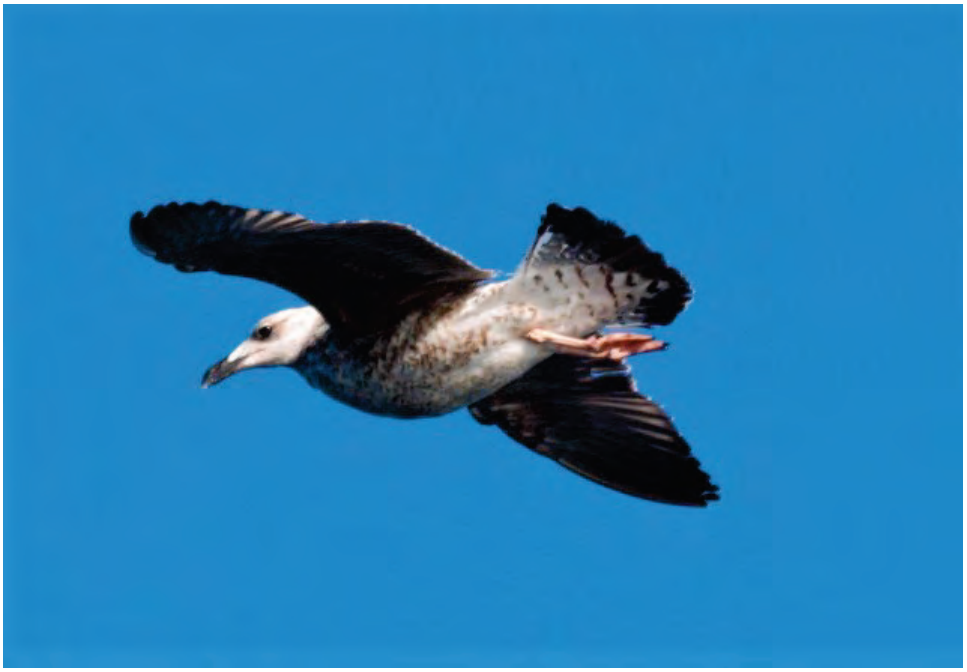
Figure 1: Survey Location for the Winter 2019 Marine Bird Survey



PHOTOGRAPHIC LOG



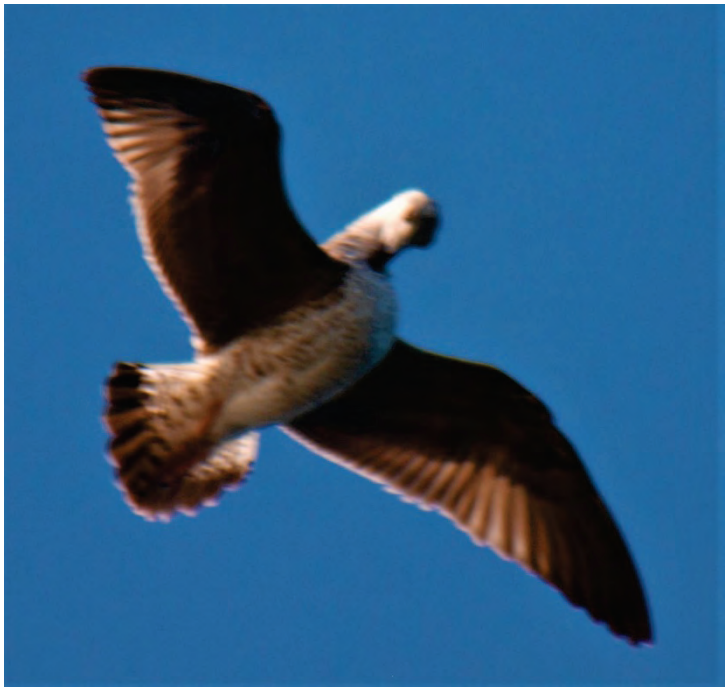
Photograph 1. Great Black-backed Gull in immature plumage.



Photograph 2: Immature Great Black-backed Gull.



Photograph 3: Great Black-backed Gull in immature plumage, soaring above the Tom Madden drill ship.



Photograph 4: Great Black-backed Gull in immature plumage, preening while soaring above the Tom Madden drill ship.



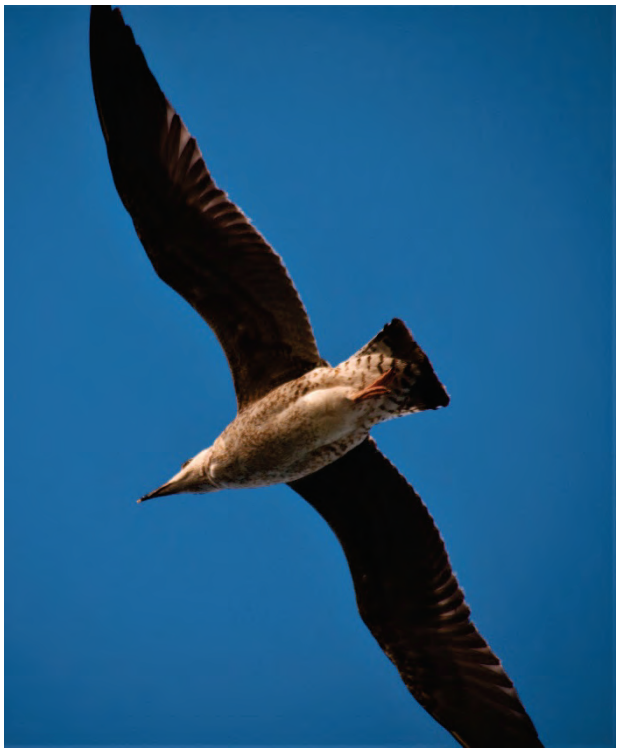
Photograph 5: Great Black-backed Gull in immature plumage, soaring above the Tom Madden drill ship.



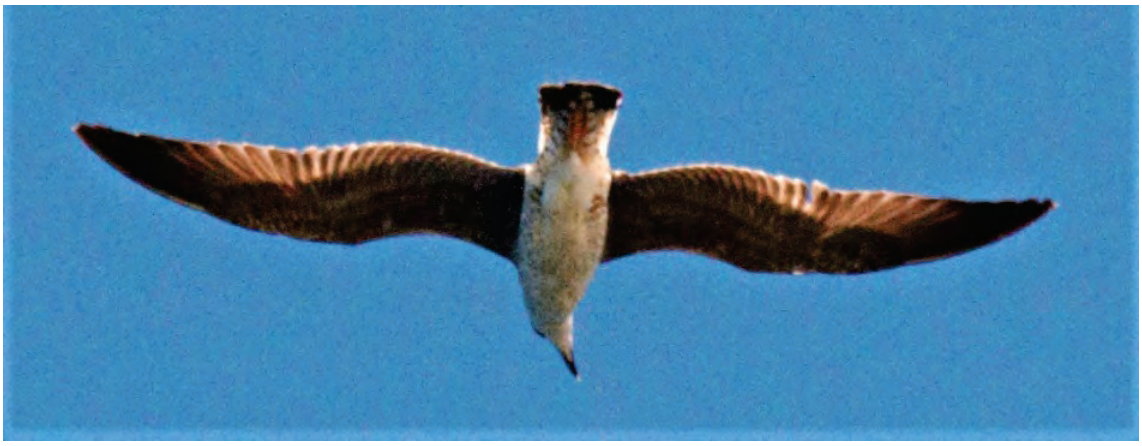
Photograph 6: Great Black-backed Gull in immature plumage, soaring above the Tom Madden drill ship.



Photograph 7: Great Black-backed Gull in immature plumage, soaring near the Tom Madden drill ship.



Photograph 8: Great Black-backed Gull in immature plumage, soaring above the Tom Madden drill ship.



Photograph 9: Great Black-backed Gull in immature plumage, soaring above the Tom Madden drill ship.



Photograph 10: Great Black-backed Gull in immature plumage, foraging a few meters above the water to the north of the Tom Madden drill ship.



Photograph 11: Masked Booby in late immature plumage, soaring above the Tom Madden drill ship.



Photograph 12: Masked Booby in young adult plumage, flying north of the Tom Madden drill ship.



Photograph 13: Masked Booby in young adult plumage, flying near the water on the north side of the Tom Madden drill ship.



Photograph 14: Two Masked Booby flying on the north side of the Tom Madden drill ship.



Photograph 15: Masked Booby in young adult plumage, flying on the north side of the Tom Madden drill ship.



Photograph 16: Masked Booby in young adult plumage, flying on the north side of the Tom Madden drill ship.



Photograph 17: Masked Booby in late immature plumage, flying above the Tom Madden drill ship.



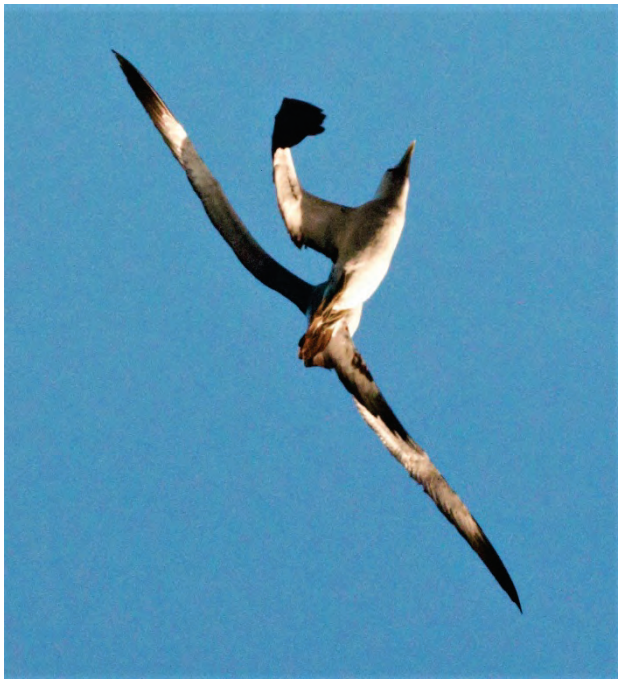
Photograph 18: Masked Booby in adult plumage, flying near the water on the north side of the Tom Madden drill ship.



Photograph 19: Masked Booby in adult plumage, flying near the water on the north side of the Tom Madden drill ship.



Photograph 20: Masked Booby in young adult plumage, flying near the water on the north side of the Tom Madden drill ship.



Photograph 21: Aerial coupling of Masked Booby on the north side of the Tom Madden drill ship.



Photograph 22: Two Masked Booby on the north side of the Tom Madden drill ship.



Photograph 23: Two Masked Booby in the water on the north side of the Tom Madden drill ship.



Photograph 24: Two Masked Booby flying north of the Tom Madden drill ship.



Photograph 25: Masked Booby in young adult plumage, flying low over the water on the north side of the Tom Madden drill ship.



Photograph 26: Paired Masked Booby in late immature and adult plumage, respectively, flying on north side of the Tom Madden drill ship.



Photograph 27: Masked Booby in late immature plumage, soaring over the Tom Madden drill ship.



Photograph 28: Masked Booby in late immature plumage, flying low over the water on the north side of the Tom Madden drill ship.



Photograph 29: Masked Booby in young adult plumage, flying low over the water on the north side of the Tom Madden drill ship.



Photograph 30: Masked Booby pair in late immature and young adult plumage, flying low over the water on the north side of the Tom Madden drill ship.



Photograph 31: Masked Booby in late immature plumage, soaring above the Tom Madden drill ship.



Photograph 32: Masked Booby in young adult plumage, soaring above the Tom Madden drill ship.



Photograph 33: Brown Noddy in adult plumage, flying low over the water on the north side of the Tom Madden drill ship.



Photograph 34: Brown Noddy in adult plumage, foraging a few meters above the water on the north side of the Tom Madden drill ship. Note the deterioration in the outermost flight feathers in the left wing, noted in all observations of this species, denoting the same individual.



Photograph 35: Brown Noddy in adult plumage, foraging just above the water on the north side of the Tom Madden drill ship.



Photograph 36: Brown Noddy in adult plumage, foraging just above the water on the north side of the Tom Madden drill ship.



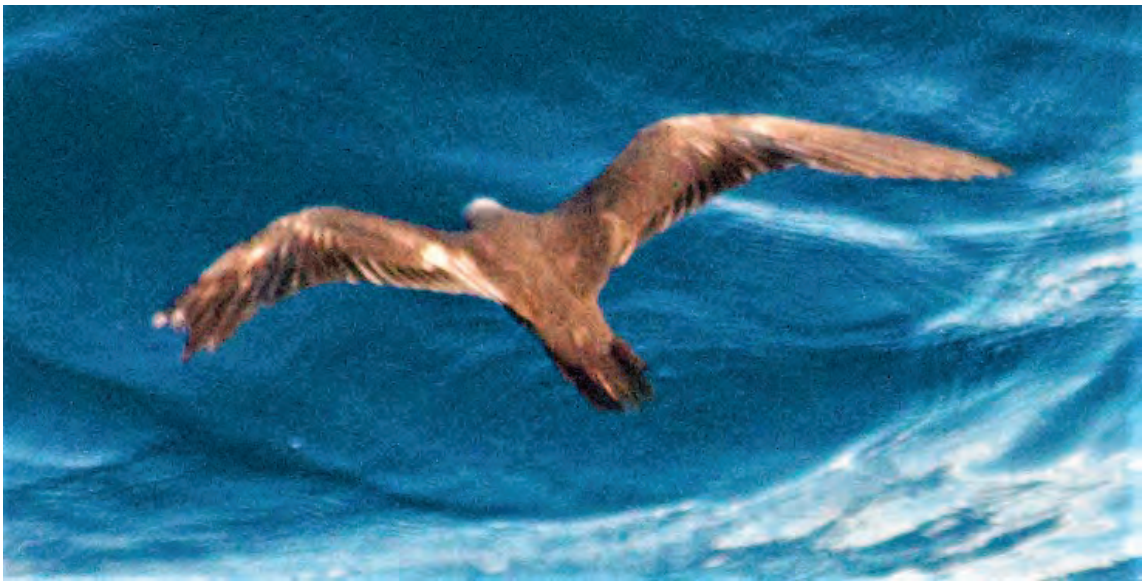
Photograph 37: Brown Noddy in adult plumage, flying low near jumping mackerel on the north side of the Tom Madden drill ship.



Photograph 38: Brown Noddy in adult plumage, flying low on the north side of the Tom Madden drill ship.



Photograph 39: Brown Noddy in adult plumage, flying low on the north side of the Tom Madden drill ship.



Photograph 40: Brown Noddy in adult plumage, flying low on the north side of the Tom Madden drill ship.



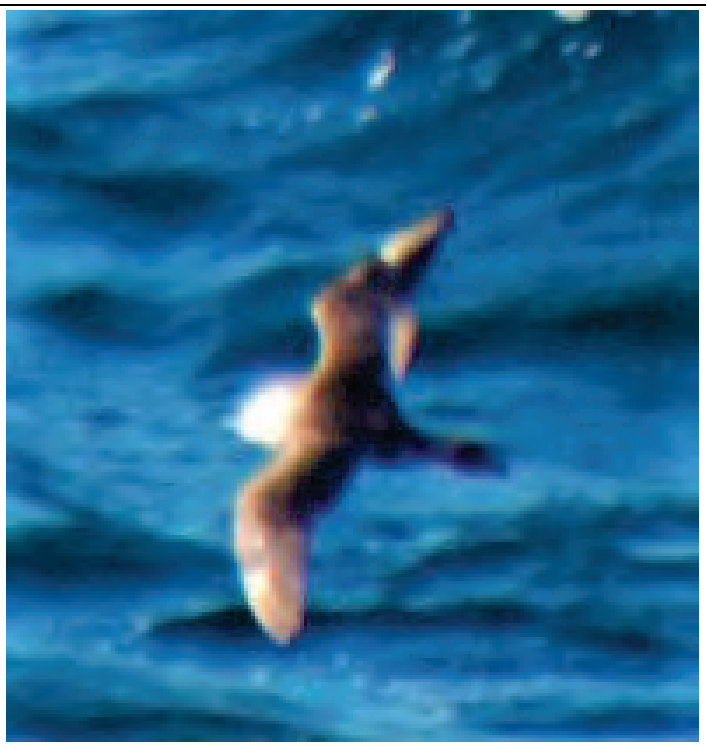
Photograph 41: Brown Noddy in adult plumage, flying low on the north side of the Tom Madden drill ship.



Photograph 42: Two light-phase Pomerine Jaegers in adult plumage, flying near the water on the north side of the Tom Madden drill ship.



Photograph 43: Light-phase Pomerine Jaeger in adult plumage, flying low on the north side of the Tom Madden drill ship.



Photograph 44: Light-phase Pomerine Jaeger flying low on the north side of the Tom Madden drill ship.



Photograph 45: Female Magnificent Frigatebird flying on the north side of the Tom Madden drill ship.



Photograph 46: Magnificent Frigatebird foraging a few meters above the water to the north of the Tom Madden drill ship.



Photograph 47: Female Magnificent Frigatebird flying low on the north side of the Tom Madden drill ship.



Photograph 48: Magnificent Frigatebird in immature plumage flying north of the Tom Madden drill ship.



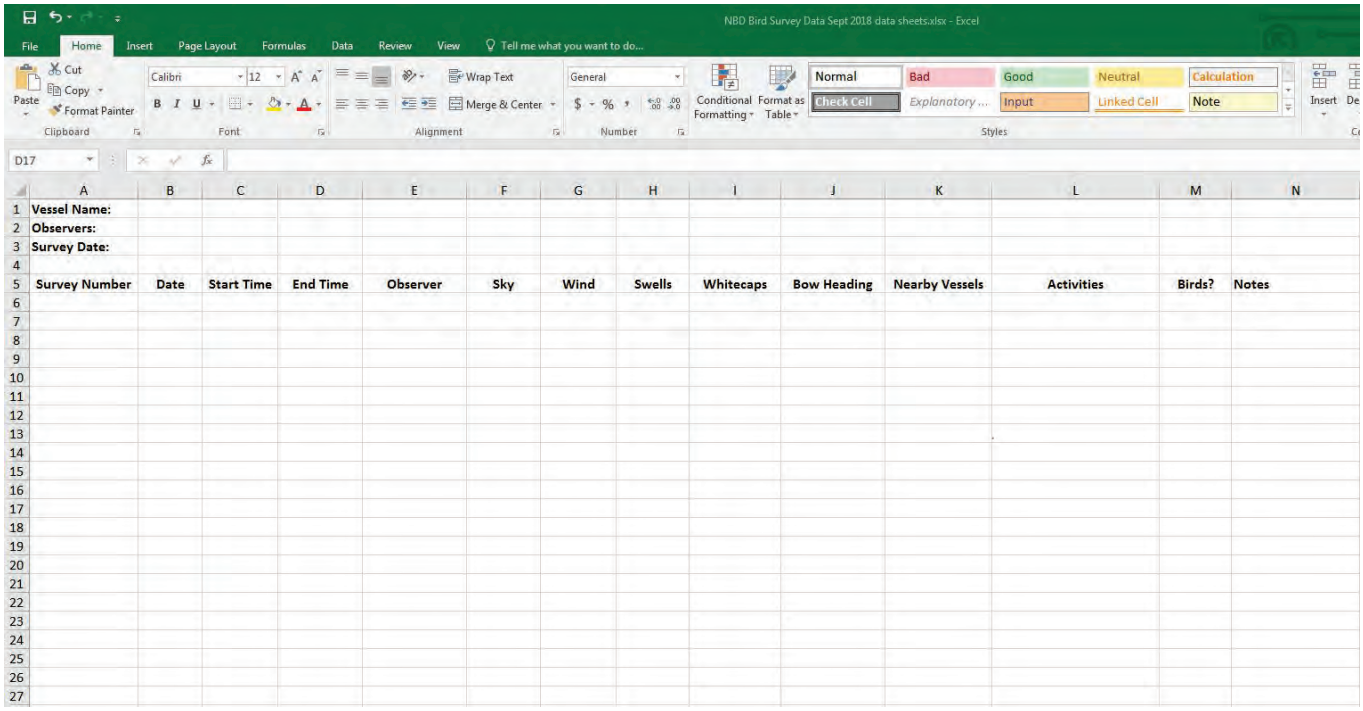
Photograph 49: Magnificent Frigatebird in immature plumage with fish, likely flying fish or mackerel.



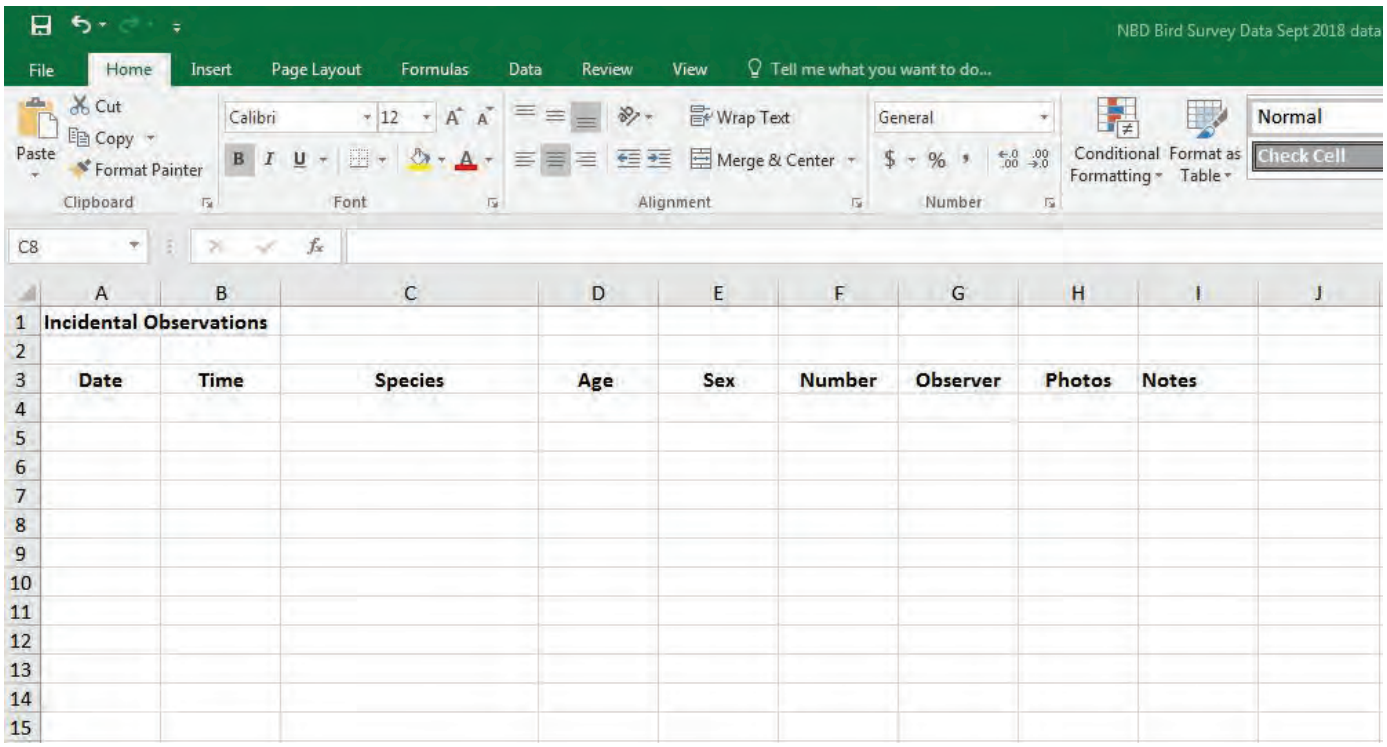
Photograph 50: Magnificent Frigatebird in immature plumage with fish and male Magnificent Frigatebird in young adult plumage in pursuit, on north side of the Tom Madden drill ship.

ATTACHMENT 1 DATA ENTRY TEMPLATES

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ERM

180 Admiral Cochran Drive Suite 400
Annapolis, Maryland 21401

Telephone: +1 (410) 266 0006
Fax: +1 (410) 266 6894

www.erm.com

Memo

To	Jena Lococo, Kari Ehmling
From	Julia Tims, Brian O'Shea, and Jeffrey McCrary
Date	31 May 2019
Reference	Year 2 Marine Bird Study—Survey 3
Subject	Interim Report

1 Introduction

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), Environmental Resources Management (ERM) conducted two marine bird surveys (Surveys 1a and 1b), collectively referred to herein as the Spring 2019 Survey, in the Stabroek Block and surrounding waters offshore Guyana in April 2019. The Spring 2019 Survey was the third of a series of five surveys conducted as part of EEPGL's Year 2 Marine Bird Study. This study is a continuation of the Year 1 Marine Bird Study conducted pursuant to a condition of the Environmental Permit for the Liza Phase 1 Development Project. The Year 2 Marine Bird Study is an elective study commissioned by EEPGL and is not being conducted pursuant to any regulatory requirement.

This memorandum summarizes the results and highlights the key findings of the Spring 2019 Survey. After completion of the Year 2 Marine Bird Study surveys, ERM will prepare a full report that details the results of all Year 2 surveys and compares those results with the results of all surveys conducted to date.

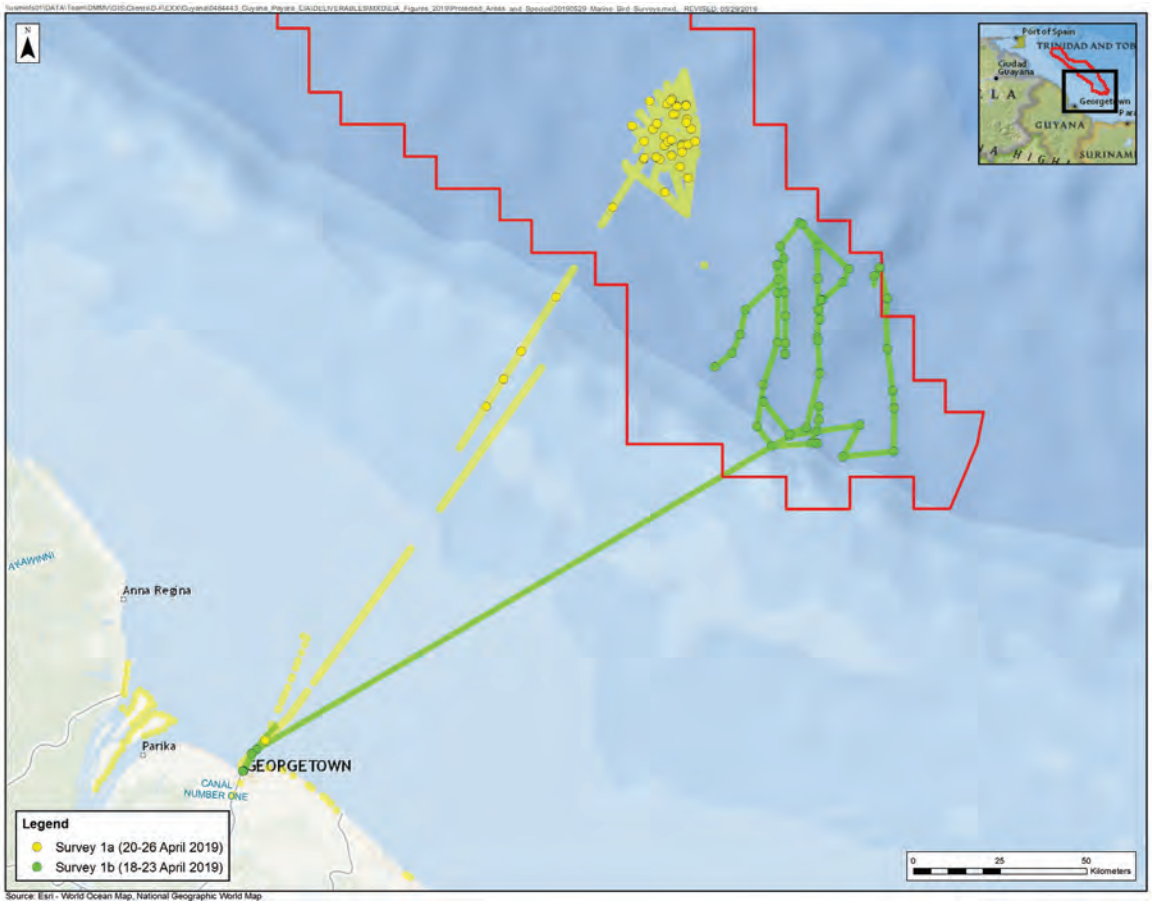
2 Survey Approach and Methods

Two marine bird survey events were conducted in the south-central and eastern portions of the Stabroek Block and in the area between the Stabroek Block and the Guyana coast in April 2019 (Figure 1). International and Guyanese bird specialists were stationed on moving vessels during the surveys. The two surveys included the following:

- Survey 1a was conducted from the *Captain Grady* from 20 April through 26 April 2019. Dr. Brian O'Shea, an international specialist, and Mr. Meshach Pierre, a Guyanese bird surveyor, conducted the survey.
- Survey 1b was conducted from the *Thor Magni* and *Delta Monarch*[1] from 18 April through 23 April 2019. Dr. Jeffrey McCrary, an international specialist, and Mr. Garey Sway, a Guyanese bird surveyor, conducted the survey.

[1] The survey involved a planned personnel transfer from the *Thor Magni* to the *Delta Monarch* on 21 April 2019.

Figure 1: Location of EEPGL-Commissioned Spring 2019 Marine Bird Surveys



This survey applied the protocol established for prior EEPGL-commissioned marine bird surveys to facilitate comparison of data across surveys. During each survey, one or two observers were stationed on each vessel's top deck. To minimize observer fatigue and eyestrain caused by continuous observation, observers conducted 30-minute surveys, each followed by a 15- or 30-minute break, between the hours of 05:30 and 17:30. During each 30-minute observation period, the observers continuously scanned the vessel and the ocean surrounding the vessel to locate and identify any birds present. The observers noted the locations of birds relative to the vessel (general direction or, when possible, compass heading), along with their estimated distance from the observer (greater or fewer than 300 meters [984.3 feet]) and direction of movement. Whenever possible, observers collected global positioning system (GPS) points at the location of sightings and photographed birds for documentation and, in some cases, species identification or confirmation. At the beginning of each 30-minute observation period, the observers noted sky condition, wind strength, intensity of swells, density of whitecaps (which tend to impede visibility of birds near the water surface), boat speed, and bow direction. In addition to the survey data, surveyors also recorded incidental observations of birds (i.e., birds observed outside of the observation periods).

Observers recorded data electronically in Microsoft Excel using a data entry template developed for this survey by ERM and the specialist team. The template is compatible with EEPGL's Geographic

Information System (GIS) platform (Attachment 1). Observers also field-tested an electronic data-entry format developed in Survey123 using an iPad.

Weather conditions for both surveys 1a and 1b were windy and seas were rough, with winds consistently exceeding 15 to 20 knots and medium to high swells. There was no significant rainfall during either survey event. Due to windy and rough conditions at sea and the complexity of the data collection involving taking GPS points and photographs of each bird sighting plus attempting to provide real-time species identification, the Survey123 data entry on the iPad was conducted post-survey instead of real-time, as initially conceived.

3 Results Summary

3.1 Survey 1a

Survey 1a was performed aboard the *Captain Grady*, which traveled from Georgetown to the Stabroek Block on 20 April, then crisscrossed the Payara Project Development Area continuously from 21 April through 25 April before returning to Georgetown on 26 April (Figure 1). This survey covered seven full days, during which two observers conducted 104 30-minute observation periods (79 in the Payara Project Development Area and 25 along the transit route). These counts yielded 228 individual birds of 18 species. Of these 18 species, 11 were pelagic species that occur almost exclusively offshore in this region; 5 were nearshore marine species (2 of which were only observed in transit to and from the Stabroek Block); and 2 were Nearctic-breeding shorebirds seen migrating through the survey area. The dominant marine bird species observed was Wilson's Storm-Petrel (*Oceanites oceanicus*), although Masked Booby (*Sula dactylatra*) and Sooty Tern (*Onychoprion fuscatus*) were also common, and Leach's Storm-Petrel (*Oceanodroma leucorhoa*; International Union for Conservation of Nature (IUCN) Vulnerable) was observed daily.

The observers recorded birds on 77 of 104 counts (74 percent). Incidental observations yielded another 46 individuals and 1 additional species, bringing the total number of birds observed to 274 and the total number of species to 19 (Table 1). All 19 species were documented with photographs. At least four of the species (Red-billed Tropicbird [*Phaethon aethereus*], White-tailed Tropicbird [*Phaethon lepturus*], Long-tailed Jaeger [*Stercorarius longicaudus*], and Arctic Tern [*Sterna paradise*]) have not previously been documented in Guyana's offshore waters and represent new records for the country.

Table 1: Bird Species Observed from the *Captain Grady*, 20 April through 26 April 2019.

Common Name	Species	Category	Number of Individuals Observed during Surveys and Incidental Observations
Wilson's Storm-Petrel	*Oceanites oceanicus*	Pelagic	62
Sooty Tern	*Onychoprion fuscatus*	Pelagic	43
Masked Booby	*Sula dactylatra*	Pelagic	42
Unidentified storm-petrel	Hydrobatidae sp.	Pelagic	36
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Pelagic	18
Manx/Audubon's Shearwater [a]	*Puffinus puffinus/lherminieri*	Pelagic	13
Black Skimmer	*Rynchops niger*	Nearshore Marine	12
Magnificent Frigatebird	*Fregata magnificens*	Nearshore Marine	12

Common Name	Species	Category	Number of Individuals Observed during Surveys and Incidental Observations
Common Tern	*Sterna hirundo*	Nearshore Marine	9
Red-billed Tropicbird	*Phaethon aethereus*	Pelagic	6
Whimbrel	*Numenius phaeopus*	Shorebird	5
Laughing Gull	*Leucophaeus atricilla*	Nearshore marine	3
Pomarine Jaeger	*Stercorarius pomarinus*	Pelagic	3
Long-tailed Jaeger	*Stercorarius longicaudus*	Pelagic	2
Royal Tern	*Thalasseus maximus*	Nearshore Marine	2
Arctic Tern	*Sterna paradise*	Pelagic	1
Cory's Shearwater	*Calonectris borealis*	Pelagic	1
Semipalmated Plover	*Charadrius semipalmatus*	Shorebird	1
White-tailed Tropicbird	*Phaethon lepturus*	Pelagic	1
Jaeger sp.	*Stercorarius* sp.	Pelagic	1

[a] Both species confirmed but the proportion of each species within the thirteen individuals observed was not certain so the data were recorded as either Manx Shearwater or Audubon's Shearwater.

3.2 Survey 1b

Survey 1b was conducted from the *Thor Magni* and the *Delta Monarch*, which traversed the eastern portion of the Stabroek Block, from 18 April through 23 April 2019 (Figure 1). This survey covered four full days and two partial days, during which two observers conducted 58 30-minute observation periods (6 along the transit route within the nearshore environment and 52 in the Stabroek Block) (Figure 1). These observation periods yielded 845 individual birds of 31 species (Table 2). The majority of the bird sightings (790) were recorded during the six observation periods that were conducted in the nearshore environment (within 10 kilometers [6.2 miles] of shore) (Table 2). The 52 observations conducted in the Stabroek Block yielded 55 individual birds of 10 species, all of which were marine birds. The dominant marine bird species observed during this survey was Masked Booby, followed by unidentified petrel or storm-petrel species, Wilson's Storm-Petrel, Leach's Storm-Petrel, and Audubon's Shearwater (*Puffinus lherminieri*).

The survey documented birds during 31 of the observation periods (53 percent). Surveyors had no incidental observations of birds during this survey.

Table 2: Bird Species Observed from the *Thor Magni* and the *Delta Monarch*, 18 April through 23 April 2019

Common Name	Species	Category	Number of Bird Sightings during Surveys and Incidental Observations
Laughing Gull	*Leucophaeus atricilla*	Coastal	309 [a]
Magnificent Frigatebird	*Fregata magnificens*	Nearshore Marine	247 [a]
Rock Pigeon (feral)	*Columba livia*	Terrestrial	144 [a]
Masked Booby	*Sula dactylatra*	Pelagic	24
Snowy Egret	*Egretta thula*	Coastal	24 [a]

Common Name	Species	Category	Number of Bird Sightings during Surveys and Incidental Observations
Gray-breasted Martin	*Progne chalybea*	Terrestrial	13 [a]
Little Blue Heron	*Egretta caerulea*	Coastal	9 [a]
Tricolored Heron	*Egretta tricolor*	Coastal	8 [a]
Unidentified petrel or storm-petrel		Pelagic	8
Wilson's Storm-Petrel	*Oceanites oceanicus*	Pelagic	6
Great Kiskadee	*Pitangus sulphuratus*	Terrestrial	6 [a]
Leach's Storm-Petrel	*Oceanodroma leucorhoa*	Pelagic	5
Audubon's Shearwater	*Puffinus lherminieri*	Pelagic	5
Cattle Egret	*Bubulcus ibis*	Coastal	5 [a]
Neotropic Cormorant	*Phalacrocorax brasilianus*	Coastal	4 [a]
Royal Tern	*Thalasseus maximus*	Coastal	3 [a]
Great Egret	*Ardea alba*	Coastal	3 [a]
Masked/Red-footed Booby	*Sula* sp.	Pelagic	3
Scarlet Ibis	*Eudocimus ruber*	Coastal	2 [a]
Black-crowned Night-Heron	*Nycticorax nycticorax*	Coastal	2 [a]
White-winged Swallow	*Tachycineta albiventer*	Terrestrial	2 [a]
Short-tailed Swift	*Chaetura brachyura*	Terrestrial	2 [a]
Black Skimmer	*Rynchops niger*	Coastal	2 [a]
Brown Booby	*Sula leucogaster*	Pelagic	2
Tropical Mockingbird	*Mimus gilvus*	Terrestrial	1 [a]
White-tailed Tropicbird	*Phaethon lepturus*	Pelagic	1
Carib Grackle	*Quiscalus lugubris*	Terrestrial	1 [a]
Spotted Sandpiper	*Actitis macularius*	Coastal	1 [a]
House Wren	*Troglodytes aedon*	Terrestrial	1 [a]
Great shearwater	*Ardenna gravis*	Pelagic	1
Long-tailed Jaeger	*Stercorarius longicaudus*	Pelagic	1
Unidentified shearwater species	*Puffinus* sp.	Pelagic	1
Unidentified tern species	*Sterninae* sp.	Coastal/Nearshore Marine/Pelagic	1 [a]

[a] Sightings of these species were made only while the survey vessels were in the nearshore environment (<10 kilometers [6.2 miles] from shore).

4 Discussion

To date, EEPGL has commissioned nine separate marine bird survey events within the Stabroek Block and in the area between the Stabroek Block and Georgetown, Guyana, which have been grouped by year and season for data analysis purposes, as summarized in Table 3.

Table 3: Summary of EEPGL-Commissioned Marine Bird Surveys 2017-2019

Survey Name	Number of Survey Events per Survey	Survey Date	Vessel Name	Vessel Type [a]
Fall 2017 Survey	1	30 September 2017–7 October 2017	Multiple unnamed fishing vessels	Mobile
Spring 2018 Survey	2			
Survey 1a	—	9 April 2018–15 April 2018	*Drifter98*	Mobile
Survey 1b	—	8 April 2018–15 April 2018	Unnamed fishing vessel	Mobile
Fall 2018 Survey	3			
Survey 1a	—	15 September 2018–25 September 2018	*Chouest Sable*	Mobile
Survey 1b	—	17 September 2018–1 October 2018	*Sea Service*	Mobile
Survey 1c	—	1 October 2018–6 October 2018	*Noble Bob Douglas*	Stationary
Winter 2019 Survey	1	28 January 2019–4 February 2019	*Noble Tom Madden*	Stationary
Spring 2019 Survey	2			
Survey 1a	—	18 April 2019–23 April 2019	*Captain Grady*	Mobile
Survey 1b	—	20 April 2019–26 April 2019	*Thor Magni* and *Delta Monarch*	Mobile

[a] Vessel type refers to whether the survey occurred aboard a stationary or mobile vessel. The stationary vessels were drill ships and the mobile vessels were various types of drill ship support vessels or sampling vessels.

A preliminary comparison of the Spring 2019 Survey results with those of the prior EEPGL-commissioned marine bird surveys, including the Spring 2018 survey that was conducted during a similar timeframe as this year (mid-April), indicates the following:

- The Spring 2019 Survey documented higher numbers of pelagic and nearshore marine bird species (i.e., species that spend most of their time in the nearshore and offshore marine environment) than any prior EEPGL-commissioned marine bird survey, particularly Survey 1a aboard the *Captain Grady*, which documented 17 pelagic and nearshore marine species. Some of the prior EEPGL-commissioned marine bird surveys had higher species richness overall but lower richness of strictly pelagic and nearshore marine bird species.

- The Spring 2019 Survey yielded more observations of shearwaters (three species, see Tables 1 and 2) than in any of the prior EEPGL-commissioned marine bird surveys. It is likely that the Spring 2019 Survey coincided with this year's peak northward migration for these shearwater species, which were observed during the April 2018 survey but in fewer numbers.

- Overall bird species composition documented during the Spring 2019 Survey was similar to that observed during the Spring 2018 Survey, although several species observed during the Spring 2019 Survey represent additions to the cumulative list for offshore marine bird surveys in Guyana, and at least four—Red-billed Tropicbird, White-tailed Tropicbird, Long-tailed Jaeger, and Arctic Tern—are new records for the country (Attachment 2 Photographic Log). As in the Spring 2018 Survey, the bird species composition documented within and near the Stabroek Block was dominated by storm-petrels of at least two species—Wilson's Storm-Petrel, an abundant seabird breeding in the far southern Atlantic, and Leach's Storm-Petrel, which breeds in New England and maritime Canada and is listed as Vulnerable by the IUCN. Neither of these species was observed during the Fall 2018 Survey or the Fall 2017 Survey, indicating that their use of offshore Guyana waters is strictly seasonal (spring). The presence of these birds in substantial numbers during the spring surveys of both years (2018 and 2019) highlights the importance of this area as a regular migration waypoint for these species from both northern and southern hemispheres.

- Movements of most seabirds during the Spring 2019 Survey did not show any strong directionality indicating migration or seasonal movement toward breeding areas, with the exception of Common Terns (*Sterna hirundo*) and Arctic Terns, which were always seen moving north towards their breeding grounds. Many seabirds approached the *Captain Grady*, and several species—particularly Wilson's Storm-Petrel, Masked Booby, and both species of tropicbirds—often followed the boat for extended periods of time. No birds were observed landing on the vessel. Although birds were relatively common in the survey area—we observed birds on 74 percent of our 30-minute counts, the highest proportion of any EEPGL marine survey conducted to date—there were no large concentrations of birds documented or obvious features of the marine environment that might have attracted the birds that were observed. Birds did not seem to congregate around mats of *Sargassum*, which were frequently encountered and often extensive, nor were they attracted to a large bloom of phytoplankton (tentatively identified as *Trichodesmium* sp.) that covered a vast area of the sea surface in and beyond the survey area.

- The Fall 2018 Survey remains the outlier in terms of the presence (and preponderance) of migratory landbird and shorebird species.[2] The Spring 2018, Winter 2019, and Spring 2019 surveys documented very few shorebird or landbird migrant species from North America. This result was anticipated for the Winter 2019 Survey since these are migrating species and so would only be expected to occur during fall and winter. The absence of these species during the Spring 2018 and Spring 2019 surveys was probably due to the timing of these surveys being after the migratory period for these species and the less protracted nature of spring versus fall migration. Most migratory landbirds, if still moving through the area in mid-April in 2018 or 2019,

[2] Barn Swallow (*Hirundo rustica*), a migrant landbird from North America, and Semipalmated Sandpiper (*Calidris pusilla*) were among the most numerous birds observed from the stationary vessel the *Noble Bob Douglas* in September 2018.

were likely in a hurry to reach their northern breeding areas and thus were likely passing overhead at altitudes that rendered them invisible to surveyors.

- The results of the Spring 2019 Survey support our previous assertion that bird surveys from mobile vessels produce higher counts of species and individuals than those conducted on stationary vessels, and are a more effective way to survey small-bodied seabirds that fly close to the water's surface, as most of the seabirds encountered during these surveys do. Since the surveys began in 2017, observers on mobile vessels have consistently recorded higher bird frequency than observers on stationary vessels. The data gathered to date also indicate that more seabirds were attracted to the moving vessels compared to the stationary ones and the large transit area covered by the moving vessel probably increased the likelihood of observing birds. However, it is important to note that surveys from stationary vessels offer some advantages, including having the observers situated much higher above the water surface (over 100 meters [328.1 feet] above), which is optimal for surveying migrating birds that fly near observer height or higher. In addition, stationary vessels are less prone to weather-related challenges that the surveyors encounter on the smaller moving vessels (e.g., intense wave action and boat movement, sea spray, etc.).

The results of the Spring 2019 Survey and the prior EEPGL-commissioned marine bird surveys make clear that the Guyana offshore avifauna changes substantially and consistently across a broad geographic area over the course of the year. Data from spring, winter, and fall surveys conducted in and around the Stabroek Block since 2017 suggest that seasonal differences in community composition are driven by the occurrence of species that breed at northern latitudes and move offshore during the winter months, traveling as far south as the coast of northern South America and sometimes congregating in areas with abundant resources (e.g., Common Tern, Leach's Storm-Petrel). Many of the species observed during the Spring 2019 Survey were northern breeders that had not yet departed for the breeding grounds (or were passing through, e.g., Arctic Tern). These results bolster the preliminary conclusions made from prior EEPGL-commissioned survey work that Guyana's offshore marine ecosystem supports a dynamic bird community and may be an important staging area[3] for seabirds breeding in both the northern and southern hemispheres.

5 Next Steps

The final two marine bird surveys in the Year 2 Marine Bird Study will be conducted between late June and mid-July 2019 (Survey 4 of 5 of the Year 2 Marine Bird Study) and between mid-September and mid-October 2019 (Survey 5 of 5 of the Year 2 Marine Bird Study). ERM will coordinate with EEPGL regarding vessel availability to support these surveys.

The abundance and diversity of seabirds in Guyana offshore waters during the northern summer remain virtually unknown, and will be revealed by the next round of surveys to be conducted in June/July 2019. We expect to find evidence of species turnover, as Nearctic breeders are replaced by species moving north from the southern Atlantic, either to spend the non-breeding season off the coast of Guyana, or to use the area en route to more productive waters further north. Data from the summer 2019 season will fill an important gap in our understanding of this dynamic bird community.

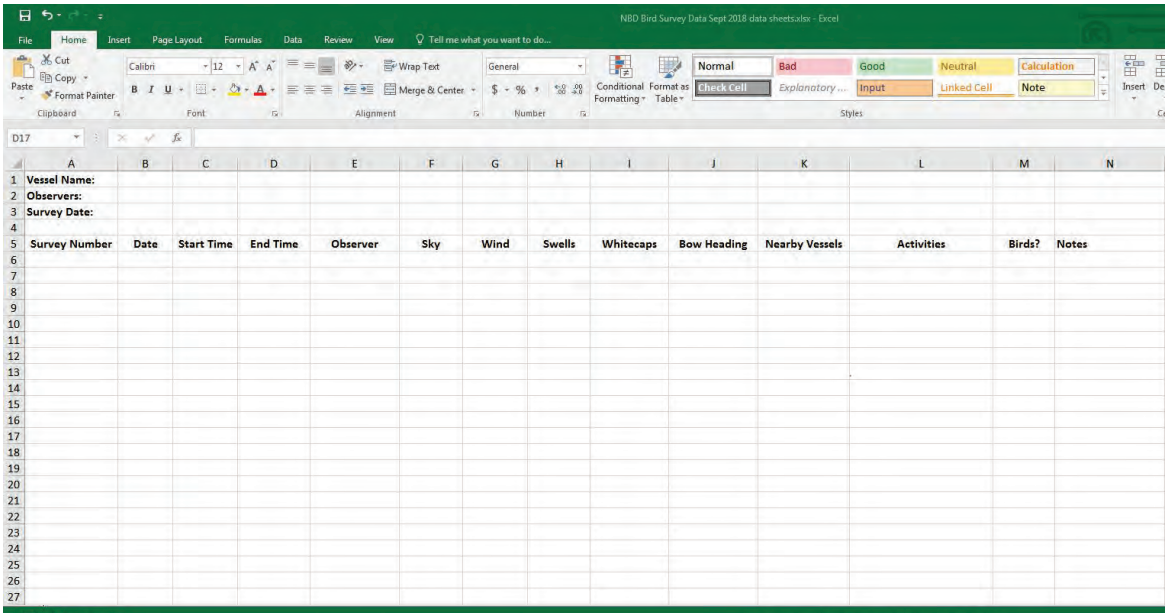
[3] Staging areas are areas along bird migration corridors that are consistently used by migrating birds for foraging and resting.

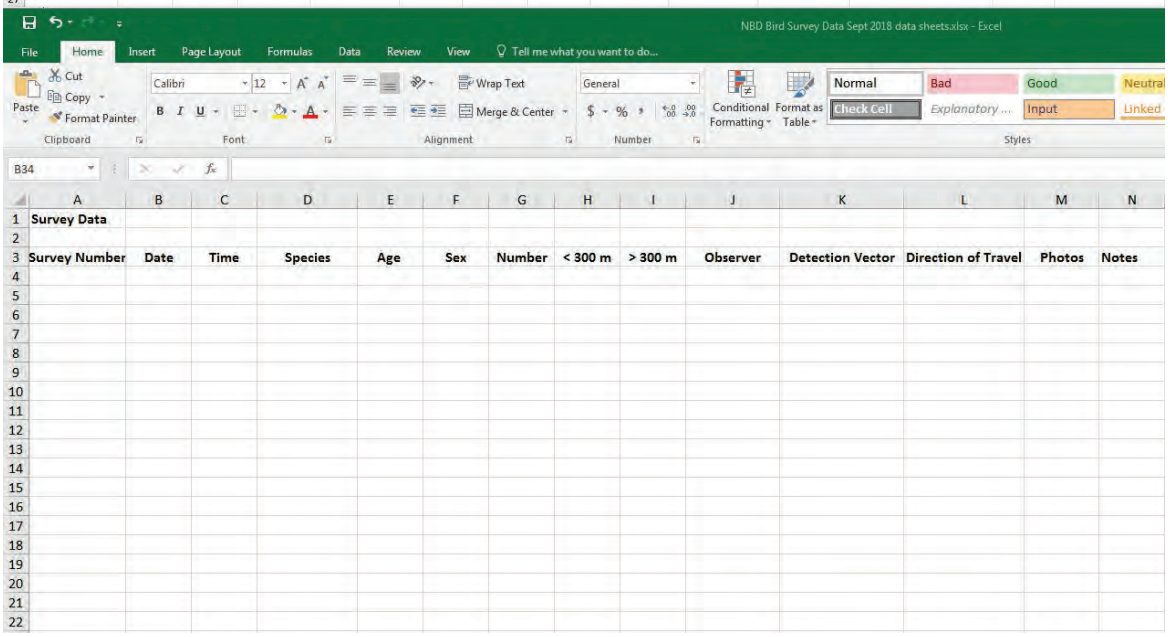
Due to windy and rough conditions at sea and the complexity of the data collection involving taking GPS points and photographs of each bird sighting plus attempting to provide real-time species identification, the Survey123 data entry on the iPad was conducted post-survey instead of real-time, as initially conceived. The surveyors determined that real-time data collection using the iPad-based Survey123 format is not feasible for the marine bird survey without compromising data quality and observer safety. As such, future marine bird surveys will revert to real-time paper or Excel-based data collection and that data will be transferred to the Survey123 program post-survey for integration into the Project GIS.

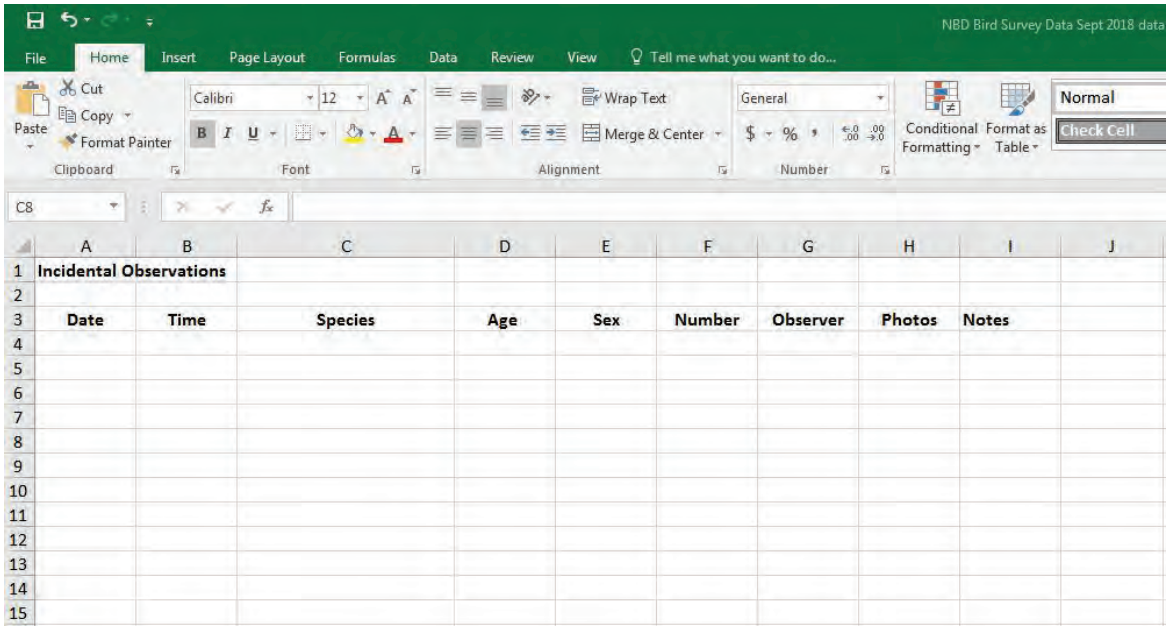
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ATTACHMENT 1 DATA ENTRY TEMPLATES

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ATTACHMENT 2 PHOTOGRAPHIC LOG

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Arctic Tern (*Sterna paradisaea*)



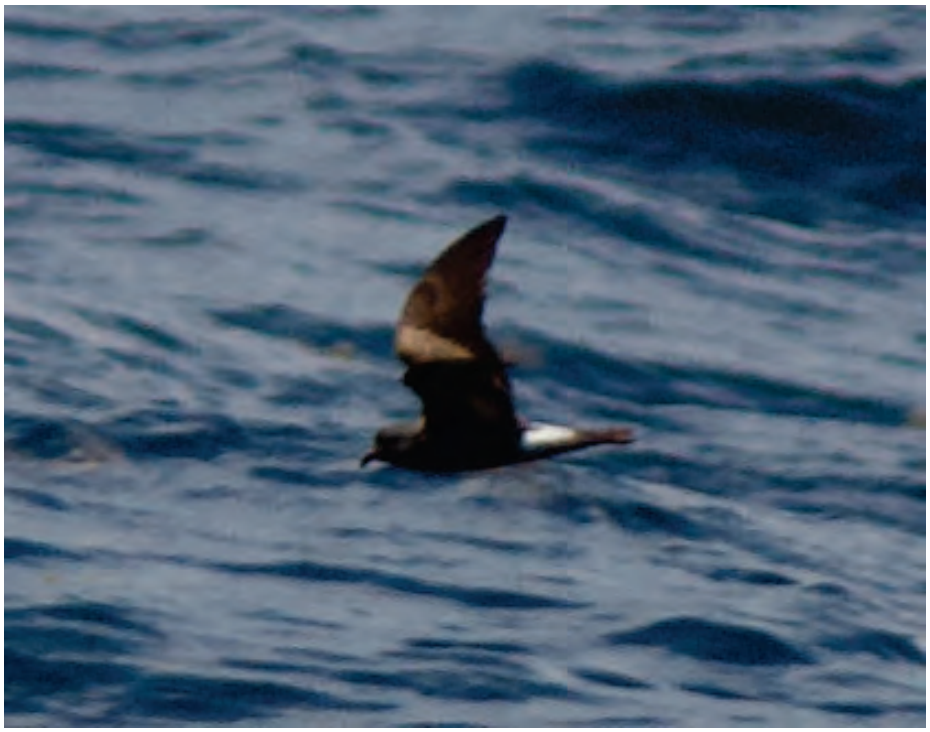
Black Skimmers *(Rynchops niger*)



Cory's Shearwater (*Calonectris diomedea*)—Breeding Adult



Laughing Gull (*Leucophaeus atricilla*)



Leach's Storm-Petrel (*Oceanodroma leucorhoa*)



Long-tailed Jaeger (*Stercorarius longicaudus*)



Magnificent Frigatebird (*Fregata magnificens*)



Masked Booby (*Sula dactylatra*)



Masked Booby (*Sula dactylatra*)



Masked Booby (*Sula dactylatra*) Foraging in the Stabroek Block



Masked Booby (*Sula dactylatra*) Diving into a School of Fish



Masked Booby (*Sula dactylatra*) Soaring above the Survey Vessel



Red-billed Tropicbird (*Phaethon aethereus*)



Red-billed Tropicbird (*Phaethon aethereus*)



Pomarine Jaeger (*Stercorarius pomarinus*)



Shearwater Species (*Puffinis* sp.)



Semipalmated Plover (*Charadrius semipalmatus*)



Sooty Tern (*Onychoprion fuscatus*)



Wilson's Storm-Petrel (*Oceanites oceanicus*)



Atlantic Bottlenose Dolphin (*Tursiops truncatus*)



Garey Sway, Guyanese Bird Surveyor, aboard the *Delta Monarch*



Jeffrey McCrary, International Bird Surveyor, aboard the *Delta Monarch*



Garey Sway and Jeffrey McCrary aboard the Transfer Vessel Traveling Between the *Thor Magni* and the *Delta Monarch*

APPENDIX M

Coastal Bird Survey Reports

Resubmitted without changes

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ERM

210 New Market Street
Georgetown, Guyana

Telephone: +592 5010625
www.erm.com

Technical Memorandum

To	Jena Lococo, Kari Ehmling
From	Julia Tims
Date	27 November 2018
Reference	Year 2 Coastal Bird Study—Survey 1
Subject	Interim Report

1 Introduction

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), Environmental Resources Management (ERM) conducted a survey of coastal birds along the coastline of Guyana within Regions 2–6 in September and October 2018. This survey is the first of a series of five surveys to be conducted as part of EEPGL's Year 2 Coastal Bird Study. This study is a continuation of the Year 1 Coastal Bird Study, which was conducted in conjunction with EEPGL's Enhanced Coastal Sensitivity Mapping work in 2017 and 2018. The Year 2 Coastal Bird Study is an elective study commissioned by EEPGL and is not being conducted pursuant to any regulatory requirement.

This memo summarizes the results and highlights the key findings of the September/October 2018 coastal bird survey. ERM will prepare a full report detailing the results of all Year 2 surveys and comparing results across surveys in late 2019 after completion of the Year 2 Coastal Bird Study surveys.

2 Survey Objectives

The objective of this first survey event of the Year 2 Coastal Bird Study was to document the distribution, abundance, and diversity of coastal birds in Regions 2–6. Documentation of coastal bird breeding sites, another objective of the Year 2 Coastal Bird Study, will be conducted in conjunction with the four quarterly coastal bird survey events planned for 2019.

3 Survey Approach and Methods

3.1 Timing and Location of Survey

On 14 and 15 September 2018 and 30 September through 3 October 2018, a bird survey team including Waldyke Prince (Guyanese bird specialist and survey lead), Garey Sway (Guyanese bird specialist), Philip Odwin (Guyanese bird survey advanced trainee), and Jeffrey McCrary (international bird specialist) surveyed coastal birds at 92 sites along the Guyana coastline in Regions 2–6 (Table 1). Attachment 1 lists the 92 coastal and island survey sites along with their region and primary habitat and includes a mapbook that depicts the locations of the sites. The coastal habitat types that were surveyed included mangrove (riverine and coastal), mudflat, plantation (island surveys only), and sandy beach.

Table 1: Number of Coastal Bird Survey Sites Surveyed in the September/October 2018 Coastal Bird Survey in Regions 2 through 6

Region	Geographic Range of Survey Area	Total Number of Survey Sites
2	Between the east bank of the Pomeroon River and the Supenaam River	6
3 (Coastal)	Region 3 coastal shoreline to Ruimzeight	7
3 (Essequibo Islands)	Tiger, Hog, Leguan, and Wakenaam Islands	52
4	Kingston seaside to the Mahaica River mouth	16
5	Sans Souci to Woodley Park	6
6	Maida Seaside to Springlands	5
Total		**92**

3.2 Survey Methods

3.2.1 Coastal Point Count Surveys

Surveyors conducted 15-minute point count surveys at the survey sites within Regions 2–6 that were established during the Year 1 Coastal Bird Survey (Table 1 and Attachment 1). To the extent practicable, surveys were conducted in the morning hours between 06:00 and 10:00, when birds are most active. However, this was not always possible due to tidal stage and related site accessibility or other constraints.

From each survey site, observations were made within a radius of approximately 500 meters around the survey site. Survey sites were electronically recorded using GPS and photographed. Observers recorded data on a hard copy data form developed for this survey by ERM and the specialist team (Attachment 4). Surveyors subsequently transferred the hard copy data into an electronic Excel-based data-entry template that is compatible with EEPGL's Geographic Information System (GIS) platform.

The following information was collected during each point count survey:

- Survey location (latitude and longitude or GPS coordinates of the survey site)
- Date
- Observation type (incidental, transect survey, point count survey)
- Start/stop time of survey
- Brief site/habitat description and site ID
- Weather (% cloud cover, precipitation, wind speed, wind direction, temperature)
- For each species seen or heard:
  - Species identification (or lowest taxonomic level identifiable)
  - Number of individuals (if in a group)

3.2.2 Island Point Count Surveys

Surveys of the Region 3 island sites (Essequibo Islands) were conducted via boat. These sites were surveyed from the water using the same point count methodology as the land-based surveys described above.

4 Results Summary

This survey documented 128 species and 21,887 birds, representing 33 bird families. Coastal sites documented 90 species and island sites documented 73 species, with 35 species recorded at both coastal and island sites and 38 species recorded only at the island sites. Of the 128 species observed during this survey, six (all shorebirds) were new to the list of species documented from the Year 1 Coastal Bird Study. All of the species documented during this survey have been previously recorded in Guyana. Attachment 2 contains the survey data for the September/October 2018 coastal bird survey.

The following bird families were particularly well-represented in terms of numbers of species and/or individuals observed.

- *Accipitridae* and other birds of prey—17 species
- *Tyrannidae* (tyrant flycatchers)—17 species
- *Scolopacidae* (sandpipers)—14 species
- *Ardeidae* (herons)—9 species
- *Laridae* (gulls)—7 species
- *Charadriidae* (plovers and lapwings)—6 species
- *Icteridae* (orioles, grackles, and cowbirds)—8 species
- *Columbidae* (pigeons and doves)—5 species
- *Thraupidae* (tanagers)—5 species

The most common shorebirds observed during the September/October 2018 survey were Semipalmated Sandpiper (*Calidris pusilla*), Semipalmated Plover (*Charadrius semipalmatus*), White-Rumped Sandpiper (*Calidris fuscicollis*), Lesser Yellowlegs (*Tringa flavipes*), Sanderling (*Calidris alba*), Short-Billed Dowitcher (*Limnodromus griseus*), and Spotted Sandpiper (*Actitis macularius*). The most common colonial waterbirds observed were Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*), Scarlet Ibis (*Eudocimus ruber*), and Tricolored Heron (*Egretta tricolor*). Twenty species of migratory shorebirds were documented during the September/October 2018 survey, six more than documented during the Year 1 Coastal Bird Study. This is likely because this survey appears to have coincided with the peak period for fall shorebird migration this year.[1] Of the six species not recorded during the Year 1 Coastal Bird Study, two are not frequently documented in Guyana: Red Knot (*Calidris canutus*) and Hudsonian Godwit (*Limosa haemastica*).

[1] Peak migratory periods are variable from year to year, based on weather and other factors.

Four species of international conservation concern[2] were documented during the survey: Rufous Crab Hawk (*Buteogallus aequinoctialis*), Bicolored Conebill (*Conirostrum bicolor*), Semipalmated Sandpiper, and Red Knot. The current International Union for the Conservation of Nature (IUCN) Red List status for all of these species is "Near Threatened", and all but the Red Knot were previously observed during the Year 1 Coastal Bird Study. Only one of the three species of local conservation interest [3] documented during the Year 1 Coastal Bird Study was observed again during this survey: the Silvered Antbird (*Sclateria naevia*). The other two species that were previously observed are the Gray-headed Kite (*Leptodon cayennensis*) and the subspecies *fumosus* of Fuscous Flycatcher (*Cnemotriccus fuscatus*). Both of these species were observed on the Essequibo Islands during the fall 2017 survey of the Year 1 Coastal Bird Study, but were not recorded at any sites during this survey.

Consistent with the Year 1 Coastal Bird Study, sites with exposed mudflats had the highest abundance of birds of any habitat surveyed and the riverine mangrove habitats of the Essequibo Islands supported the highest species richness (number of species), followed by mudflats and then coastal mangroves. The 63-Beach and 61-Beach shorelines in Region 6, even though they are sandy beaches rather than mudflats, provide foraging grounds for *Calidris sp*. and Semipalmated Plover. Physical evidence and information provided by locals to the survey team document that shorebird hunting is common at these sites.

4.1 Regional Results

Table 2 presents total bird abundance and species richness, by region, recorded during the September/October 2018 coastal bird survey. Region 6 had the greatest total abundance (10,236 birds) followed by Region 5 (3,891 birds) and Region 2 (3,278 birds). This differed from the Year 1 Coastal Bird Study[4], during which Region 4 had the highest total abundance followed by Region 2. The September/October 2018 survey results also differed from the Year 1 Coastal Bird Study in the large number of birds observed in Regions 5 and 6 during the September/October 2018 survey (over 3,000 birds observed at one site in Region 5 and almost 10,000 birds documented at two sites in Region 6). This is nearly double the number of birds observed at these sites during the fall 2017 survey of the Year 1 Coastal Bird Study, and is likely because the September/October 2018 survey appears to have coincided with the peak shorebird migration through Guyana.

Region 3 had the greatest species richness (80 species), followed by Region 4 (63 species). This is a similar result to that of the Year 1 surveys except that the number of species recorded at the

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[2] The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN Red List) is the definitive authority on global species conservation status. Species considered to be of international conservation concern are those with IUCN Red List status of Near Threatened, Vulnerable, Endangered, or Critically Endangered.

[3] Species of local conservation interest are species that are considered by Guyanese and international bird specialists to be rare and/or declining in Guyana or have very limited distribution in Guyana but are not species of global conservation concern based on their IUCN Red List status.

[4] Throughout this report, when referring to results of the Year 1 Coastal Bird Study, this includes all Year 1 survey data combined. If a particular survey is referenced (e.g., fall 2017 survey), the statement applies only to that survey.

Region 3 sites during this survey was lower than that recorded during the Year 1 Coastal Bird Study (80 versus 104 species, respectively).

These data provide further evidence to support one of the key preliminary findings of the Year 1 Coastal Bird Study—that there is high seasonal and inter-annual variability in species richness and abundance across sites and regions.

Eleven species occurred in all five regions surveyed as compared to seven species recorded in all regions during the Year 1 Coastal Bird Study. Nine of these 11 species are considered marine species (e.g., terns and gulls) and 24 are wetland-specific species, including the mangrove-specialists Rufous Crab Hawk and Bicolored Conebill (both IUCN Red List Near Threatened).

Table 2: Total Bird Species Abundance and Richness Recorded in Regions 2 through 6 during the September/October 2018 Coastal Bird Survey

Region	Bird Abundance (Number of Individual Birds)	Bird Species Richness (Number of Bird Species)
2	3,278	50
3	1,381	80
4	3,101	63
5	3,891	56
6	10,236	50

4.2 Site-Specific Results

4.2.1 Data Summary

The highest bird abundance documented in this survey occurred at Maida Seaside in Region 6 (6,553 birds), followed by Bush Lot in Region 5 (3,281 birds) and Phillipe Seaside in Region 6 (3,238 birds). The highest species richness occurred on Wakenaam Island in Region 3 (52 species), followed by Moor Park in Region 5 (37 species) and Enmore in Region 4 and Leguan Island in Region 3 (32 species each).

The lowest bird abundances (<10 birds) were recorded at Hopetown and Wooley Park in Region 5 (0 and 6 birds, respectively) and 61-Beach in Region 6 (9 birds). These same sites also had the lowest species richness of the sites surveyed.

Due to logistical considerations, several coastal sites had to be surveyed during or near high tide so the number and diversity of birds observed at these sites was likely lower than what would be expected during optimal tidal conditions. These sites included Springlands, Turkeyen, Ogle, Philadelphia, 63-Beach, 61-Beach, Farm, Meter-Meer-Zorg, Leonora, and Enmore.

With the exception of the Ruimzeight site in Region 3 - where mangroves were removed and replaced with boulder riprap along the shoreline (see Attachment 3 for photos of this area), surveyors documented no alterations or distinct physical changes to any of the survey sites since the last survey conducted in April 2018. The change in habitat at the Ruimzeight site likely contributed to the

distinct reduction in bird abundance and diversity observed there during this survey. Only 33 birds of nine species were recorded during this survey, compared with 175 birds of 24 species recorded during the fall 2017 survey.

4.2.2 Important Bird Habitats

The 10 sites identified as Important Bird Habitats within Regions 2 through 6[5] during the Year 1 Coastal Bird Study all had high numbers and diversity of birds during this survey, indicating consistent, concentrated use of these areas by large numbers of birds and bird species across multiple survey events and validating the Year 1 Coastal Bird Study designation of these sites as Important Bird Habitats. No new Important Bird Habitats were designated based on the results of the September/October 2018 survey.

As summarized above, particularly high numbers of shorebirds were recorded during the September/October 2018 survey at Bush Lot and the Maida and Phillipe seasides in Regions 5 and 6. All of these sites were designated as Important Bird Habitats during the Year 1 Coastal Bird Study. This survey confirmed that the shorebirds that forage on the mudflats between Maida and Phillipe also forage in the former rice fields located behind the shoreline in this area that are currently being used for shrimp farming. Some of these shrimp ponds are becoming shallower due to revegetation and accretion of mud, providing the perfect combination of shallow water and the right consistency of mud to attract foraging shorebirds and waterbirds at high tide when the mudflat is not exposed.

In addition to the important foraging habitats within the mudflats and inland shrimp farms between Maida and Phillipe, the mangroves that line the shoreline in this area support thousands of breeding and roosting waterbirds, including Scarlet Ibis, all of the egret and heron species found along the Guyana coast, Snail Kite (*Rostrhamus sociabilis*), and Smooth-billed Ani (*Crotophaga ani*). The multiple uses of this area during critical life stages and functions (breeding, roosting, and foraging) by a large variety of Guyana's coastal bird species makes the area between Maida and Phillipe one of the most valuable Important Bird Habitats of the 10 identified to date in Regions 2 through 6.

Survey data and historical information provided by a local fisherman documented regular, concentrated use of the mangroves at and near the Victoria site (Region 4) by roosting and breeding waterbirds, including Scarlet Ibis and numerous other mangrove-specialist species. This further corroborates the Year 1 Coastal Bird Study designation of this site as an Important Bird Habitat. Little is known about the number and species assemblage of birds using this site and the timing of breeding, so a focus of the 2019 coastal bird surveys will be to document these important use factors at this and other sites.

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[5] The Year 1 Coastal Bird Study defined Important Bird Habitats as sites that support one or more of the following: (1) predictable congregations of migratory shorebirds; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest. The Important Bird Habitats identified within Regions 2 through 6 during the Year 1 Coastal Bird Survey include: Exmouth Seaside, Walton Hall Seaside, Essequibo Island Complex, Ogle Seaside, Triumph-BV Seaside, Enmore Seaside, Hope Beach Seaside, Victoria Seaside, Bush Lot Seaside, and the area between Maida and Phillipe.

During the April 2018 survey conducted as part of the Year 1 Coastal Bird Study, hundreds of Black-bellied Whistling Ducks (*Dendrocygna autumnalis*) were observed on Leguan Island. The surveyors noted that this island, particularly its extensive rice farms, could be an important roosting or resting site for this species, but that additional data were needed to make this determination. Interestingly, this species was not observed on any of the islands (or any of the surveyed sites) during the September/October 2018 survey. The 2019 surveys will aim to help determine if this area is indeed important, at least seasonally, for this species.

5 Discussion

Overall, particularly at the regional level, coastal bird species richness, species assemblage, and habitat use documented during the September/October 2018 survey was similar to that observed during the Year 1 Coastal Bird Study, including the fall 2017 survey event - to which this survey is most comparable. Conversely, bird abundance was markedly different during this survey compared with prior surveys—more than double that of the fall 2017 survey and roughly equivalent to the abundance of all three Year 1 Coastal Bird Study survey events combined. This difference was primarily driven by high shorebird abundance recorded at three sites in Regions 5 and 6 (Bush Lot, Maida, and Phillipe) during this survey, which was likely due to the timing of the survey at these sites in early October 2018, which appears to have coincided with peak shorebird migration through Guyana this year.

The site-specific results from this survey and the three Year 1 Coastal Bird Study survey events were much more variable across sites and survey events than the regional results, with the exception of the sites designated as Important Bird Habitats, which consistently showed higher numbers and/or diversity of birds across multiple survey events. This is an expected finding given that birds are highly mobile and coastal bird presence and abundance are often dictated by the location of food resources, time of day, tidal stage, and other factors. Accordingly, only sites with high quality and consistent food supply or other important resources (e.g., nesting or roosting sites) would be expected to regularly support high concentrations of birds. The consistency in the data observed for the Important Bird Habitats across survey events validates the Year 1 Coastal Bird Study designation of these sites as Important Bird Habitats.

The timing of this survey was slightly different than in fall 2017[6] and a different species assemblage of migratory shorebirds was observed, including six species not observed during the fall 2017 survey and observations of species that are not often observed in Guyana such as Red Knot and Hudsonian Godwit. This demonstrates the importance of surveying during different periods of the year and that even slight differences in survey timing can make a difference in terms of species observed and bird abundance.

As documented in the Year 1 Coastal Bird Study, bird detection rates, particularly at the coastal survey sites, were strongly influenced by both tidal stage and time of day. It is a known limitation of

[6] The fall 2017 survey was split into two survey periods based on surveyor availability—one in mid-late September and another in mid-late October. This September/October 2018 survey was also split into two periods, but the timing of this survey's data collection periods was earlier in September and earlier in October than the 2017 fall survey.

this type of survey to sometimes experience suboptimal survey conditions at a given site (e.g., the optimal tidal stage does not always coincide with optimal time of day for surveying birds, surveyor availability, or logistical requirements). In these circumstances, the survey team has adjusted the survey approach to the extent possible to minimize this effect (e.g., by focusing on mangrove sites during high tide). To address this issue during future surveys, the survey team will split into two groups, allowing for more sites whose bird communities are strongly influenced by tidal condition to be surveyed during the optimal mid- to low-tide range. This approach is possible due to the increased number of surveyors that will be involved in the 2019 survey events (two leads and two or three trainees).

6 Next Steps

The next coastal bird survey will be conducted in January/February 2019. Prior to this survey, a training session led by the Guyanese survey leads Leon Moore and Wally Prince will be conducted in Georgetown, Guyana. The training will cover coastal bird identification and survey techniques, data recording protocols, and electronic data management, and all trainees that will be involved in the 2019 surveys will attend.

ATTACHMENT 1 COASTAL BIRD SURVEY SITES AND MAPBOOK

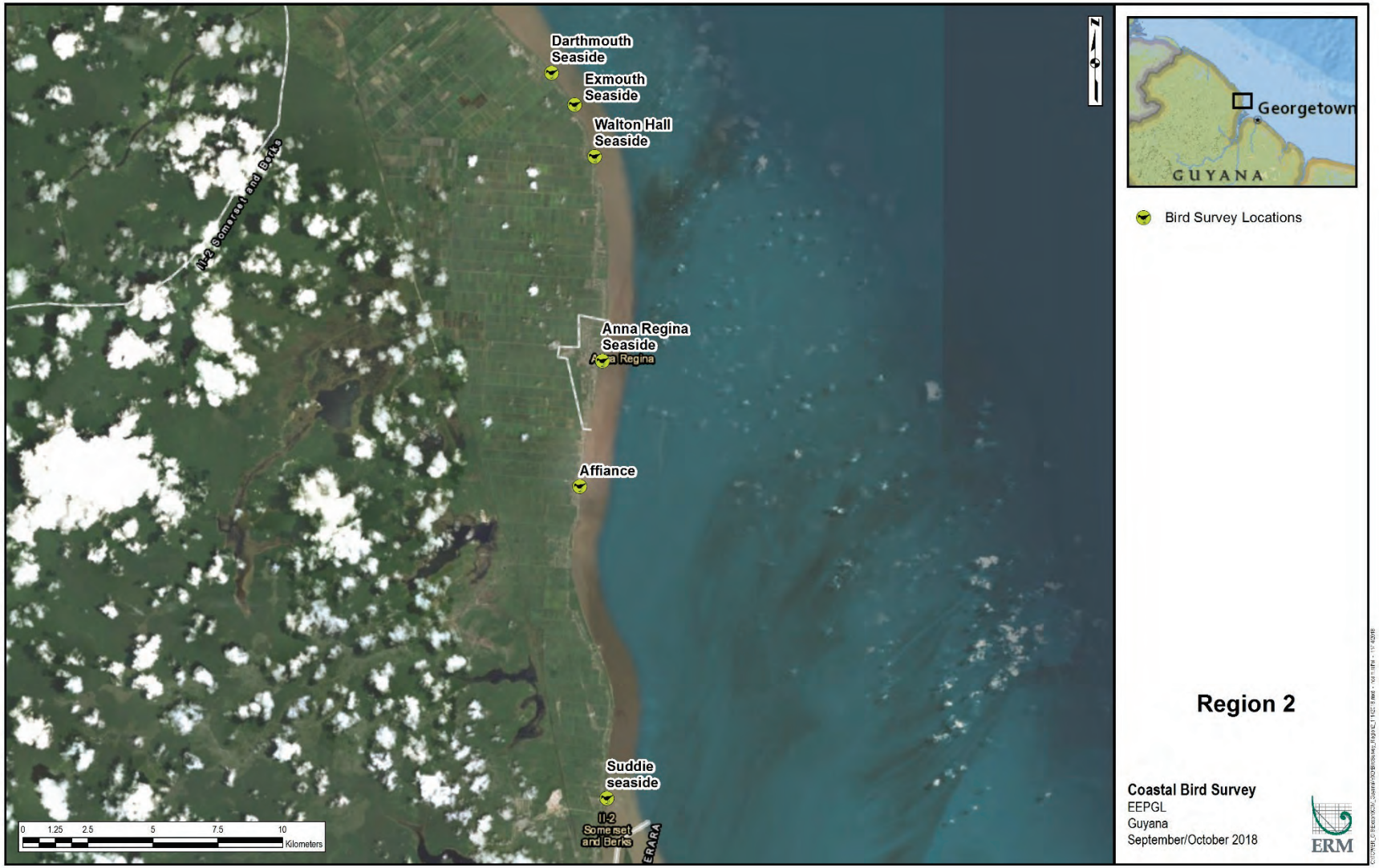
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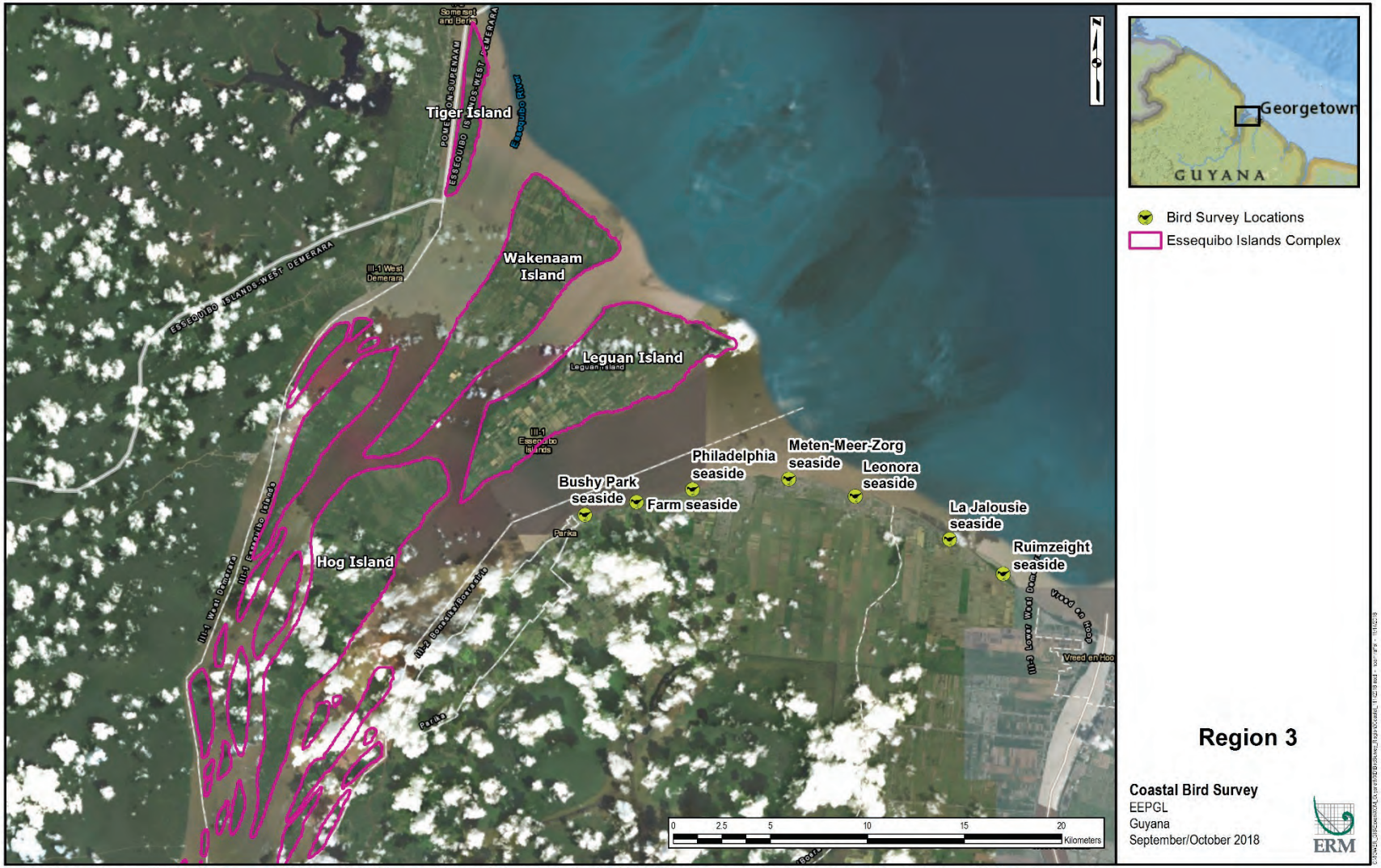
Coastal Bird Survey Sites for Regions 2–6, September/October 2018

Survey Site	Name	Region	Habitat Type
Coastal Sites			
DM-R2	Dartmouth	2	Sea wall, mudflat
EX-R2	Exmouth	2	Mudflat
WH-R2	Walton Hall	2	Mudflat and tidal wetland
AR-R2	Anna Regina	2	Mudflat
AF-R2	Affiance	2	Sea wall, mudflat, mangrove
SU-R2	Suddie	2	Sand beach, jetty
BP-R3	Bushy Park	3	Sand beach
FR-R3	Farm	3	Sea wall, mudflat
PH-R3	Philadelphia	3	Sea wall, mudflat
MM-R3	Meten-Meer-Zoor	3	Sea wall, mudflat
LN-R3	Lenora	3	Sea wall, mudflat
L J-R3	La Jalousie	3	Sea wall, mudflat
RZ-R3	Ruimzeight	3	Sea wall, mudflat
KS-R4	Kingston	4	Sand beach, jetty
TK- R4	Turkeyen	4	Sea wall, mudflat
OG-R4	Ogle	4	Mudflats
LBI-R4	LBI Seawall	4	Mudflat, mangrove
BV-R4	BV-Triumph	4	Sea wall, intertidal wetland, mudflat
LU-R4	Lusignan	4	Mudflat
PA-R4	Paradise	4	Mangrove
EM-R4	Enmore	4	Mudflat
VT-R4	Victoria	4	Sea wall, intertidal wetland, mudflat, mangrove
NZ-R4	Nooten Zuil	4	Seawall–open, some mangrove
HB-R4	Hope Beach	4	Mudflat, mangrove
HC-R4	Hope Canal	4	Mudflat, mangrove
Bee-R4	Bee Hive	4	Mangrove
CB-R4	Clonbrook	4	Mudflat, mangrove
UN-R4	Unity	4	Sand beach, jetty
MA-R4	Mahaica	4	Mudflat, mangrove
SS-R5	Sans Souci	5	Mangrove
AB-R5	Abary	5	Sand beach
MP-R5	Moor Park	5	Mangrove and mudflat
BL-R5	Bush Lot	5	Mudflat
HT-R5	Hopetown	5	Mangrove
WP-R5	Woodley Park	5	Mangrove
MS-R6	Maida Seaside	6	Sand beach

Survey Site	Name	Region	Habitat Type
PS-R6	Phillipe Seaside	6	Sand beach
61B-R6	61-Beach Seaside	6	Sand beach
63B-R6	63-Beach Seaside	6	Sand beach
SL-R6	Springlands	6	Sand beach
Essequibo Island Sites			
Tig1-R3	Tiger Island 1	3	Sand beach, mangrove
Tig2-R3	Tiger Island 2	3	Sand beach, mangrove
Tig3-R3	Tiger Island 3	3	Sand beach, mangrove
Tig4-R3	Tiger Island 4	3	Mangrove
Tig5-R3	Tiger Island 5	3	Mangrove
Tig6-R3	Tiger Island 6	3	Sand beach, mangrove
Tig7-R3	Tiger Island 7	3	Sand beach, mangrove
Tig8-R3	Tiger Island 8	3	Sand beach, mangrove
Tig9-R3	Tiger Island 9	3	Sand beach, mangrove
Wak1-R3	Wakenaam 1	3	Sand beach, mangrove
Wak2-R3	Wakenaam 2	3	Sand beach, mangrove
Wak3-R3	Wakenaam 3	3	Sand beach, mangrove
Wak4-R3	Wakenaam 4	3	Sand beach, mangrove
Wak5-R3	Wakenaam 5	3	Sand beach, mangrove
Wak6-R3	Wakenaam 6	3	Sand beach, mangrove
Wak7-R3	Wakenaam 7	3	Sans beach, mangrove
Wak8-R3	Wakenaam 8	3	Sand beach, mangrove
Wak9-R3	Wakenaam 9	3	Sand beach, mangrove
Wak10-R3	Wakenaam 10	3	Cement wall, some mangrove
Wak11-R3	Wakenaam 11	3	Cement wall, some mangrove
Wak12-R3	Wakenaam 12	3	Mangrove
Wak13-R3	Wakenaam 13	3	Mangrove
Wak14-R3	Wakenaam 14	3	Mangrove
Wak15-R3	Wakenaam 15	3	Mangrove
Wak16-R3	Wakenaam 16	3	Mangrove
Wak17-R3	Wakenaam 17	3	Mangrove
Wak18-R3	Wakenaam 18	3	Mangrove
Leg1-R3	Leguan 1	3	Cement wall
Leg2-R3	Leguan 2	3	Cement wall
Leg3-R3	Leguan 3	3	Cement wall, mangrove
Leg4-R3	Leguan 4	3	Mangrove, plantation
Leg5-R3	Leguan 5	3	Sand beach, plantation
Leg6-R3	Leguan 6	3	Mudflat, mangrove

Survey Site	Name	Region	Habitat Type
Leg7-R3	Leguan 7	3	Mudflat, mangrove
Leg8-R3	Leguan 8	3	Mudflat, mangrove
Leg9-R3	Leguan 9	3	Mudflat, mangrove
Leg10-R3	Leguan 10	3	Mudflat, mangrove
Leg11-R3	Leguan 11	3	Mangrove
Leg12-R3	Leguan 12	3	Mangrove
Leg13-R3	Leguan 13	3	Mangrove
Leg14-R3	Leguan 14	3	Mangrove
Leg15-R3	Leguan 15	3	Mangrove
Hog1-R3	Hog Island 1	3	Mudflat, mangrove
Hog2-R3	Hog Island 2	3	Mudflat, mangrove
Hog3-R3	Hog Island 3	3	Mudflat, mangrove
Hog4-R3	Hog Island 4	3	Mudflat, mangrove
Hog5-R3	Hog Island 5	3	Mudflat, mangrove
Hog6-R3	Hog Island 6	3	Mudflat, mangrove
Hog7-R3	Hog Island 7	3	Mangrove
Hog8-R3	Hog Island 8	3	Mangrove
Hog9-R3	Hog Island 9	3	Mangrove


Darthmouth
Seaside
Exmouth
Seaside
Walton Hall
Seaside
II-2 Somerset and Berks
Anna Regina
Seaside
Affiance
Suddie
seaside
II-2
Somerset
and Berks
ERARA
0 1.25 2.5 5 7.5 10
Kilometers
N
Georgetown
GUYANA
Bird Survey Locations
Region 2
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM


Tiger Island
Wakenaam Island
Leguan Island
Hog Island
Bushy Park seaside
Farm seaside
Philadelphia seaside
Meten-Meer-Zorg seaside
Leonora seaside
La Jalousie seaside
Ruimzeight seaside
Parika
Vreed en Hoop
Georgetown
GUYANA
Bird Survey Locations
Essequibo Islands Complex
0 2.5 5 10 15 20
Kilometers
Region 3
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM


Kingston Seaside
Turkeyen Seaside
Ogle Seaside
LBI Seawall
Triumph - BV Seaside
Lusignan Seaside
Paradise
Enmore Seaside
Victoria Seaside
Hope Beach Seaside
Nooten Zuil
Hope Canal
Bee Hive
Clonbrook
Unity
Mahaica River mouth
Georgetown
Zoological Park
Turkeyen
Atlanti Ville
South Ruimveldt Gardens
Lamaha Springs
Agricola
0 1 2 4 6 8
Kilometers
Georgetown
GUYANA
Bird Survey Locations
Region 4
Coastal Bird Survey
EEPGL
Guyana
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ERM


Sans Souci
Abary
Moor Park
Bush Lot
Hopetown
Woodley Park
V-2
Mahaicony/Berbice
Berbice River
VI-2 East
Canje/E.
C. Berb
0
2.5
5
10
15
20
Kilometers
N
Georgetown
GUYANA
Bird Survey Locations
Region 5
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM


Maida
Phillipe Seaside
61-Beach Seaside
63-Beach Seaside
Springlands
Georgetown
GUYANA
Legend
Region 6
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM
0 2.5 5 10 15 20
Kilometers

ATTACHMENT 2 COASTAL BIRD SURVEY DATA FOR REGIONS 2-6, SEPTEMBER/OCTOBER 2018

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A: Coastal Bird Survey Data for Regions 2–3, September/October 2018

TAXA			SURVEYED SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Wak-R3	Tig-R3	Leg-R3	Hog - R3	**Total**
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*		2									14							**16**
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	12		1	4														**17**
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*																		**0**
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*																7		**7**
Ardeidae	Cocoi Heron	*Ardea cocoi*														1		1		**2**
Ardeidae	Little Blue-Heron	*Egretta caerulea*	23	25	16		1									1		6		**72**
Ardeidae	Tricolored Heron	*Egretta tricolor*	13	6	3	2	3							1	1			2		**31**
Ardeidae	Striated Heron	*Butorides striata*								2									1	**3**
Ardeidae	Great Egret	*Ardea alba*		2			1					2	6	4			1			**16**
Ardeidae	Snowy Egret	*Egretta thula*		120	83	43	6				1	5	82	50	20	12		33	7	**462**
Ardeidae	Cattle Egret	*Bubulcus ibis*	3		2								2			1				**8**
Aramidae	Limpkin	*Aramus guarauna*	1				2													**3**
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	1	11	7	1	1					2						26		**49**
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*																		**0**
Cathartidae	Turkey Vulture	*Catharthes aura*	5	8	3	1	1	7								5	6	8	6	**50**
Cathartidae	Black Vulture	*Coragyps atratus*	1								2									**3**
Accipitridae	Osprey	*Pandion haliaetus*		1												1				**2**
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*														1				**1**
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*														1				**1**
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*																		**0**
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*										2			3				1	**6**

TAXA			SURVEYED SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Wak-R3	Tig-R3	Leg-R3	Hog - R3	**Total**
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*										1								**1**
Accipitridae	Grey-lined Hawk	*Buteo nitidus*														2				**2**
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*														1	1			**2**
Accipitridae	Roadside Hawk	*Rupornis magnirostris*														3	1			**4**
Cracidae	Little Chacalaca	*Ortalis motmot*							2											**2**
Jacanidae	Wattled Jacana	*Jacana jacana*	2		2								1							**5**
Charadriidae	Southern Lapwing	*Vanellus chilensis*														1				**1**
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*			14		40	4	1				8	2			4	150	9	**232**
Charadriidae	Collared Plover	*Charadrius collaris*																		**0**
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*											6							**6**
Scolopacidae	Red Knot	*Calidris canutus*																		**0**
Scolopacidae	Sanderling	*Calidris alba*										2								**2**
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*																		**0**
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	1		1	1			1			1	2		3	4		5	1	**20**
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	200	500	910	80												51		**1741**
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*																		**0**
Scolopacidae	Least Sandpiper	*Calidris minutilla*																		**0**
Scolopacidae	Western Sandpiper	*Calidris mauri*											2							**0**
Scolopacidae	Calidris sp.	*Calidris sp.*		500			15									2				**517**
Scolopacidae	Whimbrel	*Numenius phaeopus*			4	1	2													**7**
Scolopacidae	Willet	*Tringa semipalmata*			1											5		2		**8**
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*				3														**3**

TAXA			SURVEYED SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Wak-R3	Tig-R3	Leg-R3	Hog - R3	**Total**
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*		80	39	50	20													**189**
Scolopacidae	Yellowlegs sp.	*Tringa sp.*		50										1	1					**52**
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*			9		1													**10**
Charadriidae	Hudsonian Godwit	*Limosa haemastica*																		**0**
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*		4			8													**12**
Charadriidae	Plover sp.	*Pluvialis sp.*																		**0**
Laridae	Laughing Gull	*Leucophaeus atricilla*	2										12	1		1		1		**17**
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	1	11	1	3	4						2							**22**
Laridae	Large-billed Tern	*Phaetusa simplex*										2	3		1	4	21	14		**45**
Laridae	Royal Tern	*Thalasseus maximus*																		**0**
Laridae	Common Tern	*Sterna hirundo*		3																**3**
Laridae	Least Tern	*Sternula antillarum*																		**0**
Laridae	Black Skimmers	*Rynchops niger*	3	9	2															**14**
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*														3			1	**4**
Accipitridae	Snail Kite	*Rostrhamus sociabilis*								1			1		1					**3**
Falconidae	Northern Crested Caracara	*Caracara cheriway*																		**0**
Falconidae	Yellow-headed Caracara	*Milvago chimachima*			1									1		2	1	2		**7**
Strigidae	Great Horned Owl	*Bubo virginianus*															1			**1**
Columbidae	Rock Pigeon	*Columba livia domestica*					3						1							**4**
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*																		**0**
Columbidae	Ruddy Ground-Dove	*Columba plumbea*							2		5	4	5	1						**17**
Columbidae	Common Ground-Dove	*Columbina passerina*																		**0**

TAXA			SURVEYED SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Wak-R3	Tig-R3	Leg-R3	Hog - R3	**Total**
Columbidae	White-tipped Dove	*Leptotila verreauxi*														1		1		**2**
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*																	14	**14**
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*														4				**4**
Cuculidae	Striped Cuckoo	*Tapera naevia*														1				**1**
Cuculidae	Little Cuckoo	*Coccycua minuta*																		**0**
Cuculidae	Greater Ani	*Crotophaga major*														4				**4**
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	3			7					6		1						3	**20**
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*														1				**1**
Trochilidae	White-chested Emerald	*Amazilia brevirostris*									1									**1**
Trochilidae	Emerald sp	*Amazilia sp.*														1	1	1		**3**
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*														2				**2**
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*														1	1			**2**
Alcedinidae	Toco Toucan	*Ramphastos toco*																		**0**
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*																		**0**
Alcedinidae	Green Kingfisher	*Chloroceryle americana*														2				**2**
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*																		**0**
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*														2	1	2		**5**
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*														1		2		**3**
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	4			3	2											1		**10**
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*											2							**2**
Thamnophilidae	Silvered Antbird	*Sclateria naevia*														6	1			**7**
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*														12		4		**16**

TAXA			SURVEYED SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Wak-R3	Tig-R3	Leg-R3	Hog - R3	**Total**
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*																		**0**
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	1	2	2	3		7	1	3	2	5	25	4		20	1	14	2	**92**
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*							2											**2**
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	1	2		2	2	1	3	1	2		2			5	3	2	2	**28**
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*						1								1				**2**
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*				2	2			2	1		2			8		5		**22**
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*														2	2		2	**6**
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*															1			**1**
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*							4							2				**6**
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*															1			**1**
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*				3			2				2	4		17	1	10	6	**45**
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	2			1												1		**4**
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*														1				**1**
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*														2				**2**
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*														1				**1**
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	2			1	1		3	2		2	1	1		2				**15**
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*																1		**1**
Hirundinidae	Gray-breasted Martin	*Progne chalybea*			2		3	3	11	1	8	7	4	4		7	2	7	2	**61**
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*				2									1		2			**5**
Hirundinidae	Barn Swallow	*Hirundo rustica*			40		20	107			5					11	33	16		**232**
Troglodytidae	Southern House-wren	*Troglodytes aedon*				1				2	2									**5**
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*														2				**2**

TAXA			SURVEYED SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Wak-R3	Tig-R3	Leg-R3	Hog - R3	**Total**
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*																3		**3**
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	2						2					2		4	2	2		**14**
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*														2				**2**
Thraupidae	Turquoise Tanager	*Tangara mexicana*																	3	**3**
Thraupidae	Bananaquit	*Coereba flaveola*																	1	**1**
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*				2			1											**3**
Cardinalidae	Grayish Saltator	*Saltator coerulescens*																		**0**
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*				2						3		1						**6**
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	4																	**4**
Parulidae	Yellow Warbler	*Setophaga petechia*									1					2		1		**4**
Icteridae	Yellow Oriole	*Icterus nigrogularis*				2	1		2	1				2		2				**10**
Icteridae	Giant Cowbird	*Molothrus oryzivorus*																159	2	**161**
Icteridae	Shiny Cowbird	*Molothrus bonariensis*					2				1									**3**
Icteridae	Carib Grackle	*Quiscalus lugubris*										2	2		2	2				**8**
Icteridae	Crested Oropendola	*Psarocolius decumanus*														4				**4**
Icteridae	Yellow-rumped Cacique	*Cacicus cela*															70			**70**
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*		9	3	3	6			5										**26**
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*																		**0**
BIRD ABUNDANCE			**287**	**1345**	**1146**	**223**	**147**	**130**	**37**	**20**	**37**	**40**	**188**	**79**	**33**	**186**	**158**	**540**	**63**	**4659**
SPECIES DIVERSITY			**22**	**19**	**22**	**25**	**24**	**7**	**14**	**10**	**13**	**14**	**24**	**15**	**9**	**52**	**23**	**32**	**17**	**104**

Site Name Abbreviations: DM-Darthmouth, EX-Exmouth, WH-Walton Hall, SU-Suddie, BP-Bushy Park, FR-Farm, PH-Philadelphia, MM-Meten-Meer-Zorg, LN-Leonora, LJ-La Jalousie, RZ-Ruimzeight, Wak-Wakenaam Island, Tig-Tiger Island, Leg-Leguan Island, Hog-Hog Island

B: Coastal Bird Survey Data for Region 4, September/October 2018

TAXA			SURVEYED SITES- REGION 4															
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CL-R4	UN-R4	MA-R4	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	9	26	32		2	3			3								75
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*		1	2		8	1		1	10		3						26
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*			1			2		2	1								6
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*																	0
Ardeidae	Cocoi Heron	*Ardea cocoi*											1						1
Ardeidae	Little Blue-Heron	*Egretta caerulea*				30	10	104		13	4			1	1			2	165
Ardeidae	Tricolored Heron	*Egretta tricolor*		3	3	23	10			4		2	1	1	1		1	1	50
Ardeidae	Striated Heron	*Butorides striata*								1									1
Ardeidae	Great Egret	*Ardea alba*		3	37		4	4	1			1							50
Ardeidae	Snowy Egret	*Egretta thula*	2	2	19	79	7	200		23		4	5	2	1		8		352
Ardeidae	Cattle Egret	*Bubulcus ibis*																	0
Aramidae	Limpkin	*Aramus guarauna*																	0
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*			1	21	38	130	2	13	30	5	21		13		15		289
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*																	0
Cathartidae	Turkey Vulture	*Catharthes aura*								1	2		1		1		3		8
Cathartidae	Black Vulture	*Coragyps atratus*													1				1
Accipitridae	Osprey	*Pandion haliaetus*																	0
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*																	0
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*																	0
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*																	0
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*											1					1	2
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*																	0

TAXA			SURVEYED SITES- REGION 4															
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CL-R4	UN-R4	MA-R4	Total
Accipitridae	Grey-lined Hawk	*Buteo nitidus*													1				1
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*																	0
Accipitridae	Roadside Hawk	*Rupornis magnirostris*																	0
Cracidae	Little Chacalaca	*Ortalis motmot*																	0
Jacanidae	Wattled Jacana	*Jacana jacana*							2	7				2					11
Charadriidae	Southern Lapwing	*Vanellus chilensis*																	0
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	110		96		33	18			2		1		34		3		297
Charadriidae	Collared Plover	*Charadrius collaris*																	0
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	2										1						3
Scolopacidae	Red Knot	*Calidris canutus*									38				22				60
Scolopacidae	Sanderling	*Calidris alba*	6							3									9
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*																	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	2	1	3		4			2	2		7	1	5		3	1	31
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	11				101	86		3	12							5	218
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*																	0
Scolopacidae	Least Sandpiper	*Calidris minutilla*																	0
Scolopacidae	Western Sandpiper	*Calidris mauri*																	0
Scolopacidae	Calidris sp.	*Calidris sp.*						500		85									585
Scolopacidae	Whimbrel	*Numenius phaeopus*			1		9	50		9	2		1						72
Scolopacidae	Willet	*Tringa semipalmata*	2					8		8									18
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*								3			2						5
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*					33	2			4						17		56
Scolopacidae	Yellowlegs sp.	*Tringa sp.*																	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*																	0

TAXA			SURVEYED SITES- REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CL-R4	UN-R4	MA-R4	Total
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	2																2
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*						3		6	2								11
Charadriidae	Plover sp.	*Pluvialis sp.*																	0
Laridae	Laughing Gull	*Leucophaeus atricilla*	5	2	1	5		1											14
Laridae	Gull-billed Tern	*Gelochelidon nilotica*								3	1								4
Laridae	Large-billed Tern	*Phaetusa simplex*		2			2			2			1						7
Laridae	Royal Tern	*Thalasseus maximus*		1						2							4		7
Laridae	Common Tern	*Sterna hirundo*				1	1	21											23
Laridae	Least Tern	*Sternula antillarum*						50		25	5						2		82
Laridae	Black Skimmers	*Rynchops niger*	1			30		100		50	8				8		8	123	328
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*																	0
Accipitridae	Snail Kite	*Rostrhamus sociabilis*		2			3			4	1	1		2	5			1	19
Falconidae	Northern Crested Caracara	*Caracara cheriway*																	0
Falconidae	Yellow-headed Caracara	*Milvago chimachima*				1				1					1				3
Strigidae	Great Horned Owl	*Bubo virginianus*																	0
Columbidae	Rock Pigeon	*Columba livia domestica*	**6**				**2**											16	24
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*											1						1
Columbidae	Ruddy Ground-Dove	*Columba plumbea*		2				2	2										6
Columbidae	Common Ground-Dove	*Columbina passerina*								2	4			2	2			1	11
Columbidae	White-tipped Dove	*Leptotila verreauxi*																	0
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*																	0
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*																2	2

TAXA			SURVEYED SITES- REGION 4															
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CL-R4	UN-R4	MA-R4	Total
Cuculidae	Striped Cuckoo	*Tapera naevia*																	0
Cuculidae	Little Cuckoo	*Coccycua minuta*																	0
Cuculidae	Greater Ani	*Crotophaga major*																	0
Cuculidae	Smooth-billed Ani	*Crotophaga ani*								2									2
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*																	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*																	0
Trochilidae	Emerald sp	*Amazilia sp.*																	0
Apodidae	Short-tailed Swift	*Chaetura brachyura*	3																3
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*																	0
Ramphastidae	Toco Toucan	*Ramphastos toco*																	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*																	0
Alcedinidae	Green Kingfisher	*Chloroceryle americana*																	0
Alcedinidae	American Pygmy Kingfisher	*Chloroceryle aenea*																	0
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*																	0
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*																	0
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*								2	2								4
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*		2															2
Thamnophilidae	Silvered Antbird	*Sclateria naevia*																	0
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*											2						2
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*																	0
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	5	2		3	5	3	3	5	3	2	2	3	5		2		43
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*																	0
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	2			2			1	2	1								8

TAXA			SURVEYED SITES- REGION 4															
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CL-R4	UN-R4	MA-R4	Total
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*																	0
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*								2	2			1				4	9
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*																	0
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*																	0
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*																	0
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*																	0
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*									4		4						8
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*												1					1
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*																	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*																	0
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*																	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*		3		1					1								5
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*																	0
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	4	4		3	2	1	3	5	2		2	1	3		1		31
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*						1										2	3
Hirundinidae	Barn Swallow	*Hirundo rustica*	9	1	3			2	1	3					10				29
Troglodytidae	Southern House-wren	*Troglodytes aedon*					2								2				4
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*																	0
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*																	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*							2										2
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*																	0
Thraupidae	Turquoise Tanager	*Tangara mexicana*																	0
Thraupidae	Bananaquit	*Coereba flaveola*																	0

TAXA			SURVEYED SITES- REGION 4															
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CL-R4	UN-R4	MA-R4	Total
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*													2				2
Cardinalidae	Grayish Saltator	*Saltator coerulescens*																	0
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*							1										1
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*																	0
Parulidae	Yellow Warbler	*Setophaga petechia*																	0
Icteridae	Yellow Oriole	*Icterus nigrogularis*																	0
Icteridae	Giant Cowbird	*Molothrus oryzivorus*																	0
Icteridae	Shiny Cowbird	*Molothrus bonariensis*						4											4
Icteridae	Carib Grackle	*Quiscalus lugubris*																	0
Icteridae	Crested Oropendola	*Psarocolius decumanus*																	0
Icteridae	Yellow-rumped Cacique	*Cacicus cela*																	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*																	0
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*							2										2
BIRD ABUNDANCE			**181**	**57**	**199**	**199**	**276**	**1296**	**20**	**294**	**146**	**15**	**57**	**17**	**118**	**NA***	**67**	**159**	**3101**
SPECIES DIVERSITY			**17**	**16**	**12**	**12**	**19**	**24**	**11**	**32**	**25**	**6**	**18**	**11**	**19**	**NA***	**12**	**12**	**68**

Site Name Abbreviations: KS-Kingston, TK-Turkeyen, OG-Ogle, LBI-La Bonne Intention, BV-Triumph, LU-Lusignan, PA-Paradise, EM-Enmore, VT-Victoria, NZ-Nooten Zuil, HB-Hope Beach, HC-Hope Canal, Bee-BeeHive, Cl-Clonbrook, UN-Unity, MA-Mahaica

C: Coastal Bird Survey Data for Regions 5-6, September/October 2018

TAXA			SURVEYED SITES - REGIONS 5 AND 6											
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	**Total**
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	10	5	2					3	3			**23**
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*		4		2			83					**89**
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*			4					6				**10**
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*												**0**
Ardeidae	Cocoi Heron	*Ardea cocoi*		1	2	12			12	6				**33**
Ardeidae	Little Blue Heron	*Egretta caerulea*			74	119			250	83				**526**
Ardeidae	Tricolored Heron	*Egretta tricolor*	1						11					**12**
Ardeidae	Striated Heron	*Butorides striata*			1	1			1					**3**
Ardeidae	Great Egret	*Ardea alba*			4	3				15				**22**
Ardeidae	Snowy Egret	*Egretta thula*	2		46	134			300	426				**908**
Ardeidae	Cattle Egret	*Bubulcus ibis*												**0**
Aramidae	Limpkin	*Aramus guarauna*			2									**2**
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*			10				4	8				**22**
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*		3										**3**
Cathartidae	Turkey Vulture	*Catharthes aura*	2	5						1	1			**9**
Cathartidae	Black Vulture	*Coragyps atratus*		5									10	**15**
Accipitridae	Osprey	*Pandion haliaetus*		1										**1**
Accipitridae	Common Black Hawk	*Buteogallus anthracinus*												**0**
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*												**0**
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*				1								**1**
Accipitridae	Rufous Crab Hawk	*Buteogallus aequinoctialis*								2				**2**
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*			2									**2**
Accipitridae	Grey-lined Hawk	*Buteo nitidus*												**0**

TAXA			SURVEYED SITES - REGIONS 5 AND 6											
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	**Total**
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*												**0**
Accipitridae	Roadside Hawk	*Rupornis magnirostris*			1									**1**
Jacanidae	Wattled Jacana	*Jacana jacana*			7	4								**11**
Charadriidae	Southern Lapwing	*Vanellus chilensis*				2								**2**
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*			11	20						25		**56**
Charadriidae	Collared Plover	*Charadrius collaris*										13		**13**
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*										4		**4**
Scolopacidae	Red Knot	*Calidris canutus*		1										**1**
Scolopacidae	Sanderling	*Calidris alba*		1								4	2	**7**
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*			40	110			220					**370**
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	2	3	4	9			3	3				**24**
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*		46	50	30			100			11	260	**497**
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*			3									**3**
Scolopacidae	Least Sandpiper	*Calidris minutilla*							23			2		**25**
Scolopacidae	Calidris sp.	*Calidris sp.*			100	2000			5300	580				**7980**
Scolopacidae	Whimbrel	*Numenius phaeopus*	1		2	2			1	2	1	1		**10**
Scolopacidae	Willet	*Tringa semipalmata*								10				**10**
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*				4								**4**
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	1		20	500				2010		2		**2533**
Scolopacidae	Yellowlegs sp.	*Tringa sp.*							100					**100**
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*				300								**300**
Charadriidae	Hudsonian Godwit	*Limosa haemastica*										4		**4**
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*				6			8			6		**20**
Charadriidae	Plover sp.	*Pluvialis sp.*								50				**50**

TAXA			SURVEYED SITES - REGIONS 5 AND 6											
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	**Total**
Laridae	Laughing Gull	*Leucophaeus atricilla*			17	4						12		**33**
Laridae	Gull-billed Tern	*Gelochelidon nilotica*								1		2		**3**
Laridae	Large-billed Tern	*Phaetusa simplex*	1	1							2	5	1	**10**
Laridae	Royal Tern	*Thalasseus maximus*										3		**3**
Laridae	Common Tern	*Sterna hirundo*										12		**12**
Laridae	Least Tern	*Sternula antillarum*										3		**3**
Laridae	Black Skimmer	*Rynchops niger*							120	2		20		**142**
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*												**0**
Accipitridae	Snail Kite	*Rostrhamus sociabilis*			1									**1**
Falconidae	Northern Crested Caracara	*Caracara cheriway*		2									1	**3**
Falconidae	Yellow-headed Caracara	*Milvago chimachima*												**0**
Strigidae	Great Horned Owl	*Bubo virginianus*		1										**1**
Columbidae	Ruddy Ground Dove	*Columba plumbea*						2						**2**
Columbidae	Common Ground Dove	*Columbina passerina*			3			1	4	2				**10**
Columbidae	White-tipped Dove	*Leptotila verreauxi*			1	2								**3**
Psittacidae	Red-shouldered Macaw	*Diopsittaca nobilis*												**0**
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	8	3	4	4								**19**
Cuculidae	Striped Cuckoo	*Tapera naevia*												**0**
Cuculidae	Little Cuckoo	*Coccycua minuta*		1										**1**
Cuculidae	Greater Ani	*Crotophaga major*	1											**1**
Cuculidae	Smooth-billed Ani	*Crotophaga ani*							2					**2**
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*												**0**
Trochilidae	White-chested Emerald	*Amazilia brevirostris*			2									**2**
Trochilidae	Emerald sp.	*Amazilia sp.*												**0**

TAXA			SURVEYED SITES - REGIONS 5 AND 6											
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	**Total**
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*												**0**
Ramphastidae	Toco Toucan	*Ramphastos toco*												**0**
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*		1										**1**
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	1							1				**2**
Alcedinidae	American Pygmy Kingfisher	*Chloroceryle aenea*												**0**
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	2											**2**
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*												**0**
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*			5	2								**7**
Thamnophilidae	Silvered Antbird	*Sclateria naevia*												**0**
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	2						2	2				**6**
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*			2									**2**
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	4		10	3		2	4	5	2			**30**
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	3		2					4				**9**
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	1											**1**
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	2											**2**
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*												**0**
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*			1									**1**
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*												**0**
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*												**0**
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	4		4	4			2	6				**20**
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*			4									**4**
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*												**0**
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	2		2									**4**
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*												**0**

TAXA			SURVEYED SITES - REGIONS 5 AND 6											
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	**Total**
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*						1						**1**
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*												**0**
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	2	3	8	3				5			7	**28**
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*											1	**1**
Hirundinidae	Barn Swallow	*Hirundo rustica*	6						3			5	20	**34**
Troglodytidae	Southern House Wren	*Troglodytes aedon*												**0**
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*												**0**
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*								2				**2**
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*			2									**2**
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*												**0**
Thraupidae	Turquoise Tanager	*Tangara mexicana*												**0**
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*								2				**2**
Cardinalidae	Grayish Saltator	*Saltator coerulescens*			1					1				**2**
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*												**0**
Parulidae	Yellow Warbler	*Setophaga petechia*												**0**
Icteridae	Yellow Oriole	*Icterus nigrogularis*	2											**2**
Icteridae	Giant Cowbird	*Molothrus oryzivorus*												**0**
Icteridae	Crested Oropendola	*Psarocolius decumanus*												**0**
Icteridae	Yellow-rumped Cacique	*Cacicus cela*												**0**
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*												**0**
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*			3									**3**
BIRD ABUNDANCE			**60**	**87**	**457**	**3281**	**0**	**6**	**6553**	**3238**	**9**	**134**	**302**	**14127**
SPECIES DIVERSITY			**22**	**18**	**37**	**26**	**0**	**4**	**21**	**27**	**5**	**18**	**8**	**83**

Site Name Abbreviations: SS-Sans Souci, AB-Abary, MP-Moor Park, BL-Bush Lot, HT-Hope Town, WP-Woodley Park, MS-Maida Seaside, PS-Phillipe Seaside. 61B-61 Beach, 63B-63 Beach, SL-Springlands

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ATTACHMENT 3 PHOTOGRAPHIC LOG—COASTAL BIRD SURVEY SEPTEMBER/OCTOBER 2018

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Large-billed Terns (*Phaetusa simplexgularis*) at Tiger Island seaside



Yellow-hooded Blackbird (*Chrysomus icterocephalus*) at Tiger Island



Toco Toucan (*Ramphastus toco*) at Wakenaam shoreline



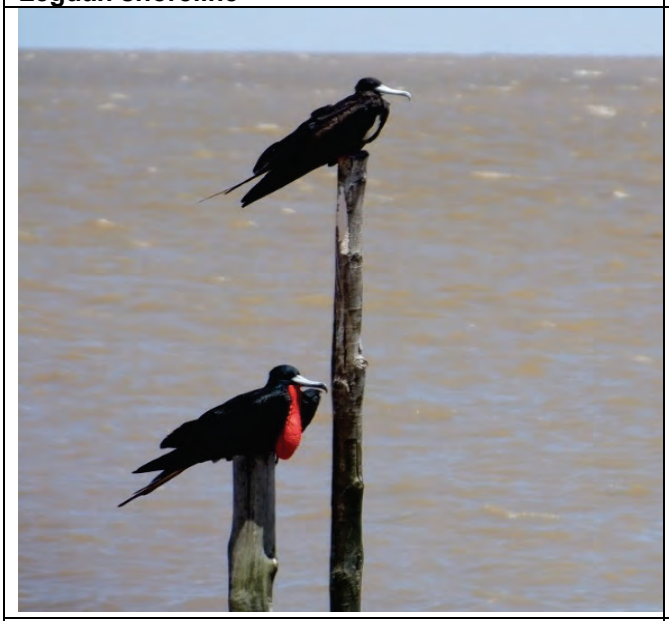
Scarlet Ibis (*Eudocimus ruber*) at Leguan mudflats



Semipalmated Sandpipers (*Calidris pusilla*) at Leguan shoreline



Semipalmated Plovers (*Charadrius semipalmatus*) at Leguan shoreline



Magnificent Frigatebirds (*Fregata magnificens*)



Laughing Gulls (*Leucophaeus atricilla*) and Snowy Egrets (*Egretta thula*)



Lesser Yellowlegs (*Tringa flavipes*) on the shoreline at Anna Regina



Whimbrel (*Numenius phaeopus*) at Affiance seaside



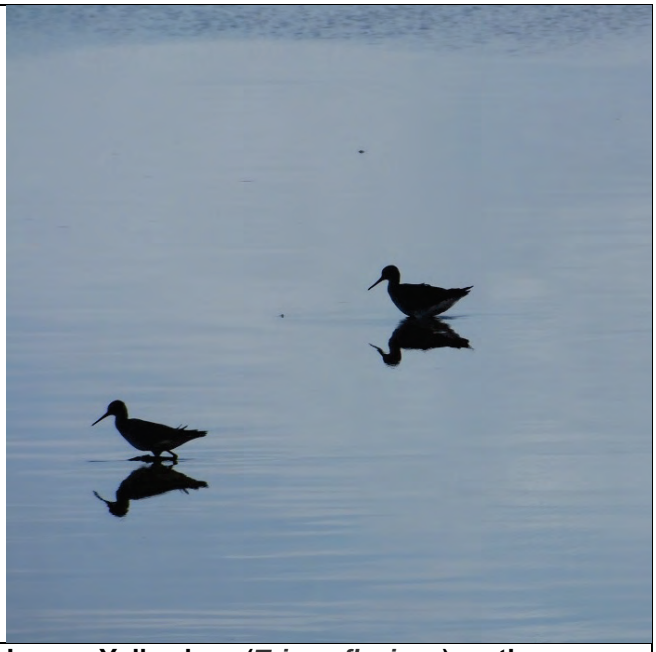
Brown Pelicans and Black Skimmers at Darthmouth shoreline



Mixed waterbird and shorebird flock at Walton Hall seaside



Short-billed Dowitcher (*Limnodromus griseus*) in the background—Region 2



Lesser Yellowlegs (*Tringa flavipes*) on the mudflats at Exmouth seaside Region 2



Black-bellied Plover (*Pluvialis squatarola*)



Hudsonian Godwit (*Limosa haemastica*) observed on 63-beach Region 6



The La Jalousie site has hardened—no longer a soft mud shoreline and now better for birds



The La Jalousie site hardened due to sand and clay shift—annual occurrence



Ruimzeight site with Jeffrey McCrary & driver Francis Kam



Jeffrey McCrary noticing the removal of mangroves from the Ruimzeight shoreline

		
Philip Odwin—field assistant at the Darthmouth site in Region 2		**Garey Sway & Wally Prince surveying birds at Ogle seaside**

ATTACHMENT 4 DATA FORM USED FOR THE COASTAL BIRD SURVEY

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Date: ……		ST GPS:……	End GPS:……
Start Time: ……		…….	…….
End Time: ……		Weather :…….	
Location:……		Descript:…….	
Obs:…….		……	

Species Name	#	Notes/Activities	Habitat Info etc

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ERM

210 New Market Street
Georgetown, Guyana

Telephone: +592 501 0625
www.erm.com

Technical Memorandum

To	Jena Lococo, Kari Ehmling
From	Waldyke Prince and Julia Tims
Date	23 April 2019
Reference	Year 2 Coastal Bird Study
Subject	Interim Report – Survey 2

1 Introduction

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), Environmental Resources Management (ERM) conducted a survey in January and February 2019 of coastal birds along the coastline of Guyana within Regions 2–6. This survey is the second of a series of five surveys to be conducted as part of EEPGL's Year 2 Coastal Bird Study. This study is a continuation of the Year 1 Coastal Bird Study, which was conducted in conjunction with EEPGL's Enhanced Coastal Sensitivity Mapping work in 2017 and 2018. The Year 2 Coastal Bird Study is an elective study commissioned by EEPGL and is not being conducted pursuant to any regulatory requirement.

This memo summarizes the results and highlights the key findings of the January/February 2019 coastal bird survey. ERM will prepare a full report that details the results of all Year 2 surveys and compares those results across surveys in late 2019 after completion of the Year 2 Coastal Bird Study surveys.

2 Survey Objectives

The objective of this survey event of the Year 2 Coastal Bird Study was to document the distribution, abundance, and diversity of coastal birds in Regions 2–6. Documentation of coastal bird breeding sites, another objective of the Year 2 Coastal Bird Study, will be conducted in conjunction with the remaining coastal bird survey events planned for 2019.

3 Survey Approach and Methods

3.1 Timing and Location of Survey

On 22 January through 2 February 2019, a bird survey team including Waldyke Prince (Guyanese bird specialist and survey lead) and Philip Odwin (Guyanese bird survey advanced trainee) surveyed coastal birds at 92 sites along the Guyana coastline in Regions 2–6 (Table 1). Attachment 1 lists the 92 coastal and island survey sites, along with their region and primary habitat, and includes a mapbook that depicts the locations of the sites. The coastal habitat types that were surveyed included mangrove (riverine and coastal), mudflat, plantation (island surveys only), and sandy beach.

Table 1: Number of Coastal Bird Survey Sites Surveyed in the January/February 2019 Coastal Bird Survey in Regions 2 through 6

Region	Geographic Range of Survey Area	Total Number of Survey Sites
2	Between the east bank of the Pomeroon River and the Supenaam River	6
3 (Coastal)	Region 3 coastal shoreline to Ruimzeight	7
3 (Essequibo Islands)	Tiger, Hog, Leguan, and Wakenaam Islands	52
4	Kingston seaside to the Mahaica River mouth	16
5	Sans Souci to Woodley Park	6
6	Maida Seaside to Springlands	5
Total		**92**

3.2 Survey Methods

3.2.1 Coastal Point Count Surveys

Surveyors conducted 15-minute point count surveys at the survey sites within Regions 2–6 that were established during the Year 1 Coastal Bird Survey (Table 1 and Attachment 1). To the extent practicable, surveys were conducted in the morning hours between 06:00 and 10:00, when birds are most active. However, this was not always possible due to tidal stage and related site accessibility or other constraints.

From each survey site, observations were made within a radius of approximately 500 meters around the survey site. Survey site locations were electronically recorded using GPS and the sites were photographed. Observers recorded data using an IPad equipped with the Survey 123 application and a tailored electronic data collection template developed for this survey by ERM (Attachment 2). This electronic data collection system is compatible with ERM's EEPGL Project Geographic Information System (GIS) platform.

The following information was collected during each point count survey:

- Survey location (latitude and longitude or GPS coordinates of the survey site)
- Date
- Observation type (incidental, transect survey, point count survey)
- Start/stop time of survey
- Brief site/habitat description and site ID
- Weather (% cloud cover, precipitation, wind speed, wind direction, temperature)
- For each species seen or heard:
  - Species identification (or lowest taxonomic level identifiable)
  - Number of individuals (if in a group)

3.2.2 Island Point Count Surveys

Surveys of the Region 3 island sites (Essequibo Islands) were conducted via boat. These sites were surveyed from the water using the same point count methodology as the land-based surveys described above.

4 Results Summary

The January/February 2019 coastal bird survey documented 123 species and 13,709 birds, representing 33 bird families. Coastal sites documented 106 species and island sites documented 69 species, with 51 species recorded at both coastal and island sites. No species were documented at 10 of the survey sites (four of the coastal Region 4 sites including Paradise, Nooten Zuil, Hope Canal, and Clonbrook; and six of the Region 3 island sites including Tiger Island 9, Wakenaam 1, Wakenaam 13, Leguan 8, Leguan 9, and Hog Island 7).

Of the 123 species observed during this survey, 21 were not observed during the most recent EEPGL-commissioned coastal bird survey (September/October 2018), and six were new to the list of species documented from all prior EEPGL-commissioned coastal bird surveys[1]. The six new species were: Black Hawk-eagle (*Spizaetus tyrannus*), Orange-winged Parrot (*Amazona amazonica*), Yellow-breasted Flycatcher (*Tolmomyias flaviventris*), Wing-barred Seedeater (*Sporophila americana*), *Phaethornis* sp. (hummingbird), and *Tringa* sp. (a type of wading bird that includes sandpipers, yellowlegs, and tattlers). With the exception of the*Tringa* sp., which are waterbirds, the new species observed during this survey typically inhabit inland habitats and are not commonly associated with coastal area. All of the species documented during this survey have been previously recorded in Guyana. Attachment 3 contains the survey data for the January/February 2019 coastal bird survey.

The following bird families were particularly well-represented in terms of numbers of species and/or individuals observed:

- *Tyrannidae* (tyrant flycatchers)—15 species
- *Scolopacidae* (sandpipers)—13 species
- *Accipitridae* and other birds of prey—10 species
- *Ardeidae* (herons)—9 species
- *Thraupidae* (tanagers)—9 species
- *Laridae* (gulls)—7 species
- *Icteridae* (orioles, grackles, and cowbirds)—6 species
- *Columbidae* (pigeons and doves)—5 species
- *Falconidae* (falcons and caracaras)—5 species
- *Charadriidae* (plovers and lapwings)—4 species
- *Psittacidae* (true parrots)—4 species

[1] Prior EEPGL-commissioned coastal bird surveys include the three surveys comprising the Year 1 Coastal Bird Study and the September/October 2018 survey.

Fifteen species of migratory shorebirds were documented during the January/February 2019 survey, indicating that these birds are overwintering in Guyana. This is approximately the same number of migratory shorebird species observed during the Year 1 Coastal Bird Study (14) and five fewer species than were observed during the September/October 2018 survey. The September/October 2018 survey appears to have coincided with the peak period for fall shorebird migration that year, so it is expected that a higher number of species would be documented during that survey compared with this survey, which was conducted outside the migratory period.[2]

The most common shorebirds (in terms of abundance) observed during the January/February 2019 survey were *Calidris sp*., Semipalmated Plover (*Charadrius semipalmatus*), Semipalmated Sandpiper (*Calidris pusilla*), Lesser Yellowlegs (*Tringa flavipes*), Sanderling (*Calidris alba*), Greater Yellowlegs (*Tringa melanoleuca*), and Whimbrel (*Numenius phaeopus*). The most common colonial waterbirds observed were Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*), Great Egret (*Ardea alba*), Scarlet Ibis (*Eudocimus ruber*), and Tricolored Heron (*Egretta tricolor*).

Consistent with the prior surveys, sites with exposed mudflats had the highest abundance of birds of any habitat surveyed and sites with coastal mangrove habitat had the highest species richness.

The Red Knot (*Calidris canutus*), a shorebird species that is not frequently observed in Guyana but was observed during the September/October 2018 survey, was again documented during the January/February 2019 survey, indicating that this species overwinters in Guyana. This is new information regarding this species' wintering range, although it is not surprising since the species is known to overwinter in neighboring Suriname and French Guiana.

4.1 Regional Results

Table 2 presents total bird abundance and species richness, by region, recorded during the January/February 2019 coastal bird survey. Region 4 had the greatest total bird abundance (4,096 birds), followed by Region 5 (3,592 birds) and Region 6 (3,551 birds). Region 3 had the greatest species richness (87 species) with most (69) of the species found on the Essequibo Islands sites, followed by Region 5 (58 species) (Figure 1). This is a similar result to that of prior surveys.

Thirteen species were recorded in all five regions surveyed, as compared to seven species recorded in all regions during the Year 1 Coastal Bird Study and 11 species recorded in all regions during the September/October 2018 survey. Seven of these 13 species are considered wetland-specific species, including the mangrove-specialists Rufous Crab Hawk and Bicolored Conebill (both IUCN Red List Near Threatened).

[2] Peak migratory periods are variable from year to year, based on weather and other factors.

Table 2: Total Bird Abundance and Species Richness Recorded in Regions 2 through 6 during the January/February 2019 Coastal Bird Survey

Region	Bird Abundance (Number of Individual Birds)	Bird Species Richness (Number of Bird Species)
2	1,022	39
3	1,347	87
4	4,096	52
5	3,592	58
6	3,551	47

Other notable comparisons of results from this survey and that of prior surveys[3] include:

- Overall bird abundance recorded during the January/February 2019 surveys was lower in most regions than in prior surveys (Figure 1). Where bird abundance was higher during this survey compared with prior surveys (Region 3 Coastal and Region 4), the result was due to one site within the region having large numbers of birds, as opposed to high numbers of birds being present across all or multiple sites within that region.
- Although overall bird abundance was generally lower during the January/February 2019 survey, some species had much higher abundance during this survey than previously recorded. For example, the following species' abundances were more than double what was recorded for those species during one or more prior surveys: Great Egret, Semipalmated Plover, Greater Yellowlegs, Snail Kite (*Rostrhamus sociabilis*), Blue-grey Tanager (*Thraupis episcopus*), Silver-beaked Tanager (*Ramphocelus carbo*), Blue-black Grassquit (*Volatinia jacarina*), Yellow Oriole (*Icterus nigrogularis*), Shiny Cowbird (*Molothrus bonariensis*), and Carib Grackle (*Quiscalus lugubris*). With the exception of Great Egret, Semipalmated Plover, and Greater Yellowlegs, which are waterbirds and shorebirds, and Snail Kite, which is a raptor, the species with comparatively high abundance are passerine (perching) birds that are typically associated with inland habitats such as forests and pasturelands.
- During the September/October 2018 survey, Region 6 had the highest bird abundance recorded of any survey conducted to date (10,236 birds) (Figure 1). The higher bird abundance observed during the September/October 2018 survey was likely because that survey appears to have coincided with the peak fall shorebird migration through Guyana that year.
- The Region 3 Essequibo Island sites had the greatest species richness during this survey and (with one exception) during most of the prior surveys (Figure 2). This is likely because the

[3] Prior surveys include the September/October 2018 survey and the two surveys that comprise the Year 1 Coastal Bird Study (September/October 2017 and April 2018). Throughout this report, when referring to results of "prior surveys", all Year 1 survey data and the September/October 2018 data are combined and the data presented in this report are the average of the three surveys. If a particular survey is referenced (e.g., fall 2017 survey), the statement applies only to that survey, and the raw data are presented.

Essequibo Islands offer a higher diversity of bird habitats compared with the other coastal sites and habitat diversity is typically correlated with higher bird species richness.

- During the January/February 2019 survey, numerous species, including but not limited to Greater Yellowlegs, Yellow Oriole, Carib Grackle, Bicolored Conebill, and Rufous Crab-hawk, were observed in regions and sites where they had not been observed in prior surveys.

These data provide further evidence to support one of the key preliminary findings of the Year 1 Coastal Bird Study—that there is high seasonal and inter-annual variability in species richness and abundance across sites and regions.

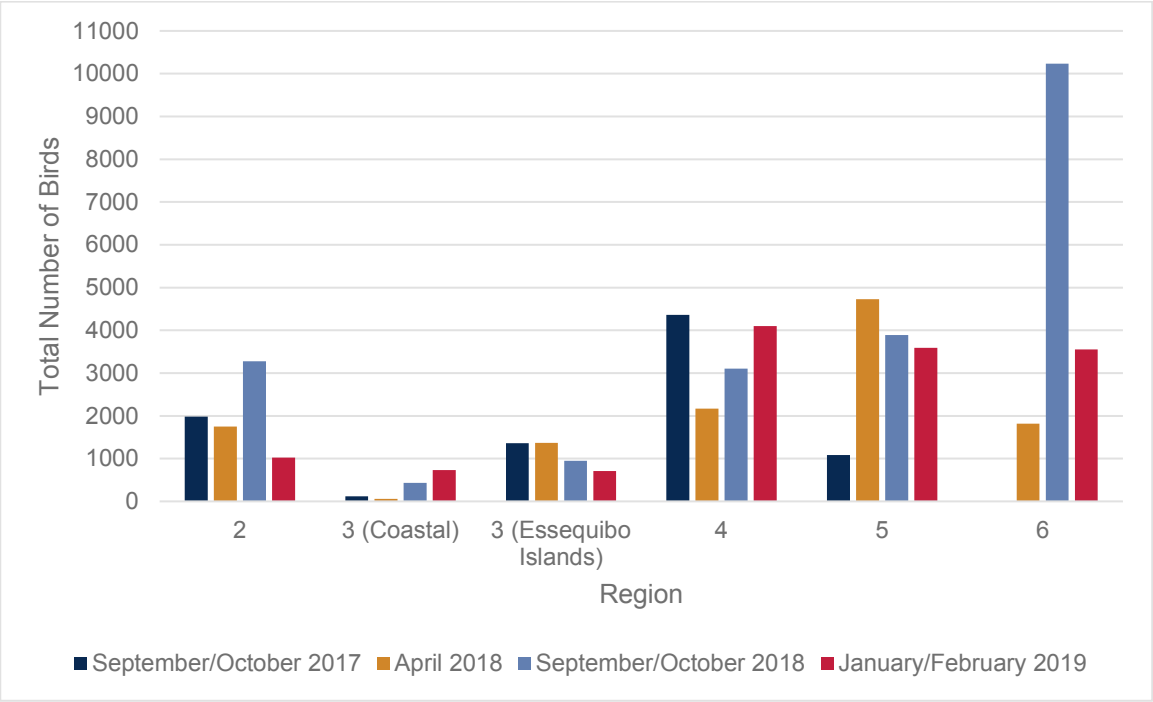


Figure 1: Total Bird Abundance per Region and Survey Period[4]

[4] Region 6 was not surveyed during the September/October 2017 survey because this region was not included in the scope of the coastal bird survey at that time. Region 6 was added to the scope of the coastal bird survey in April 2018.

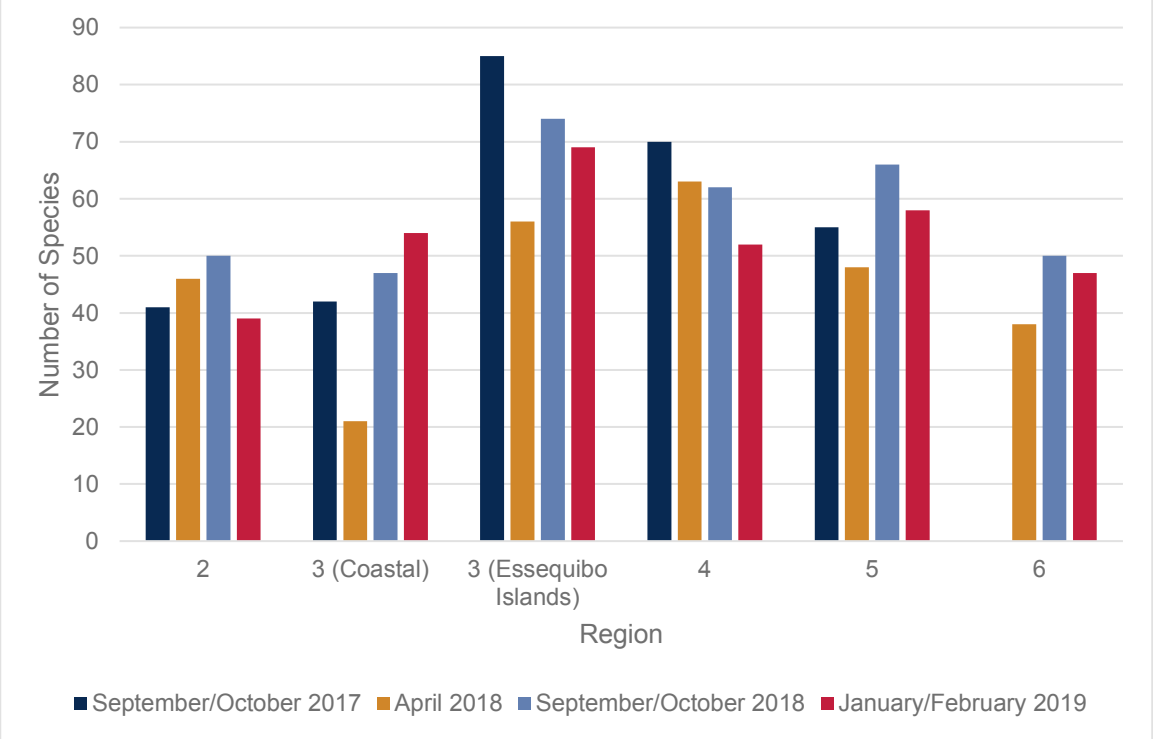


Figure 2: Total Species Richness per Region and Survey Period

4.2 Site-Specific Results

The highest bird abundance documented in this survey occurred at Bush Lot Seaside in Region 5 (3,177 birds), followed by Ogle Seaside in Region 4 (2,542 birds), and Phillipe Seaside in Region 6 (2,115 birds). The highest species richness occurred in Region 3 (Essequibo Islands sites) on Leguan Island 3 (44 species), Wakenaam Island (37 species), and Tiger Island (31 species), followed by Phillipe Seaside in Region 6 (27 species), Moor Park in Region 5 (26 species), and Maida Seaside in Region 6 (23 species). Table 3 compares the highest abundance and species richness across all survey sites for all surveys conducted to date.

Table 3: Comparison of Sites with Highest Bird Abundance and Species Richness Across All Surveys Conducted to Date

Survey Period	Site	Highest Abundance	Site	Highest Species Richness
September/ October 2017	Ogle Seaside, Region 4	891	Leguan Island, Region 3	61
	Anna Regina, Region 2	658	Tiger Island, Region 3	33
	Exmouth, Region 2	928	Wakenaam Island, Region 3	32
April 2018	Lusignan, Region 4	979	Leguan Island, Region 3	34
	Exmouth, Region 2	656	Wakenaam Island, Region 3	34
	Leguan Island, Region 3	637	Victoria, Region 4	26
			Walton Hall, Region 2	25

Survey Period	Site	Highest Abundance	Site	Highest Species Richness
September/ October 2018	Maida Seaside, Region 6	6,553	Wakenaam Island,Region 3	52
	Bush Lot, Region 5	3,281	Moor Park, Region 5	37
	Phillipe Seaside, Region 6	3,238	Enmore, Region 4	32
			Leguan Island, Region 3	32
January/ February 2019	Bush Lot, Region 5	3,177	Leguan Island, Region 3	44
	Ogle Seaside, Region 4	2,542	Wakenaam Island, Region 3	37
	Phillipe Seaside, Region 6	2,115	Tiger Island, Region 3	31

The January/February 2019 survey had a higher number of survey sites with no birds or low abundance and/or species richness compared with prior surveys. No birds were documented at four of the coastal Region 4 sites (Paradise, Nooten Zuil, Hope Canal, and Clonbrook) and at six of the Region 3 island sites (Tiger Island 9, Wakenaam 1, Wakenaam 13, Leguan 8, Leguan 9, and Hog Island 7). Further, low bird abundance (<10 birds) was recorded at BV-Triumph in Region 4 and 10 Essequibo Island sites (Region 3). No or low bird abundance at these coastal sites is most likely attributed to survey timing (survey conducted at suboptimal tidal stage or time of day) and no or low bird abundance at some of the island sites is most likey due to the survey site selection methodology[5]. The birds that inhabit the islands usually congregate along the shoreline in groups that move around following their food resource (i.e., schools of fish) so given their clumped distribution and the high number of survey points along the island shorelines, it is not unexpected to have survey sites with no or few birds and it is not indicative of overall bird abundance and species richness of the islands points as a whole (Figures 1 and 2 and Table 3).

4.3 Special Status Species

Five species of international conservation concern[6] were documented during the survey: White-bellied Piculet (*Picumnus spilogaster*), Rufous Crab Hawk (*Buteogallus aequinoctialis*), Bicolored Conebill (*Conirostrum bicolor*), Semipalmated Sandpiper, and Red Knot. The current International Union for the Conservation of Nature (IUCN) Red List status for the White-bellied Piculet is "Vulnerable." This species was previously observed during the Year 1 Coastal Bird Study, but was not documented during the September/October 2018 survey. The four remaining species are designated "Near Threatened," and all were observed during prior surveys.

[5] As described in the Year 1 Coastal Bird Study Report, there are more island survey points than coastal survey points (52 vs. 40) due to the nature of the survey site selection process around the islands, which established points at set distances around the circumference of the islands rather than identifying survey sites based on habitat and site accessibility as done with the coastal sites.

[6] The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN Red List) is the definitive authority on global species conservation status. Species considered to be of international conservation concern are those with IUCN Red List status of Near Threatened, Vulnerable, Endangered, or Critically Endangered.

Only one of the three species of local conservation interest[7] documented during prior surveys was observed again during this survey: Silvered Antbird (*Sclateria naevia*). The other two such species that were previously observed are Gray-headed Kite (*Leptodon cayennensis*) and the subspecies *fumosus* of Fuscous Flycatcher (*Cnemotriccus fuscatus*). Both of these species were observed on the Essequibo Islands during the September/October 2017 survey of the Year 1 Coastal Bird Study, but have not been recorded on subsequent surveys.

4.4 Important Bird Habitats

The 10 sites identified as Important Bird Habitats within Regions 2 through 6[8] during the Year 1 Coastal Bird Study all had high numbers and diversity of birds during prior surveys. During this survey, low abundances (<45 birds) were observed at four of these sites: Exmouth, BV-Triumph, Victoria, and Hope Beach. However, for the number of birds present, the sites were still relatively species-rich. For example, 5 different species were observed at the site with the fewest recorded birds (BV-Triumph with 9 birds). Seasonality is likely a factor in the low abundances at these sites; however, the consistent, concentrated use of these areas by a relatively large number of bird species across multiple survey events validates the Year 1 Coastal Bird Study designation of these sites as Important Bird Habitats. Further, similar to the September/October 2018 survey, high numbers of shorebirds were again recorded during the January/February 2019 survey at Bush Lot and the Maida and Phillipe seasides in Regions 5 and 6, and Ogle in Region 4. All of these sites were designated as Important Bird Habitats during the Year 1 Coastal Bird Study. No new Important Bird Habitats were designated based on the results of the January/February 2019 survey.

5 Discussion

Overall bird abundance recorded during the January/February 2019 surveys was lower in most regions than in prior surveys. Notably, bird abundance during this survey was approximately 60 percent of that recorded during the September/October 2018 survey, which was itself more than double that of the September/October 2017 survey, and roughly equivalent to the abundance of all three Year 1 Coastal Bird Study survey events combined. This difference was primarily driven by high shorebird abundance recorded at three coastal sites in Regions 5 and 6 (Bush Lot, Maida, and Phillipe) during the September/October 2018 survey, which was likely due to the timing of the survey at these sites in early October 2018, which appears to have coincided with peak shorebird migration through Guyana that year.

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[7] Species of local conservation interest are species that are considered by Guyanese and international bird specialists to be rare and/or declining in Guyana or have very limited distribution in Guyana but are not species of global conservation concern based on their IUCN Red List status.

[8] The Year 1 Coastal Bird Study defined Important Bird Habitats as sites that support one or more of the following: (1) predictable congregations of migratory shorebirds; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest. The Important Bird Habitats identified within Regions 2 through 6 during the Year 1 Coastal Bird Survey include: Exmouth Seaside, Walton Hall Seaside, Essequibo Island Complex, Ogle Seaside, Triumph-BV Seaside, Enmore Seaside, Hope Beach Seaside, Victoria Seaside, Bush Lot Seaside, and the area between Maida and Phillipe.

This survey evidenced no distinct trend in bird species richness when compared with prior surveys (species richness was variable across regions and sites compared with prior surveys), except for the Essequibo Island sites, which maintained consistently high species richness across the island sites collectively.

The most notable finding of the January/February 2019 survey was the different bird species assemblage documented during this survey compared with prior surveys.

Of the 123 species observed during this survey, 21 species were not observed during the previous September/October 2018 survey and six were new to the list of species documented from all prior EEPGL-coordinated surveys. Of the six new species observed, five are typically associated with inland habitats. Further, 25 species that were recorded during prior surveys, including numerous migratory shorebirds such as the White-rumped Sandpiper, Western Sandpiper, and Hudsonian Godwit, were absent during this survey. The different bird species assemblage is likely due to the timing of this survey during the winter period, when many migratory birds are not present and the species assemblage is dominated by resident birds (bird species present in Guyana year round) and wintering birds (bird species that spend the winter months in Guyana).

6 Next Steps

A subsequent coastal bird survey was conducted in late March and early April 2019. As discussed with EEPGL in late 2018 and assessed by the survey team during the January/February 2019 survey, some changes to the survey points were warranted to increase survey coverage in under-surveyed portions of the coastline and to eliminate points that have marginal habitats, consistently few birds, suboptimal views of the coastline, etc. Specifically, three additional coastal points in Regions 5 and 6 were added for the March/April 2019 survey to increase survey coverage of the coastline in this area. The additional survey effort required to include these new points in the survey was offset by reducing the number of survey points around the Essequibo Islands. The island points are very similar in terms of habitat and, as documented in this survey and prior surveys, there are usually island points with few to no birds observed. The survey team recommended reducing the island points to include only those that are optimal sites for survey (i.e., dropping points where there have been consistently few birds during prior surveys or where views of the shoreline are not optimal).

ATTACHMENT 1 COASTAL BIRD SURVEY SITES AND MAPBOOK

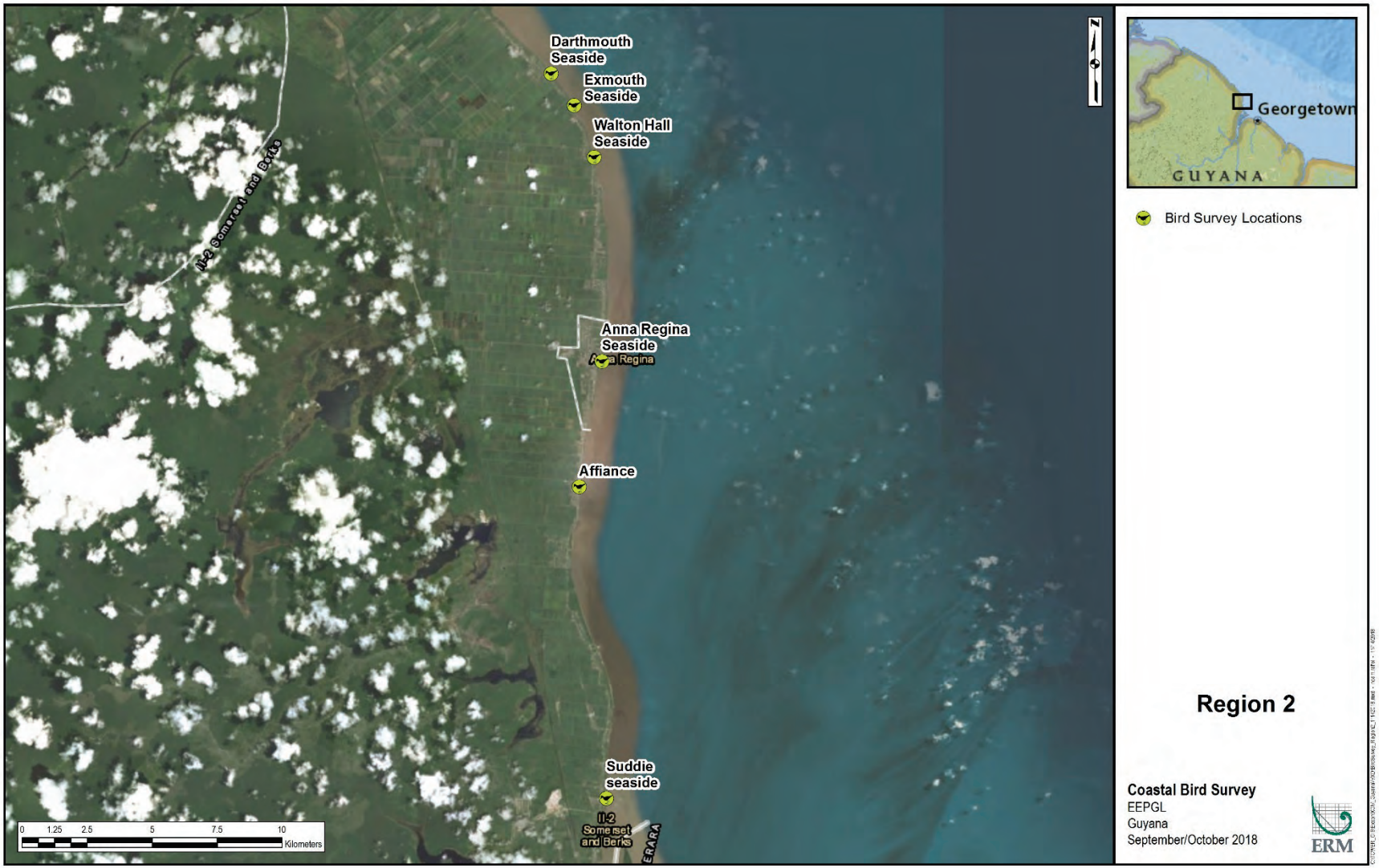
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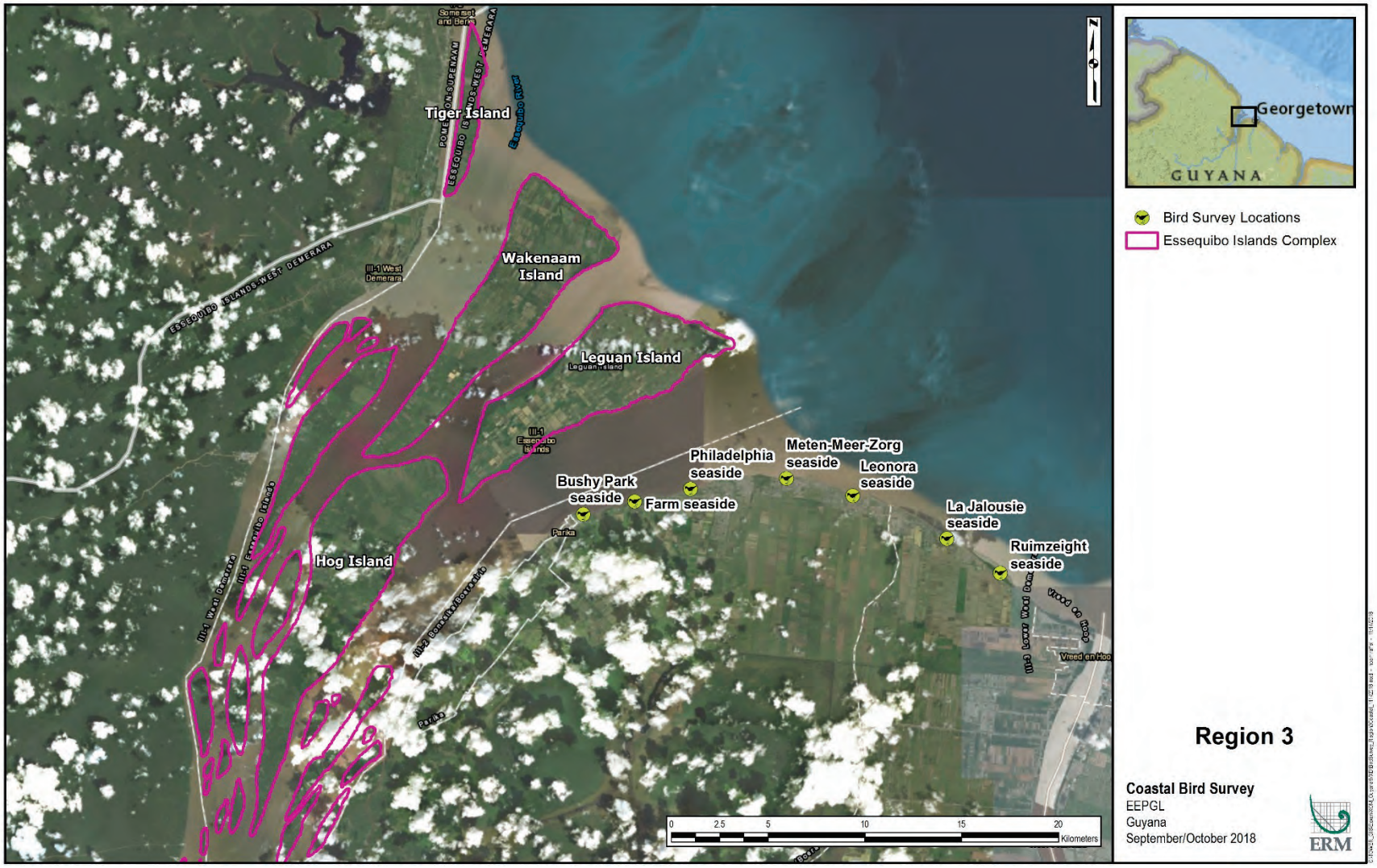
Coastal Bird Survey Sites for Regions 2–6, January/February 2019

Survey Site	Name	Region	Habitat Type
Coastal Sites			
DM-R2	Dartmouth	2	Sea wall, mudflat
EX-R2	Exmouth	2	Mudflat
WH-R2	Walton Hall	2	Mudflat and tidal wetland
AR-R2	Anna Regina	2	Mudflat
AF-R2	Affiance	2	Sea wall, mudflat, mangrove
SU-R2	Suddie	2	Sand beach, jetty
BP-R3	Bushy Park	3	Sand beach
FR-R3	Farm	3	Sea wall, mudflat
PH-R3	Philadelphia	3	Sea wall, mudflat
MM-R3	Meten-Meer-Zoor	3	Sea wall, mudflat
LN-R3	Lenora	3	Sea wall, mudflat
LJ-R3	La Jalousie	3	Sea wall, mudflat
RZ-R3	Ruimzeight	3	Sea wall, mudflat
KS-R4	Kingston	4	Sand beach, jetty
TK- R4	Turkeyen	4	Sea wall, mudflat
OG-R4	Ogle	4	Mudflats
LBI-R4	LBI Seawall	4	Mudflat, mangrove
BV-R4	BV-Triumph	4	Sea wall, intertidal wetland, mudflat
LU-R4	Lusignan	4	Mudflat
PA-R4	Paradise	4	Mangrove
EM-R4	Enmore	4	Mudflat
VT-R4	Victoria	4	Sea wall, intertidal wetland, mudflat, mangrove
NZ-R4	Nooten Zuil	4	Seawall–open, some mangrove
HB-R4	Hope Beach	4	Mudflat, mangrove
HC-R4	Hope Canal	4	Mudflat, mangrove
Bee-R4	Bee Hive	4	Mangrove
CB-R4	Clonbrook	4	Mudflat, mangrove
UN-R4	Unity	4	Sand beach, jetty
MA-R4	Mahaica	4	Mudflat, mangrove
SS-R5	Sans Souci	5	Mangrove
AB-R5	Abary	5	Sand beach
MP-R5	Moor Park	5	Mangrove and mudflat
BL-R5	Bush Lot	5	Mudflat

Survey Site	Name	Region	Habitat Type
HT-R5	Hopetown	5	Mangrove
WP-R5	Woodley Park	5	Mangrove
MS-R6	Maida Seaside	6	Sand beach
PS-R6	Phillipe Seaside	6	Sand beach
61B-R6	61-Beach Seaside	6	Sand beach
63B-R6	63-Beach Seaside	6	Sand beach
SL-R6	Springlands	6	Sand beach
Essequibo Island Sites			
Tig1-R3	Tiger Island 1	3	Sand beach, mangrove
Tig2-R3	Tiger Island 2	3	Sand beach, mangrove
Tig3-R3	Tiger Island 3	3	Sand beach, mangrove
Tig4-R3	Tiger Island 4	3	Mangrove
Tig5-R3	Tiger Island 5	3	Mangrove
Tig6-R3	Tiger Island 6	3	Sand beach, mangrove
Tig7-R3	Tiger Island 7	3	Sand beach, mangrove
Tig8-R3	Tiger Island 8	3	Sand beach, mangrove
Tig9-R3	Tiger Island 9	3	Sand beach, mangrove
Wak1-R3	Wakenaam 1	3	Sand beach, mangrove
Wak2-R3	Wakenaam 2	3	Sand beach, mangrove
Wak3-R3	Wakenaam 3	3	Sand beach, mangrove
Wak4-R3	Wakenaam 4	3	Sand beach, mangrove
Wak5-R3	Wakenaam 5	3	Sand beach, mangrove
Wak6-R3	Wakenaam 6	3	Sand beach, mangrove
Wak7-R3	Wakenaam 7	3	Sans beach, mangrove
Wak8-R3	Wakenaam 8	3	Sand beach, mangrove
Wak9-R3	Wakenaam 9	3	Sand beach, mangrove
Wak10-R3	Wakenaam 10	3	Concrete wall, some mangrove
Wak11-R3	Wakenaam 11	3	Concrete wall, some mangrove
Wak12-R3	Wakenaam 12	3	Mangrove
Wak13-R3	Wakenaam 13	3	Mangrove
Wak14-R3	Wakenaam 14	3	Mangrove
Wak15-R3	Wakenaam 15	3	Mangrove
Wak16-R3	Wakenaam 16	3	Mangrove
Wak17-R3	Wakenaam 17	3	Mangrove
Wak18-R3	Wakenaam 18	3	Mangrove
Leg1-R3	Leguan 1	3	Concrete wall

Survey Site	Name	Region	Habitat Type
Leg2-R3	Leguan 2	3	Concrete wall
Leg3-R3	Leguan 3	3	Concrete wall, mangrove
Leg4-R3	Leguan 4	3	Mangrove, plantation
Leg5-R3	Leguan 5	3	Sand beach, plantation
Leg6-R3	Leguan 6	3	Mudflat, mangrove
Leg7-R3	Leguan 7	3	Mudflat, mangrove
Leg8-R3	Leguan 8	3	Mudflat, mangrove
Leg9-R3	Leguan 9	3	Mudflat, mangrove
Leg10-R3	Leguan 10	3	Mudflat, mangrove
Leg11-R3	Leguan 11	3	Mangrove
Leg12-R3	Leguan 12	3	Mangrove
Leg13-R3	Leguan 13	3	Mangrove
Leg14-R3	Leguan 14	3	Mangrove
Leg15-R3	Leguan 15	3	Mangrove
Hog1-R3	Hog Island 1	3	Mudflat, mangrove
Hog2-R3	Hog Island 2	3	Mudflat, mangrove
Hog3-R3	Hog Island 3	3	Mudflat, mangrove
Hog4-R3	Hog Island 4	3	Mudflat, mangrove
Hog5-R3	Hog Island 5	3	Mudflat, mangrove
Hog6-R3	Hog Island 6	3	Mudflat, mangrove
Hog7-R3	Hog Island 7	3	Mangrove
Hog8-R3	Hog Island 8	3	Mangrove
Hog9-R3	Hog Island 9	3	Mangrove


Darthmouth
Seaside
Exmouth
Seaside
Walton Hall
Seaside
Anna Regina
Seaside
Affiance
Suddie
seaside
II-2
Somerset
and Berks
ERARA
0 1.25 2.5 5 7.5 10
Kilometers
N
Georgetown
GUYANA
Bird Survey Locations
Region 2
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM


Tiger Island
Wakenaam Island
Leguan Island
Hog Island
Philadelphia seaside
Meten-Meer-Zorg seaside
Leonora seaside
Bushy Park seaside
Farm seaside
La Jalousie seaside
Ruimzeight seaside
Parika
Georgetown
GUYANA
Bird Survey Locations
Essequibo Islands Complex
Region 3
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM
0 2.5 5 10 15 20
Kilometers


Kingston Seaside
Turkeyen Seaside
Ogle Seaside
LBI Seawall
Triumph - BV Seaside
Lusignan Seaside
Paradise
Enmore Seaside
Victoria Seaside
Hope Beach Seaside
Nooten Zuil
Hope Canal
Bee Hive
Clonbrook
Unity
Mahaica River mouth
National Park
Atlanti Ville
Turkeyen
Zoological Park
South Ruimveldt Gardens
Lamaha Springs
Agricola
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Kilometers
Georgetown
GUYANA
Bird Survey Locations
Region 4
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM


Sans Souci
Abary
Moor Park
Bush Lot
Hopetown
Woodley Park
V-2
Mahaicony/Berbice
Berbice River
VI-2 East
Camp/E.
C. Berb
0
2.5
5
10
15
20
Kilometers
Georgetown
GUYANA
Bird Survey Locations
Region 5
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM


Maida
Phillipe Seaside
61-Beach Seaside
63-Beach Seaside
Springlands
Rose Hall
New Amsterdam
Providence
Glasgow
Corriverton
Bovem Corantijn River
GUYANA
Georgetown
Legend
Region 6
Coastal Bird Survey
EEPGL
Guyana
September/October 2018
ERM
0 2.5 5 10 15 20
Kilometers

ATTACHMENT 2 ELECTRONIC DATA ENTRY TEMPLATE FOR THE COASTAL BIRD SURVEY

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Bird Survey

Date *
Monday, April 08, 2019

Time *
5:38 PM

Location *



Survey Device Name

Survey Site Code

Survey Site Code

Observation ID *
1904081738

Method of Observation
- Visual
- Audio
- Other

Weather
- Sunny
- Partly Sunny
- Cloudy
- Light Rain
- Heavy Rain
- Other

Temperature C

Species Observed

Species Observed

Number of Individuals *

Unique Behaviour?
- Feeding
- Roosting
- Nesting
- None
- Other

Location/Habitat

Take or Insert Photo

External Camera IDs

1 of 1

General Description

Are you at the Site?
- (•) Yes
- ( ) No

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ATTACHMENT 3 COASTAL BIRD SURVEY DATA FOR REGIONS 2-6, JANUARY/FEBRUARY 2019

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A. Coastal Bird Survey Data for Regions 2 and 3, January/February 2019

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0	9
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	0	0	2	0	5	0	0	0	0	0	0	0	0	0	0	0	0	7
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Cocoi Heron	*Ardea cocoi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Ardeidae	Little Blue-Heron	*Egretta caerulea*	0	0	5	54	5	0	0	0	0	0	0	0	15	0	1	11	0	91
Ardeidae	Tricolored Heron	*Egretta tricolor*	0	0	4	11	2	0	0	0	0	0	0	0	0	0	0	10	0	27
Ardeidae	Striated Heron	*Butorides striata*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Ardeidae	Great Egret	*Ardea alba*	0	0	0	3	0	0	0	0	0	2	1	1	22	1	0	3	0	33
Ardeidae	Snowy Egret	*Egretta thula*	0	0	63	160	43	0	0	0	0	2	0	0	250	0	15	44	1	578
Ardeidae	Cattle Egret	*Bubulcus ibis*	2	0	2	0	0	0	0	0	0	0	0	0	30	0	0	1	0	35
Aramidae	Limpkin	*Aramus guarauna*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	0	0	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Turkey Vulture	*Catharthes aura*	2	0	3	1	3	9	0	0	0	0	0	0	0	6	19	8	6	57
Cathartidae	Black Vulture	*Coragyps atratus*	0	0	0	0	0	0	0	0	0	0	0	1	0	3	0	0	0	4
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Osprey	*Pandion haliaetus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	3	0	0	5

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	3	0	7
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	2
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Cracidae	Little Chacalaca	*Ortalis motmot*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacanidae	Wattled Jacana	*Jacana jacana*	0	2	3	0	0	0	0	2	0	0	1	0	0	0	0	0	0	8
Charadriidae	Southern Lapwing	*Vanellus chilensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	0	0	250	35	17	0	0	0	0	0	0	0	0	15	0	35	0	352
Charadriidae	Collared Plover	*Charadrius collaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Red Knot	*Calidris canutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Sanderling	*Calidris alba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	1	0	0	1	0	0	1	0	0	0	1	0	1	1	3	6	0	15
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	0	0	50	30	0	0	0	0	0	0	1	0	100	0	0	18	0	199
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Scolopacidae	Least Sandpiper	*Calidris minutilla*	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Scolopacidae	Western Sandpiper	*Calidris mauri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Calidris sp.	*Calidris sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Whimbrel	*Numenius phaeopus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Willet	*Tringa semipalmata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*	0	0	0	17	7	0	0	0	0	0	0	0	0	0	0	0	0	24
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	0	0	3	32	51	0	0	0	0	0	0	0	21	0	0	0	0	107
Scolopacidae	Yellowlegs sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Tringa sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Plover sp.	*Pluvialis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Laughing Gull	*Leucophaeus atricilla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Laridae	Large-billed Tern	*Phaetusa simplex*	0	8	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0	10
Laridae	Royal Tern	*Thalasseus maximus*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Laridae	Common Tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Least Tern	*Sternula antillarum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Laridae	Black Skimmer	*Rynchops niger*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																	
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Falconidae	Bat Falcon	*Falco rufigularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Northern Crested Caracara	*Caracara cheriway*	0	0	0	0	3	2	0	0	0	0	0	0	0	2	0	0	0	7
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	0	0	0	0	0	0	0	0	2	0	0	1	0	3	3	5	4	18
Falconidae	Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae	Great Horned Owl	*Bubo virginianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Columbidae	Rock Pigeon	*Columba livia domestica*	0	0	0	0	0	0	0	0	0	0	11	0	2	0	0	0	0	13
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	1	0	3
Columbidae	Ruddy Ground-Dove	*Columba plumbea*	2	2	0	0	0	0	7	0	3	9	0	2	2	0	2	1	0	30
Columbidae	Common Ground-Dove	*Columbina passerina*	0	2	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	4
Columbidae	White-tipped Dove	*Leptotila verreauxi*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	3
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11	11
Psittacidae	Red-bellied Macaw	*Orthopsittaca manilatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4	0	0	4
Psittacidae	Orange-winged Parrot	*Amazona amazonica*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	18	0	22
Cuculidae	Striped Cuckoo	*Tapera naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Cuculidae	Little Cuckoo	*Coccycua minuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Greater Ani	*Crotophaga major*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	3	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	7

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																	
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*	0	0	0	0	0	0	1	0	0	0	0	0	0	3	1	3	0	8
Trochilidae	Emerald sp	*Amazilia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Phaethornis sp. (Hummingbird)	*Phaethornis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	2	0	5
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	3	4
Alcedinidae	Toco Toucan	*Ramphastos toco*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	8	2	12
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	2	0	1	2	2	0	0	2	2	0	2	2	0	2	0	0	0	17
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	0	3
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	2	0	6
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	6	6	2	16
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	0	0	0	0	0	0	0	1	2	0	0	2	0	0	0	3	0	8

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																	
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Tyrannidae	Yellow Breasted Flycatcher	*Tolmomyias flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	4
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	4	0	4	2	7	0	5	3	3	5	5	7	5	7	30	26	12	125
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	2	0	0	5	2	0	0	1	1	0	1	4	3	1	5	14	2	41
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	0	2	0	0	0	0	2	0	0	0	0	0	0	4	4	15	2	29
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	2	0	5
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	0	4	0	0	0	0	0	0	0	0	0	2	0	4	12	18	10	50
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	2
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	2	0	5
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	0	1	0	0	0	0	2	2	0	2	0	0	0	0	0	0	0	7
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	3

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	0	0	9	0	6	5	0	2	5	5	7	18	3	0	44	17	17	138
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	0	4
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Troglodytidae	Southern House-wren	*Troglodytes aedon*	0	2	0	0	2	0	0	0	2	0	2	0	0	0	0	0	0	8
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	10	0	14
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	2	0	0	0	0	0	0	0	1	0	0	2	2	3	7	7	0	24
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	0	0	0	0	0	0	0	0	1	2	0	0	0	2	12	0	0	17
Thraupidae	Torquoise Tanager	*Tangara mexicana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bananaquit	*Coereba flaveola*	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	3
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2	6
Thraupidae	Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	0	2	0	0	0	0	1	0	0	2	4	2	11
Thraupidae	Burnished-buff Tanage	*Tangara cayana*	0	0	0	0	0	0	4	0	0	0	0	2	0	0	0	0	0	6
Thraupidae	Red-capped Cardinal	*Paroaria gularis*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	3	0	5
Thraupidae	Wing-barred Seedeater	*Sporophila americana*	0	0	0	0	0	0	2	0	2	0	0	2	0	0	0	2	0	8
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	0	2
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	0	0	0	2	0	0	0	1	1	2	0	10	2	1	0	0	0	19

TAXA			SURVEYED COASTAL SITES - REGION 2 AND 3																	
Family Name	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	L J-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Parulidae	Yellow Warbler	*Setophaga petechia*	0	0	0	0	0	0	0	0	1	2	0	0	0	2	1	0	0	6
Icteridae	Yellow Oriole	*Icterus nigrogularis*	0	0	0	0	2	0	2	0	0	0	0	2	0	2	0	2	0	10
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	3	0	0	0	0	0	1	2	2	7	0	0	0	0	0	0	0	15
Icteridae	Carib Grackle	*Quiscalus lugubris*	0	2	0	0	5	0	0	0	2	23	3	0	5	0	0	0	0	40
Icteridae	Crested Oropendola	*Psarocolius decumanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	0	0	0	0	0	0	0	0	0	0	0	0	0	15	0	0	0	15
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*	0	3	0	0	0	0	0	0	0	0	0	0	4	0	0	0	0	7
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picidae	White-bellied Piculet	*Picumnus spilogaster*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	4
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	0	0	0	0	0	0	1	0	0	0	0	2	0	0	2	0	0	5
BIRD ABUNDANCE			26	32	405	381	162	16	42	20	39	62	38	68	467	98	212	326	76	**2470**
SPECIES DIVERSITY			13	12	15	16	16	3	19	12	21	12	13	22	16	31	37	44	14	**97**

Site Name Abbreviations: DM-Darthmouth, EX-Exmouth, WH-Walton Hall, SU-Suddie, BP-Bushy Park, FR-Farm, PH-Philadelphia, MM-Meten-Meer-Zorg, LN-Leonora, LJ-La Jalousie, RZ-Ruimzeight, Wak-Wakenaam Island, Tig-Tiger Island, Leg-Leguan Island, Hog-Hog Island

B: Coastal Bird Survey Data for Region 4, January/February 2019

TAXA			SURVEYED COASTAL SITES - REGION 4																
Family Name	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	1	2	0	0	2	0	0	0	2	0	0	0	0	0	0	0	7
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	1	5	0	0	0	0	0	0	0	0	0	0	0	0	12	0	18
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*	0	0	1	13	0	0	0	2	0	0	0	0	0	0	0	0	16
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Cocoi Heron	*Ardea cocoi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Little Blue-Heron	*Egretta caerulea*	0	6	124	80	0	0	0	9	0	0	0	0	0	0	0	0	219
Ardeidae	Tricolored Heron	*Egretta tricolor*	0	10	27	9	0	26	0	0	0	0	0	0	0	0	0	2	74
Ardeidae	Striated Heron	*Butorides striata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Great Egret	*Ardea alba*	0	14	78	24	0	17	0	9	9	0	2	0	0	0	0	0	153
Ardeidae	Snowy Egret	*Egretta thula*	0	28	450	350	0	120	0	89	2	0	0	0	4	0	0	130	1173
Ardeidae	Cattle Egret	*Bubulcus ibis*	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	2
Aramidae	Limpkin	*Aramus guarauna*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	0	0	39	22	4	37	0	11	0	0	0	0	0	0	0	0	113
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Turkey Vulture	*Catharthes aura*	0	0	0	0	0	0	0	2	0	0	5	0	1	0	0	1	9
Cathartidae	Black Vulture	*Coragyps atratus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Osprey	*Pandion haliaetus*	0	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	3
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*	0	0	0	0	0	2	0	1	0	0	2	0	0	0	2	1	8
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 4																
Family Name	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Cracidae	Little Chacalaca	*Ortalis motmot*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacanidae	Wattled Jacana	*Jacana jacana*	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	5
Charadriidae	Southern Lapwing	*Vanellus chilensis*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	32	11	300	0	0	0	0	0	0	0	0	0	0	0	0	0	343
Charadriidae	Collared Plover	*Charadrius collaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Red Knot	*Calidris canutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Sanderling	*Calidris alba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	1	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	3
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	0	0	300	0	0	0	0	0	0	0	0	0	0	0	0	0	300
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Scolopacidae	Least Sandpiper	*Calidris minutilla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Western Sandpiper	*Calidris mauri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Calidris sp.	*Calidris sp.*	0	0	800	0	0	0	0	25	0	0	0	0	0	0	0	0	825
Scolopacidae	Whimbrel	*Numenius phaeopus*	0	1	16	0	0	7	0	0	0	0	0	0	0	0	0	0	24
Scolopacidae	Willet	*Tringa semipalmata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*	0	0	50	15	0	0	0	0	0	0	0	0	0	0	0	0	65
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	0	0	350	50	0	50	0	0	0	0	0	0	0	0	0	0	450
Scolopacidae	Yellowlegs sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Tringa sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Plover sp.	*Pluvialis sp.*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Laridae	Laughing Gull	*Leucophaeus atricilla*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Large-billed Tern	*Phaetusa simplex*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2

TAXA			SURVEYED COASTAL SITES - REGION 4																
Family Name	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Laridae	Royal Tern	*Thalasseus maximus*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Laridae	Common Tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Least Tern	*Sternula antillarum*	0	0	3	9	0	0	0	0	0	0	0	0	0	0	0	0	12
Laridae	Black Skimmer	*Rynchops niger*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	0	0	0	71	0	2	0	0	0	0	0	0	0	0	0	2	75
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	3
Falconidae	Bat Falcon	*Falco rufigularis*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Falconidae	Northern Crested Caracara	*Caracara cheriway*	0	0	1	0	0	0	0	0	1	0	0	0	0	0	0	2	4
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae	Great Horned Owl	*Bubo virginianus*	0	0	0	14	0	0	0	0	2	0	0	0	0	0	0	0	16
Columbidae	Rock Pigeon	*Columba livia domestica*	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	0	0	0	0	0	2	0	0	0	0	0	0	2	0	0	0	4
Columbidae	Ruddy Ground-Dove	*Columba plumbea*	0	0	0	0	0	0	0	5	0	0	0	0	3	0	0	0	8
Columbidae	Common Ground-Dove	*Columbina passerina*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Columbidae	White-tipped Dove	*Leptotila verreauxi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Red-bellied Macaw	*Orthopsittaca manilatus*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Orange-winged Parrot	*Amazona amazonica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Striped Cuckoo	*Tapera naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Little Cuckoo	*Coccycua minuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Greater Ani	*Crotophaga major*	0	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	4
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Emerald sp	*Amazilia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 4																
Family Name	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Trochilidae	Phaethornis sp. (Hummingbird)	*Phaethornis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Toco Toucan	*Ramphastos toco*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	0	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	5
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	1	0	2	5	0	3	0	5	8	0	5	0	3	0	1	8	41
Tyrannidae	Yellow Breasted Flycatcher	*Tolmomyias flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	3	0	0	0	0	2	0	0	0	0	2	0	3	0	3	1	14
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	0	0	0	0	0	0	0	2	3	0	7	0	0	0	0	2	14
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 4																
Family Name	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	0	0	0	2	0	2	0	14	8	0	7	0	2	0	2	0	37
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	0	0	0	2	0	0	0	0	2	0	0	0	0	0	0	4	8
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Troglodytidae	Southern House-wren	*Troglodytes aedon*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Torquoise Tanager	*Tangara mexicana*	0	0	0	2	0	0	0	0	1	0	0	0	0	0	0	2	5
Thraupidae	Bananaquit	*Coereba flaveola*	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Burnished-buff Tanage	*Tangara cayana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Red-capped Cardinal	*Paroaria gularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Wing-barred Seedeater	*Sporophila americana*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 4															
Family Name	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	0	0	0	3	0	0	0	3	1	0	0	0	0	0	0	0	7
Parulidae	Yellow Warbler	*Setophaga petechia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow Oriole	*Icterus nigrogularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Carib Grackle	*Quiscalus lugubris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Crested Oropendola	*Psarocolius decumanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picidae	White-bellied Piculet	*Picumnus spilogaster*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIRD ABUNDANCE			47	81	2542	671	9	280	0	187	43	0	34	0	24	0	20	158	**4096**
SPECIES DIVERSITY			9	10	16	16	5	16	0	18	14	0	9	0	11	0	5	13	**52**

Site Name Abbreviations: KS-Kingston, TK-Turkeyen, OG-Ogle, LBI-La Bonne Intention, BV-Triumph, LU-Lusignan, PA-Paradise, EM-Enmore, VT-Victoria, NZ-Nooten Zuil, HB-Hope Beach, HC-Hope Canal, Bee-BeeHive, Cl-Clonbrook, UN-Unity, MA-Mahaica

C: Coastal Bird Survey Data for Regions 5 and 6, January/February 2019

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6											
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	0	0	0	0	0	0	0	0	0	0	0	0
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	4	13	2	0	2	0	5	0	0	0	0	26
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*	0	0	1	0	0	0	0	5	0	0	0	6
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	0	0	1	0	0	0	0	0	0	0	0	1
Ardeidae	Cocoi Heron	*Ardea cocoi*	0	0	0	0	1	0	2	0	0	0	0	3
Ardeidae	Little Blue-Heron	*Egretta caerulea*	0	0	1	167	55	0	37	28	0	0	0	288
Ardeidae	Tricolored Heron	*Egretta tricolor*	0	0	0	0	0	0	3	21	0	0	0	24
Ardeidae	Striated Heron	*Butorides striata*	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Great Egret	*Ardea alba*	0	14	0	12	0	0	45	5	0	0	0	76
Ardeidae	Snowy Egret	*Egretta thula*	1	6	2	37	65	1	250	200	0	0	2	564
Ardeidae	Cattle Egret	*Bubulcus ibis*	0	0	0	0	0	0	0	0	0	0	0	0
Aramidae	Limpkin	*Aramus guarauna*	0	0	0	0	0	0	0	0	0	0	0	0
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	0	0	10	2	16	0	19	8	0	0	0	55
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Turkey Vulture	*Catharthes aura*	1	2	0	0	0	0	0	3	0	0	3	9
Cathartidae	Black Vulture	*Coragyps atratus*	3	0	0	0	0	0	0	0	4	15	3	25
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*	0	0	1	0	0	0	0	0	0	0	0	1
Accipitridae	Osprey	*Pandion haliaetus*	1	0	0	0	1	0	1	0	0	1	0	4
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6											
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*	2	0	0	0	1	0	0	2	0	0	0	5
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	0	0	0	0	1	0	0	0	0	0	0	1
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	0	0	0	0	2	0	0	0	2	0	0	4
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	0	0	0	0	0	0	0
Cracidae	Little Chacalaca	*Ortalis motmot*	0	0	0	0	0	0	0	0	0	0	0	0
Jacanidae	Wattled Jacana	*Jacana jacana*	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Southern Lapwing	*Vanellus chilensis*	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	0	11	0	500	0	0	100	200	0	346	2	1159
Charadriidae	Collared Plover	*Charadrius collaris*	0	0	0	0	0	0	0	0	0	12	0	12
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Red Knot	*Calidris canutus*	0	0	0	0	0	0	0	0	0	7	0	7
Scolopacidae	Sanderling	*Calidris alba*	0	0	0	200	0	0	0	100	0	37	0	337
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	1	0	0	3	0	0	2	0	0	0	0	6
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	0	0	20	400	0	0	0	200	0	23	0	643
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Least Sandpiper	*Calidris minutilla*	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Western Sandpiper	*Calidris mauri*	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Calidris sp.	*Calidris sp.*	0	0	0	1500	0	0	0	500	0	0	0	2000
Scolopacidae	Whimbrel	*Numenius phaeopus*	0	0	0	3	2	0	5	5	0	0	0	15

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6										
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Scolopacidae	Willet	*Tringa semipalmata*	0	0	5	0	0	0	0	0	0	0	0	5
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*	0	0	0	4	0	0	50	0	0	0	0	54
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	0	0	0	100	1	0	400	800	0	0	0	1301
Scolopacidae	Yellowlegs sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*	0	0	0	3	0	0	0	0	0	0	0	3
Scolopacidae	Tringa sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	0	0	0	12	0	0	3	3	0	0	0	18
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Plover sp.	*Pluvialis sp.*	0	0	2	12	0	0	0	0	0	0	0	14
Laridae	Laughing Gull	*Leucophaeus atricilla*	0	0	1	16	13	0	0	0	0	0	1	31
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Large-billed Tern	*Phaetusa simplex*	0	0	0	0	0	0	0	0	0	0	2	2
Laridae	Royal Tern	*Thalasseus maximus*	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Common Tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Least Tern	*Sternula antillarum*	0	0	2	0	0	0	17	0	0	0	0	19
Laridae	Black Skimmer	*Rynchops niger*	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	0	0	0	0	0	0	0	7	0	0	0	7
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Bat Falcon	*Falco rufigularis*	0	0	0	0	0	0	0	0	1	0	1	2
Falconidae	Northern Crested Caracara	*Caracara cheriway*	0	0	0	0	0	0	0	1	0	0	1	2
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	0	0	0	0	0	0	1	0	0	0	0	1

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6											
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Falconidae	Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae	Great Horned Owl	*Bubo virginianus*	0	0	0	0	0	0	0	0	0	0	9	9
Columbidae	Rock Pigeon	*Columba livia domestica*	0	0	0	0	2	0	0	0	0	0	0	2
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	0	0	0	0	2	0	0	0	0	0	0	2
Columbidae	Ruddy Ground-Dove	*Columba plumbea*	0	0	0	0	0	5	0	0	0	0	0	5
Columbidae	Common Ground-Dove	*Columbina passerina*	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae	White-tipped Dove	*Leptotila verreauxi*	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Red-bellied Macaw	*Orthopsittaca manilatus*	3	6	0	0	0	0	0	0	0	0	0	9
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	2	0	0	0	0	0	0	0	0	0	0	2
Psittacidae	Orange-winged Parrot	*Amazona amazonica*	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Striped Cuckoo	*Tapera naevia*	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Little Cuckoo	*Coccycua minuta*	0	0	11	0	0	5	0	0	0	0	0	16
Cuculidae	Greater Ani	*Crotophaga major*	0	2	0	0	0	0	0	0	0	0	0	2
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Emerald sp	*Amazilia sp.*	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Phaethornis sp. (Hummingbird)	*Phaethornis sp.*	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	0	0	0	0	0	0	1	0	0	0	0	1

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6											
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Alcedinidae	Toco Toucan	*Ramphastos toco*	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	0	0	0	0	0	0	0	0	0	0	0	0
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	0	0	1	0	0	0	0	0	0	0	0	1
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	0	0	0	0	0	0	2	0	0	0	0	2
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*	0	0	0	0	0	0	0	2	0	0	0	2
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*	0	2	4	3	0	0	0	2	0	0	0	11
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	2	2	0	0	0	0	0	0	0	0	0	4
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	0	0	3	0	0	0	0	0	0	0	0	3
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	2	2	2	3	0	7	4	4	2	0	2	28
Tyrannidae	Yellow Breasted Flycatcher	*Tolmomyias flaviventris*	2	0	0	0	2	0	0	0	0	0	0	4
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	0	0	0	0	0	0	2	0	1	0	2	5
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	3	0	0	0	3	0	0	0	0	0	0	6
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	0	3	0	0	1	0	0	0	0	0	0	4
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6											
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	2	2	2	0	3	4	2	4	0	0	0	19
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	0	0	0	0	0	0	2	0	0	0	0	2
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	0	2	2	0	0	0	0	0	0	0	0	4
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	0	0	2	0	2	0	0	2	0	0	0	6
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	1	0	0	0	0	0	0	0	0	0	3	4
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	0	0	0	0	0	0	0	0	0	0	0	0
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	0	0	0	0	0	0	0	0	0	0	0	0
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	0	2	2	0	0	0	1	2	0	0	0	7
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0	0	0	0	0	0	0	0	0	0	0
Troglodytidae	Southern House-wren	*Troglodytes aedon*	0	0	0	0	0	0	0	2	0	0	0	2
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*	0	0	3	0	0	0	0	0	0	0	0	3
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	3	8	0	0	3	0	0	0	0	0	0	14
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6											
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Thraupidae	Torquoise Tanager	*Tangara mexicana*	0	2	0	0	2	3	0	5	0	0	0	12
Thraupidae	Bananaquit	*Coereba flaveola*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Burnished-buff Tanage	*Tangara cayana*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Red-capped Cardinal	*Paroaria gularis*	0	0	2	0	0	1	0	0	0	0	0	3
Thraupidae	Wing-barred Seedeater	*Sporophila americana*	0	0	0	0	0	2	0	0	0	0	0	2
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	0	0	0	0	0	0	0	0	0	0	0	0
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	0	2	2	0	2	0	0	2	0	0	0	8
Parulidae	Yellow Warbler	*Setophaga petechia*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow Oriole	*Icterus nigrogularis*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Carib Grackle	*Quiscalus lugubris*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Crested Oropendola	*Psarocolius decumanus*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	0	0	1	0	0	0	0	0	0	0	0	1
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*	0	0	4	0	2	0	0	2	0	0	0	8
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 5 AND 6										
Family Name	Common Name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	MS-R6	PS-R6	61B-R6	63B-R6	SL-R6	Total
Picidae	White-bellied Piculet	*Picumnus spilogaster*	0	0	0	0	0	0	0	0	0	0	0	0
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*	0	0	0	0	0	0	0	0	0	0	0	0
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	0	0	0	200	0	0	0	0	0	0	0	200
BIRD ABUNDANCE			33	81	89	3177	184	28	954	2115	10	441	31	**7143**
SPECIES DIVERSITY			16	17	26	19	23	8	23	27	5	7	12	**73**

Site Name Abbreviations: SS-Sans Souci, AB-Abary, MP-Moor Park, BL-Bush Lot, HT-Hope Town, WP-Woodley Park, MS-Maida Seaside, PS-Phillipe Seaside. 61B-61 Beach, 63B-63 Beach, SL-Springlands

ATTACHMENT 4 PHOTOGRAPHIC LOG—COASTAL BIRD SURVEY JANUARY/FEBRUARY 2019

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Orange-winged Parrot (*Amazona amazonica*) at Hog Island



Scarlet Ibis (*Eudocimus ruber*)



Spotted Sandpiper (*Actitis macularius*) at the Enmore site



Black-collared Hawk (*Busarellus nigricollis*) at the Hopetown site



White-chested Emerald (*Amazilia brevirostris*)



Yellow Oriole (*Icterus nigrogularis*)



White-bellied Piculet (*Picumnus spilogaster*)



Yellow-breasted Flycatcher (*Tolmomyias flaviventris*) at Affiance seaside



Bicolored Conebill (*Conirostrum bicolor*) at the Maida site



Spotted Tody-flycatcher (*Todirostrum maculatum*) at the Maida site



Hopetown survey site – looking west



Hopetown survey site – looking east



Shorebirds at the Ogle site



Wading birds at the Anna Regina site



Section of the Bush Lot site



Black mangroves at the Moor Park site

ERM

210 New Market Street
Georgetown, Guyana

Telephone: +592 501 0625
www.erm.com

Technical Memorandum

To	Jena Lococo, Kari Ehmling
From	Waldyke Prince and Julia Tims
Date	22 May 2019
Reference	Year 2 Coastal Bird Study
Subject	Interim Report – Survey 3

1 Introduction

On behalf of Esso Exploration and Production Guyana Limited (EEPGL), Environmental Resources Management (ERM) conducted a survey in March and April 2019 of coastal birds along the coastline of Guyana, in Regions 2 through 6. This survey is the third of a series of five surveys to be conducted as part of EEPGL's Year 2 Coastal Bird Study. This study is a continuation of the Year 1 Coastal Bird Study, which was conducted in conjunction with EEPGL's Enhanced Coastal Sensitivity Mapping work in 2017 and 2018. The Year 2 Coastal Bird Study is an elective study commissioned by EEPGL and is not being conducted pursuant to any regulatory requirement.

This memorandum summarizes the results and highlights the key findings of the March/April 2019 coastal bird survey. After completion of the Year 2 Coastal Bird Study surveys, ERM will prepare a full report that details the results of all Year 2 surveys and compares those results with the results of all surveys conducted to date.

2 Survey Objectives

The objective of the March/April 2019 survey of the Year 2 Coastal Bird Study was to document the distribution, abundance, and diversity of coastal birds in Regions 2–6. Documentation of coastal bird breeding sites, another objective of the Year 2 Coastal Bird Study, is underway and will be concluded in conjunction with the remaining coastal bird surveys planned for 2019.

3 Survey Approach and Methods

3.1 Timing and Location of Survey

From 27 March through 4 April 2019, a bird survey team including Waldyke Prince (Guyanese bird specialist and survey lead) and Philip Odwin (Guyanese bird survey advanced trainee) surveyed coastal birds at 69 sites along the Guyana coastline in Regions 2–6 (Table 1 and Attachment 1).

As discussed with EEPGL in late 2018 and assessed by the survey team during the January/February 2019 survey, some changes to the previously designated survey points were warranted for this and future surveys. These changes will increase survey coverage in under-surveyed portions of the coastline, specifically Region 6, and eliminate what the surveyors determined were redundant points (points that were too close together and similar in habitat type

and condition to adjacent points[1]) or ineffective points (e.g., marginal habitats, consistently few birds, suboptimal views of the coastline). Three additional coastal survey points in Region 6 were added to increase survey coverage of the coastline in this region and 23 survey points were eliminated from the Essequibo Islands survey points.

Attachment 1 lists the 69 coastal and island survey sites that were surveyed in March/April 2019 and will continue to be surveyed for the remainder of the Year 2 Coastal Bird Survey. Attachment 1 also includes a mapbook that depicts the locations of the sites. The coastal habitat types surveyed included mangrove (riverine and coastal), intertidal and tidal wetlands, mudflat, plantation (island surveys only), vegetated low bank, sand beach, and man-made coastal habitat types such as sea wall and jetty.

Table 1: Number of Coastal Bird Survey Sites Surveyed in the March/April 2019 Coastal Bird Survey in Regions 2 through 6

Region	Geographic Range of Survey Area	Total Number of Survey Sites
2	Between the east bank of the Pomeroon River and the Supenaam River	6
3 (Coastal)	Coastal shoreline to Ruimzeight	7
3 (Essequibo Islands)	Tiger, Hog, Leguan, and Wakenaam Islands	26
4	Kingston Seaside to the Mahaica River mouth	16
5	Sans Souci to Woodley Park	6
6	Maida Seaside to Springlands	8
Total		**69**

3.2 Survey Methods

3.2.1 Coastal Point Count Surveys

Surveyors conducted 15-minute point count surveys at the 69 survey sites in Regions 2 through 6. To the extent practicable, surveys were conducted in the morning hours between 06:00 a.m. and 10:00 a.m., when birds are most active. However, this was not always possible due to tidal stage and related site accessibility or other constraints.

From each survey site, observations were made within a radius of approximately 500 meters (0.3 mile) around the survey site. Survey site locations were electronically recorded using GPS and the sites were photographed. Observers recorded data using an iPad equipped with the Survey 123

[1] At the outset of this study in 2017, surveyors pre-determined survey points for the Essequibo Islands portion of the survey based on a set distance (2 kilometers [0.6 mile]) between survey points (not accounting for habitat conditions, ability to effectively view the shoreline etc.). After a full year of survey, the surveyors determined that the survey of the island sites should include fewer points spaced further apart to maximize the rigor of the survey (removal of suboptimal or redundant survey points) and to minimize the potential for the same birds being counted multiple times at adjacent survey points.

application and a tailored electronic data collection template developed for this survey by ERM (Attachment 2). This electronic data collection system is compatible with ERM's EEPGL Project Geographic Information System (GIS) platform.

The following information was collected during each point count survey:

- Survey location (latitude and longitude or GPS coordinates of the survey site)
- Date
- Observation type (incidental, transect survey, point count survey)
- Start/stop time of survey
- Brief site/habitat description and site identification
- Weather (percent cloud cover, precipitation, wind speed, wind direction, temperature)
- For each species seen or heard:
  - Species identification (or lowest taxonomic level identifiable)
  - Number of individuals (if in a group)

3.2.2 Island Point Count Surveys

Surveys of the Region 3 island sites (Essequibo Islands) were conducted via boat. These sites were surveyed from the water using the same point count methodology as the land-based surveys described above.

4 Results Summary

The March/April 2019 coastal bird survey documented 109 species and 9,901 birds, representing 37 bird families. Coastal sites documented 98 species and island sites documented 48 species, with 36 species recorded at both coastal and island sites and 12 species recorded only at island sites. No species were documented at four of the survey sites, all of which are in Regions 3 and 4: La Jalousie (Region 3 Coastal), Tiger Island 9 (Region 3 Islands), LBI Seawall (Region 4), and Bee Hive (Region 4).

Of the 109 species observed during this survey, nine were not observed during the most recent January/February 2019 survey, and four were new to the list of species documented from all prior EEPGL-commissioned coastal bird surveys.[2] The four new species were: Lesser Black-backed Gull (*Larus fuscus*), Glittering-throated Emerald (*Amazilia fimbriata*), White-lined Tanager (*Tachyphonus rufus*), and Pearl Kite (*Gampsonyx swainsonii*). With the exception of the Lesser Black-backed Gull, the new species observed during this survey typically inhabit forest and other inland habitats and are not distinctively associated with coastal habitats. The Lesser Black-backed Gull is considered accidental along the coast of Guyana, with its typical range extending from the east coast of North America to the Gulf of Mexico. Attachment 3 contains the raw survey data for the March/April 2019 coastal bird survey.

[2] Prior EEPGL-commissioned coastal bird surveys include the three surveys comprising the Year 1 Coastal Bird Study, the September/October 2018 survey, and the January/February 2019 survey.

The following bird families were well-represented in terms of numbers of species and/or individuals observed:

- *Accipitridae* and *Falconidae* (raptors)—11 species; 119 individuals
- *Ardeidae* (herons)—9 species; 2,825 individuals
- *Charadriidae* (plovers and lapwings)—4 species; 757 individuals
- *Columbidae* (pigeons and doves)—5 species; 108 individuals
- *Hirundinidae* (swallows)—3 species; 122 individuals
- *Icteridae* (orioles, grackles, and cowbirds)—5 species; 140 individuals
- *Laridae* (gulls)—7 species; 331 individuals
- *Scolopacidae* (sandpipers)—11 species; 4,349 individuals
- *Thraupidae* (tanagers)—9 species; 72 individuals
- *Tyrannidae* (tyrant flycatchers)—16 species; 427 individuals

Sixteen species of migratory shorebirds were documented during the March/April 2019 survey, approximately the same number of migratory shorebirds observed during the January/February 2019 survey (15 species). The September/October 2018 survey documented 20 migratory shorebird species; that survey appears to have coincided with the peak period for fall shorebird migration that year. The March/April 2019 survey may have occurred earlier in this year's spring migration period,[3] given that the data do not indicate a substantial decline in or absence of overwintering shorebirds or an increase in shorebird species known to overwinter south of Guyana (and thus pass through Guyana during their annual northward spring migration).

The most abundant shorebirds observed during the March/April 2019 survey were unidentified sandpipers (*Calidris* sp.), Lesser Yellowlegs (*Tringa flavipes*), Semipalmated Plover (*Charadrius semipalmatus*), Semipalmated Sandpiper (*Calidris pusilla*), Greater Yellowlegs (*Tringa melanoleuca*), Sanderling (*Calidris alba*), and Least Sandpiper (*Calidris minutilla*). The most common colonial waterbirds observed were Snowy Egret (*Egretta thula*), Little Blue Heron (*Egretta caerulea*), Scarlet Ibis (*Eudocimus ruber*), Great Egret (*Ardea alba*), and Cattle Egret (*Bubulcus ibis*).

Consistent with prior surveys, sites with exposed mudflats had the highest abundance of birds of any habitat surveyed (average of 225 individuals per site). However, while previous surveys had highest species richness at mangrove sites, the March/April 2019 surveys had higher richness at mudflats (average of 13 species per site), with lower richness at mangrove and sandy beach habitats (average of 9.5 to 10 species per site). Habitat categories are not exclusive, so some sites contain a mixture of habitat types.

4.1 Regional Results

Table 2 presents total and average bird abundance and species richness by region recorded during the March/April 2019 coastal bird survey. Region 5 had the greatest overall bird abundance (3,131 total birds, with an average of 522 birds per site). Region 4 had the second highest total abundance (2,315 birds) but Region 2 and Region 6 had higher average abundances per site (270 and 267 birds

[3] Peak migratory periods are variable from year to year, based on weather and other factors.

per site, respectively). Region 4 had the greatest total species richness (62 species), while Region 5 had the highest average richness (18 species per site); most sites had similar average species richness (range of 13 to 18 species per site), except for Region 3 island sites, which only had an average of 5 species per site.

Sixteen species were recorded in all five regions surveyed, which is more than in previous surveys; thirteen species were recorded in all regions during the January/February 2019 surveys and 11 species were recorded in all regions during the September/October 2018 surveys. Six of these 16 species are considered wetland-specific species.

Table 2: Total Bird Species Abundance and Richness Recorded in Regions 2 through 6 during the March/April 2019 Coastal Bird Survey

Region	Bird Abundance (Number of Individual Birds)	Average Abundance per Site	Bird Species Richness (Number of Bird Species)	Average Richness per Site
2	1,624	270	44	15
3 Coastal	395	66	44	13
3 Islands	296	11	48	5
4	2,315	165	62	13
5	3,131	522	51	18
6	2,140	267	59	15

Other notable comparisons of results from this survey and that of prior surveys[4] include:

- Total bird abundance and average bird abundance per site was generally lower during the March/April 2019 survey across regions compared to most of the prior surveys (Figures 1 and 2). Abundance varies within and between regions and survey periods without a clear trend. One survey period of note is the September/October 2018 survey, which likely coincided with peak bird migration given the consistently high abundance and species richness across regions; Region 6 had over 10,000 birds total, and over 2,000 birds on average per site in the September/October 2018 survey.
- Although overall bird abundance was generally lower during the March/April 2019 survey, some species had much higher abundance during this survey than previously recorded. A few species had drastically higher numbers compared to the January/February 2019 survey, including: Laughing Gull (*Leucophaeus atricilla*), Least Sandpiper, and Least Tern (*Sternula antillarum*). These species, similarly to many other waterbirds and shorebirds, are found in large flocks, and therefore are almost always recorded in either very high or very low abundance depending on flock presence. A few species with unusually high abundance in the January/February 2019

[4] Prior surveys include the September/October 2018 and January/February 2019 surveys, and the Year 1 Coastal Bird Study surveys of September/October 2017 and April 2018.

survey were again recorded in high numbers in March/April 2019: Greater Yellowlegs, Snail Kite (*Rostrhamus sociabilis*), Blue-grey Tanager (*Thraupis episcopus*), Yellow Oriole (*Icterus nigrogularis*), Shiny Cowbird (*Molothrus bonariensis*), and Carib Grackle (*Quiscalus lugubris*). This is unique for passerine species (and Snail Kite, a raptor) which are typically found in lower abundance and associated with inland habitats such as forests and pasturelands.

- Although the Region 3 island sites had the greatest total species richness during most survey periods, they had a lower average richness (species per site; Figures 3 and 4). There are more sites surveyed on Region 3 islands compared to other regions, so more species are recorded overall in those surveys. In March/April 2019, half of the island sites were discontinued from surveying, decreasing the total species richness recorded for the Essequibo Islands as a whole.
- During the March/April 2019 survey, numerous species were observed in regions and at sites where they had not been observed previously, including but not limited to: Cattle Egret, Least Tern, Grey-lined Hawk (*Buteo nitidus*), Striped Cuckoo (*Tapera naevia*), and Brown-throated Parakeet (*Eupsittula pertinax*).

These data provide further evidence to support one of the key preliminary findings of the Year 1 Coastal Bird Study—that there is high seasonal and inter-annual variability in species richness and abundance across sites and regions.

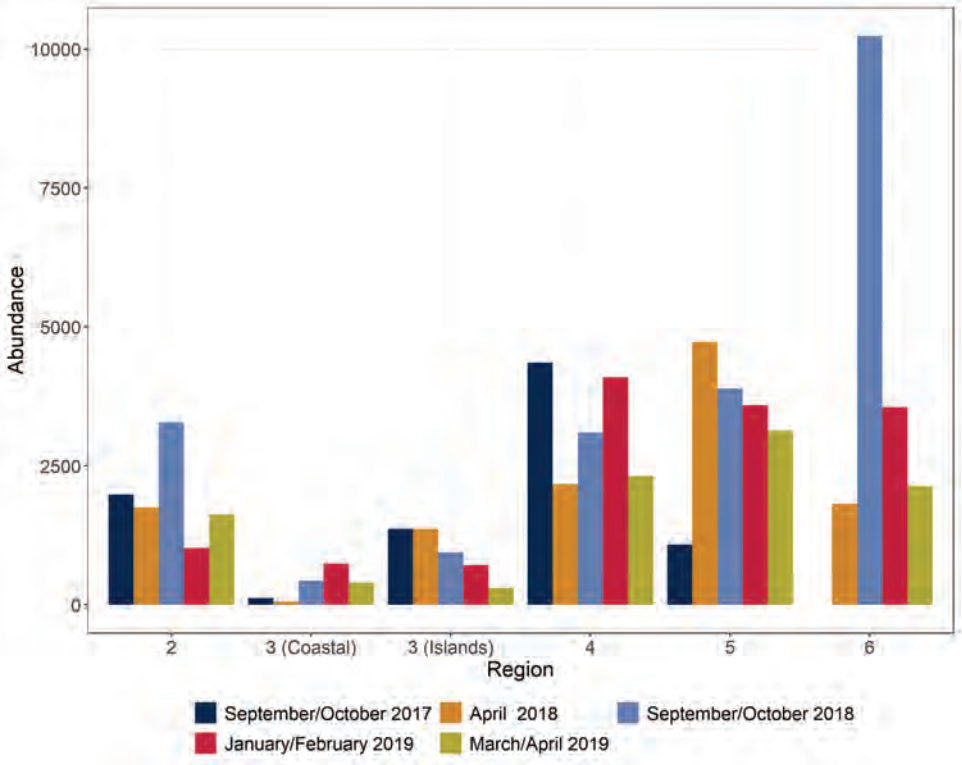


Figure 1: Total Bird Abundance per Region and Survey Period[5]

[5] Region 6 was not surveyed during the September/October 2017 survey because this region was not included in the scope of the coastal bird survey at that time. Region 6 was added to the scope of the coastal bird survey in early 2018.

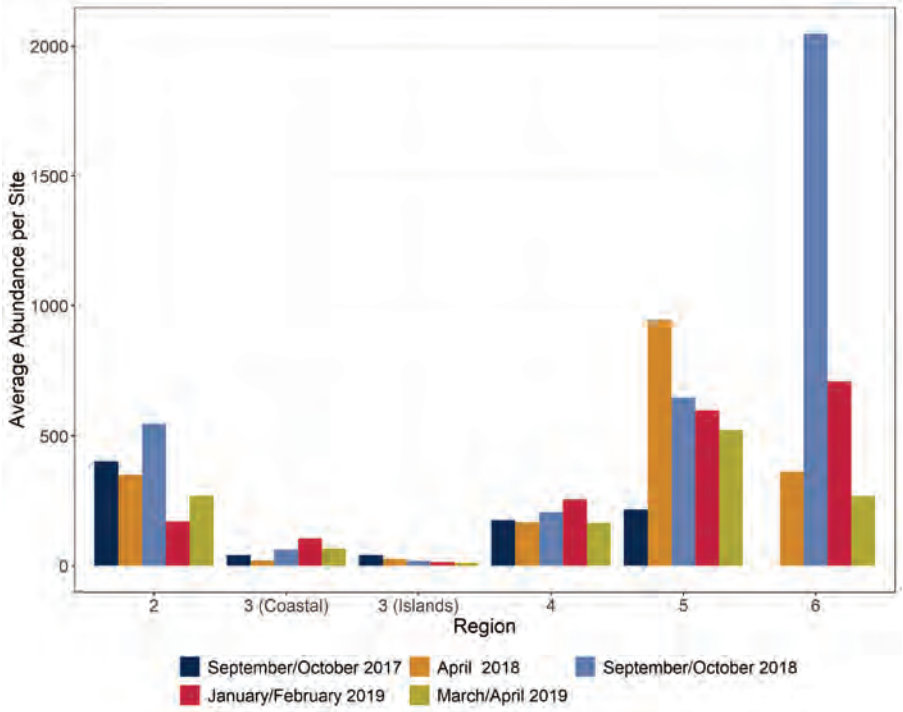


Figure 2: Average Bird Abundance per Site, by Region and Survey Period

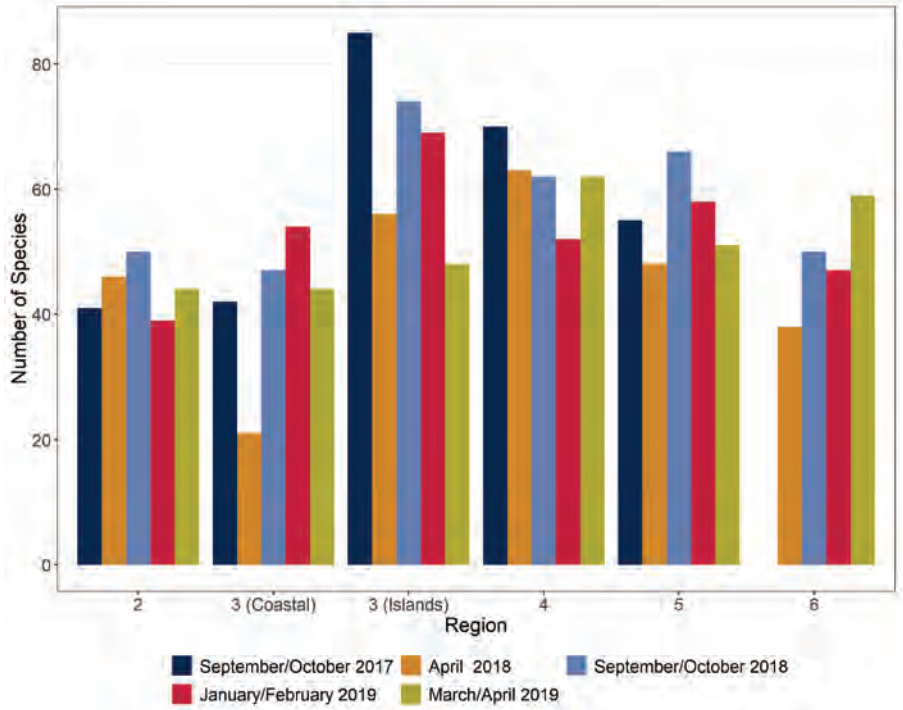


Figure 3: Total Species Richness per Region and Survey Period

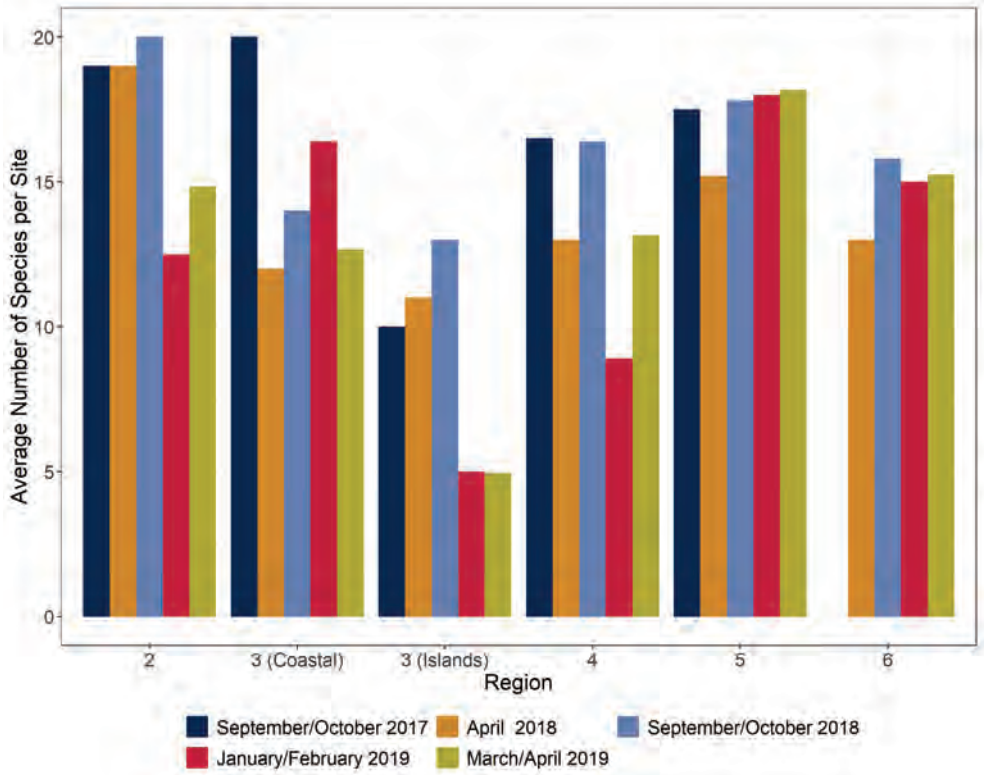


Figure 4: Average Species Richness per Site by Region and Survey Period

4.2 Site-Specific Results

The highest bird abundance documented in the March/April 2019 survey occurred at Bush Lot Seaside in Region 5 (1,398 birds), the same site which had the highest abundance in the January/February 2019 survey (though that survey had higher site abundances, with 3,177 birds; Table 3). Two other sites had particularly high abundance: Hopetown in Region 5 (1,132 birds) and Maida Seaside in Region 4 (1,000 birds). The highest species richness occurred in Region 6 at Phillipe Seaside and Maida Seaside (27 species at each site). Both Maida Seaside and Phillipe Seaside have had some of the highest species abundance in previous surveys, but never the highest richness (Table 3).

Table 3: Comparison of Sites with Highest Bird Abundance and Species Richness Across All EEPGL-Commissioned Surveys Conducted to Date

Survey Period	Site	Highest Abundance	Site	Highest Species Richness
September/ October 2017	Ogle Seaside, Region 4	891	Leguan Island, Region 3	61
	Anna Regina, Region 2	658	Tiger Island, Region 3	33
	Exmouth, Region 2	928	Wakenaam Island, Region 3	32
April 2018	Lusignan, Region 4	979	Leguan Island, Region 3	34
	Exmouth, Region 2	656	Wakenaam Island, Region 3	34
	Leguan Island, Region 3	637	Victoria, Region 4	26
			Walton Hall, Region 2	25
September/ October 2018	Maida Seaside, Region 6	6,553	Wakenaam Island, Region 3	52
	Bush Lot, Region 5	3,281	Moor Park, Region 5	37
	Phillipe Seaside, Region 6	3,238	Enmore, Region 4	32
			Leguan Island, Region 3	32
January/ February 2019	Bushlot Seaside, Region 5	3,177	Leguan Island, Region 3	44
	Ogle Seaside, Region 4	2,542	Wakenaam Island, Region 3	37
	Phillipe Seaside, Region 6	2,115	Tiger Island, Region 3	31
March/April 2019	Bushlot Seaside, Region 5	1,398	Maida Seaside, Region 6	27
	Hopetown, Region 5	1,132	Phillipe Season, Region 6	27
	Maida Seaside, Region 6	1,000	Anna Regina, Region 2	25

The three new sites surveyed in Region 6 had lower bird abundance than the other survey sites in this region (average abundance of 45 individuals per new site and 342 individuals per other sites) but higher species richness compared to the other Region 6 sites (average species richness of 17 species per new site and 14 species per other sites). The new sites appeared to have a lower bird abundance because two other Region 6 sites had much higher abundance, Maida Seaside and Phillipe Seaside (abundance of 1,000 and 610 individuals, respectively), which skewed the average higher. Excluding those two outliers, the new Region 6 sites had similar abundance to the other sites in Region 6 (range of 34 to 158 individuals at new sites and 6 to 158 individuals at other sites). Species richness was consistently high at the new sites (range of 17 to 19 species per site), while the other Region 6 sites had lower richness except at Maida Seaside and Phillipe Seaside.

4.3 Special Status Species

Five species of international conservation concern[6] were documented during the survey: White-bellied Piculet (*Picumnus spilogaster*), Rufous Crab Hawk (*Buteogallus aequinoctialis*), Bicolored Conebill (*Conirostrum bicolor*), Semipalmated Sandpiper, and Red Knot (*Calidris canutus*). The current International Union for the Conservation of Nature (IUCN) Red List status for the White-bellied Piculet is "Vulnerable." The four remaining species are designated as "Near Threatened." All five species were documented in the January/February 2019 survey, and all but the White-bellied Piculet were also documented in the September/October 2018 survey.

None of the three species of local conservation interest[7] documented during prior surveys was observed again during this survey. The Silvered Antbird (*Sclateria naevia*) was recorded in January/February 2019, while the Gray-headed Kite (*Leptodon cayennensis*) and the subspecies *fumosus* of Fuscous Flycatcher (*Cnemotriccus fuscatus*) were observed on the Essequibo Islands during the fall 2017 survey of the Year 1 Coastal Bird Study; none of them have been recorded on subsequent surveys.

4.4 Important Bird Habitats

The 10 sites identified as Important Bird Habitats within Regions 2 through 6[8] during the Year 1 Coastal Bird Study mostly had high bird abundance and species richness. Consistent with the most recent previous surveys, high numbers of shorebirds were recorded at Bush Lot, Maida Seaside, Phillipe Seaside, and Ogle in Regions 4 through 6 (over 600 birds per site). Only two sites had low abundances (fewer than 45 birds) during the March/April 2019 survey: Exmouth and Hope Beach. However, these sites still had a relatively high species richness, with 9 species at Hope Beach (20 birds total) and 13 species at Exmouth (38 birds total). Overall, more of the Important Bird Habitats were recorded to have high abundance and species richness compared to the January/February 2019 survey, possibly due to seasonality or other survey aspects such as tide level. The consistent, concentrated use of these areas by a relatively large number of bird species across multiple survey events validates the Year 1 Coastal Bird Study designation of these sites as Important Bird Habitats. No new Important Bird Habitats were designated based on the results of the March/April 2019 survey. Results from the three new Region 6 survey sites do not indicate that these sites warrant

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[6] The International Union for the Conservation of Nature (IUCN) Red List of Threatened Species (IUCN Red List) is the definitive authority on global species conservation status. Species considered to be of international conservation concern are those with IUCN Red List status of Near Threatened, Vulnerable, Endangered, or Critically Endangered.

[7] Species of local conservation interest are species that are considered by Guyanese and international bird specialists to be rare and/or declining in Guyana or have very limited distribution in Guyana but are not species of global conservation concern based on their IUCN Red List status.

[8] The Year 1 Coastal Bird Study defined Important Bird Habitats as sites that support one or more of the following: (1) predictable congregations of migratory shorebirds; (2) concentrations of roosting and/or nesting wading birds; (3) unique habitat that supports large numbers of riverine forest- and mangrove-dependent species; and (4) important nesting sites for regional endemic species of conservation interest. The Important Bird Habitats identified within Regions 2 through 6 during the Year 1 Coastal Bird Survey include: Exmouth Seaside, Walton Hall Seaside, Essequibo Island Complex, Ogle Seaside, Triumph-BV Seaside, Enmore Seaside, Hope Beach Seaside, Victoria Seaside, Bush Lot Seaside, and the area between Maida and Phillipe.

designation as Important Bird Habitats; however, additional survey data to be collected during the remaining two surveys planned for summer and fall 2019 will be reviewed to further evaluate this preliminary determination.

5 Discussion

The March/April 2019 survey data continue the trend from prior surveys of high seasonal and inter-annual variability in species richness and abundance across sites and regions. This survey had lower overall bird abundance compared to the two most recent previous surveys (January/February 2019 and September/October 2018) but slightly higher overall bird abundance compared to the first two surveys (September/October 2017 and April 2018) (Table 3). Overall species richness was lower in March/April 2019 compared to all prior surveys. It is possible that the March/April 2019 survey occurred early in the spring migratory period this year and did not capture migrants passing though Guyana from areas further south on their way to their northern breeding grounds, which would have increased both species richness and abundance. This was also the first survey in which no Region 3 Island sites ranked among the highest in total species richness: Region 3 Island sites generally had some of the lowest species richness and abundance with fewer than 5 species and fewer than 10 birds at half of the island sites surveyed. Future surveys planned for summer and fall 2019 will shed light on whether the March/April 2019 survey results for the Essequibo Islands were an anomaly or related to the change in survey sites or other factors such as tidal stage or location of food resources during the surveys.

Four bird species recorded during this survey were new to the list of species documented from all prior EEPGL-commissioned coastal bird surveys. Three of these four species typically inhabit forest and other inland habitats and are not distinctively associated with coastal habitats. The fourth species, the Lesser Black-backed Gull, is an occasional transient species in Guyana's coastal and offshore habitats. No new species of local or international conservation concern were documented during the March/April 2019 survey (only previously documented species) and no new Important Bird Habitats were identified. The three new Region 6 survey points yielded expected results based on habitat type: species richness and abundance were generally in line with the average species richness and abundance previously recorded at the other survey sites in this region, excluding unusually high records.

6 Next Steps

The final two coastal bird surveys in the Year 2 Coastal Bird Study will be conducted between late June and mid-July 2019 (Survey 4 of 5 of the Year 2 Coastal Bird Study) and between mid-September and mid-October 2019 (Survey 5 of 5 of the Year 2 Coastal Bird Study). Documentation and mapping of coastal bird breeding sites in Regions 2 through 6 will be concluded in conjunction with these surveys.

ATTACHMENT 1 COASTAL BIRD SURVEY SITES AND MAPBOOK

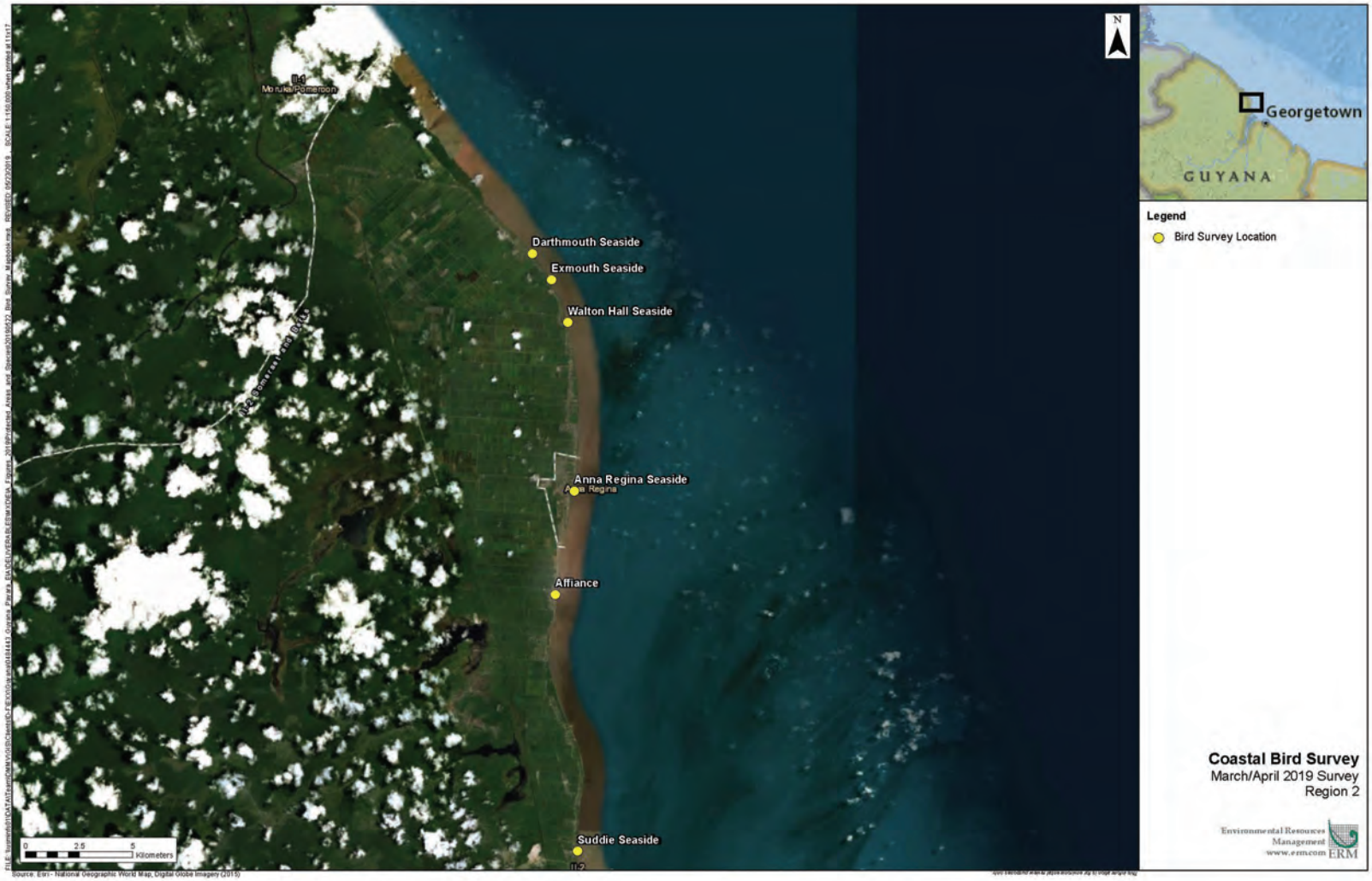
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Coastal Bird Survey Sites, Regions 2–6, March/April 2019

Survey Site	Name	Region	Habitat Type
Coastal Sites			
DM-R2	Dartmouth	2	Sea wall, mudflat
EX-R2	Exmouth	2	Mudflat
WH-R2	Walton Hall	2	Mudflat and tidal wetland
AR-R2	Anna Regina	2	Mudflat
AF-R2	Affiance	2	Sea wall, mudflat, mangrove
SU-R2	Suddie	2	Sand beach, jetty
BP-R3	Bushy Park	3	Sand beach
FR-R3	Farm	3	Sea wall, mudflat
PH-R3	Philadelphia	3	Sea wall, mudflat
MM-R3	Meten-Meer-Zoor	3	Sea wall, mudflat
LN-R3	Lenora	3	Sea wall, mudflat
L J-R3	La Jalousie	3	Sea wall, mudflat
RZ-R3	Ruimzeight	3	Sea wall, mudflat
KS-R4	Kingston	4	Sand beach, jetty
TK- R4	Turkeyen	4	Sea wall, mudflat
OG-R4	Ogle	4	Mudflat
LBI-R4	LBI Seawall	4	Mudflat, mangrove
BV-R4	BV-Triumph	4	Sea wall, intertidal wetland, mudflat
LU-R4	Lusignan	4	Mudflat
PA-R4	Paradise	4	Mangrove
EM-R4	Enmore	4	Mudflat
VT-R4	Victoria	4	Sea wall, intertidal wetland, mudflat, mangrove
NZ-R4	Nooten Zuil	4	Sea wall–open, some mangrove
HB-R4	Hope Beach	4	Mudflat, mangrove
HC-R4	Hope Canal	4	Mudflat, mangrove
Bee-R4	Bee Hive	4	Mangrove
CB-R4	Clonbrook	4	Mudflat, mangrove
UN-R4	Unity	4	Sand beach, jetty
MA-R4	Mahaica	4	Mudflat, mangrove
SS-R5	Sans Souci	5	Mangrove
AB-R5	Abary	5	Sand beach
MP-R5	Moor Park	5	Mangrove and mudflat
BL-R5	Bush Lot	5	Mudflat
HT-R5	Hopetown	5	Mangrove
WP-R5	Woodley Park	5	Mangrove
MS-R6	Maida Seaside	6	Sand beach
PS-R6	Phillipe Seaside	6	Sand beach
61B-R6	61-Beach Seaside	6	Sand beach
63B-R6	63-Beach Seaside	6	Sand beach
SL-R6	Springlands	6	Sand beach
AS-R6*	Alness Seaside	6	Sand beach
EPS-R6*	Bush Lot Village	6	Mudflat, mangrove
W61B-R6*	No. 57 Village	6	Mudflat, vegetated low bank
Essequibo Island Sites			
Tig1-R3	Tiger Island 1	3	Sand beach, mangrove
Tig3-R3	Tiger Island 3	3	Sand beach, mangrove
Tig5-R3	Tiger Island 5	3	Mangrove
Tig7-R3	Tiger Island 7	3	Sand beach, mangrove
Tig9-R3	Tiger Island 9	3	Sand beach, mangrove
Wak1-R3	Wakenaam 1	3	Sand beach, mangrove
Wak3-R3	Wakenaam 3	3	Sand beach, mangrove
Wak5-R3	Wakenaam 5	3	Sand beach, mangrove
Wak7-R3	Wakenaam 7	3	Sand beach, mangrove
Wak9-R3	Wakenaam 9	3	Sand beach, mangrove
Wak11-R3	Wakenaam 11	3	Cement wall, some mangrove

Survey Site	Name	Region	Habitat Type
Wak13-R3	Wakenaam 13	3	Mangrove
Wak15-R3	Wakenaam 15	3	Mangrove
Wak17-R3	Wakenaam 17	3	Mangrove
Leg1-R3	Leguan 1	3	Cement wall
Leg3-R3	Leguan 3	3	Cement wall, mangrove
Leg5-R3	Leguan 5	3	Sand beach, plantation
Leg7-R3	Leguan 7	3	Mudflat, mangrove
Leg9-R3	Leguan 9	3	Mudflat, mangrove
Leg11-R3	Leguan 11	3	Mangrove
Leg13-R3	Leguan 13	3	Mangrove
Leg15-R3	Leguan 15	3	Mangrove
Hog1-R3	Hog Island 1	3	Mudflat, mangrove
Hog3-R3	Hog Island 3	3	Mudflat, mangrove
Hog5-R3	Hog Island 5	3	Mudflat, mangrove
Hog7-R3	Hog Island 7	3	Mangrove
Hog9-R3	Hog Island 9	3	Mangrove

* New survey site added in March/April 2019 to increase coverage of the Region 6 coastline


N
Georgetown
GUYANA
Legend
Bird Survey Location
Darthmouth Seaside
Exmouth Seaside
Walton Hall Seaside
Anna Regina Seaside
Affiance
Suddie Seaside
Coastal Bird Survey
March/April 2019 Survey
Region 2
Environmental Resources Management
www.erm.com
ERM
0
2.5
5
Kilometers


N
Georgetown
GUYANA
Legend
Bird Survey Location
Region 3 Essequibo Islands Survey Area
Coastal Bird Survey
March/April 2019 Survey
Region 3
Environmental Resources Management
www.ermcom
ERM
Meten-Meer-Zorg Seaside
Leonora Seaside
Farm Seaside
Philadelphia Seaside
Bushy Park Seaside
La Jalousie Seaside
Ruimzeight Seaside
Leguan Island
III-1 West Demerara
III-1 Essequibo Islands
Parika
Essequibo River
ESSEQUIBO ISLANDS-WEST DEMERARA
POMEROON-SUPENAAM
0
2.5
5
Kilometers
Source: Esri - National Geographic World Map, Digital Globe Imagery (2015)


N
Georgetown
GUYANA
Legend
Bird Survey Location
Atlantic
Atlantisch
Ruimzeight Seaside
Kingston Seaside
Turkeyen Seaside
Ogle Seaside
LBI Seawall
Triumph - BV Seaside
Lusignan Seaside
Paradise
Enmore Seaside
Victoria Seaside
Hope Beach Seaside
Nooten Zuil
Hope Canal
Bee Hive
Clonbrook
Unity
Mahaica River mouth
GEORGETOWN
Turkeyen
Vreed en Hoop
Lamaha Springs
Georgetown
Mobilissa/la Reconnai
III-3 Lower West Demerara
Vreed en Hoop
III-3 Lower West Demerara
0
2.5
5
Kilometers
Coastal Bird Survey
March/April 2019 Survey
Region 4
Environmental Resources Management
www.erm.com
ERM


Sans Souci
Abary
Moor Park
Bush Lot Seaside
Hopetown
Woodley Park
V-2
Mahaicony/Berbice
Berbice River
VI-2 East
Canje/E.
C. Berb
New Amsterdam
Overwinning
EAST BERBICE
MAHAICONY
0
2.5
5
Kilometers
N
Georgetown
GUYANA
Legend
Bird Survey Location
Coastal Bird Survey
March/April 2019 Survey
Region 5
Environmental Resources
Management
www.erm.com
ERM


N
Georgetown
GUYANA
Legend
Bird Survey Location
Maida Seaside
Rose Hall
Rose Hall
Alness Seaside
Phillipe Seaside
Bush Lot Village
VI-2 East Canje/E. C. Berb
VI-3 Black Bush Polder
ERBICE-CORENTYNE
ICA-BERBICE
0
2.5
5
Kilometers
Source: Esri - National Geographic World Map, Digital Globe Imagery (2015)
Coastal Bird Survey
March/April 2019 Survey
Region 6
Environmental Resources Management
www.ermcom
ERM



Coastal Bird Survey
March/April 2019 Survey
Region 6

Environmental Resources Management
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ERM

ATTACHMENT 2 ELECTRONIC DATA ENTRY TEMPLATE FOR THE COASTAL BIRD SURVEY

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Bird Survey

Date *
Monday, April 08, 2019

Time *
5:38 PM

Location *



Survey Device Name

Survey Site Code

Survey Site Code

Observation ID *
1904081738

Method of Observation
- Visual
- Audio
- Other

Weather
- Sunny
- Partly Sunny
- Cloudy
- Light Rain
- Heavy Rain
- Other

Temperature C

Species Observed

Species Observed

Number of Individuals *

Unique Behaviour?
- Feeding
- Roosting
- Nesting
- None
- Other

Location/Habitat

Take or Insert Photo

External Camera IDs

1 of 1

General Description

Are you at the Site?
- (•) Yes
- ( ) No

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ATTACHMENT 3 COASTAL BIRD SURVEY DATA, REGIONS 2-6, MARCH/APRIL 2019

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A. Coastal Bird Survey Data for Regions 2 and 3, March/April 2019

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	0	0	4	1	0	1	0	0	0	0	0	0	4	3	0	0	0	13
Fringillidae	Violaceous Euphonia	*Euphonia violacea*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	2
Ardeidae	Cocoi Heron	*Ardea cocoi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Ardeidae	Little Blue-Heron	*Egretta caerulea*	0	0	17	17	29	0	0	0	0	0	0	0	0	0	0	1	0	64
Ardeidae	Tricolored Heron	*Egretta tricolor*	0	0	0	9	8	0	0	0	0	0	0	0	0	0	0	0	0	17
Ardeidae	Striated Heron	*Butorides striata*	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	2
Ardeidae	Great Egret	*Ardea alba*	0	0	4	15	56	0	0	0	0	0	0	0	0	0	0	0	0	75
Ardeidae	Snowy Egret	*Egretta thula*	0	0	65	157	400	0	0	0	0	0	0	0	21	0	7	8	0	658
Ardeidae	Cattle Egret	*Bubulcus ibis*	0	0	0	0	0	0	0	0	0	0	0	0	200	0	0	1	0	201
Aramidae	Limpkin	*Aramus guarauna*	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	2
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	0	0	29	37	52	0	0	0	0	0	0	0	0	0	9	0	0	127
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Turkey Vulture	*Catharthes aura*	2	0	0	2	3	2	0	0	0	0	0	0	0	4	9	4	3	29

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Cathartidae	Black Vulture	*Coragyps atratus*	0	0	0	2	0	0	0	0	0	0	0	0	0	0	1	0	5	8
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Osprey	*Pandion haliaetus*	0	0	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	3	0	4
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Long-winged Harrier	*Circus buffoni*	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Accipitridae	Pearl Kite	*Gampsonyx swainsonii*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cracidae	Little Chacalaca	*Ortalis motmot*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacanidae	Wattled Jacana	*Jacana jacana*	0	5	0	0	0	0	0	1	0	0	2	0	0	0	0	0	0	8

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Charadriidae	Southern Lapwing	*Vanellus chilensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	0	0	170	10	30	0	0	0	0	0	0	0	0	0	0	0	0	210
Charadriidae	Collared Plover	*Charadrius collaris*	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	15
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Red Knot	*Calidris canutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Sanderling	*Calidris alba*	0	0	0	27	0	0	0	0	0	0	0	0	0	0	0	0	0	27
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	1	0	0	0	0	0	0	2	0	0	0	0	0	0	7	1	1	12
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	0	0	0	50	12	0	0	0	1	0	0	0	0	0	0	0	0	63
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Least Sandpiper	*Calidris minutilla*	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15
Scolopacidae	Western Sandpiper	*Calidris mauri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Calidris sp.	*Calidris sp.*	0	0	0	60	0	0	0	0	0	0	0	0	0	0	0	0	0	60
Scolopacidae	Whimbrel	*Numenius phaeopus*	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Scolopacidae	Willet	*Tringa semipalmata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	0	0	4	38	30	0	0	0	0	0	0	0	0	0	0	0	0	72

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Scolopacidae	Yellowlegs sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Charadriidae	Plover sp.	*Pluvialis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Laughing Gull	*Leucophaeus atricilla*	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	1	2	0	0	0	0	0	0	0	0	0	0	0	0	3
Laridae	Large-billed Tern	*Phaetusa simplex*	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Laridae	Royal Tern	*Thalasseus maximus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Common Tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Least Tern	*Sternula antillarum*	0	0	1	40	0	0	0	0	0	0	1	0	0	0	0	0	0	42
Laridae	Black Skimmer	*Rynchops niger*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laredae	Lesser Black-backed Gull	*Larus fuscus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	1	0	0	0	0	41	0	1	0	0	1	0	0	0	0	0	0	44
Falconidae	Bat Falcon	*Falco rufigularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Northern Crested Caracara	*Caracara cheriway*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	0	0	0	0	0	1	0	0	0	0	0	0	0	4	2	1	1	9
Falconidae	Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae	Great Horned Owl	*Bubo virginianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae	Rock Pigeon	*Columba livia domestica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Columbidae	Ruddy Ground-Dove	*Columba plumbea*	5	2	0	3	0	0	0	2	0	5	0	0	0	0	0	0	0	17
Columbidae	Common Ground-Dove	*Columbina passerina*	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Columbidae	White-tipped Dove	*Leptotila verreauxi*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	0	2	7
Psittacidae	Red-bellied Macaw	*Orthopsittaca manilatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Psittacidae	Orange-winged Parrot	*Amazona amazonica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Striped Cuckoo	*Tapera naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Little Cuckoo	*Coccycua minuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Cuculidae	Greater Ani	*Crotophaga major*	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
Trochilidae	Emerald sp	*Amazilia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	4	10
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Toco Toucan	*Ramphastos toco*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2	1	0	5
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	2	4	4	2	0	0	0	0	0	2	0	0	0	0	1	0	0	15

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																	
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	4	0	0	6
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2	0	0	4
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	0	0	0	0	0	0	2	1	2	0	0	0	0	0	0	2	0	7
Tyrannidae	Yellow Breasted Flycatcher	*Tolmomyias flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	2	2	4	5	4	2	4	3	5	9	8	0	3	3	10	8	6	78
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	1	2	0	2	3	0	3	2	2	0	0	0	2	0	2	6	1	26
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	0	1	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	3
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	0	0	0	0	0	0	0	3	2	0	0	0	0	0	1	6	3	15
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	0	0	0	0	0	0	2	1	0	0	0	0	0	0	0	2	0	5

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	0	2	0	0	0	0	0	2	0	0	0	0	0	2	6	2	7	21
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	2	2	4	0	0	0	0	0	0	0	2	0	0	0	0	0	0	10
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	2
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Brown-crested Flycatcher	*Myiarchus tyrannulus*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Tyrannidae	Yellow-crowned Tyrannulet	*Tyrannulus elatus*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Tyrannidae	Fork-tailed Flycatcher	*Tyrannus savana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	2	2	3	4	5	6	4	7	0	4	1	0	4	0	12	6	2	62
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1
Troglodytidae	Southern House-wren	*Troglodytes aedon*	0	0	0	0	0	0	0	2	0	2	2	0	2	0	0	0	0	8
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	0	2	0	0	0	0	0	0	3	2	0	0	0	0	0	0	0	7
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	1	0	3
Thraupidae	Turquoise Tanager	*Tangara mexicana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bananaquit	*Coereba flaveola*	0	0	0	0	0	0	2	2	0	0	0	0	0	0	3	0	0	7
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	0	0	0	0	0	0	0	0	0	0	0	0	0	4	2	0	2	8
Thraupidae	Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	0	2	2	0	0	0	0	0	0	2	2	0	8
Thraupidae	Burnished-buff Tanage	*Tangara cayana*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Thraupidae	Red-capped Cardinal	*Paroaria gularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Thraupidae	Wing-barred Seedeater	*Sporophila americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	4
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	0	0	0	0	0	0	0	2	2	4	2	0	0	0	0	2	0	12
Thraupidae	White-lined Tanager	*Tachyphonus rufus*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4
Parulidae	Yellow Warbler	*Setophaga petechia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow Oriole	*Icterus nigrogularis*	0	0	0	2	0	0	0	0	0	0	0	0	2	0	6	0	0	10
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	0	0	0	0	0	0	0	0	0	3	4	0	0	0	0	15	0	22
Icteridae	Carib Grackle	*Quiscalus lugubris*	0	9	5	28	4	0	0	0	0	0	0	0	0	0	0	0	0	46
Icteridae	Crested Oropendola	*Psarocolius decumanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	0	2	0	0	0	0	0	0	0	0	0	0	0	12	8	17	0	39
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	3
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 2 AND 3																
FAMILY NAME	Common name	Scientific Names	DM-R2	EX-R2	WH-R2	AR-R2	AF-R2	SU-R2	BP-R3	FR-R3	PH-R3	MM-R3	LN-R3	LJ-R3	RZ-R3	Tig-R3	Wak-R3	Leg-R3	Hog-R3	Total
Picidae	White-bellied Piculet	*Picumnus spilogaster*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	2
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	1	0	3
Phaethornis	Phaethornis sp. (Hummingbird)	Phaethornis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trina	Trina sp.	*Trina sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIRD ABUNDANCE			23	38	335	520	655	53	31	41	22	38	23	0	240	47	113	94	42	2315
SPECIES DIVERSITY			11	13	17	25	17	6	14	20	10	13	9	0	10	14	28	24	15	136

Site Name Abbreviations: DM-Darthmouth, EX-Exmouth, WH-Walton Hall, SU-Suddie, BP-Bushy Park, FR-Farm, PH-Philadelphia, MM-Meten-Meer-Zorg, LN-Leonora, LJ-La Jalousie, RZ-Ruimzeight, Wak-Wakenaam Island, Tig-Tiger Island, Leg-Leguan Island, Hog-Hog Island

B: Coastal Bird Survey Data for Region 4, March/April 2019

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	0	1	0	0	31	9	3	0	0	0	0	0	0	0	0	0	44
Fringillidae	Violaceous Euphonia	*Euphonia violacea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*	0	0	11	0	19	9	0	0	0	0	0	0	0	0	0	0	39
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	1	19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
Ardeidae	Cocoi Heron	*Ardea cocoi*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Ardeidae	Little Blue-Heron	*Egretta caerulea*	2	38	23	0	23	5	0	26	7	0	0	0	0	0	0	0	124
Ardeidae	Tricolored Heron	*Egretta tricolor*	4	21	5	0	11	7	0	8	0	0	0	0	0	0	0	2	58
Ardeidae	Striated Heron	*Butorides striata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Great Egret	*Ardea alba*	0	9	5	0	10	3	0	15	8	0	0	2	0	1	0	0	53
Ardeidae	Snowy Egret	*Egretta thula*	10	250	16	0	47	21	0	100	4	0	4	8	0	2	1	5	468
Ardeidae	Cattle Egret	*Bubulcus ibis*	0	0	0	0	2	0	0	0	0	0	0	4	0	0	0	0	6
Aramidae	Limpkin	*Aramus guarauna*	0	0	0	0	0	0	1	0	2	0	0	0	0	0	0	0	3
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	0	7	10	0	17	28	0	18	0	0	2	1	0	0	0	0	83
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Turkey Vulture	*Catharthes aura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Black Vulture	*Coragyps atratus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Osprey	*Pandion haliaetus*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*	0	0	0	0	0	2	0	0	0	1	0	0	0	0	0	0	3
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	1
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Long-winged Harrier	*Circus buffoni*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Pearl Kite	*Gampsonyx swainsonii*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cracidae	Little Chacalaca	*Ortalis motmot*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacanidae	Wattled Jacana	*Jacana jacana*	0	0	0	0	4	0	2	0	0	0	0	0	0	0	0	0	6
Charadriidae	Southern Lapwing	*Vanellus chilensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	0	36	0	0	0	0	0	0	8	0	0	0	0	22	0	0	66
Charadriidae	Collared Plover	*Charadrius collaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Red Knot	*Calidris canutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Sanderling	*Calidris alba*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	1	0	0	0	7	0	0	0	0	2	1	2	0	1	0	0	14
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	0	100	200	0	0	0	0	0	15	0	0	0	0	0	0	0	315

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Least Sandpiper	*Calidris minutilla*	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	10
Scolopacidae	Western Sandpiper	*Calidris mauri*	0	0	40	0	0	0	0	0	0	0	0	0	0	0	0	0	40
Scolopacidae	Calidris sp.	*Calidris sp.*	17	0	200	0	100	0	0	0	0	0	0	0	0	0	0	0	317
Scolopacidae	Whimbrel	*Numenius phaeopus*	0	4	0	0	0	2	0	0	0	0	0	0	0	0	0	0	6
Scolopacidae	Willet	*Tringa semipalmata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*	0	25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	25
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	0	165	75	0	25	25	0	0	0	0	0	0	0	0	0	0	290
Scolopacidae	Yellowlegs sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Plover sp.	*Pluvialis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Laughing Gull	*Leucophaeus atricilla*	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	10
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Laridae	Large-billed Tern	*Phaetusa simplex*	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	3
Laridae	Royal Tern	*Thalasseus maximus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Common Tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Least Tern	*Sternula antillarum*	0	0	1	0	0	0	0	1	2	0	0	0	0	0	0	0	4
Laridae	Black Skimmer	*Rynchops niger*	0	23	0	0	5	0	0	0	0	0	0	0	0	0	0	0	28

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Laredae	Lesser Black-backed Gull	*Larus fuscus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	0	0	0	0	3	1	1	1	0	0	0	0	0	0	0	0	6
Falconidae	Bat Falcon	*Falco rufigularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Northern Crested Caracara	*Caracara cheriway*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	2	0	0	0	2	2	0	0	0	0	1	1	0	1	0	0	9
Falconidae	Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae	Great Horned Owl	*Bubo virginianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae	Rock Pigeon	*Columba livia domestica*	4	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	9
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae	Ruddy Ground-Dove	*Columba plumbea*	0	0	0	0	0	0	4	0	8	0	0	0	0	0	0	0	12
Columbidae	Common Ground-Dove	*Columbina passerina*	0	0	0	0	0	0	4	0	5	0	0	10	0	3	0	0	22
Columbidae	White-tipped Dove	*Leptotila verreauxi*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Red-bellied Macaw	*Orthopsittaca manilatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Psittacidae	Orange-winged Parrot	*Amazona amazonica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Striped Cuckoo	*Tapera naevia*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Cuculidae	Little Cuckoo	*Coccycua minuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Cuculidae	Greater Ani	*Crotophaga major*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Emerald sp	*Amazilia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Toco Toucan	*Ramphastos toco*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	0	0	0	0	0	0	0	2	2	2	0	0	0	0	0	0	6
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	0	0	0	0	2	0	2	0	0	0	0	2	0	0	0	3	9

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Tyrannidae	Yellow Breasted Flycatcher	*Tolmomyias flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	5	5	3	0	6	2	5	9	7	5	4	8	0	4	0	3	66
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	0	0	0	0	0	0	0	0	2	0	2	2	0	2	0	2	10
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	0	0	0	0	0	0	4	4	0	5	2	6	0	0	2	2	25
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	2
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	0	0	0	0	0	0	4	0	0	0	0	0	0	0	0	0	4
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Brown-crested Flycatcher	*Myiarchus tyrannulus*	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	4
Tyrannidae	Yellow-crowned Tyrannulet	*Tyrannulus elatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Fork-tailed Flycatcher	*Tyrannus savana*	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	0	2	2	0	3	2	2	0	4	3	3	7	0	0	4	2	34
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	5
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Troglodytidae	Southern House-wren	*Troglodytes aedon*	0	0	0	0	2	0	2	0	0	4	0	0	0	0	0	2	10
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	2	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	4
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Turquoise Tanager	*Tangara mexicana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bananaquit	*Coereba flaveola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	2
Thraupidae	Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2

TAXA			SURVEYED COASTAL SITES - REGION 4																
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Thraupidae	Burnished-buff Tanage	*Tangara cayana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Red-capped Cardinal	*Paroaria gularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Wing-barred Seedeater	*Sporophila americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	0	2	0	0	0	0	0	0	2	0	0	0	0	0	0	0	4
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	5
Thraupidae	White-lined Tanager	*Tachyphonus rufus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parulidae	Yellow Warbler	*Setophaga petechia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow Oriole	*Icterus nigrogularis*	0	0	0	0	0	0	2	0	2	2	0	0	0	0	0	0	6
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Icteridae	Carib Grackle	*Quiscalus lugubris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Crested Oropendola	*Psarocolius decumanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picidae	White-bellied Piculet	*Picumnus spilogaster*	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1

TAXA			SURVEYED COASTAL SITES - REGION 4															
FAMILY NAME	Common name	Scientific Names	KS-R4	TK-R4	OG-R4	LBI-R4	BV-R4	LU-R4	PA-R4	EM-R4	VT-R4	NZ-R4	HB-R4	HC-R4	Bee-R4	CB-R4	UN-R4	MA-R4	Total
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phaethornis	Phaethornis sp. (Hummingbird)	Phaethornis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trina	Trina sp.	*Trina sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
BIRD ABUNDANCE			48	709	601	0	326	130	51	186	86	32	20	60	0	38	7	21	2315
SPECIES DIVERSITY			10	17	14	0	21	17	19	11	19	13	9	14	0	9	3	8	62

Site Name Abbreviations: KS-Kingston, TK-Turkeyen, OG-Ogle, LBI-La Bonne Intention, BV-Triumph, LU-Lusignan, PA-Paradise, EM-Enmore, VT-Victoria, NZ-Nooten Zuil, HB-Hope Beach, HC-Hope Canal, Bee-BeeHive, Cl-Clonbrook, UN-Unity, MA-Mahaica

C: Coastal Bird Survey Data for Regions 5 and 6, March/April 2019

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Fregatidae	Magnificent Frigatebird	*Fregata magnificens*	1	0	0	0	0	0	0	1	0	0	0	0	0	0	2
Fringillidae	Violaceous Euphonia	*Euphonia violacea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pelecanidae	Brown Pelican	*Pelecanus occidentalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Yellow-crowned Night-Heron	*Nyctanassa violacea*	0	0	0	0	0	0	0	0	9	9	0	0	0	0	18
Ardeidae	Black-crowned Night-Heron	*Nycticorax nycticorax*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ardeidae	Cocoi Heron	*Ardea cocoi*	0	0	0	0	0	0	0	2	0	0	1	0	0	0	3
Ardeidae	Little Blue-Heron	*Egretta caerulea*	15	0	27	63	44	0	1	19	1	37	0	0	0	0	207
Ardeidae	Tricolored Heron	*Egretta tricolor*	0	0	0	0	0	0	0	17	0	7	11	0	0	1	36
Ardeidae	Striated Heron	*Butorides striata*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Ardeidae	Great Egret	*Ardea alba*	0	5	0	17	0	0	4	55	1	0	19	0	0	0	101
Ardeidae	Snowy Egret	*Egretta thula*	2	4	83	197	94	0	2	165	1	100	0	0	0	21	669
Ardeidae	Cattle Egret	*Bubulcus ibis*	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
Aramidae	Limpkin	*Aramus guarauna*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Threskiornithidae	Scarlet Ibis	*Eudocimus ruber*	0	0	23	19	23	0	0	2	0	4	9	0	0	0	80
Cathartidae	Lesser Yellow-headed Vulture	*Cathartes burrovianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cathartidae	Turkey Vulture	*Catharthes aura*	0	11	0	0	0	0	0	0	0	0	1	0	0	1	13
Cathartidae	Black Vulture	*Coragyps atratus*	0	17	0	0	0	0	0	1	0	0	3	0	0	0	21
Accipitridae	Black Hawk-Eagle	*Spizaetus tyrannus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Accipitridae	Osprey	*Pandion haliaetus*	1	0	0	0	0	0	0	2	0	0	0	0	0	0	3
Accipitridae	Common Black-Hawk	*Buteogallus anthracinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Great Black Hawk	*Buteogallus urubitinga*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Accipitridae	Savanna Hawk	*Buteogallus meridionalis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Rufous Crab-Hawk	*Buteogallus aequinoctialis*	2	0	2	2	1	0	0	1	1	2	4	0	1	0	16
Accipitridae	Black-collared Hawk	*Busarellus nigricollis*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Accipitridae	Grey-lined Hawk	*Buteo nitidus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Zone-tailed Hawk	*Buteo albonotatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Roadside Hawk	*Rupornis magnirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Plumbeous Kite	*Ictinia plumbea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Long-winged Harrier	*Circus buffoni*	0	0	0	0	0	0	0	1	0	1	0	0	0	0	2
Accipitridae	Pearl Kite	*Gampsonyx swainsonii*	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1
Cracidae	Little Chacalaca	*Ortalis motmot*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Jacanidae	Wattled Jacana	*Jacana jacana*	0	0	1	0	0	2	0	0	0	0	2	0	0	0	5
Charadriidae	Southern Lapwing	*Vanellus chilensis*	0	0	0	0	0	3	0	0	0	0	0	0	0	0	3
Charadriidae	Semipalmated Plover	*Charadrius semipalmatus*	0	2	0	95	65	0	0	100	0	20	12	4	40	120	458
Charadriidae	Collared Plover	*Charadrius collaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Scolopacidae	Ruddy Turnstone	*Arenaria interpres*	0	0	0	15	0	0	0	0	0	0	0	0	50	0	65
Scolopacidae	Red Knot	*Calidris canutus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Sanderling	*Calidris alba*	0	0	0	57	0	0	0	0	0	0	0	0	36	0	93
Scolopacidae	White-rumped Sandpiper	*Calidris fuscicollis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Spotted Sandpiper	*Actitis macularius*	0	0	1	8	0	0	1	0	0	2	0	0	0	0	12
Scolopacidae	Semipalmated Sandpiper	*Calidris pusilla*	0	0	0	138	80	0	0	30	0	20	23	0	0	0	291
Scolopacidae	Solitary Sandpiper	*Tringa solitaria*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Least Sandpiper	*Calidris minutilla*	0	0	9	31	24	0	0	0	0	7	12	0	0	0	83
Scolopacidae	Western Sandpiper	*Calidris mauri*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Calidris sp.	*Calidris sp.*	0	0	250	400	600	0	0	200	0	200	0	0	0	0	1650
Scolopacidae	Whimbrel	*Numenius phaeopus*	0	0	0	4	0	0	0	0	0	2	0	0	0	0	6
Scolopacidae	Willet	*Tringa semipalmata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Greater Yellowlegs	*Tringa melanoleuca*	0	2	7	100	50	0	0	0	0	100	14	0	0	0	273
Scolopacidae	Lesser Yellowlegs	*Tringa flavipes*	0	0	0	200	80	0	0	240	10	50	27	0	0	0	607
Scolopacidae	Yellowlegs sp.	*Tringa sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Scolopacidae	Short-billed Dowitcher	*Limnodromus griseus*	0	0	1	0	0	0	0	0	0	0	0	0	0	0	1
Charadriidae	Hudsonian Godwit	*Limosa haemastica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Black-bellied Plover	*Pluvialis squatarola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Charadriidae	Plover sp.	*Pluvialis sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Laridae	Laughing Gull	*Leucophaeus atricilla*	0	0	0	0	10	0	0	80	0	0	0	0	0	0	90
Laridae	Gull-billed Tern	*Gelochelidon nilotica*	0	0	0	12	7	0	0	1	2	9	0	0	0	0	31
Laridae	Large-billed Tern	*Phaetusa simplex*	0	0	0	15	0	0	0	0	0	0	0	0	0	1	16
Laridae	Royal Tern	*Thalasseus maximus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Laridae	Common Tern	*Sterna hirundo*	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1
Laridae	Least Tern	*Sternula antillarum*	0	0	3	0	0	0	0	0	0	0	0	0	0	0	3
Laridae	Black Skimmer	*Rynchops niger*	0	0	0	11	15	0	0	62	0	5	0	0	0	0	93
Laredae	Lesser Black-backed Gull	*Larus fuscus*	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
Falconidae	Laughing Falcon	*Herpetotheres cachinnans*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Accipitridae	Snail Kite	*Rostrhamus sociabilis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Bat Falcon	*Falco rufigularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Falconidae	Northern Crested Caracara	*Caracara cheriway*	0	0	0	0	0	1	0	0	0	0	0	0	1	0	2
Falconidae	Yellow-headed Caracara	*Milvago chimachima*	0	0	0	0	2	4	0	2	0	0	3	0	0	0	11
Falconidae	Peregrine Falcon	*Falco peregrinus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Strigidae	Great Horned Owl	*Bubo virginianus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Columbidae	Rock Pigeon	*Columba livia domestica*	0	0	0	0	0	0	0	0	0	0	0	0	0	2	2

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Columbidae	Pale-vented Pigeon	*Patagioenas cayennensis*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2
Columbidae	Ruddy Ground-Dove	*Columba plumbea*	2	0	0	0	0	4	0	0	0	6	0	0	0	0	12
Columbidae	Common Ground-Dove	*Columbina passerina*	0	0	5	0	0	4	0	0	0	4	0	0	0	0	13
Columbidae	White-tipped Dove	*Leptotila verreauxi*	0	0	0	0	2	9	1	0	0	0	0	0	0	0	12
Psittacidae	Red-Shouldered Macaw	*Diopsittaca nobilis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Red-bellied Macaw	*Orthopsittaca manilatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Psittacidae	Brown-throated Parakeet	*Eupsittula pertinax*	2	4	0	0	0	11	0	0	0	0	0	2	0	0	19
Psittacidae	Orange-winged Parrot	*Amazona amazonica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Striped Cuckoo	*Tapera naevia*	0	0	0	0	0	0	0	0	0	2	0	0	0	0	2
Cuculidae	Little Cuckoo	*Coccycua minuta*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Greater Ani	*Crotophaga major*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cuculidae	Smooth-billed Ani	*Crotophaga ani*	0	0	0	0	0	0	0	0	5	0	0	0	0	0	5
Trochilidae	Fork-tailed Woodnymph	*Thalurania furcata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	White-chested Emerald	*Amazilia brevirostris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trochilidae	Emerald sp	*Amazilia sp.*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ramphastidae	Short-tailed Swift	*Chaetura brachyura*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6													
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Ramphastidae	White-throated Toucan	*Ramphastos tucanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Toco Toucan	*Ramphastos toco*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Ringed Kingfisher	*Megaceryle torquata*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Alcedinidae	Green Kingfisher	*Chloroceryle americana*	1	2	0	0	0	0	0	1	0	0	0	0	0	0	4
Apodidae	American Pygmy Kingfisher	*Chloroceryle aenea*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Dendrocolaptidae	Straight-billed Woodcreeper	*Dendroplex picus*	0	0	0	0	0	0	0	0	0	0	2	0	0	0	2
Dendrocolaptidae	Striped Woodcreeper	*Xiphorhynchus obsoletus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Furnaridae	Yellow-chinned Spinetail	*Certhiaxis cinnamomeus*	0	0	0	0	0	2	0	0	2	0	0	0	0	0	4
Furnaridae	Pale-breasted Spinetail	*Synallaxis albescens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Silvered Antbird	*Sclateria naevia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thamnophilidae	Black-crested Antshrike	*Thamnophilus*	0	2	4	0	3	2	0	2	0	3	0	0	0	0	16
Thamnophilidae	Barred Antshrike	*Thamnophilus doliatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Elaenia	*Elaenia flavogaster*	0	0	0	0	0	0	2	0	0	0	0	0	0	0	2
Tyrannidae	Yellow Breasted Flycatcher	*Tolmomyias flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Tyrannidae	Great Kiskadee	*Pitangus sulphuratus*	3	4	4	2	6	4	2	0	0	6	6	0	0	0	37
Tyrannidae	Lesser Kiskadee	*Pitangus lictor*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Kingbird	*Tyrannus melancholicus*	2	0	2	2	2	4	0	4	3	3	3	0	0	0	25
Tyrannidae	Gray Kingbird	*Tyrannus dominicensis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Rusty-margined Flycatcher	*Myiozetetes cayanensis*	2	0	0	0	0	2	0	0	0	0	0	0	0	0	4
Tyrannidae	Short-crested Flycatcher	*Myiarchus ferox*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-bellied Flycatcher	*Empidonax flaviventris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Boat-billed Flycatcher	*Megarynchus pitangua*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Common Tody Flycatcher	*Todirostrum cinereum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Spotted Tody Flycatcher	*Todirostrum maculatum*	2	4	4	6	4	4	4	4	4	4	4	0	0	0	44
Tyrannidae	Pied Water Tyrant	*Fluvicola pica*	0	0	0	2	0	3	0	0	0	0	0	0	0	0	5
Tyrannidae	Helmeted Pygmy Tyrant	*Lophotriccus galeatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Mouse-colored Tyrannulet	*Phaeomyias murina*	0	2	0	0	0	0	0	0	2	0	0	0	0	0	4
Tyrannidae	White-lored Tyrannulet	*Ornithion inerme*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Tropical Mockingbird	*Mimus gilvus*	0	0	0	0	0	2	0	0	0	0	0	0	0	0	2

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6													
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Tyrannidae	Cinnamon Attila	*Attila cinnamomeus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Southern Beardless-Tyrannulet	*Camptostoma obsoletum*	0	0	0	0	0	0	0	0	2	4	0	0	0	0	6
Tyrannidae	Piratic Flycatcher	*Legatus leucophaius*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Brown-crested Flycatcher	*Myiarchus tyrannulus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Yellow-crowned Tyrannulet	*Tyrannulus elatus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tyrannidae	Fork-tailed Flycatcher	*Tyrannus savana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirundinidae	Gray-breasted Martin	*Progne chalybea*	2	4	0	0	0	2	3	3	3	0	0	0	0	2	19
Hirundinidae	White-winged Swallow	*Tachycineta albiventer*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hirundinidae	Barn Swallow	*Hirundo rustica*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Troglodytidae	Southern House-wren	*Troglodytes aedon*	0	2	0	0	0	0	2	2	2	0	0	0	0	0	8
Vireonidae	Slaty-capped Shrike-vireo	*Vireolanius leucotis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Vireonidae	Ashy-headed Greenlet	*Hylophilus pectoralis*	0	0	0	0	0	0	0	0	4	0	0	0	0	0	4
Vireonidae	Lemon-chested Greenlet	*Hylophilus thoracicus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-grey Tanager	*Thraupis episcopus*	2	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Thraupidae	Silver-beaked Tanager	*Ramphocelus carbo*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Thraupidae	Turquoise Tanager	*Tangara mexicana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bananaquit	*Coereba flaveola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Bicolored Conebill	*Conirostrum bicolor*	0	0	0	0	0	0	2	2	2	0	0	0	0	0	6
Thraupidae	Palm Tanager	*Thraupis palmarum*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Burnished-buff Tanage	*Tangara cayana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Red-capped Cardinal	*Paroaria gularis*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Wing-barred Seedeater	*Sporophila americana*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cardinalidae	Grayish Saltator	*Saltator coerulescens*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	Blue-black Grassquit	*Volatinia jacarina*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thraupidae	White-lined Tanager	*Tachyphonus rufus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Emberizidae	Grassland Yellowfinch	*Sicalis luteola*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parulidae	Yellow Warbler	*Setophaga petechia*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow Oriole	*Icterus nigrogularis*	0	0	2	2	0	2	2	0	0	2	0	0	0	0	10
Icteridae	Giant Cowbird	*Molothrus oryzivorus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Shiny Cowbird	*Molothrus bonariensis*	0	0	0	0	0	0	3	0	0	0	0	0	0	0	3
Icteridae	Carib Grackle	*Quiscalus lugubris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Crested Oropendola	*Psarocolius decumanus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

TAXA			SURVEYED COASTAL SITES - REGIONS 5 AND 6														
FAMILY NAME	Common name	Scientific Names	SS-R5	AB-R5	MP-R5	BL-R5	HT-R5	WP-R5	AS-R6	MS-R6	EPS-R6	PS-R6	W61B-R6	61B-R6	63B-R6	SL-R6	Total
Icteridae	Yellow-rumped Cacique	*Cacicus cela*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Yellow-hooded Blackbird	*Chrysomus icterocephalus*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Icteridae	Red-breasted Meadowlark	*Sturnella militaris*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Galbulidae	Green-tailed Jacamar	*Galbula galbula*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Picidae	White-bellied Piculet	*Picumnus spilogaster*	0	0	0	0	0	0	2	0	2	0	2	0	0	0	6
Picidae	Crimson-crested Woodpecker	*Campephilus melanoleucos*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Turdidae	Pale-breasted Thrush	*Turdus leucomelas*	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phaethornis	Phaethornis sp. (Hummingbird)	Phaethornis sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Trina	Trina sp.	*Trina sp.*	0	0	0	0	20	0	0	0	0	0	0	0	0	0	20
BIRD ABUNDANCE			39	65	428	1398	1132	69	34	1000	56	610	158	6	128	148	5271
SPECIES DIVERSITY			14	14	17	23	20	21	17	27	18	27	19	2	5	7	110

Site Name Abbreviations: SS-Sans Souci, AB-Abary, MP-Moor Park, BL-Bush Lot, HT-Hope Town, WP-Woodley Park, AS-Alness Seaside, MS-Maida Seaside, EPS-Bush Lot Village, PS-Phillipe Seaside. W61B-Village No.57, 61B-61 Beach, 63B-63 Beach, SL-Springlands

ATTACHMENT 4 PHOTOGRAPHIC LOG—COASTAL BIRD SURVEY MARCH/APRIL 2019

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Looking West at Alness Seaside (New Region 6 Survey Site)



Looking East at Alness Seaside (New Region 6 Survey Site)



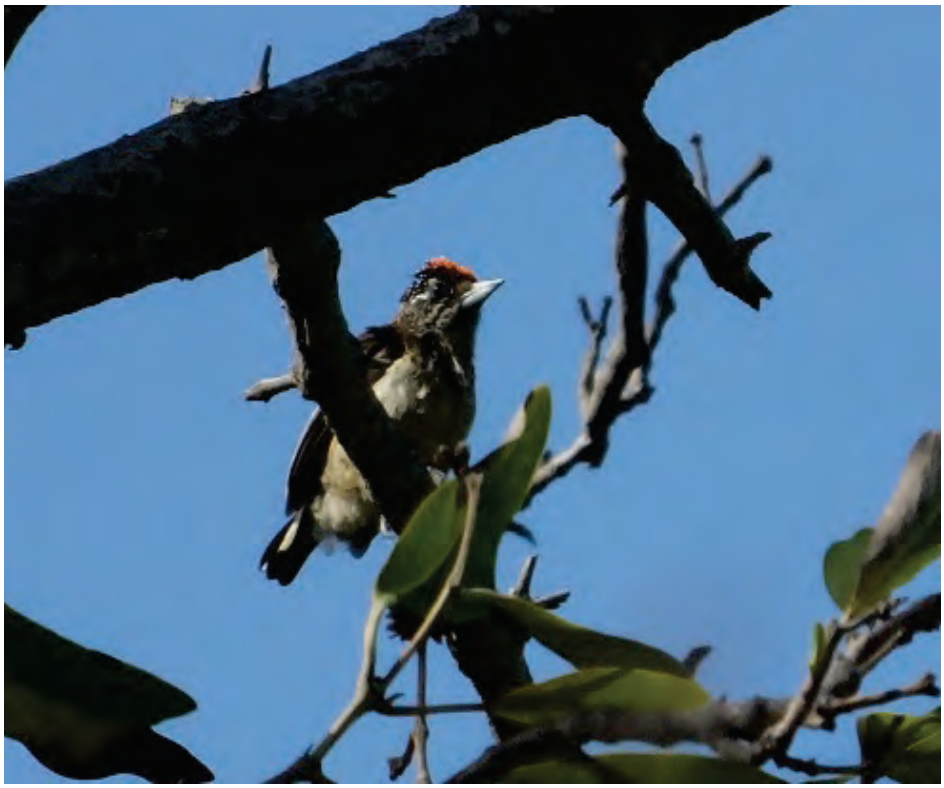
Seaside at Bush Lot Village (New Region 6 Survey Site)



Seaside at No. 57 Village (New Region 6 Survey Site)



Red-capped Cardinal (*Paroaria gularis*) Observed During the Essequibo Islands Survey



White-bellied Piculet (*Picumnus spilogaster*) at Alness Seaside (Region 6)



Lesser Yellowlegs (*Tringa flavipes*) at No. 57 Village Seaside (Region 6)



Bananaquit (*Coereba flaveola*) Observed During the Essequibo Islands Survey



Scarlet Ibis (*Eudocimus ruber*) and Multiple Egret Species at Affiance Seaside (Region 2)



Crested Caracara (*Caracara cheriway*) at 63-Beach (Region 6)



Grassland Yellow-finch (*Sicalis luteola*) at Dartmouth (Region 2)



Orange-winged Parrot (*Amazona amazonica*) at La Jalousie (Region 3)



Changes at the Meten-Meer-Zorg Survey Site (Region 3) looking east. Shoreline stabilization work is taking place involving the placement of boulders as riprap in front of the sea wall.



Changes at the Meten-Meer-Zorg Survey Site (Region 3) looking west. Filling against sea wall with boulder riprap.



Crab-eating Raccoon (*Procyon cancrivorus*) and Snowy Egret (*Egretta thula*, in background) at Phillipe Seaside (Region 6)

APPENDIX N

Nearshore and Offshore Fisheries Study Summary Report—Dry Season 2018–2019

Resubmitted without changes

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ExxonMobil

Nearshore and Offshore Fisheries Study Summary Report

Dry Season 2018 - 2019

July 2019

Project No.: 0484443

The business of sustainability

ERM

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Acronyms and Abbreviations

Acronym	Description
EEPGL	Esso Exploration and Production Guyana Limited
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
kg	kilogram
UTM	Universal Transverse Mercator
WGS	World Geodetic System

EXECUTIVE SUMMARY

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for approval of Phase 1 of the Liza Development Project in the Stabroek Block offshore Guyana. The Guyana EPA approved both the Application and the Environmental Impact Assessment on 1 June 2017, and issued an Environmental Permit for the Liza Phase 1 Development Project. As a condition of the permit, the EPA required EEPGL to conduct a study of the marine fish community offshore Guyana. Environmental Resources Management (ERM), EEPGL's environmental consultant, developed an approach that included two seasonal surveys per year (one in the dry season and one in the wet season) in the deepwater, continental shelf, and nearshore zones, as well as a fish landing study at the major landing sites across the coast. EEPGL elected to add an estuarine/riverine component to the EPA-required components during the second seasonal survey in April 2018. The results of the first year of study were reported to the Guyana EPA in May 2018.

EEPGL subsequently elected to repeat the study for a second year in 2018-2019. EEPGL also elected to add an ichthyoplankton component to the 2018-2019 study. This report describes the results of the first season of the 2018-2019 study year and is organized as follows:

1. Continental Shelf Component—conducted aboard Guyanese-flagged vessels to collect data on fish and benthos using trawls and longlines;
2. Nearshore Component—conducted from small boats at or near the shore in the shallow subtidal zone, using gillnets and cast nets;
3. Estuarine/Riverine Component—conducted from small boats using electrofishing equipment; and
4. Ichthyoplankton Component—conducted in parallel with the continental shelf, nearshore, and estuarine components using oblique and vertically towed plankton nets.

The fish landing study was expanded into a standalone participatory fishing study, and the results of that study were reported separately.

All of the components listed above except the ichthyoplankton component were completed once in the wet season and once in the dry season in 2017-2018. The ichthyoplankton assessment was added for the 2018-2019 survey year, but unlike the four other components—which were defined geographically, the ichthyoplankton component involved collecting samples across a variety of settings (e.g., deepwater, continental shelf, nearshore, etc.). Another component (a deepwater assessment) was also completed during the prior 2017-2018 study year, but was not completed during the 2018-2019 year's first season because rough sea conditions in the Stabroek Block made it impossible to safely deploy the deepwater fish traps in December 2018. Therefore, the decision was made to postpone this element of the survey until second quarter 2019.

The continental shelf component was completed in December 2018. The continental shelf component consisted of sampling at four transects roughly perpendicular to the coast containing 13 sampling stations. The four transects were established offshore as follows: near the Shell Beach Protected Area in Region 1 (transect EOP-R1), Region 3 (transects EOP-R2 and EOP-R3), Region 4 (transect EOP-R4 or TRAWL), and Region 5 (transect EOP-R5). The continental shelf sampling stations were placed along these transects and selected to sample a cross-section of different depths, benthic habitats, geological seabed substrates, and known fishing areas and zones.

The nearshore component was completed in January 2019. Twelve nearshore stations were sampled from small boats at/or near the shore in the shallow subtidal zone. The nearshore stations were selected based on factors such as bathymetry, type of tide, habitat conditions, accessibility and other

environmental factors, but were located near the main landing sites of fishing vessels along the coast, as well as near the mouths of rivers or canals where small-scale fishing captains moor their vessels.

In addition to the nearshore component, the estuarine/riverine component was also completed in January 2019. The main rivers draining the coastal plain (the Pomeroon, Essequibo, Berbice, Demerara, and Mahaica rivers) were sampled during this assessment using electrofishing equipment on board a small shallow-draft fishing vessel. Sample stations were located in the estuarine portions of each river.

The ichthyoplankton component was completed concurrently with the continental shelf, nearshore, and continental shelf components from December 2018-January 2019. The final component of the study—the fish landing component commercial fisheries landing sites—was completed during February 2019 at the main landing sites along the coast in Regions 2, 3, 4, 5, and 6.

Sixty-four species of fish were captured at the continental shelf stations. The EOR3 and TRAWL transects produced the highest biomass of the continental shelf transects. Transect EOR3 produced the highest species richness of the continental shelf transects. The B Stations tended to be the most species-rich stations on the continental shelf. In addition to accounting for the highest number of fish species in the survey, the trawl samples from the continental shelf also produced a variety of benthic bycatch. Although not the focus of this assessment, the benthic bycatch data are noteworthy because of the diversity of species captured and the distribution of the bycatch. Numerous benthic species that are not part of the commercial fisheries in Guyana were captured. Benthic bycatch was widespread across the continental shelf sample stations, and included live corals at several locations.

Forty-six species of fish were captured at the nearshore stations, many of which were also captured on the continental shelf. With 14 species, the Siluriformes (catfishes) represented the most diverse group (order) in the nearshore zone. The Sciaenidae family was the second most diverse group (family) in the nearshore zone, with 13 species. Most of the species captured during the wet season were anadromous and likely entered the coastal area from the sea in response to increased freshwater discharge to the coastal zone, or were euryhaline species that entered the study area from further up the rivers. The nearshore fish data indicate not only a heterogeneous distribution of total fish biomass, but also a heterogeneous distribution of biomass by fish species across the coast.

Thirteen species of fish were captured at the estuarine stations. The estuarine sampling indicated a fish community with a coastal-marine affinity in origin, even during the wet season. Most of the fish captured at the estuarine stations were juvenile marine species. The results of the estuarine component illustrate the importance of the estuaries and particularly the mangroves as nursery habitat for many marine species, as well as the key supporting role that estuaries (and mangroves in particular) play in sustaining Guyana’s marine ichthyofauna and marine fisheries.

1. INTRODUCTION

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for approval of initial offshore oilfield development in the Stabroek Block (referred to as the Liza Phase 1 Development Project). The Liza Phase 1 Development consists of 17 subsea development wells and a Floating Production, Storage, and Offloading vessel (essentially a converted oil tanker) that will be located approximately 120 miles offshore of Georgetown, Guyana, to process, store, and offload the recovered oil. Per Guyanese law, EEPGL submitted an Environmental Impact Assessment, prepared by Environmental Resources Management (ERM), to support its Application for Environmental Authorisation for the Liza Phase 1 Development Project. The Guyana EPA approved both the Application and the Environmental Impact Assessment on 1 June 2017, and issued an Environmental Permit for the Liza Phase 1 Development Project. The Environmental Permit included the following requirement to complete a minimum of 1 year of fishery studies within a year of permit issuance:

> "conduct fishery dependent studies in the nearshore zone, augmented by fishery-independent studies in the nearshore and offshore zones. Field methods shall include a sufficient variety of survey techniques to capture surface, mid-water, and bottom-oriented fish. The objective of the study shall be to develop a more complete understanding of the marine fish community outside the Liza Area of Interest. The study shall include at least one wet and one dry season (notionally several weeks duration each) to enable comparison of data across seasons."

1.1 Year 1 (2017-2018) Activities

In accordance with the above Environmental Permit condition, EEPGL engaged ERM to complete a study that includes industrial[1] and small-scale[2] fishery techniques in order to develop a more complete understanding of the marine fish community outside the Liza Area of Interest. The study included four direct sampling components and one interview-based component.

The direct sampling components included:

1. Deepwater fish sampling
2. Continental shelf fish sampling
3. Nearshore fish sampling
4. Estuarine/riverine juvenile fish sampling

In addition to the above direct-sampling components, ERM also conducted a fish landing component at several active fish landing sites throughout Regions 1-6. This component included a combination of observational and interview-based techniques and constituted the bulk of the fishery-dependent study effort. In addition, some (but not all) of the sampling conducted under components 2, 3, and 4 above used methods and sampling gear that are also used in industrial and artisanal fishing activities in Guyana. These elements may therefore also be considered to have fishery-dependent elements. Component 1 was considered fishery-independent because there is currently no deepwater trap-based fishery operating on the outer continental slope in Guyana, and the sampling gear used for this component was specially designed and constructed for this study.

[1] Primarily for sale, typically larger volume than small-scale fisheries

[2] Typically small volume, and often using traditional techniques and little technology; sometimes referred to as "artisanal" fisheries

The results of the Post-Permit studies were used to inform an update of the Liza Phase 1 Development Project Environmental Impact Statement and the Liza Phase 1 Development Project Environmental and Socioeconomic Management Plan, which EEPGL submitted to the EPA in May 2018.

1.2 Year 2 (2018-2019) Activities

After completing the minimum of two seasons of fish surveys required by the Environmental Permit for the Liza Phase 1 Development Project, EEPGL elected to continue the study for another year, which extended the study through the second quarter 2019. The second year of study included the same major components as the first year of study, but for the second year of study, EEPGL elected to add plankton sampling to the field program. Plankton sampling was carried out concurrently with the deepwater, continental shelf, nearshore, and estuarine elements.

Guyana has a humid tropical climate characterized by two wet and dry seasons. Heavy rains typically occur between mid-April and late-July, and again from mid-November to the end of January, while the balance of the year is relatively dry. The field activities described in this dry season report were conducted from December 2018 through early February 2019. As Figure 1 shows, rainfall data from meteorological stations in Georgetown and New Amsterdam indicate that Guyana's coastal region was transitioning into the dry season during the initial portion of the survey period, but had fully entered the dry season by the end of the survey period in February 2019. The results discussed herein are therefore characteristic of transitional/dry season conditions.

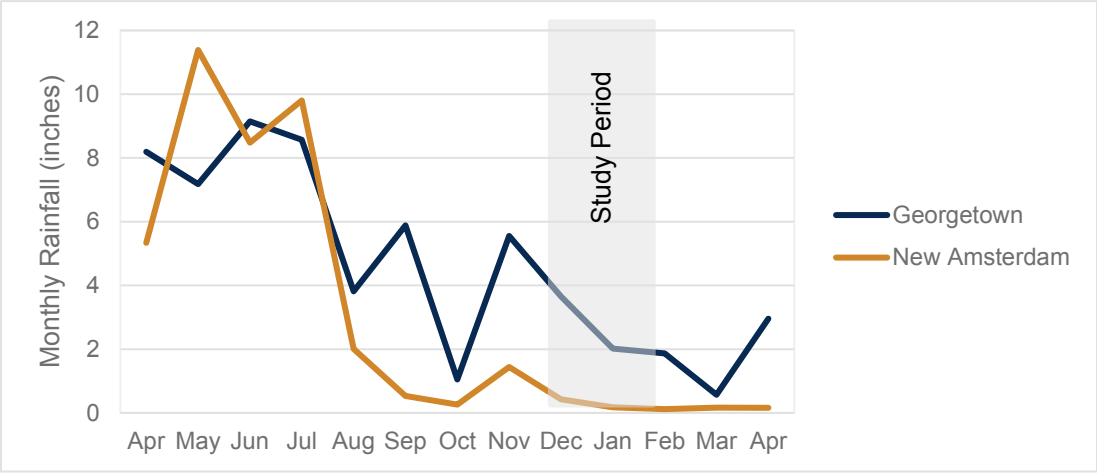


Figure 1: Coastal Rainfall Data, April 2018-April 2019

2. OBJECTIVES

The main goal of the second year of the fish study was to continue to characterize the fish community offshore Guyana using industrial and small-scale fishery techniques. The primary objectives underpinning this goal were:

- Continue to develop the species lists that were initially developed during the first study year for the nearshore, continental shelf, and deepwater offshore zones.
- Identify the main fish taxa occurring within each zone (e.g., continental shelf, nearshore zone, etc.).
- Describe any important life history or ecological characteristics (such as reproductive status or gut contents) of the main species caught.
- Collect information on benthic biological communities on an opportunistic basis (primarily on the continental shelf).

In addition to these primary objective, the study had the following secondary objectives:

- Collect information on water quality conditions in the estuarine, nearshore, continental shelf, and deepwater marine zones.
- Develop local capacity in marine survey techniques among government regulatory staff as well as local Guyanese contractors.

This report describes the results of the first season of field work conducted during the second year of the fish study (i.e., the transitional/dry season portion of the 2018/2019 study year).

3. DISTRIBUTION OF SAMPLING STATIONS

Direct sampling stations (i.e., all sample stations excluding the fish landing interview stations) were distributed from the estuaries to the outer continental slope in areas between the Stabroek Block and the Guyana coast. Fish landing interview stations were located at centers of fishery-related commerce and supporting activity across the Guyana coast. At least one interview site was located in each coastal region except Region 1.

3.1 Continental Shelf Sampling Stations

3.1.1 2018 Dry Season Continental Shelf Sampling Stations

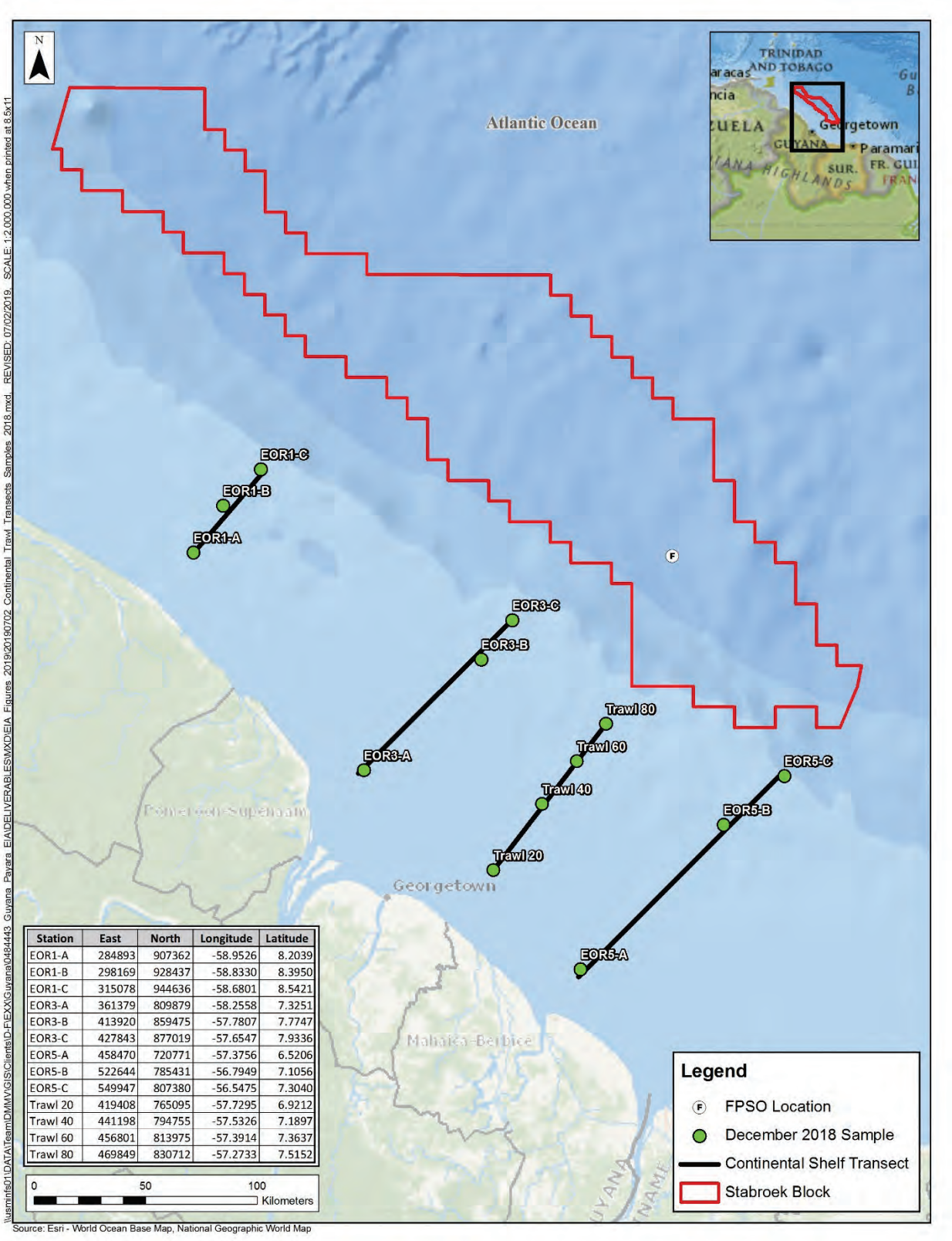
Thirteen continental shelf stations were arranged along four transects roughly perpendicular to the coast. The four transects were established with reference to the coastal regions as follows: near the Shell Beach Protected Area in Region 1 (transect EOP-R1), Region 3 (transect EOP-R2 and EOP-R3), Region 4 (transect EOP-R4 or TRAWL), and Region 5 (transect EOP-R5). The three main transects (EOP-R1, EOP-R3, and EOP-R5) were arranged approximately equidistant to each other with a northeasterly orientation, and the fourth (EOPR-4 or TRAWL) was stablished exclusively for trawl sampling and located between the EPR3 and EPR5 transects.

The stations were labeled “A,” “B,” and “C,” in order of increasing depth. Table 1 shows the coordinates of the 2018 dry season sampling stations. The stations are depicted graphically in Figure 2.

Table 1: 2018 Dry Season Continental Shelf Sampling Stations

Station	Depth (meters)	Location UTM-WGS 84 Coordinates		
		Zone	East	North
EOR1-A	35	21 P	284893	907362
EOR1-B	126	21 P	298169	928437
EOR1-C	200	21 P	315078	944636
EOR3-A	60	21 P	361379	809879
EOR3-B	160	21 P	423920	859475
EOR3-C	250	21 P	427843	877019
EOR5-A	60	21 P	458470	720771
EOR5-B	110	21 P	522644	785431
EOR5-C	250	21 P	549947	807380
TRAWL 20	20	21 P	419408	765095
TRAWL 40	40	21 P	441198	794755
TRAWL 60	60	21 P	456801	813975
TRAWL 80	80	21 P	469849	830712

UTM = Universal Transverse Mercator; WGS = World Geodetic System



Station	East	North	Longitude	Latitude
EOR1-A	284893	907362	-58.9526	8.2039
EOR1-B	298169	928437	-58.8330	8.3950
EOR1-C	315078	944636	-58.6801	8.5421
EOR3-A	361379	809879	-58.2558	7.3251
EOR3-B	413920	859475	-57.7807	7.7747
EOR3-C	427843	877019	-57.6547	7.9336
EOR5-A	458470	720771	-57.3756	6.5206
EOR5-B	522644	785431	-56.7949	7.1056
EOR5-C	549947	807380	-56.5475	7.3040
Trawl 20	419408	765095	-57.7295	6.9212
Trawl 40	441198	794755	-57.5326	7.1897
Trawl 60	456801	813975	-57.3914	7.3637
Trawl 80	469849	830712	-57.2733	7.5152

Figure 2: Locations of 2018 Dry Season Continental Shelf Sampling Stations

3.1.2 2018 Dry Season Nearshore Sampling Stations

Nearshore sampling stations were located based on observations of fishing activity, habitat characteristics, and input received from informal conversations with fisherfolk and former fisheries officers. The nearshore sampling stations were generally located near main fish landing sites along the coast, or near the mouths of rivers or canals where small-scale fishing captains moor their vessels. Table 2 shows the coordinates of the dry season sampling stations. The sampling stations are depicted graphically in Figure 3.

Table 2: 2018 Dry Season Nearshore Sampling Stations

Station	Location UTM-WGS 84 Coordinates			Approximate Depth (meters)	Local Geographic Reference
	Zone	East	North		
EPR1-12	21 P	189809	930246	1.5	~1 mile offshore of the Shell Beach Protected Area
EPR1-11	21 P	271748	880661	1.5	~1 mile offshore of the Shell Beach Protected Area
EPR1-10	21 P	283544	869442	1.2	~1 mile offshore of the Shell Beach Protected Area
EPR1-9	21 P	295703	858349	1.6	~1 mile offshore of the Shell Beach Protected Area
EPR2-8	21 P	328819	824613	1.8	Coser
EPR2-7	21 P	338439	806706	1.8	Hampton Court
EPR2-6	21 P	337808	793031	1.5	Cullen Beach
EPR4-3	21 P	394947	746959	1.4	Hope
EPR3-Mahaica	21 P	401196	743189	1.4	Mahaica
EPR4-4	21 P	371455	754932	0.8	Marriott Hotel (Georgetown)
EPR5-2	21 P	423580	719339	0.5	Belladrum
EPR5-1	21 P	434826	712355	2.0	Bushlot

UTM = Universal Transverse Mercator; WGS = World Geodetic System

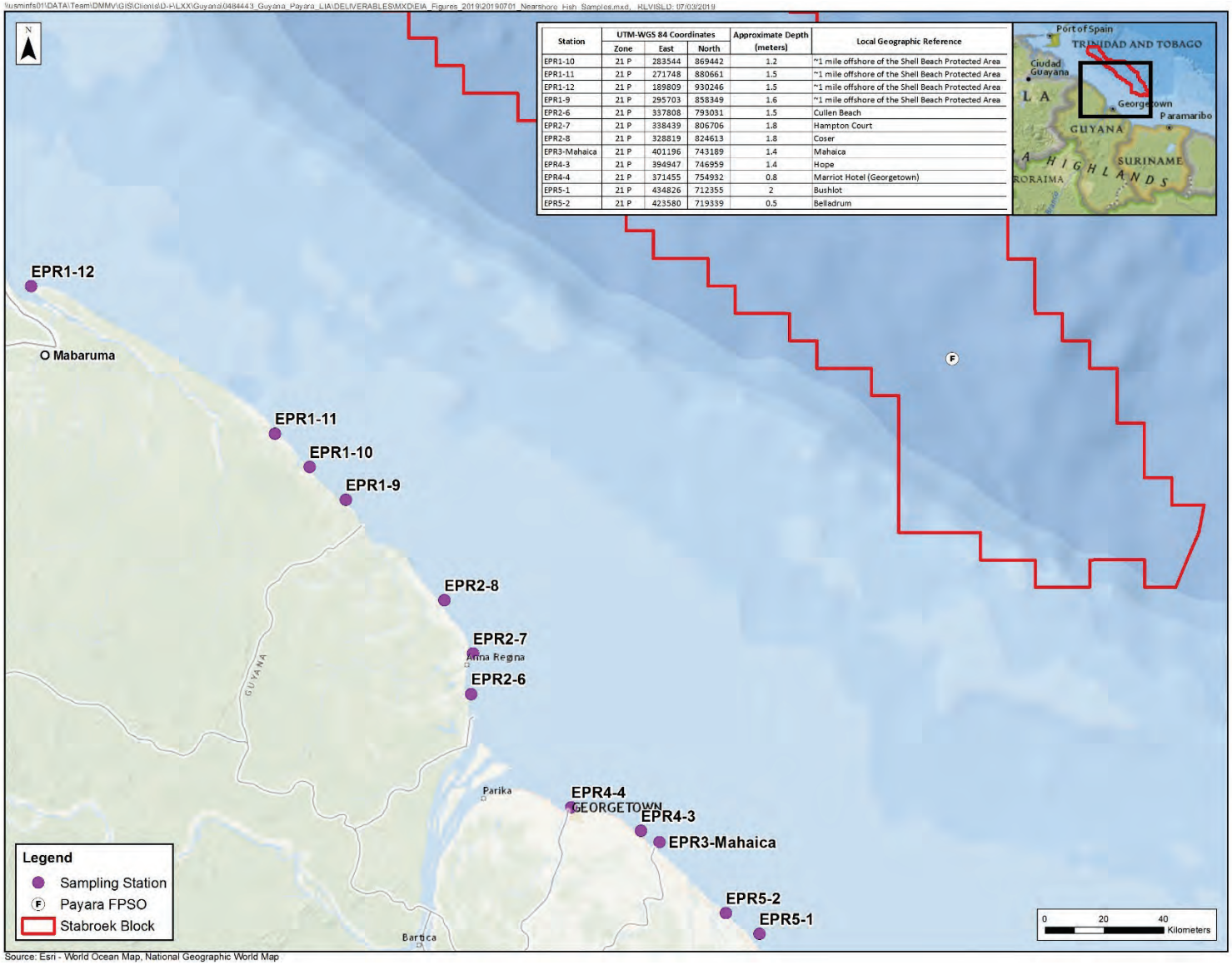


Figure 3: Locations of 2018 Dry Season Nearshore Sampling Stations

3.1.3 2018 Dry Season Estuarine/Riverine Sampling Stations

Estuarine/riverine sampling stations were located within the estuarine portions of the main rivers draining Guyana's coastal plain. Five major rivers (the Pomeroon, Essequibo, Demerara, Mahaica, and Berbice rivers) were sampled to assess the species composition of the estuarine fish community and evaluate the continuity between the estuarine and marine fish communities. The locations of the five estuarine sampling stations are depicted in Table 3 and Figure 4.

Table 3: 2018 Dry Season Estuarine/Riverine Sampling Locations

Station	UTM—WGS 84 Coordinates		River
	East	North	
EPE-RB	441009	696398	Berbice
EPE-RM	398686	740680	Mahaica
EPE-RD	371078	751795	Demerara
EPE-RE	336146	774007	Essequibo
EPE-RP	308778	840460	Pomeroon

UTM = Universal Transverse Mercator; WGS = World Geodetic System

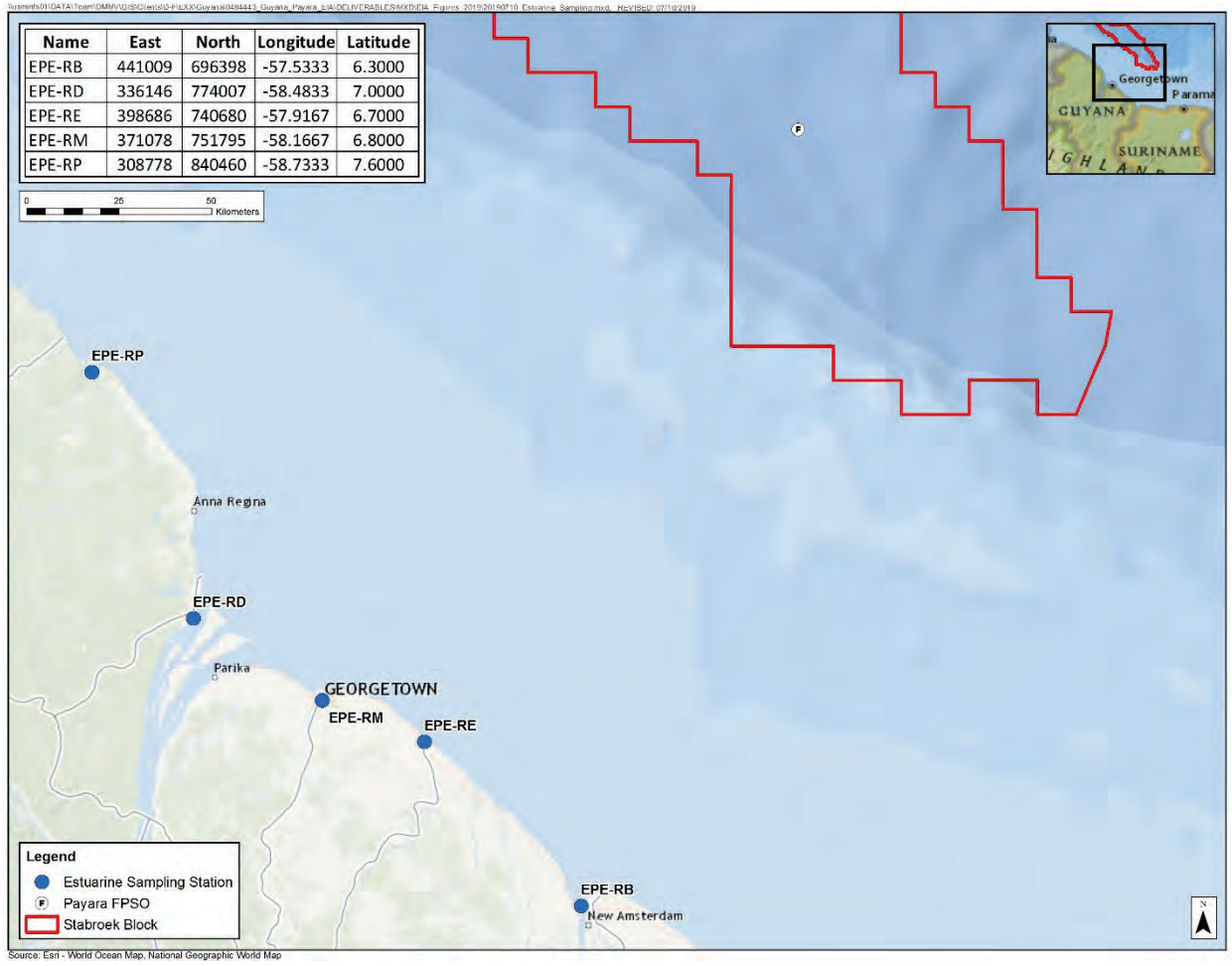


Figure 4: Locations of 2018 Dry Season Estuarine Assessment Sampling Stations

3.1.4 2018 Dry Season Ichthyoplankton Sampling Stations

The study area was defined using a transect approach that extended from the nearshore zone to the 2,000-meter (6,561.7-foot) isobath offshore zone (i.e., the location of the Stabroek Block). To describe the ichthyoplankton community, the study area was surveyed using five perpendicular transects that extended from the nearshore to the offshore waters, with five stations per transect, plus another four stations at specific locations of interest, including one each in the vicinity of the Payara and Liza Project Development Areas, one station at the mouth of the Waini River, and one station at the mouth of the Essequibo River—for a total of 29 stations. This total included 7 nearshore and 22 offshore stations. Ichthyoplankton samples are currently being processed; therefore, this report only reflects the outcomes of a subset of samples consisting of samples from seven nearshore and ten offshore stations. Figure 5 depicts the locations for samples that have been processed to date.

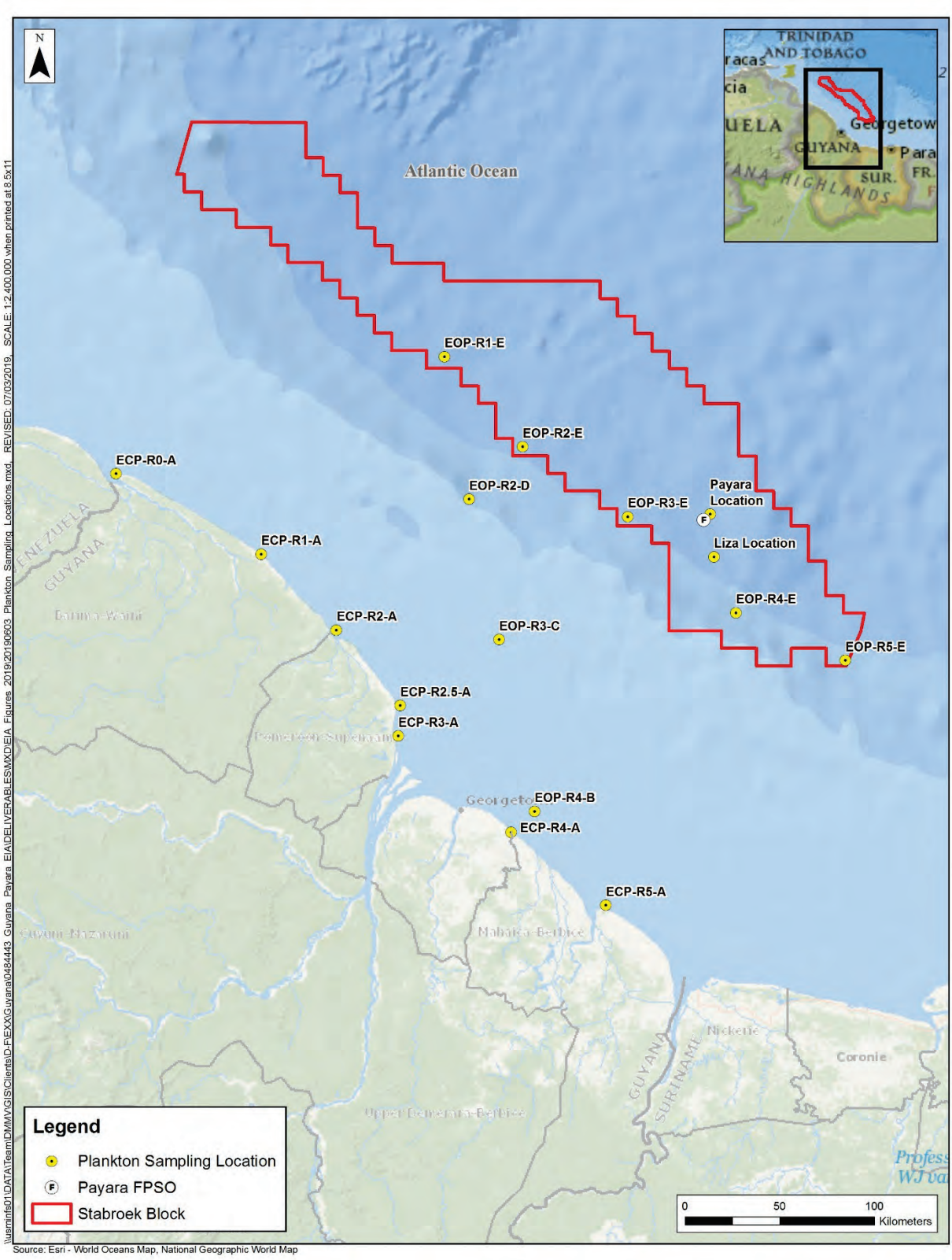


Figure 5: Locations of 2018 Dry Season Ichthyoplankton Assessment Sampling Stations

4. METHODS AND EQUIPMENT

The methodologies and equipment used to sample the fish community were generally similar to the methods used in the first year of the fish study. These methods are summarized by component/oceanographic zone.

1. Continental Shelf Component: trawl, gillnet, and longline
2. Nearshore Component: cast net, seine, and longline
3. Estuarine Component: electrofishing equipment

Full descriptions of each of these sampling methods are provided in the fish study's first year-end report (ERM 2018). Water quality assessment and fish landing assessment methods also followed ERM (2018).

In addition to the above-mentioned sampling methods, which were carried over from the first study year, ERM added two new methodologies for the 2018 dry/transitional season fish survey: gillnetting in the nearshore zone, and ichthyoplankton sampling with conic plankton nets in all zones. Descriptions of these new methodologies are provided below.

4.1 Nearshore Gillnet Sampling Procedure

Nearshore gillnets were deployed at the surface and at the bottom in 7 to 8 feet of water at each station. Each net contained up to three panels of mesh sizes (mesh sizes of 0.25 inch, 1 inch, and 2.5 inches). The gillnets used in this study were made of nylon monofilament. Each panel was 50 meters long by 2 meters wide (i.e., for a total net set length of 100 square meters).

Buoys were affixed at the ends of each surface multipanel net to maintain adequate positive buoyancy. Bottom nets were arranged similarly, but additional ballast was added to the bottom net sets to keep them on the sea floor. A halyard connected the bottom net set to a buoy to mark the location of the net set and maintain the net set at the desired depth. Surface and bottom net sets were deployed from the vessel side in the direction of the current. After the last buoy was released, the end was attached to the ship's bow and the engines were shut down to allow the net to fish. Each multipanel net was allowed to soak for 2 hours excluding time to deploy and retrieve.

4.2 Ichthyoplankton Sampling Procedure

Ichthyoplankton were collected at three different depths using conical-cylindrical plankton nets towed behind the ERM-contracted vessel at a speed of 2 knots using an oblique approach (i.e., v-pattern through the water column; see Figure 6). The tow duration was standardized between 15 and 20 minutes. Plankton samples were collected at the surface in the offshore stations, at mid-depths (50 to 150 meters [164 to 492.1 feet) on the continental shelf, and near the bottom in the nearshore stations. A double Bongo net (0.7-meter mouth diameter) provided with a 500-micrometer mesh was used (see Figure 6). Each mesh was attached to a collection container. A calibrated flowmeter was mounted in the center of each mouth for determination of the volume of filtered water.

The Bongo net was put into the water connected to a towrope. The boat traveled at a speed of 2 knots[3] for 15 to 20 minutes. The start and end time of each sampling period was recorded. Once brought on board, the net was carefully rinsed and the collection containers removed from the meshes and poured into pre-marked jars, labeled with date, time, and location. In the nearshore environment, a smaller Bongo net was used (0.25-meter [2.3-foot] mouth diameter), deployed from a small-scale fishing boat.

[3] Measured with Global Positioning System, towed against the current

The biological material captured in the 500-micrometer mesh collection container was preserved in formaldehyde solution, and buffered with sodium tetraborate diluted in sea water to effect an approximate final concentration of 4 percent.[4] Ichthyoplankton was identified to the lowest taxonomic level practicable using keys and references. The filtered volume was calculated and used to standardize the abundance of fish eggs and larvae per 100 cubic meters of filtered water.

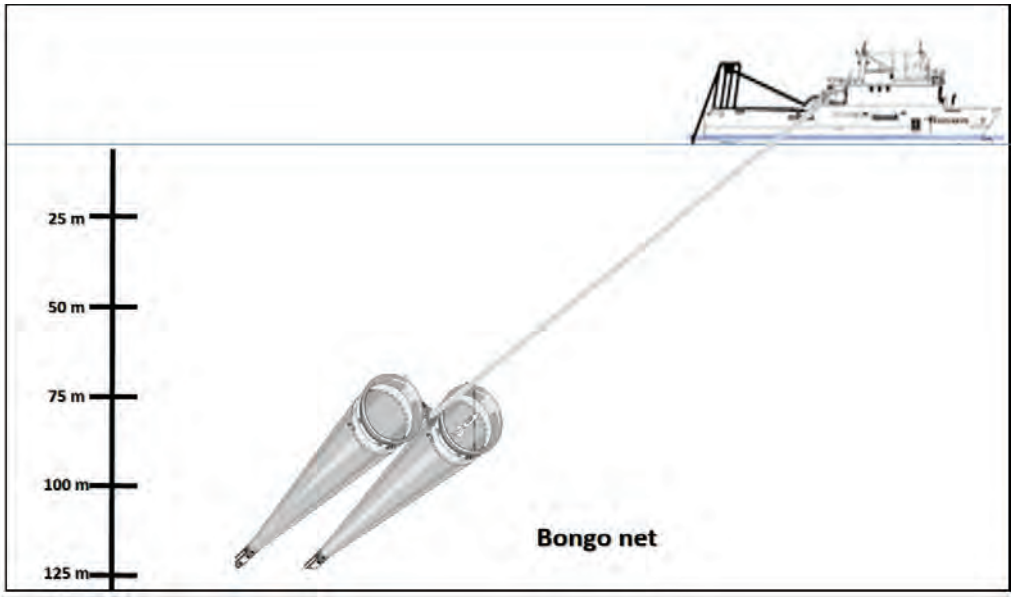


Figure 6: View of Oblique Trawl Using a Bongo Net

[4] All materials were purchased locally, to the extent that they are available.

5. RESULTS

5.1 Continental Shelf Sampling Results

5.1.1 Species Richness

Thirteen stations were sampled across four transects on the continental shelf during the 2018 dry season survey. These stations produced 64 species (see Table 4). The three most diverse families in the continental shelf samples were the Sciaenidae (drums and croakers), Ariidae (sea catfishes), and Lutjanidae (snappers). The volume of fish captured on the continental shelf precluded counting each fish in the samples to evaluate species abundance, so fish were divided by species and the total biomass per species was calculated.

Table 4: Fish Biomass from the Continental Shelf Assessment

Species	Common Name	Total Biomass per species (kg)	Percent of Total Biomass
Albula vulpes	bonefish	8.1	2.50
Amphiarius rugispinis	softhead sea catfish	0.38	0.12
Anableps anableps	four eyes	1.2	0.37
Anchoa sp.	unidentified anchovy	3.17	0.98
Anchoa spinifer	spicule anchovy	4.71	1.45
Anchovia surinamensis	Surinam anchovy	3.92	1.21
Anchoviella sp.	unidentified anchovy	0.2	0.06
Aspredinichthys filamentosus	banyaman	9.65	2.98
Aspredo aspredo	banjo	9.19	2.83
Bagre bagre	coco sea catfish	2.5	0.77
Bollmannia sp.	unidentified goby	23.5	7.25
Brachyplatystoma filamentosum	piraĺba	0.01	>0.001
Caranx sp.	unidentified jack	0.01	>0.001
Cathorops arenatus	white spring cariss	0.83	0.26
Cathorops spixii	cuirass	0.97	0.30
Centropomus ensiferus	swordspine snook	0.01	0.00
Chaetodipterus faber	Atlantic spadefish	3.94	1.21
Colomesus psittacus	banded puffer	5.3	1.63
Cynoscion acoupa	white bashaw	14	4.32
Cynoscion virescens	sea trout	0.01	>0.001
Cynoscion steindachneri	smalltooth weakfish	6	1.85
Diapterus rhombeus	caitipa mojarra	0.02	0.00
Genyatremus luteus	annafolk	4.1	1.26
Hypophthalmus edentatus	highwaterman catfish	10.35	3.19
Larimus spp.	unidentified drum	1.18	0.36
Lobotes surinamensis	Atlantic tripletail	0.008	0.00
Lonchurus lanceolatus	longtail croaker	5.99	1.85

Species	Common Name	Total Biomass per species (kg)	Percent of Total Biomass
Lycengraulis batesii	Bates' sabretooth anchovy	0.0	0.00
Micropogonias furnieri	bashaw basha	3.41	1.05
Mugil incilis	parassi mullet	3.46	1.07
Nebris microps	smalleye croaker	0.002	>0.001
Odontognathus mucronatus	Guiana longfin herring	5.02	1.55
Pimelodus blochii	Bloch's catfish	6	1.85
Plagioscion squamosissimus	white basha	1.4	0.43
Polydactylus virginicus	barbu	5.58	1.72
Potamarius sp.	unidentified sea catfish	3.03	0.93
Pseudauchenipterus nodosus	cocosoda catfish	6.19	1.91
Pterengraulis atherinoides	wingfin anchovy	13.02	4.01
Sciades herzbergii	pemecou sea catfish	4.75	1.46
Sciades couma	couma sea catfish	17.57	5.42
Sciades sp.	unidentified sea catfish	14.07	4.34
Stellifer sp.	unidentified drum/croaker	0	0.00
Stellifer brasiliensis	rockhead	0.9	0.28
Stellifer chaoi	chao stardrum	5.6	1.73
Trachinotus carolinus	Florida pompano	0.01	>0.001
Trichiurus lepturus	largehead hairtail	0.01	>0.001

kg = kilogram

The EOR3 transect, located offshore of the Essequibo River, accounted for the highest number of species (42 species, or approximately 66 percent of all continental shelf species), followed by the EOR1 transect, located off Region 1 (38 species or approximately 59 percent of all total continental shelf species). Transect EOR5, located near the Berbice River, accounted for only slightly fewer species (35 species or approximately 55 percent of all continental shelf species). The TRAWL transect, despite only being sampled via trawl (rather than by a combination of trawl, gillnet, and longline) still accounted for 29 species (almost 70 percent of the species captured on transect EOR3, or approximately 45 percent of all continental shelf species), thereby demonstrating the much greater efficiency of the trawl compared to the other two sampling methods, at least in the moderate depths of the continental shelf.

Table 5: Total Species Richness from the Continental Shelf by Transect

Transect	Species Richness	Percent of Total Species Richness
EOR3	42	65.62
EOR1	38	59.38
EOR5	35	54.69
Trawl	29	45.31

The B stations accounted for the highest numbers of species in aggregate across all transects. The A and C stations accounted for 31 and 30 species respectively, approximately 29 percent fewer species than the B stations. There was also an approximate 20 percent difference between the B stations and the A and C stations in terms of the percentage of all fish species captured across the continental shelf.

Table 6: Total Species Richness from the Continental Shelf by Station Group

Transect	Species Richness	Percent of Total Species Richness
C Stations	30	46.88
B Stations	43	67.19
A Stations	31	48.44

5.1.2 Reproductive Status and Sexual Ratio

Most fish for which sex was determinable were males, although females were abundant in a few species including cobia (*Rachycentron canadum*), grey triggerfish (*Balistes capriscus*), and bashaw (*Micropogonias furnieri*). Most males were observed to be in Phase II (maturing). Testicles were consistently observed, along with well-developed ducts. Based on the observation of the presence of ovaries with visible oocytes filling most of the abdominal cavity, the vast majority of female fish were in Phases II and III (maturing and/or recovering). Figure 7 depicts the number of male and female fish of discernible sex at each continental shelf sampling station.

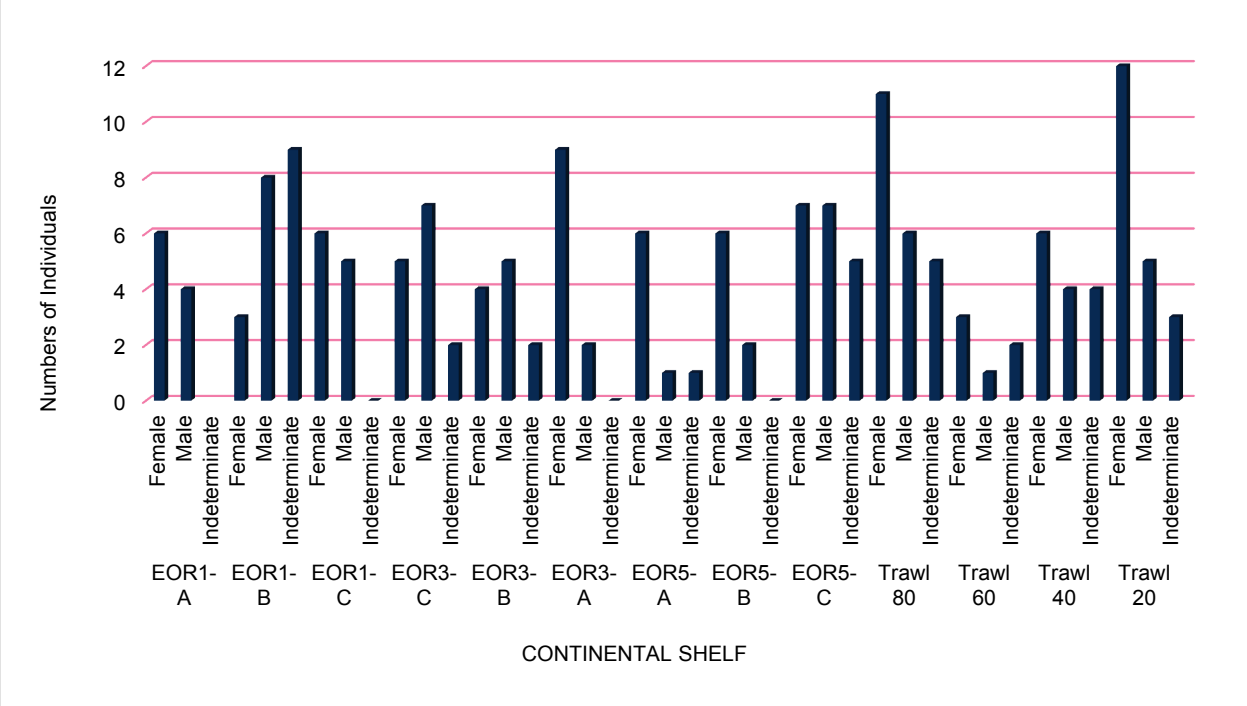


Figure 7: Number of Individuals with Identifiable Sex Characteristics from Continental Shelf Stations

5.1.3 Gut Contents of Species Captured Using Gillnets, Longline, and Trawl

Stomach contents demonstrated shrimp were a primary food item for coastal fish, particularly at stations A and B. This is consistent with the habitat preferences of crustaceans, such as seabob and prawns, which are abundant in shallow coastal waters. Shrimp comprised nearly 80 percent of Siluriformes (catfishes) stomach contents, especially white spring cariss.

Several species of Sciaenids, including white bashaw, bangamary (*Macrodon ancylodon*), shorthead drum (*Larimus breviceps*), rake stardrum (*Stellifer rastrifer*), smalltooth weakfish (*Cynoscion*

steindachneri), silver seatrout (*Cynoscion nothus*), and white basha (*Plagioscion squamosissimus*), also had large numbers of shrimp in their digestive tracts, but small fish (probably anchovies) were more common in the drum gut contents than in the catfish.

Most specimens captured with trawl and longline gear had empty stomachs; the only species captured via longline that had identifiable stomach contents were dolphinfish and bashaw basha. Stomach contents in dolphinfish consisted entirely of fish (probably anchovies), while bashaw stomach contents consisted of unidentifiable crustacean remains.

5.1.4 Benthic Incidental Take in Trawl Samples

A variety of non-target (incidental catch or bycatch) species were captured with trawl gear at various continental shelf stations (Figure 8). Bycatch included holothurians (*Holothuroidea* sp.), Echinoidea (*Eucidaris tribuloides*, *Hygrosoma* sp.), Asteroidea (*Astropecten americanus, Astopecten marginatus*, *Anthenoides guyanensis, Luidia clathrata*), and several crustacean taxa (Stomatopoda: *Squilla empusa;* Decapoda-Brachyura: *Hepatus gronovii, Callinectes* sp.), and mollusks (Gastropoda: *Distorcio clathrata*, *Turritela variegata*, *Tonna galea;* Bivalvia: *Euvola chazaliei*, *Arcinella;* Cephalopoda: *Loligo pelaei*), as well as the ahaermatipic and haermatipic corals *Madrepora oculata* and *Solenosmilia variabilis.* Attachment 1 provides representative photographs of some of the non-target benthic species captured on the continental shelf.

5.1.5 Water Quality Conditions at the Continental Shelf Sampling Stations

Water quality data collected during the continental shelf survey are reported in Attachment 2.

5.2 Nearshore Sampling Results

5.2.1 Species Richness

Twenty stations were sampled across the nearshore zone during the 2018 dry season survey. These stations produced 46 species (see Table 7). The three most diverse families in the nearshore samples were the Sciaenidae (drums and croakers), Ariidae (sea catfishes) and Engraulidae (anchovies).

Table 7: Total Species Richness from the Nearshore Assessment

Species	Common Name	Species Richness	Percent of Total Species Richness
Cathorops arenatus	white spring cariss	101	14.05
Mugil incilis	parassi mullet	96	13.35
Hypophthalmus edentatus	highwaterman catfish	90	12.52
Stellifer sp.	unidentified drum/croaker	90	12.52
Sciades herzbergii	pemecou sea catfish	81	11.27
Lycengraulis batesii	Bates' sabretooth anchovy	42	5.84
Pseudauchenipterus nodosus	cocosoda catfish	27	3.76
Cynoscion acoupa	white bashaw	23	3.2
Bagre bagre	coco sea catfish	16	2.23
Amphiarius rugispinis	softhead sea catfish	15	2.09
Colomesus psittacus	banded puffer	15	2.09

Species	Common Name	Species Richness	Percent of Total Species Richness
Anchoa spinifer	spicule anchovy	12	1.67
Sciades couma	couma sea catfish	12	1.67
Larimus spp.	unidentified drum	10	1.39
Anableps anableps	four eyes	9	1.25
Chaetodipterus faber	Atlantic spadefish	9	1.25
Polydactylus virginicus	barbu	8	1.11
Anchoviella sp.	unidentified anchovy	7	0.97
Cynoscion steindachneri	smalltooth weakfish	6	0.84
Stellifer chaoi	chao stardrum	6	0.83
Aspredinichthys filamentosus	banyaman	5	0.7
Cynoscion virescens	sea trout	4	0.56
Anchovia surinamensis	Surinam anchovy	3	0.42
Centropomus ensiferus	swordspine snook	3	0.42
Sciades sp.	unidentified sea catfish	3	0.42
Caranx sp.	unidentified jack	2	0.28
Plagioscion squamosissimus	white basha	2	0.28
Stellifer brasiliensis	rockhead	2	0.28
Trachinotus carolinus	Florida pompano	2	0.28
Albula vulpes	bonefish	1	0.14
Anchoa sp.	unidentified anchovy	1	0.14
Aspredo aspredo	banjo	1	0.14
Bollmannia sp.	unidentified goby	1	0.14
Brachyplatystoma filamentosum	piraÍba	1	0.14
Cathorops spixii	cuirass	1	0.14
Diapterus rhombeus	caitipa mojarra	1	0.14
Genyatremus luteus	annafolk	1	0.14
Lobotes surinamensis	Atlantic tripletail	1	0.14
Lonchurus lanceolatus	longtail croaker	1	0.14
Micropogonias furnieri	bashaw basha	1	0.14
Nebris microps	smalleye croaker	1	0.14
Odontognathus mucronatus	Guiana longfin herring	1	0.14
Pimelodus blochii	Bloch's catfish	1	0.14
Potamarius sp.	unidentified sea catfish	1	0.14
Pterengraulis atherinoides	wingfin anchovy	1	0.14
Trichiurus lepturus	largehead hairtail	1	0.14

Region 2 had the highest species richness out of the five regions sampled. Its proximity to the largest river in Guyana (the Essequibo) probably contributed to the relatively high number of species captured in that region, although it is notable that stations in closest proximity to river mouths (e.g., EPR2-6, EPR1-12, EPR4-4) often produced fewer species than nearby stations that were in the same region but further away from river mouths. The reason for this is unclear, but it may be related to freshwater inputs from the rivers excluding purely marine species from the stations nearest to the river mouths, but not from sites further away.

Table 8: Total Species Richness from the Nearshore Stations

	Species Richness	Percent of Total Species Richness
EPR1-12	4	8.16
EPR1-11	6	12.24
EPR1-10	5	10.2
EPR1-9	10	20.4
EPR2-8	16	32.65
EPR2-7	17	34.69
EPR2-6	8	16.32
EPR3-Mahaica	7	14.28
EPR4-4	10	20.40
EPR4-3	16	32.65
EPR5-2	13	26.53
EPR5-1	4	8.16

5.2.2 Reproductive Status and Sexual Ratio

Individuals with immature gonads represented a significant portion of the catch at the nearshore stations, but adults with recognizable sex organs were more abundant at the nearshore stations than the continental shelf stations. Males outnumbered females at all the Region 1 stations, females outnumbered males at all the Region 2 stations, and ratios were mixed in other regions (Figure 8). Female specimens showed a wider range of gonadal development than males, particularly in Region 1. A large number of individuals of undetermined sex (86 individuals) were collected at stations south of EPR2-7, but mature individuals with identifiable sexual characteristics were prevalent along the northwest coast, which may indicate that spawning activity occurs at different times in different locations along the coast.

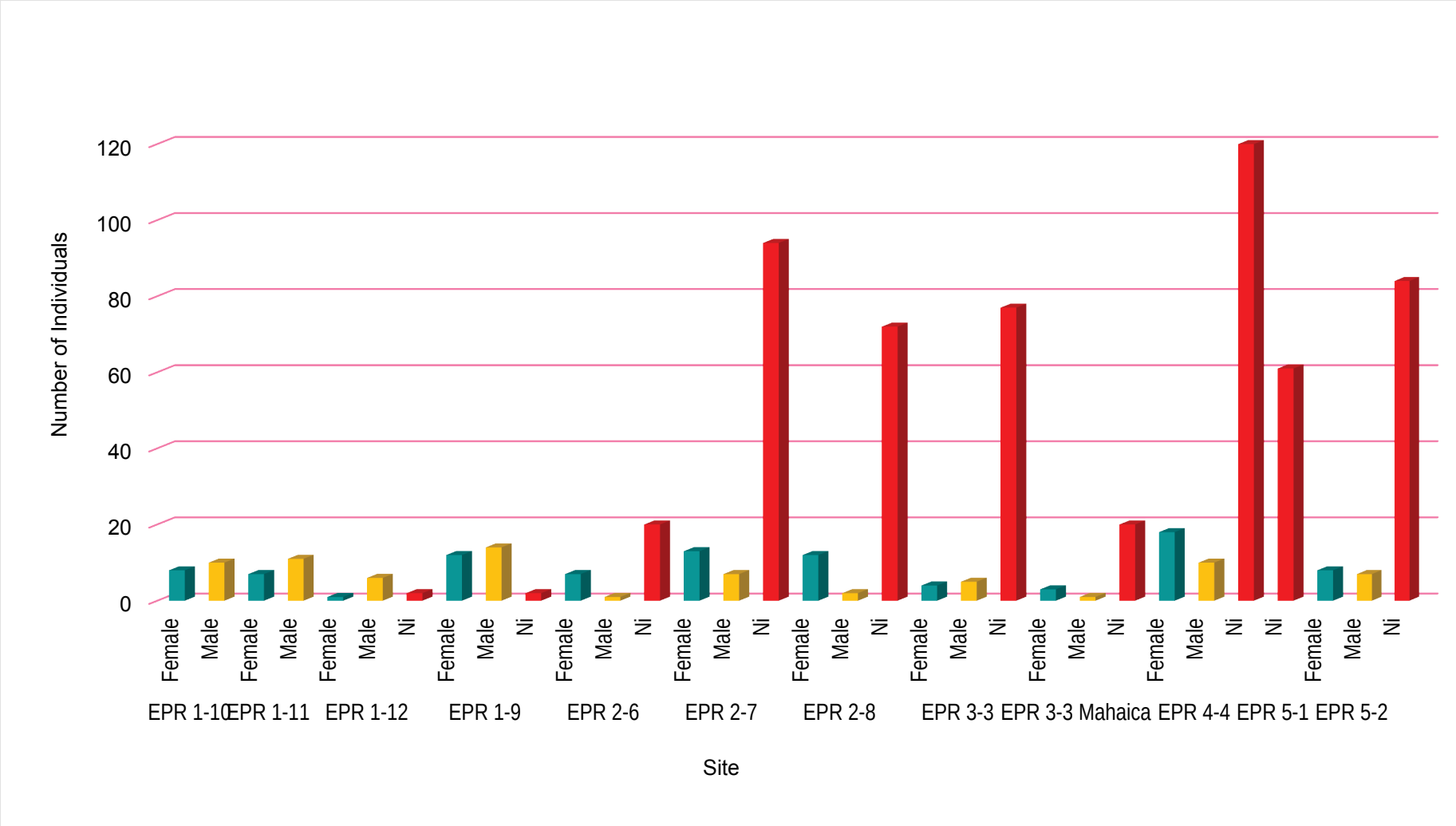


Figure 8: Number of Individuals with Identifiable Sex Characteristics from Nearshore Stations

5.3 Estuarine/Riverine Assessment

5.3.1 Total Abundance and Biomass

Five stations were sampled across the estuarine zone during the 2018 dry season survey. These stations produced 13 species (see Table 9). The three most diverse families in the estuarine samples were the Sciaenidae (drums and croakers), Ariidae (sea catfishes), and Engraulidae (anchovies).The results of the 2018 dry season estuarine survey indicate a fish community with a coastal-marine affinity in origin. As summarized in Table 9, the most common species in the estuarine samples were parassi mullet followed by ladyfish, *Stellifer* sp. (rockhead), banded puffer (*Colomesus psittacus*), zabaleta anchovy (*Anchovia clupeoides*), and false herring (*Harengula clupeola*). All other species accounted for less than 5 percent of the total abundance. As depicted in Figure 9, three of these species (ladyfish, rockhead, and banded puffer) were also the most widespread across the estuaries sampled.

Table 9: Total Species Richness from the Estuarine Assessment

Species	Common Name	Species Richness	Percent of Total Species Richness
Mugil incilis	parassi mullet	82	30.70
Elops saurus	ladyfish (larvae)	58	21.70
Stellifer sp.	rockhead	33	12.40
Colomesus psittacus	banded puffer	29	10.90
Anchovia clupeoides	zabaleta anchovy	24	9.00
Harengula clupeola	false herring	17	6.40
Hypostomus plecostomus	suckermouth catfish	8	3.00
Sciades sp.	unidentified sea catfish	6	2.20
Caranx sp.	unidentified jack	5	1.90
Sciades herzbergii	pemecou sea catfish	2	0.70
Anableps anableps	four eyes	1	0.40
Apionichthys dumerili	longtail sole	1	0.40
Cathorops arenatus	white spring cariss	1	0.40

No river produced more than six species in the 2018 dry season survey. The Pomeroon, Demerara, and Berbice rivers each produced six species, while the Mahaica River produced 4 species and the Essequibo River produced 3 species (Table 10).

Table 10: Species Richness from Estuarine Stations

	Species Richness	Percent of Total Species Richness
EPE-RP	6	46.15
EPE-RE	3	23.08
EPE-RD	6	46.15
EPE-RM	4	30.77
EPE-RB	6	46.15

The species composition of the fish communities in the five rivers sampled during the 2018 dry season survey demonstrated a high degree of uniqueness in each of the rivers. No species appeared in more than three rivers, and most appeared in only two rivers or a single river (Figure 9).

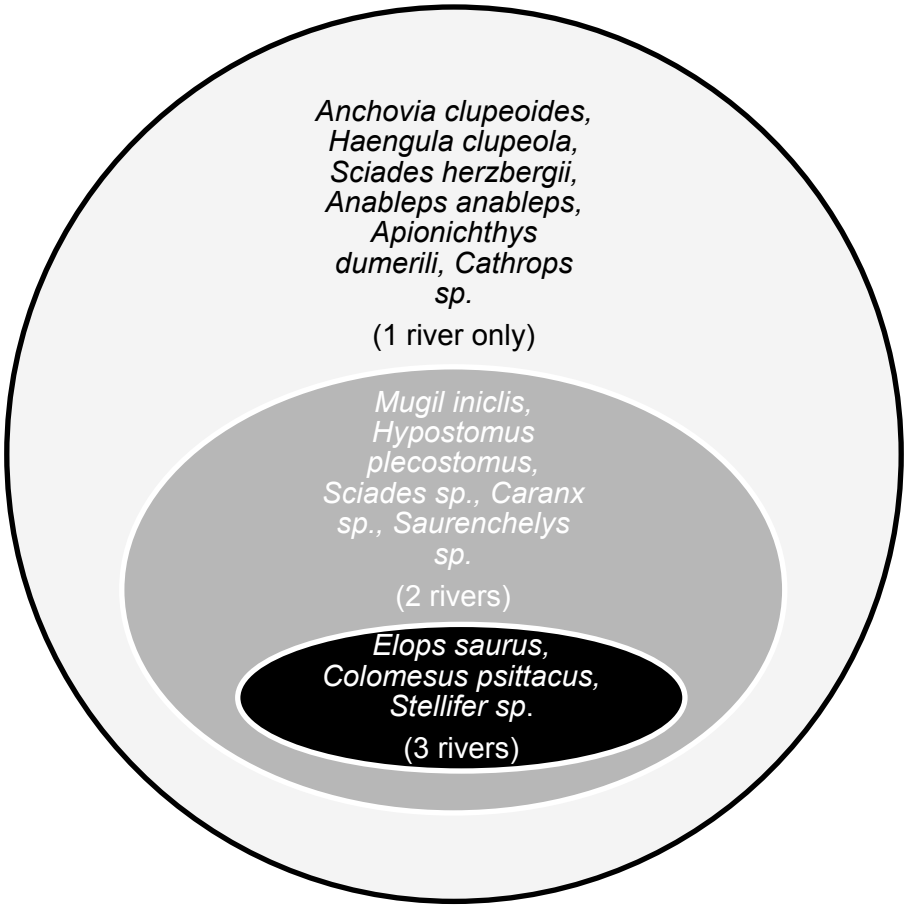


Figure 9: Number of Species in Common across the Estuarine Sample Stations

5.3.1 Water Quality Conditions at the Estuarine Sampling Stations

Water quality data collected during the estuarine survey are reported in Attachment 3.

5.4 Ichthyoplankton Sampling Results

A total of 8,107 marine organisms representing 152 taxa (including unidentified eggs) were identified in the ichthyoplankton samples. Overall, 13 taxa (including unidentified eggs as a “taxon”) accounted for 90 percent of the catch (Figures 10 and 11) and 4,967 individuals (61 percent of the catch belonged to the Engraulidae [anchovy] and Sciaenidae [drum or croaker] families). More marine organisms were collected in the day samples (n = 5,515) than the night samples (n = 1,789), which was expected given the number of day samples was almost double. Engraulidae dominated the day samples of the catch (n = 3,795 or 67.8 percent), and Sciaenidae dominated the night samples (n = 971 or 54.2 percent) (Figure 10).

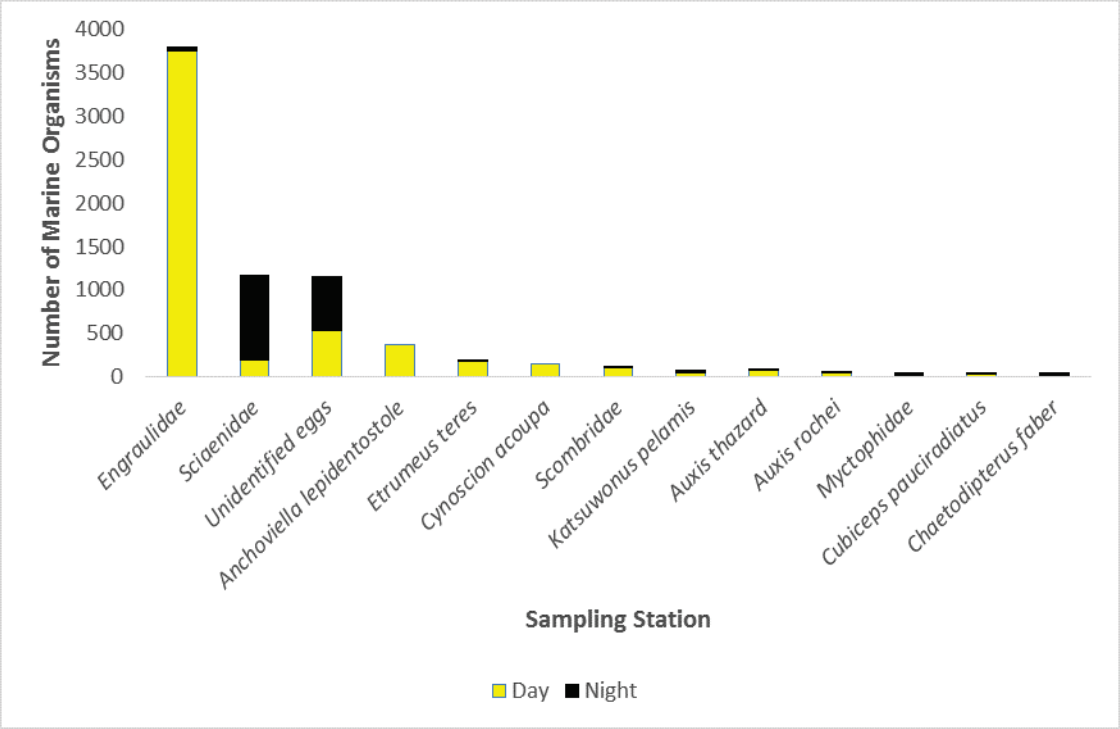


Figure 10: Number of Marine Organisms by Taxon for Top 90 Percent Taxa (Including Unidentified Eggs) Collected by Time of Day

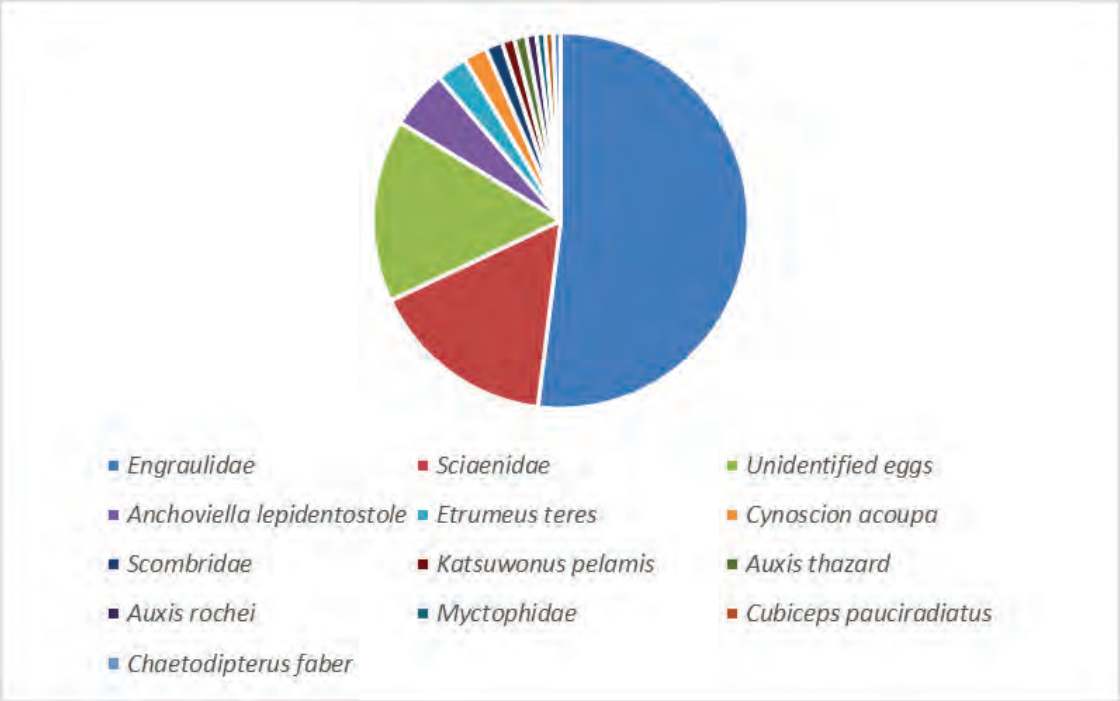


Figure 11: Percent of Taxa (Including Unidentified Eggs) Represented in the Ichthyoplankton Samples

In terms of the species able to be identified to a specific genus species, broadband anchovy (*Anchoviella lepidentostole*), red-eye round herring (*Etrumeus teres*), and acoupa weakfish (*Cynoscion acoupa*) were the most abundant taxa, representing around 9 percent (n = 713) of the catch.

Overall, 78 percent of the marine organisms were collected at four stations (ECP-R3-A, EOP-R4-B, ECP-R2.5-A, and EOP-R4-E) (Figure 12). Two of these stations were located nearshore (ECP-R3-A and ECP-R2.5-A) and the other two stations were located offshore (EOP-R4-B and EOP-R4-E). There were slightly more marine organisms (n = 1,173 or 15 percent collected) in the nearshore (ECP-R3-A, ECP-R2.5-A, ECP-R0-A, ECP-R2-A, ECP-R5-A, ECP-R4-A, ECP-R1-A) stations (n = 4,640 or 57 percent) than the offshore (EOP-R4-B, EOP-R4-E, EOP-R3-C, Payara, EOP-R5-E, EOP-R2-E, Liza, EOP-R2-D, EOP-R3-E, and EOP-R1-E) stations (n = 3,467 or 43 percent). Most (n = 3,721 or 40.3 percent) of the marine organisms were collected at one nearshore station (ECP-R3-A) (Figure 12). Despite the greater number of marine organisms collected at nearshore stations, the mean numbers of taxa collected at the offshore stations (mean of 26.8 taxa) were greater than the mean numbers collected at the nearshore stations (mean of 10 taxa).

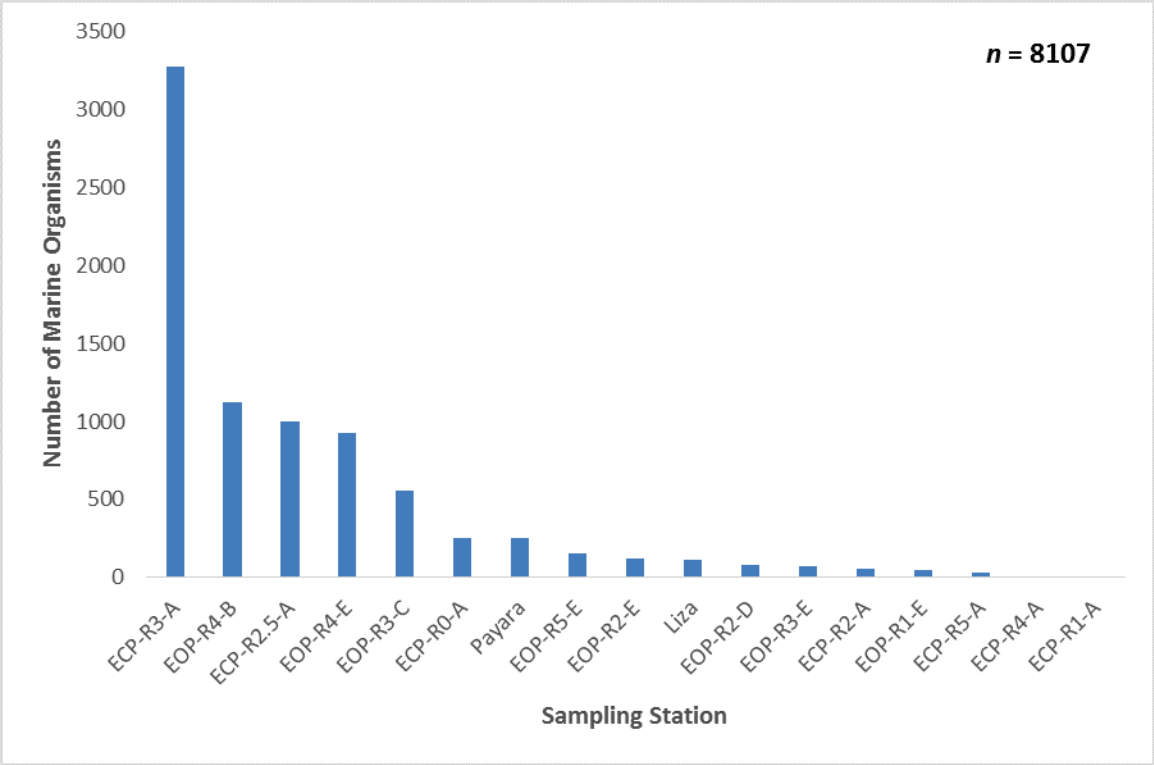


Figure 12: Number of Marine Organisms (Including Unidentified Eggs) Collected at Each Sampling Station

The spatial distribution of the primary taxa (top 13 percent) collected differed among sampling stations; taxa were not uniformly distributed in terms of abundance (percent of total) within and among sampling stations (Figure 13). For instance, *Anchoviella lepidentostole* was the only taxa (100 percent) collected at station ECP-RO-A and *Cynoscion acoupa* represented 80 percent of the catch at station ECP-RA-A. The most abundant taxa (Engraulidae and Sciaenidae) were collected at stations ECP-R3-A (n = 3,245) and EOP-R4-B (n = 971), respectively. Unidentified eggs were primarily collected at stations EOP-R3-C and EOP-R4-E.

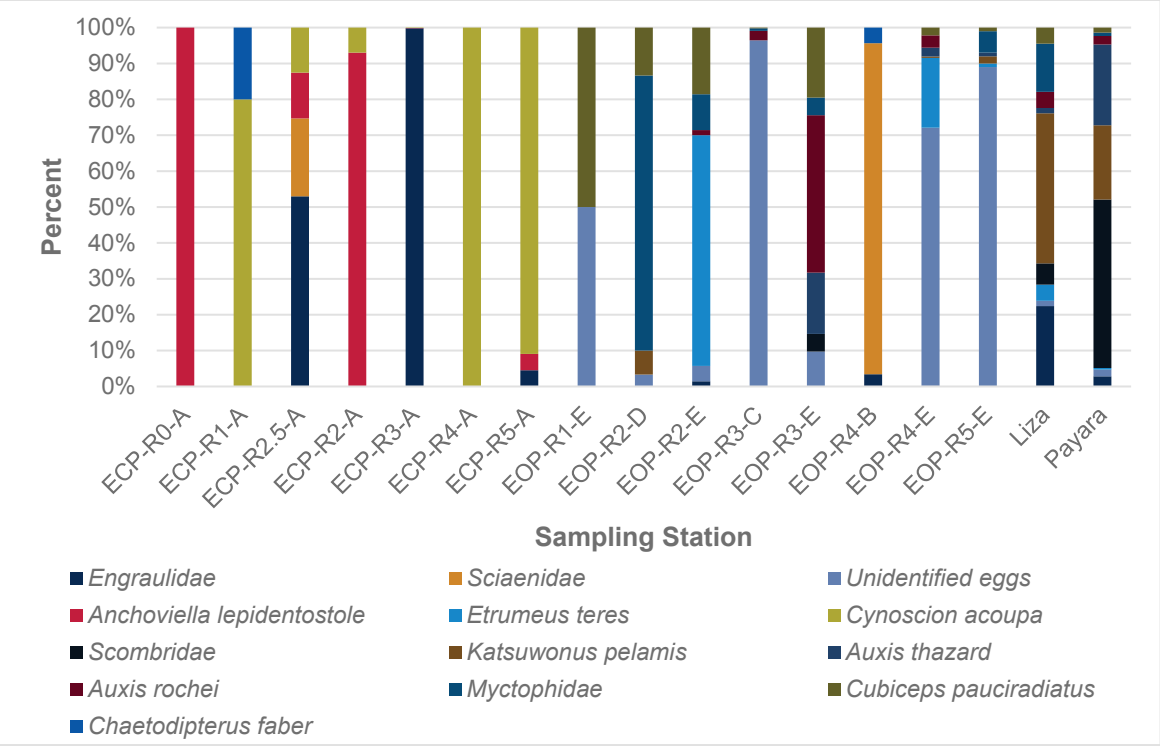


Figure 13: Primary Taxa (Including Unidentified Eggs) Collected at Each Sampling Station; Percent of Total

6. DISCUSSION

A total of 107 species were captured in the three zones (nearshore, continental shelf, and rivers/estuaries) sampled during the 2018 dry season fish survey. Trawls accounted for the largest number of species captured, followed by longlines and gillnets.

6.1 Continental Shelf Assessment

Sixty-four species were captured at the continental shelf stations. More diverse catches were collected at the A and B stations than the deeper stations, probably because increasing depth made it more difficult to sample the northern ends of the transects. Unidentified flying fish (*Exocetus* sp.*)* were observed regularly at the deeper stations, while dolphinfish and trigger fish were observed sporadically in these areas. Squid were often observed in these areas at night because they were attracted to the vessel lights. The B trawl stations, which generally correspond to the mid- to outer-portion of the continental shelf approximately 40 to 105 kilometers (25 to 65 miles) offshore, accounted for the greatest number of species of any of the continental shelf stations. Visual observations made by the field team indicate that the B zone is an area of transition from the stained, highly turbid water near shore to clearer waters more characteristic of offshore conditions, an observation that is supported by the turbidity data collected from the A, B, and C stations (Attachment 2). Although additional data analysis would be required to validate this, the B stations seemed to support the most diverse and robust benthic community of any group of stations on the continental shelf, which would be consistent with more sunlight reaching the seafloor at the B stations than in other locations on the continental shelf due the combination of relatively shallow depths and relatively clear water.

Although benthic marine resources were not the primary target, the sampling crew reported the presence of living hard corals (*Madrepora oculata* and *Solenosmilia variabilis*) in some of the trawl samples at the B stations on transects EOR1, EOR3, and EOR5, which was also the case for the May 2018 survey. Lowe's (McConnell) 1962 landmark paper on Guyana's fishery resources noted the presence of coral fragments in trawl samples, but those coral fragments were described as dead. McConnell noted the presence of reef-associated fishes in her samples, but did not indicate the presence of living corals. The wide distribution of living corals documented in this study suggests that McConnell either overlooked living corals among the samples, or that the coral community is recovering;[5] (it has been 50 years since McConnell published the findings). Regardless of whether the benthic community at the B stations represents a long established or relatively new reef community, the findings demonstrate a diverse benthic community on the middle continental shelf at depths ranging from 40 to 90 meters (131 to 295 feet). There were relatively few benthic species captured at the A stations (mean depth 10 meters [32.8 feet]), which could have been associated with fishing pressure or the high turbidity in the area.

6.2 Nearshore Assessment

Forty-six species were captured at the nearshore stations. Abundance in the nearshore zone was highest of any of the three non-plankton components, with 716 individuals collected. The most common species observed at the nearshore stations were white spring cariss, highwaterman catfish, parassi mullet, and pemecou sea catfish. Most species captured during the wet season were anadromous species which migrate into the coastal area in response to increased freshwater discharge. Some species were euryhaline species that entered the study area from further up the rivers. Nearshore catches consisted primarily of catfish. Although several other taxonomic groups (e.g., the Scianidea) tolerate variable salinity

[5] The author of this study considered significant recovery of coral communities since the 1960s unlikely given the current prevalence of trawling on Guyana's continental shelf.

levels, the Siluriformes can tolerate the wide-ranging levels that exist along the Guyana coast. This is probably a contributing factor to their ubiquity in the Guyana nearshore marine zone.

6.3 Estuarine Assessment

Thirteen species were captured at the estuarine stations. Parassi mullet, rockhead, banded puffer, zabaleta anchovy, and false herring were the most common species collected at the estuarine stations. Leptocephalii (which are typical larval forms of elopomorphic fish [cuffum (*Megalops atlanticus*)] and eels) were also common in the estuarine samples, which indicate ecological value of the estuaries as nursery areas. The stations with the highest catches of juvenile fish were located near riparian vegetation, such as aquatic plants, grass, submerged palm trees, and plants of small size with abundant foliage. Smaller catches were associated with areas among mangrove roots.

7. REFERENCES

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Lowe (McConnell), Rosemary H. 1962. The Fishes of The British Guiana Continental Shelf, Atlantic Coast of South America, with notes on their natural history. Zoological Journal of the Linnean Society, Volume 44, Issue 301. December 1962. Retrieved from: https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1096-3642.1962.tb01964.x)

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ATTACHMENT 1 INCIDENTAL BENTHIC BYCATCH FROM THE CONTINENTAL SHELF TRAWL SAMPLES

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Benthic Crustacean and Asteroidea Species Caught at Station EOR1-B



Benthic Crustacean, Fish, and Mollusk Species Caught at Station EOR1-C



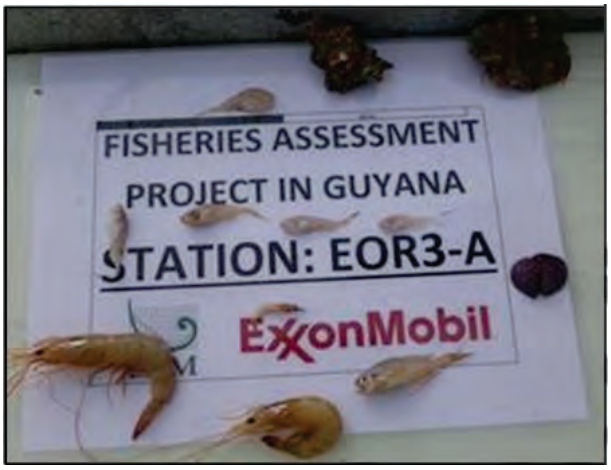
Benthic Fish, Crustacean, and Mollusk Species Caught at Station EOR3-C



Benthic Asteroidea, Fish, and Crustacean Species Caught at Station EOR3-B



Benthic Crustacean, Mollusk, and Fish Species Caught at Station EOR3-A



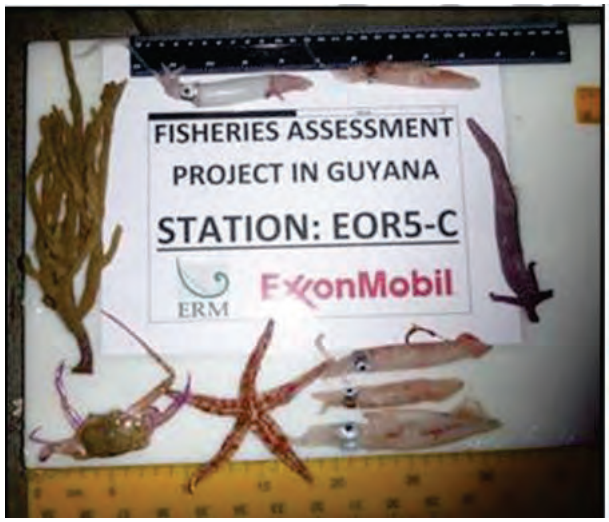
Benthic Crustacean Species Caught at Station EOR5-A



Benthic Crustacean, Echinoidea, Asteroidea, and Haermatipic Coral Species Caught at Station EOR5-B



Benthic Crustacean, Asteroidea, Mollusk, Ahaermatipic Coral, and Haermatipic Coral Species Caught at Station EOR5-C



Benthic Crustacean, Mollusk Ahaermatipic, and Haermatipic Coral Species Caught at Station Trawl 80



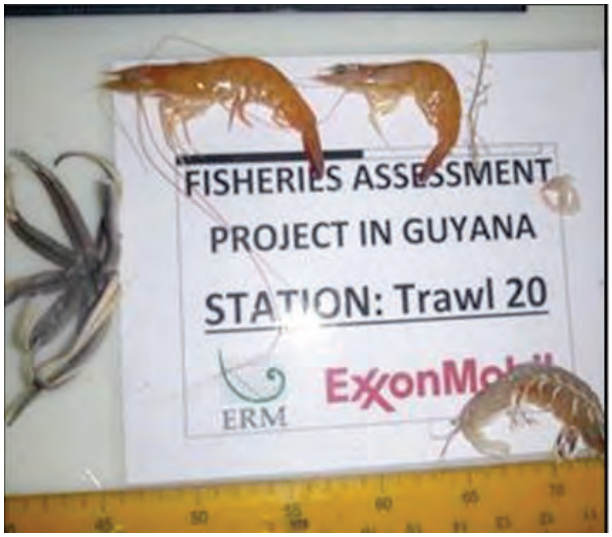
Benthic Crustacean, Asteroidea, Mollusk, and Ahaermatipic Coral Species Caught at Station Trawl 60



Benthic Crustacean, Asteroidea, Mollusk, and Haermatipic Coral Species Caught at Station Trawl 40



Benthic Crustacean and Asteroidea, Mollusk Species Caught at Station Trawl 20



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ATTACHMENT 2 *IN SITU* WATER QUALITY DATA OBTAINED DURING THE CONTINENTAL SHELF ASSESSMENT

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Sampling Date	Station	Stratum	Temp Water (ºC)	Temp Sample (ºC)	pH	DO (mg/L)	Turbidity (NTU)	Salinity (ppt)	Conductivity (µS/cm)
09/12/2018 04:20	EOR1-A	Surface	27.5	27.8	8.22	5.68	19.10	39.70	62646
09/12/2018 07:42	EOR1-B	Surface	28.7	27.7	8.20	5.84	3.11	39.50	63249
		Bottom	28.9	27.4	8.24	5.74	2.71	38.80	62566
09/12/2018 14:12	EOR1-C	Surface	30.4	28.3	8.18	5.90	1.35	39.62	62750
		Bottom	30.2	27.9	8.23	5.77	1.51	39.59	62556
10/12/2018 05:13	EOR3-C	Surface	28.8	27.8	8.19	6.23	0.91	39.49	62351
		Bottom	28.5	27.6	8.24	5.54	0.82	39.48	62303
10/12/2018 08:38	EOR3-B	Surface	29.4	27.9	8.13	6.11	5.38	39.33	62333
		Bottom	28.6	27.8	8.26	5.75	1.06	39.43	62258
10/12/2018 15:05	EOR3-A	Surface	30.7	27.9	8.08	5.49	12.30	38.46	60573
12/12/2018 22:25	EOR5-A	Surface	29.9	27.3	8.05	5.84	12.50	39.39	61359
13/12/2018 10:42	EOR5-B	Surface	34.2	26.8	8.18	5.72	5.55	39.84	61562
		Bottom	34.5	26.6	8.20	5.68	1.78	39.88	61414
13/12/2018 18:30	EOR5-C	Surface	30.3	27.2	8.21	6.64	0.58	39.38	61407
		Bottom	30.1	27	8.23	5.56	1.37	39.37	61463
14/12/2018 12:03	Trawl 80	Surface	30.4	27	8.21	5.97	1.52	40.00	62159
		Bottom	30.0	27.1	8.26	5.73	0.75	40.01	62126
14/12/2018 14:45	Trawl 60	Surface	28.9	27.8	8.12	5.93	1.18	40.01	62408
		Bottom	28.5	27.1	8.23	5.71	1.02	39.98	62362
14/12/2018 17:59	Trawl 40	Surface	29.4	27.5	8.15	6.08	4.39	39.85	62416
		Bottom	29.2	27.4	8.25	5.62	3.05	39.84	62371
14/12/2018 21:30	Trawl 20	Surface	28.6	27.2	8.15	5.52	14.40	39.45	61588

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; NTU = nephelometric turbidity unit; ppt = parts per thousand

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ATTACHMENT 3 *IN SITU* WATER QUALITY DATA OBTAINED DURING THE ESTUARINE ASSESSMENT

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Sampling Station	Parameter				
	Ambient Temperature (ºC)	Sample Temperature (ºC)	DO (mg/L)	Salinity (ppt)	Conductivity (µS/cm)
Mahaica River	26.5	27.8	5.85	3.54	6,284
Berbice River	27.5	29.6	5.66	4.79	9,445
Pomeroon River	27.0	28.1	5.27	3.43	7,600
Essequibo River	25.0	28	5.40	3.60	600
Demerara River	27.2	27	6.16	0.30	2,500

ºC = degrees Celsius; µS/cm = microSiemens per centimeter; DO = dissolved oxygen; mg/L = milligrams per liter; ppt = parts per thousand

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APPENDIX O

Protected Species Observer Summary Report

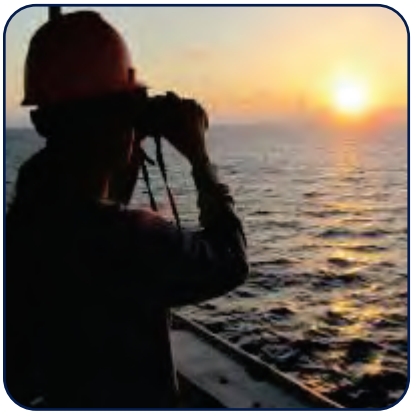
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Protected Species Observer Summary

Prepared for: ExxonMobil

ExxonMobil
Guyana
May 2018 – April 2019







Authors: Stephanie Milne and Katherine Gideon

20405 Tomball Parkway
Building 2, Suite 200
Houston, TX 77070 USA

Tel: +1 (713) 586-5950
Fax: +1 (713) 586-5955

Email:
Stephanie.milne@rpsgroup.com

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1 Executive Summary

This report summarizes the protected species observer data collected by ExxonMobil on various programs from May 2018 through April 2019 in Guyana, including visual observations performed on existing marine operations as required by multiple permits issued by the Guyana Environmental Protection Agency (EPA) for geophysical and geotechnical surveys. Data from four survey types—Geotechnical Survey, Geophysical Surveys, Vertical Seismic Profiles (VSPs), and Environmental Baseline Surveys—is summarized in this report. The following surveys are included:

3D / 4D Seismic Surveys
- NW Stabroek and SE Stabroek *Ramform Tethys* and *Ramform Atlas*: 05 December 2018 to April 2019

Field Geotechnical Survey
- Canje: 28 July 2018 to 28 September 2018
- Liza: 28 July 2018 to 28 September 2018
- Payara Geotechnical, Geophysical / AUV and Environmental Baseline: 05 September 2018 to 27 December 2018

AUV
- Hammerhead AUV Survey: 16 March 2019 – 17 April 2019

Vertical Seismic Profile
- LongTail-1 *Stena Carron* Zero Offset Vertical Seismic Profile: 02 June 2018 to 06 June 2018
- LongTail-1 *Bourbon Orca* Walk-Away Vertical Seismic Profile: 15 June 2018 to 20 June 2018
- Hammerhead *C-Installer* Walk-Away Vertical Seismic Profile: 28 August 2018 to 30 August 2018
- Pluma-1 *Noble Tom Madden* Vertical Seismic Profile: 12 November 2018 to 16 November 2018
- Pluma-1 *PSV Eland* Vertical Seismic Profile: 28 November 2018 to 29 November 2018
- Pluma-1 *PSV Eland* Vertical Seismic Profile: 11 December 2018 to 13 December 2018
- Stabroek *Stena Carron* Vertical Seismic Profile: 23 January 2019 to 03 February 2019
- Stabroek *Noble Tom Madden* Vertical Seismic Profile: 07 April 2019 to 08 April 2019
- Stabroek *Noble Tom Madden* Vertical Seismic Profile: 17 April 2019 to 19 April 2019

Environmental Baseline and Metocean Surveys
- *Sea Service* Metocean Retrieval Survey: 01 October 2018 to 06 October 2018
- SE Stabroek / Kaieteur *Proteus* Environmental Baseline Survey: 08 April 2019 to 15 April 2019

During all surveys, two protected species observers (PSOs) provided by RPS were on board the vessels to undertake visual observations in accordance with Joint Nature Conservation Committee (JNCC) *guidelines for minimizing the risk of injury and disturbance to marine mammals from seismic surveys*. During the Stabroek Seismic Surveys, there was also one passive acoustic monitoring (PAM) Operator provided by RPS on board each vessel to undertake acoustic observations in accordance with JNCC guidelines.

In accordance with permit requirements, ExxonMobil mandated that soft starts would be delayed for sea turtles in addition to marine mammals if detected within the 500-meter exclusion zone during the search period prior to initiation of the source and if the source activity ceased or reduced power, a silent period of only 20 minutes would be permitted after which a soft-start was required to resume source operations. Note: this does not apply to the Environmental Baseline surveys as there was no acoustic source utilized on these surveys.

Throughout all surveys, PSOs conducted visual observations for a total of 3092 hours and 19 minutes. PAM Operators performed acoustic monitoring for a total of 792 hours and 30 minutes.

During the seismic surveys and VSPs, the seismic source was active for a total of 1420 hours and 14 minutes. This included 1190 hours and 20 minutes while in production, 72 hours and 31 minutes while at full volume or partial volume while not in production, 100 hours and 35 minutes of soft-start, and 56 hours and 48 minutes conducting source testing. There was no use of the mitigation source throughout any survey. During the AUV survey, there was a total of 2117 hours and 50 minutes of AUV Payload Ops, 322 hours and 20 minutes of CTD activity, 417 hours and 42 minutes of Box and Piston Core activity, and 711 hours and 15 minutes of Side Scan Sonar (SSS), Multi-Beam Sonar (MBS), and Sub-Bottom Profiler (SBP) activity.

There were 749 total protected species detections recorded during all surveys, including 539 visual detections and 210 acoustic detections. Visual detections consisted of 11 detections of whales, 526 detections of dolphins and 2 detections of turtles. Acoustic detections consisted of 210 detections of dolphins

There were a total of 12 mitigation actions conducted throughout these surveys due to marine mammals detected within the exclusion zone prior to source operations. One mitigation action occurred during the Liza Geotechnical Survey resulting in a delay to start firing. 11 mitigation actions occurred during the Stabroek Seismic Surveys all resulting in a delay to start firing. One mitigation action occurred during the Hammerhead AUV Survey resulting in a delay to start firing. All mitigation actions were taken due to dolphins within the exclusion zone.

2 Introduction

2.1 General Program Information

2.1.1 Northwest / Southeast Stabroek Seismic Survey

The SE Stabroek Seismic Survey is being conducted onboard the *Ramform Tethys* by PGS on behalf of ExxonMobil. The survey is being conducted under permit 20161122-ESGET. The survey is located in the southeast portion of the Stabroek Block off the coast of Guyana. Originally both the *Ramform Tethys* and the *Ramform Atlas* were conducting a NW Stabroek survey in the northwest portion of the Stabroek Block, but the *Ramform Atlas* suspended operations in December 2018. The SE Stabroek project started 05 December 2018 and is currently ongoing through the end of 2019.

2.1.2 Canje Field Geotechnical Survey

The Canje Field Geotechnical Survey was conducted by Benthic Geotech on behalf of ExxonMobil. The survey area was located off the coast of Guyana within the Canje Block of the Guyana-Suriname Basin. The survey was conducted under permit 20161202-CSPEP issued by the Environmental Protection Agency of Guyana. The survey consisted of three phases. The first phase of operations utilized PROD3 for soil sampling to confirm mooring sites. The second phase acquired samples with a piston corer and box corer at various locations. The final phase consisted of obtaining water samples and other environmental data using a carousel water sampler and Conductivity, Temperature and Depth (CTD) instrument.

2.1.3 Liza Field Geotechnical Survey

The Liza Field Geotechnical Survey was conducted by Benthic Geotech on behalf of ExxonMobil. The survey area was located northeast of Georgetown, Guyana within the Liza Block (also known as Stabroek Block). The survey was conducted under permit 20161202-CSPEP issued by the Environmental Protection Agency of Guyana. The survey consisted of three phases. The first phase of operations utilized PROD3 for soil sampling to confirm mooring sites. The second phase acquired samples with a piston corer and box corer at various locations. The final phase consisted of obtaining water samples and other environmental data using a carousel water sampler and Conductivity, Temperature and Depth (CTD) instrument.

2.1.4 Payara Environmental Baseline, Geophysical / Autonomous Underwater Vehicle (AUV), and Geotechnical Survey

This survey was conducted onboard the *Fugro Supporter* by Fugro on behalf of ExxonMobil. The survey was located in the Payara Area of the Stabroek block, 200 kilometers off the coast of Guyana. The survey was conducted under permit 20161122-ESGET and 20161202-CSPEP. This survey was conducted in two phases. The first phase used drop cameras, CTD instrument, box cores, and piston cores for the geotechnical survey. The second phase used an AUV equipped with Side Scan Sonar (SSS), Multi Beam

Sonar (MBS) and Sub Bottom Profiler (SBP) to map the seabed and 10 meters below for future installations.

2.1.5 Hammerhead AUV Survey

The Hammerhead Area AUV was conducted onboard the *Fugro Brasilis* by Fugro on behalf of ExxonMobil under permits 20161202-CSPEP and 20161122-ESGET. The survey was located in the Stabroek Block offshore Guyana, north-east of Georgetown, Guyana. An AUV and CTD profiler were used for operations in the earlier part of the survey.

2.1.6 LongTail-1 *Stena Carron* Zero Offset Vertical Seismic Profile

The zero-offset vertical seismic profile (ZVSP) was performed on-board the drillship *Stena Carron* by Schlumberger on behalf of ExxonMobil. The well is approximately 108 nautical miles off the coast of Guyana at a depth of 1939 meters.

2.1.7 LongTail-1 *Bourbon Orca* Walk-Away Vertical Seismic Profile

The walk-away vertical seismic profile (WAVSP) was performed on-board the *Bourbon Orca* by the seismic contractor Schlumberger on behalf of ExxonMobil. The LongTail-1 well was located approximately 108 nautical miles off the coast of Georgetown, Guyana. The water depth in this area ranged between 1900 and 2000 meters.

2.1.8 Hammerhead *C-Installer* Walk-Away Vertical Seismic Profile

The walk-above vertical seismic profile (WAVSP) was performed aboard the *MV C-Installer* by the seismic contractor Schlumberger on behalf of ExxonMobil. The well was approximately 108 nautical miles off the coast of Guyana at a depth of 1150 meters.

2.1.9 Pluma-1 *Noble Tom Madden* Vertical Seismic Profile

The vertical seismic profile was performed onboard the *Noble Tom Madden* by Schlumberger on behalf of ExxonMobil. The survey was located in the Pluma-1 block approximately 105 nautical miles from Georgetown, Guyana. Water depths were approximately 1018 meters at the well site and ranged between 1310 and 3050 meters in the surrounding areas.

2.1.10 Pluma-1 *PSV Eland* Vertical Seismic Profile November 2018

The fixed offset vertical seismic profile was performed onboard the *PSV Eland* by Schlumberger on behalf of ExxonMobil. The survey site is located in the Pluma-1 ST1 block approximately 105 nautical miles from

Georgetown, Guyana. Water depths were approximately 1018 meters at the well site and ranged between 1310 to 3050 meters in the surrounding areas.

2.1.11 Pluma-1 *PSV Eland* Vertical Seismic Profile December 2018

The walkaway vertical seismic profile was performed onboard the *PSV Eland* by Schlumberger on behalf of ExxonMobil. The survey site is located in the Pluma-1 ST1 block approximately 105 nautical miles from Georgetown, Guyana. Water depths were approximately 1018 meters at the well site and ranged between 1310 to 3050 meters in the surrounding areas.

2.1.12 Stabroek *Stena Carron* Vertical Seismic Profile

The zero offset vertical seismic profile was completed onboard the *Stena Carron* drillship by the seismic contractor Schlumberger, on behalf of ExxonMobil. The survey site is in the Stabroek block approximately 105 nautical miles from Georgetown, Guyana. Water depths were approximately 1400 meters at the well site.

2.1.13 Stabroek *Noble Tom Madden* Vertical Seismic Profile

The zero offset vertical seismic profile was completed onboard the *Noble Tom Madden*. The survey was conducted by Schlumberger on behalf of ExxonMobil. The survey site was located in the Stabroek block approximately 105 nautical miles from Georgetown, Guyana. Water depths were approximately 1845 meters at the well site.

2.1.14 Stabroek *Noble Tom Madden* Vertical Seismic Profile

The zero offset vertical seismic profile was completed onboard the *Noble Tom Madden*. The survey was conducted by Schlumberger on behalf of ExxonMobil. The survey site was located in the Stabroek block approximately 105 nautical miles from Georgetown, Guyana. Water depths were approximately 1845 meters at the well site.

2.1.15 *Sea Service* Metocean Retrieval Survey

A PSO was put onboard the *M/V Sea Service* in the Liza prospect while retrieving current buoys and trawling gear.

2.1.16 SE Stabroek / Kaieteur Environmental Baseline Survey

This environmental baseline survey was conducted by TDI-Brooks on behalf of ExxonMobil in the Guyana Kaieteur and Stabroek blocks. This survey used box coring systems and CTD profiling equipment onboard the *Proteus.*

2.2 Vessel and Seismic Equipment Specifications

2.2.1 NW and SE Stabroek Seismic Survey

The PGS *Ramform Tethys* and PGS *Ramform Atlas* were the two source and acquisition vessels utilized to complete the NW Stabroek portion of this survey; however, the two vessels worked independently of one another in different sections of the prospect area. Support vessels used during the survey were the *Thor Magni*, the *Thor Omega,* the *Ocean Fortune,* and the *Delta Monarch.* The SE Stabroek Seismic Survey is being conducted with the PGS *Ramform Tethys* as the source vessel.

The PGS *Ramform Atlas* and *Ramform Tethys* are streamer vessels 104.2 meters in length and 70 meters in breadth. The *Ramform Atlas* vessel towed 14 streamers, each 10,050 meters in length with a 75-meter separation and a tow depth of 15 meters. It also towed six acoustic source strings, at a depth of six meters and a distance of 464.7 meters from stern to center of source. Three of the strings were grouped to form a port array and three strings formed the starboard array. The two outer strings in each array consisted of 11 individual source elements while the middle string in each array contained only nine; individual elements varied in volume from 45 to 250 cubic inches. The full power discharge was the simultaneous activation of the 31 elements in an array, producing a total volume of 4,130 cubic inches, a frequency response of 10-70 Hz, and an intensity of 142 bar meters. While in production, the source was activated in a flip-flop pattern, alternating shots between the port and starboard arrays. The shot point interval for survey lines was approximately seven to nine seconds depending on vessel speed, or 18.75 meters. The *Ramform Tethys* source consisted of six source strings firing in a flip flop configuration. The source was divided into two groups of three strings which would fire on after the other. In each group of three, the two outer strings were made up of 12 source elements, only 11 of which are active during acquisition with volumes varying from 45 cubic inches to 250 cubic inches. While the center string in the group of three was made up of 10 source elements (9 active and 1 spare) with volumes ranging from 60 cubic inches to 250 cubic inches. The source arrays were towed 475 meters astern of the vessel at a depth of 6 meters. The full volume of the seismic source is 4135 cubic inches with a frequency response of 80 – 240 Hz. During production, the shot point interval was 18.75 meters. However, before the source could enter full power, a soft start was required, which began with the smallest gun and gradually increase the number of guns over a minimum of 20 minutes and a maximum of 40 minutes. (Table 1).

2.2.2 Canje and Liza Geotechnical Survey

The *Chouest Sable* is 89 meters in length and 15.5 meters in width. The vessel was fitted with specialized equipment located on the lower deck and stern of the vessel. There was no support vessel.

For the survey operation which was conducted by Benthic Geotech, the Operations manager (OM) coordinated the use of equipment and processing of samples. Benthic Geotech installed and fitted a PROD3 on the vessel's starboard side. Labs and auxiliary equipment were housed on the middle section of the stern. Benthic' s PROD3 was built, operated and maintained on board by the Benthic crew while testing of samples was carried out by CI Innovation.

The PROD3 was selected for this survey based on the capability to operate in water depths of 3000 meters, with further seabed operation of depths to 130 meters. One deployment of PROD3 can produce multiple borings since PROD3 can hover in- between test sites. PROD3 is designed for safe and environmentally conscious operations. The PROD3 is controlled using remote computer controllers and there is a reduced number of drill holes which results in less seabed disturbances while collecting quality data.

The PROD3 is mechanical and produces whirring sounds. The acoustic sounds produced may not have the potential to negatively affect cetaceans or turtles but may instead attract the animals during operations. The potential dangers exist mainly in the form of close contact of mechanical parts with the animal.

The TDI-Brooks box coring systems consist of hardware assemblies designed to be rigged together into a working core rig and deployed to the seabed for extracting a standard cubic box core. Such a core is 50cm x50cmx100cm (1-m deep) or 50cm x 50cm x50cm (0.5-m deep) in size.

The box coring system is designed to be a safe, simple, effective mechanism for acquiring large-volume undisturbed shallow sediment samples from the seabed. Such samples are essential for the accurate determination of geotechnical characteristics of submerged sediments, as well as for the assessment of the benthic ecology (infauna) as required in marine environmental impact assessments.

The sample box of the core rig is fabricated from stainless steel and is clean and smooth to minimize frictional resistance between the box and the sediment. The corers have an adjustable weight capability so that the weight stack can be fine-tuned to suit the different seabed conditions that may be encountered.

Once the box corer is safely deployed, it is lowered to the seabed while performing the navigation protocols for lateral positioning, and then a core sample is acquired at the client-specified site. Upon retrieval on deck the box corer is secured with the safety pin in the closed position and placed on its stand. The lid is opened, and the contents inspected for quality and acceptability of the box core sample. The overlying water is siphoned off (gently as the water level approaches the surface of the mud so as to not disturb the surficial layers) to expose the sediment for sub-sampling, descriptions, and photography. The box corer is typically tilted slightly to one corner to facilitate pooling of the last amounts of water. The box coring system does not produce any acoustic sounds.

The TDI-Brooks 3-inch-diameter piston coring (PC) system consists of various hardware assemblies designed to be safely and robustly fastened together into a working core rig and deployed to the seabed for extracting a piston core. Such a core rig can be assembled to be 10 to 40 feet long and is 3 inches in barrel ID. The main winch, main-line coring rope, and the PC coring A-Frame are used for deploying and retrieving the 3-in. piston core rig. In addition to the deployed hardware, several assemblies are mounted to the vessel working deck to manage the deployment and retrieval of the coring rig. These assemblies include the main sheave from a starboard or port-side coring A-Frame. However, it was deployed on the *Chouest Sable* from the stern of the vessel. There are also core-head and trigger winches with their hydraulic power pack to aid with deployment.

A piston corer uses a free fall of the coring rig to achieve the desired initial force on impact, and a sliding piston inside the core barrel to reduce inside wall friction with the sediment and to assist in the rapid evacuation of displaced water from the top of the corer. These elements act in concert to maximize core recovery. It uses a trigger assembly to release and allow the corer to free-fall with the core barrel tip starting just above the seabed. The piston corer does not produce any acoustic sounds.

The carousel water sampler has no moving-shaft seals, each bottle has its own magnetically activated lanyard release latch. These mechanisms aid in easy release especially in water of low temperatures. It has been extensively deployed throughout the world's oceans for oceanographic water sampling. Carousels require a custom design that is suited for the intended bottle size. The carousel used for the survey was built to meet specific application requirements. It is also designed to be connected to the CTD oceanography instrument.

2.2.3 Payara Geotechnical, Geophysical / AUV and Environmental Baseline

The *Fugro Supporter* is a 74.5-meter-long and 12 meter wide vessel used for this survey.

For Phase 1 of the project, a geotechnical survey was conducted utilizing the same box coring system and piston coring system as the Canje and Liza Survey. Phase 2 was the AUV baseline survey. The AUV, operating at 1800 – 2300m water depth used multibeam sonar (200kHz), side scan sonar (200kHz and 400kHz), and a sub-bottom profiler (1 – 10kHz). These acoustic instruments were not initiated until at the seabed.

2.2.4 Hammerhead AUV Survey

The *Fugro Brasilis* was utilized to complete this survey. An Automated Underwater Vehicle (AUV) and CTD profiler was used for operations conducted by the Fugro Geotechnical survey team onboard. The survey consisted of launching and recovering the CTD profiler to determine the speed of sound from the surface to the seafloor. The AUV, which was submerged underwater for periods lasting no longer than 48 hours to run survey lines several meters above the seabed. The AUV was configured during a pre-dive setup while on board the vessel. The pre-dive took ~45 minutes prior to each dive, which lasted ~48 hours. The vehicle was stored in a container located at the back deck of the vessel and deployed astern of the centre of the vessel, using an automated ramp mechanism. The AUV would then be communicated with via a Tow Fish, which was deployed and towed astern, to the starboard side of the vessel at a depth of 30 metres. Once survey periods were complete, the AUV would be communicated with to begin an ascent to the surface. The Tow Fish would be taken out of the water when the AUV has 250 metres of water left until it arrived on surface. Radio communication was used to send necessary commands to the vehicle and a grappling gun was used to capture and retrieve the vehicle from the water and back onto the vessel. Project parameters are found in Table 2.

2.2.5 Vertical Seismic Profiles

The vertical seismic profiles were all conducted from with the acoustic source deployed at a depth of approximately five meters. The acoustic source consisted of six airgun elements, resulting in a total source volume of 1200 in^3 (Table 3).

Table 1. Seismic Acquisition Parameters Summary Table

General Specifications		
Client / Contractor:	ExxonMobil / PGS	
Program/Project Name:	Stabroek 3D / 4D Guyana	
Program Period:	08 December 2018 to ongoing	
Type of Survey:	3D Seismic	
General Location:	Stabroek Block, Offshore Guyana	
Prospect Size (km²):	11200	
Vessel / Vessel Length (m):	*Ramform Tethys* / 104.2 *Ramform Atlas* / 104.2 (only used for NW Stabroek Seismic Survey)	
Support/Chase Vessels:	*Thor Omega, Thor Magni, Ocean Fortune, Delta Monarch*	
Vessel Configuration description:	Dual source, Dual receivers	
Energy Source (Airgun) Specifications		
	PGS *Ramform Tethys*	*PGS Ramform Atlas*
Total source volume (in^3)	4135	4130
Number of source arrays:	6	2 (activated in alternating “flip-flop” sequence)
Total number of source elements per array / In full volume source	12 elements outer arrays (11 active, 1 spare) 10 elements inner arrays (9 active, 1 spare) / 34 elements	11 elements x 2 sub-arrays per array, 9 elements x 1 sub-array per array = 31 active elements at full volume per shot
Source depth:	6 meters	6 meters
Source distance astern (meters):	475 meters	464.7 meters to COS (506m antenna / NRP to COS, 41.3m antenna / NRP to stern)
Source frequency (Hz):	80	10 – 70
Source intensity (dB re 1µPa or bar meters)	212.5	142
Shot point interval (meters and seconds)	18.75 m	18.75 meters / 7 – 9 seconds (depending on vessel speed)
Recording System Specifications:		
Number of streamers or nodes/cables:	14	14
Streamer depth (meters):	15 and 13 (Streamers 1 and 14)	15
Streamer length /separation (meters)	10050 meters in length and 75 meters separation	10,050 meters in length and 75 meters separation
Streamer description:	Geostreamer	Geostreamer

Table 2. AUV Acquisition Parameters Summary Table

General Specifications			
Client / Contractor:	Fugro		
Program/Project Name:	Hammerhead AUV Survey		
Program Period:	16 March 2019 to 17 April 2019		
General Location:	Stabroek Block of Guyana		
Prospect Size (km^2):	26800		
Vessel / Vessel Length (m):	Fugro Brasilis / 65.65 meters		
Energy Source AUV Specifications			
Vehicle Altitude:	42 meters		
Ping rate:	3.0 Hz (All systems)		
Sub-bottom Profiler (SBP):	Kongberg 300-6 SBP	Frequency: 1-10 kHz	Pulse rate of 20m/sec, Record length of 200m/sec
Side Scan Sonar (SSS):	Edgetech 2200M	Frequency: 120 kHz (Low), 410 kHz (High)	Range of 200m
Multibeam Echo Sounder (MBES)	Kongsberg EM302	Frequency: 200 kHz	Range of 250m
Energy Source Hull mount Specifications			
Multibeam Echo Sounder (MBES)	Kongsberg EM2040	Frequency: 30 kHz	
Sub-bottom Profiler (SBP):	Edgetech 7X	Frequency: 1-6 kHz	
Single Beam Echo Sounder	Kongsberg EA600	Frequency: 200kHz, 38kHz	

Table 3. VSP Surveys Acquisition Parameter Summary Table

General Specifications	
Client / Contractor:	Schlumberger
Type of Survey:	VSP
General Location:	Guyana
Energy Source (Airgun) Specifications	
Total source volume (in^3)	1200
Number of source arrays:	1
Total number of source elements per array / In full volume source	6
Source depth:	5 meters

2.3 Passive Acoustic Monitoring (PAM) Parameters

A Passive Acoustic Monitoring (PAM) system, designed to detect most species of marine mammals found in the waters off Guyana, was installed on board each seismic source vessel during the 3D programs (NW and SE Stabroek). The system was provided by Seiche Measurements and consisted of a conventionally towed hydrophone array cable, deck cable, data processing unit, headphones for aural monitoring, and a

rack mounted computer with an acoustic analysis software package. In addition to the main array setup, a full spare system was available on each source vessel to serve as a back-up in case of equipment failure.

Each hydrophone array consisted of two broadband hydrophone elements (200Hz to 200kHz) and two standard hydrophone elements (2kHz to 200kHz) and a depth gauge (100m capacity) potted directly into the 14-millimeter cable.

At the data processing unit, a buffer box circuitry splits each hydrophone input into low frequency and high frequency band outputs. Four hydrophone channels are input to an *ASIO* sound card to be digitized at 48 kilohertz (two channels). This was the primary audio input for lower frequency detections in *Pamguard*. The *RME Fireface800* software allowed the PAM Operator to control which hydrophone signals were monitored over headphones. The headphone mix could consist of the raw hydrophone signals or the processed playback signal from the data processing unit. The high frequency output of the buffer box was digitized at the buffer box by the National Instruments data acquisition card at 333 kilohertz (two channels). The custom rack mount data processing unit contained Intel core i5 processors with clock speeds of 3.40 gigahertz and eight gigabytes of RAM. Two wide screen computer monitors were provided to divide the monitoring into low frequency and high frequency displays. Figure 1 outlines the system data flow for the PAM system. An entire second electronic processing system and rack mounted data processing unit were configured for use as spares.

Pamguard was the primary software utilized. *Pamguard* is an open-source software program that is widely considered the world standard for acoustic detection, localization, and classification for mitigation regarding marine mammals and for research into their abundance, distribution, and behavior (www.*Pamguard*.org).

One monitor was configured for monitoring high frequency clicks, and the second monitor was configured for monitoring low frequency moans, creaks, whistles, clicks, and burst pulses. The high frequency monitor received the raw audio from the *National Instruments DAQ* sound card and contained *Pamguard* modules for monitoring and recording high frequency cetacean clicks, spectrogram, and a sound recorder. The low frequency monitor received raw audio from the *ASIO Fireface* sound card and contained a more elaborate configuration of *Pamguard* modules than the high frequency monitor. This included a click detector, whistle and moan detector, spectrogram, depth gauge display and tracker, map with a GPS feed from the vessel, and a sound recorder.

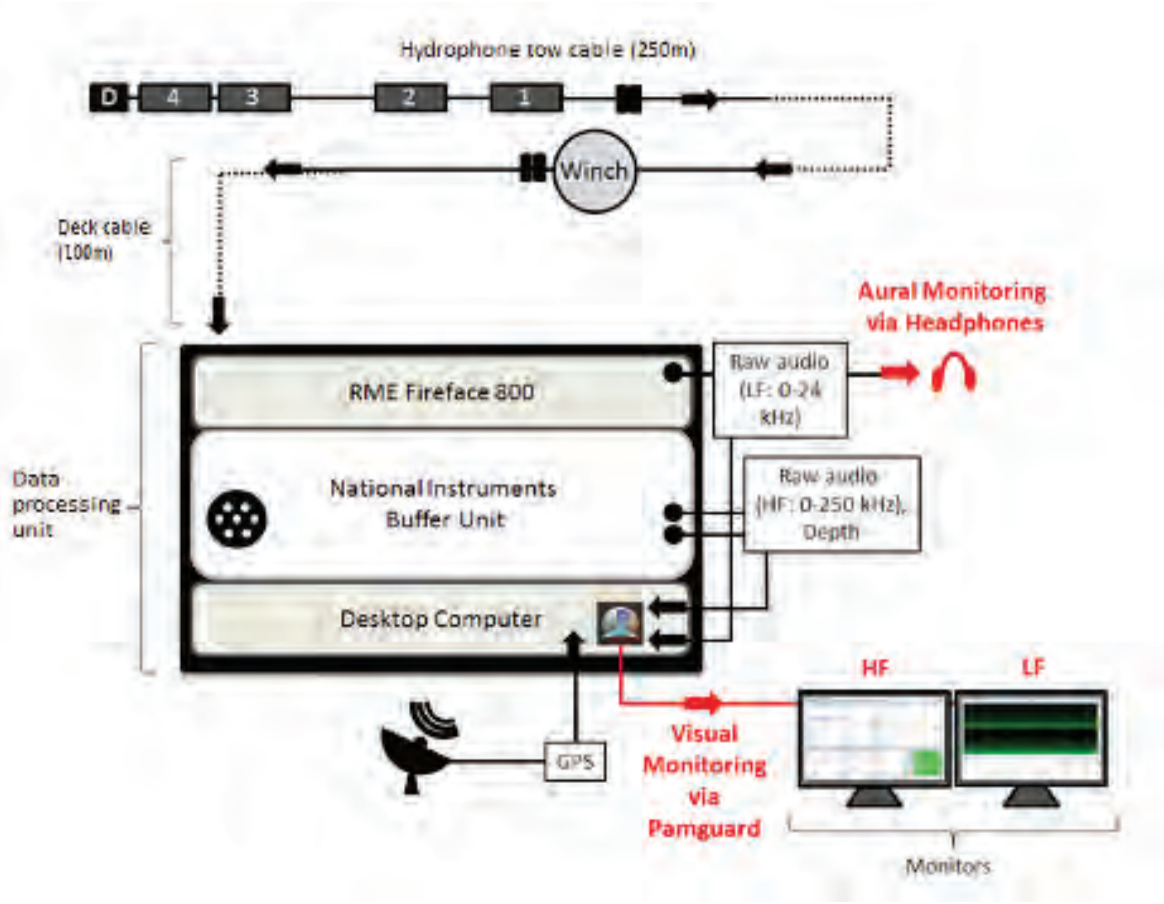


Figure 1. Data pathway through PAM system

3 Methodology

3.1 Visual Survey Methodology

Visual monitoring for protected species was conducted by two PSOs provided by RPS, each of whom have completed a PSO training program. One observer was on watch at a time and monitored the exclusion zone and surrounding areas during all daytime operations when the acoustic source was in the water, regardless of source activity.

Observers scanned the sea surface with the naked eye and the aid of various binoculars. Shifts lasted no more than four hours followed by a break of no less than two hours. Monitoring occurred daily beginning at dawn (defined as approximately 15 minutes before sunrise) and continued throughout the day until the exclusion zone could no longer be effectively observed due to darkness (approximately 15 minutes after sunset).

PSOs collected data at approximately 20-minute intervals while on watch and recorded in observation logs. Daily observation logs included information about environmental conditions, vessel and survey operations, marine debris observed, any vessel/gear and wildlife interactions, and any wildlife sightings.

Identification of marine mammals and sea turtles and wildlife was made or confirmed using identification guides:

- *Guide to Marine Mammals and Turtles of the U.S. Atlantic & Gulow frequency of Mexico* (Wynne, K. and Schwartz, M. 1999)
- *Guide to Marine Mammals of the World* (Reeves et al. 2002).
- *Sea Birds of the World (Harrison, Peter, Princeton University press, Princeton, New Jersey, 2003)*

Distances to protected species were determined visually by comparing an animal or an object's position relative to other vessels and/or installations at known distances, and/or by use of reticle binoculars. Prior to the initiation of the source for ramp-ups or tests during daylight hours, dedicated watches of no less than 30 minutes in waters less than 200 meters and 60 minutes in waters greater than 200 meters were conducted to monitor for protected species within the exclusion zone. Communication between visual observers, PAM Operators and seismic operators was carried out using handheld very high-frequency (VHF) radios.

3.2 Acoustic Monitoring Methodology

One PAM Operator was present on board each seismic source vessel to conduct acoustic monitoring prior to all ramp ups conducted during periods of reduced visibility and/or darkness. In addition, acoustic monitoring was conducted opportunistically during source operations as much as possible, allowing breaks for the PAM Operator to maintain concentration.

Acoustic monitoring was conducted nightly, beginning approximately 15 to 20 minutes prior to dusk, and continuing until daylight, so long as the PAM hydrophone cable was deployed. Acoustic monitoring overlapped visual monitoring efforts by 15 to 20 minutes at dawn and dusk.

During an acoustic monitoring period, the PAM Operator aurally monitored audio feed using Sennheiser headphones from up to all four hydrophone elements which was first mixed using a RME *Fireface800* unit. Visualizations of the audio feed were also monitored via the *Pamguard* software on two computer

monitors: one configured to display low frequency modules and the other configured to display the high frequency modules.

Audible clicks, burst pulses, moans, and creaks at frequencies less than 24 kilohertz, including sperm whale clicks and delphinid whistles and clicks, can be detected on the low frequency spectrogram display, the low frequency click detector display, and the low frequency whistle/moan detector display within *Pamguard*.

Vocalizations at frequencies greater than 24 kilohertz including pulse emissions from beaked whales, Kogia whales, and various delphinid species are detected on high frequency click detector displays. The click detector is configured to sample audio at 333 kilohertz for vocalizations with frequency spectra up to approximately 166.5 kilohertz.

During an acoustic monitoring period, the Operators were specifically looking for a combination of factors that may indicate biological pulse emissions. The Operators monitored for click trains on the high frequency bearing/time display; specifically, click trains that showed a progressive change in bearing (Figure 2). When click trains were present, individual clicks were highlighted by the Operator, and the click spectrum module referenced to determine if the clicks had broadband frequencies and consistent peak intensities near a frequency of 30 kilohertz or higher. The click waveform display module provided additional indication of an acoustic detection; biological pulse emissions are generally associated with clean, extremely brief waveforms (Figure 3). Operators also referenced the high frequency amplitude/time display module during monitoring periods; the intensity of pulse emissions generally register at higher intensities than a majority of the ambient noise with click amplitudes for delphinid clicks registering between 155 and 190 decibels relative to 1 micro Pascal (Figure 4). Additionally, consistent click intervals are indicators of pulse emissions; intervals are designated by the unit clicks per second. High frequency dolphin click trains vary widely in click intervals with most click trains displaying an interval of 5 to 40 clicks per second. Click trains within this range are labelled as *echolocation* click trains. Additionally, pulse emissions with much higher click intervals of more than 200 clicks per second are labelled as *burst pulses*. Recorded sound files of vocalizing marine mammals were analyzed using *Spectrogram 16*, visualization software that allows the operators to slow down and aurally/visually audit for ultrasonic pulse emissions recorded during a high frequency acoustic detection.

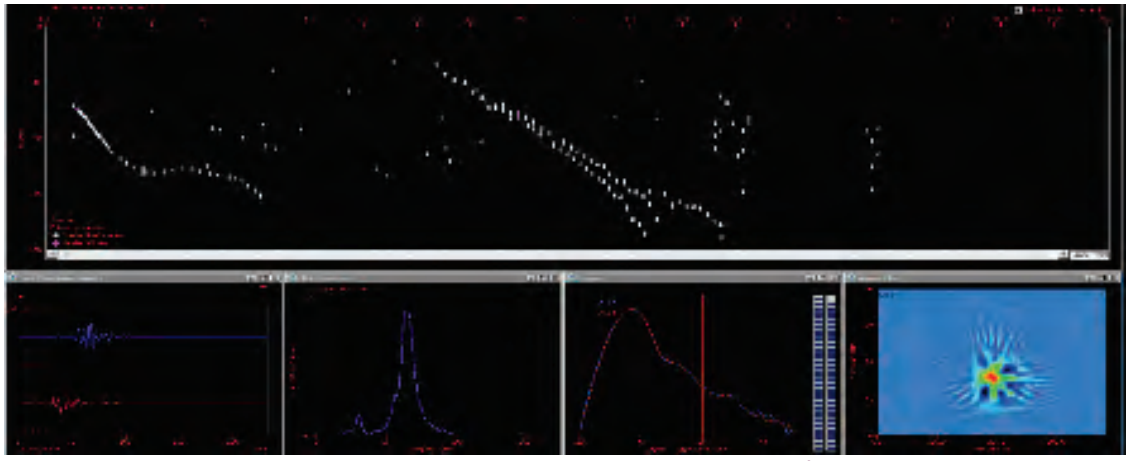


Figure 2: High frequency delphinid click trains on the bearing/time display

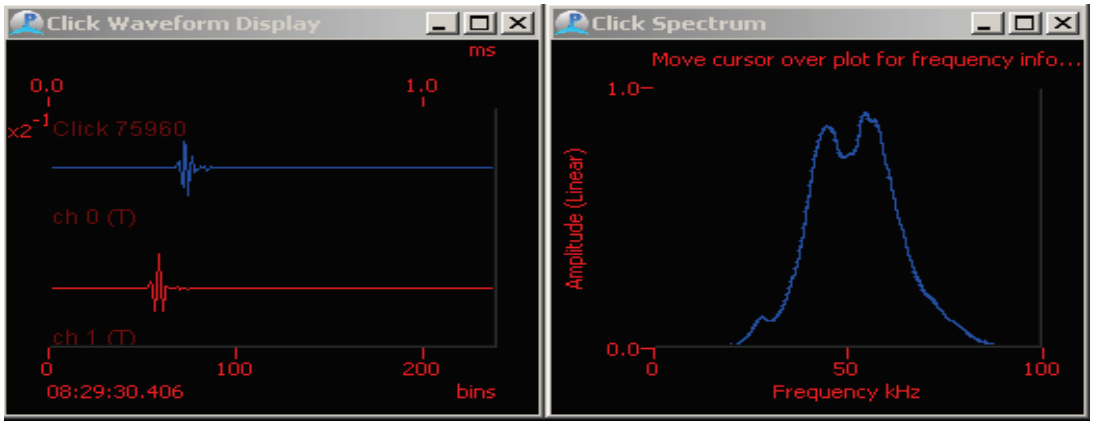


Figure 3: Clean click waveform display and click spectrum of delphinid pulse emissions

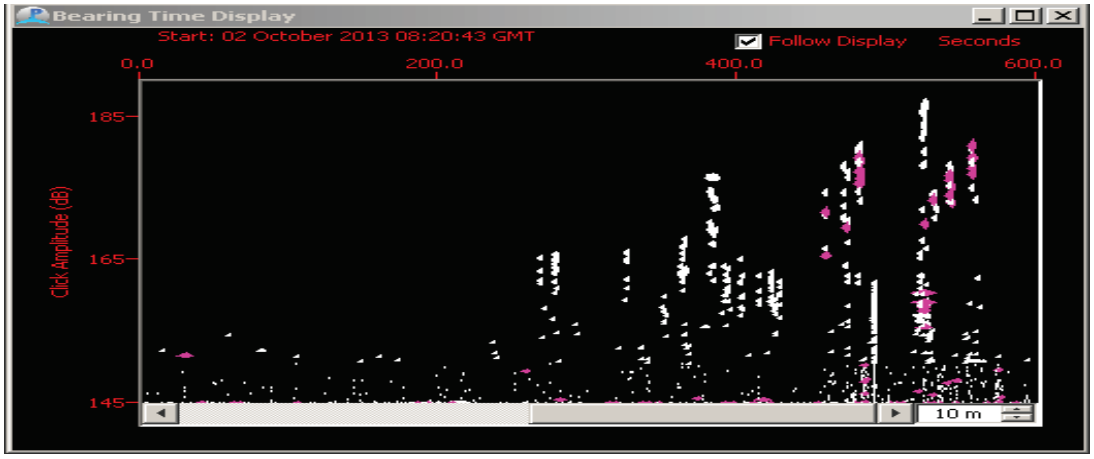


Figure 4: The amplitude/time module during a high frequency delphinid detection

Pamguard contains a function for calculating the range to vocalizing marine mammals based upon the least squares fit test. This method is most effective with animals that are relatively stationary in comparison to the moving vessel, such as sperm whales. The mathematical function estimates the range to vocalizing marine mammals by calculating the most likely crossing of a series of bearing lines generated from tracked clicks or whistles and plotted on a map display. Since the hydrophones are linear, and in close proximity to each other, there is a left-right ambiguity to these localizations, meaning that there is a 1:2 probability that recorded vocalizations are originating from the equal but opposite bearing to that indicated in *Pamguard's* bearing/time display. Thus, a bearing of zero degrees refers to a location directly ahead of the hydrophone array while a bearing of 180 degrees is directly astern of the hydrophone array. A 90-degree bearing could be located at either 90 or 270 degrees in relation to the array. All bearings for acoustic detections indicated in this report are relative to the hydrophone, and this left/right ambiguity should be understood.

Since ultrasonic sounds have a high attenuation rate in water, the distance of a mammal detected vocalizing at frequencies greater than 24 kilohertz is generally estimated to be well within the 500-meter exclusion zone. When the distance to a vocalizing animal could not be determined by *Pamguard*, the experienced PAM Operator made a distance estimation assisted by the noise or detection score system developed by Gannier et al. (2002). Gannier et al. monitored sperm whales in the Mediterranean both visually and acoustically. A scale was developed based upon the strength or intensity of the sperm whale

clicks at various distances that were then measured when the sperm whales surfaced and were visually observed. Although the scale is subjective, and sounds produced in marine environments will vary according to local conditions, the scale provides a measure for approximating distances when using a single, linear hydrophone array.

Sound recordings were made using a recorder whenever potential marine mammal vocalizations were detected by the PAM Operator.

PAM Operators communicated with seismic personnel via handheld VHF radios or by word of mouth while in the instrument room.

3.3 Detections Data Analysis Methodology

Raw visual and acoustic detection data from the seismic survey (NW and SE Stabroek), the three field geotechnical surveys, the two environmental baseline surveys, the Hammerhead AUV survey, and all 9 VSPs were compiled and analyzed for the following:

- Average closest approach by species and species group to active and silent source
- Mitigation action summary by species and species group
- Percent of detections by species and species group resulting in a mitigation action
- Detection rate (detections per hour of effort) by monitoring method

Statistical analysis was not completed during the analysis due to the low sample size available. Source activity for all analysis was grouped as “source active” or “source silent”, where “source active” included full volume, soft start, and all other reduced volume including the mitigation source. This was done due to the small sample size of data, making further categorization impractical.

Closest approach by species and species group to active and silent source

All visual and acoustic detections during surveys which utilized an acoustic source—surface seismic, AUV, and VSPs—were compiled and grouped based on species and source activity. The number of detections that fell into each category were counted and the average closest approach to the source were calculated for each group using Excel. Detections were then combined into species groups (whales, dolphins, and turtles) and the same analysis was run for the groups.

Mitigation actions

All visual and acoustic detections were compiled and grouped based on species and mitigation actions implemented. The number of detections that fell into each category were compiled and percentages of detections for each species resulting in a mitigation action were calculated using Excel. Detections were then combined into species groups (whales, dolphins, and turtles) and the same analysis was run for the groups.

Detection rate

The total numbers of visual and acoustic detections were tallied, along with the total visual and acoustic monitoring effort for all surveys. Monitoring effort was converted into decimal numbers for analysis and the total number of detections were divided by the total monitoring effort to determine the detection rates for visual, acoustic, and total detections. VSP data was excluded from this analysis due to the static nature of the surveys in comparison to the seismic and AUV surveys, with only a small area covered in VSP surveys, leading to potential bias in detection rate.

4 Survey Data

4.1 Source Operations Summary

Over the course of all of the survey programs, except the geotechnical surveys where there was no source, the seismic source was active for a total of 1420 hours and 14 minutes including: 100 hours and 35 minutes spent in ramp up, 56 hours and 48 minutes spent conducting source testing, 1190 hours and 20 minutes in production, and 72 hours and 31 minutes spent at full volume or partial volume not in production, including time prior to the start of lines and during line changes. During the AUV survey, there was a total of 2117 hours and 55 minutes of AUV Payload Operations, 322 hours and 20 minutes of CTD operations, 417 hours and 42 minutes of box and piston core operations, and 711 hours and 15 minutes of SSS, MBS, SBP operations (Figure 5, Figure 6, and Figure 7).

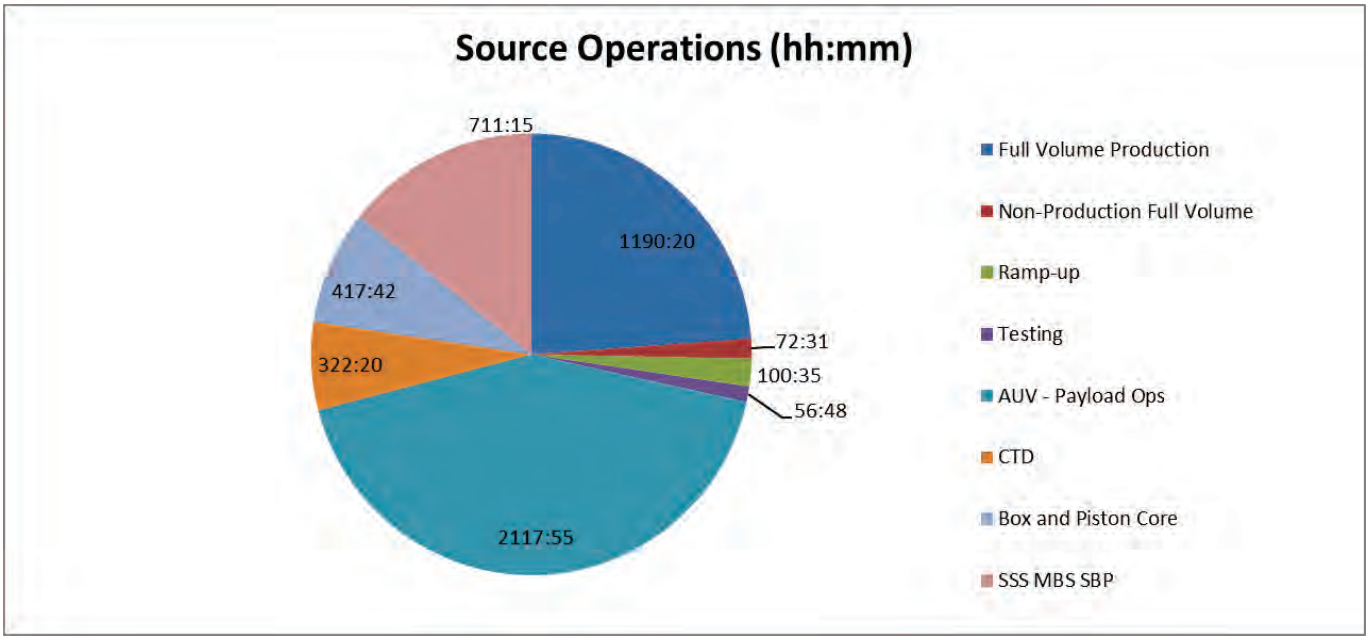


Figure 5: Breakdown of acoustic source operations

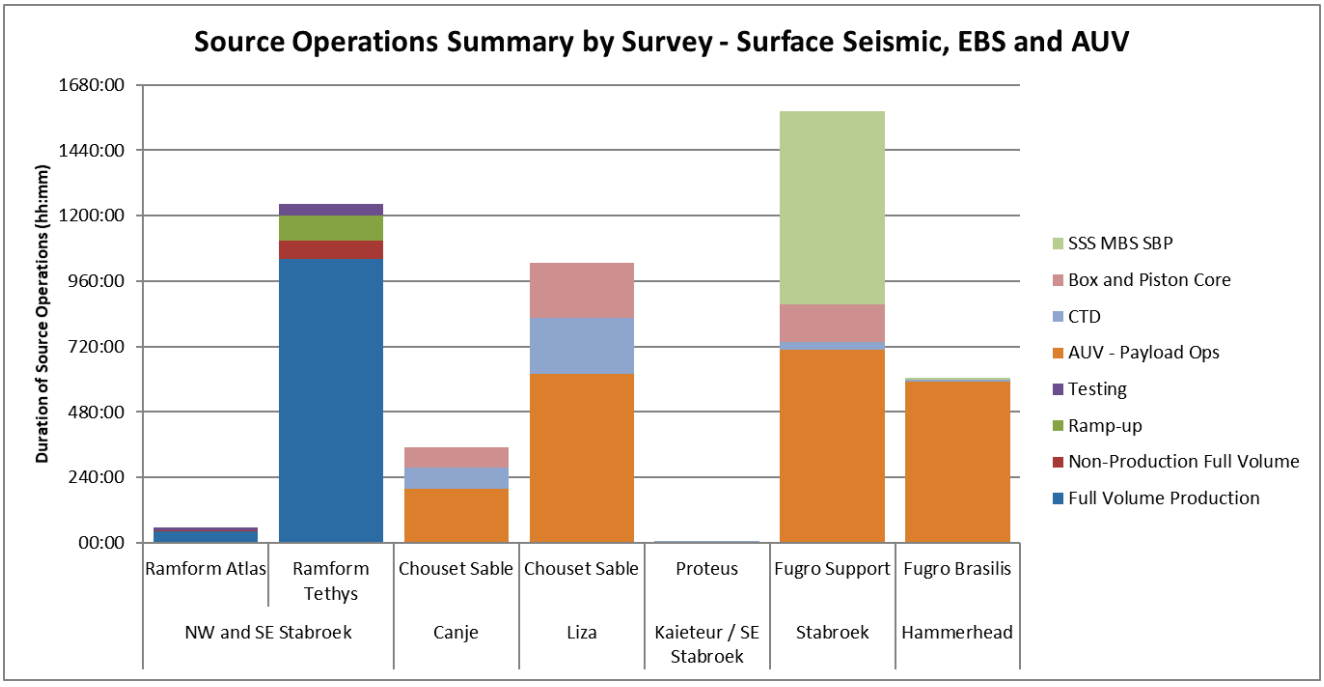


Figure 6: Breakdown of source operations by source activity and survey for surface seismic, EBS and AUV projects

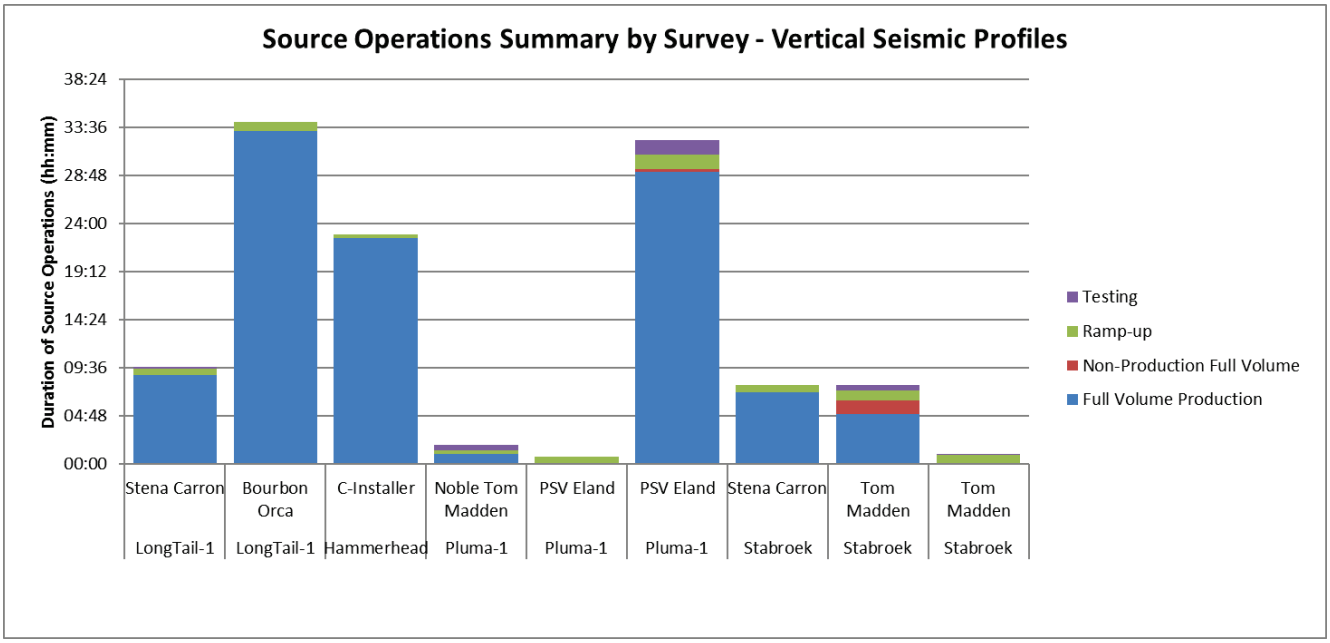


Figure 7. Breakdown of source operations by source activity and survey for vertical seismic profiles

4.2 Visual Monitoring Summary

PSOs conducted visual observations throughout these surveys for a total of 3092 hours and 19 minutes. Visual observations while the source was active accounted for 1615 hours and 53 minutes, observations during periods of source inactivity accounted for 1476 hours and 26 minutes, and observations during the AUV survey accounted for 795 hours and 02 minutes (Figure 8).

The duration of monitoring during source silence and activity on VSP surveys is summarized in Figure 9. The duration of visual monitoring on each of the Environmental Baseline surveys is summarized in Figure 10.

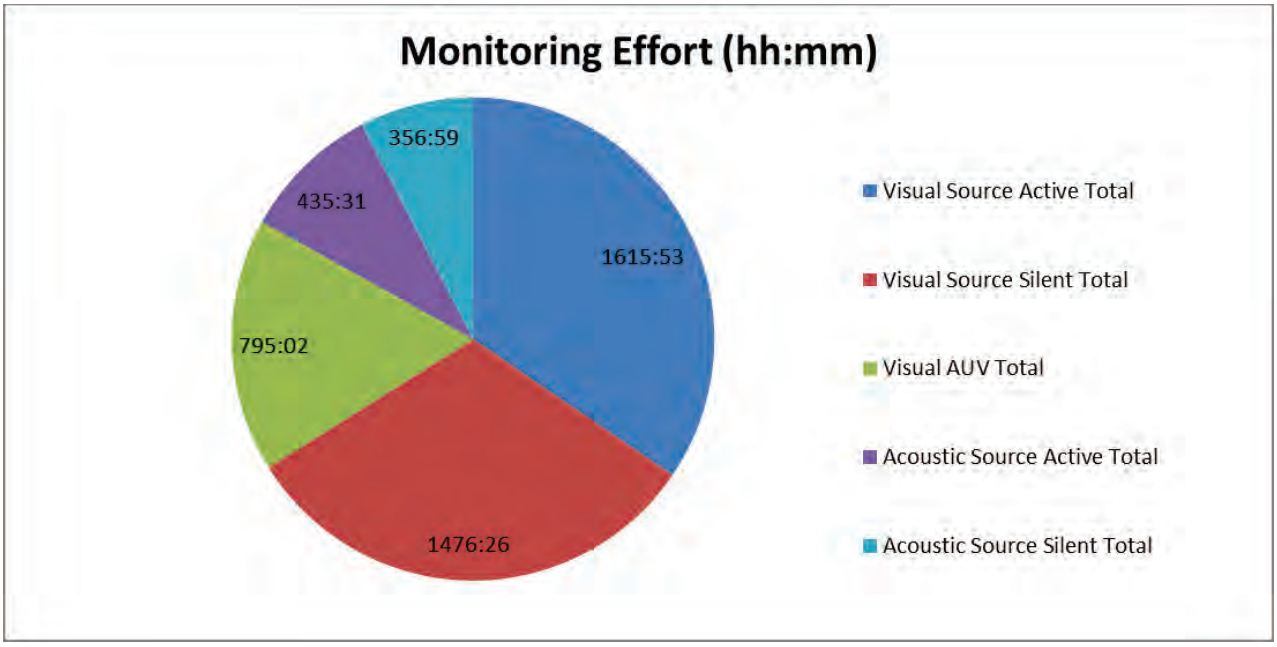


Figure 8. Monitoring effort summary for all projects

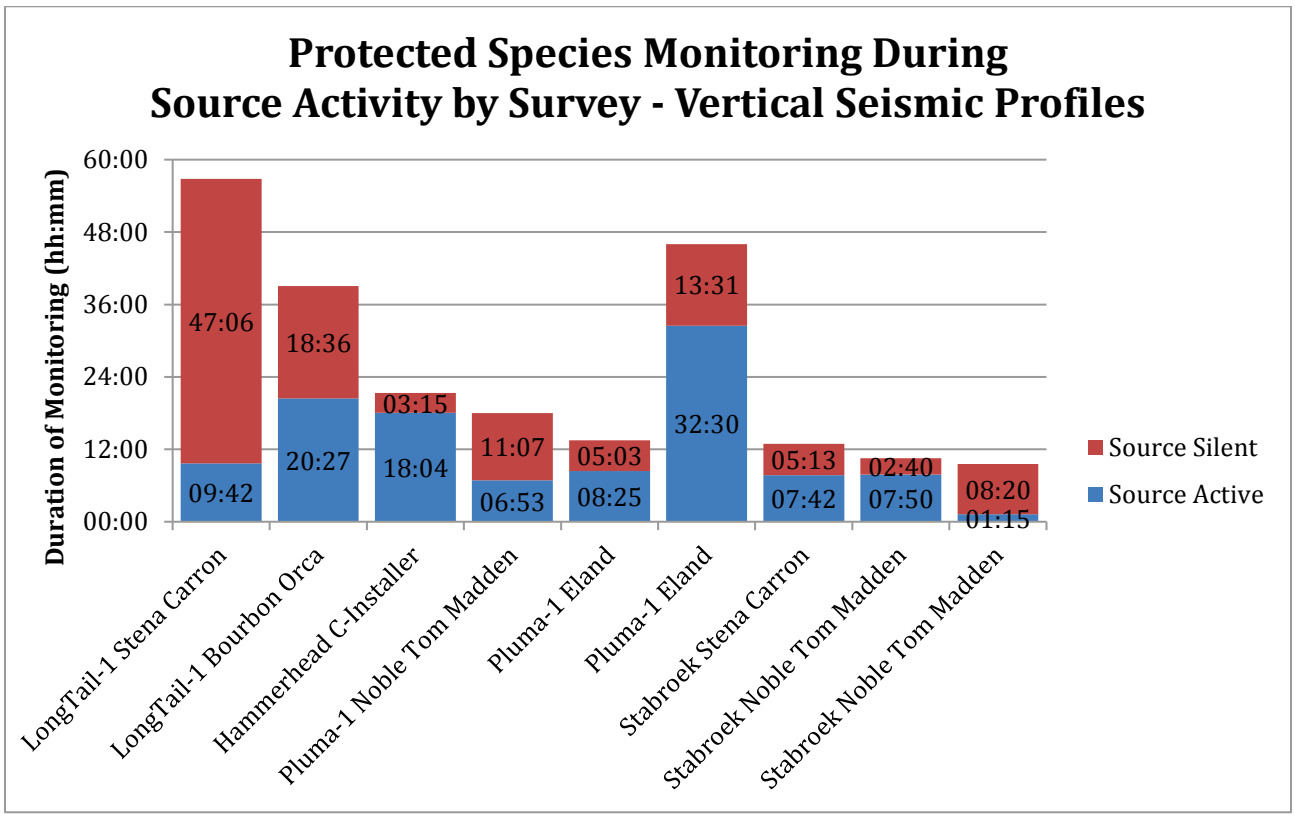


Figure 9. Breakdown of visual and acoustic monitoring while source active and silent by survey for vertical seismic profiles

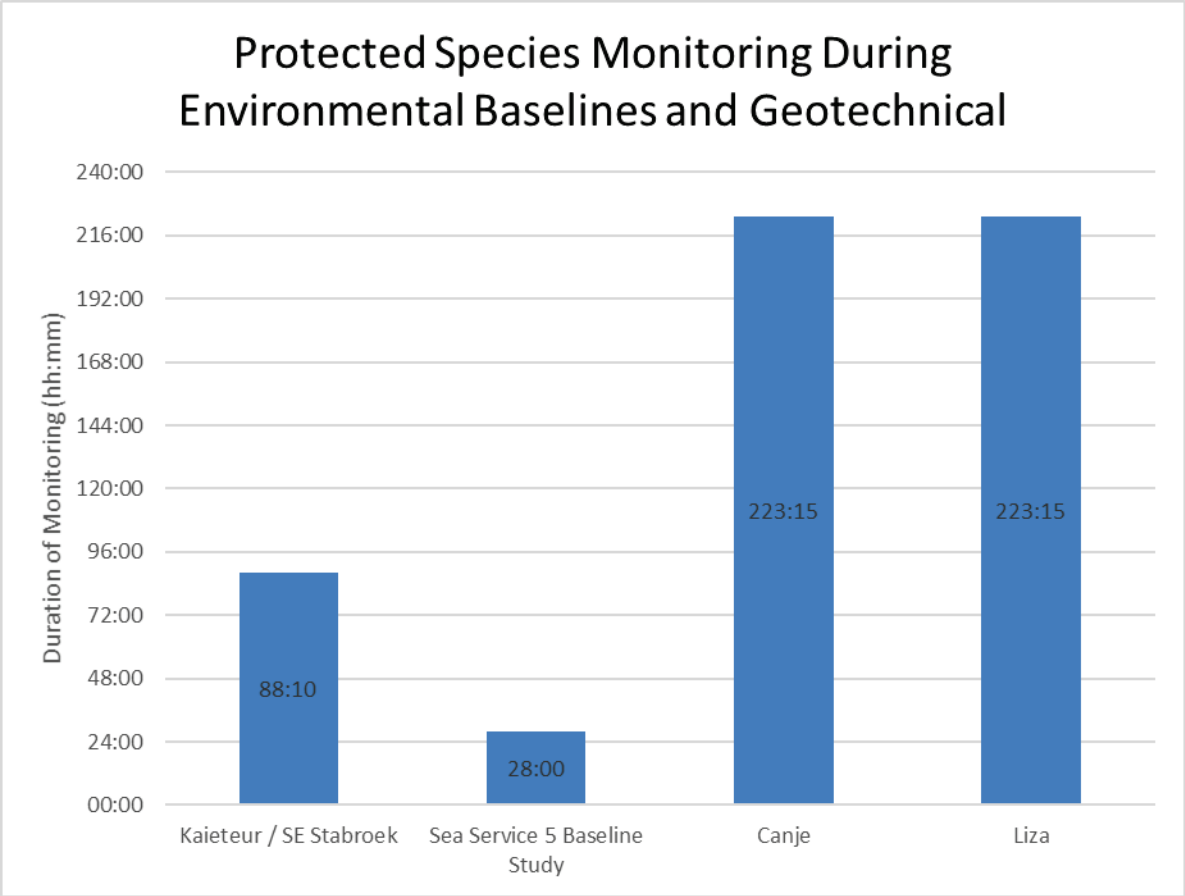


Figure 10. Protected species monitoring summary during Environmental Baselines and Geotechnical Surveys

4.3 Acoustic Monitoring Summary

Passive acoustic monitoring (PAM) was conducted for a total of 792 hours and 30 minutes throughout the NW and SE Stabroek 3D, which included 435 hours and 31 minutes of acoustic observations while the source was active and 356 hours and 59 minutes while the source was inactive (Figure 11).

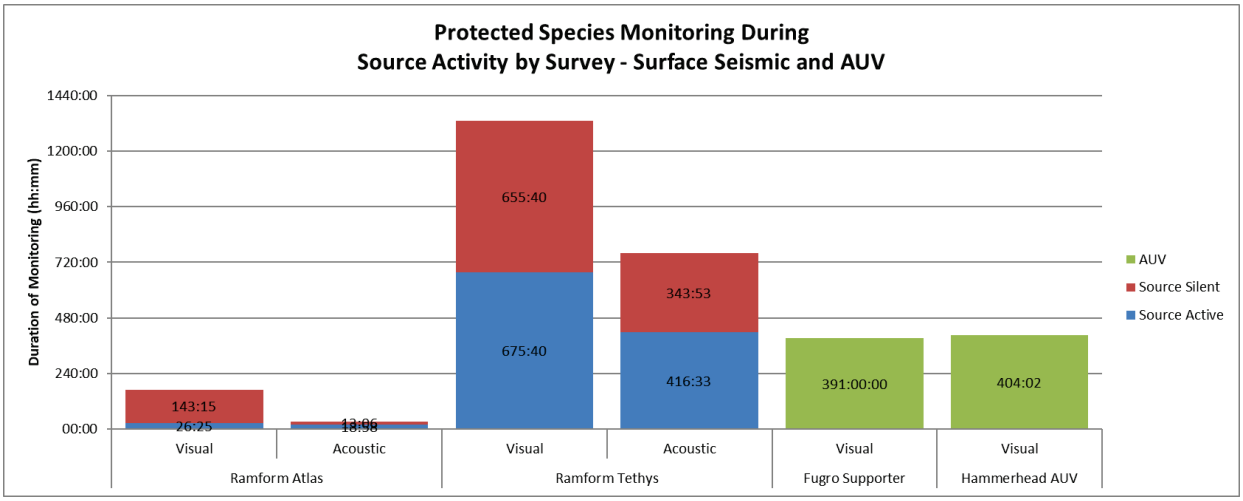


Figure 11: Breakdown of visual and acoustic monitoring while source active and silent by survey for surface seismic and AUV

4.4 Mitigation Actions

The *Joint Nature Conservation Committee (JNCC) guidelines for minimising the risk of injury and disturbance to marine mammals from seismic surveys* were implemented during each of the survey programs summarized in this report. As such, delays to initiation of the sound source, airguns or otherwise, were implemented if marine mammals or sea turtles were detected inside the 500-meter exclusion zone around the center of the sound source in the search period conducted prior to initiating the source from silence.

There was a total of 12 mitigation actions conducted throughout these surveys due to marine mammals detected within the exclusion zone prior to source operations, with 11.65% of all detections during surveys with source activity resulting in mitigation actions. 10 mitigation actions occurred during the NW and SE Stabroek survey and were delays to initiation of the source, all were undertaken for dolphin detections. One mitigation action occurred during the Liza Geotechnical survey and was a delay to the initiation of the source for a dolphin detection. One mitigation action occurred during the Hammerhead survey and was a delay to initiation of the source for dolphin detections.

4.5 Wildlife Summary

4.5.1 Protected Species Detections Summary

There were 749 total protected species detections recorded during all surveys, including 539 visual detections and 210 acoustic detections (Table 4). The majority of detections were of dolphins (98.3% of

all detections, 92.9% of visual detections and 100% of acoustic detections), with acoustic detections of unidentifiable dolphins accounting for all detections (58.2%).

Table 4. Summary of visual and acoustic detections

Species	Number of Visual Detections	Number of Acoustic Detections	Total Number of Detections
Bryde's Whale	4	0	4
Unidentified Baleen Whale	0	0	0
Unidentified Whale	1	0	1
Unidentified Beaked Whale	0	0	0
Sperm Whale	1	0	1
Unidentified Cetacean	5	0	5
All Whales	**11**	**0**	**11**
Atlantic Spotted Dolphin	10	0	10
Clymene Dolphin	100	0	100
Common Bottlenose Dolphins	34	0	34
Common Dolphin	31	0	31
Fraser's Dolphin	0	0	0
Long-Beaked Common Dolphin	21	0	21
Melon-headed Whales	30	0	30
Pantropical Spotted Dolphins	106	0	106
Pygmy Killer Whale	10	0	10
Risso's Dolphin	8	0	8
Rough-toothed Dolphins	5	0	5
Short-finned Pilot Whales	34	0	34
Spinner Dolphin	123	0	123
Unidentifiable dolphin	14	210	224
All Dolphins	**526**	**210**	**736**
Green Sea Turtle	0	0	0
Hawksbill Sea Turtle	0	0	0
Loggerhead Sea Turtle	2	0	0
Olive Ridley Sea Turtle	0	0	0
Unidentified Shelled Sea Turtle	0	0	0
All Turtles	**2**	**0**	**2**
TOTAL	**539**	**210**	**749**

The visual detections included whales, dolphins and sea turtles while acoustic detections consisted of dolphins (Table 4, Figure 12, Figure 13).

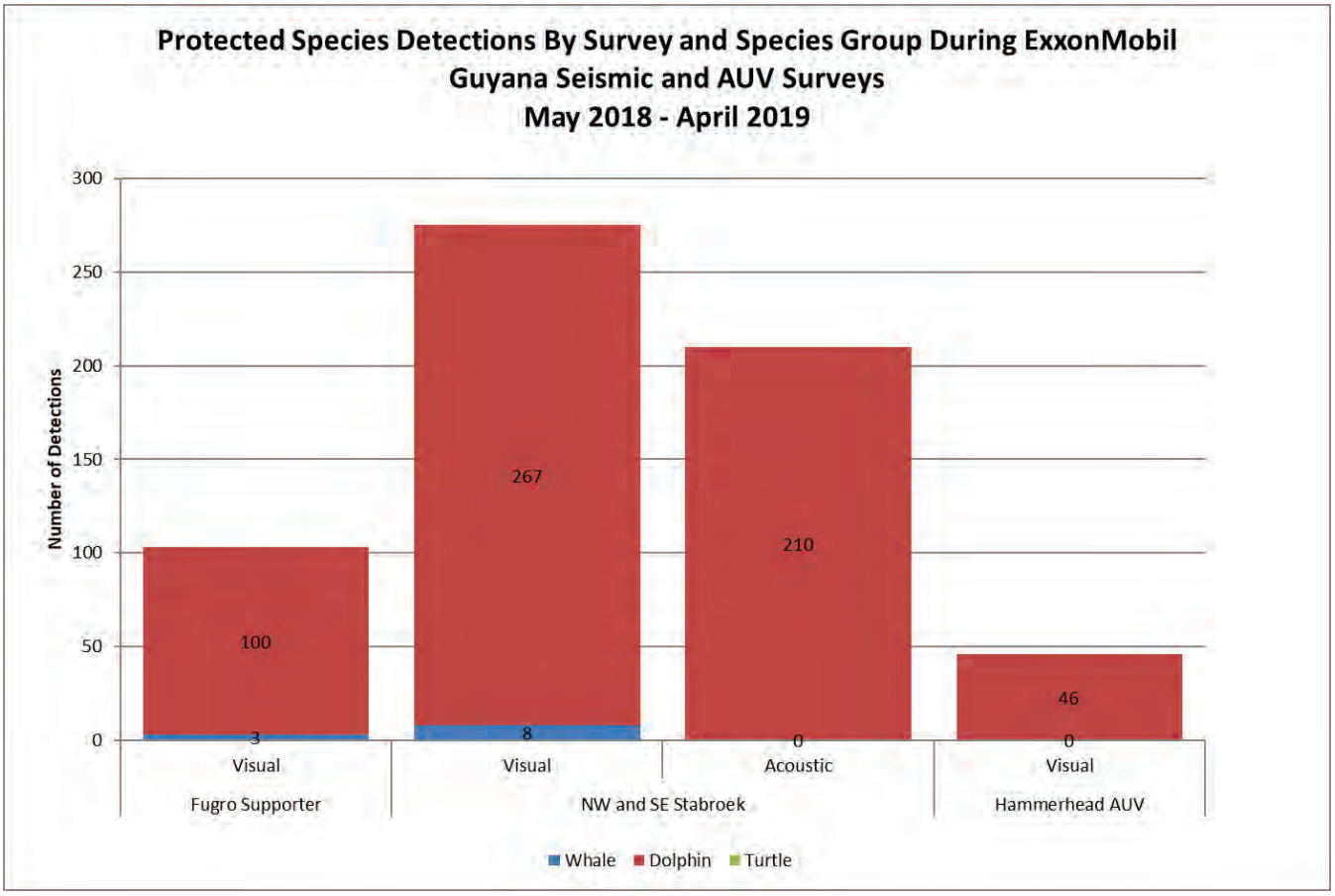


Figure 12. Protected species detections by species group on each of the ExxonMobil Guyana seismic and AUV surveys

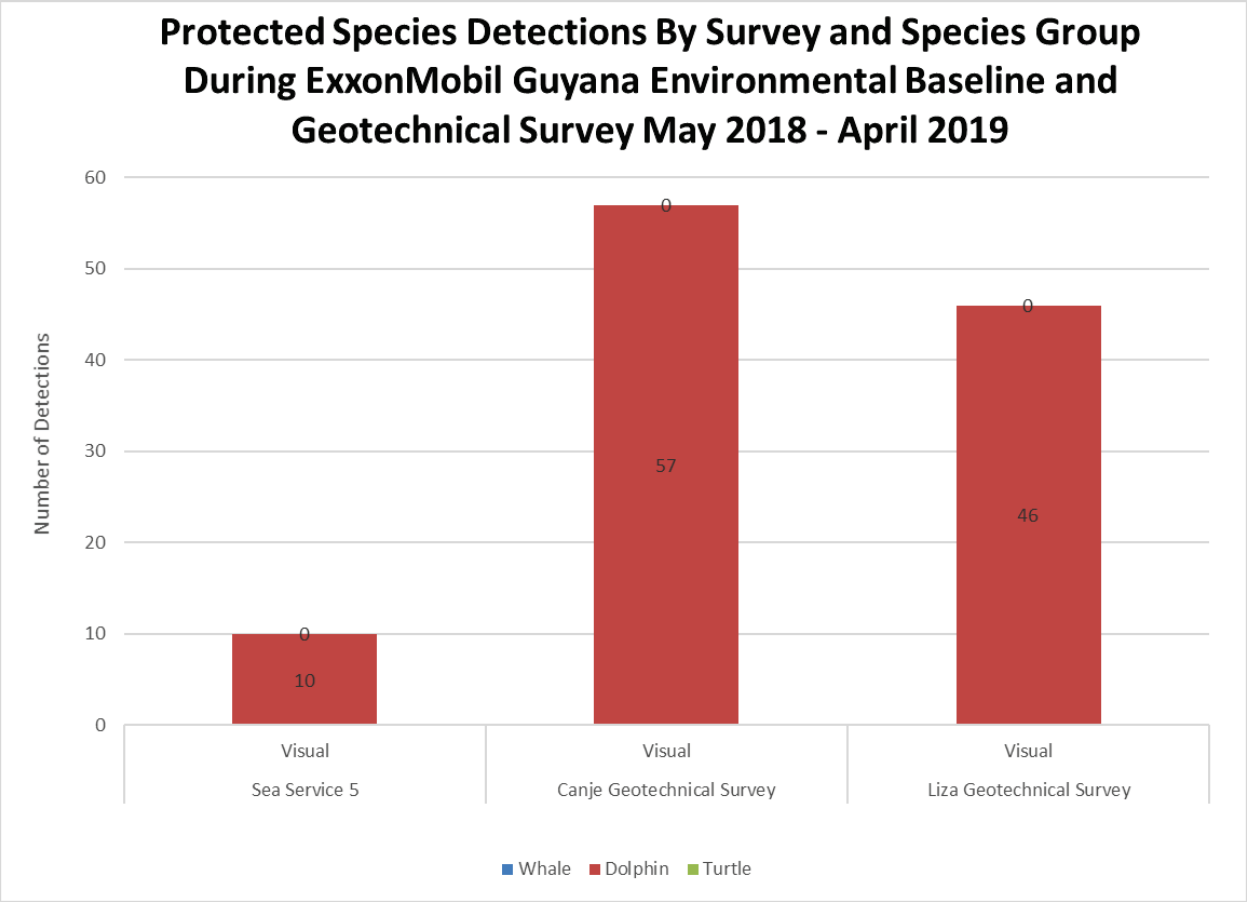


Figure 13. Protected species detections by species group on each of the ExxonMobil Guyana Environmental Baseline and Geotechnical surveys

A total of 15 different identified species were observed over the course of all of the programs, two species of whales, 12 species of delphinid and one species of sea turtles (Figure 14).

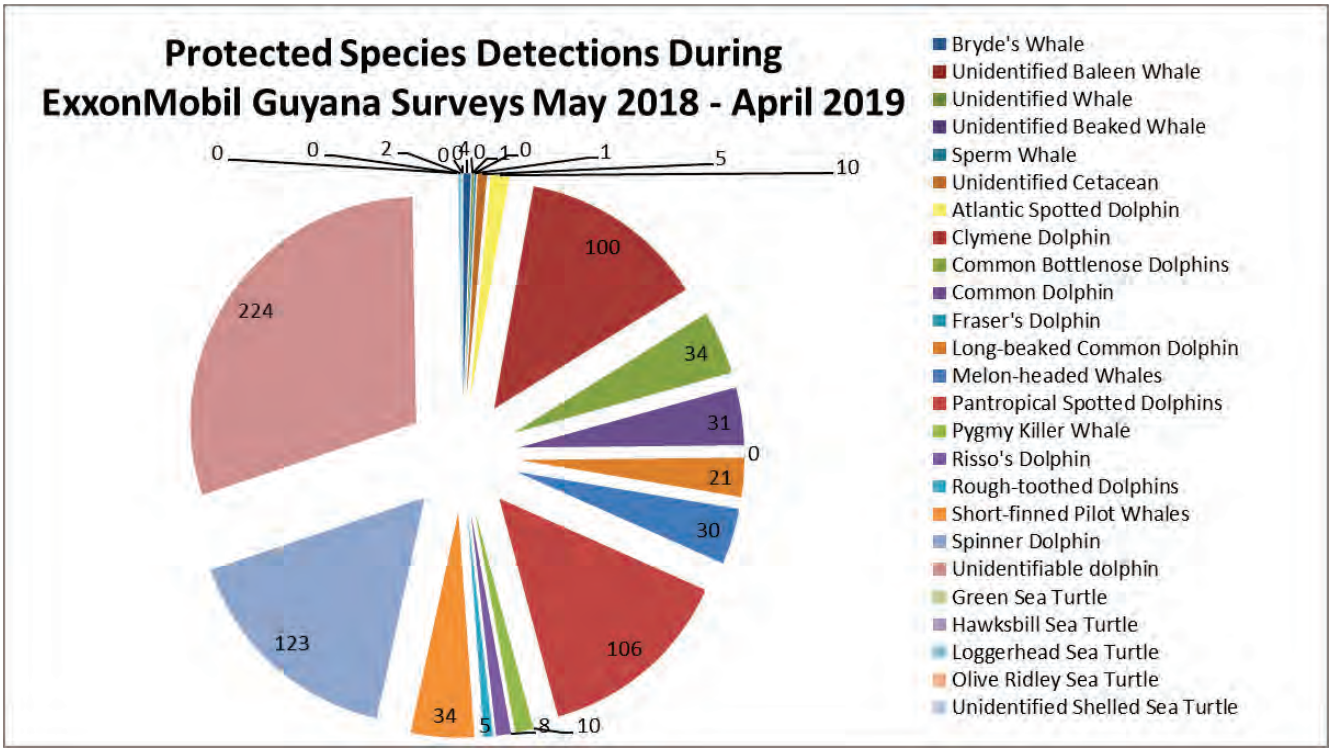


Figure 14: Protected species detections (visual and acoustic) shown as a breakdown by species over all ExxonMobil Guyana programs during May 2018 – April 2019

Of the 103 total protected species detections made during all programs, 42 occurred while the acoustic source was active. Of the detections during source activity, four occurred during soft starts, three occurred during reduced power source testing, and 35 occurred during full volume production. The remaining 61 protected species detections occurred while the acoustic source was silent—this total includes the surveys where no source activity occurred (Figure 15).

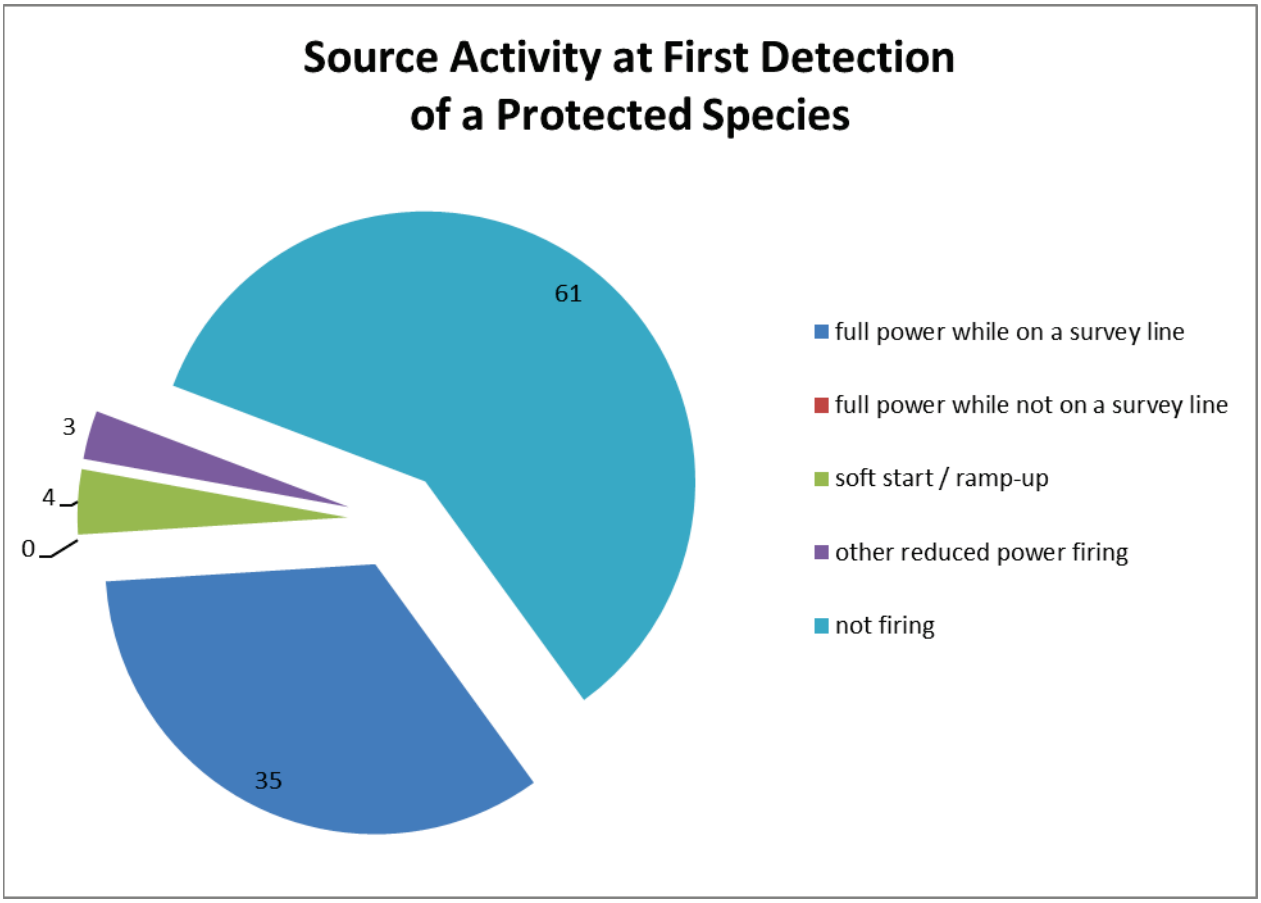


Figure 15: Seismic source activity at the initial detection of a marine mammal or sea turtle

4.5.2 Visual Detections

Protected species were visually detected on 526 occasions during the surveys included in this summary. Delphinids were detected more frequently than any other species group, with 12 species identified in 523 separate visual detection events. Two whale species were identified, Bryde's whales and sperm whales and additional sightings were made of unidentified whale and unidentified cetaceans. A total of 11 whale detections were made visually during all of the programs. One sea turtle species were observed and a total of 2 sea turtles were detected (Figure 16, Table 4).

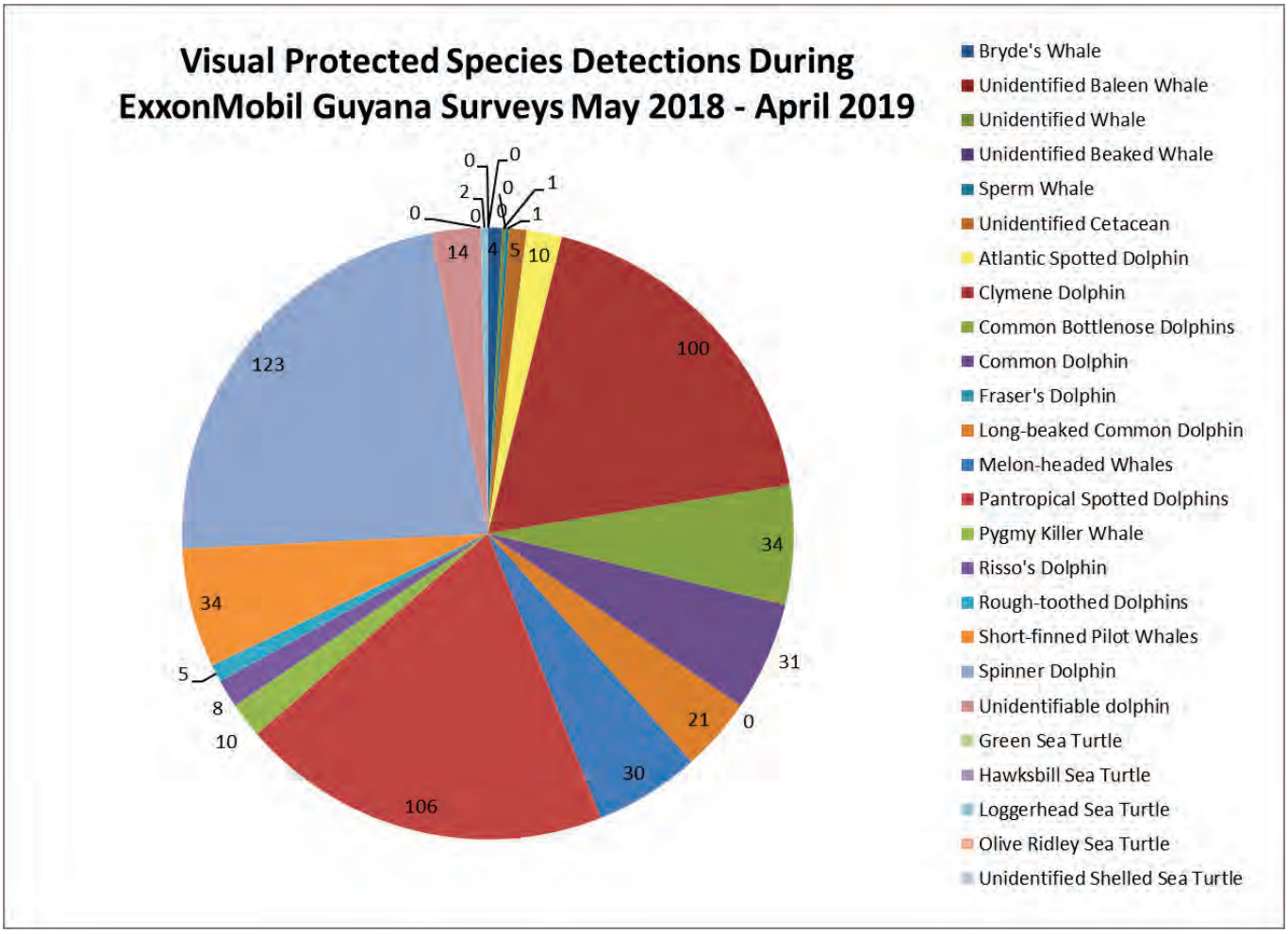


Figure 16: Visual protected species detections shown as a breakdown by species over all ExxonMobil Guyana programs during May 2018 – April 2019

4.5.3 Acoustic Detections

Marine mammals were acoustically detected on 210 occasions throughout this survey where unidentified delphinids were the only detections. (Figure 17, Table 4).

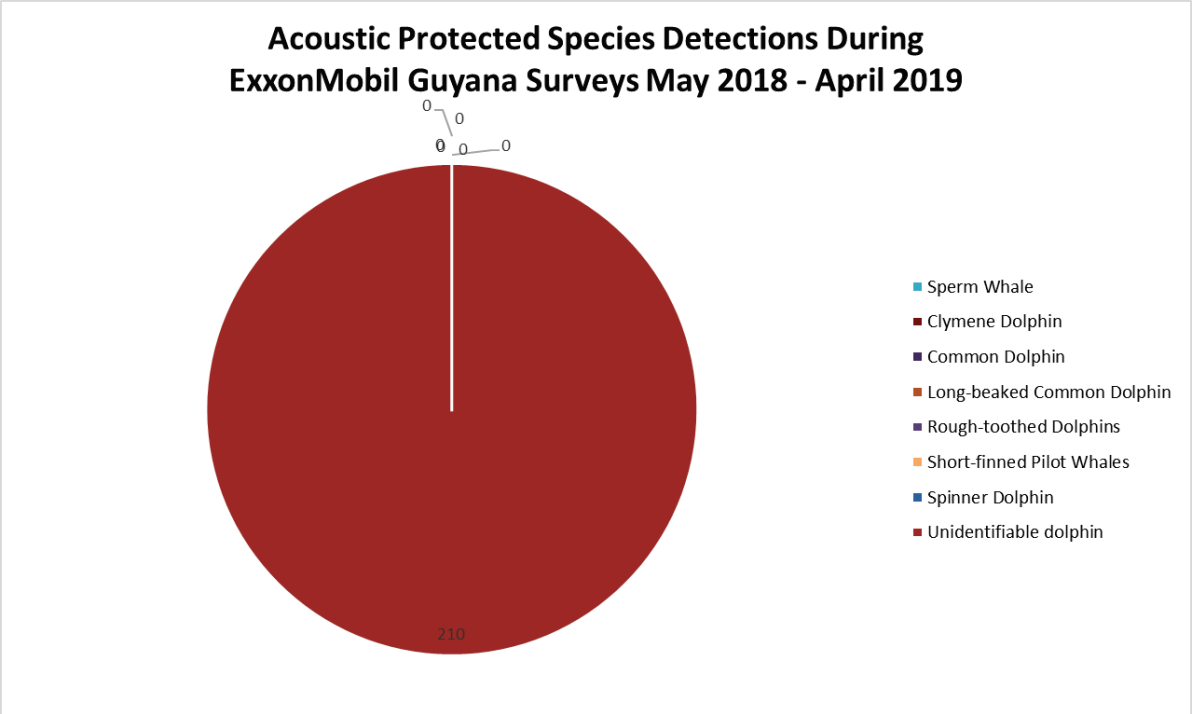


Figure 17: Acoustic protected species detections shown as a breakdown by species over all ExxonMobil Guyana programs during May 2018 – April 2019

A summary of detections across all surveys is provided in Table 5. Figure 18 shows the distribution of visual protected species detections, while Figure 19 depicts acoustic protected species detections.

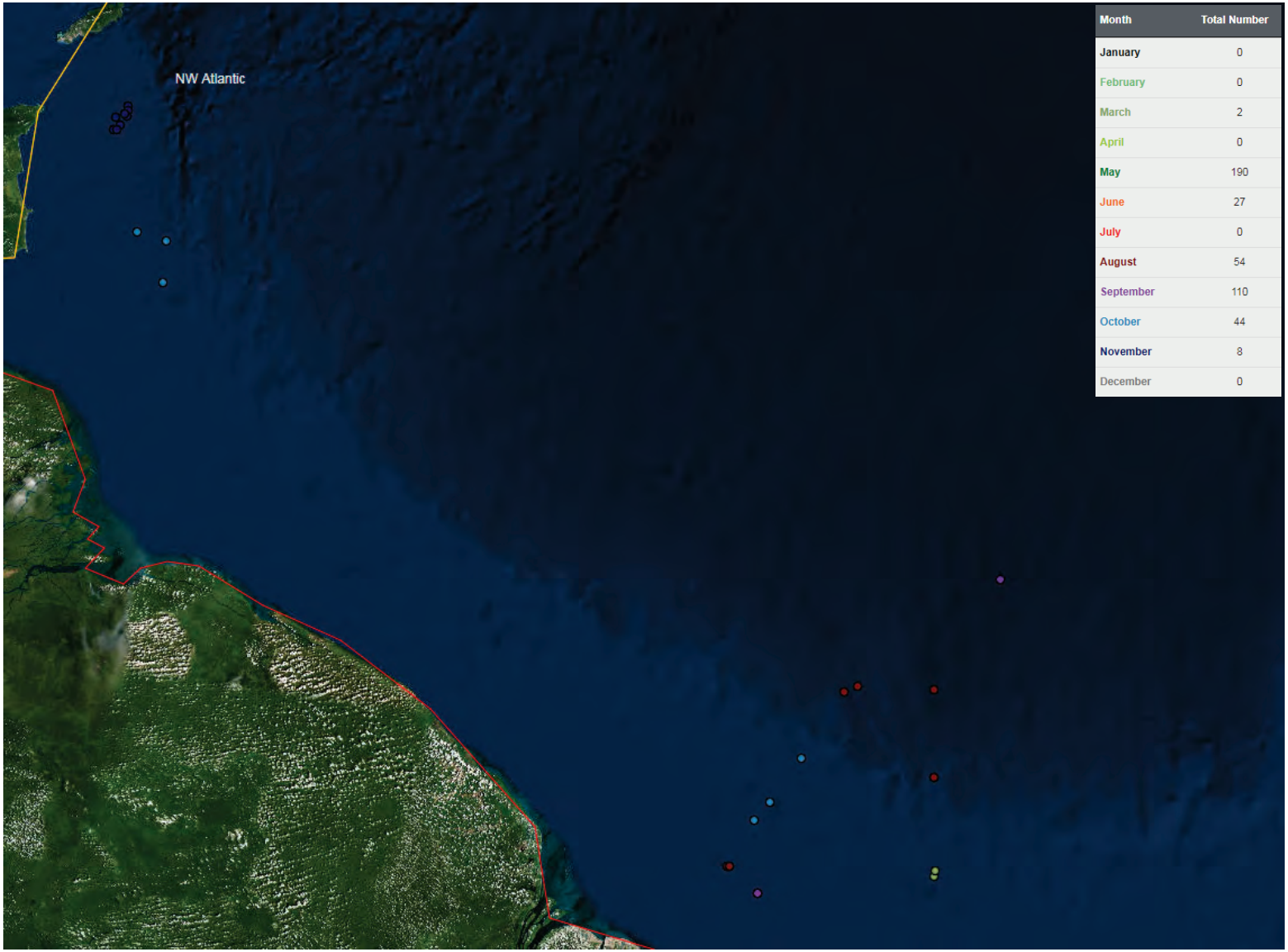
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Table 5: Protected species visual and acoustic detection summary during the May 2018 – April 2019 ExxonMobil Guyana survey programs

	Canje Geotechnical Survey	Liza Geotechnical Survey	SE Stabroek Ramform Tethys		NW Stabroek Ramform Atlas		Payara Geotechnical and Geophysical Survey	Hammerhead AUV	Sea Service	Total Number of Detection Events
	Visual	Visual	Visual	Acoustic	Visual	Acoustic	Visual	Visual	Visual	
Bryde's Whale			3		1					**4**
Unidentified Baleen Whale										
Unidentified Whale			1							**1**
Unidentified Beaked Whale										
Sperm Whale							1			**1**
Unidentified Cetacean			3				2			**5**
Total number of whale detections	**0**	**0**	**7**	**0**	**1**	**0**	**3**	**0**	**0**	**11**
Atlantic Spotted Dolphin			10							**10**
Clymene Dolphin							100			**100**
Common Bottlenose Dolphins			15					14	5	**34**
Common Dolphin	17	14								**31**
Fraser's Dolphin										
Long-beaked Common Dolphin		21								**21**
Melon-headed Whales			30							**30**
Pantropical Spotted Dolphin			77					29		**106**
Pygmy Killer Whale			10							**10**
Risso's Dolphin	8									**8**
Rough-toothed Dolphin									5	**5**
Short-finned Pilot Whales	32		2							**34**
Spinner Dolphin			120					3		**123**
Unidentifiable dolphin		11	3	204		6				**224**
Total number of dolphin detections	**57**	**46**	**267**	**204**	**0**	**6**	**100**	**46**	**10**	**736**
Total number of marine mammal detections	**57**	**46**	**274**	**204**	**1**	**6**	**103**	**46**	**10**	**747**
Green Sea Turtle										
Hawksbill Sea Turtle										
Loggerhead Sea Turtle			1		1					**2**
Olive Ridley Sea Turtle										
Unidentified Shelled Sea Turtle										
Total number of sea turtle detections	**0**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**2**

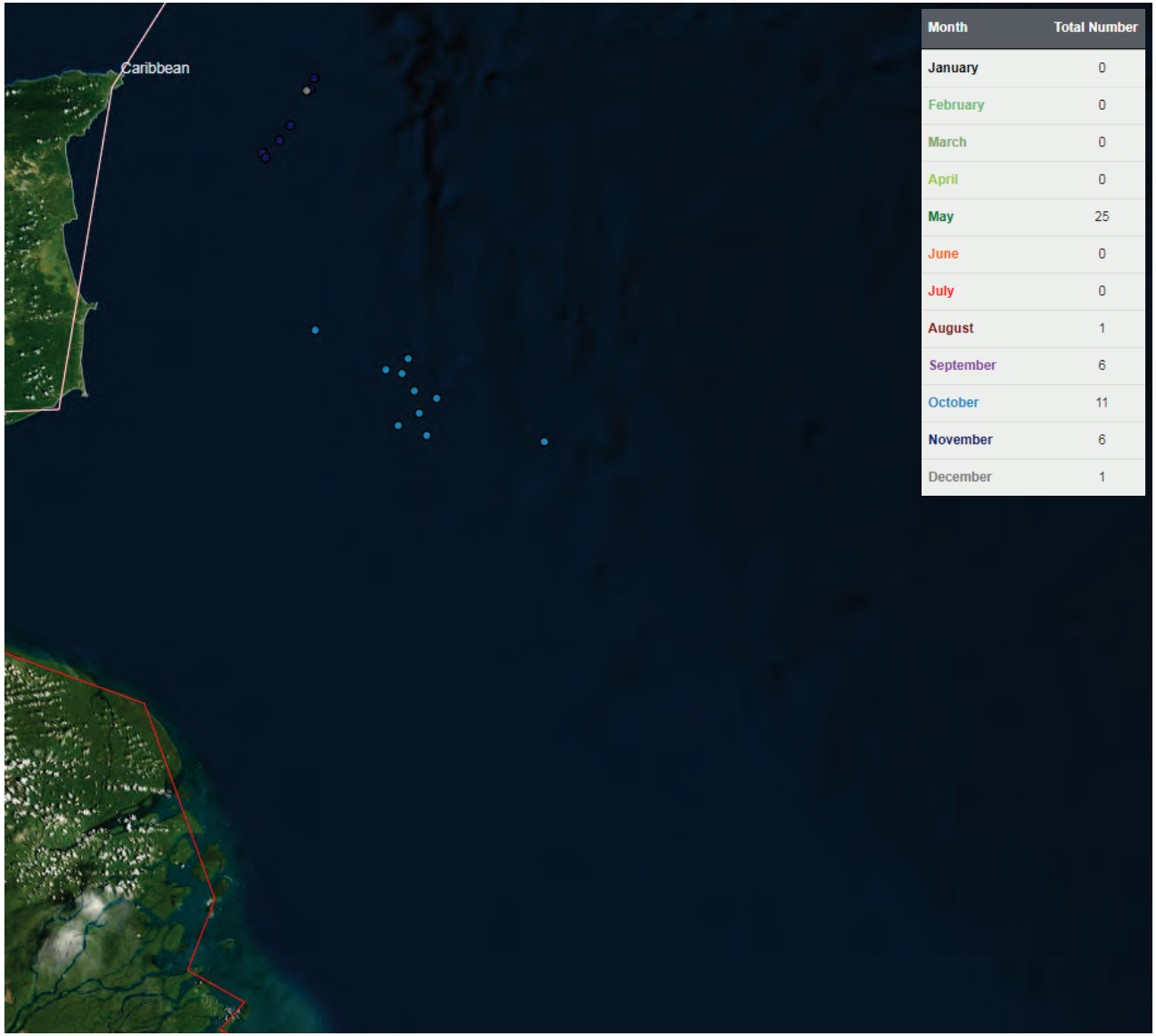
Note: Only surveys with detections are included in this table

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Month	Total Number
January	0
February	0
March	2
April	0
May	190
June	27
July	0
August	54
September	110
October	44
November	8
December	0

Figure 18: Distribution of visual detections by month during ExxonMobil Guyana 2018 - 2019 programs.



Month	Total Number
January	0
February	0
March	0
April	0
May	25
June	0
July	0
August	1
September	6
October	11
November	6
December	1

Figure 19: Distribution of acoustic detections by month during ExxonMobil Guyana 2018 – 2019 programs.

4.5.4 Other Wildlife Summary

In addition to data collected during marine mammal and sea turtle detections, PSOs also recorded observations for other wildlife observed during monitoring watches. Additional wildlife observed throughout this survey included 24 avian species and 5 fish species.

The most frequently observed avian species in terms of number of individuals observed was the masked booby (*Sula dactylatra*, 68.44%) which had 579 individuals recorded. Other frequently observed avian species, included magnificent frigatebird (*Fregata magnificens*, 3.9%, 33 individuals), unidentified birds (5.32%, 45 individuals), barn swallow (*Hirundo rustica*, 10.42%, 88 individuals), brown booby (*Sula leucogaster*, 8.39%, 71 individuals), and pomarine jaeger (1.42% with 12 individuals) (Figure 20, Table 6).

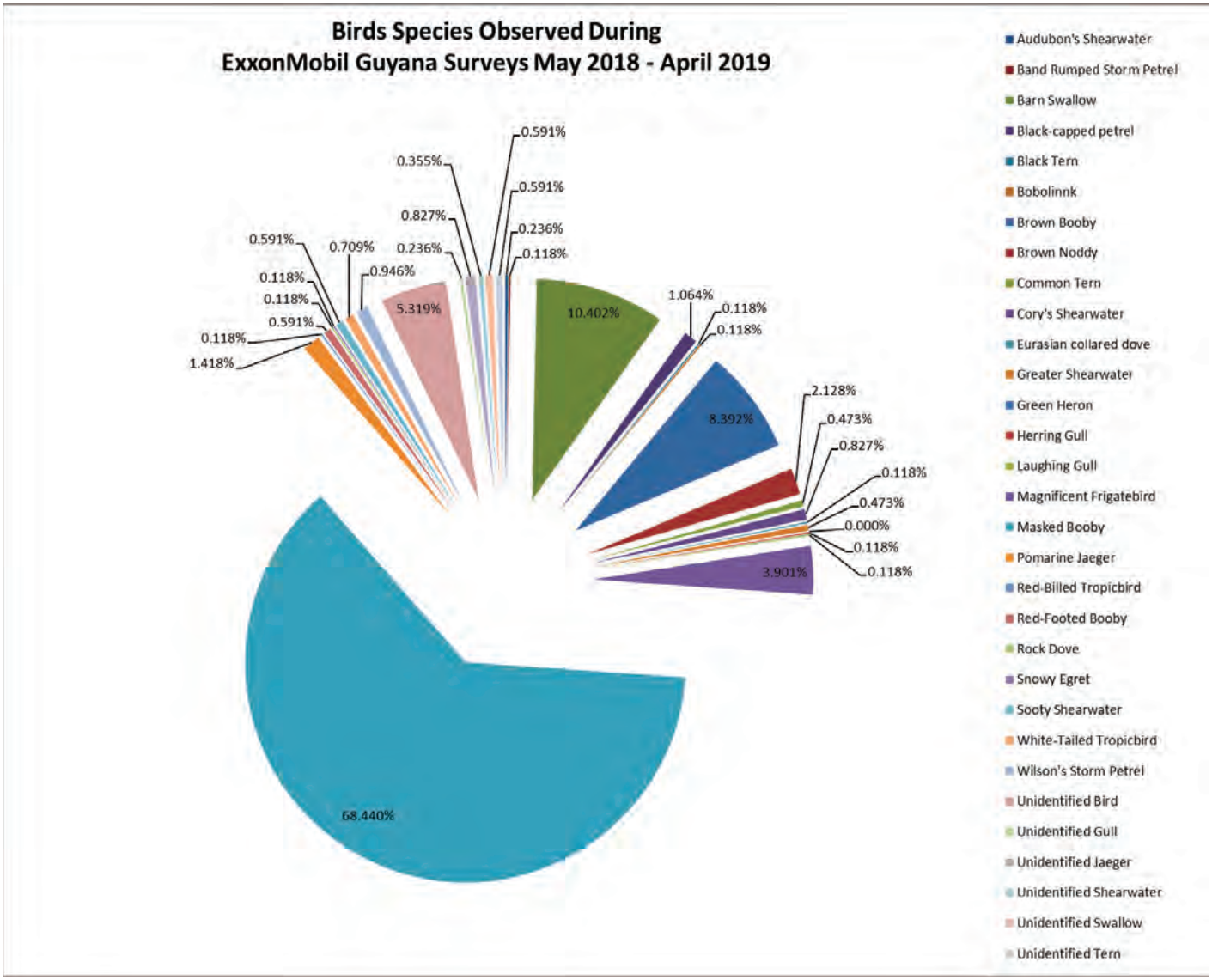


Figure 20: Bird species observed during the ExxonMobil Guyana May 2018 – April 2019 surveys

Table 6. Bird species identified throughout May 2018 - April 2019 surveys

Common name	*Species*	Number of Individuals	Number of Days Observed
Audubon's Shearwater	*Puffinus lherminieri*	2	2
Band Rumped Storm Petrel	*Oceanodroma castro*	1	1
Barn Swallow	*Hirundo rustica*	88	13
Black-capped petrel	*Pterodroma hasitata*	9	6
Black Tern	*Sula leucogaster*	1	1
Bobolinnk	*Dolichonyx oryzivorus*	1	1
Brown Booby	*Sula leucogaster*	71	35
Brown Noddy	*Anous stolidus*	18	5
Common Tern	*Sterna hirundo*	4	3
Cory's Shearwater	*Calonectris diomedea*	7	5
Eurasian collared dove	*Streptopelia decaocto*	1	1
Greater Shearwater	*Puffinus gravis*	4	4
Herring Gull	*Larus argentatus*	1	1
Laughing Gull	*Larus artricilla*	1	1
Magnificent Frigatebird	*Fregata magnificens*	33	22
Masked Booby	*Sula dactylatra*	579	104
Pomarine Jaeger	*Stercorarius pomarinus*	12	6
Red-Billed Tropicbird	*Phaethon aethereus*	1	1
Red-Footed Booby	*Sula*	5	4
Rock Dove	*Columba livia*	1	1
Snowy Egret	*Egretta thula*	1	1
Sooty Shearwater	*Puffinus griseus*	5	5
White-Tailed Tropicbird	*Phaethon lepturus*	6	7
Wilson's Storm Petrel	*Oceanitus oceanicus*	8	7
Unidentified Bird		45	19
Unidentified Gull		2	2
Unidentified Jaeger		7	2
Unidentified Shearwater		3	1
Unidentified Swallow		5	2
Unidentified Tern		5	3

The most commonly observed fish species in terms of number of individuals observed was the unidentified flying fish (Family Exocoetidae, 85.89%) which had 9351 individuals recorded throughout the surveys. Other notable fish species observed, skipjack tuna (*Katsuwonus pelamis*, 2.43%, 265 individuals), mahi mahi (*Coryphaena hipparus*, 10.88%, 1184 individuals), and Atlantic tripletail (*Lobotes surinamensis*, 0.046%, 5 individuals over 33 days) (Figure 21, Table 7).

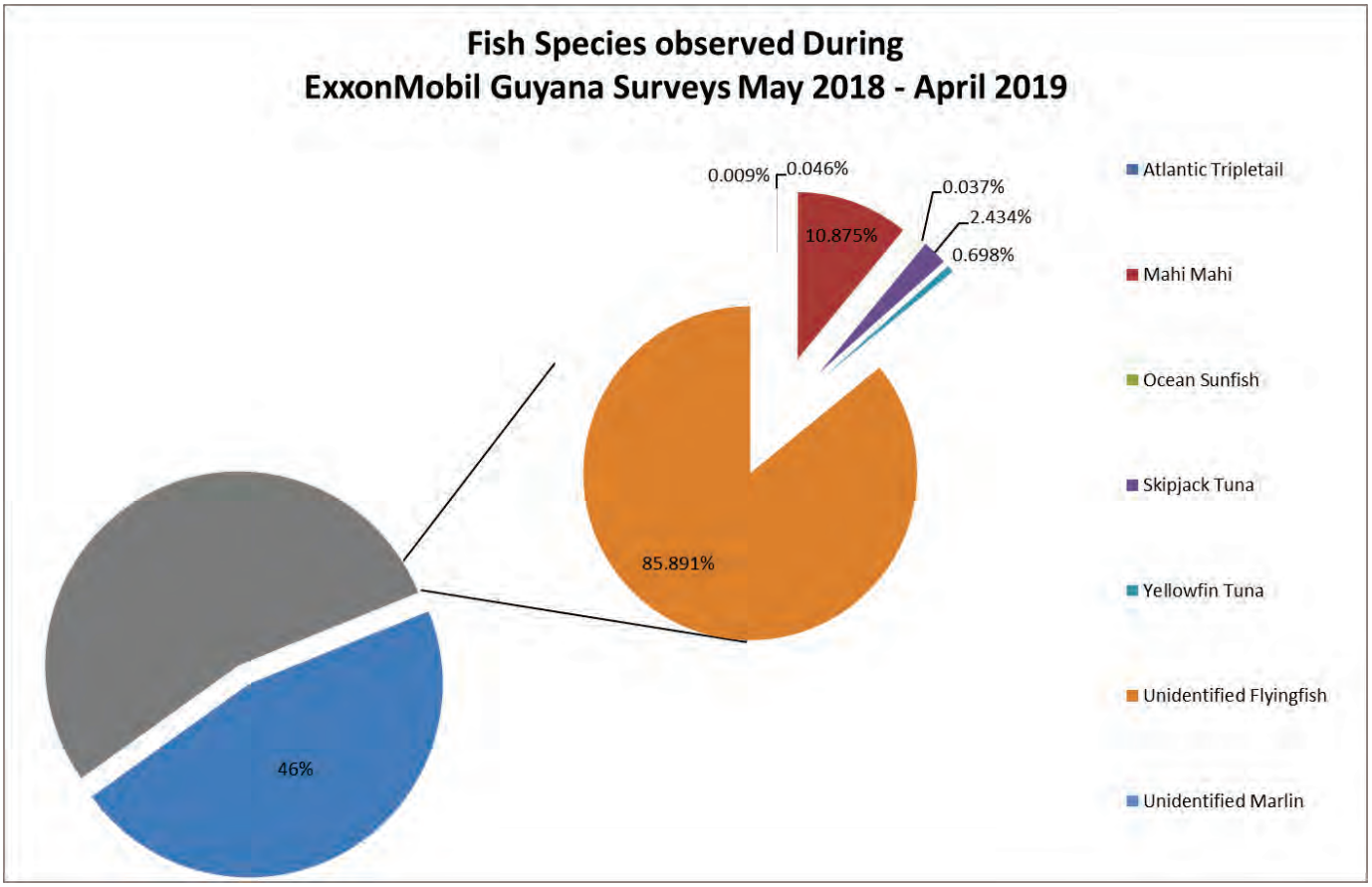


Figure 21: Fish species observed during the ExxonMobil Guyana May 2018 – April 2019 surveys

Table 7. Fish species observed

Common name	*Species*	Number of Individuals	Number of Days Observed
Atlantic Tripletail	*Lobotes surinamensis*	5	1
Mahi Mahi	*Coryphaena hippurus*	1184	49
Ocean Sunfish	*Mola mola*	4	1
Skipjack Tuna	*Katsuwonus pelamis*	265	13
Yellowfin Tuna	*Thunnus albacares*	76	26
Unidentified Flying fish		9351	122
Unidentified Marlin		1	1
Unidentified Shark		4	4
Unidentified Tuna		2126	60

4.6 Closest Approach to the Source

All species groups (whales, dolphins, and turtles) observed during surveys with source activity—surface seismic, AUV, and VSPs—were recorded at greater average distances from the active source than from the silent source (Figure 22).

Statistical analysis was not completed during the analysis due to the low sample size available. Source activity for all analysis was grouped as “source active” or “source silent”, where “source active” included full volume, soft start, and all other reduced volume including the mitigation source. This was done due to the small sample size of data, making further categorization impractical.

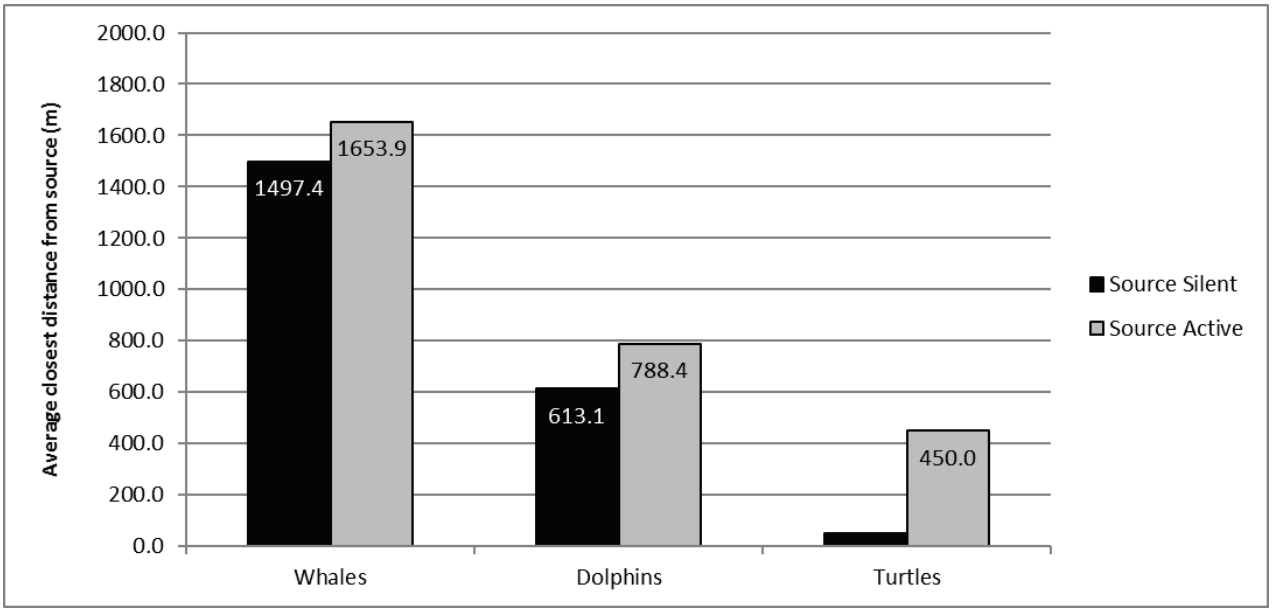


Figure 22. Average closest distance from source

Average distances from the active and silent source varied by species, with only five species (Unidentifiable whale, melon-headed whale, pantropical spotted dolphin, spinner dolphin, and loggerhead sea turtle) being observed at average closer distances during source activity than source silence (Figure 23). Common bottlenose and Risso's dolphin where only observed when the source was silent (Figure 23).

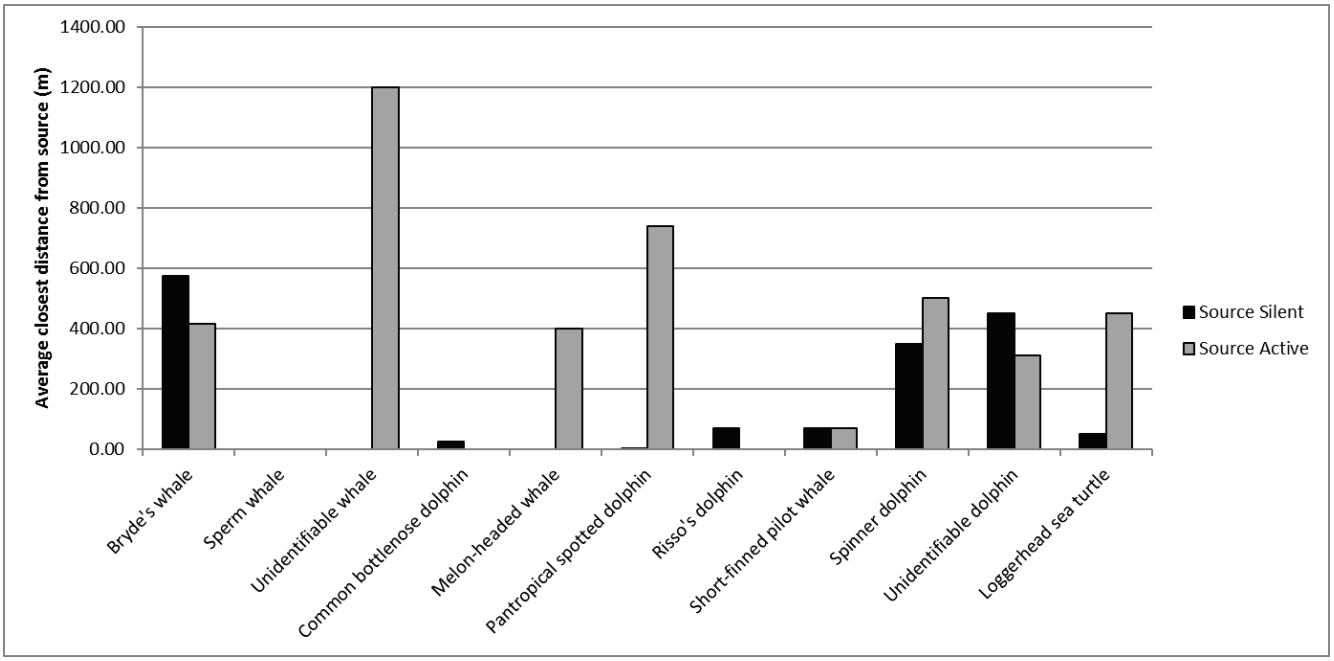


Figure 23. Average closest distance from the source by species

4.7 Detection Rate

There was a total of 38 visual detections and 65 acoustic detections throughout all surveys, excluding the VSPs, for a total of 103 detections. There were 1702.03 hours of visual monitoring conducted, for a visual detection rate of 0.0223 detections per hour of effort. There were 792.30 hours of acoustic monitoring conducted, for an acoustic detection rate of 0.0820 detections per hour of effort. The overall detection rate for the project was 0.0413 detections per hour of monitoring effort (Table 8).

Table 8. Detection rate summary

Number of Visual Detections	38
Visual Monitoring Effort (hours)	1702.03
Visual Detection Rate (Detections per hour)	0.0223
Number of Acoustic Detections	65
Acoustic Monitoring Effort (hours)	792.30
Acoustic Detection Rate (Detections per hour)	0.0820
Total Number of Detections	103
Total Monitoring Effort (hours)	2494.30
Overall Detection Rate (Detections per hour)	0.0413

5 Discussion

Very broad comparisons to the Stone (2015) and Barkaszi et al (2012) papers were made, as the scale of this study is not comparable to those. Stone (2015) analyzed protected species observer data from 1,196 seismic surveys over a period of 16 years, comprising over 190,000 hours of monitoring effort—over 181,000 hours of visual monitoring and over 9,000 hours of acoustic monitoring—with a total of 9,073 detections of marine mammals. Barkaszi et al (2012) analyzed protected species observer data from seismic surveys over a period of six years, comprising 194,273 hours of visual monitoring effort with a total of 3,963 sightings of protected species. This analysis, in comparison, includes data from 15 surveys, including seven short VSP surveys, over the span of four years, comprising 15,696 hours of monitoring effort—9786 hours of visual monitoring effort and 5910 hours of acoustic monitoring effort—with a total of 580 detections of protected species. Despite the disparity in scales, comparisons of general trends across all three studies are possible.

In all studies, dolphins were the predominantly observed species group followed by whales. Turtles were the least commonly observed species for this study and Barkaszi et al (2012)—turtles were not included in Stone (2015). The species composition of recorded sightings varied from study to study, which is expected due to the difference in study area between the studies—Stone (2015) analyzed data offshore the United Kingdom, Barkaszi et al (2012) analyzed data from the U.S. Gulf of Mexico, and this study focuses on data offshore Guyana.

Across all studies, the spatial distribution of dolphin and turtle detections was fairly consistent across the surveyed areas, however visual and acoustic whale detections only occurred beyond the 2000-meter isobath. This is consistent with knowledge of habitat use by species groups, as whales are known to inhabit deeper waters, while dolphins and turtles have wider distribution across various depths.

Closest approach to the source for this study was calculated as both an average and a median by species and species group, while Stone (2015) and Barkaszi et al (2012) analyzed only the median closest approach to the source with Stone (2015) analyzing this by species and Barkaszi et al (2012) analyzing it by species group. Similar to the analysis conducted by Stone (2015), closest approach was analyzed based on source activity with only two categories—source active and source silent—where “source active” comprised full volume, soft start, and all other reduced volume activity including the mitigation source, due to the small sample size of this data. These comparisons were made based on the “large array” data in Stone (2015), as the parameters for a “large array” were sources with production output greater than 500 in^3 and the sources utilized in the ExxonMobil Guyana surveys were >4000 in^3 for seismic surveys, and 1200in^3 for VSPs. Barkaszi et al (2012) analyzed this separately by source volume, so comparisons with this study are made in reference to the full volume results from that study—as the majority of detections from this study were during full volume.

The average closest approach to the source by species group for whales and turtles were higher during source activity than source silence. The average closest approach to the source for dolphins was also higher during source activity than source silence. This was similar to the results from Barkaszi et al 2012. The average and median closest approach to the source by species generally agreed with the findings of Stone (2015), with most individual species exhibiting a larger closest approach to the source during source activity than during source silence. Only four species overlapped between the studies—baleen whales, sperm whales, Risso’s dolphin, and bottlenose dolphin—however, there was only one recorded Risso’s dolphin for this study and 3 recorded closest approaches for bottlenose dolphins, so the direct comparison is limited to baleen whales and sperm whales. In both studies, Baleen whales were recorded at much greater distances at closest approach during source activity than source silence, while sperm whales were

observed to have equal median closest approaches by Stone (2015) and were observed at greater median closest approaches during source silence than source activity in this study.

The implementation of mitigation actions for this study and Stone (2015) was limited to delays to the initiation of source activity as the surveys analyzed implemented JNCC guidelines. During the surveys analyzed by Barkaszi et al (2012), mitigation actions included delays to the initiation of source activity as well as shutdowns of the active source for certain species. For comparability to this study and Stone (2015), we will only include information on the delays to initiation of source activity. Across all three studies, mitigation actions were implemented for less than 3% of all protected species detections. Mitigation actions were minimal during the ExxonMobil Guyana surveys, with only 12 delays to the initiation of source activity, required for all 749 detections during projects with source activity, resulting in only 1.2% of detections requiring mitigation actions. Mitigation requirements based on JNCC guidelines were not implemented until the second year of the Stone (2015) study timeframe, with a total of 165 delays to the initiation of source activity, required for the 9,073 detections of marine mammals during the surveys, resulting in 1.82% of detections requiring mitigation actions. There were 32 delays to the initiation of source activity required for the 3,963 sightings of protected species during the surveys reviewed by Barkaszi et al (2010), resulting in 0.81% of all sightings requiring delays to the initiation of source activity.

While this study was limited by sample size, some correlations to similar studies with statistically significant sample size are useful and potentially insightful into the usefulness of protected species observations and the implementation of mitigation actions during seismic surveys, as well as potentially contributory toward future analysis of similar datasets.

6 References

Barkaszi, M.J., M. Butler, R. Compton, A. Unietis, and B. Bennet. 2012. Seismic survey mitigation measures and marine mammal observe reports. U.S. Dept. of Interior, Bureau of Ocean Energy Management, Gulf of Mexico OCS Region, New Orleans, LA. OCS Study BOEM 2012-2015.

Stone, C.J. 2015. Marine mammal observations during seismic surveys from 1994-2010. JNCC report, No. 463a.

Appendix A: Protected Species Summary Table

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range when First Detected	Source Activity at First Det.	Source Activity at Last Det.	Closest distance to source (m)	Mitigation Actions	Total Duration Animals Observed inside EZ	Total Duration of Production Loss
Canje Geotechnical Survey																	
18-Aug-2018	1		12:45	12:48	Common dolphin	visually	08.01787	-056.55338	1658	17	600	other reduced power firing	other reduced power firing	450	none	00:00	00:00
12-Sep-2018	2		12:19	13:20	Short-finned pilot whale & Risso's dolphin	visually	08.55000	-056.23333	3020	40	400	not firing	not firing	70	none	00:30	00:00
Liza Geotechnical Survey																	
08-Aug-2018	3		12:57	13:27	Unidentifiable dolphin	visually	07.59560	-056.55340	1568	11	500	not firing	not firing	400	none	00:00	00:00
17-Aug-2018	4		11:40	11:43	Common dolphin	visually	08.01090	-056.99535	1683	10	5	not firing	not firing	30	none	00:03	00:00
21-Aug-2018	5		19:07	19:14	Long-beaked common dolphin	visually	08.03568	-056.92882	34	5	5	not firing	not firing	48	none	00:07	00:00
25-Aug-2018	6		10:15	11:16	Long-beaked common dolphin	visually	07.16704	-057.56657	32	8	10	not firing	not firing	50	delayed start of firing	01:01	00:40
25-Aug-2018	7		12:27	16:15	Long-beaked common dolphin	visually	07.16597	-057.55410	27	8	20	not firing	not firing	20	none	03:48	00:00
10-Sep-2018	8		19:30	19:44	Common dolphin	visually	07.03333	-057.41667	47	4	120	not firing	not firing	20	none	00:14	00:00
Stabroek Geotechnical, Geophysical / AUV and Environmental Baseline Fugro Supporter Survey																	
19-Sep-2018	1		11:45	11:49	Unidentifiable cetacean	visually	08.30103	-056.97785	2176	1	800	None	None		none	00:04	00:00
25-Oct-2018	2		20:35	20:51	Sperm whale	visually	08.29588	-057.04850	2238	1	1000	None	None		none	00:16	00:00
02-Dec-2018	3		12:09	12:11	Clymene dolphins	visually	08.18188	-056.60072	1976	50	200	None	None		none	00:02	00:00
06-Dec-2018	4		18:49	18:54	Clymene dolphins	visually	08.17397	-056.86623	2028	50	800	None	None		none	00:05	00:00
25-Dec-2018	5		20:39	20:43	Unidentifiable whale	visually	08.20713	-056.87652	2076	1	1400	None	None		none	00:04	00:00
NW and SE Stabroek Ramform Tethys and Ramform Atlas Survey																	
10-Dec-2018	1		19:17	19:19	Loggerhead sea turtle	Visually	08.90450	-058.43450	1884	1	50	not firing	not firing		None	00:02	00:00
21-Dec-2018		1	00:18	00:34	Unidentifiable dolphin	Acoustically	08.90082	-058.06690	2390	3	500	Full power while on survey line	Full power while on survey line		None	00:16	00:00
21-Dec-2018		2	06:15	06:18	Unidentifiable dolphin	Acoustically	08.66493	-058.06478	2050	3	500	not firing	not firing		none	00:03	00:00
21-Dec-2018	2		20:24	20:26	Bryde's whale	Visually	09.42133	-057.80500	2871	1	200	not firing	not firing	800	None	00:02	00:00

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range when First Detected	Source Activity at First Det.	Source Activity at Last Det.	Closest distance to source (m)	Mitigation Actions	Total Duration Animals Observed inside EZ	Total Duration of Production Loss
08-Dec-2018	1		19:26	19:33	Common bottlenose dolphin	Visually	08.27194	-058.19333	65	15	100	not firing	not firing		None		
16-Dec-2018		1	06:31	08:26	Unidentifiable dolphin	Acoustically	09.21050	-057.49417		6	400	Not firing	Not firing	300	Delayed start of firing	01:55	00:00
18-Dec-2018		2	22:34	22:40	Unidentifiable dolphin	Acoustically	08.82533	-058.53817	1475	4	300	Not firing	Not firing	400	Delayed start of firing	00:06	00:00
22-Dec-2018	2		18:46	18:47	Pygmy Killer Whale	Visually	09.22711	-058.08165	2614	1	250	Not firing	Not firing	800	None	00:00	00:00
27-Jan-2019		3	03:31	03:35	Unidentifiable dolphin	Acoustically	07.83333	-056.58333		1		Soft Start	Soft Start		None	00:00	00:00
29-Jan-2019		4	08:51	08:56	Unidentifiable dolphin	Acoustically	08.10000	-056.50000		4		Not firing	Not firing		None	00:00	00:00
30-Jan-2019		5	02:44	02:56	Unidentifiable dolphin	Acoustically	07.93333	-056.50000		2		Full Volume	Full Volume		None	00:00	00:00
01-Feb-2019		6	07:09	07:11	Unidentifiable dolphin	Acoustically	08.16667	-056.60000		2		Not firing	Not firing		None	00:00	00:00
01-Feb-2019		7	23:41	23:46	Unidentifiable dolphin	Acoustically	07.80000	056.58333		4		Full Volume	Full Volume		None	00:00	00:00
03-Feb-2019		8	04:03	05:02	Unidentifiable dolphin	Acoustically	08.10000	-056.48333	2300	3		Not firing	Not firing	100	None	00:59	00:00
03-Feb-2019		9	06:57	08:27	Unidentifiable dolphin	Acoustically	08.08333	-056.58333	2012	5		Not firing	Not firing	50	Delayed start of firing	01:30	01:00
04-Feb-2019		10	01:12	01:24	Unidentifiable dolphin	Acoustically	08.03333	-056.58333	2012	1		Full power while on survey line	Full power while on survey line	100	None	00:12	00:00
04-Feb-2019		11	08:10	09:03	Unidentifiable dolphin	Acoustically	07.90000	-056.50000	2077	3		Full power while on survey line	Full power while on survey line	50	None	00:53	00:00
05-Feb-2019		12	01:51	02:26	Unidentifiable dolphin	Acoustically	07.95000	-056.48333	2197	3		Full power while on survey line	Full power while on survey line	50	None	00:35	00:00
05-Feb-2019		13	05:20	05:48	Unidentifiable dolphin	Acoustically	08.15000	-056.56667	2370	4		Not firing	Not firing	200	None	00:28	00:00
08-Feb-2019		14	00:09	01:27	Unidentifiable dolphin	Acoustically	08.08333	-056.56667	2200	4		Not firing	Not firing	300	Delayed start of firing	01:18	00:33
08-Feb-2019		15	04:09	04:11	Unidentifiable dolphin	Acoustically	07.9333	-056.56667	1969	2		Full power while on survey	Full power while on survey	200	None	00:02	00:00
08-Feb-2019		16	21:45	21:47	Short-finned pilot whale	Acoustically	07.76667	-056.56667	1563	2		Full power while on survey	Full power while on survey	70	None	00:20	00:00
08-Feb-2019 09-Feb-2019		17	23:55	00:04	Unidentifiable dolphin	Acoustically	07.61667	-056.55000	2362	3		Not firing	Not firing	10	None	00:10	00:00
11-Feb-2019		18	23:23	23:35	Unidentifiable dolphin	Acoustically	08.20000	-056.55000	2371	2		Not firing	Not firing	200	None	00:46	00:00
12-Feb-2019		19	02:22	02:25	Unidentifiable dolphin	Acoustically	07.98333	-056.38333	2013	2		Full power while on survey	Full power while on survey	100	None	00:20	00:00

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range when First Detected	Source Activity at First Det.	Source Activity at Last Det.	Closest distance to source (m)	Mitigation Actions	Total Duration Animals Observed inside EZ	Total Duration of Production Loss
12-Feb-2019		20	23:48	23:51	Unidentifiable dolphin	Acoustically	07.76667	-056.55000	1588	3		Full power while on survey line	Full power while on survey line	100	None	00:10	00:00
13-Feb-2019		21	22:43	22:44	Unidentifiable dolphin	Acoustically	08.15400	-056.49857	2367	2		Not firing	Not firing	370	None	00:03	00:00
14-Feb-2019		22	08:01	08:04	Unidentifiable dolphin	Acoustically	07.63002	-056.47068	1150	3		Not firing	Not firing	350	None	00:03	00:00
14-Feb-2019		23	22:05	22:07	Unidentifiable dolphin	Acoustically	07.64338	-056.55273	1188	2		Full power while on survey line	Not firing	400	None	00:02	00:00
15-Feb-2019		24	03:42	04:09	Unidentifiable dolphin	Acoustically	07.92795	-056.46178	2053	7		Not firing	Not firing	200	None	00:27	00:00
15-Feb-2019		25	23:40	23:40	Unidentifiable dolphin	Acoustically	08.15373	-056.52015	2346	1	300	Not firing	Not firing	500	none	00:01	00:00
17-Feb-2019		26	22:57	23:10	Unidentifiable dolphin	Acoustically	07.97210	-056.44242	2211	2	500	Not firing	Not firing	500	None	00:13	00:00
26-Feb-2019	3		16:14	16:15	Loggerhead Sea Turtle	Visually	07.79087	-056.44938	1876	1	200	Full power while on survey line	Full power while on survey line	450	None	00:02	00:00
27-Feb-2019		27	01:08	01:14	Unidentifiable dolphin	Acoustically	07.91847	-056.53545	1993	3	500	Full power while on survey line	Full power while on survey line	400	None	00:06	00:00
27-Feb-2019		28	23:45	00:03	Unidentifiable dolphin	Acoustically	07.77605	-056.5333	1659	7	450	Full power while on survey line	Full power while on survey line	300	None	00:18	00:00
28-Feb-2019		29	06:13	06:25	Unidentifiable dolphin	Acoustically	07.74110	-056.44520	1711	2	500	Soft start / ramp-up	Soft start / ramp-up	450	None	00:12	00:00
28-Feb-2019		30	08:10	08:13	Unidentifiable dolphin	Acoustically	07.89688	-056.44503	2087	3	500	Full power while on survey	Full power while on survey	475	None	00:03	00:00
02-Mar-2019		31	02:19	02:55	Unidentifiable dolphin	Acoustically	08.00525	-056.44265	2254	7	450	Other reduced power firing	Not firing	350	None	00:35	00:00
02-Mar-2019		32	05:29	05:57	Unidentifiable dolphin	Acoustically	08.08638	-056.53245	2222	3	470	Not firing	Not firing	400	Delayed start of firing	00:28	00:04
02-Mar-2019	4		16:49	17:02	Atlantic spotted dolphin	Visually	08.00123	-056.47258	2215	10	200	Not firing	Not firing	471	None	00:13	00:00
03-Mar-2019		33	07:23	07:39	Unidentifiable dolphin	Acoustically	07.91063	-056.43875	2114	8	450	Full power while on survey line	Full power while on survey line	250	None	00:16	00:00
07-Mar-2019		34	06:29	06:40	Unidentifiable dolphin	Acoustically	08.13830	-056.45423	2380	3	375	Not firing	Not firing	300	None	00:11	00:00
09-Mar-2019		35	22:23	22:48	Unidentifiable dolphin	Acoustically	08.12998	-056.51852	2335	2	550	Not firing	Not firing	470	Delayed start of firing	00:25	00:00
11-Mar-2019		36	04:33	04:39	Unidentifiable dolphin	Acoustically	07.98540	-056.42540	2246	2	350	Not firing	Not firing		None	00:06	00:00
12-Mar-2019		37	04:34	05:02	Unidentifiable dolphin	Acoustically	08.08695	-056.51678	2234	7	550	Not firing	Not firing	200	Delayed start of firing	00:28	00:05

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range when First Detected	Source Activity at First Det.	Source Activity at Last Det.	Closest distance to source (m)	Mitigation Actions	Total Duration Animals Observed inside EZ	Total Duration of Production Loss
15-Mar-2019	5		16:20	16:31	Pantropical spotted dolphin	Visually	07.94354	-056.42831	2179	65	150	Full power while on survey line	Full power while on survey line	300	None	00:11	00:00
16-Mar-2019	6		17:37	17:45	Bryde's Whale	Visually	07.73559	-056.45124	1524	2	1200	Soft start / ramp-up	Soft start / ramp-up	415	none	00:08	00:00
22-Mar-2019	7		10:43	10:55	Spinner dolphin	Visually	07.95733	-056.69601	1841	70	750	Full power while on survey line	Full power while on survey line	500	None	00:12	00:00
26-Mar-2019		38	09:02	09:20	Unidentifiable dolphin	Acoustically	08.19108	-056.72422	2166	2	198	Not firing	Not firing	176	None	00:18	00:00
30-Mar-2019		39	03:53	04:08	Unidentifiable dolphin	Acoustically	07.65000	-056.66667	1036	2	400	Not firing	Not firing	300	None	00:15	00:00
30-Mar-2019	8		20:20	20:30	Unidentifiable cetacean	Visually	07.66941	-056.66042	1322	3	1500	Full power while on survey line	Not firing	1200	none	00:10	00:00
31-Mar-2019	9		13:56	14:08	Pantropical spotted dolphin	Visually	07.72053	-056.65246	1498	12	50	Full power while on survey line	Full power while on survey line	435	None	00:12	00:00
31-Mar-2019	10		16:00	16:20	Pygmy killer whale	Visually	07.63333	-056.76667	620	9	300	Not firing	Not firing	400	none	00:06	00:00
01-Apr-2019		40	05:22	05:25	Unidentifiable dolphin	Acoustically	07.86667	-056.65000	1729	2	300	Full power while on survey line	Full power while on survey line	300	None	00:03	00:00
01-Apr-2019		41	08:26	08:29	Unidentifiable dolphin	Acoustically	07.65000	-056.65000	1045	4	200	Not firing	Not firing	200	none	00:13	00:00
02-Apr-2019		42	01:38	02:00	Unidentifiable dolphin	Acoustically	07.81667	-056.63333	1672	2	300	Full power while on survey line	Full power while on survey line	300	None	00:22	00:00
02-Apr-2019 03-Apr-2019		43	23:07	00:09	Unidentifiable dolphin	Acoustically	07.71667	-056.63333	1362	5	200	Full power while on survey line	Full power while on survey line	200	none	01:02	00:00
04-Apr-2019	11		11:35	11:40	Unidentifiable whale	Visually	07.65000	-056.65000	1050	1	800	Full power while on survey line	Full power while on survey line	800	None	00:00	00:00
05-Apr-2019		44	01:59	02:49	Unidentifiable dolphin	Acoustically	07.68333	-056.63333	1232	4	300	Full power while on survey line	Full power while on survey line	300	None	00:50	00:00
05-Apr-2019		45	04:32	05:09	Unidentifiable dolphin	Acoustically	07.68333	-056.73333	1072	3	300	Not firing	Not firing	300	None	00:37	00:00
05-Apr-2019 06-Apr-2019		46	22:34	01:07	Unidentifiable dolphin	Acoustically	07.86667	-056.75000	1569	4	350	Not firing	Soft start / ramp-up	350	Delayed start of firing	02:33	00:19
07-Apr-2019		47	00:33	01:26	Unidentifiable dolphin	Acoustically	08.13333	-056.61667	2203	6	200	Not firing	Soft star / ramp-up	200	Delayed start of firing	00:28	00:06
08-Apr-2019		48	04:31	04:39	Unidentifiable dolphin	Acoustically	07.71667	-056.73333	1200	2	52	Not firing	Not firing	52	None	00:08	00:00
11-Apr-2019		49	08:51	08:59	Unidentifiable dolphin	Acoustically	07.65000	-056.75000	875	2	80	Not firing	Not firing	80	none	00:08	00:00
14-Apr-2019		50	05:14	06:06	Unidentifiable dolphin	Acoustically	08.03333	-056.78333	1977	6	60	Full power while on survey line	Full power while on survey line	60	none	00:52	00:00

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range when First Detected	Source Activity at First Det.	Source Activity at Last Det.	Closest distance to source (m)	Mitigation Actions	Total Duration Animals Observed inside EZ	Total Duration of Production Loss
15-Apr-2019		51	07:05	07:27	Unidentifiable dolphin	Acoustically	07.86667	-056.61667	1822	5	102	Full power while on survey line	Full power while on survey line	102	None	00:22	00:00
16-Apr-2019		52	02:53	03:12	Unidentifiable dolphin	Acoustically	07.73333	-056.66667	1406	2	73	Full power while on survey line	Full power while on survey line	73	None	00:13	00:00
17-Apr-2019 18-Apr-2019		53	22:37	00:16	Unidentifiable dolphin	Acoustically	08.20000	-056.7333	2174	2	105	Not firing	Not firing	105	none	00:39	00:00
19-Apr-2019		54	02:17	02:53	Unidentifiable dolphin	Acoustically	07.65000	-056.51667	1211	4	75	Full power while on survey line	Not firing	75	None	00:36	00:00
19-Apr-2019		55	09:02	09:43	Unidentifiable dolphin	Acoustically	07.90000	-056.55000	1868	2	57	Not firing	Not firing	57	None	00:41	00:00
20-Apr-2019		56	01:16	01:27	Unidentifiable dolphin	Acoustically	07.85000	-056.51667	1850	2	100	Full power while on survey line	Full power while on survey line	100	None	00:11	00:00
20-Apr-2019		57	07:24	07:30	Unidentifiable dolphin	Acoustically	07.68333	-056.71667	1079	2	80	Not firing	Not firing	80	None	00:06	00:00
20-Apr-2019	12		12:51	13:11	Melon-headed whale	Visually	08.08333	-056.71667	2005	30	400	Full power while on survey line	Full power while on survey line	400	none	00:00	00:00
21-Apr-2019		58	06:53	07:21	Unidentifiable dolphin	Acoustically	08.00000	-056.71667	1875	4	77	Full power while on survey line	Full power while on survey line	77	None	00:28	00:00
22-Apr-2019		59	02:44	03:28	Unidentifiable dolphin	Acoustically	08.16667	-056.80000	2080	2	98	Not firing	Not firing	98	None	00:44	00:00
23-Apr-2019		60	09:15	09:23	Unidentifiable dolphin	Acoustically	07.86667	-056.71667	1628	2	54	Full power while on survey line	Full power while on survey line	54	None	00:08	00:00
24-Apr-2019		61	08:01	09:05	Unidentifiable dolphin	Acoustically	08.15000	-056.71667	2190	3	60	Other reduced power firing	Other reduced power firing	60	none	01:04	00:00
26-Apr-2019		62	03:57	04:49	Unidentifiable dolphin	Acoustically	08.16667	-056.98333	1909	5	95	Full power while on survey line	Full power while on survey line	95	None	00:52	00:00
27-Apr-2019	13		15:44	15:45	Unidentifiable dolphin	Visually	08.15000	-057.10000	1719	3	10	Not firing	Not firing	350	None	00:01	00:00
28-Apr-2019 29-Apr-2019		63	23:05	00:09	Unidentifiable dolphin	Acoustically	08.18333	-057.08333	1863	3	227	Not firing	Not firing	71	Delayed start of firing	00:55	00:10
29-Apr-2019	14		20:23	21:04	Bryde's Whale	Visually	08.15000	-056.86667	2005	1	1200	Not firing	Not firing	350	None	00:04	00:00
29-Apr-2019	15		20:26	21:04	Spinner dolphin	Visually	08.18333	-056.86667	2005	50	1000	Not firing	Not firing	350	None	00:04	00:00
Hammerhead AUV Survey																	
19-Mar-2019	1		12:04	12:06	Common Bottlenose Dolphin	visually	08.19389	-057.02861	1350	10	100	not firing	not firing		none	00:02	00:00
20-Mar-2019	2		17:37	17:38	Spinner dolphin	visually	08.20861	-057.23000	841	3	250	full power while on survey line	full power while on survey line		none	00:01	00:00

Date	Visual Det. #	Acoustic Det. #	Time at Initial Det.	Time at Last Det.	Common Name	Detection Method	Latitude	Longitude	Water Depth (m)	No. of Animals	Range when First Detected	Source Activity at First Det.	Source Activity at Last Det.	Closest distance to source (m)	Mitigation Actions	Total Duration Animals Observed inside EZ	Total Duration of Production Loss
22-Mar-2019	3		21:10	21:30	Pantropical spotted dolphin	visually	07.88333	-057.00000	880	20	30	full power while on survey line	full power while on survey line	10	none	00:15	00:00
09-Apr-2019	4		21:15	21:44	Common bottlenose dolphin	visually	07.66667	-057.06667	60	4	10	not firing	not firing	25	delayed start of firing	00:29	00:49
14-Apr-2019	5		20:07	20:27	Pantropical spotted dolphin	visually	07.75000	-057.11667	250	9	150	not firing	not firing	1	none	00:21	00:00
Sea Service Metocean Retrieval Survey																	
02-Oct-2018	1		11:45	11:54	Common bottlenose dolphin	visually	07.68822	-057.20308	88	3	3	None	None		None	00:00	00:00
03-Oct-2018	2		16:35	17:04	Rough-toothed dolphin	visually	07.47505	-057.35756	53	5	4	None	None		None	00:00	00:00
03-Oct-2018	3		17:20	17:34	Common bottlenose dolphin	visually	07.38767	-057.43307	52	2	20	None	None		None	00:00	00:00

APPENDIX P

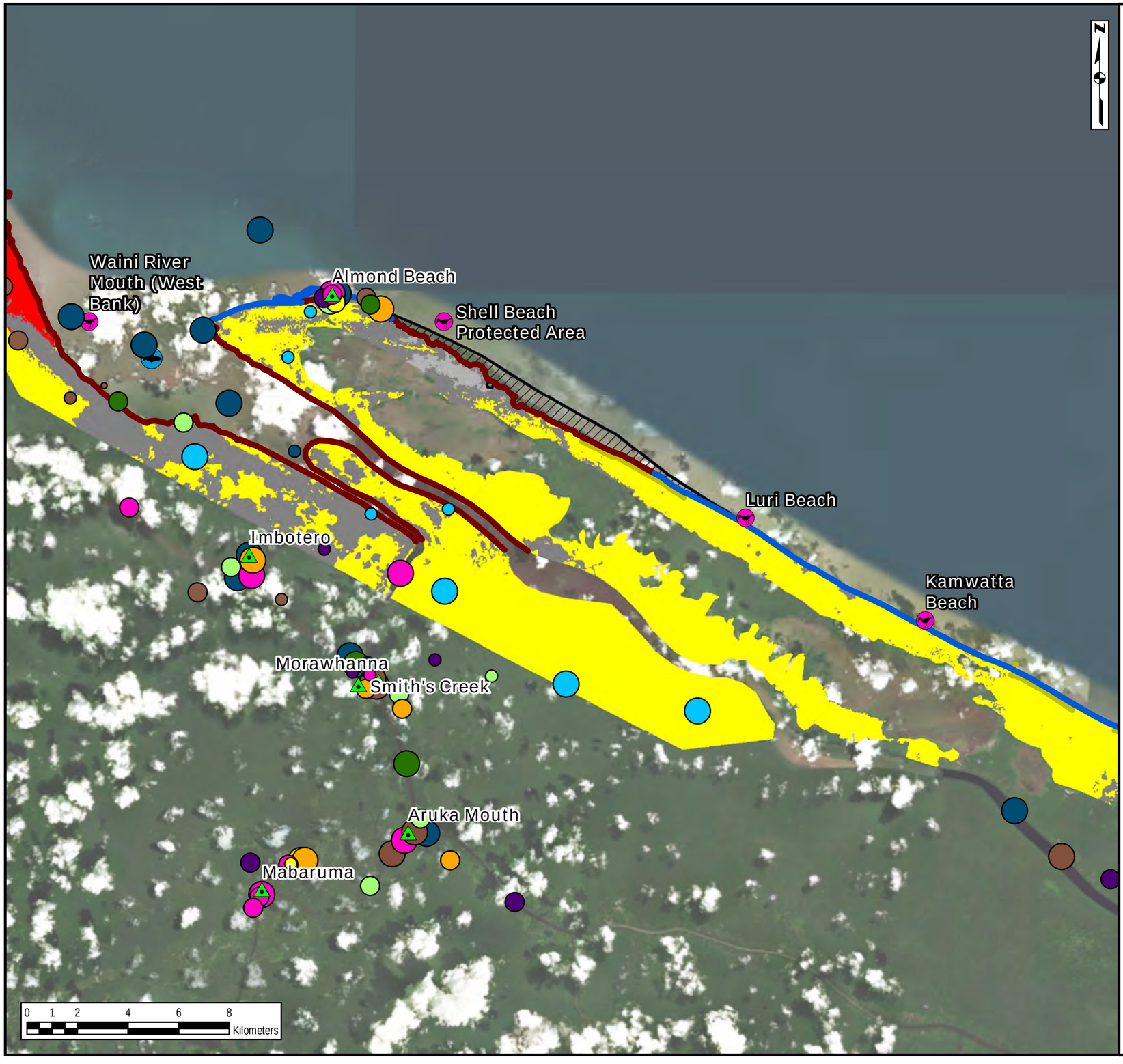
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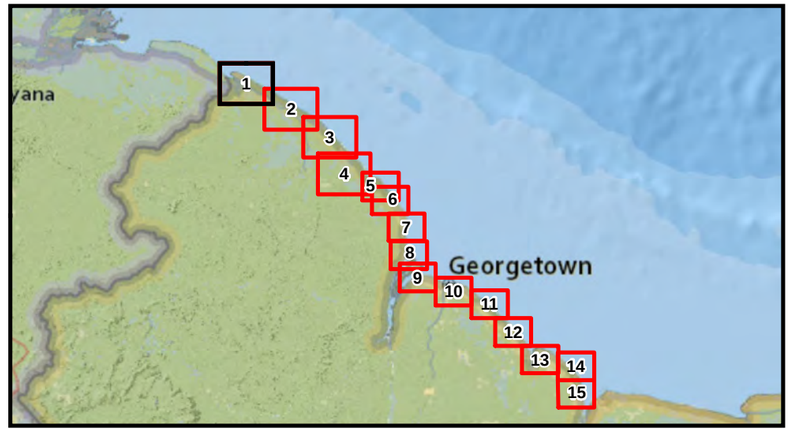
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Guyana

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Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
- Ritual / Religious
- Social / Cultural
- Trapping / Hunting
- Other

Priority

- Low
- Medium
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Environmental Sensitivity Index (ESI)

Shorelines

- 1B: Exposed, Solid Man-Made Structures
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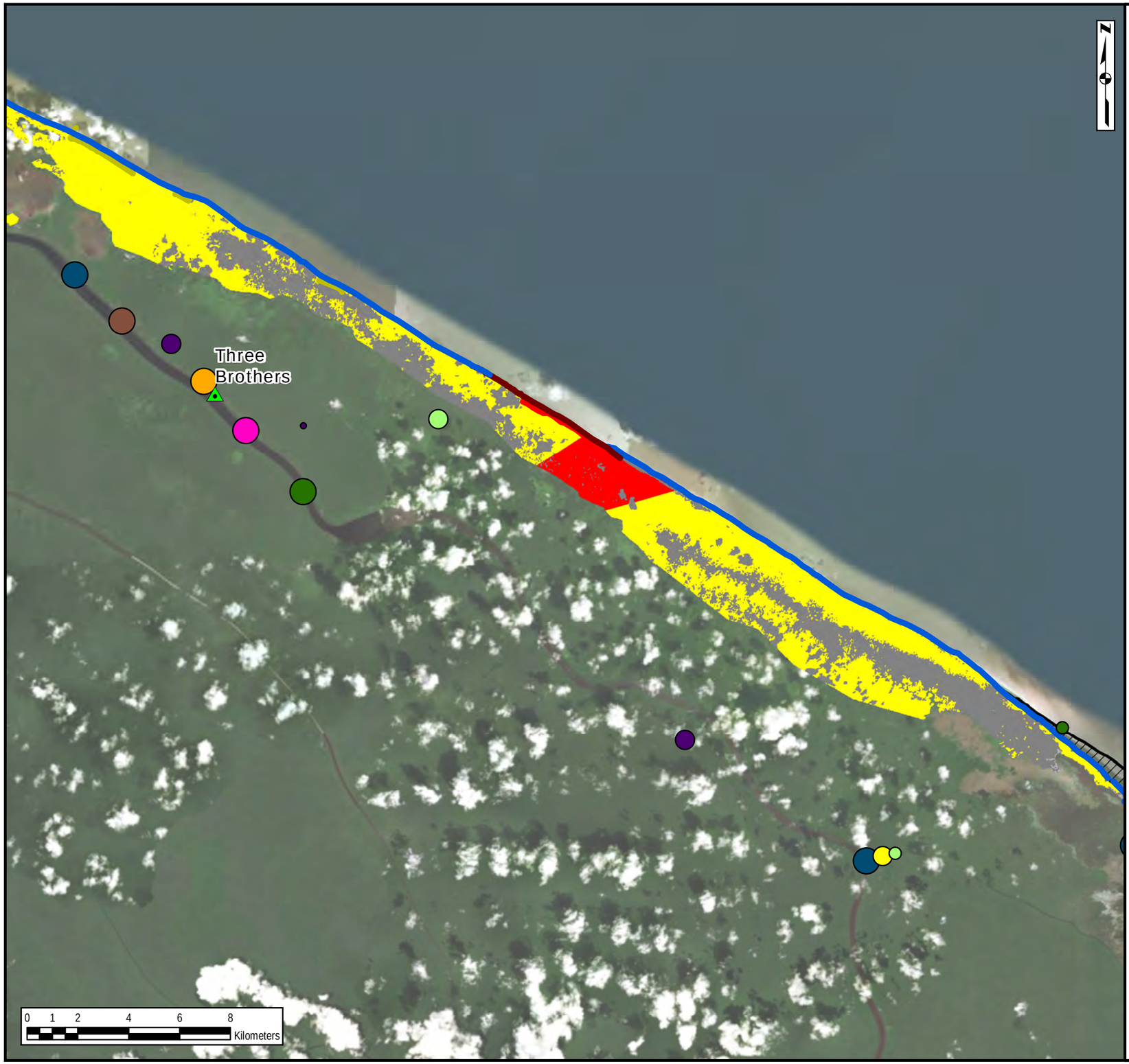
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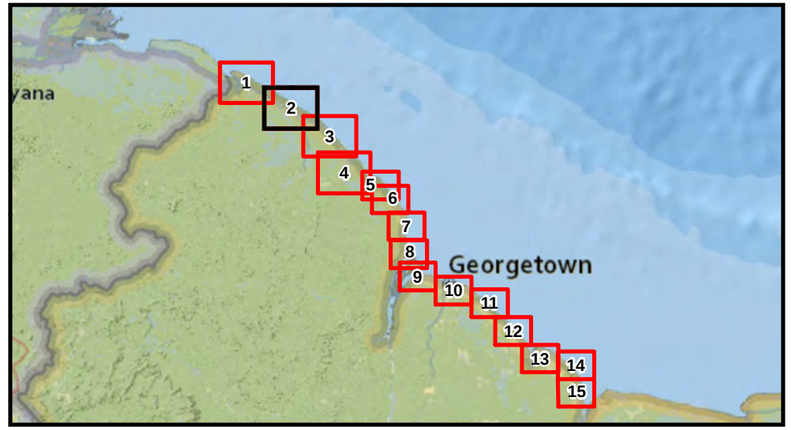
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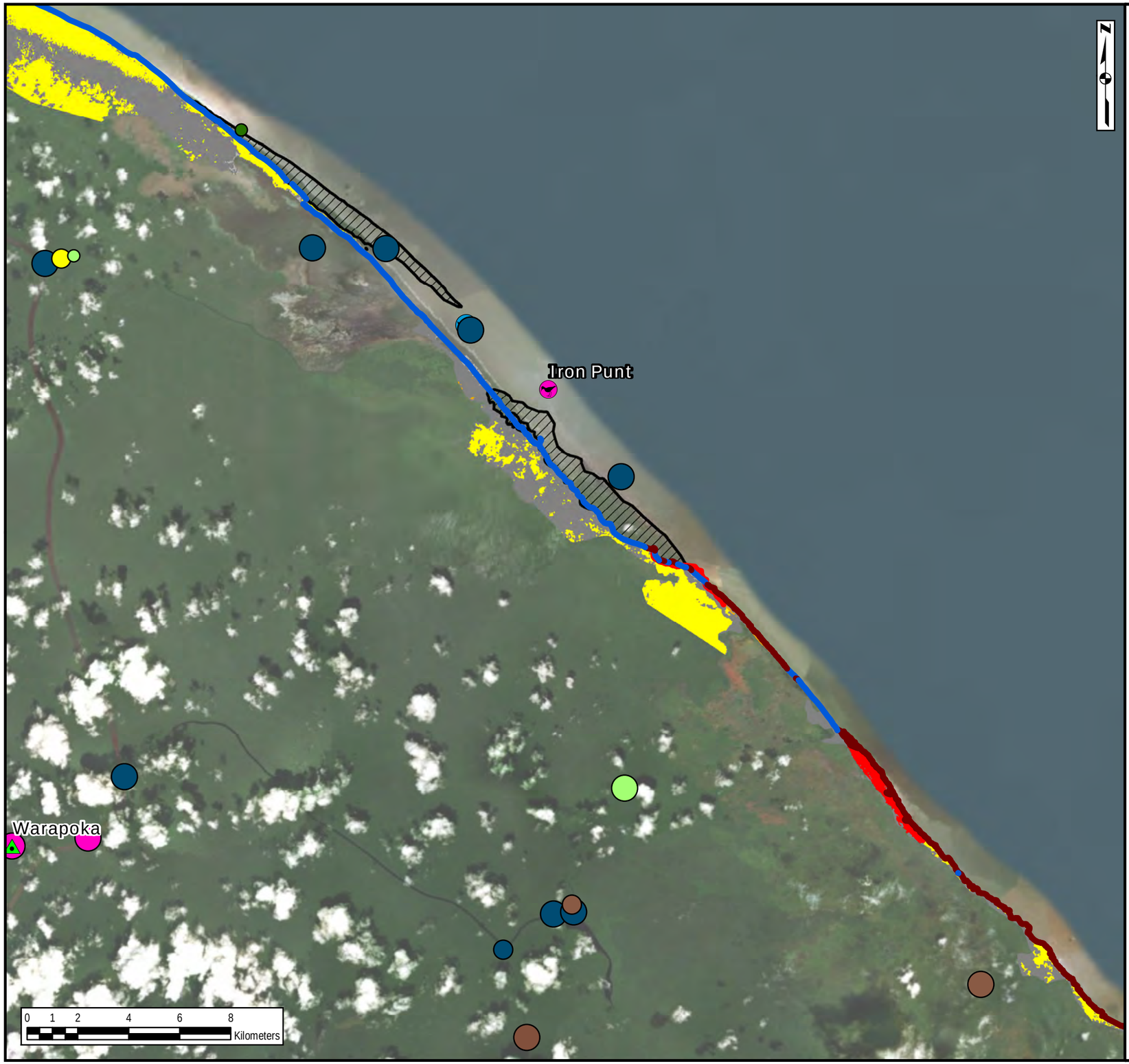
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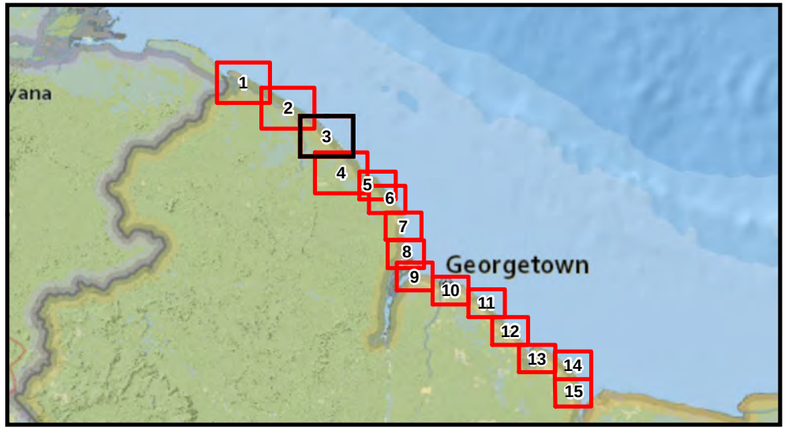
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Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

Fishing
Agriculture
Biodiversity
Carbon Sequestration
Ecotourism
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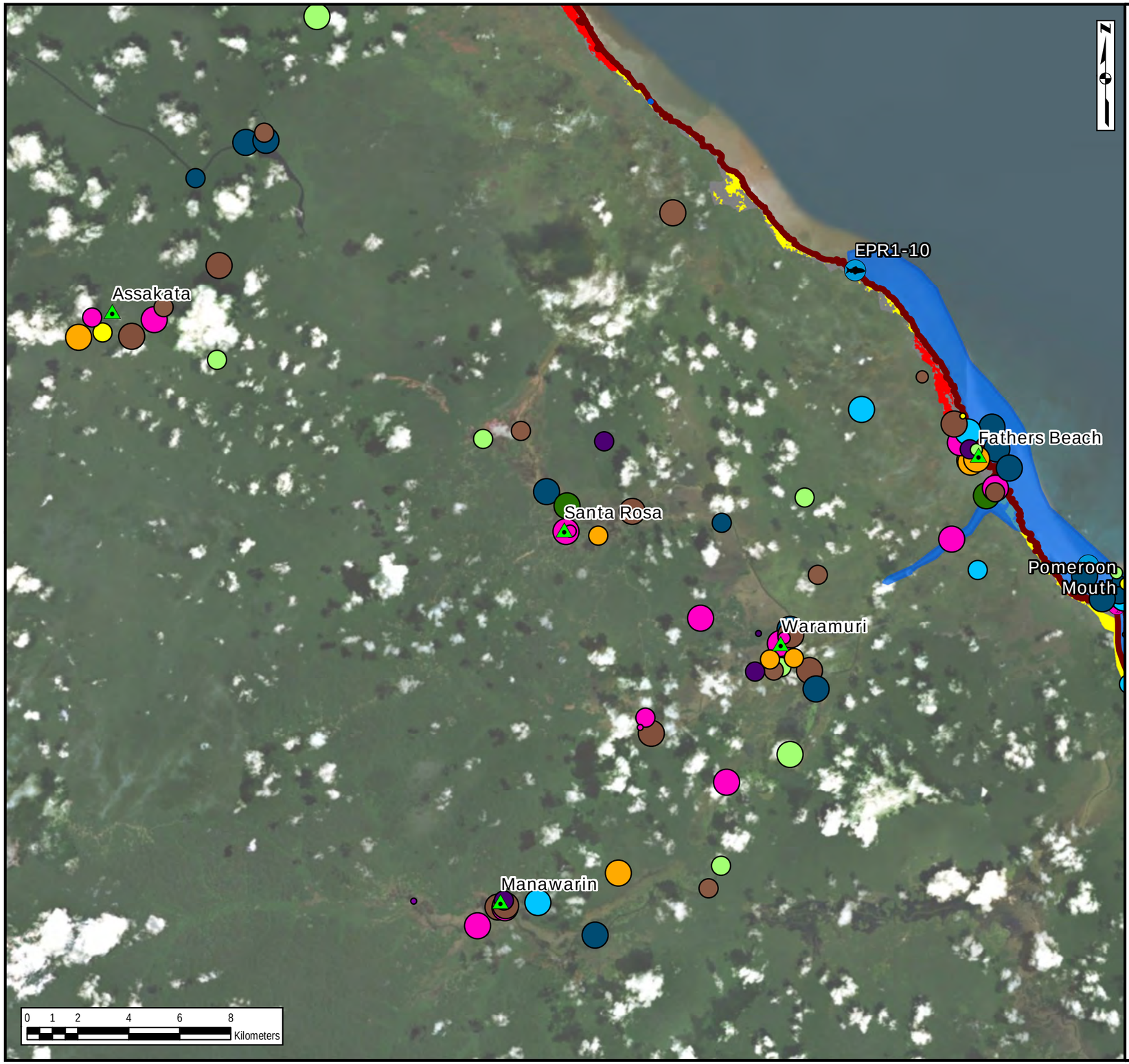
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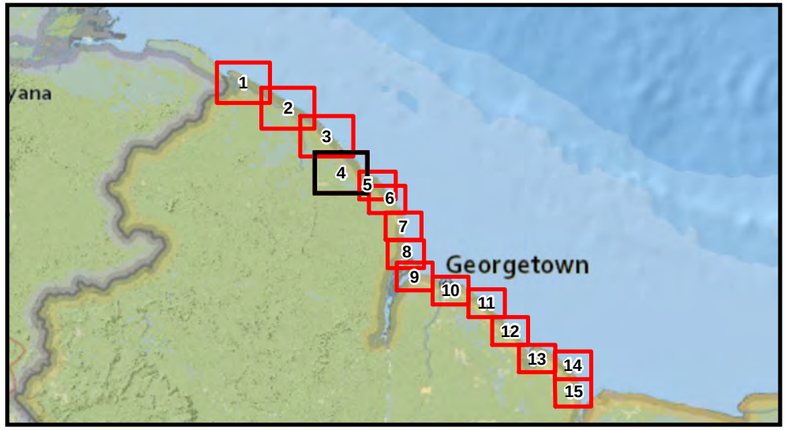
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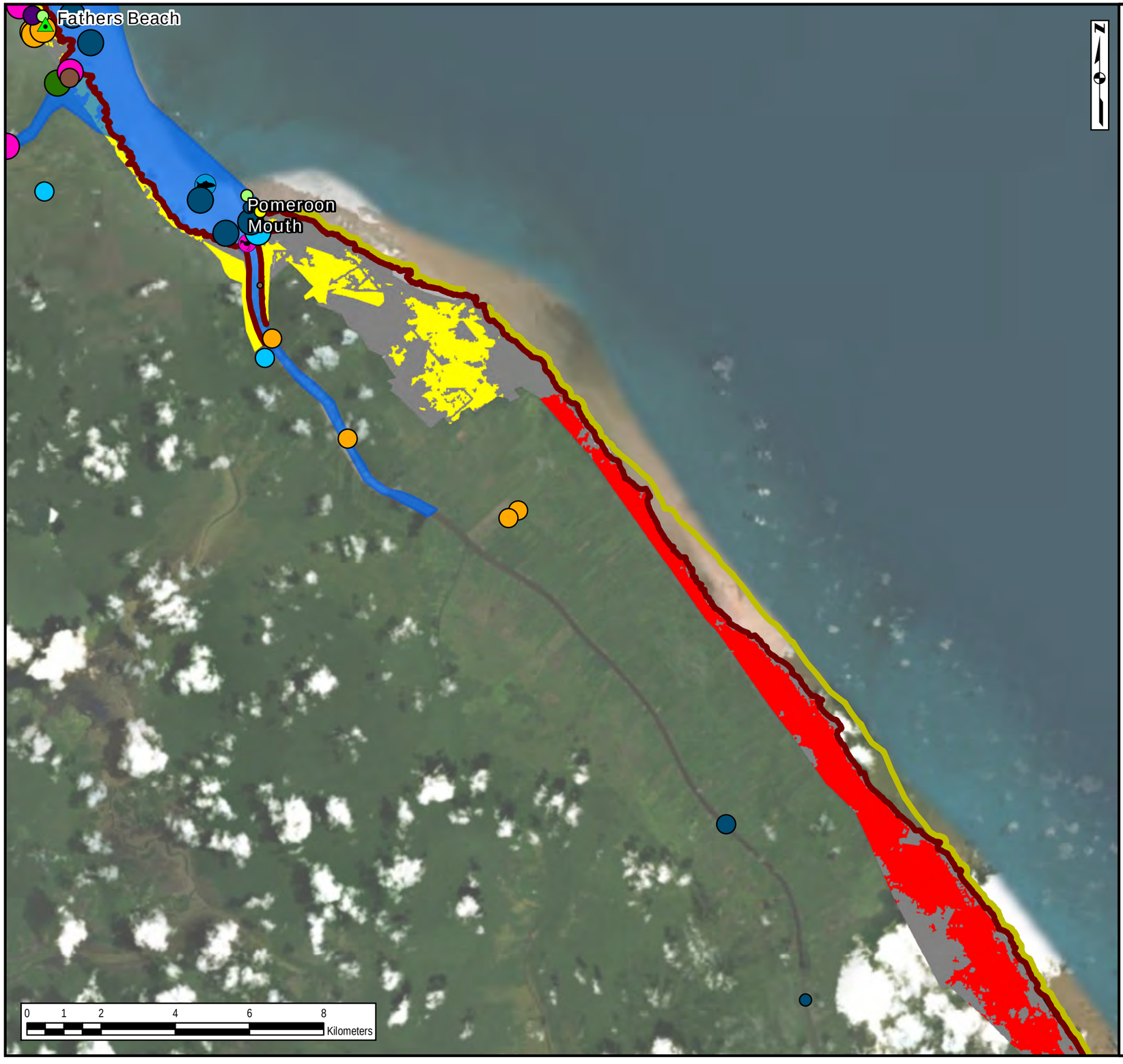
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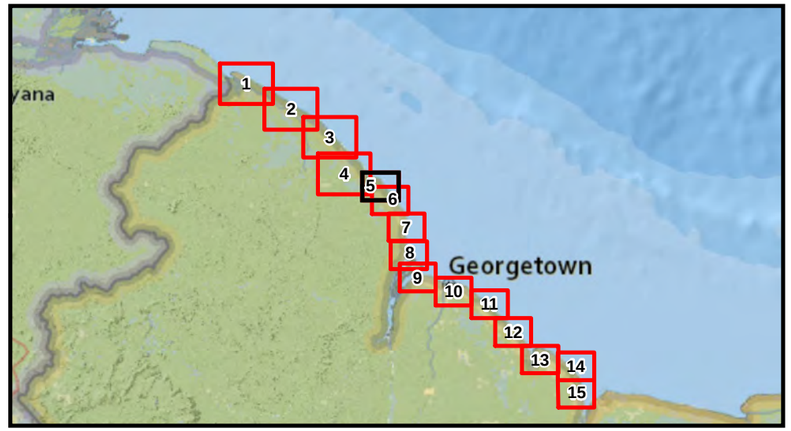
Social and Biodiversity Sensitivities

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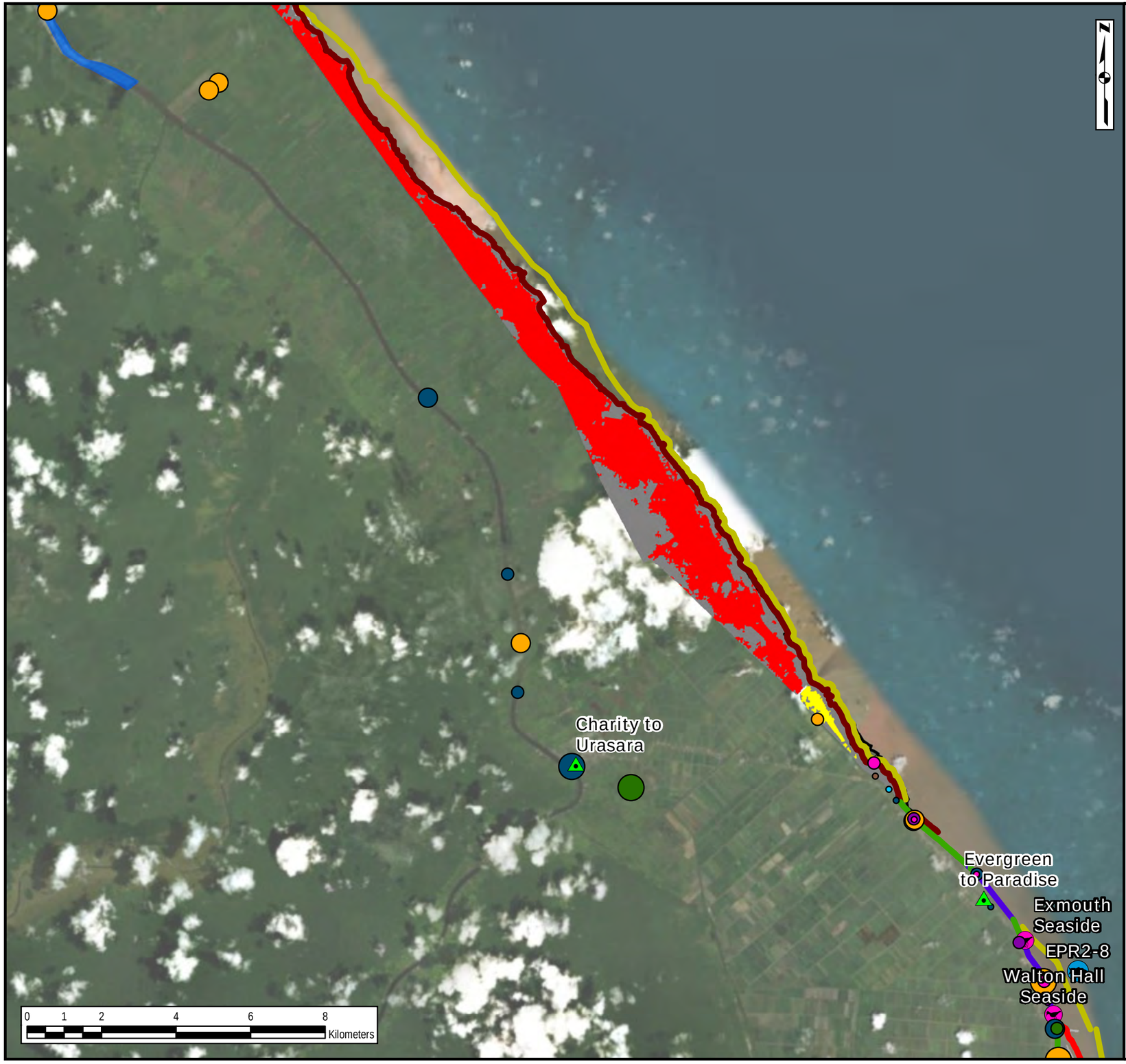
Mangrove Sensitivity

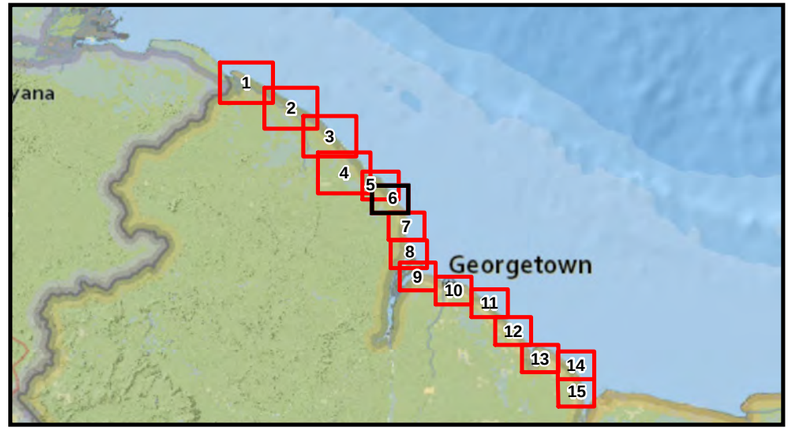
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Social and Biodiversity Sensitivities
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Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

Fishing
Agriculture
Biodiversity
Carbon Sequestration
Ecotourism
Crabbing
Mangroves
Traditional Resources
Ritual / Religious
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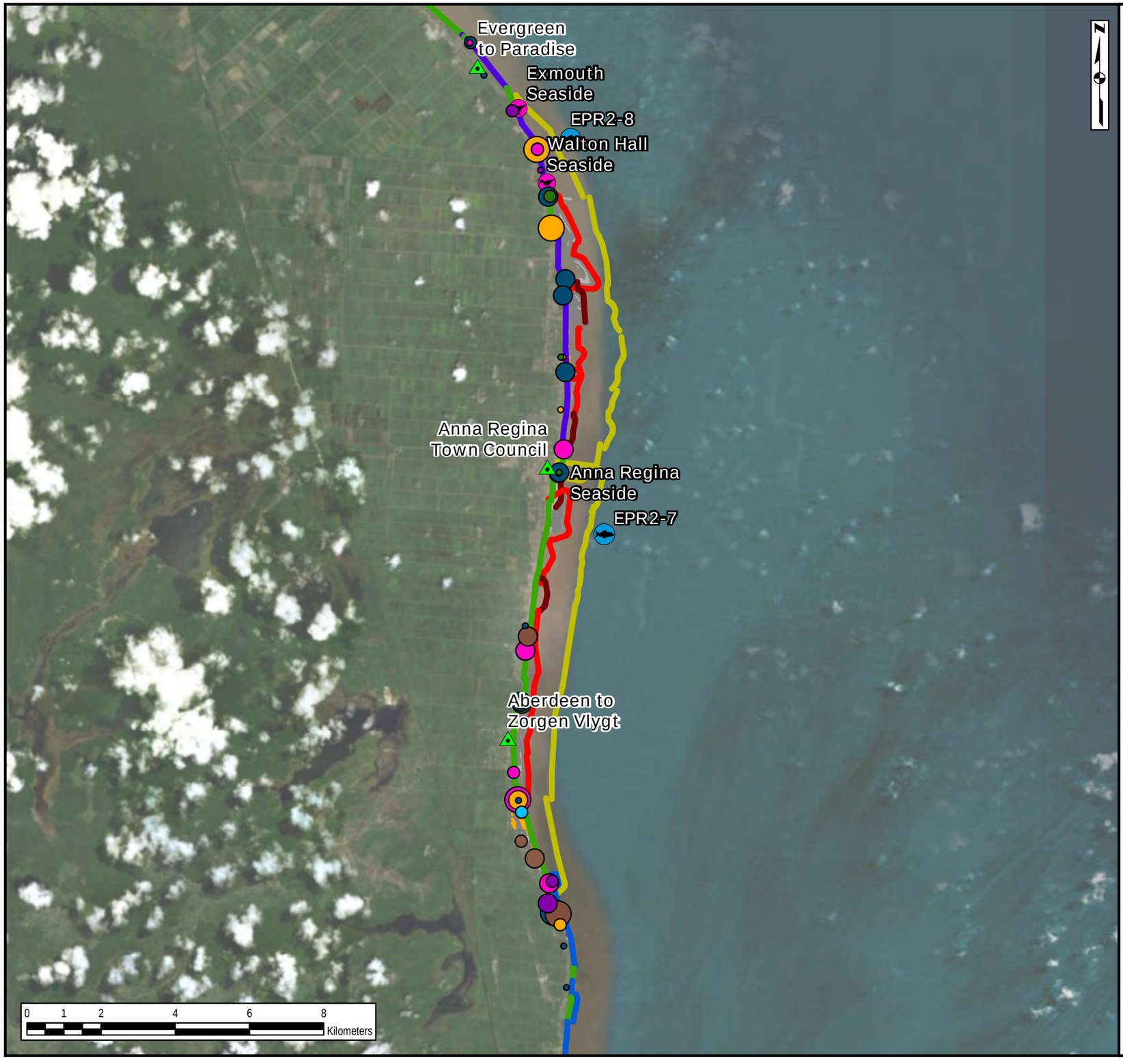
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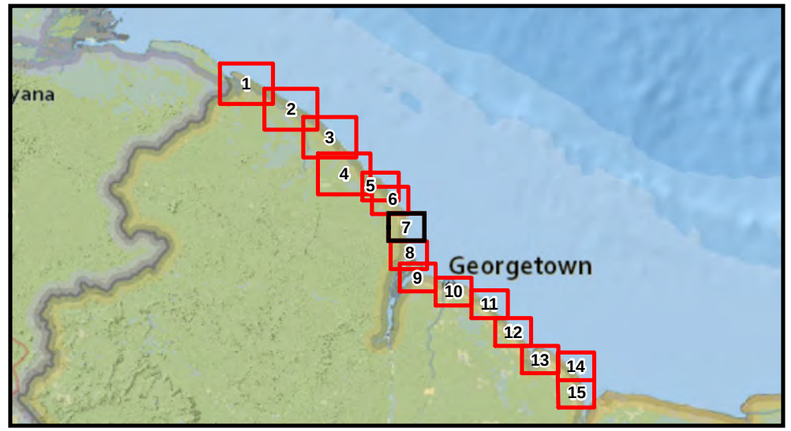
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Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

Fishing
Agriculture
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Carbon Sequestration
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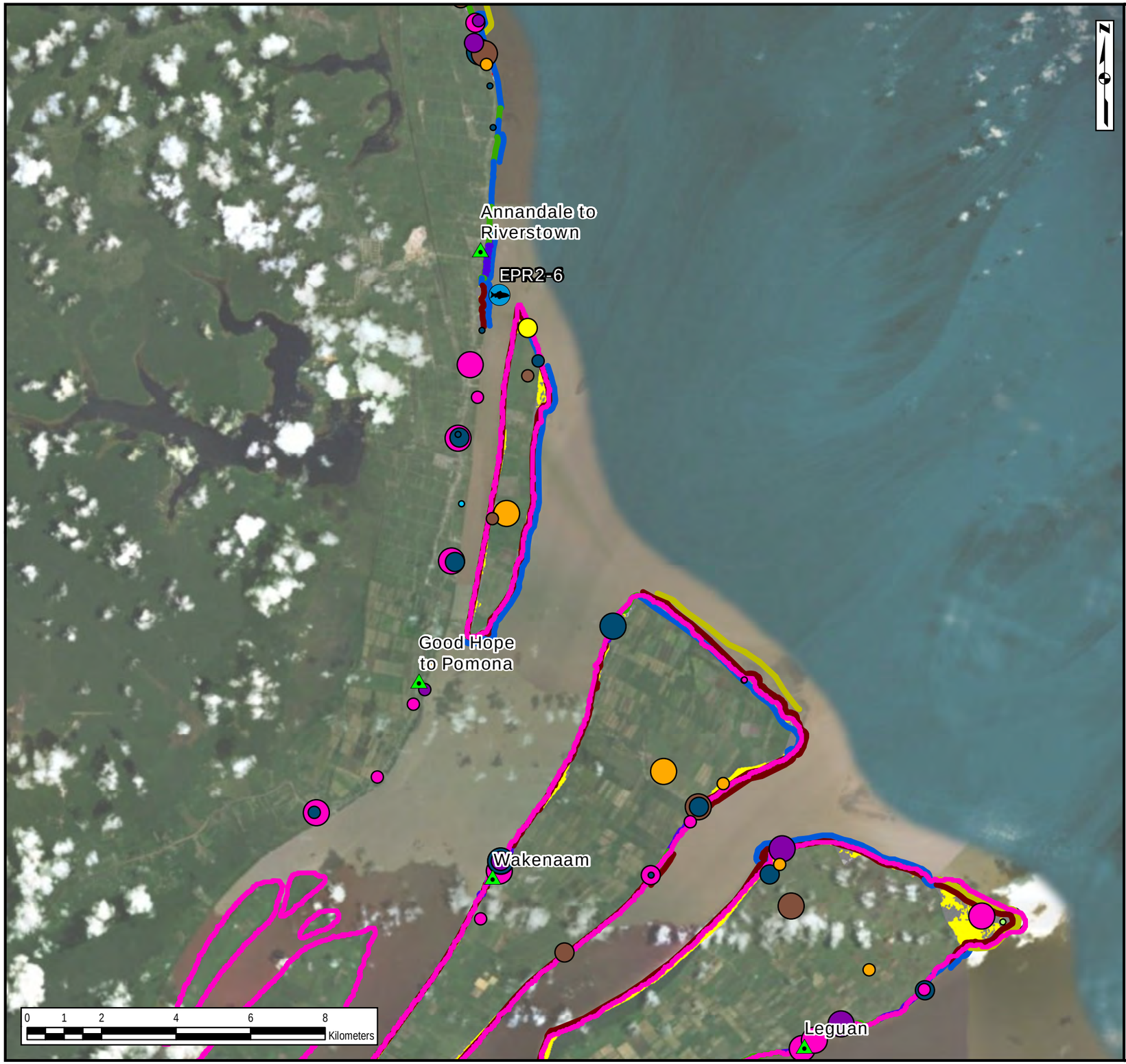
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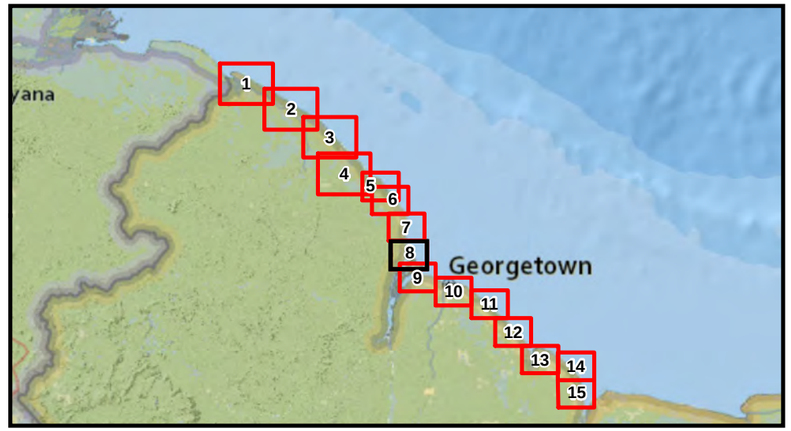
Social and Biodiversity Sensitivities

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Legend

- NDC/CDC/VC/Town Council
- Essequibo Islands Important Bird Habitat
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
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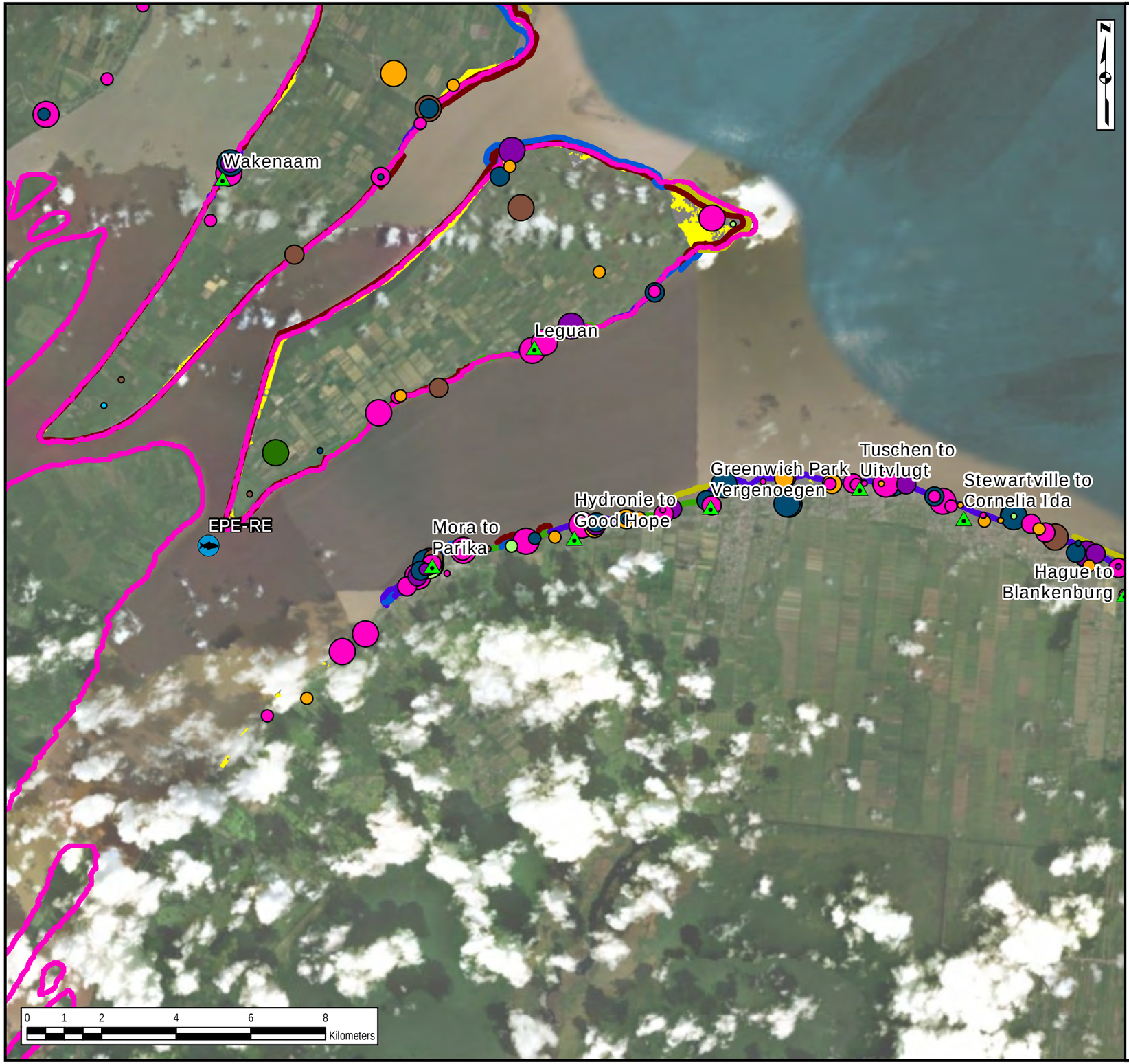
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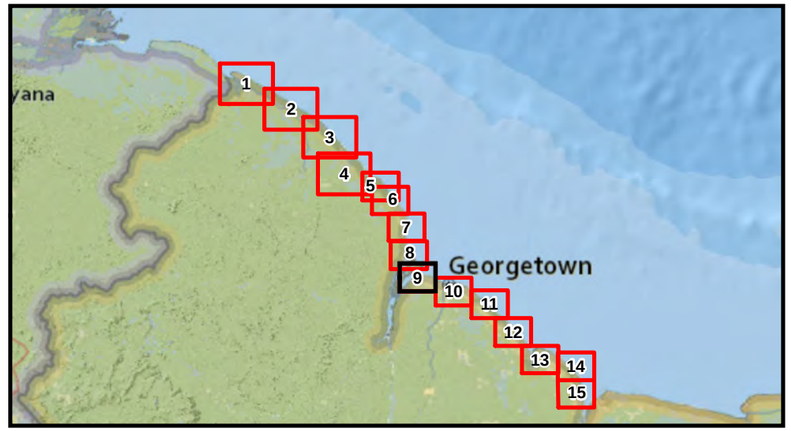
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Legend

- NDC/CDC/VC/Town Council
- Essequibo Islands Important Bird Habitat
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

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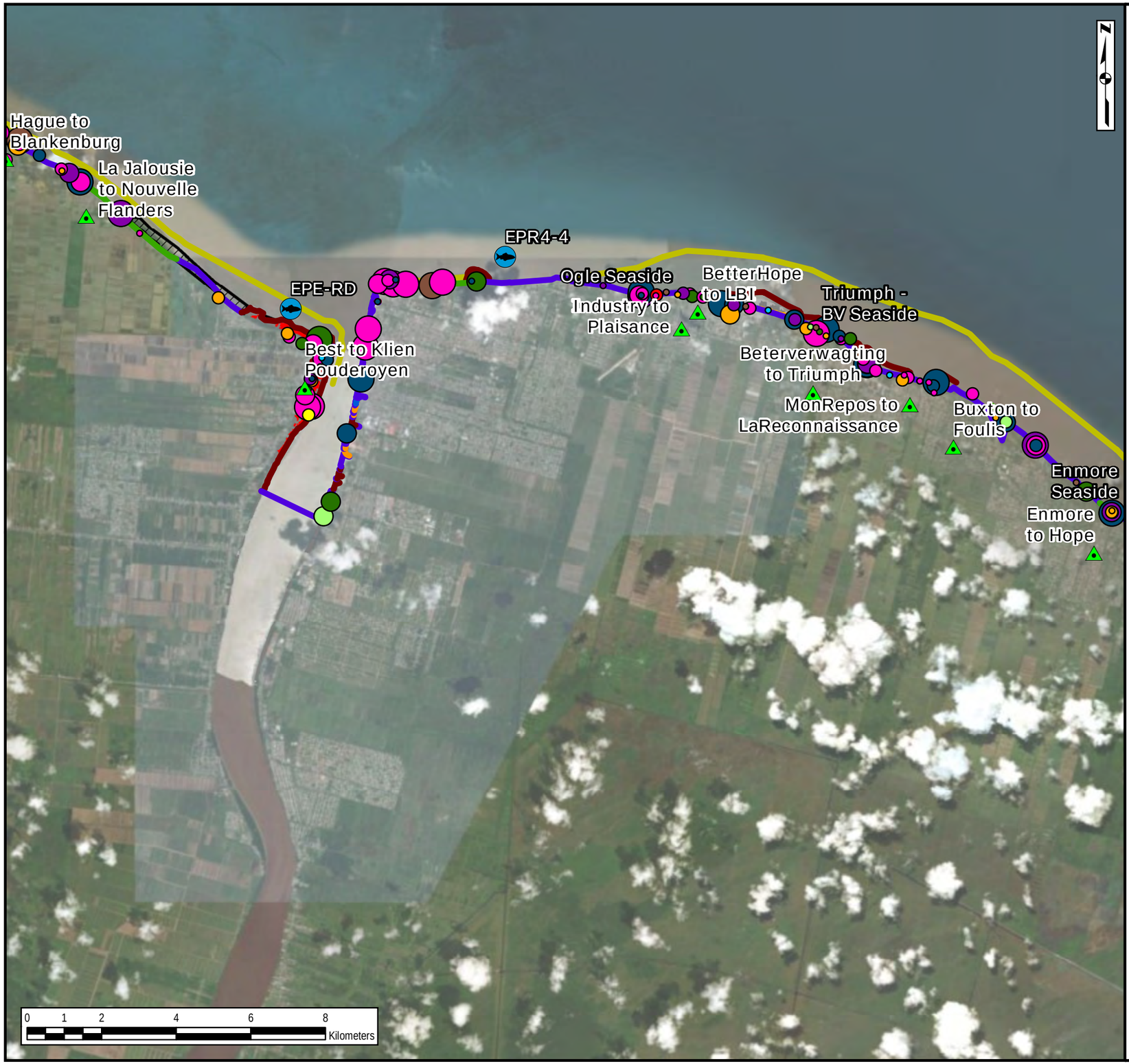
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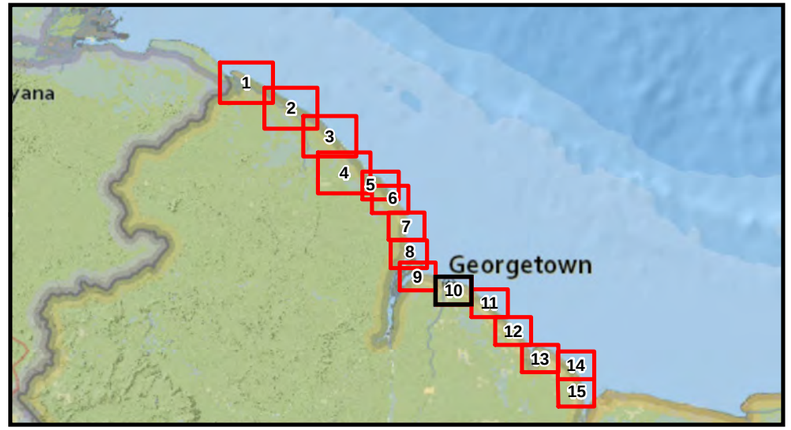
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Ecosystem Services

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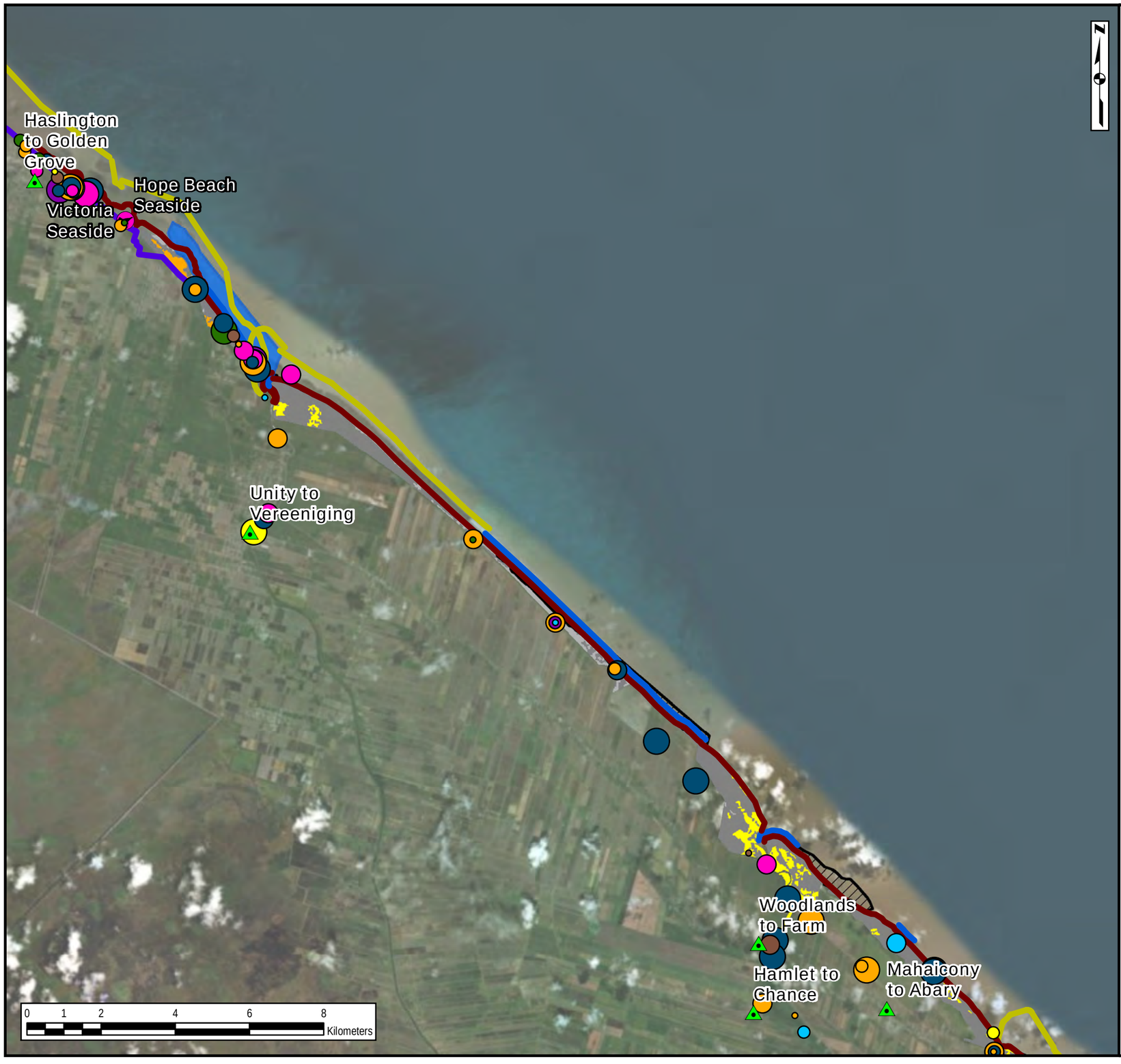
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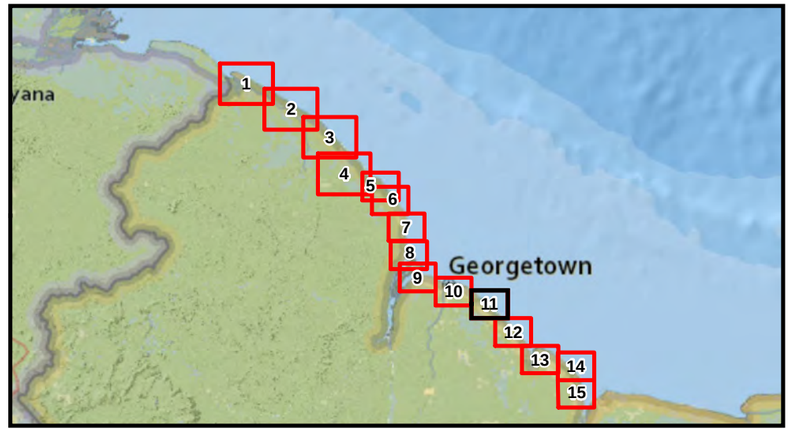
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Legend

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- Important Bird Habitats
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Ecosystem Services

Types

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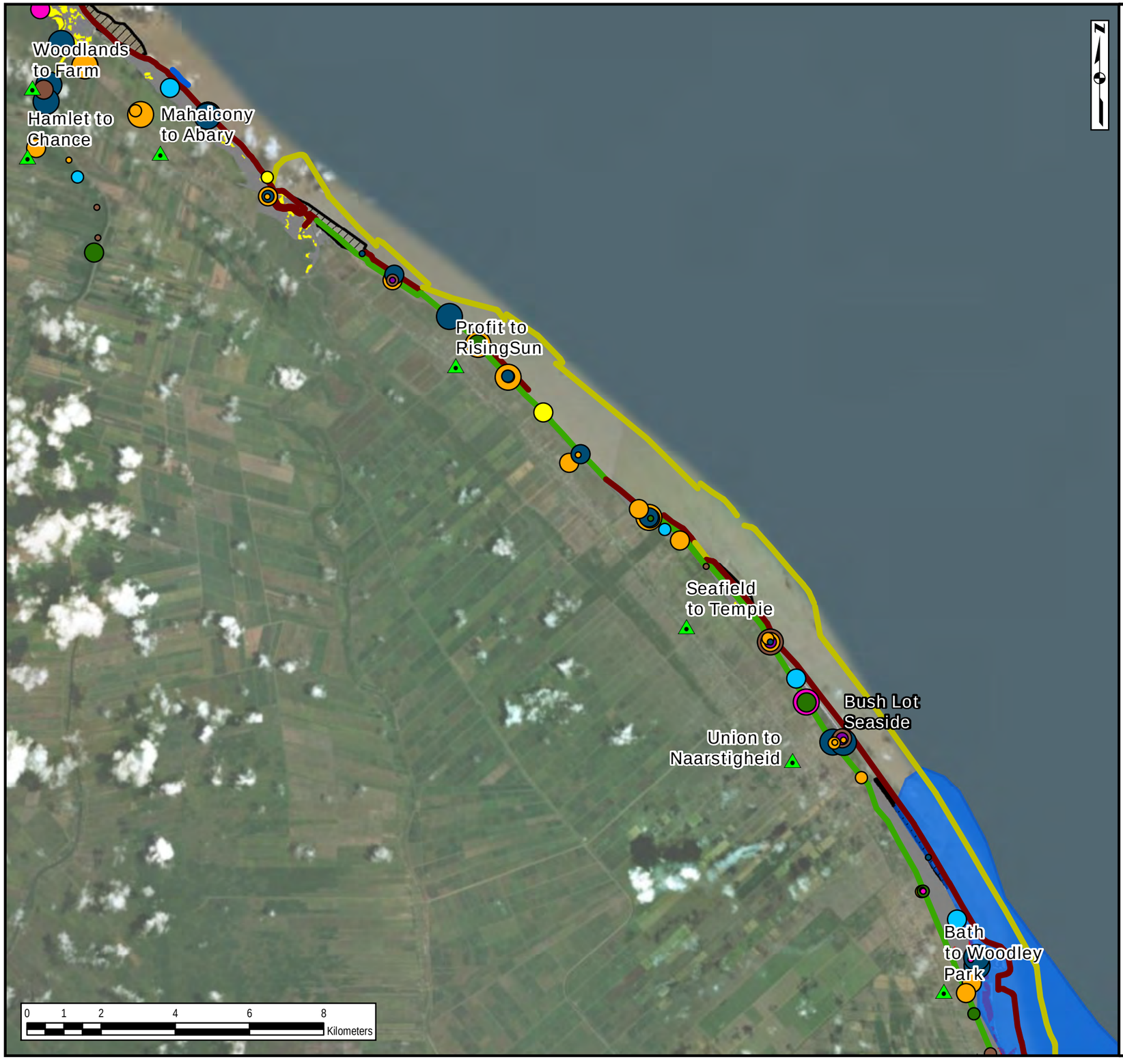
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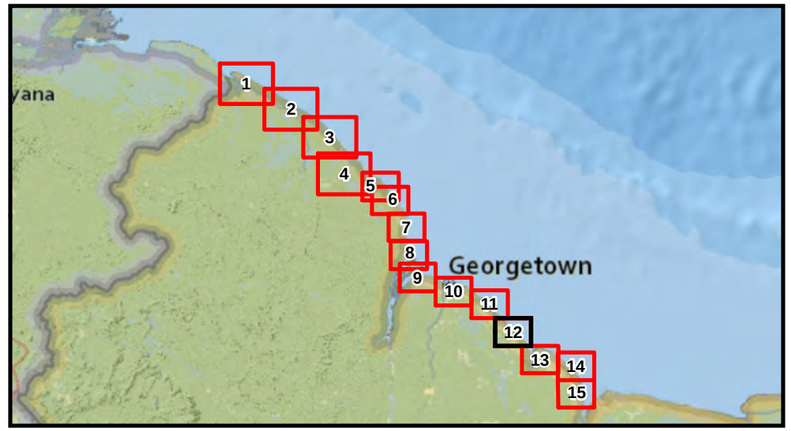
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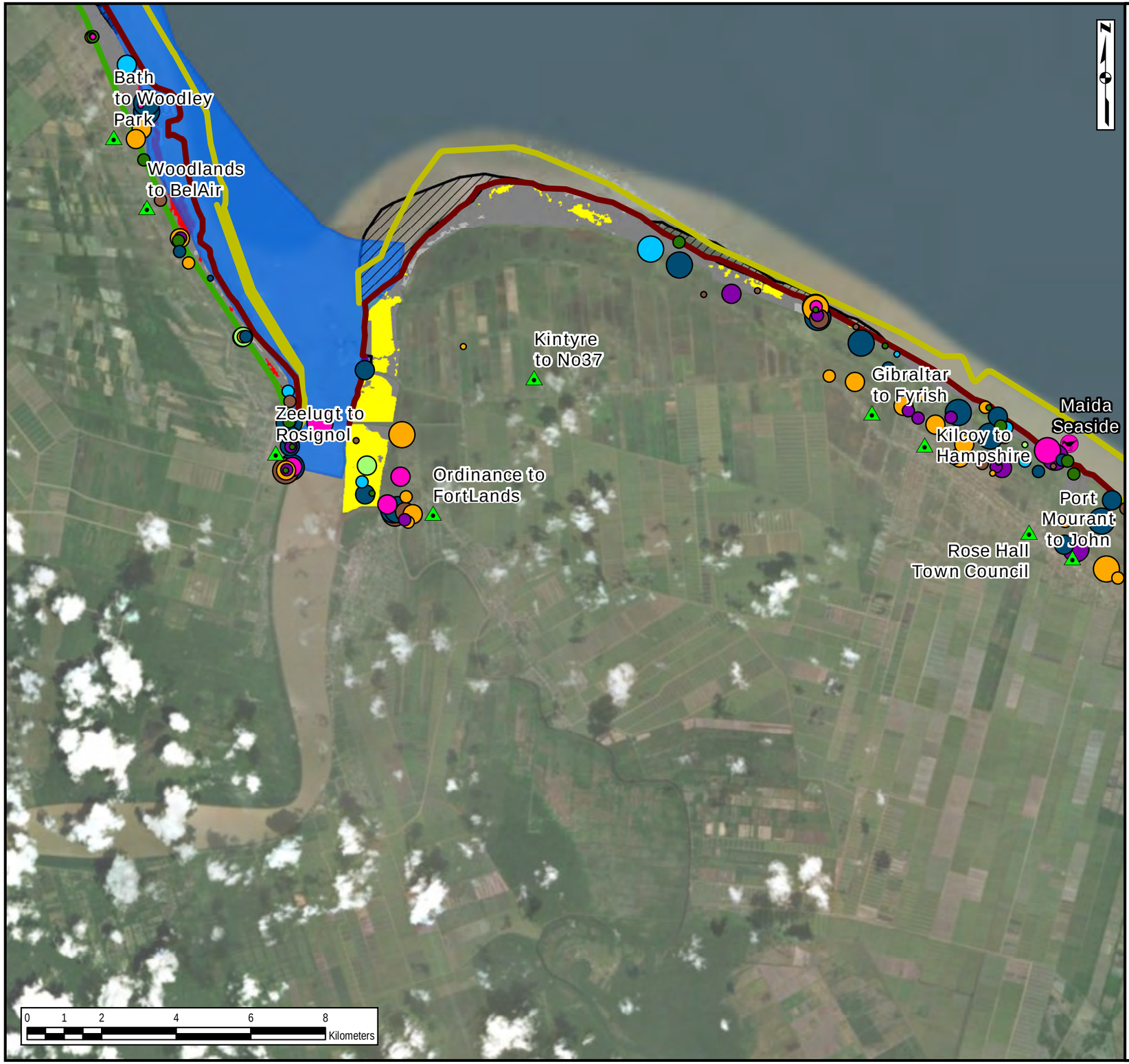
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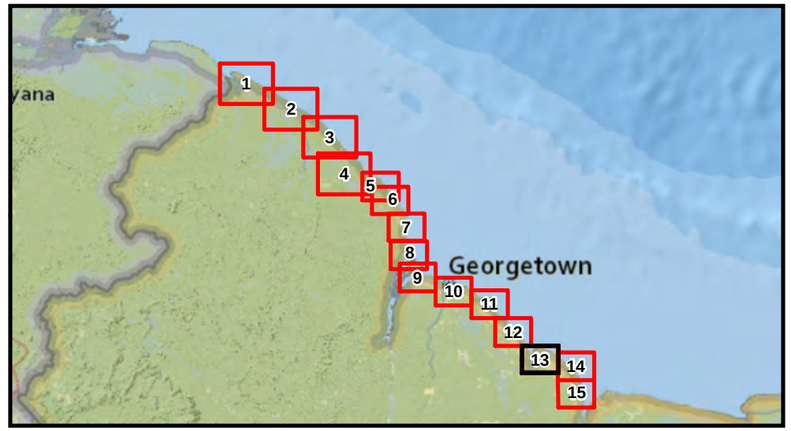
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Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
- Ritual / Religious
- Social / Cultural
- Trapping / Hunting
- Other

Priority

- Low
- Medium
- High
- Critical

Environmental Sensitivity Index (ESI)

Shorelines

- 1B: Exposed, Solid Man-Made Structures
- 3A: Fine to Medium Grained Sand Beaches
- 6B: Riprap
- 7: Exposed Tidal Flats
- 9B: Vegetated Low Banks
- 10A: Salt and Brackish Water Marshes
- 10D: Mangroves
- Important Fish Habitats Areas

Mangrove Sensitivity

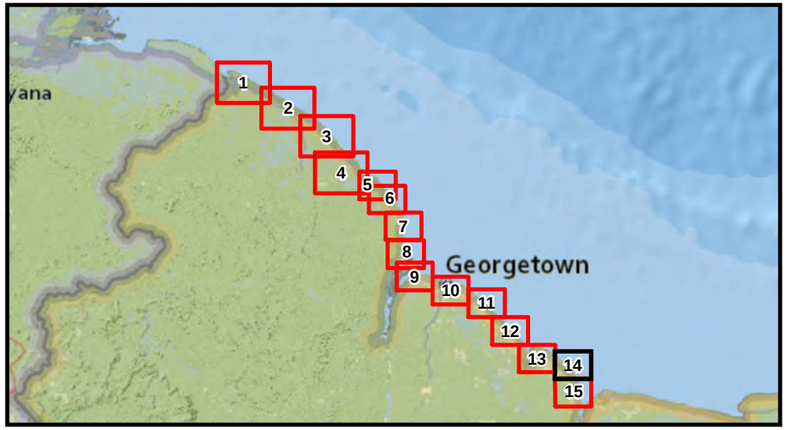
- Critical Sensitivity(Mature and Growing)
- Very High Sensitivity(Young and Growing)
- High Sensitivity(Mature and Degrading)
- Medium Sensitivity
- Low Sensitivity
- Fully Eroded

Social and Biodiversity Sensitivities
EEPGL
Regions 1-6 Guyana
Febuary 2020

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Legend

- NDC/CDC/VC/Town Council
- Important Bird Habitats
- Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
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Environmental Sensitivity Index (ESI)

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- 10D: Mangroves
- Important Fish Habitats Areas

Mangrove Sensitivity

- Critical Sensitivity(Mature and Growing)
- Very High Sensitivity(Young and Growing)
- High Sensitivity(Mature and Degrading)
- Medium Sensitivity
- Low Sensitivity
- Fully Eroded

Social and Biodiversity Sensitivities

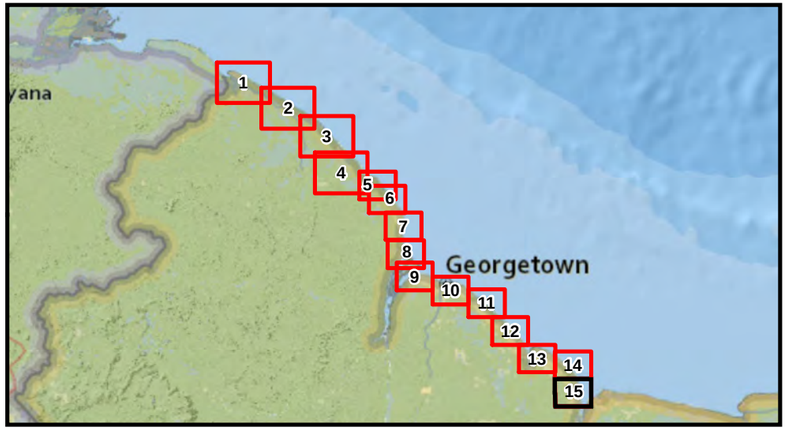
EEPGL
Regions 1-6 Guyana
Febuary 2020

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Legend

NDC/CDC/VC/Town Council
Important Bird Habitats
Important Fish Habitats

Ecosystem Services

Types

- Fishing
- Agriculture
- Biodiversity
- Carbon Sequestration
- Ecotourism
- Crabbing
- Mangroves
- Traditional Resources
- Ritual / Religious
- Social / Cultural
- Trapping / Hunting
- Other

Priority

- Low
- Medium
- High
- Critical

Environmental Sensitivity Index (ESI)

Shorelines

- 1B: Exposed, Solid Man-Made Structures
- 3A: Fine to Medium Grained Sand Beaches
- 6B: Riprap
- 7: Exposed Tidal Flats
- 9B: Vegetated Low Banks
- 10A: Salt and Brackish Water Marshes
- 10D: Mangroves
- Important Fish Habitats Areas

Mangrove Sensitivity

- Critical Sensitivity(Mature and Growing)
- Very High Sensitivity(Young and Growing)
- High Sensitivity(Mature and Degrading)
- Medium Sensitivity
- Low Sensitivity
- Fully Eroded

Social and Biodiversity Sensitivities

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Regions 1-6 Guyana
Febuary 2020

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Trinidad and Tobago

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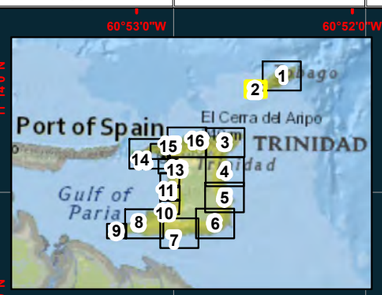
Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- Mangrove Areas (ESI
- Coral Reefs
- Turtle Nesting
- Seagrass
- IUCN Category III, IV
- Police Stations
- School
- Port or Marina
- Rock

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 1 of 16
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02 July 2019

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Buccoo Reef

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Turtle Nesting
- Seagrass
- IUCN Category III, IV
- Police Stations
- School
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 2 of 16
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St. David Reserve

Eastern Extension Matura

Matura Swamp Reserve

Matura Reserve Western Ext.

Manzanilla Ext.

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Manatees
- Coral Reefs
- Turtle Nesting
- Seagrass
- IUCN Category I, II
- IUCN Category III, IV
- Police Stations
- School
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Matura Swamp Reserve

Manzanilla Ext.

Melajo Reserve

Manzanilla Windbelt Reserve

Long Stretch Reserve

Brigand Hill Reserve

Central Range Reserve

Port of Spain

El Cerra del Aripo

TRINIDAD

Gulf of Paria

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Mangrove Areas (ESI
- Manatees
- Turtle Nesting
- IUCN Category I, II
- IUCN Category III, IV
- Kindergarten
- School
- Rock

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Eccles ville Windbelt Reserve

Nariva Windbelt Reserve

Victoria Mayo Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Mangrove Areas (ESI
- Manatees

Marine International Protected

- Marine - RAMSAR
- IUCN Category III, IV
- Police Stations
- School
- Underwater Danger /Underwater Hazard

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Victoria
Mayo Reserve

0 1 2 3 4 5 Kilometers

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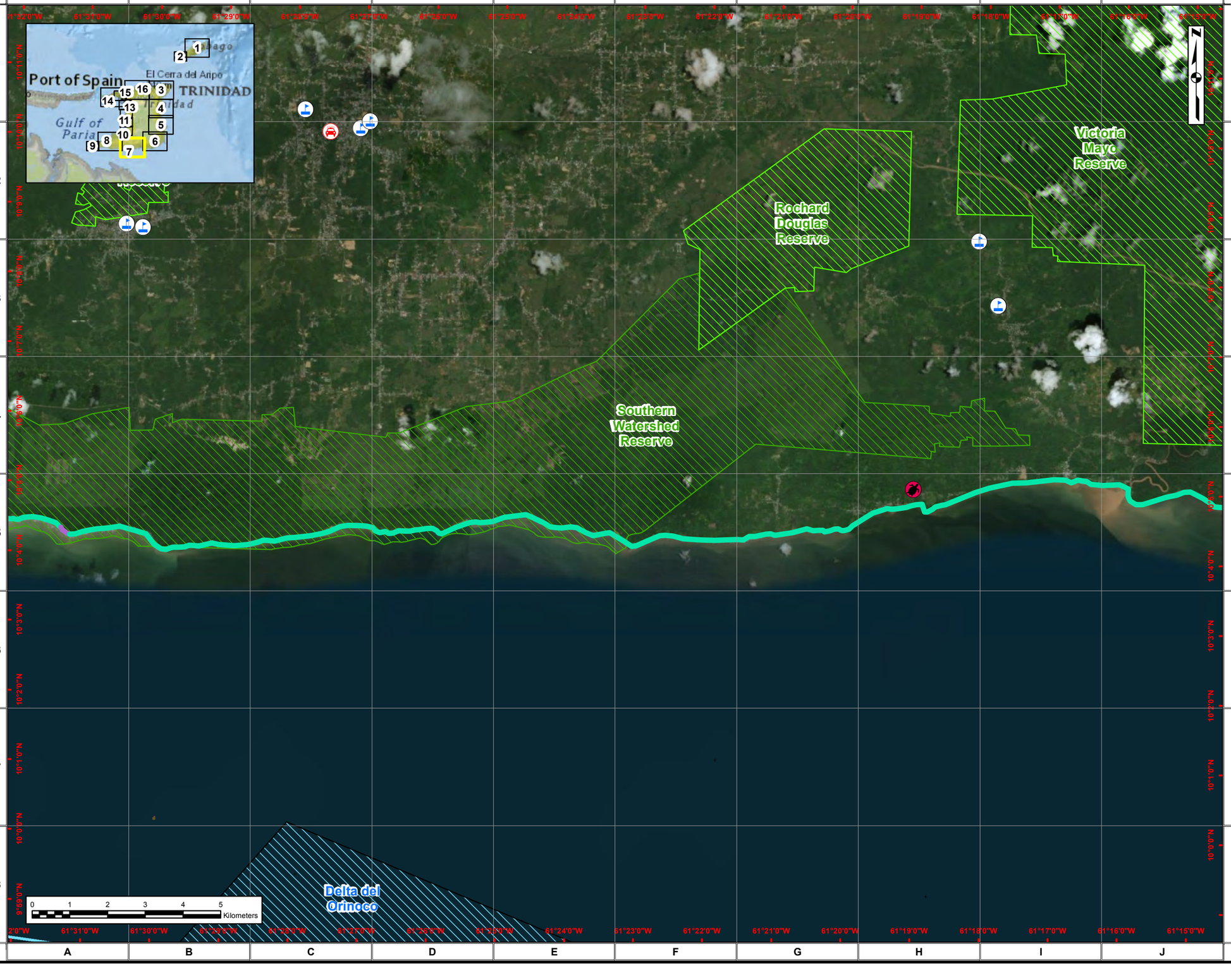
Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 9B - Vegetated low banks
- Mangrove Areas (ESI
- Manatees
- Turtle Nesting
- Seagrass
- IUCN Category III, IV
- Port or Marina
- Rock
- Shipping Route
- Seabed Pipelines

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category Not Reported
- Police Stations
- School
- Port or Marina
- Shipping Route
- Seabed Pipelines

Godineau Swamp Reserve

Morne L'Enfer Reserve

Siparia Reserve

Cap de Ville Reserve

Erin Reserve

Cedros Reserve

Southern Watershed Reserve

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
Map 8 of 16
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Shoreline Sensitivity (ESI)

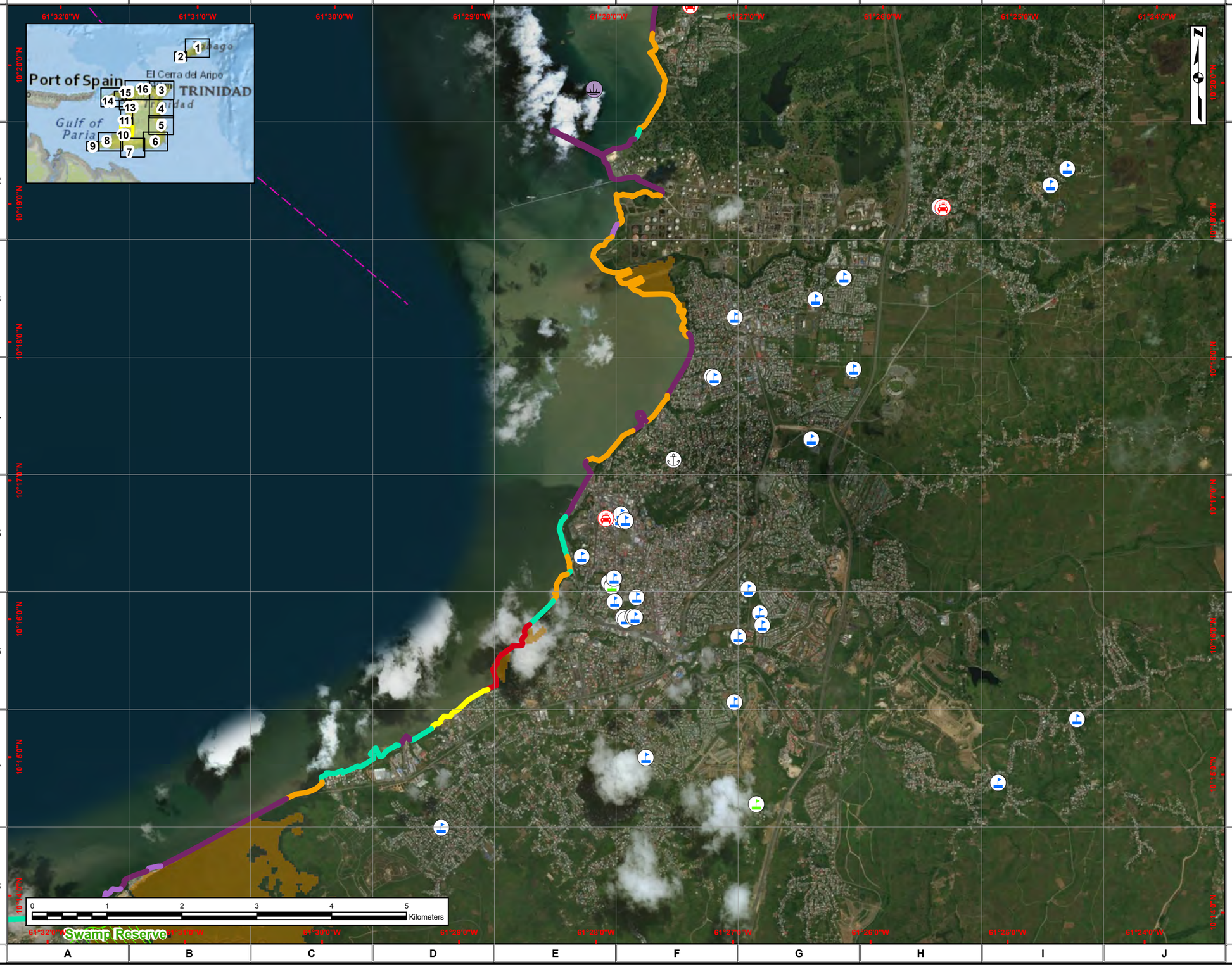
- 1/2 - Exposed cliffs, scarp slopes or
- 4/5 - Sand or gravel beach
- Mangrove Areas (ESI
- Turtle Nesting
- Police Stations
- School

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made
- 1/2 - Exposed cliffs, scarp slopes or
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI
- Seagrass
- IUCN Category III, IV
- Police Stations
- Kindergarten
- School
- Port or Marina
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- Seagrass
- Police Stations
- School
- Shipping Route

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Caroni Swamp Reserve



0 1 2 3 4 5 Kilometers

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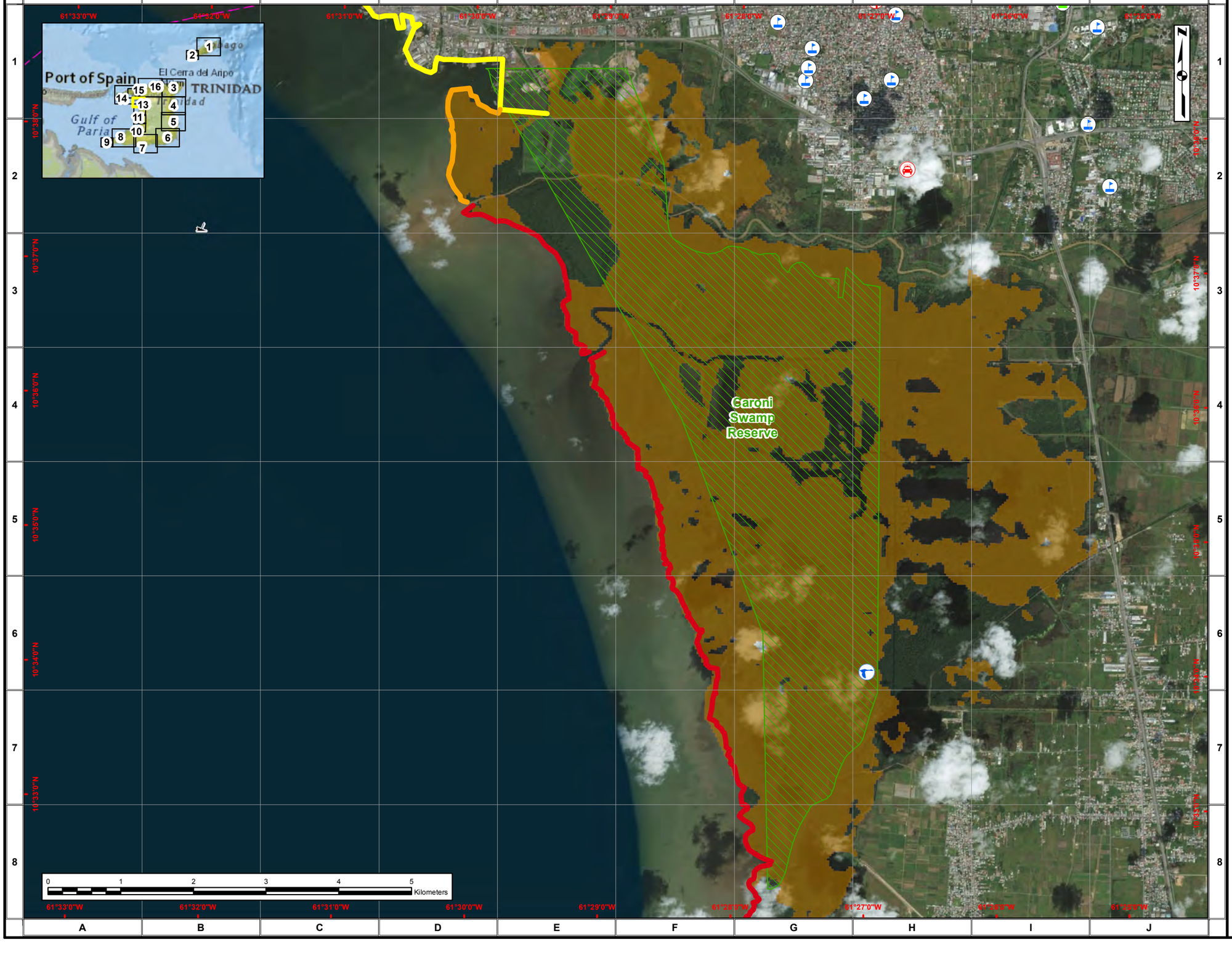
Shoreline Sensitivity (ESI)

- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- IUCN Category I, II
- Kindergarten
- School
- Port or Marina
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Shoreline Sensitivity (ESI)

- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)

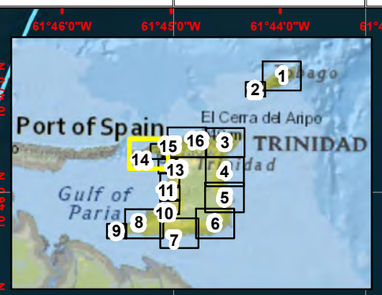
Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II
- Police Stations
- Kindergarten
- School
- Wreck
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Seagrass
- IUCN Category I, II
- Police Stations
- School
- College
- Port or Marina
- Wreck
- Shipping Route
- Seabed Cables
- Territorial Waters Boundary

Caroni Swamp Reserve

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- Mangrove Areas (ESI 10D)
- Seagrass
- Police Stations
- School
- College
- Port or Marina
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Las Cuevas Reserve

Yarra Reserve

Blanchisseuse Reserve

Paria Reserve

Nrrb.

Nrrc.

Nrra.

Tacarigua Reserve

Arima Reserve

0 1 2 3 4 5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- Turtle Nesting
- IUCN Category I, II
- IUCN Category III, IV
- Police Stations
- School

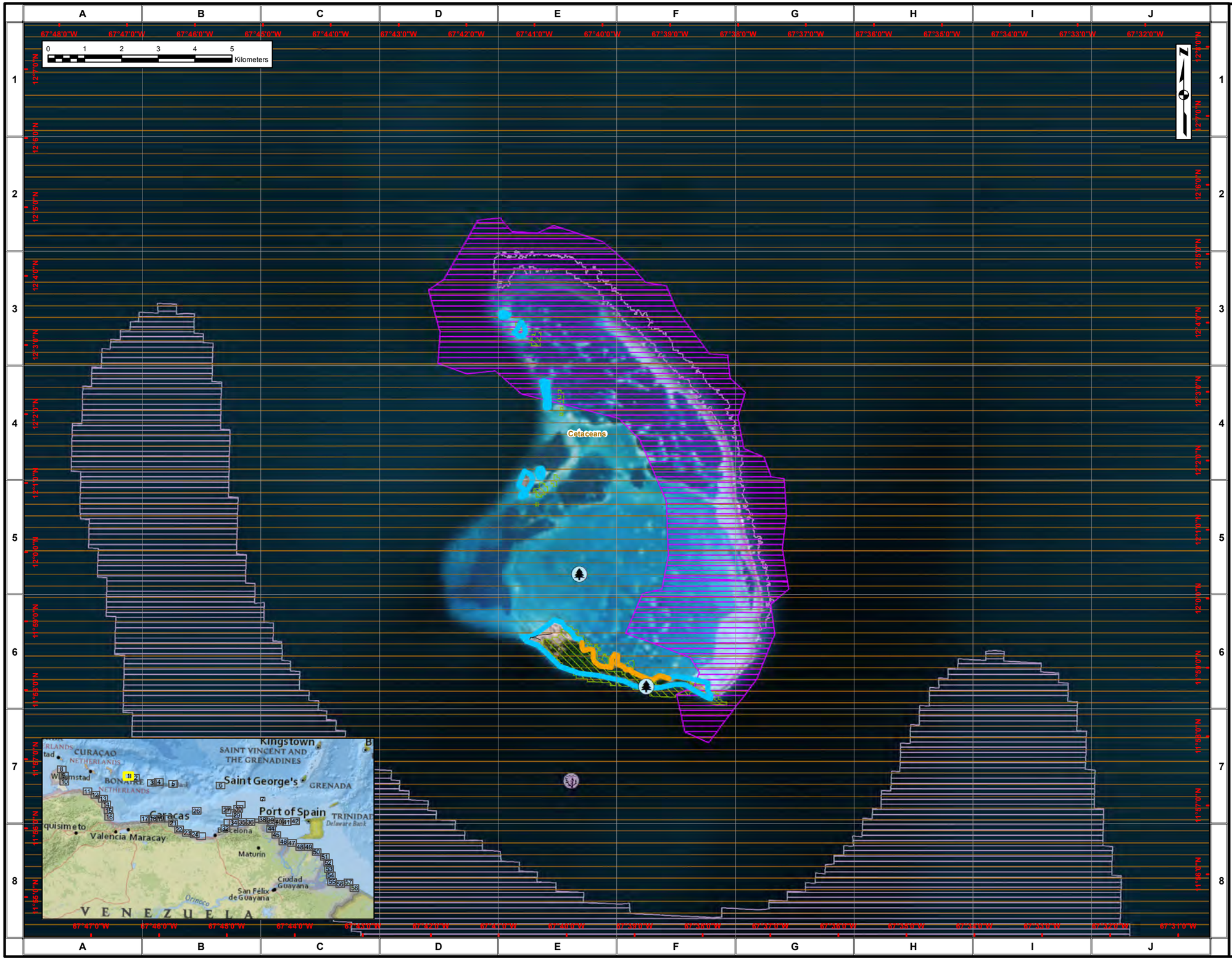
Coastal Sensitivity and Spill Response
Shoreline Access
Trinidad and Tobago
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Venezuela

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Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef

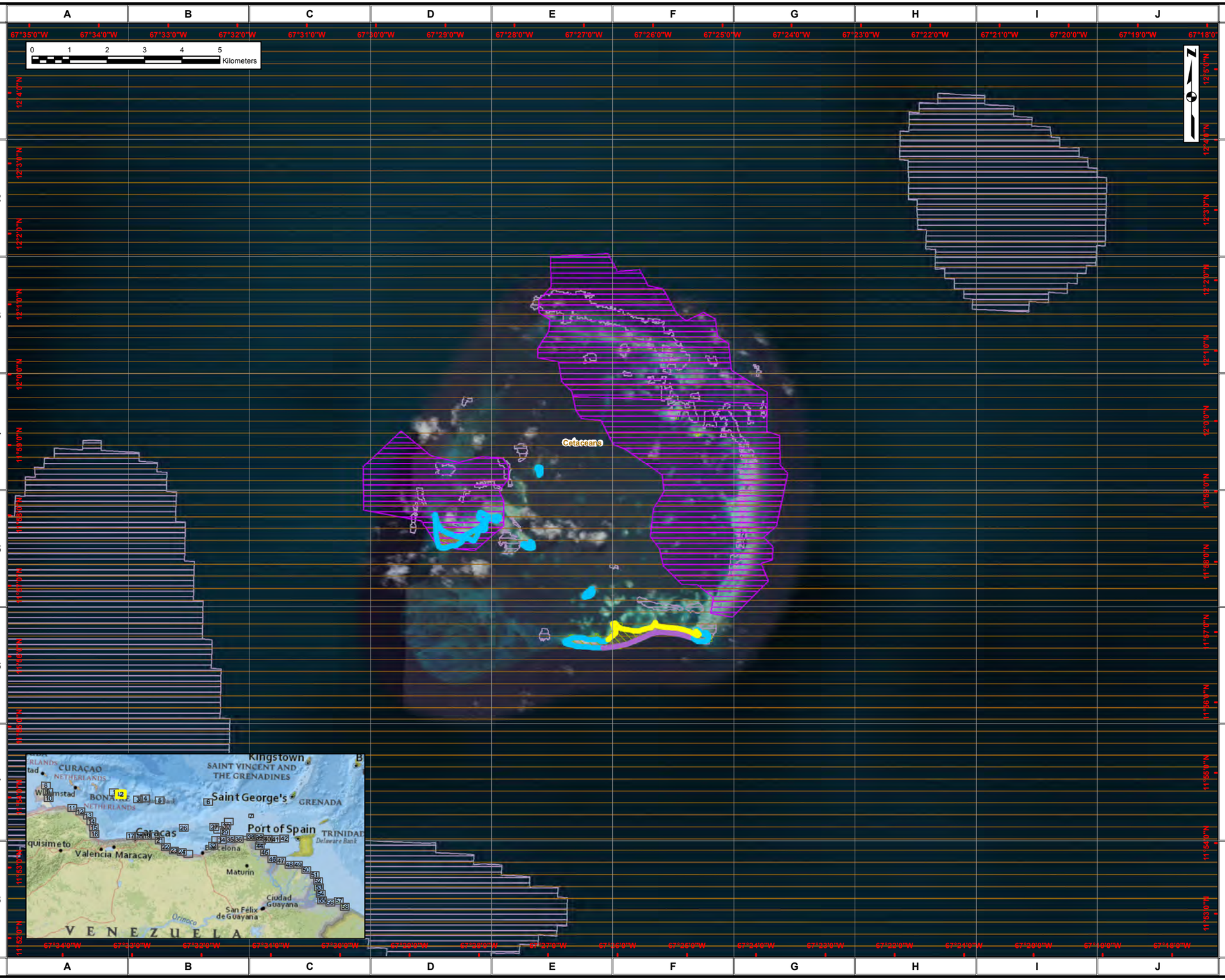
Marine National Protected

- IUCN Category Not Reported
- Access Roads and Tracks
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Aves (West)
Map 1 of 58
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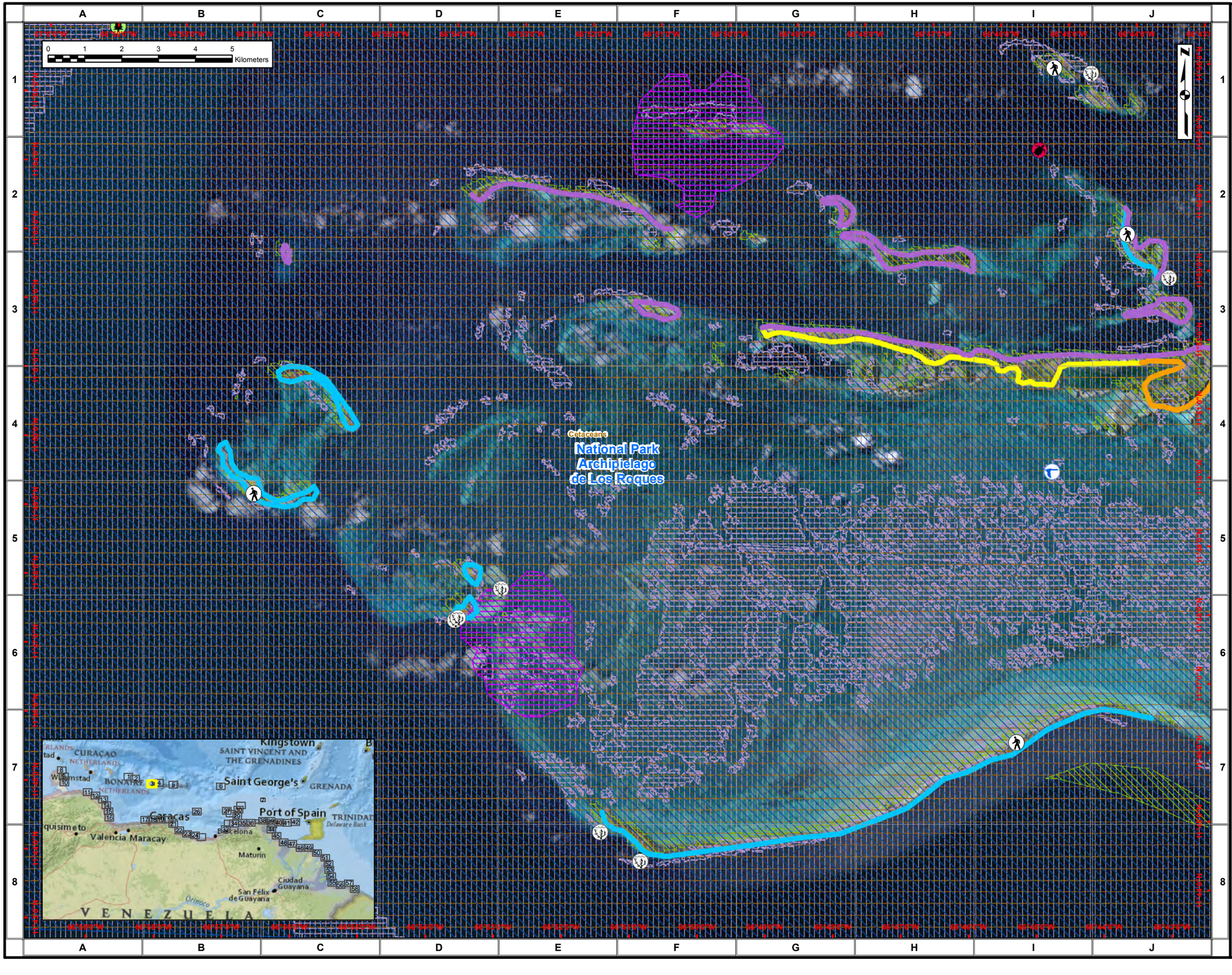
Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8 - Sheltered bedrock or man-made structures
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Aves (East)
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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef

REEF_SYSTEM

- Bleached Coral
- Seagrass

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category V & VI

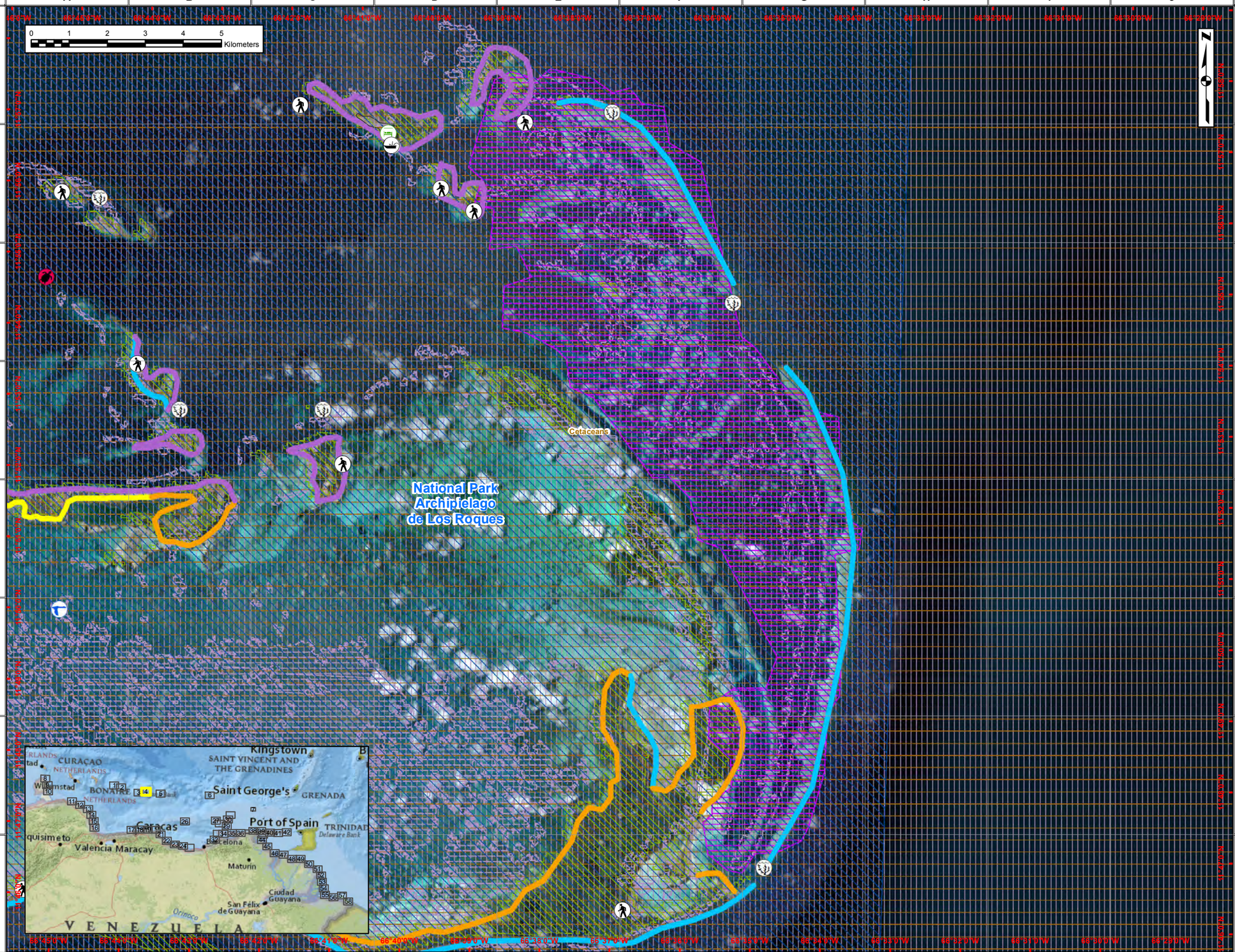
AccessType

- Access by Foot (Beach)
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla los Roques (West)
Map 3 of 58
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02 July 2019

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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8 - Sheltered bedrock or man-made structures
- 9A - Sheltered tidal flats
- 9B - Vegetated low banks
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef

REEF_SYSTEM

- Bleached Coral
- Seagrass

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II
- Fishing Dock or Landing
- Hotels
- Access Roads and Tracks

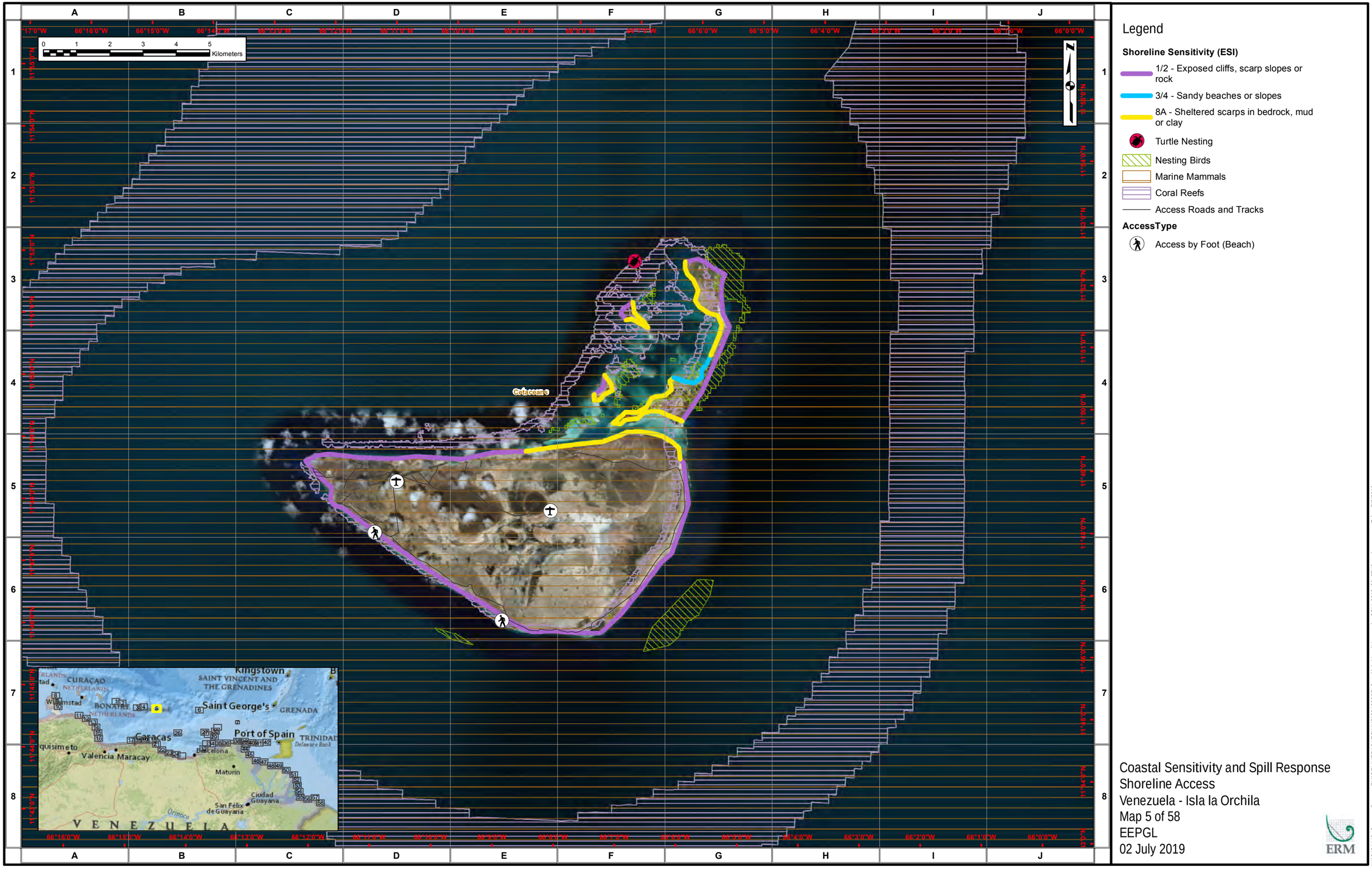
AccessType

- Access by Foot (Beach)
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla los Roques (East)
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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 8A - Sheltered scarps in bedrock, mud or clay
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Access Roads and Tracks

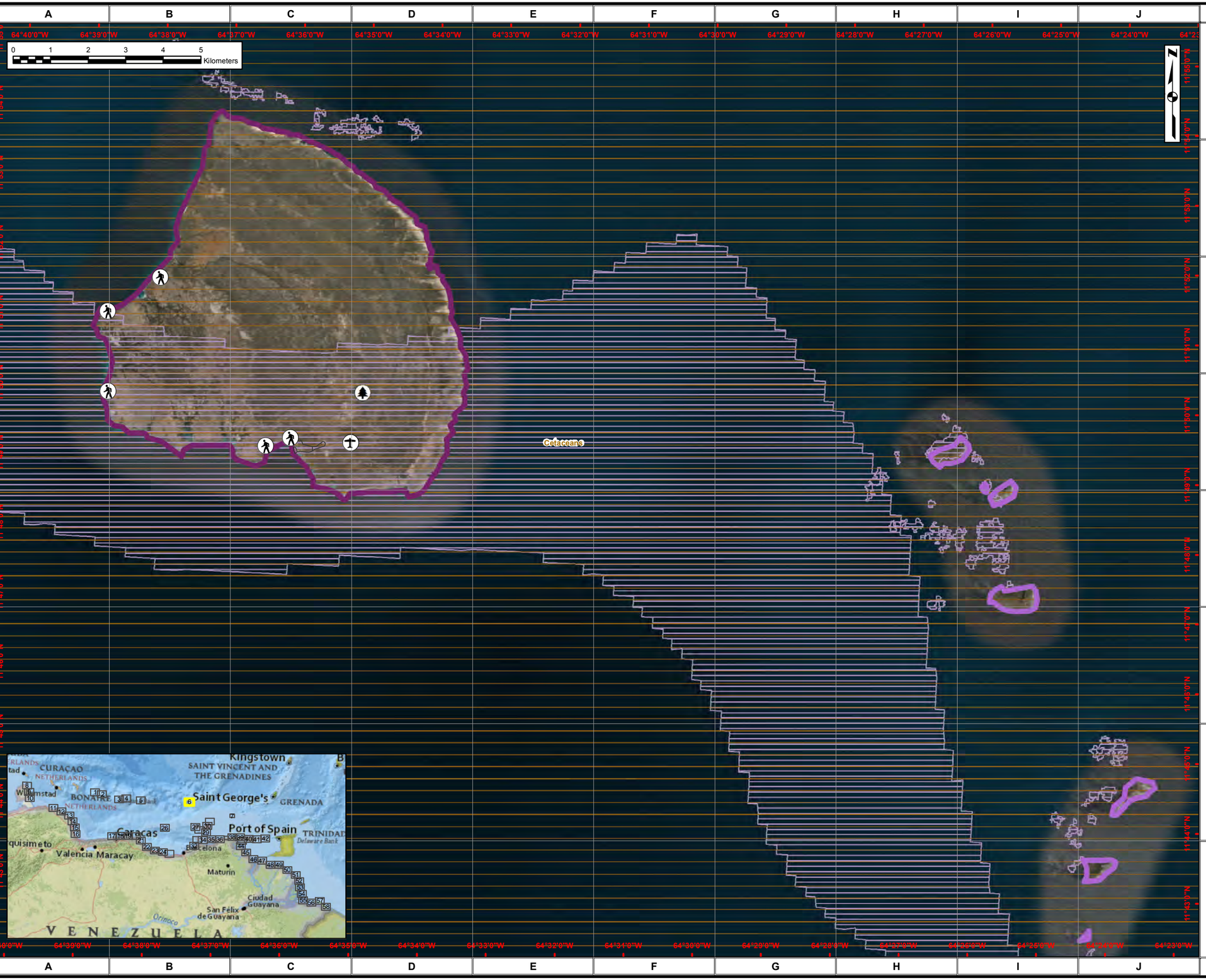
AccessType

- Access by Foot (Beach)

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla la Orchila
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- Marine Mammals
- Coral Reefs

Onshore National Protected Areas

- IUCN Category Not Reported
- Access Roads and Tracks

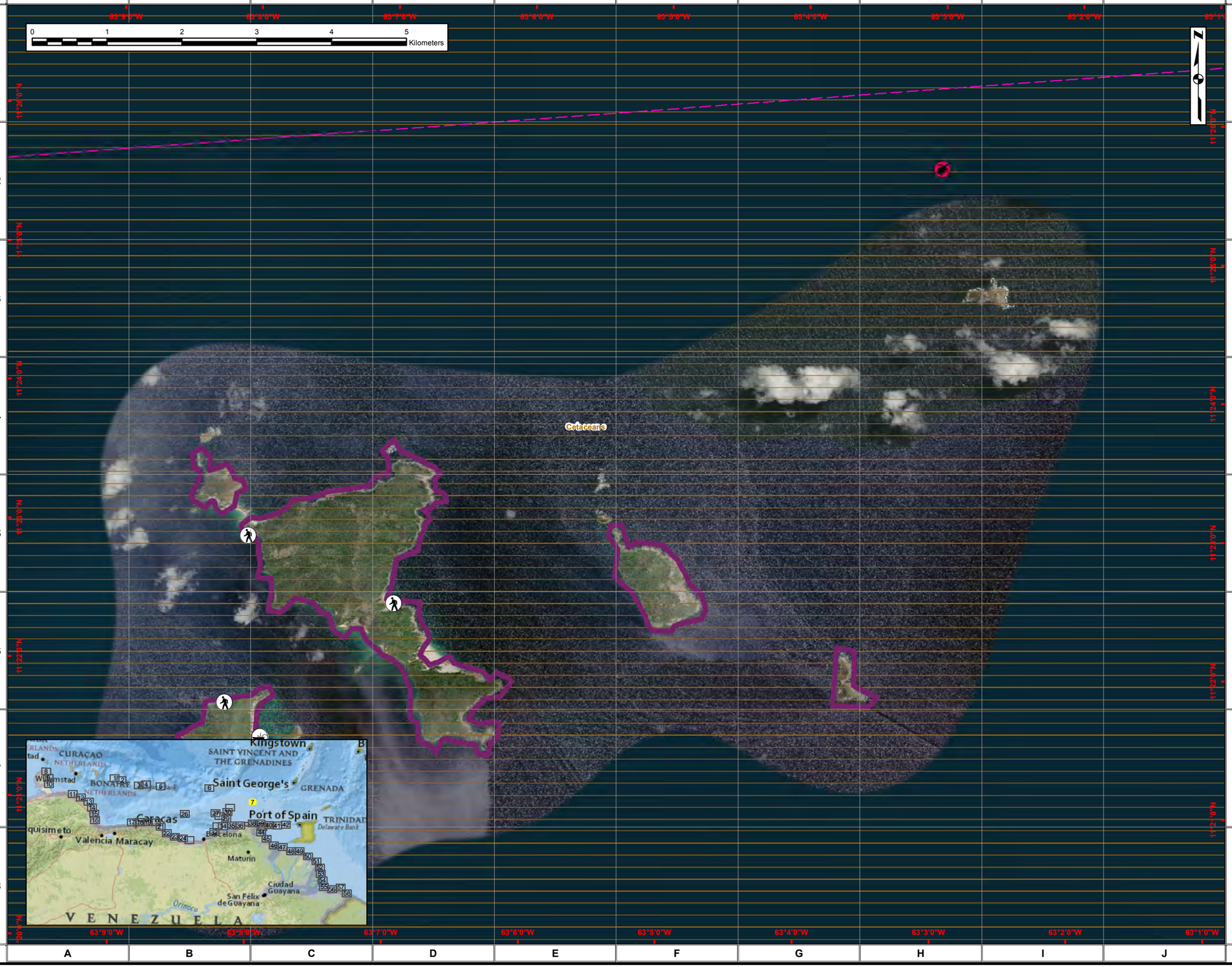
AccessType

- Access by Foot (Beach)

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla la Blanquilla
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- Turtle Nesting
- Marine Mammals
- Fishing Dock or Landing

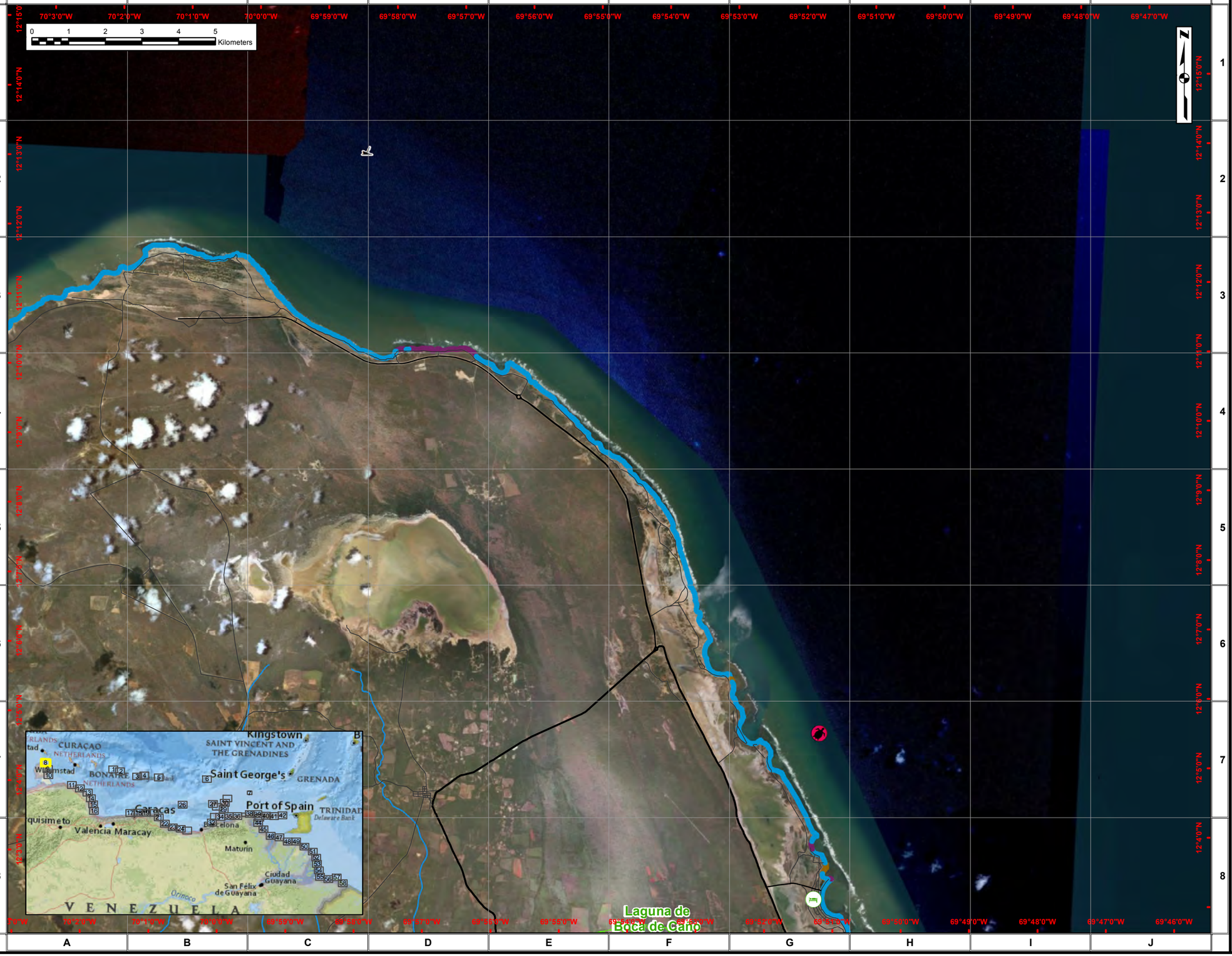
AccessType

- Access by Foot (Beach)
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla los Testigos
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Turtle Nesting

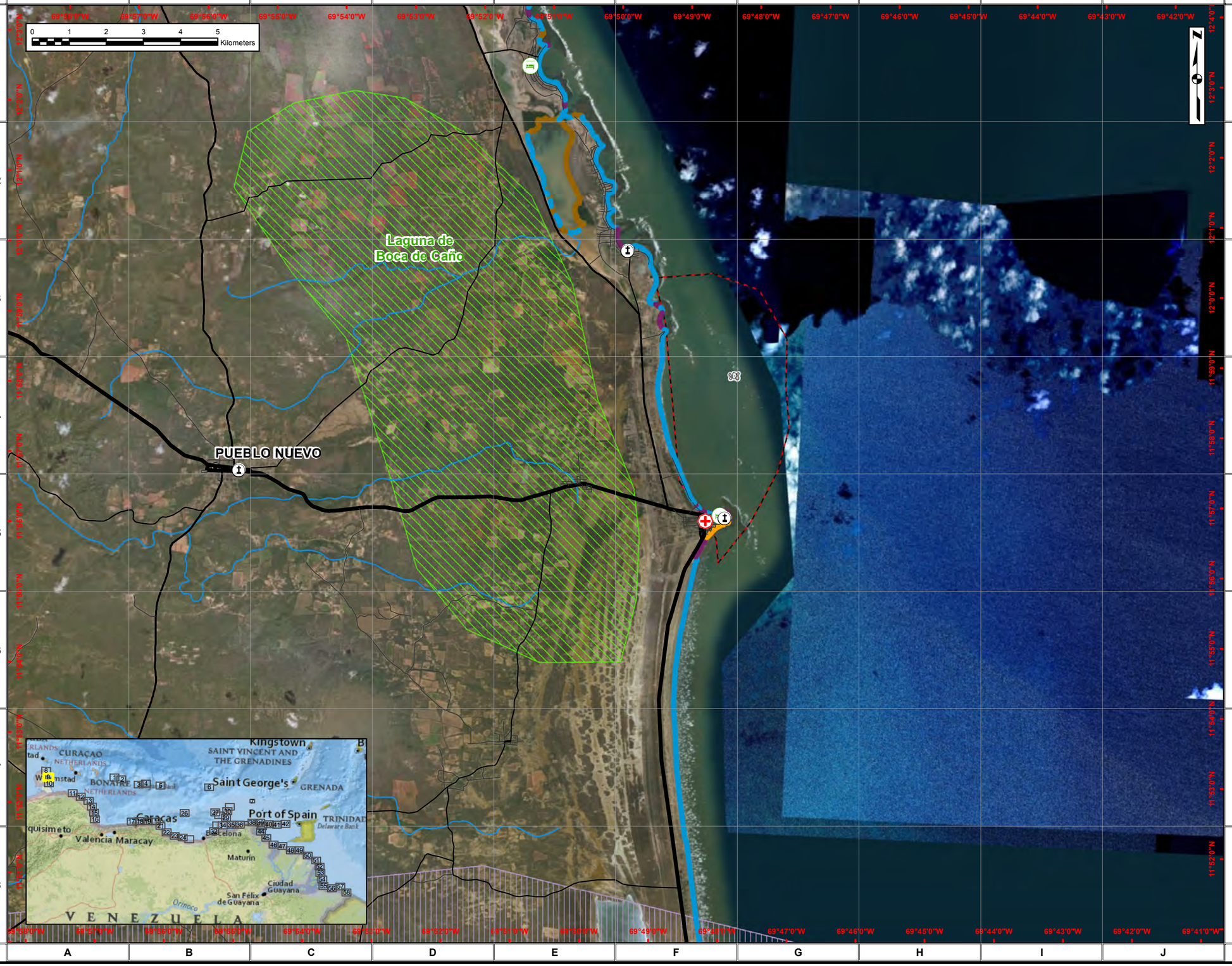
Onshore National Protected

- IUCN Category III, IV
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Wreck

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves
- Seagrass

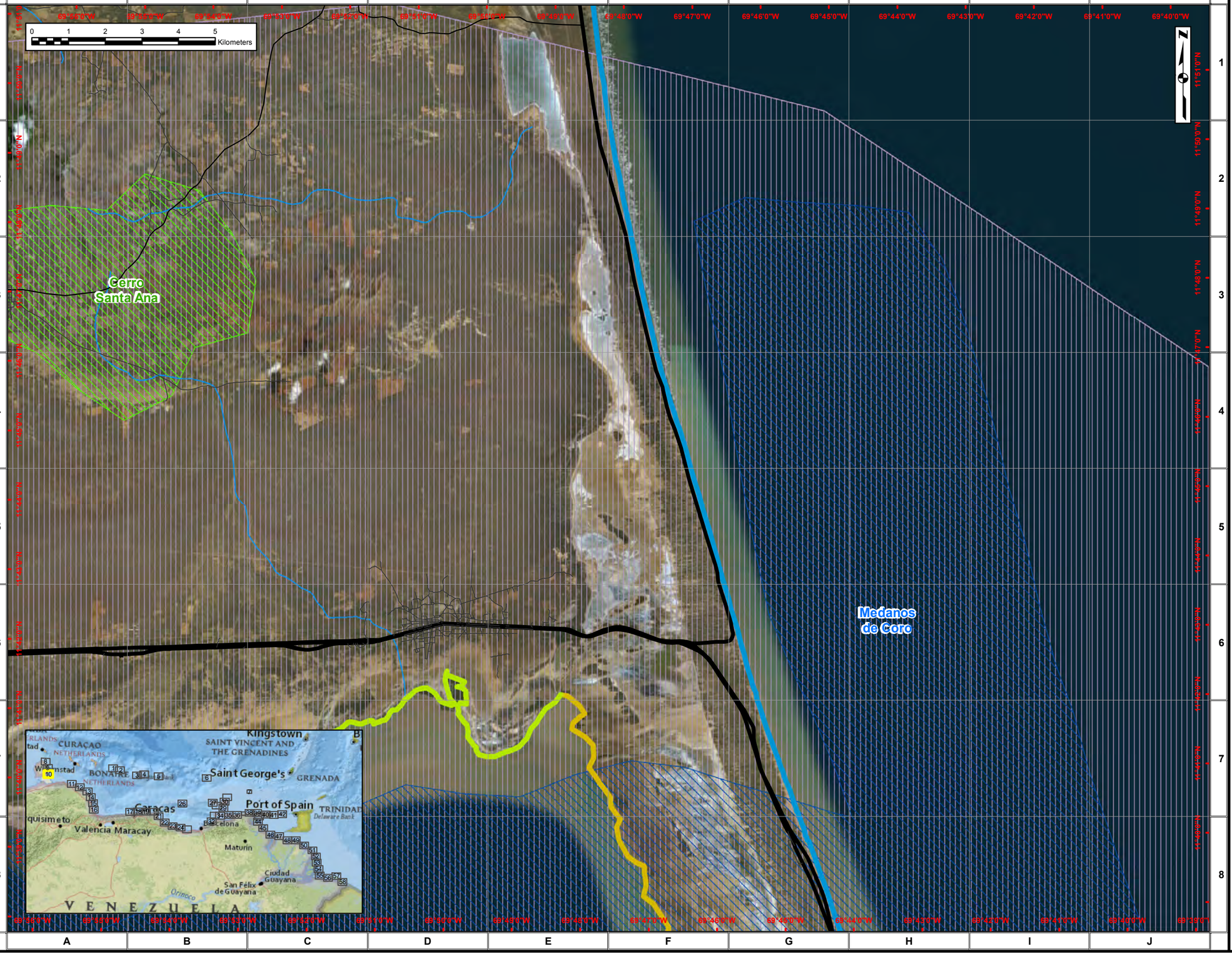
Onshore National Protected

- IUCN Category III, IV
- Hospitals
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Rock
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- Seagrass
- IUCN Category I, II

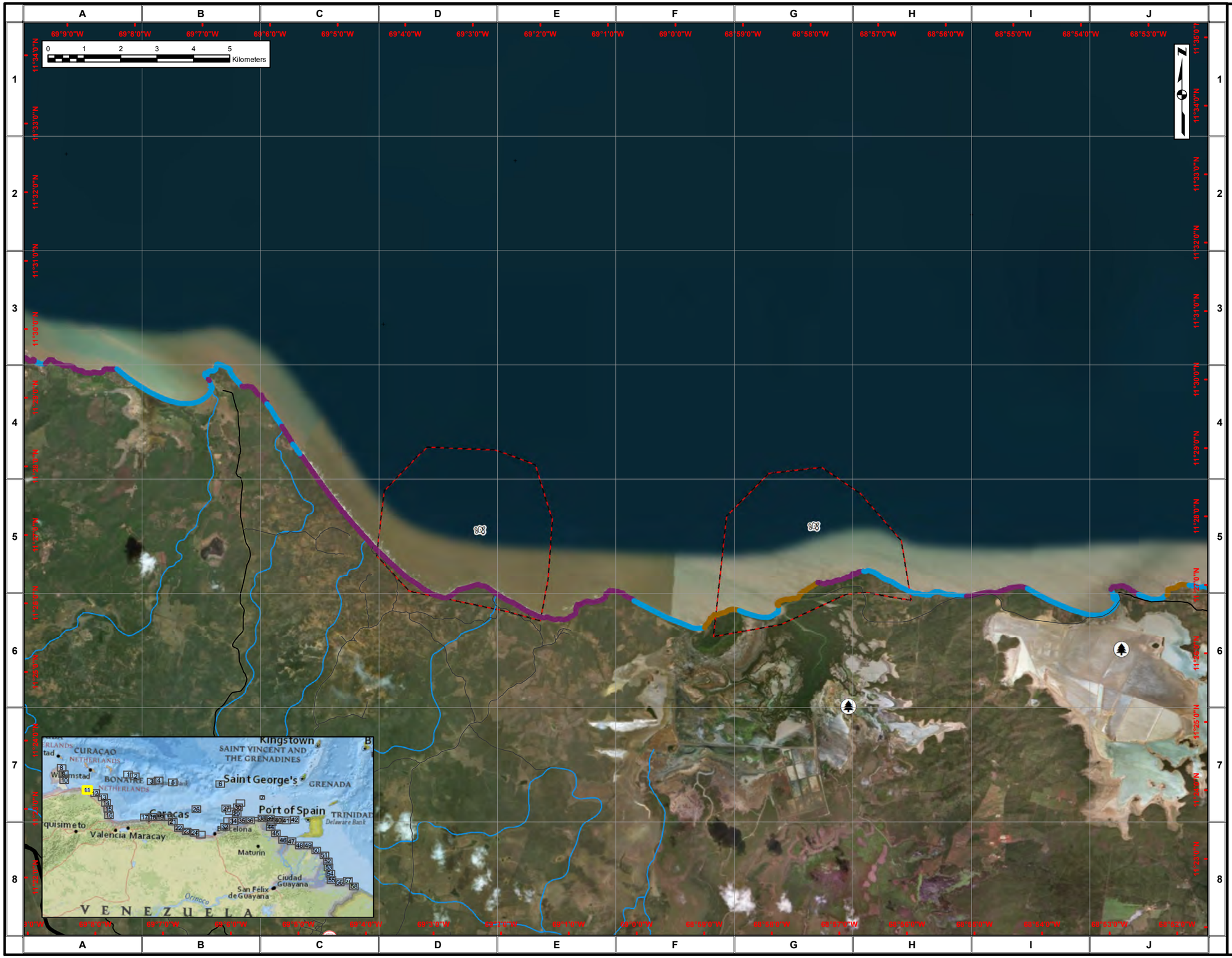
Onshore National Protected Areas

- IUCN Category III, IV
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves

Onshore National Protected

- IUCN Category Not Reported
- Police Stations
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Rock
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves

Onshore National Protected Areas

- IUCN Category Not Reported
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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0 1 2 3 4 5 Kilometers

N

SAN JUAN DE LOS CAYOS

Kingstown
SAINT VINCENT AND THE GRENADINES
Saint George's
GRENADA
CURAÇAO
NETHERLANDS
BONAIRE
Caracas
Port of Spain
TRINIDAD
Valencia
Maracay
Maturín
Ciudad Guayana
San Félix de Guayana
Orinoco
VENEZUELA

Legend

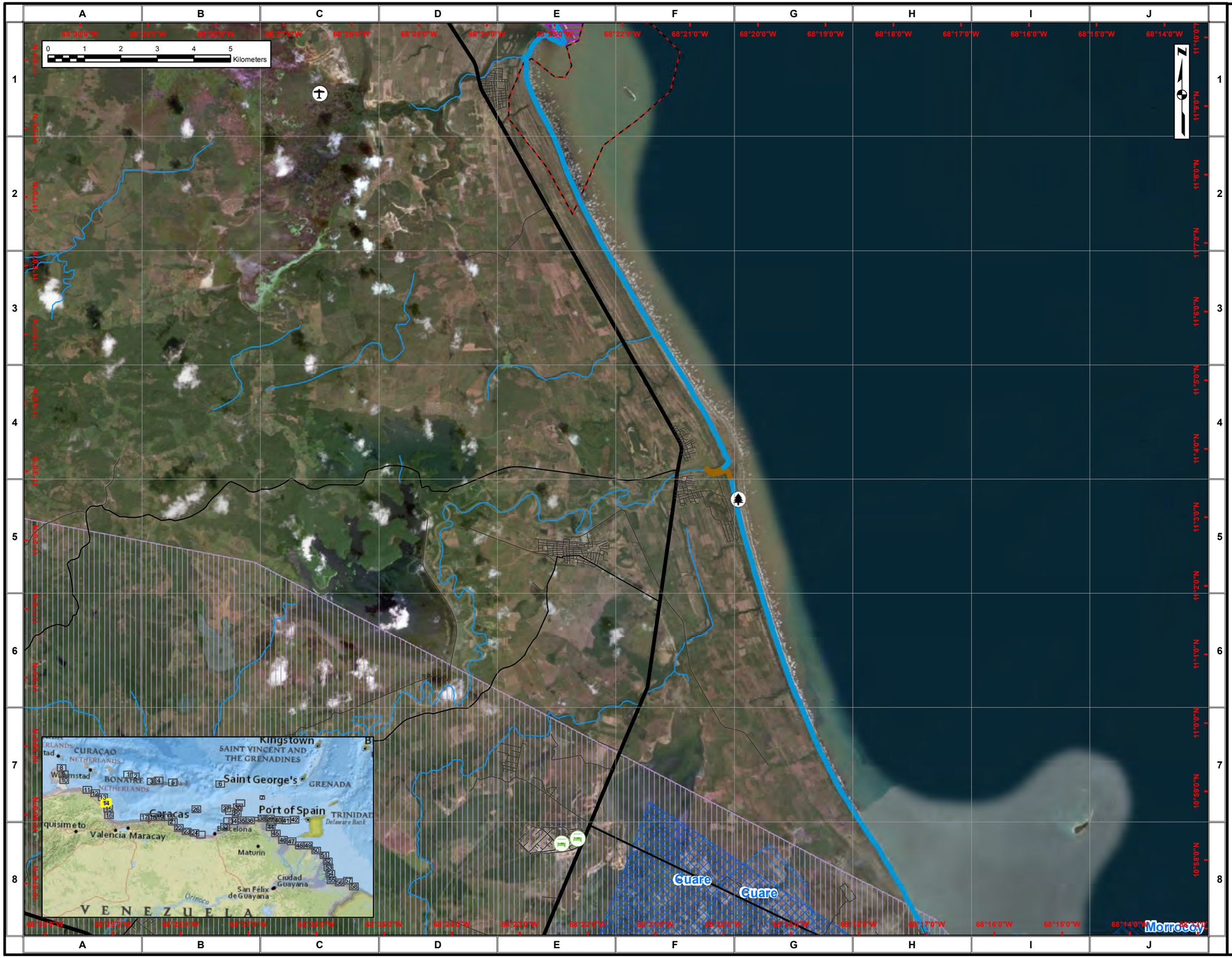
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 10D - Mangroves
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Rock
- Hazardous Areas
- Hazardous Reefs
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Seagrass

Marine International Protected Areas

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV

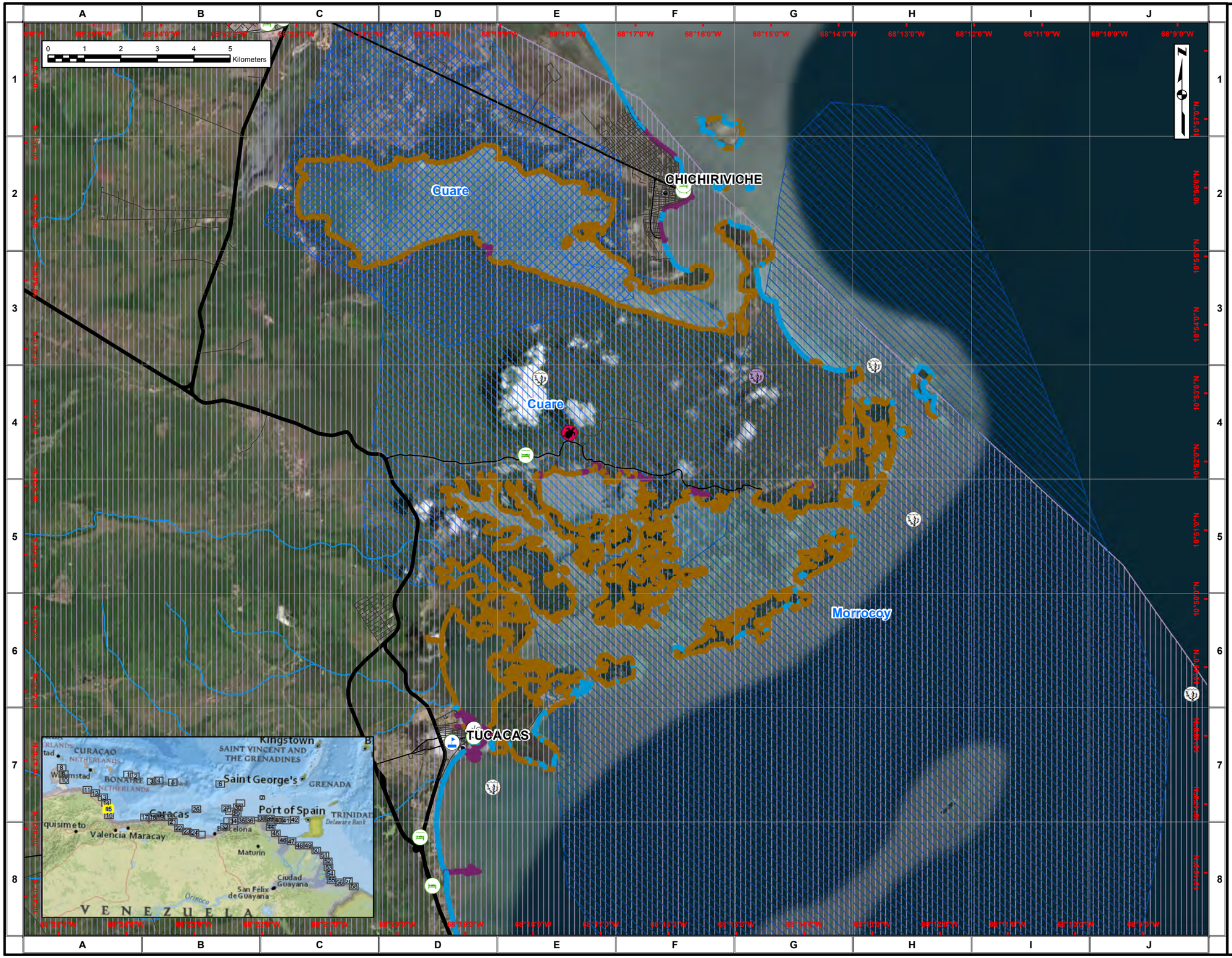
Onshore National Protected Areas

- IUCN Category Not Reported
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Hazardous Areas
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Turtle Nesting
- Coral Reef

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- Bleached Coral
- Seagrass

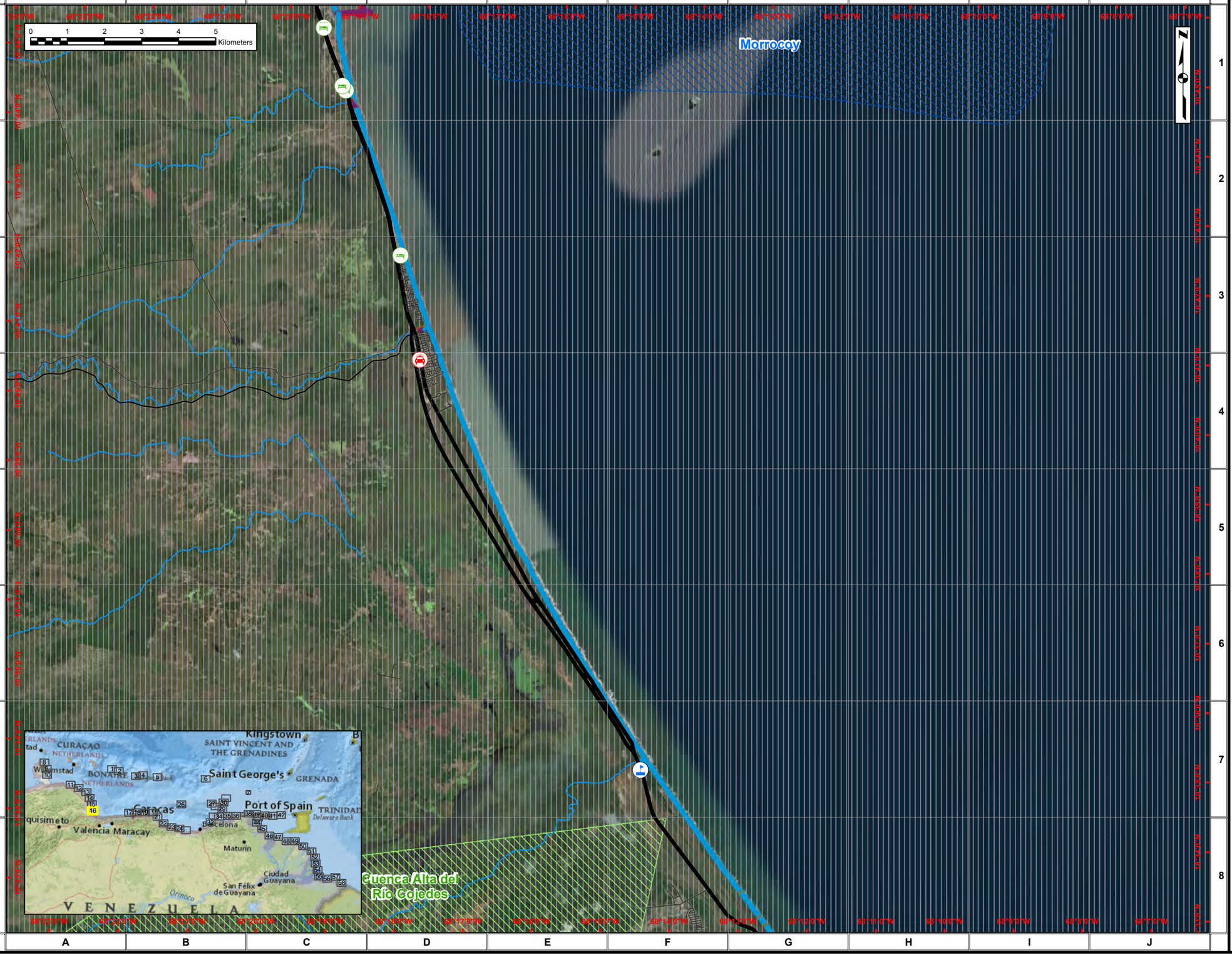
Marine International Protected Areas

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- School
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Seagrass
- IUCN Category I, II

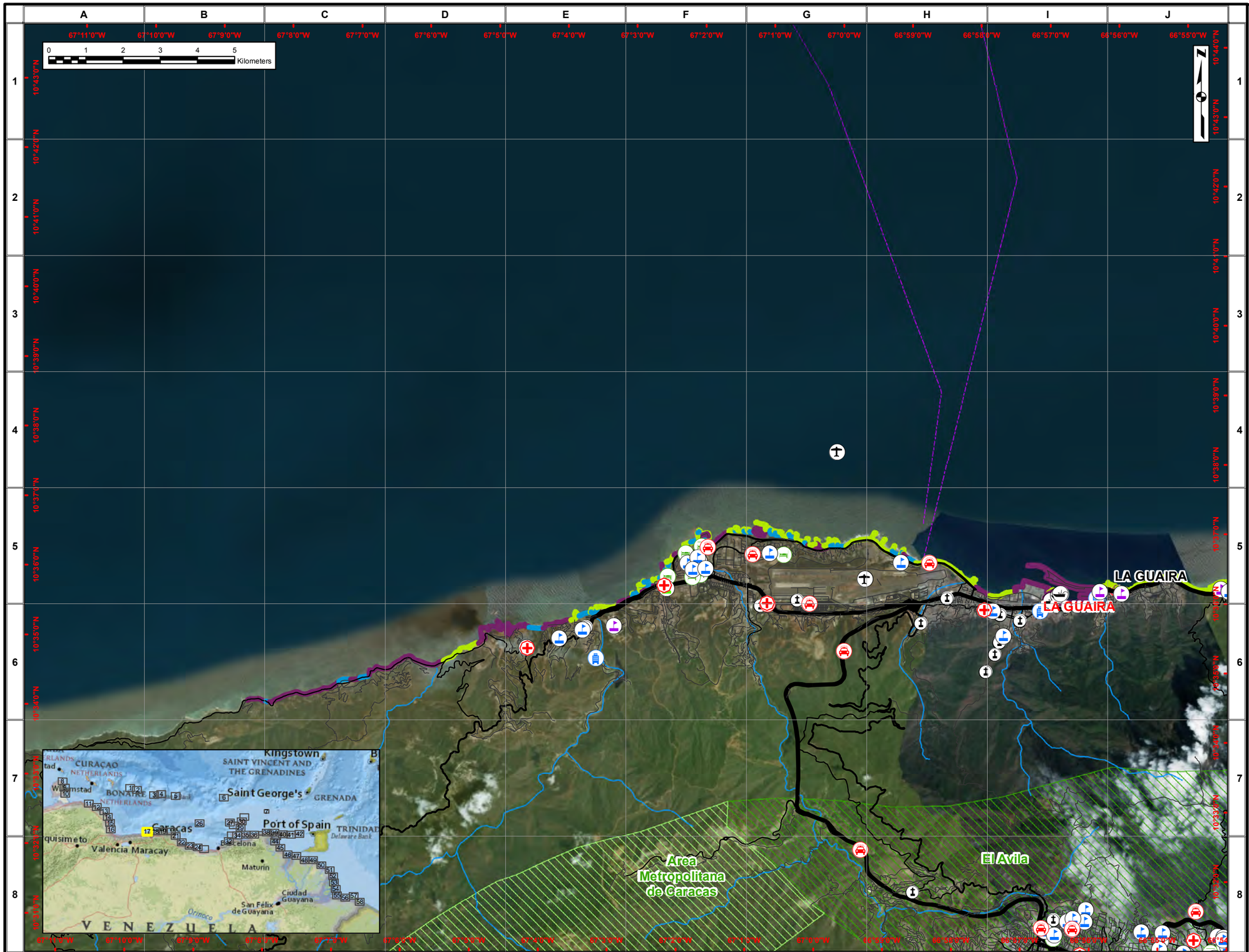
Onshore National Protected Areas

- IUCN Category V, VI
- Police Stations
- School
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category V, VI
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Seabed Cables
- State Capital
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)

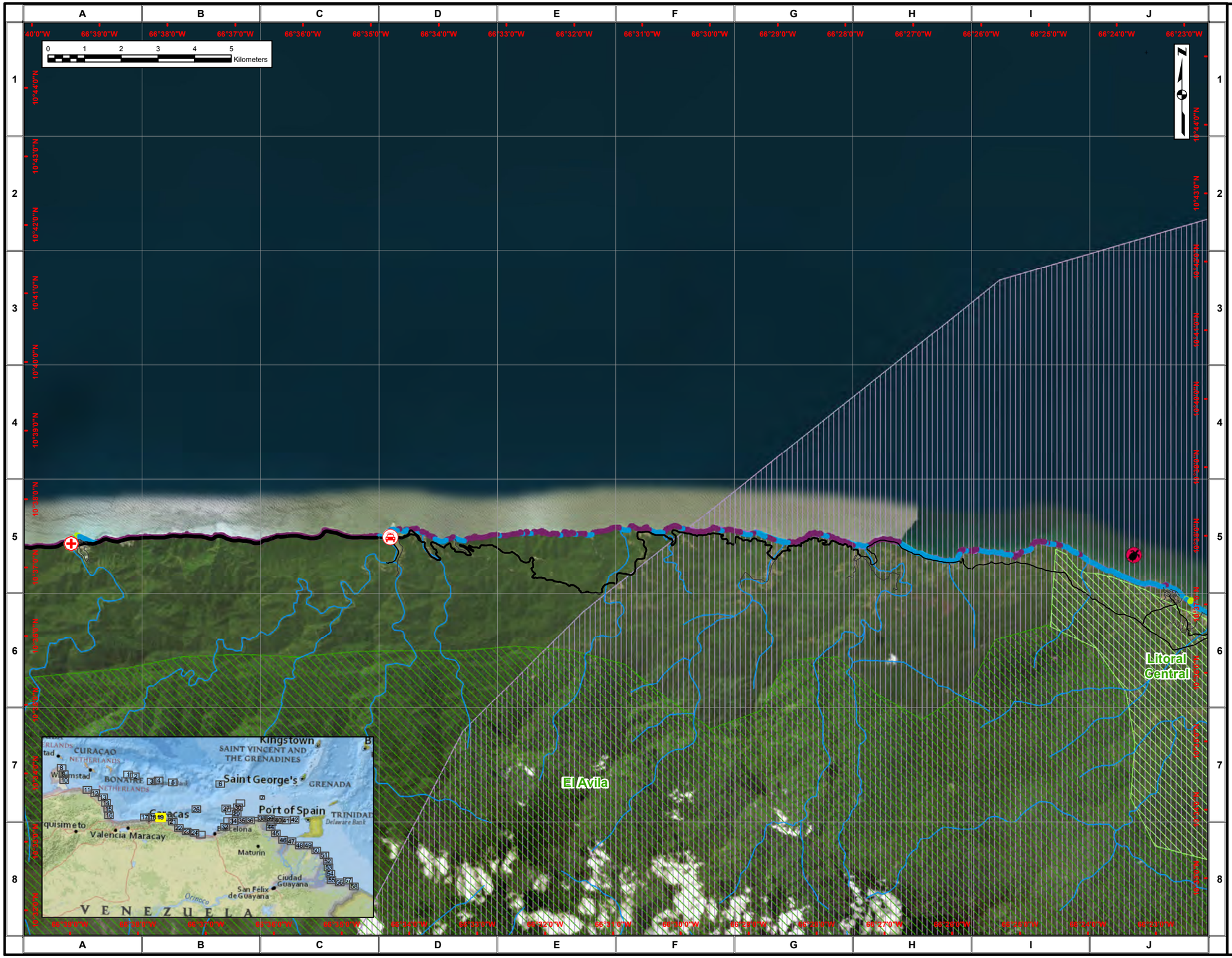
Onshore National Protected

- IUCN Category I, II
- Hospitals
- Police Stations
- School
- College
- Places of Worship
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3A - Fine to medium-grained sand beaches
- 3/4 - Sandy beaches or slopes
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Turtle Nesting
- Seagrass

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category V, VI
- Hospitals
- Police Stations
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3A - Fine to medium-grained sand beaches
- 3/4 - Sandy beaches or slopes
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Turtle Nesting
- Marine Mammals
- Seagrass

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category V, VI
- Tertiary Roads
- Access Roads and Tracks

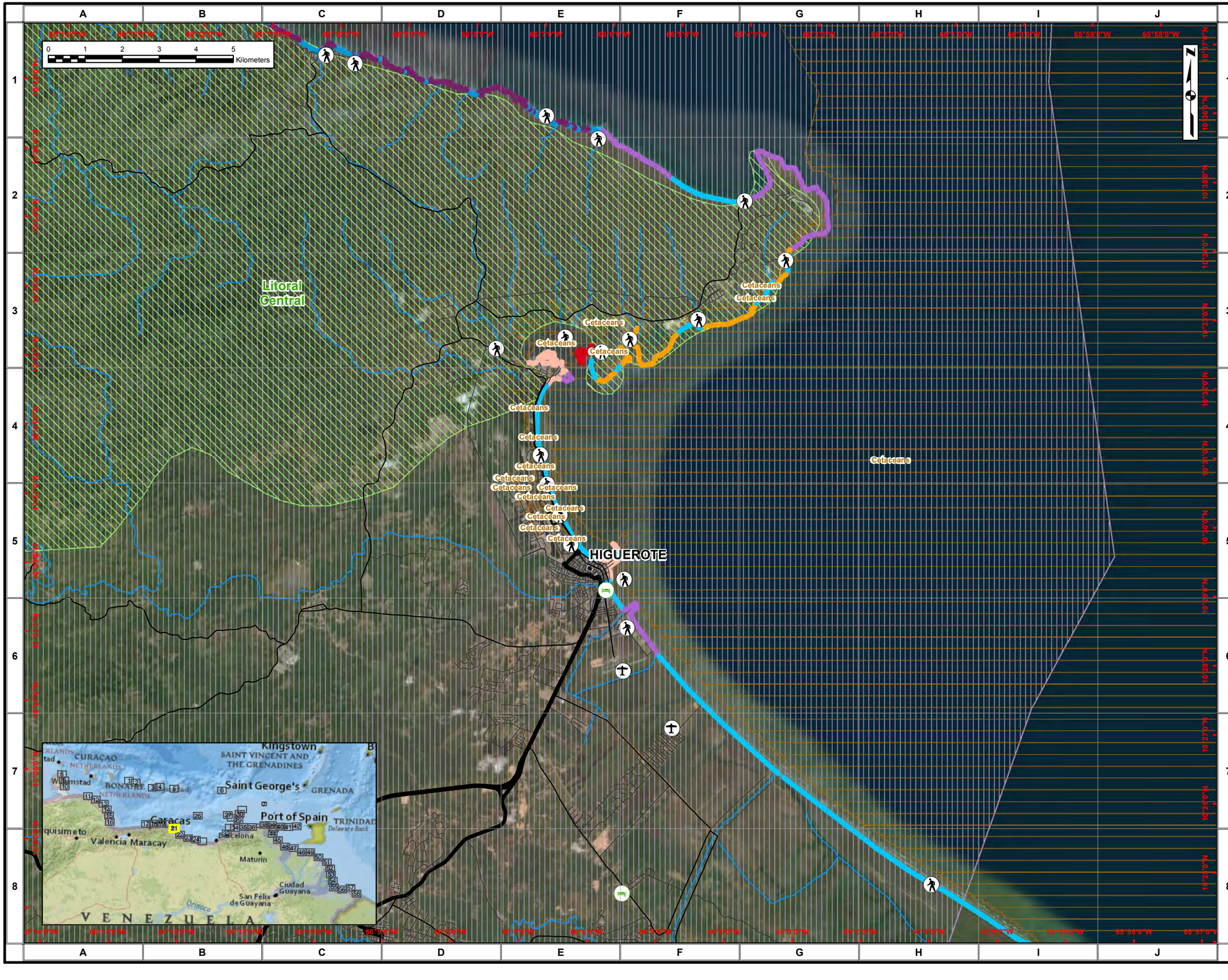
AccessType

- Access by Foot (Beach)
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Litoral Central
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3A - Fine to medium-grained sand beaches
- 3/4 - Sandy beaches or slopes
- 8B - Sheltered, solid man-made structures
- 9B - Vegetated low banks
- 10C - Swamps
- Marine Mammals
- Seagrass

Onshore National Protected

- IUCN Category V, VI
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

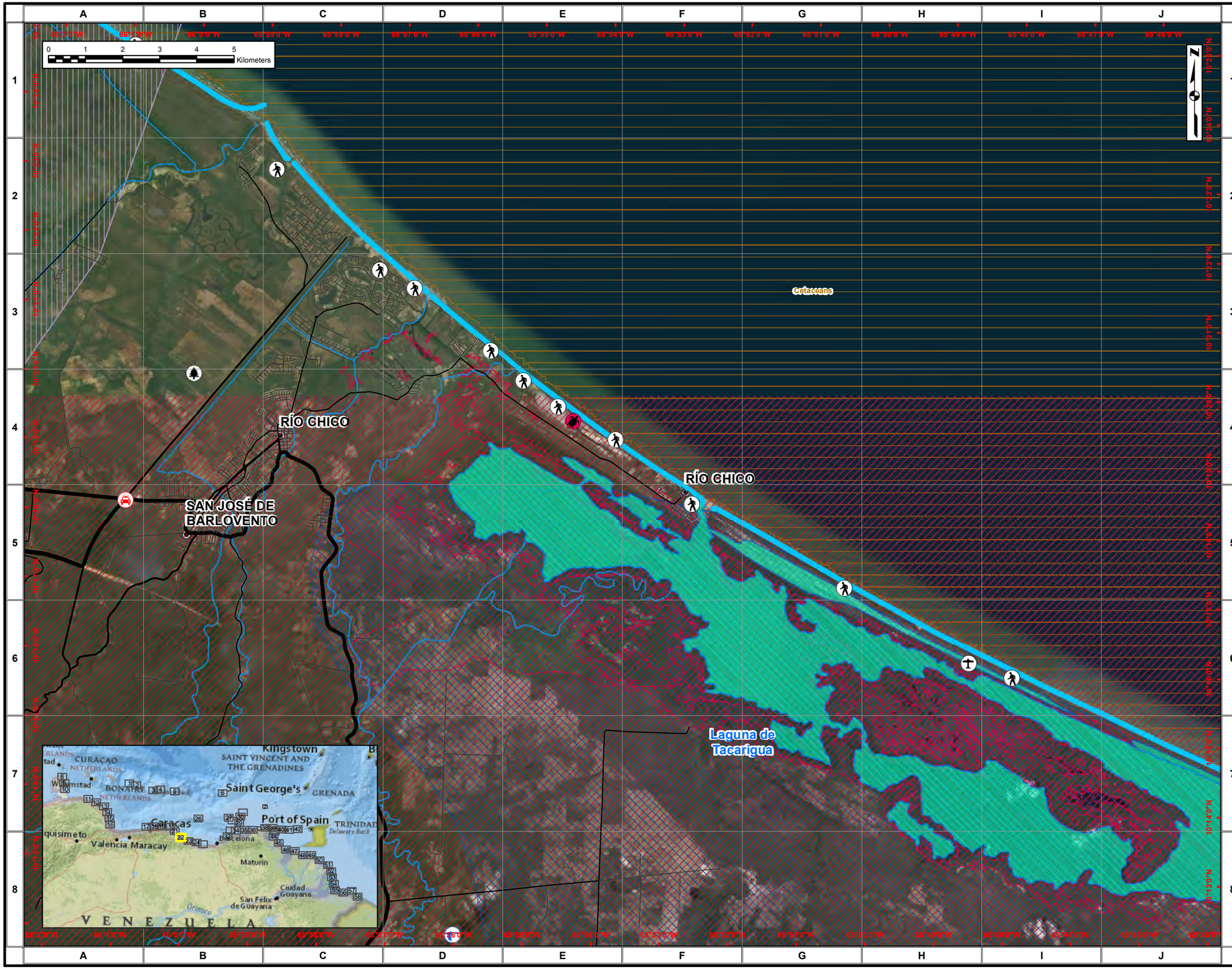
AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Brion
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Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- Turtle Nesting
- Reptiles
- Marine Mammals
- Seagrass
- Lagoon

Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category Not Reported
- Police Stations
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

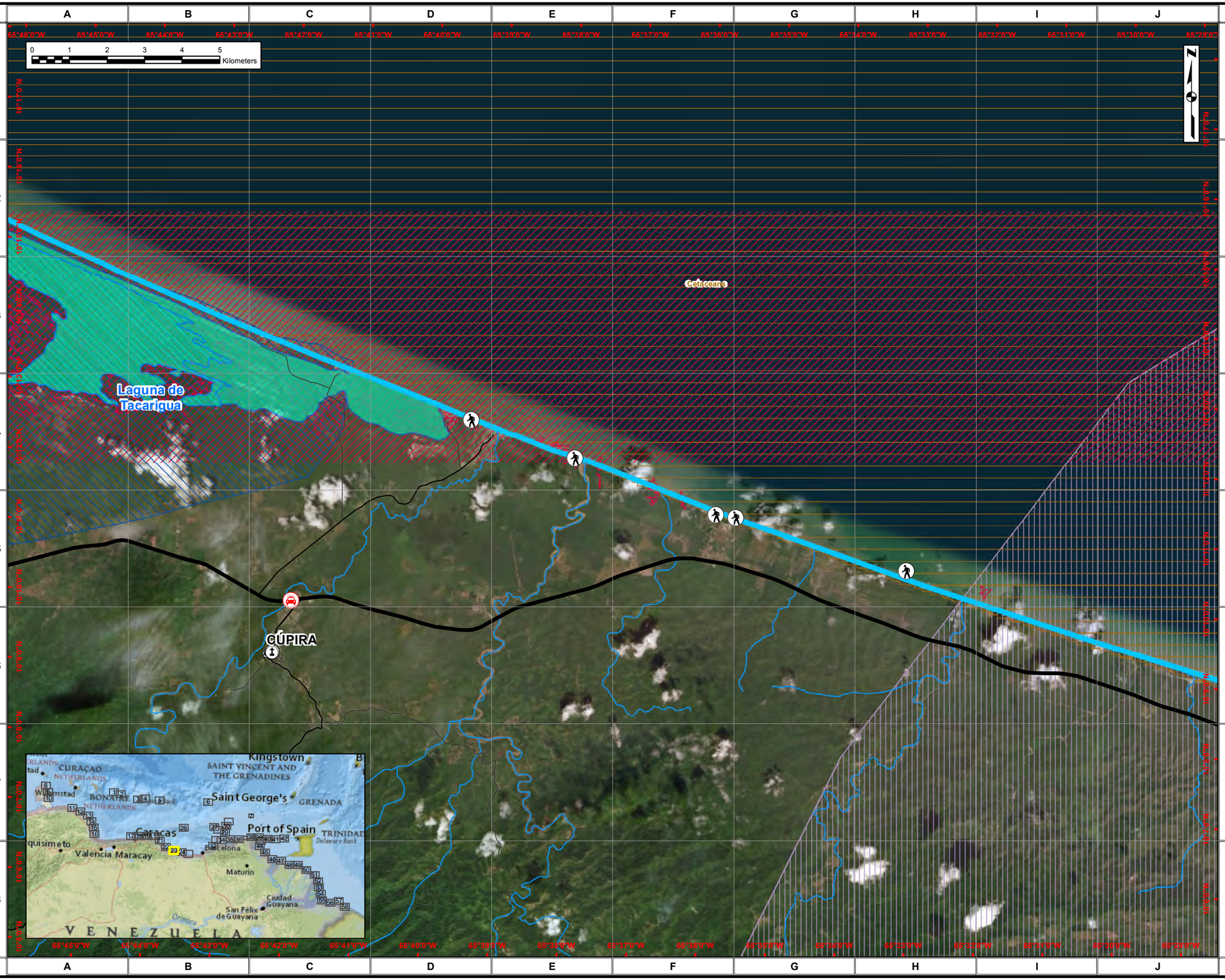
AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- Reptiles
- Marine Mammals
- Seagrass
- Lagoon
- IUCN Category I, II
- Police Stations
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

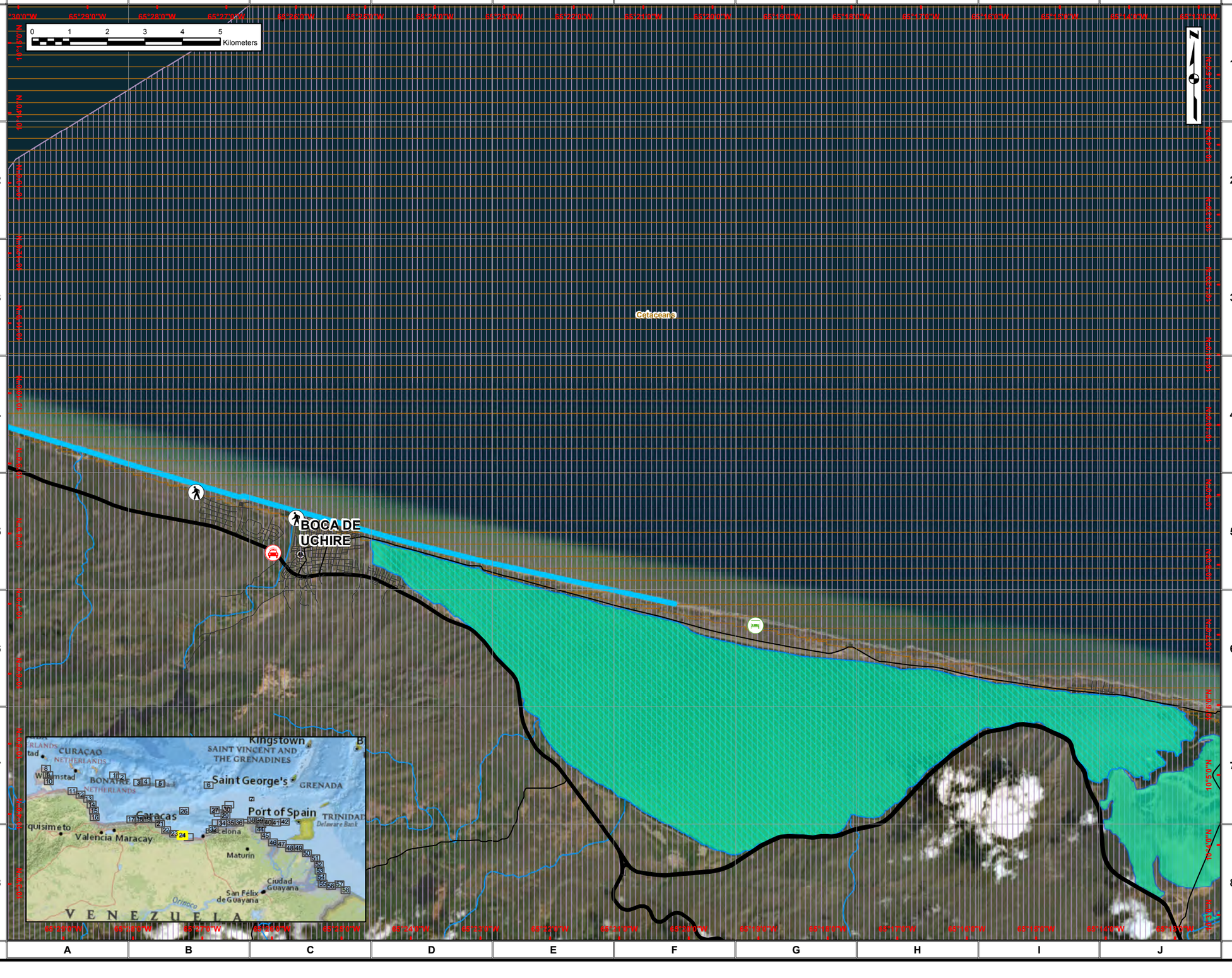
AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- Marine Mammals
- Seagrass
- Lagoon
- Police Stations
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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0 1 2 3 4 5 Kilometers

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Cetaceans

PUERTO PÍRITU

PÍRITU

Kingstown
SAINT VINCENT AND THE GRENADINES
Saint George's
GRENADA
CURAÇAO
NETHERLANDS
BONAIRE
Caracas
Port of Spain
TRINIDAD
Delaware Bank
Valencia
Maracay
Maturín
Ciudad Guayana
San Félix de Guayana
Orinoco
V E N E Z U E L A

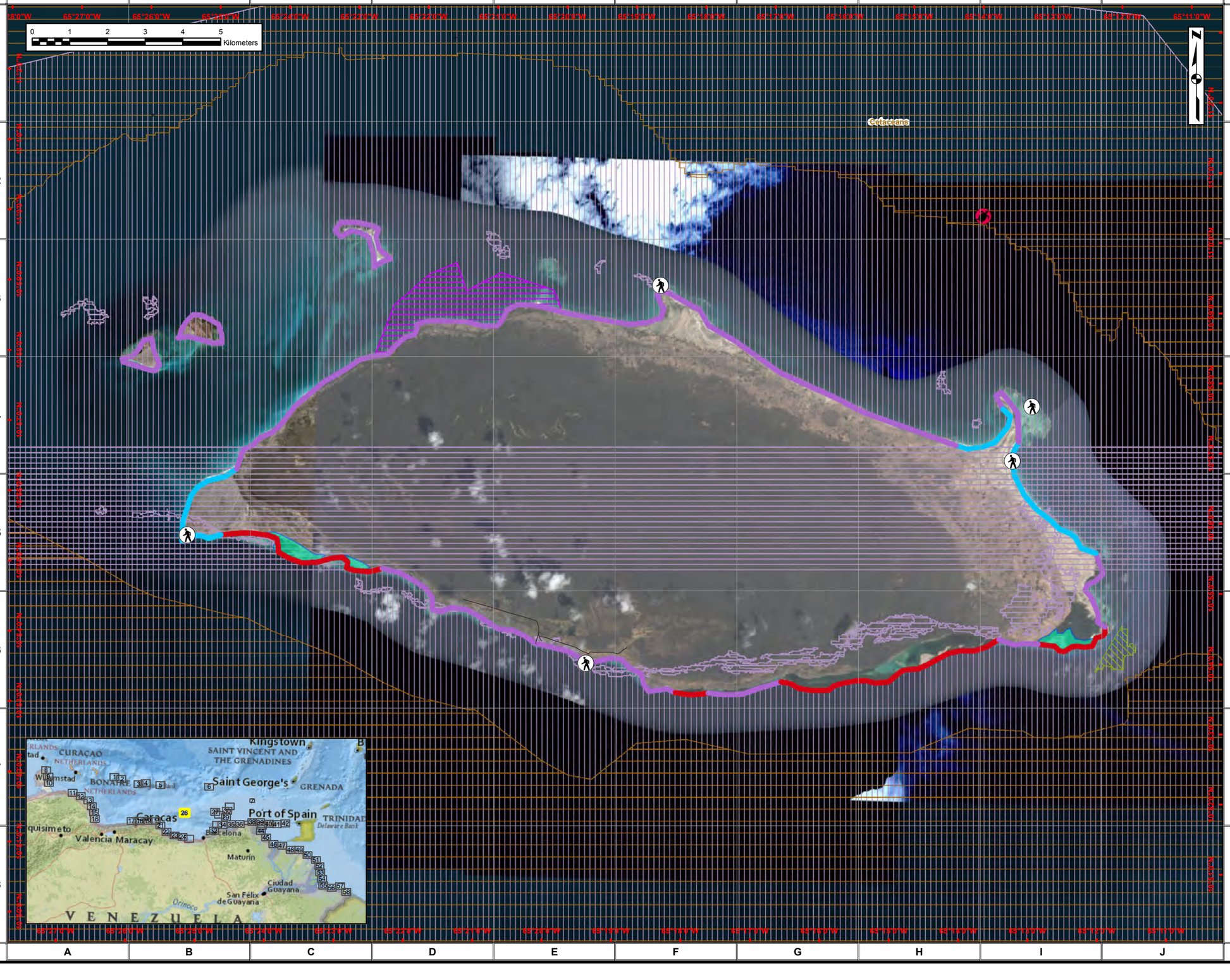
Legend

- Marine Mammals
- Coral Reef
- Seagrass
- Lagoon
- Police Stations
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de Tacarigua (West)
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Legend

Shoreline Sensitivity (ESI)

- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 10A - Salt and brackish water marshes
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Seagrass
- Lagoon
- Access Roads and Tracks

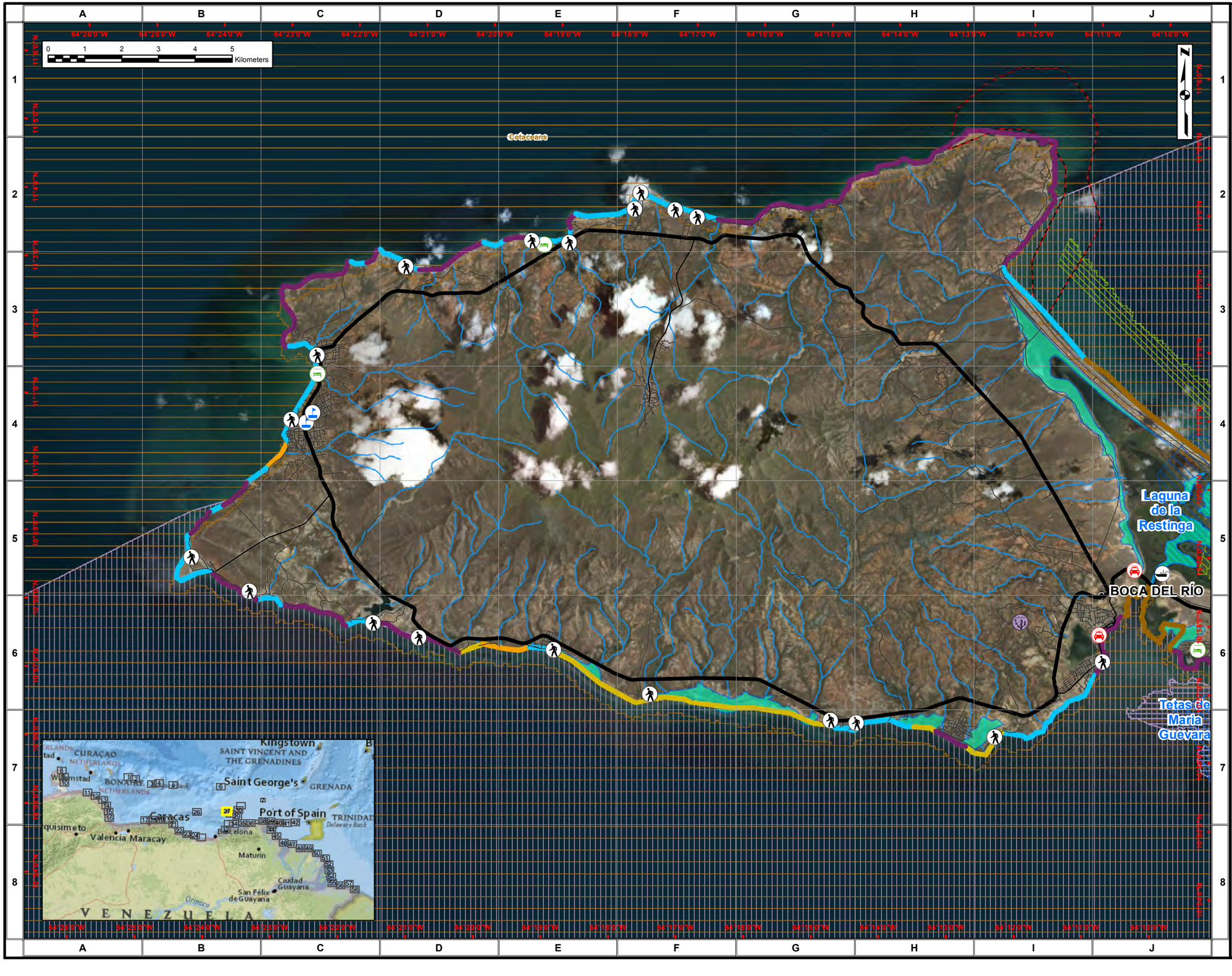
AccessType

- Access by Foot (Beach)
- Hazardous Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla la Tortuga
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef
- Seagrass
- Lagoon
- IUCN Category I, II
- IUCN Category III, IV
- Police Stations
- School
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Macano
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Coral Reef
- Seagrass
- Lagoon
- IUCN Category I, II
- IUCN Category III, IV

Onshore National Protected

- IUCN Category V & VI
- Hospitals
- Police Stations
- College
- Port or Marina
- Fishing Dock or Landing
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

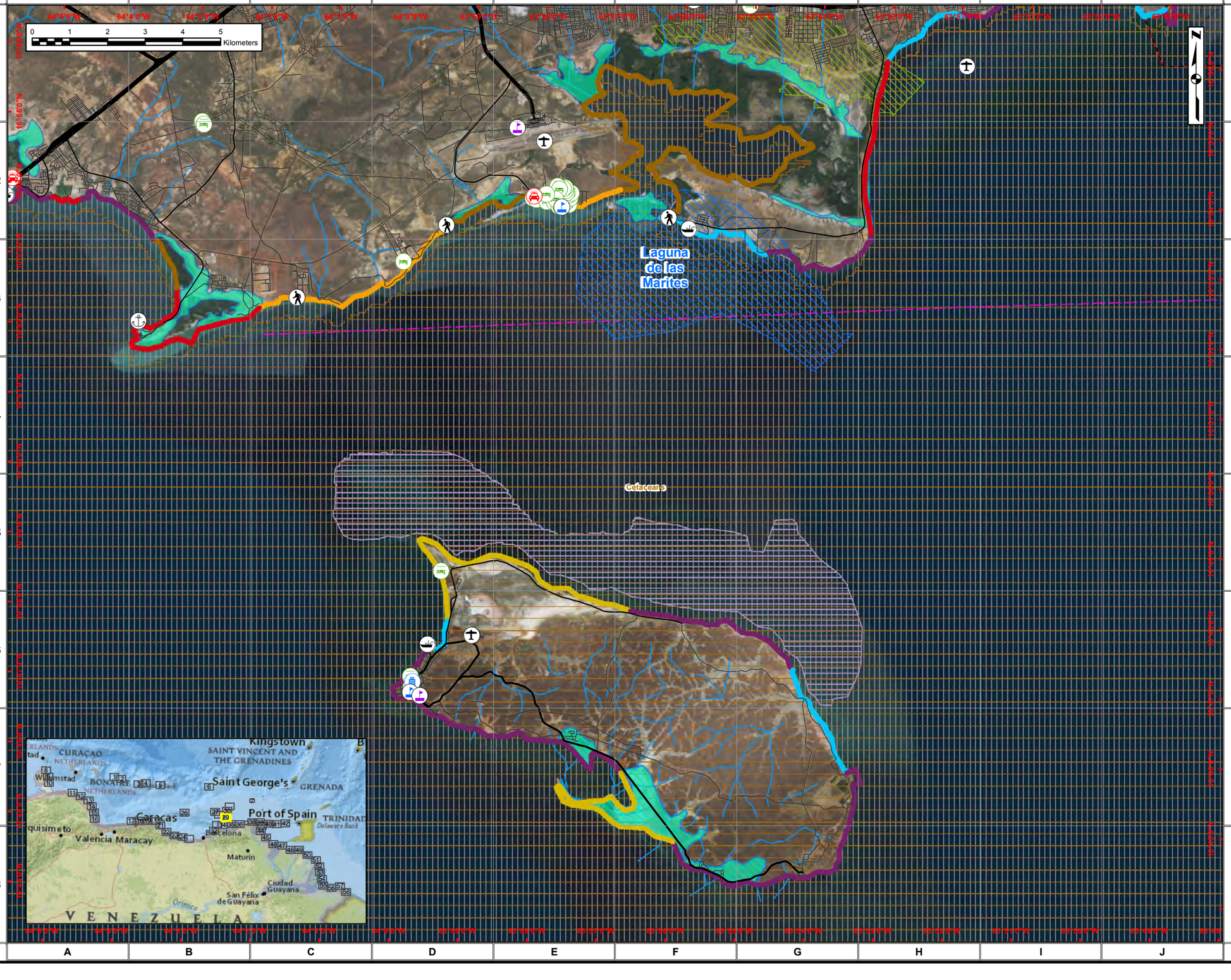
AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de la Restinga
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Seagrass
- Lagoon
- IUCN Category III, IV
- Hospitals
- Police Stations
- School
- College
- Port or Marina
- Fishing Dock or Landing
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

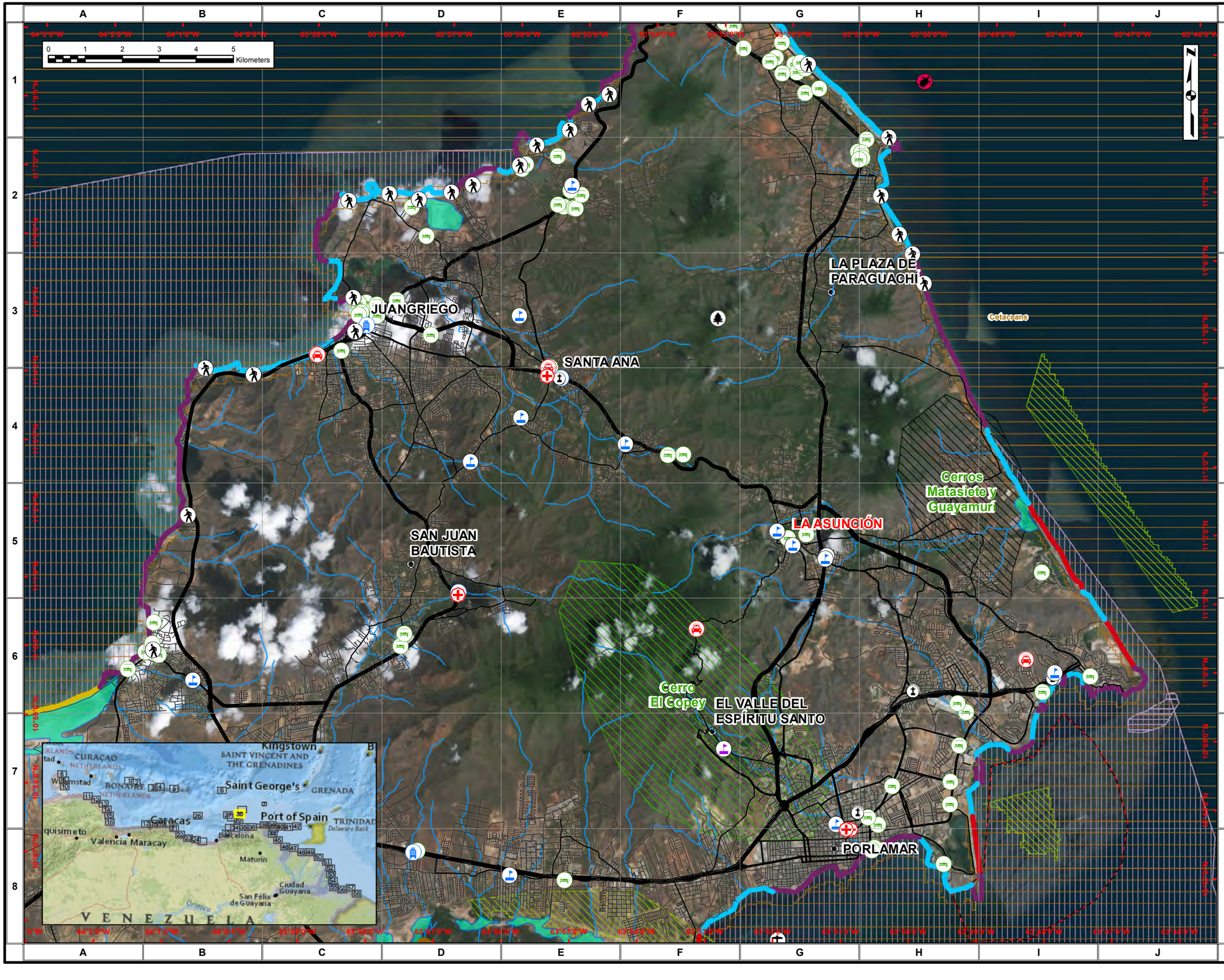
AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Laguna de las Marites / Isla Coche
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Coral Reefs
- Seagrass
- Lagoon

Onshore National Protected Areas

- IUCN Category V & VI
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category I, II
- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- College
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

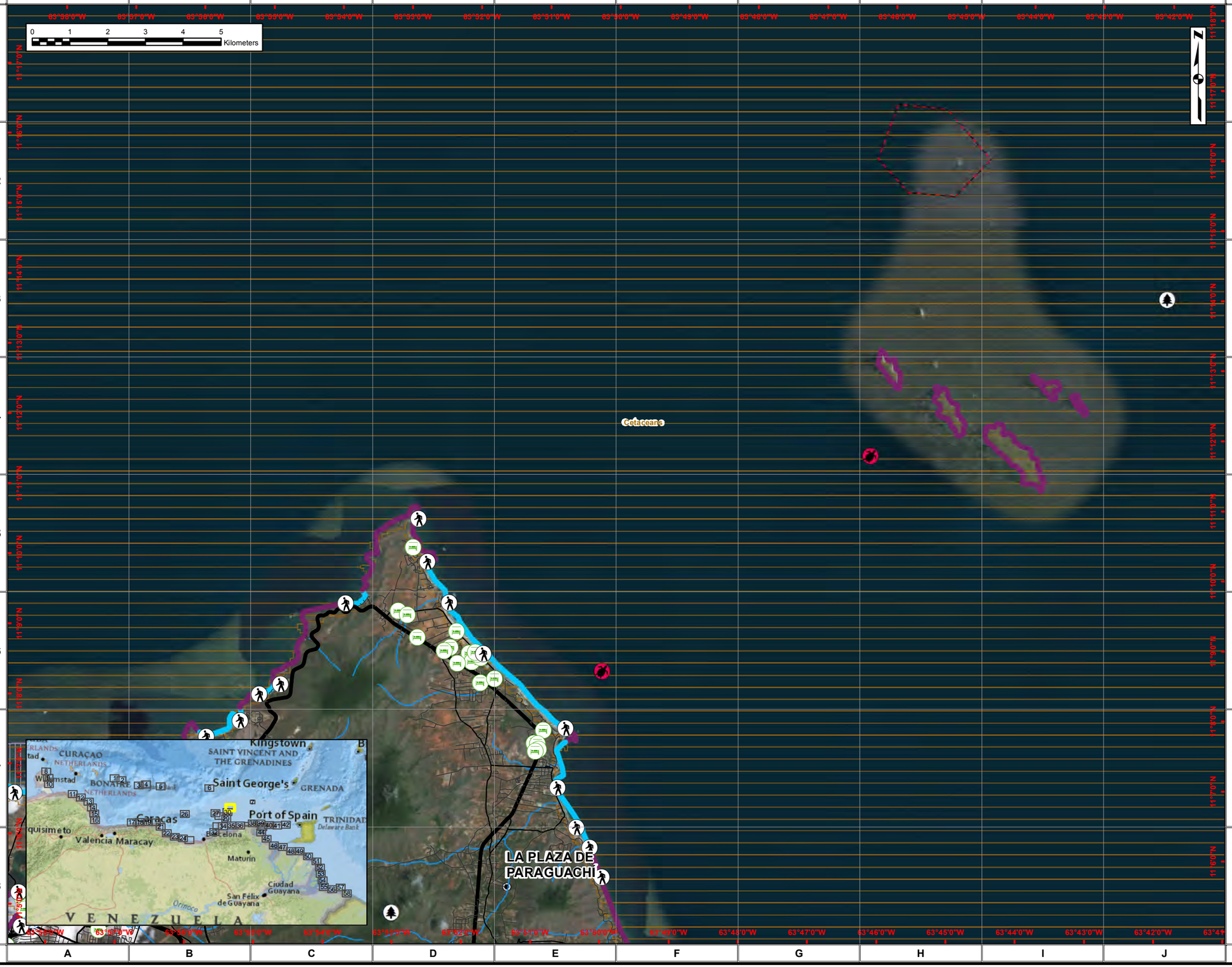
AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- State Capital
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Margarita
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- Turtle Nesting
- Marine Mammals
- Seagrass
- Lagoon

Onshore National Protected Areas

- IUCN Category Not Reported
- School
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

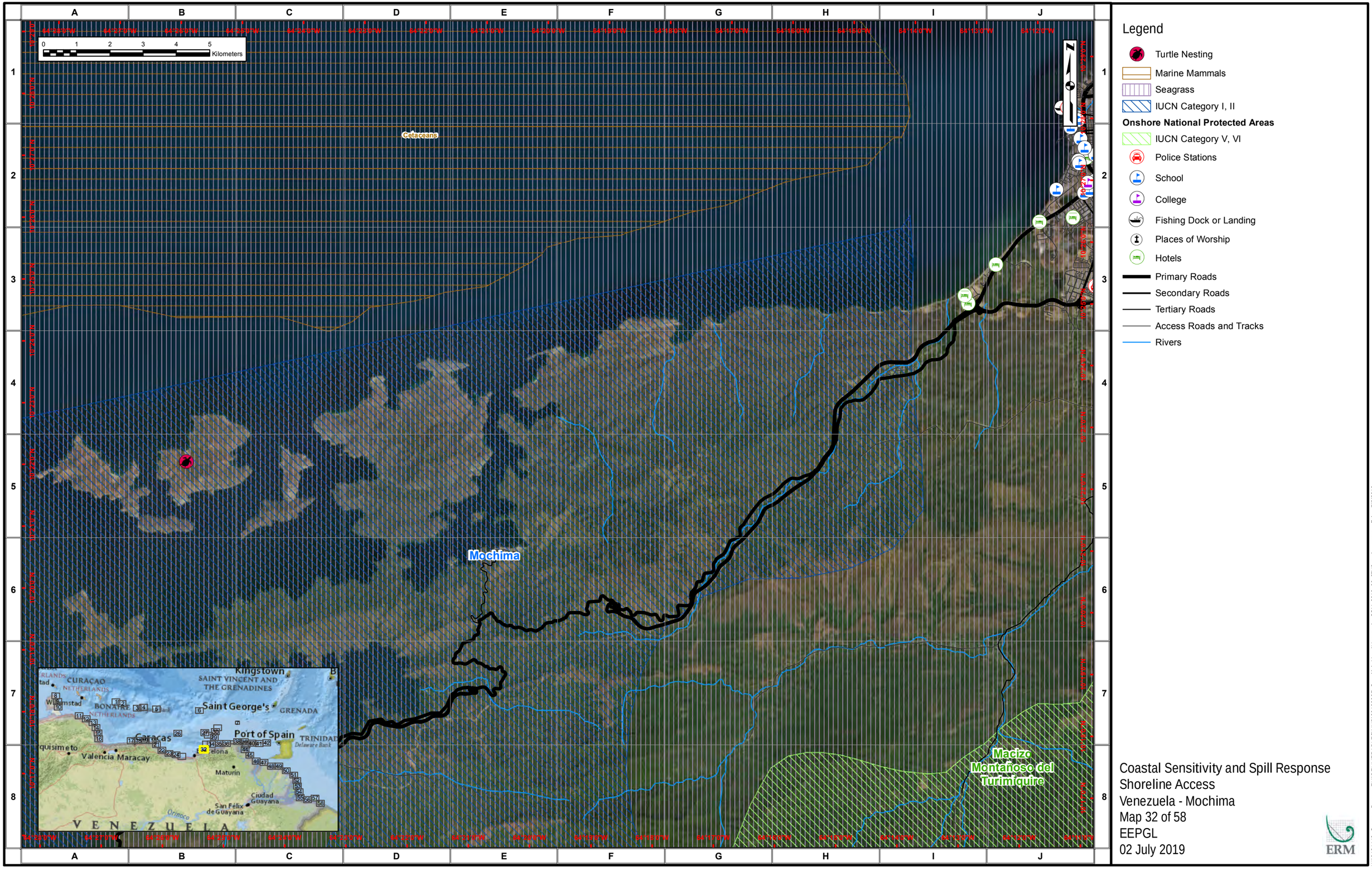
AccessType

- Access by Foot (Beach)
- Rivers
- Hazardous Areas
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Isla de Margarita (North)
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Legend

- Turtle Nesting
- Marine Mammals
- Seagrass
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category V, VI
- Police Stations
- School
- College
- Fishing Dock or Landing
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Mochima
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0 1 2 3 4 5 Kilometers

N

Cetaceans

ARAYA

Kingstown
SAINT VINCENT AND THE GRENADINES
Saint George's
GRENADA
CURAÇAO
NETHERLANDS
Willemstad
BONAIRE
NETHERLANDS
Caracas
Port of Spain
TRINIDAD
Delaware Bank
Valencia
Maracay
Barcelona
Maturín
Ciudad Guayana
San Félix de Guayana
Orinoco
V E N E Z U E L A

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 9A - Sheltered tidal flats
- 9C - Hypersaline tidal flats
- 10A - Salt and brackish water marshes
- Marine Mammals
- Seagrass
- Hospitals
- Police Stations
- School
- College
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Wreck
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Punta Arenas
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0 1 2 3 4 5 Kilometers

N

Cetaceans

Kingstown
SAINT VINCENT AND THE GRENADINES
Saint George's
GRENADA
CURAÇAO
NETHERLANDS
BONAIRE
NETHERLANDS
Caracas
Port of Spain
TRINIDAD
Delaware Bank
Valencia
Maracay
Maturín
Ciudad Guayana
San Félix de Guayana
Orinoco
V E N E Z U E L A

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 9C - Hypersaline tidal flats
- Marine Mammals
- Seagrass

Onshore National Protected Areas

- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- College
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Cumana
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals
- Seagrass
- Fishing Dock or Landing
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

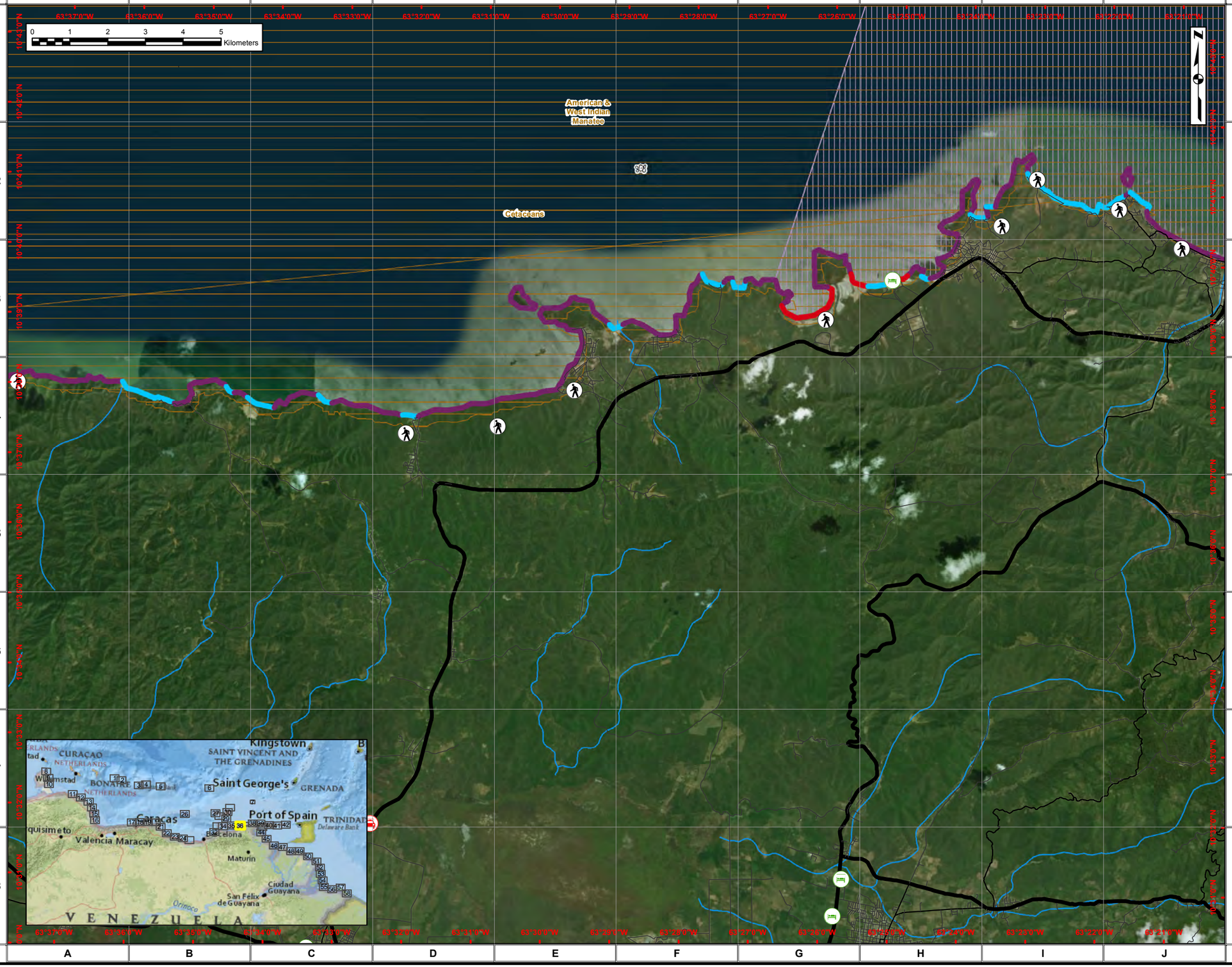
AccessType

- Access by Foot (Beach)
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Cruz Salmeron Acosta
Map 35 of 58
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 10A - Salt and brackish water marshes
- Marine Mammals
- Seagrass
- Lagoon
- Police Stations
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

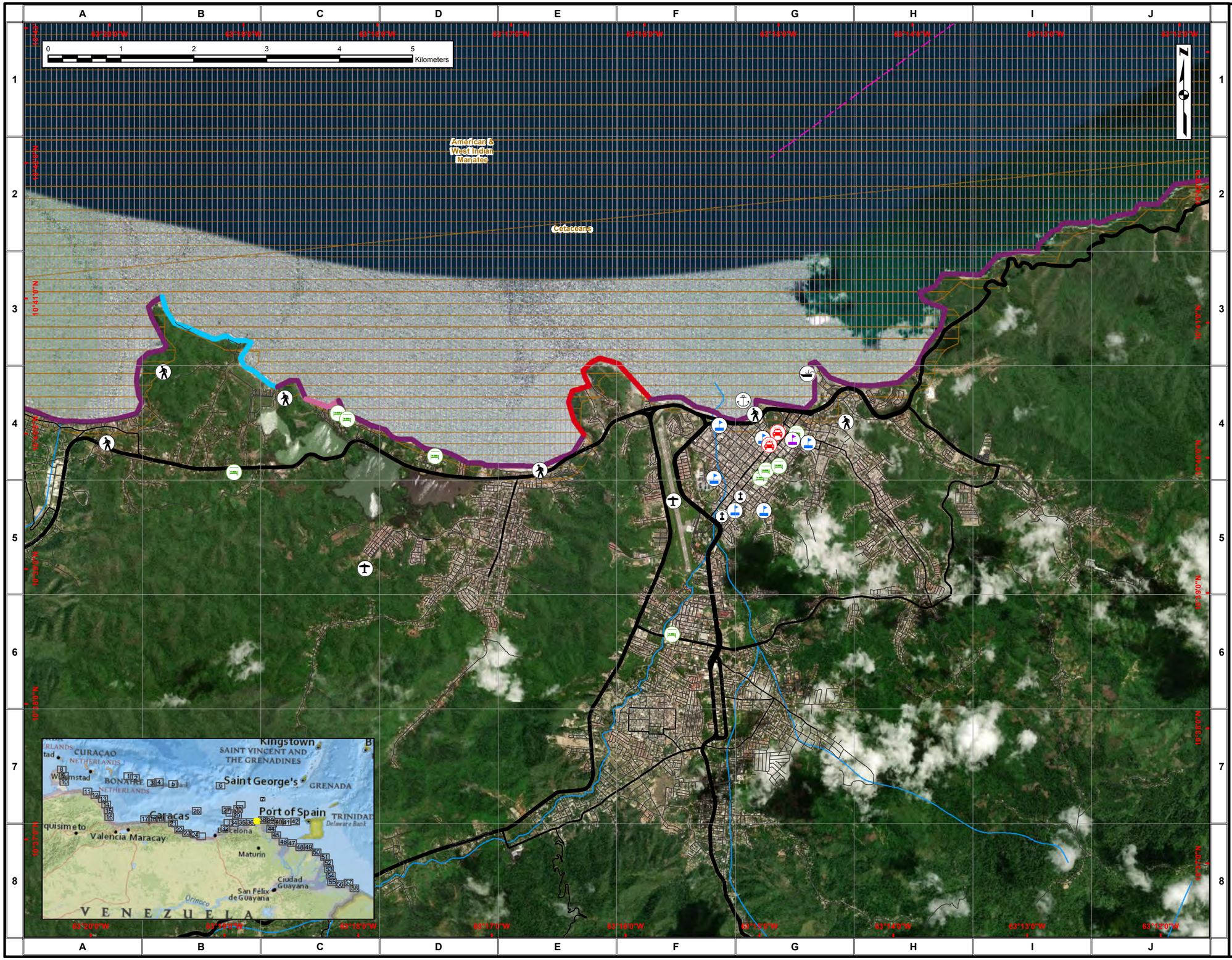
AccessType

- Access by Foot (Beach)
- Rivers
- Rock

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Saucedo to La Esmeralda
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 10A - Salt and brackish water marshes
- 10B - Freshwater marsh
- Marine Mammals
- Seagrass
- Police Stations
- School
- College
- Port or Marina
- Fishing Dock or Landing
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Carupano
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 10B - Freshwater marsh
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Marine Mammals
- Seagrass
- Fishing Dock or Landing
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

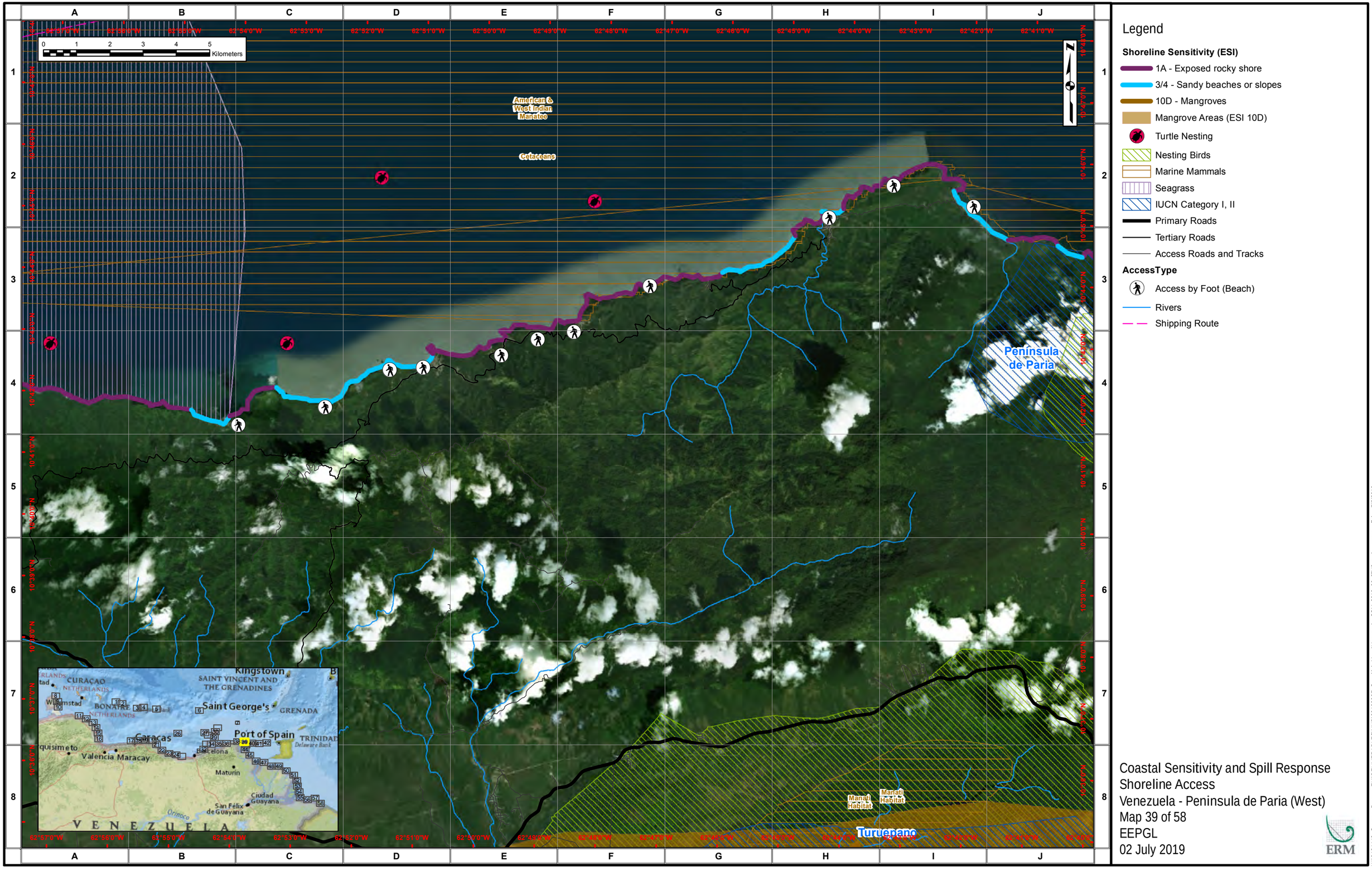
AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - El Morro de Puerto Santo
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 3/4 - Sandy beaches or slopes
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Marine Mammals
- Seagrass
- IUCN Category I, II
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

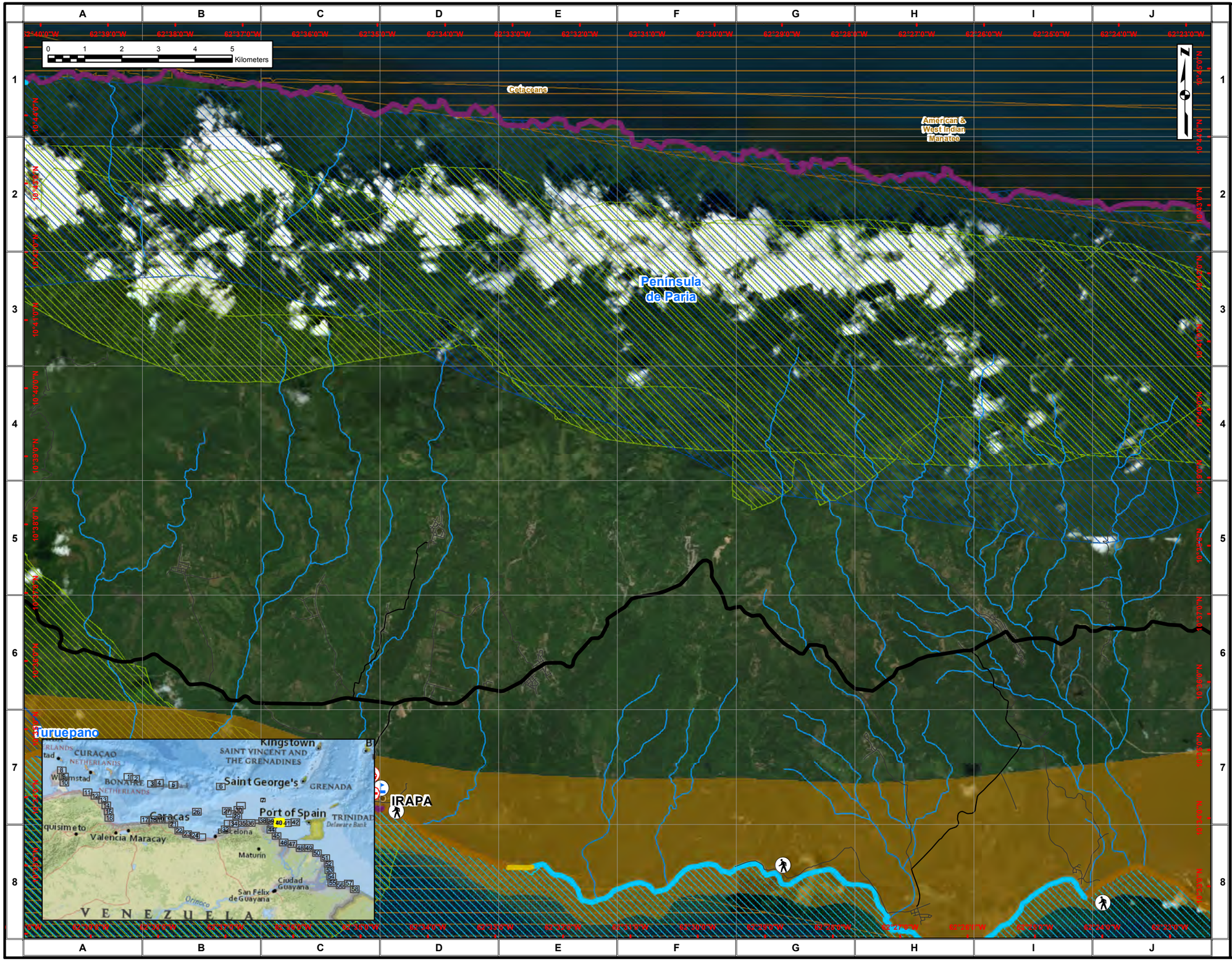
AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (West)
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category I, II
- Hospitals
- Police Stations
- School
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

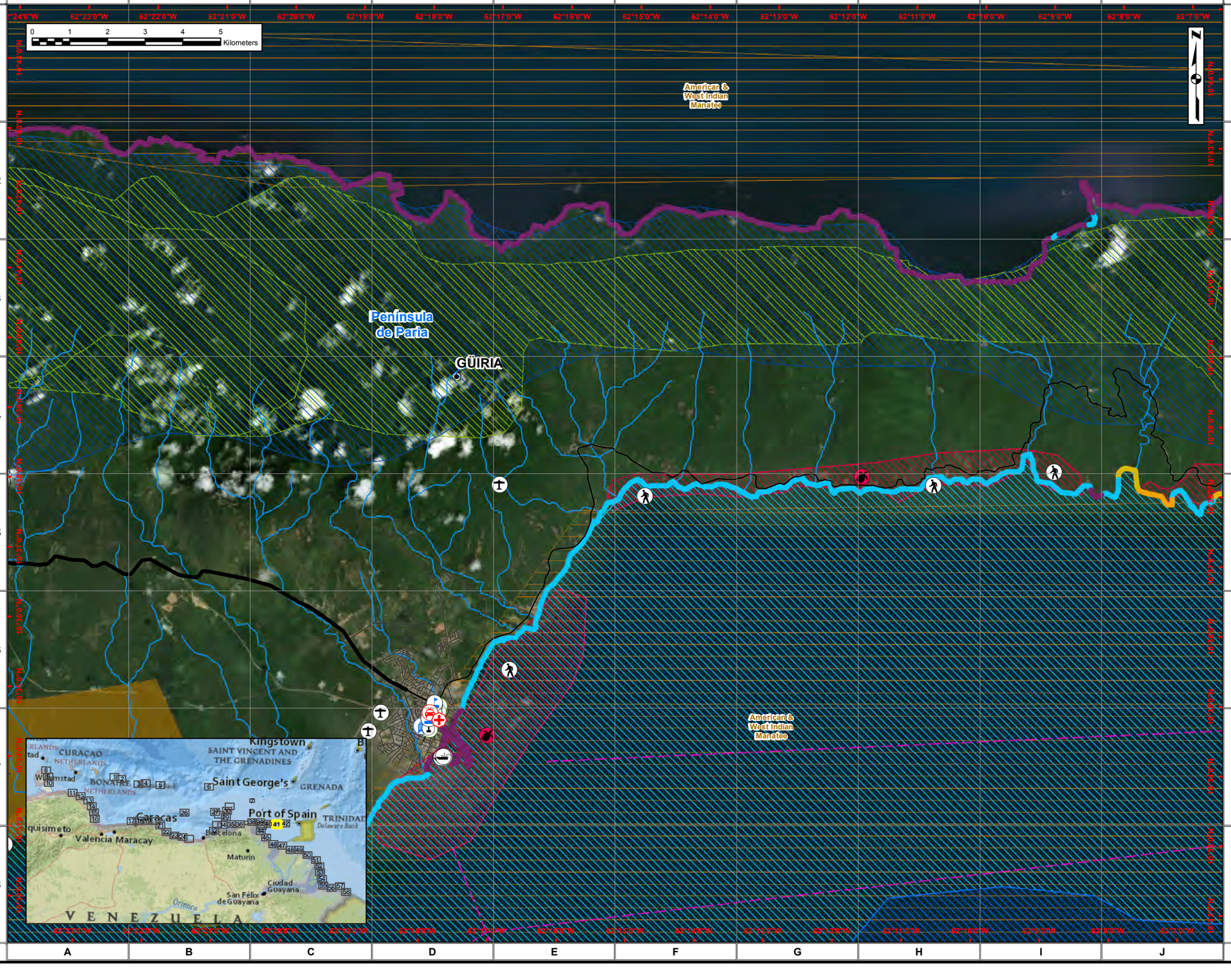
AccessType

- Access by Foot (Beach)
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (West-Central)
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- IUCN Category I, II
- Hospitals
- Police Stations
- School
- Port or Marina
- Fishing Dock or Landing
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

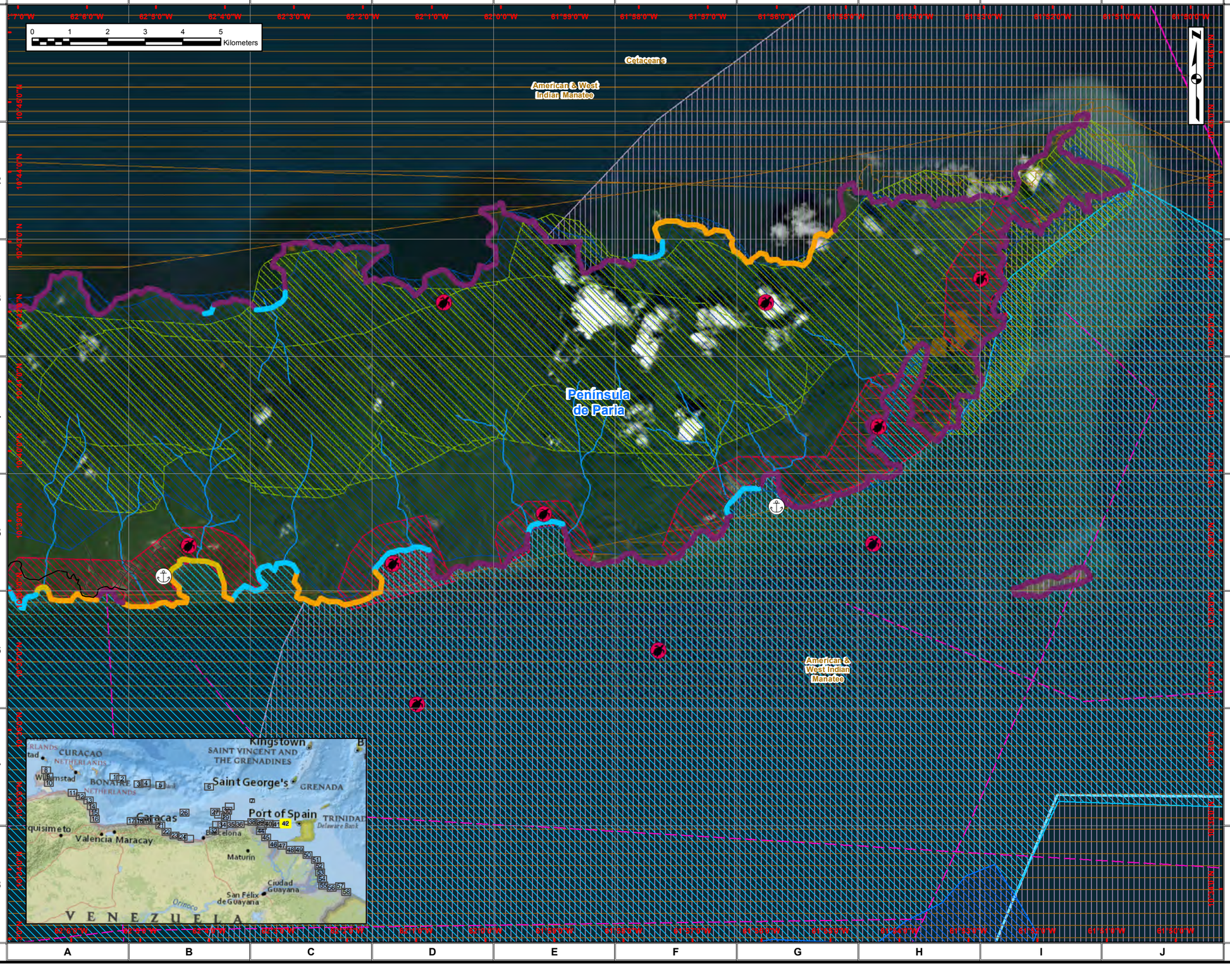
AccessType

- Access by Foot (Beach)
- Rivers
- Shipping Route
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (East-Central)
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- Seagrass
- IUCN Category I, II
- Port or Marina
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Shipping Route
- Territorial Waters Boundary

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Peninsula de Paria (East)
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Legend

Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rivers
- Municipal Capital

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Turuepano (North)
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Legend

Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category I, II

Onshore National Protected Areas

- IUCN Category Not Reported
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Turuepano (South)
Map 44 of 58
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Legend

Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals

Onshore National Protected Areas

- IUCN Category Not Reported
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Gulf of Paria (Rio de San Juan)
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals

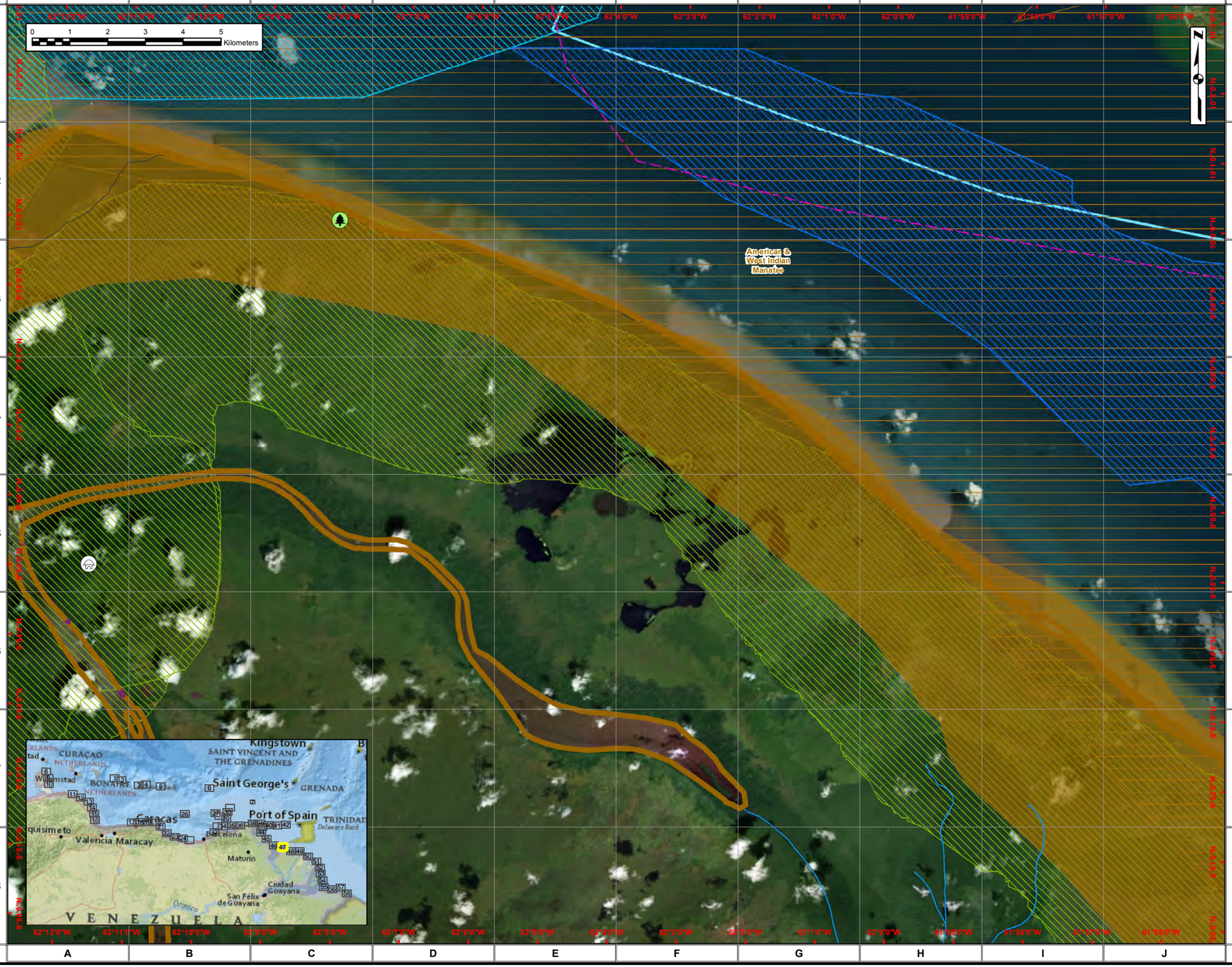
Onshore National Protected Areas

- IUCN Category Not Reported
- Hospitals
- School
- Amerindian Village
- Places of Worship
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Gulf of Paria (Isla Cotorra)
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals

Onshore National Protected Areas

- IUCN Category V & VI
- Amerindian Village
- Access Roads and Tracks
- Rivers
- Shipping Route
- Territorial Waters Boundary

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Gulf of Paria (Columbus Channel)
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0 1 2 3 4 5 Kilometers

N

American & West Indian Manatee

Manati Habitat

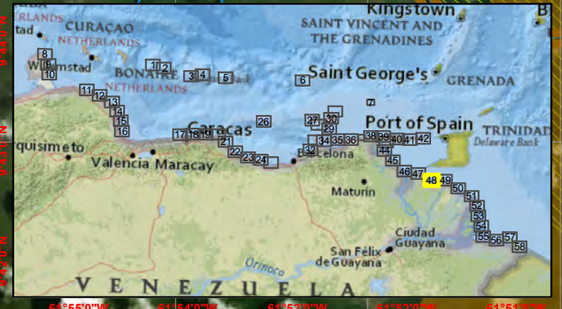
Manati Habitat

Manati Habitat

Manati Habitat

Manati Habitat

Manati Habitat



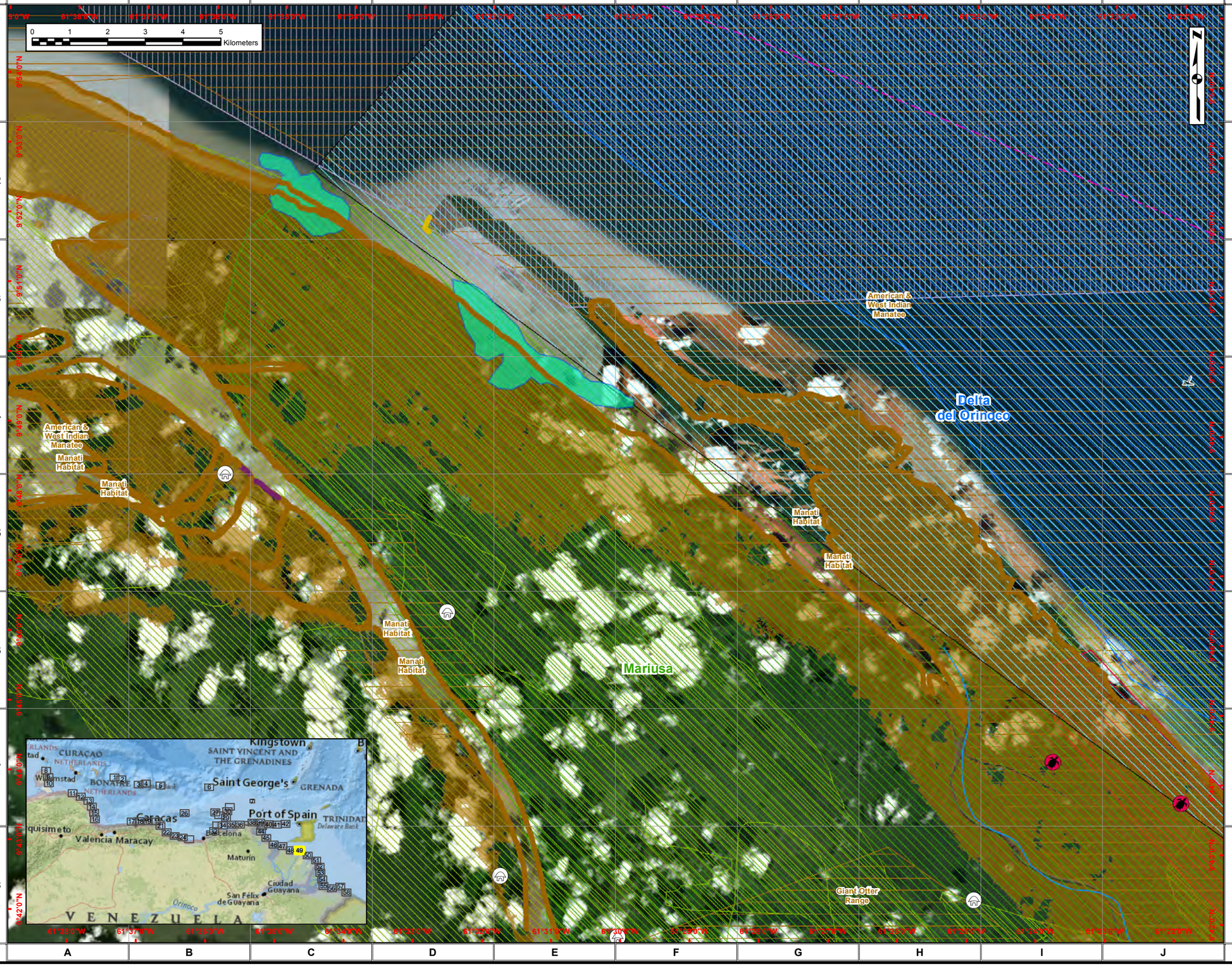
Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Tucupita (West)
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Legend

Shoreline Sensitivity (ESI)

- 1B - Exposed, solid man-made structures
- 7 - Exposed tidal flats
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- Seagrass
- Lagoon
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category I, II
- Amerindian Village
- Rivers
- Wreck
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 1
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0 1 2 3 4 5 Kilometers

N

American & West Indian Manatee

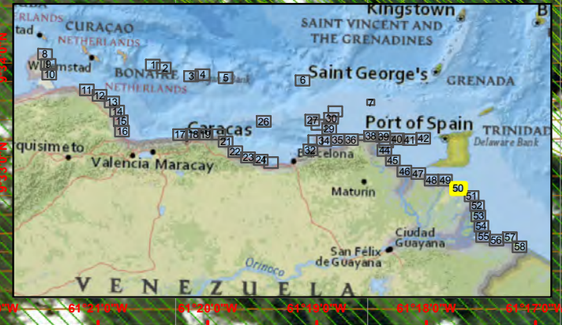
Delta del Orinoco

Mariusa

Giant Otter Range

Manati Habitat

Manati Habitat



Legend

Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- Seagrass
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category I, II
- Amerindian Village
- Rivers
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 2
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Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 3
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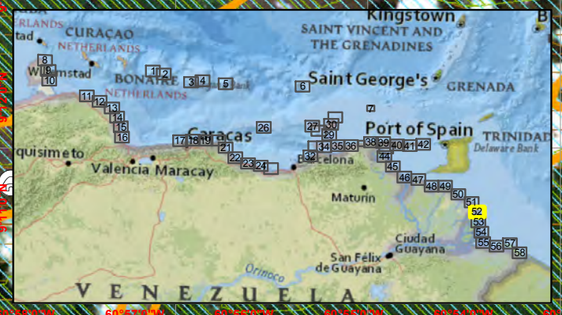
0 1 2 3 4 5 Kilometers

N

Giant Otter Range

Delta del Orinoco

American & West Indian Manatee



Legend

Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Turtle Nesting
- Nesting Birds
- Turtle Nesting Areas
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 4
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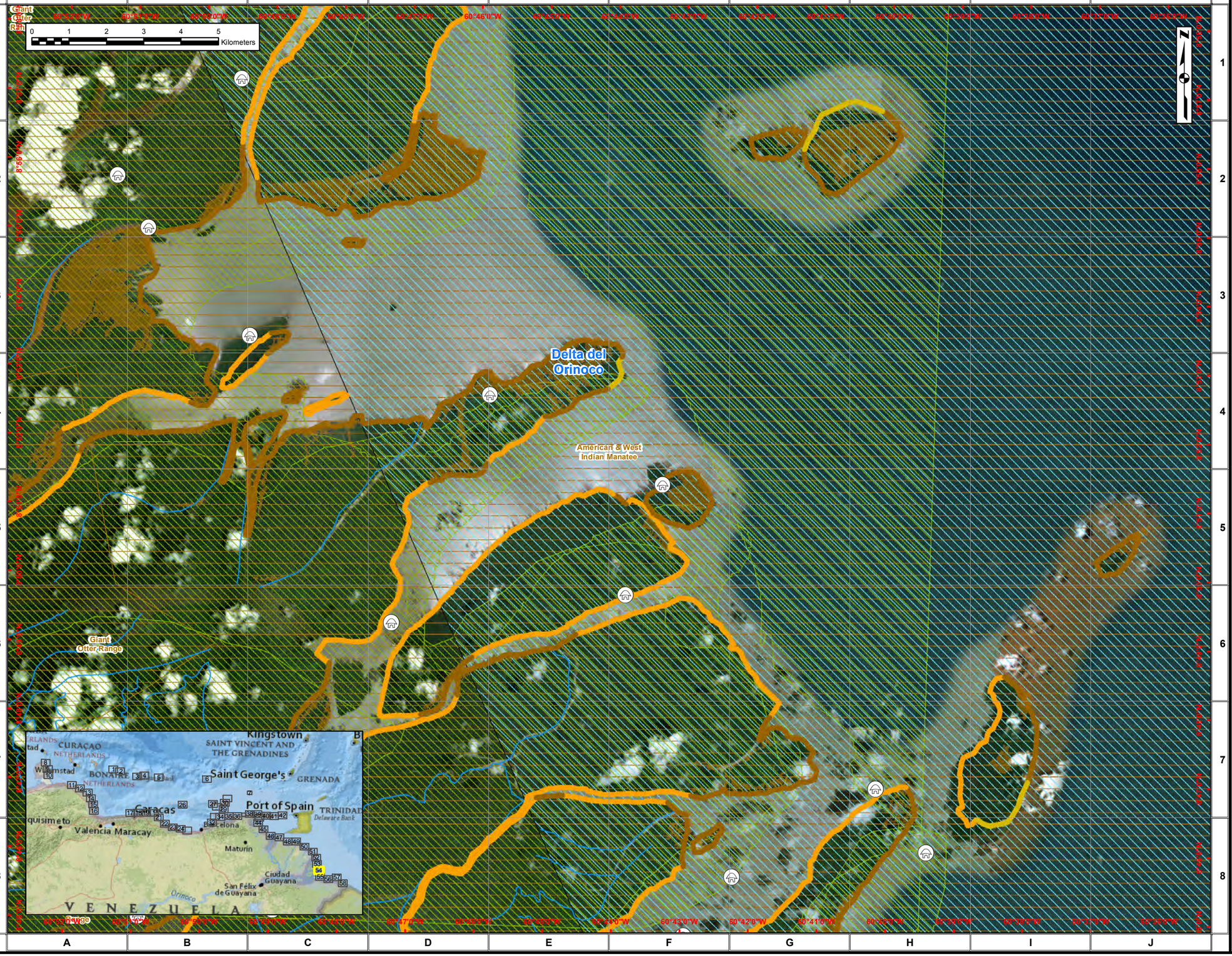
Shoreline Sensitivity (ESI)

- 3/4 - Sandy beaches or slopes
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI
- Nesting Birds
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 5
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Legend

Shoreline Sensitivity (ESI)

- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category Not Reported
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 6
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Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Nesting Birds
- Marine Mammals
- IUCN Category Not Reported

Onshore National Protected Areas

- IUCN Category V, VI
- Amerindian Village
- Rivers

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 7
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Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals
- IUCN Category Not Reported

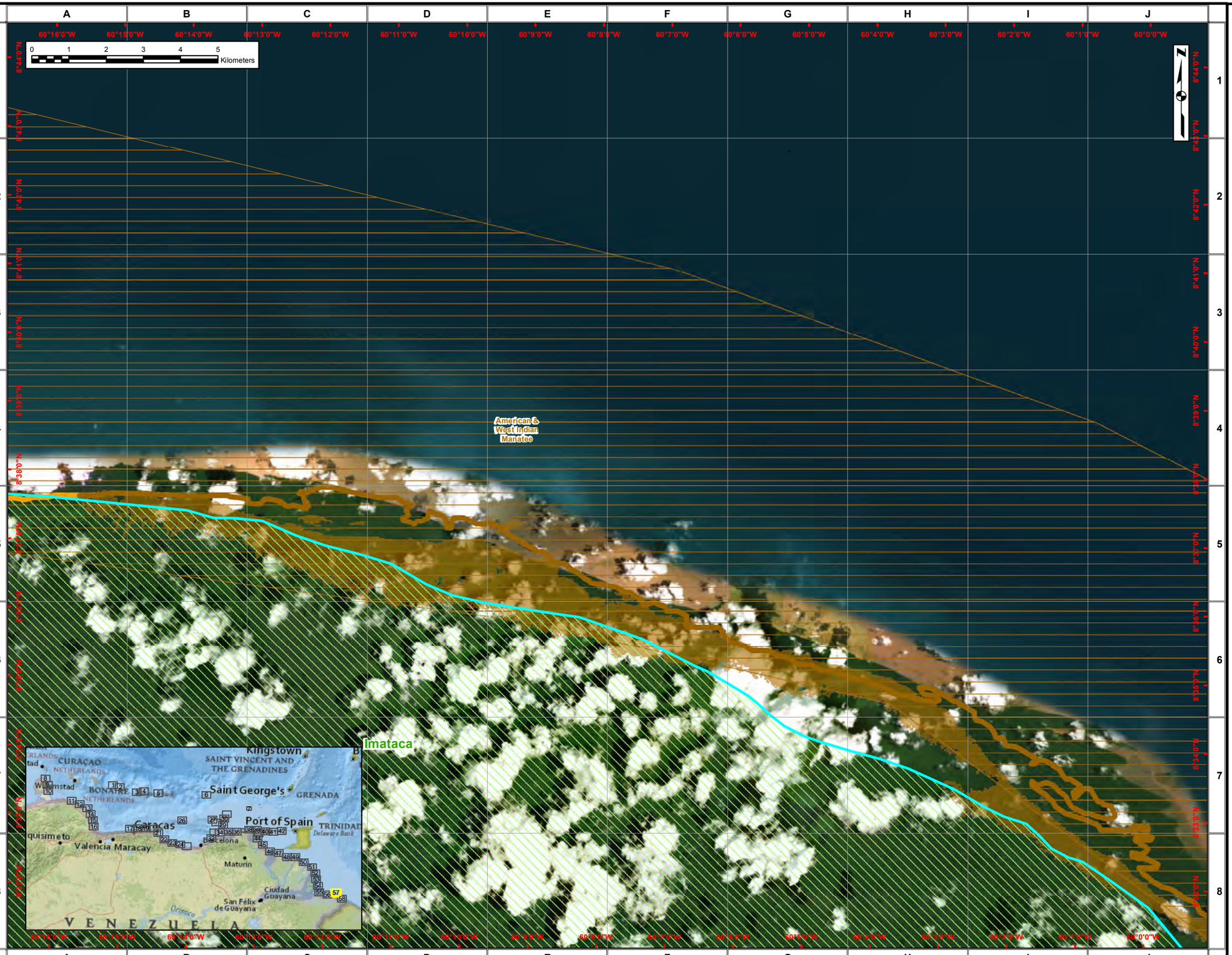
Onshore National Protected Areas

- IUCN Category V, VI

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela - Orinoco Delta 8
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Shoreline Sensitivity (ESI)

- 9B - Vegetated low banks
- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals

Onshore National Protected Areas

- IUCN Category V, VI

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Shoreline Sensitivity (ESI)

- 10D - Mangroves
- Mangrove Areas (ESI 10D)
- Marine Mammals
- IUCN Category V, VI

Onshore National Protected Areas

- IUCN Category V, VI
- Rivers
- Underwater Danger /Underwater Hazard

Coastal Sensitivity and Spill Response
Shoreline Access
Venezuela
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Grenada

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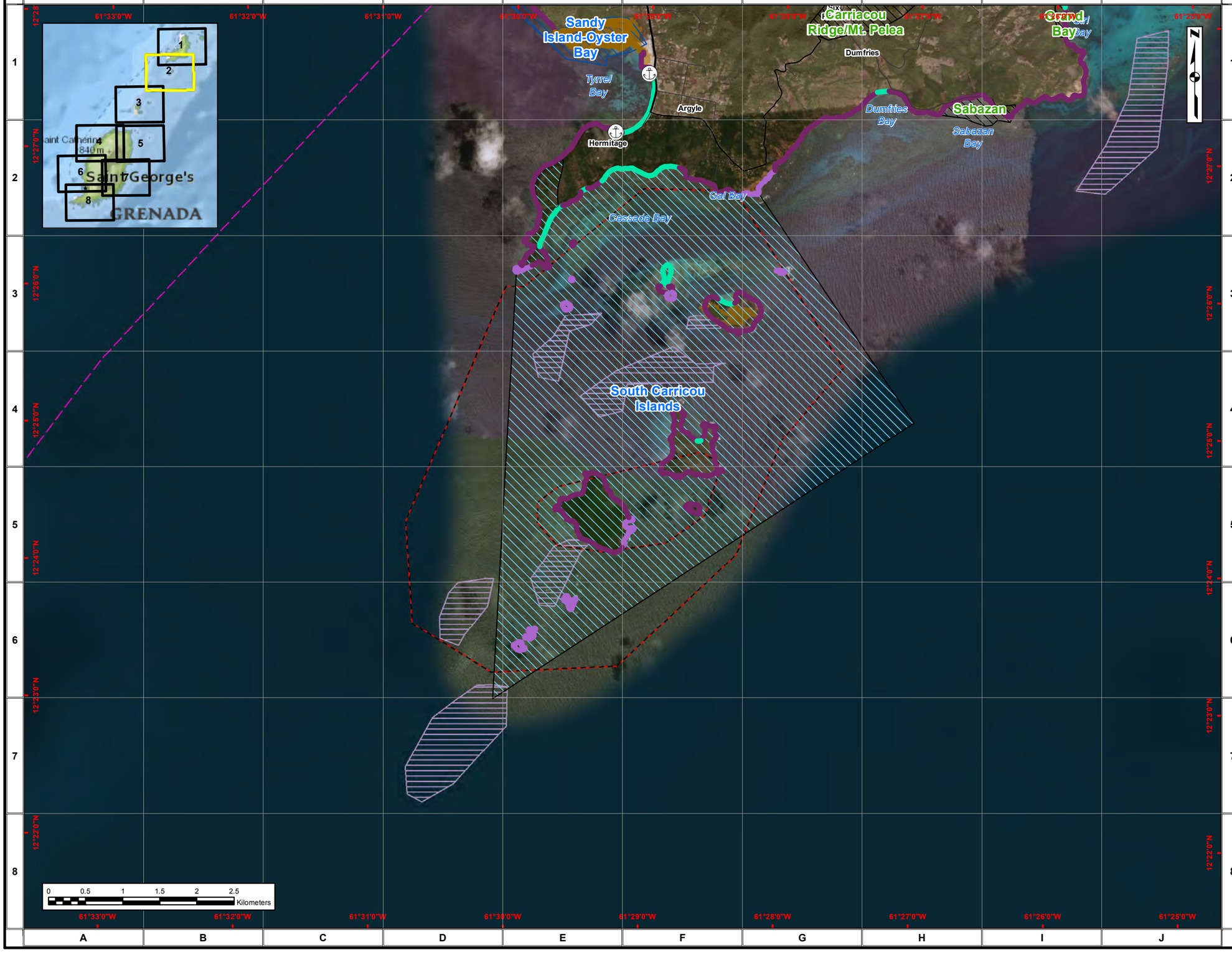
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 3/4 - Sandy beaches or slopes
- 4/5 - Sand or gravel beach
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Hospitals
- Police Stations
- Kindergarten
- School
- Port or Marina
- Ferry Dock
- Historic Site
- Places of Worship
- Government Facilities
- Hotels
- Regional Capital
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
Map 1 of 8
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category Not Reported
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Port or Marina
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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Ronde Island Group

Whale Bay

0 0.5 1 1.5 2 2.5 Kilometers

Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- IUCN Category Not Reported
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Seagrass
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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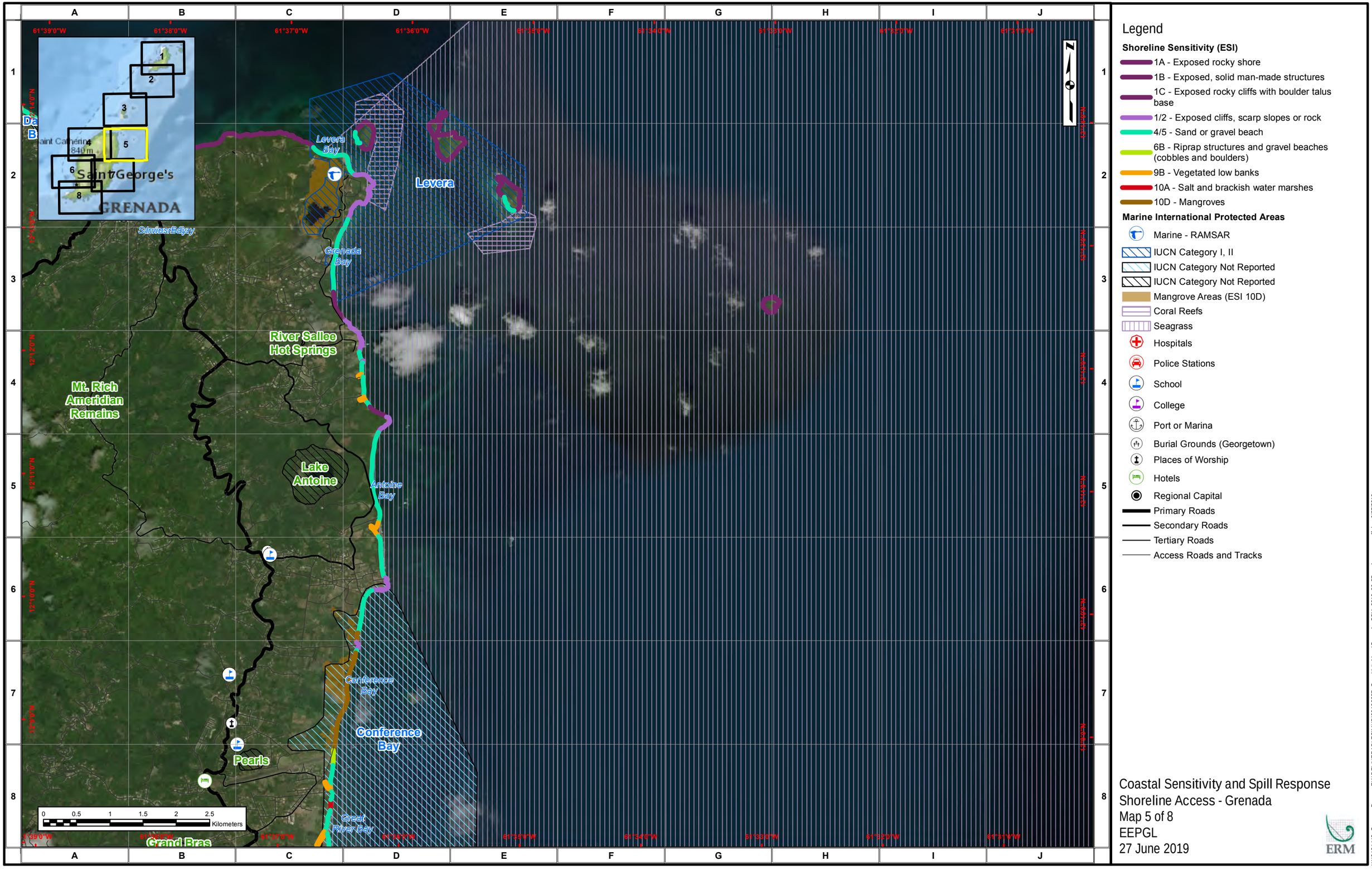
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category Not Reported
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Port or Marina
- Historic Site
- Burial Grounds (Georgetown)
- Places of Worship
- Hotels
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves

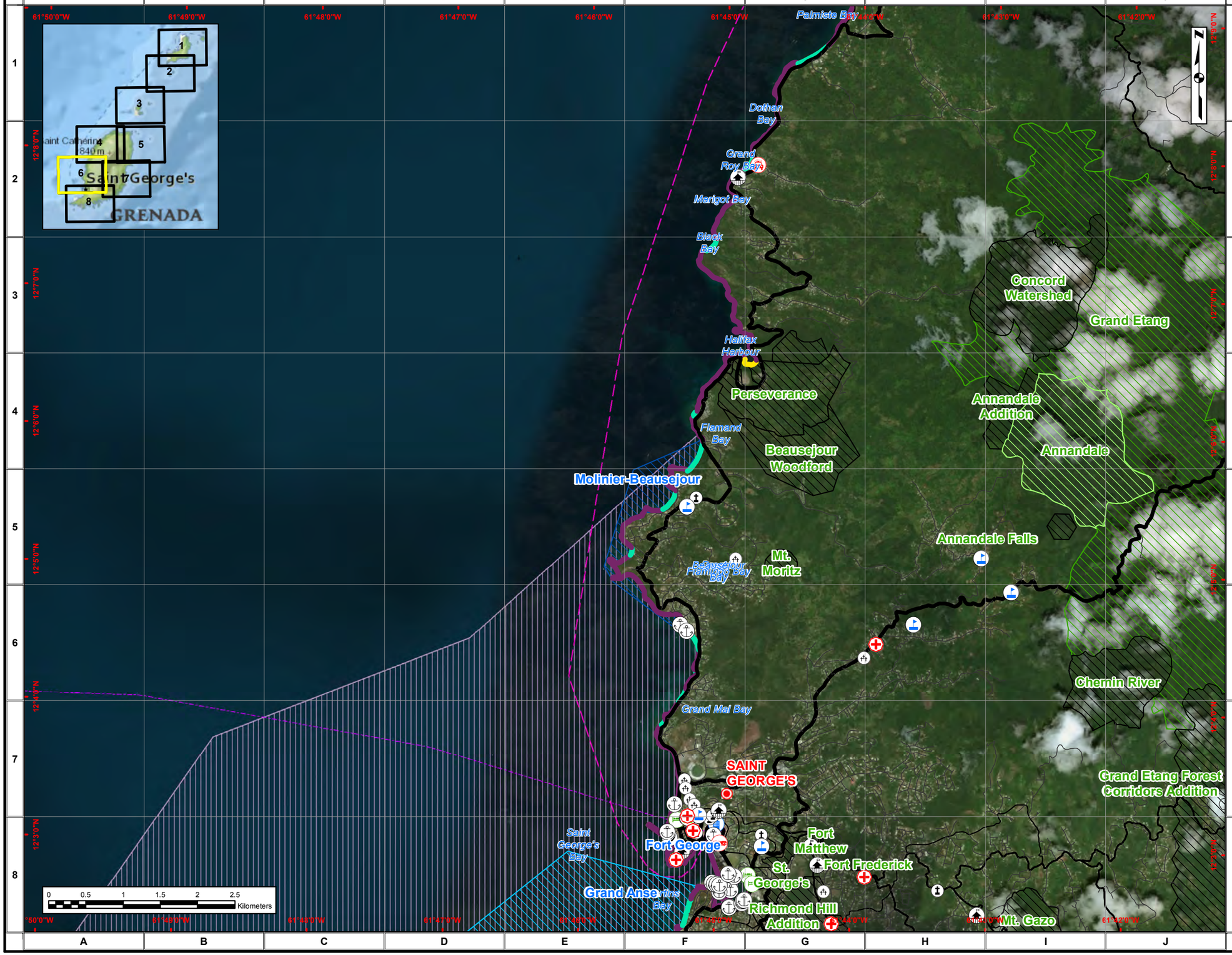
Marine International Protected Areas

- Marine - RAMSAR
- IUCN Category I, II
- IUCN Category Not Reported
- IUCN Category Not Reported
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- College
- Port or Marina
- Burial Grounds (Georgetown)
- Places of Worship
- Hotels
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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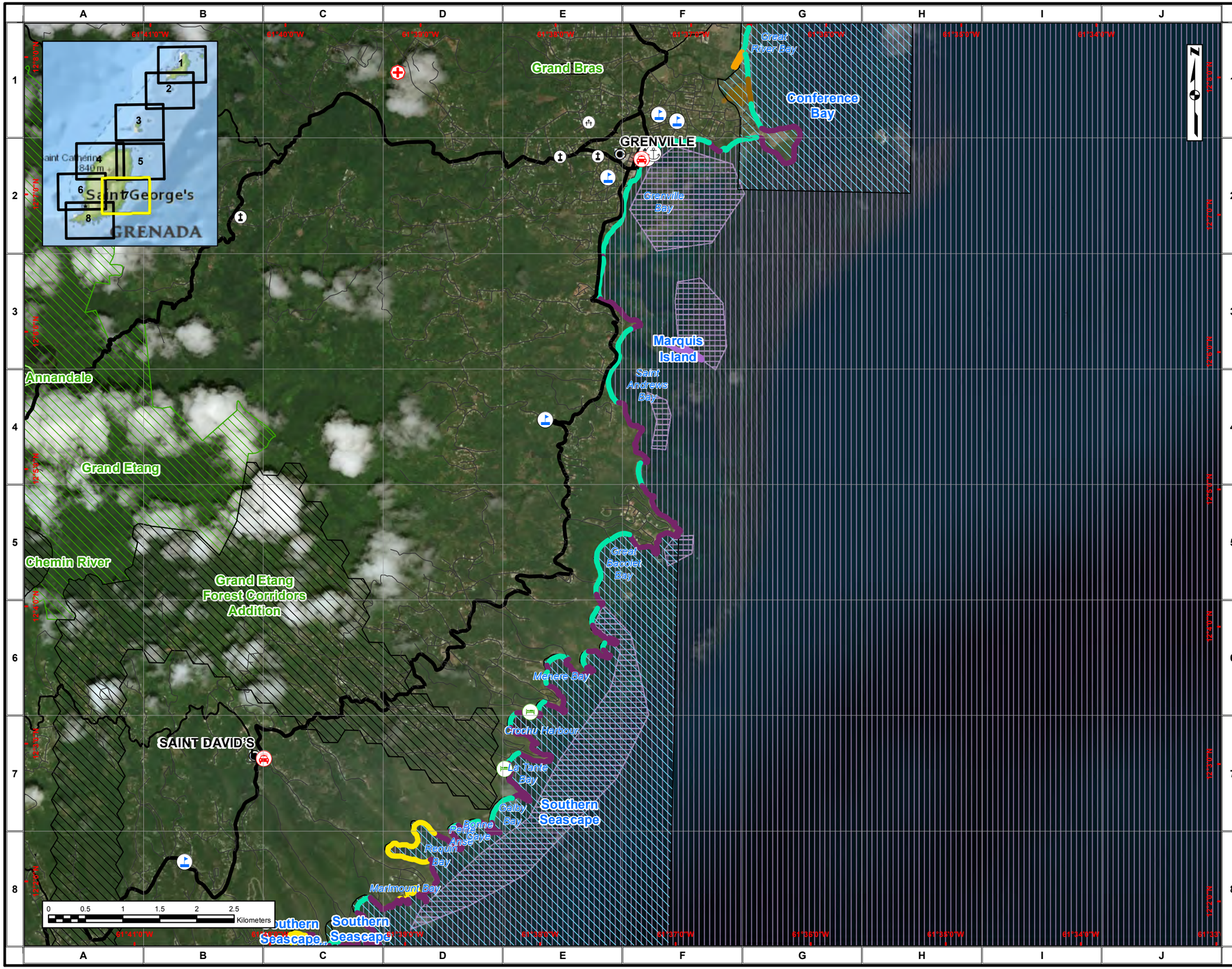
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 4/5 - Sand or gravel beach
- 8A - Sheltered scarps in bedrock, mud or clay
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- Seagrass
- Hospitals
- Police Stations
- Fire Stations (Georgetown)
- Kindergarten
- School
- Port or Marina
- Ferry Dock
- Historic Site
- Burial Grounds (Georgetown)
- Places of Worship
- Government Facilities
- Hotels
- Capital City
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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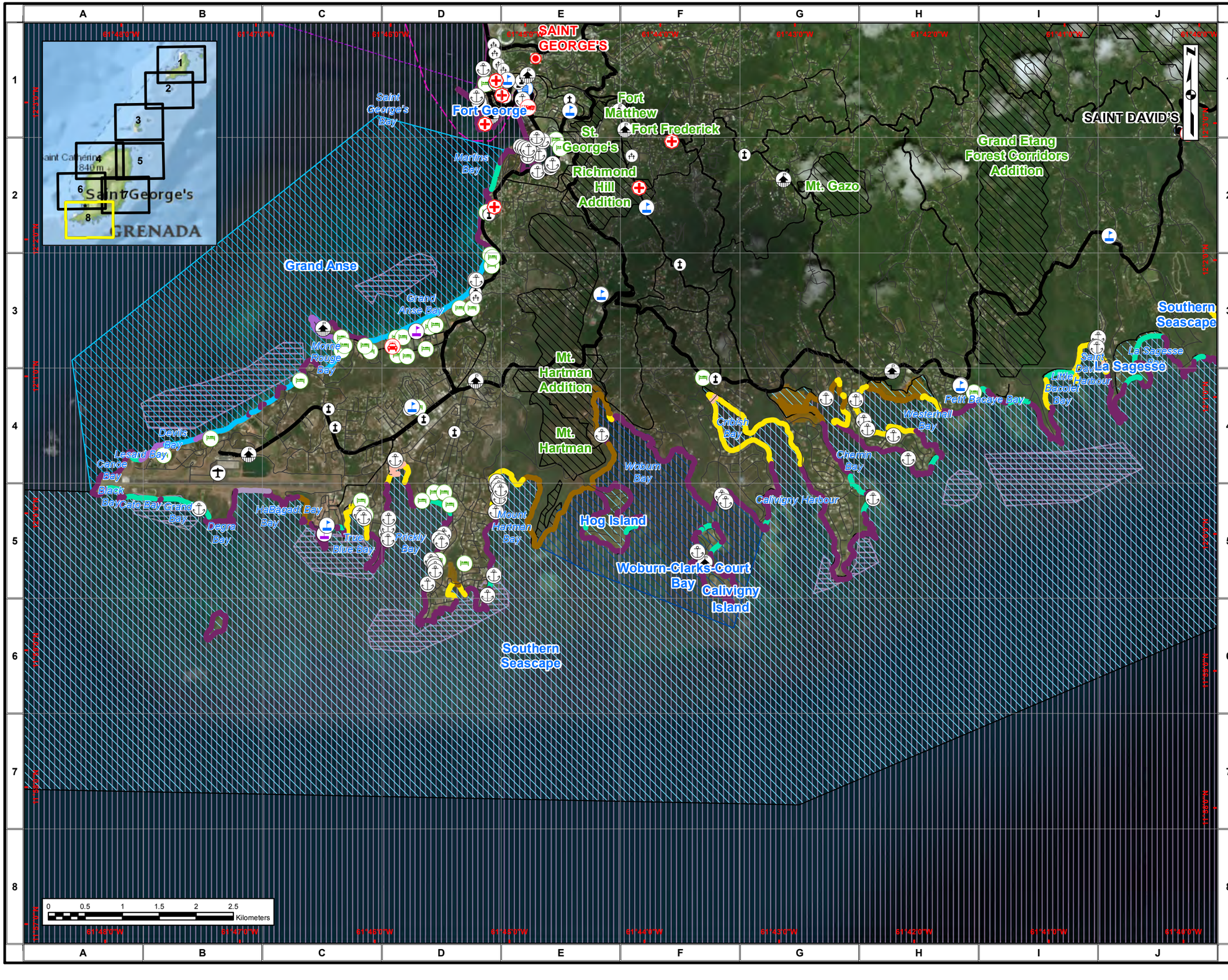
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1/2 - Exposed cliffs, scarp slopes or rock
- 4/5 - Sand or gravel beach
- 8A - Sheltered scarps in bedrock, mud or clay
- 9B - Vegetated low banks
- 10A - Salt and brackish water marshes
- 10D - Mangroves
- IUCN Category Not Reported
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- Port or Marina
- Ferry Dock
- Burial Grounds (Georgetown)
- Places of Worship
- Hotels
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access - Grenada
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 1/2 - Exposed cliffs, scarp slopes or rock
- 2B - Exposed scarps and steep slopes in clay
- 3/4 - Sandy beaches or slopes
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8A - Sheltered scarps in bedrock, mud or clay
- 8B - Sheltered, solid man-made structures
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category Not Reported
- IUCN Category Not Reported
- Mangrove Areas (ESI
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- Fire Stations (Georgetown)
- Kindergarten
- School
- College
- Port or Marina
- Ferry Dock
- Historic Site
- Burial Grounds (Georgetown)
- Places of Worship
- Government Facilities
- Hotels
- Capital City
- Regional Capital
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Wreck
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response Shoreline Access - Grenada

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St. Vincent and The Grenadines

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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 9B - Vegetated low banks
- IUCN Category III, IV

Onshore National Protected Areas

- IUCN Category III & IV
- IUCN Category V & VI
- IUCN Category I, II
- IUCN Category III, IV
- Coral Reefs
- Seagrass
- Police Stations
- School
- Fishing Dock or Landing
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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Legend

Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8A - Sheltered scarps in bedrock, mud or clay
- 8D - Sheltered rocky rubble shores
- 9B - Vegetated low banks
- IUCN Category III, IV

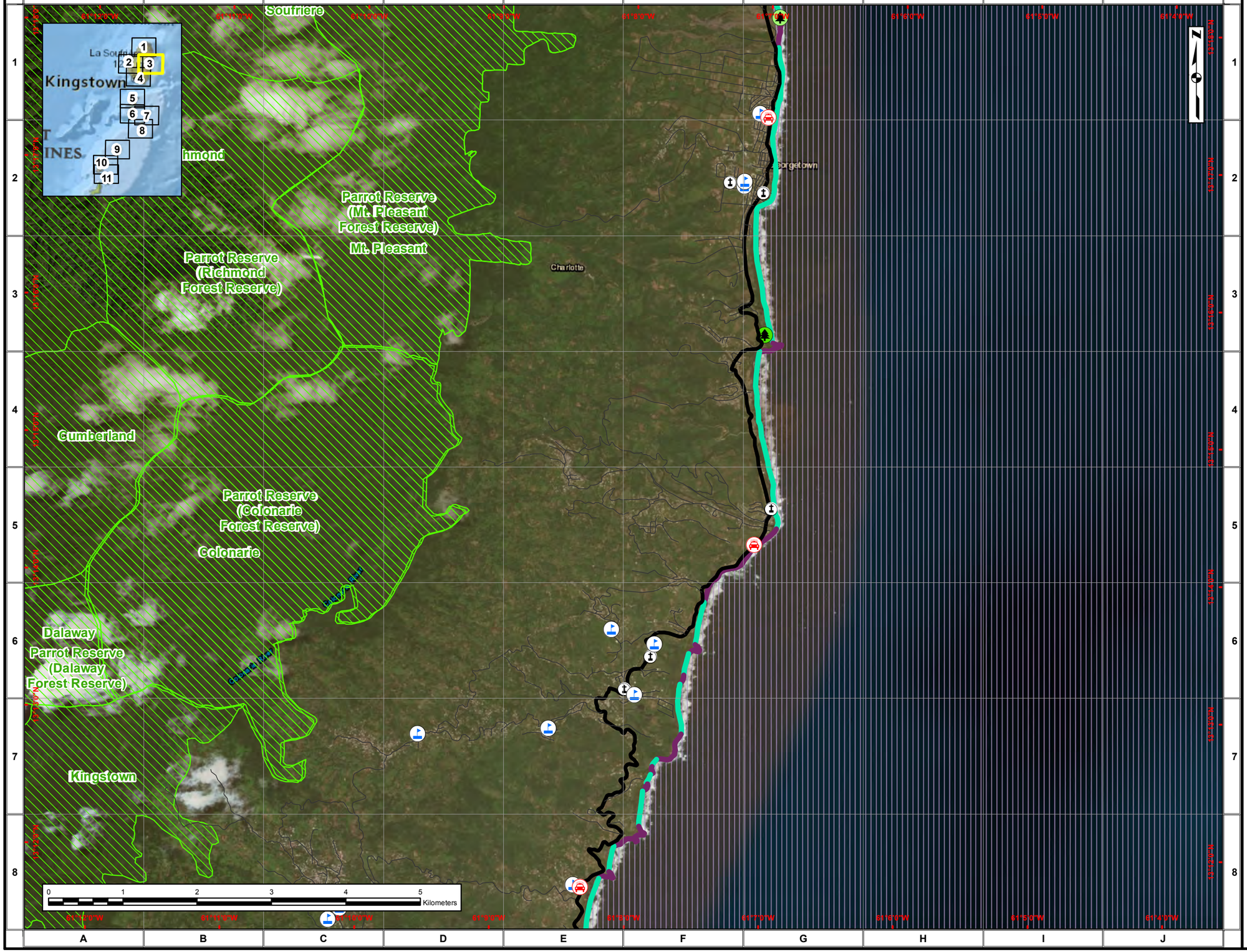
Onshore National Protected Areas

- IUCN Category III & IV
- IUCN Category V & VI
- IUCN Category III, IV
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- Port or Marina
- Fishing Dock or Landing
- Historic Site
- Places of Worship
- Government Facilities
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Underwater Danger /Underwater Hazard
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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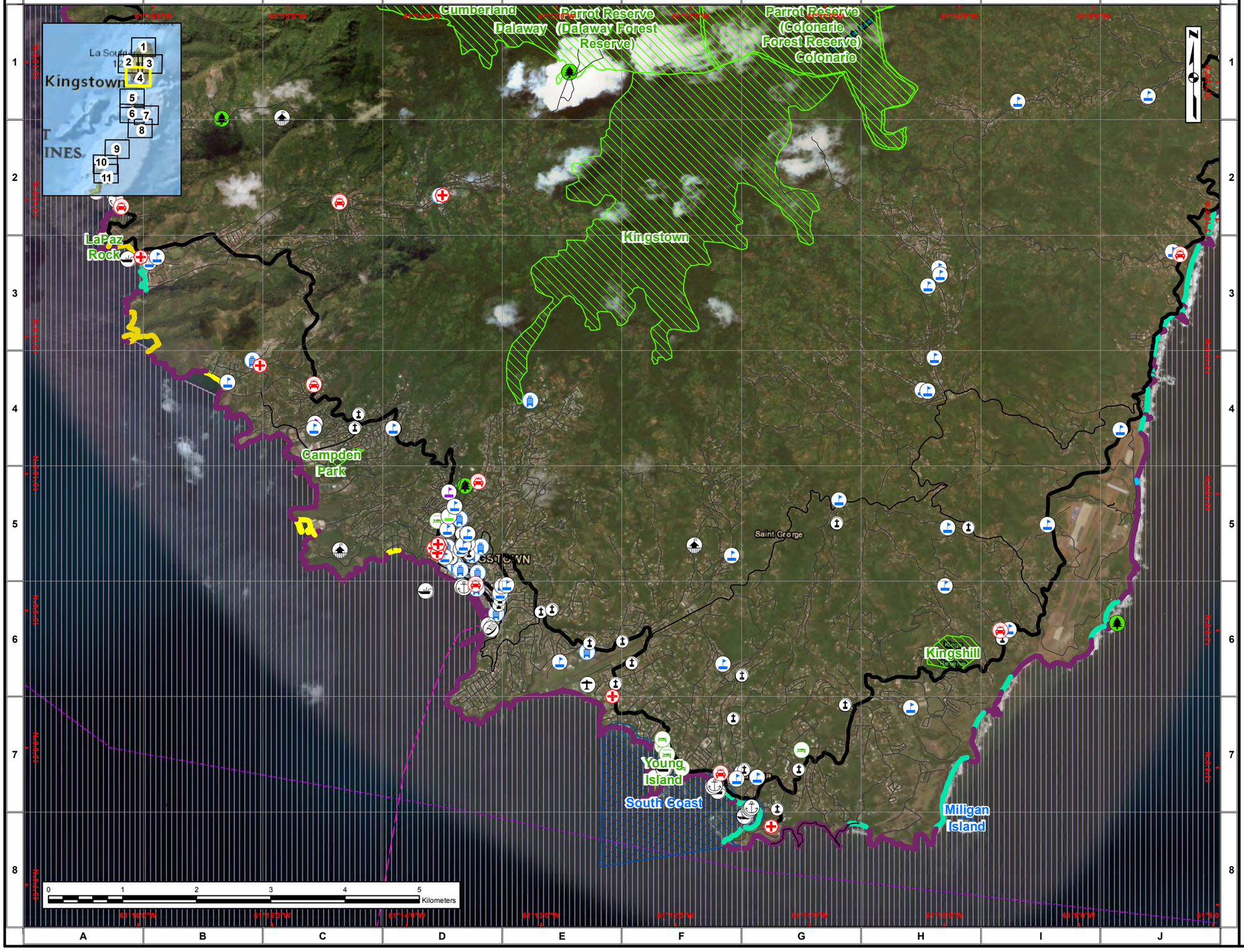
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Coastal Sensitivity and Spill Response
Shoreline Access
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 3/4 - Sandy beaches or slopes
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8A - Sheltered scarps in bedrock, mud or clay
- 8D - Sheltered rocky rubble shores
- IUCN Category I, II
- IUCN Category III, IV

Onshore National Protected

- IUCN Category III & IV
- IUCN Category III, IV
- Seagrass
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Port or Marina
- Fishing Dock or Landing
- Ferry Dock
- Historic Site
- Burial Grounds
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route
- Seabed Cables

Coastal Sensitivity and Spill Response Shoreline Access

St. Vincent and The Grenadines

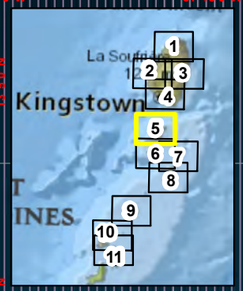
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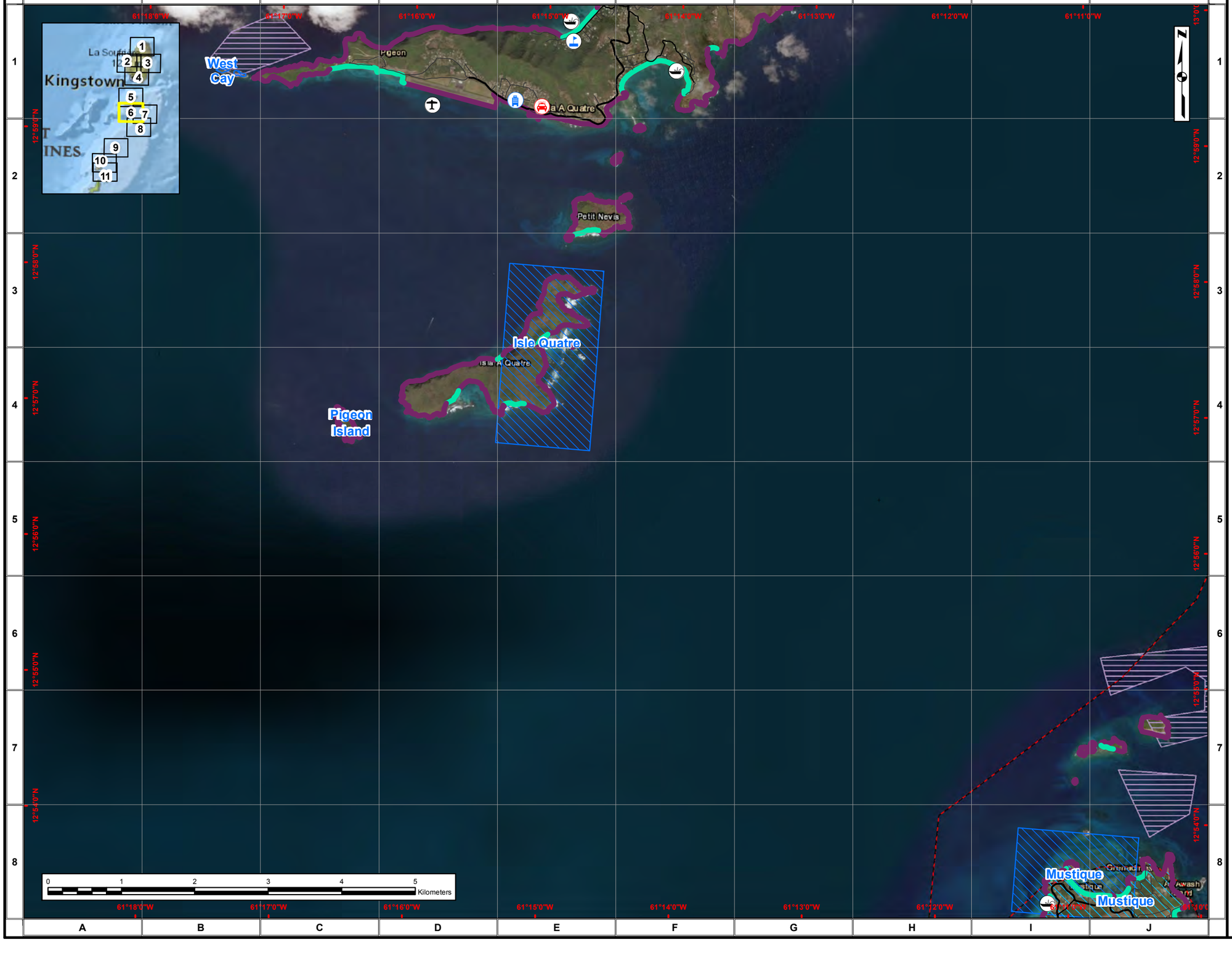
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- Seagrass
- Hospitals
- Police Stations
- School
- Fishing Dock or Landing
- Ferry Dock
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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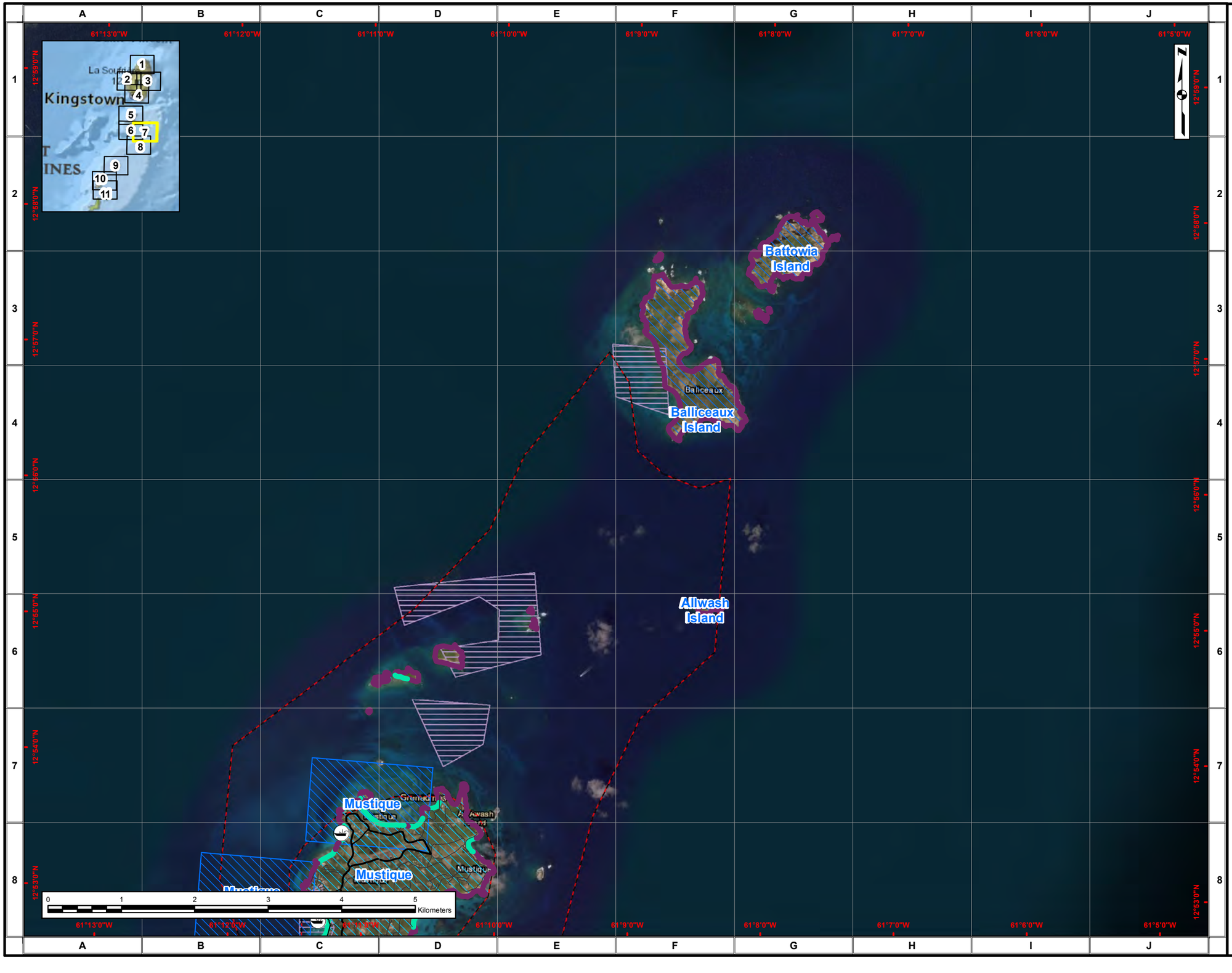
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- Police Stations
- School
- Fishing Dock or Landing
- Government Facilities
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
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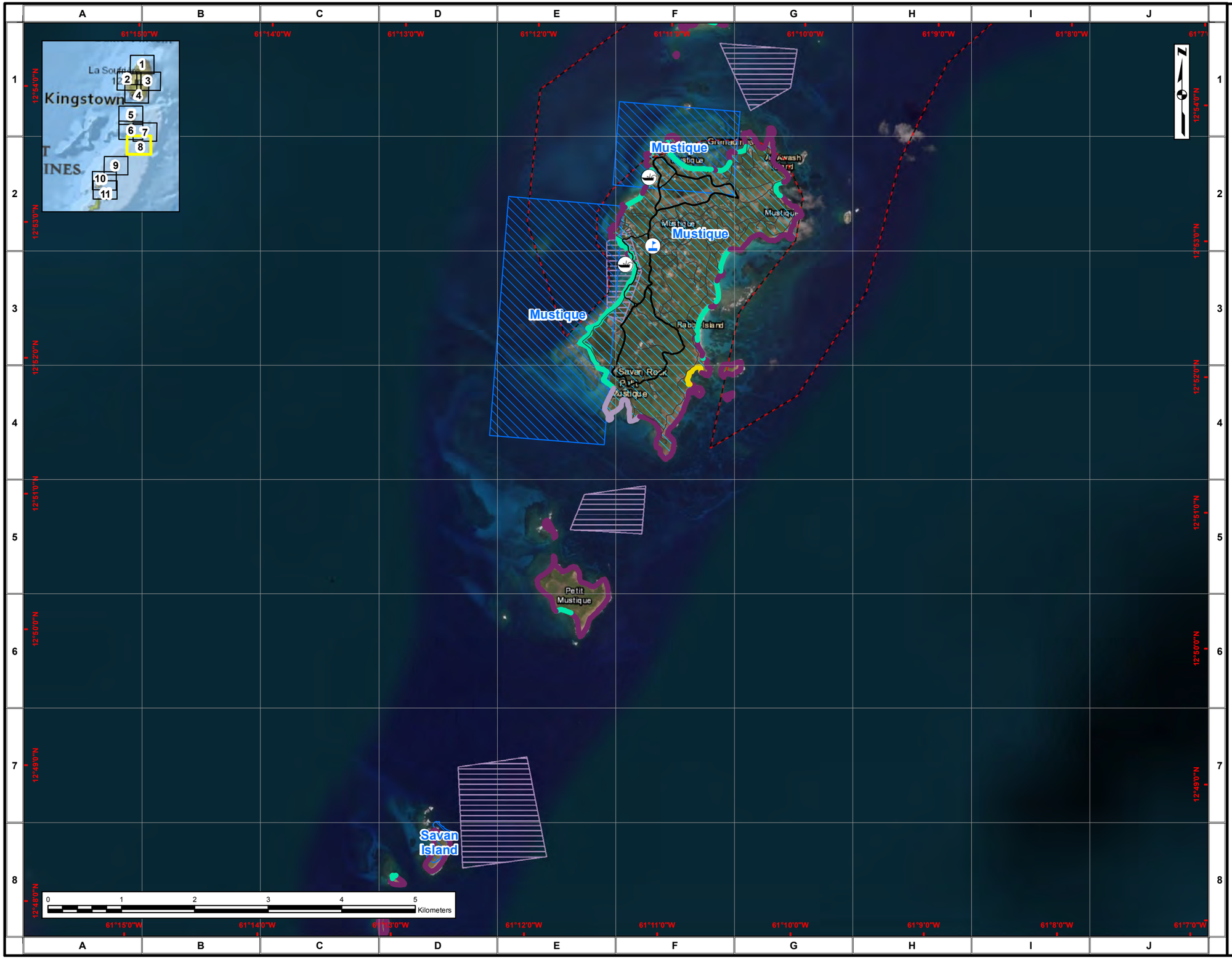
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- School
- Fishing Dock or Landing
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 7 of 11
EEPGL
02 July 2019

ERM

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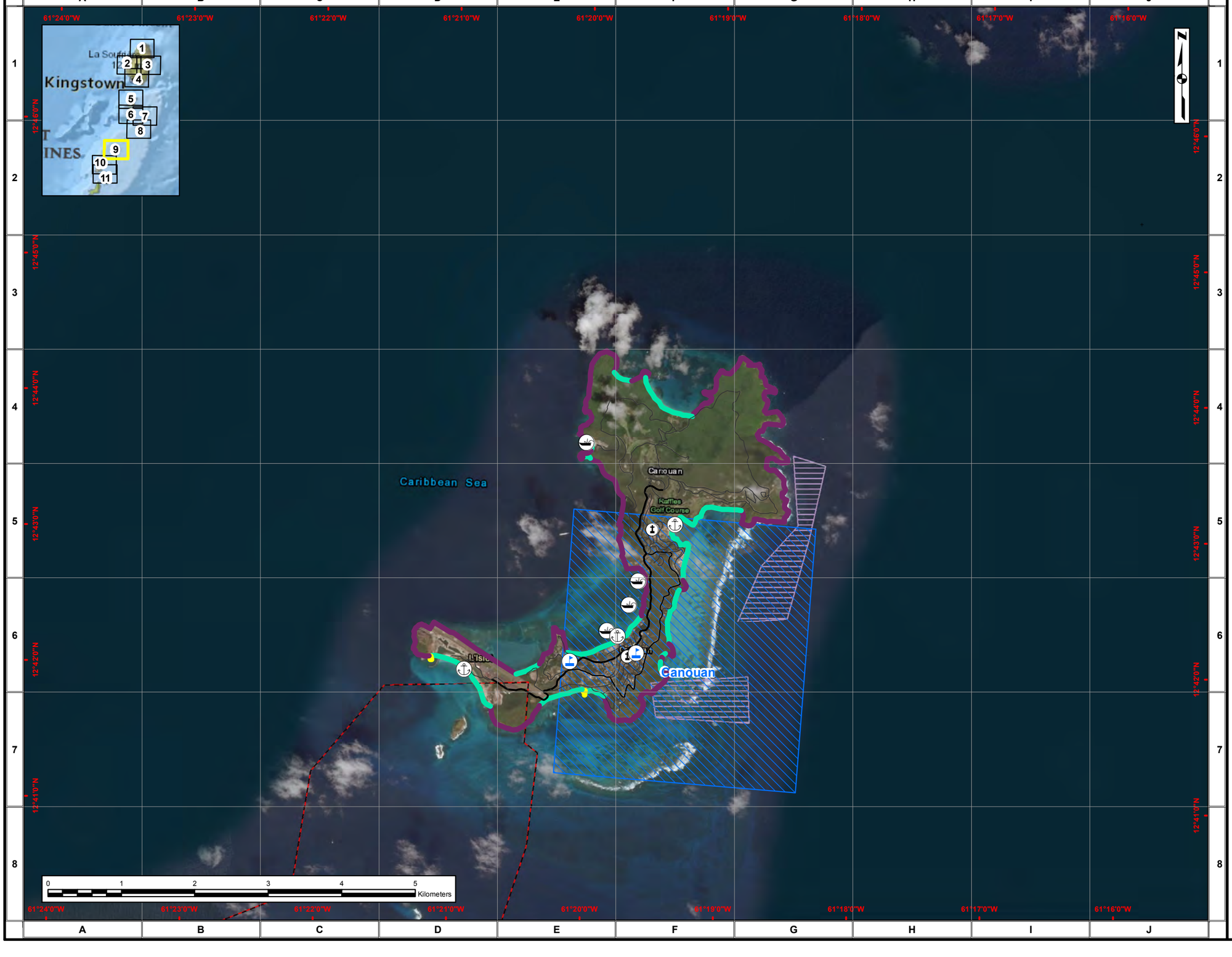
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 2B - Exposed scarps and steep slopes in clay
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 8D - Sheltered rocky rubble shores
- IUCN Category III, IV
- IUCN Category V, VI
- Coral Reefs
- School
- Fishing Dock or Landing
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 8 of 11
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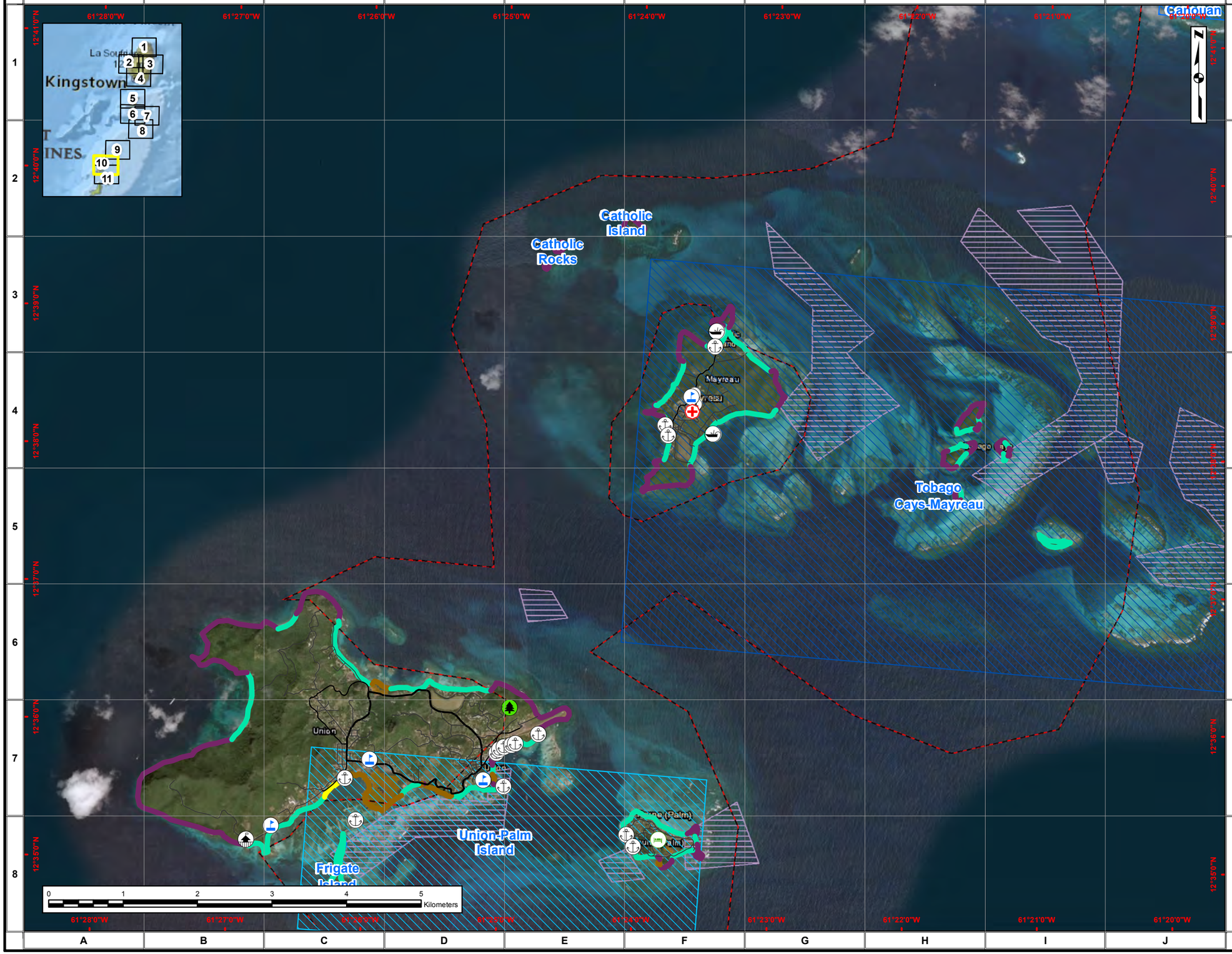
Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- IUCN Category III, IV
- Coral Reefs
- School
- Port or Marina
- Fishing Dock or Landing
- Places of Worship
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 9 of 11
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI

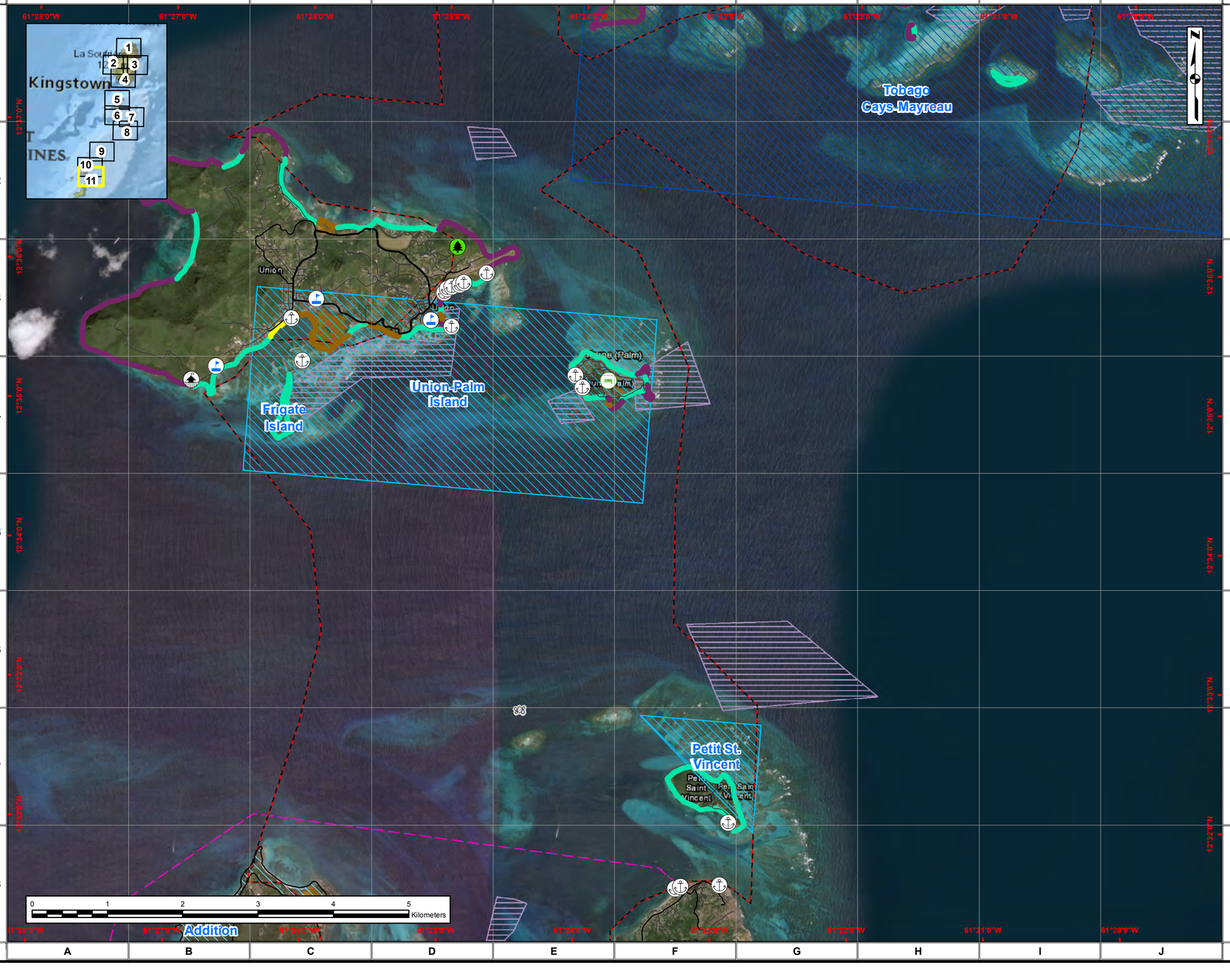
Onshore National Protected

- IUCN Category III & IV
- Mangrove Areas (ESI 10D)
- Coral Reefs
- Hospitals
- School
- Port or Marina
- Fishing Dock or Landing
- Historic Site
- Burial Grounds
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 10 of 11
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Shoreline Sensitivity (ESI)

- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 1C - Exposed rocky cliffs with boulder talus base
- 4/5 - Sand or gravel beach
- 8 - Sheltered bedrock or man-made structures
- 10D - Mangroves
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI
- IUCN Category Not Reported

Onshore National Protected

- IUCN Category III & IV
- Mangrove Areas (ESI 10D)
- Coral Reefs
- School
- Port or Marina
- Historic Site
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Hazardous Areas
- Shipping Route

Coastal Sensitivity and Spill Response
Shoreline Access
St. Vincent and The Grenadines
Map 11 of 11
EEPGL
02 July 2019

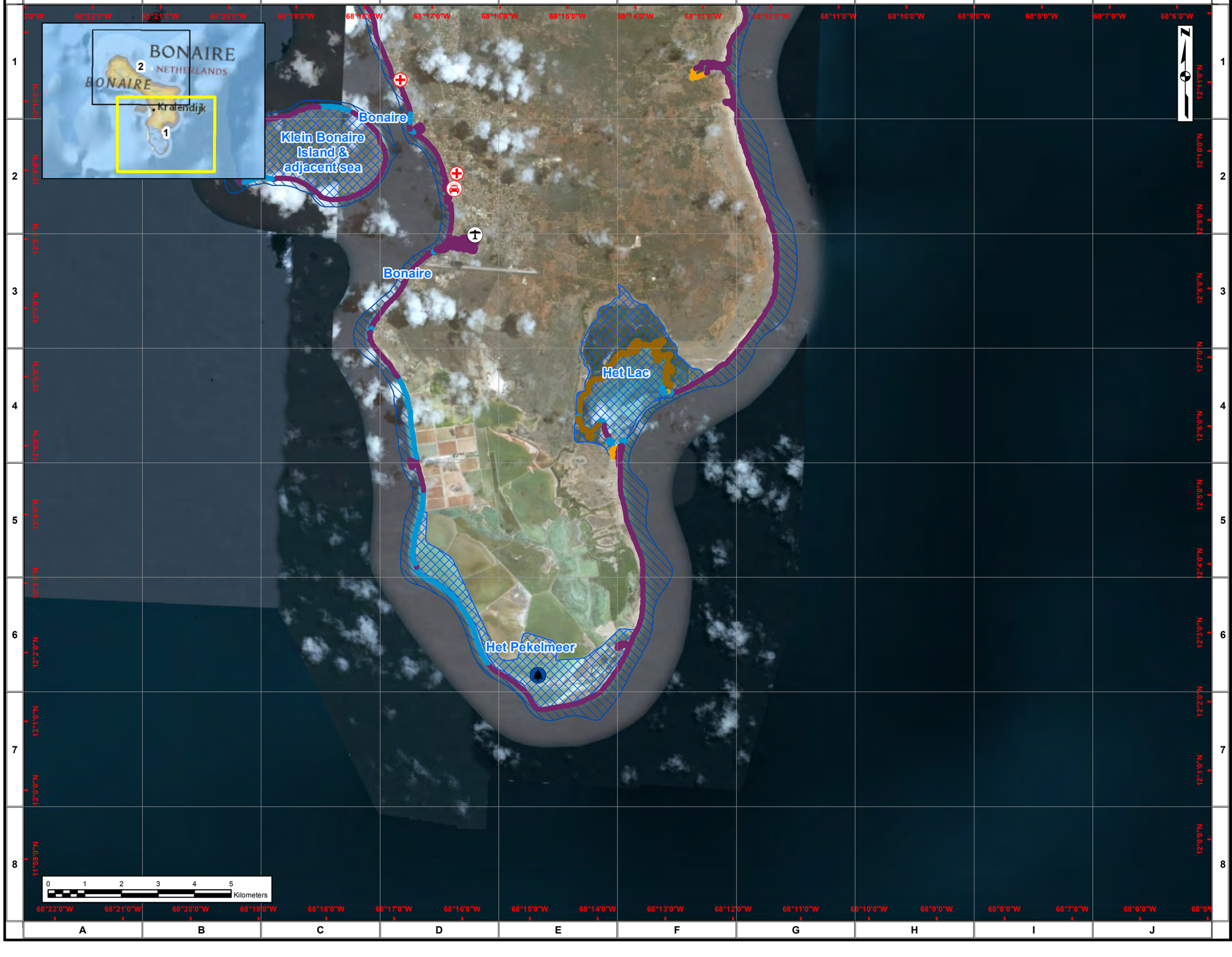
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Bonaire

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Legend

- International Marine Protected Area

Marine National Protected Areas

- IUCN Category I & II
- IUCN Category I, II
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves

Coastal Sensitivity and Spill Response
Shoreline Access
Bonaire
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Washington-Slagbaai (Bonaire)

De Slagbaai

Het Gotomeer

Bonaire

Bonaire

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category I, II
- International Onshore Protected Area
- IUCN Category I, II
- Hospitals
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks

Coastal Sensitivity and Spill Response
Shoreline Access
Bonaire
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Curaçao

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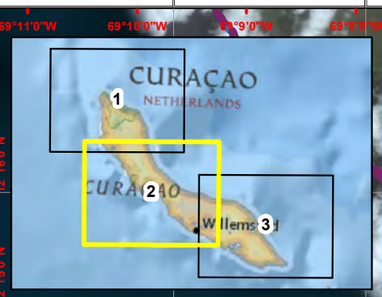
Legend

- International Onshore Protected Area
- IUCN Category I, II
- IUCN Category Not Reported
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches

Coastal Sensitivity and Spill Response
Shoreline Access
Curaçao
Map 1 of 3
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Hoffi Pastoor

Northwest Curaçao

Daaibooi

Hermanus

Rif Sint Marie

Malpais/Sint Michiel

Muizenberg

Kabouterbos

Oostpunt

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category Not Reported
- International Onshore Protected Area
- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Curaçao
Map 2 of 3
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- IUCN Category Not Reported
- International Onshore Protected Area
- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Curaçao
Map 3 of 3
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Aruba

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Legend

- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Aruba
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Bubali Pond Bird Sanctuary

Arikok National Park

Arikok National Park

Het Spaans Lagoen

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category Not Reported
- Hospitals
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Wreck
- Hazardous Areas

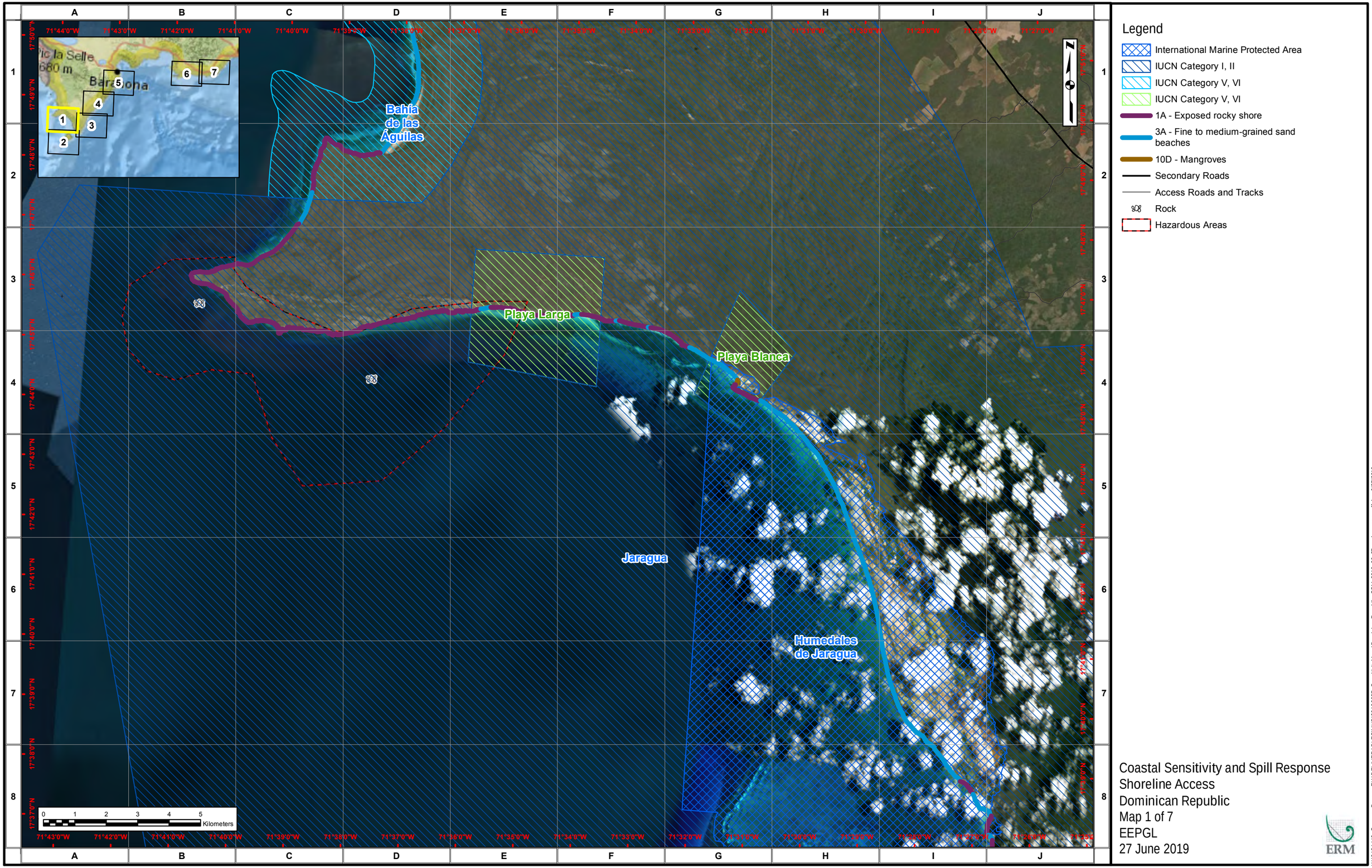
Coastal Sensitivity and Spill Response
Shoreline Access
Aruba
Map 2 of 2
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Dominican Republic

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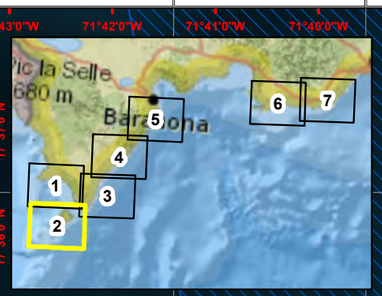
Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category V, VI
- IUCN Category V, VI
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Secondary Roads
- Access Roads and Tracks
- Rock
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 1 of 7
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Humedales de Jaragua

Jaragua

Arrecifes del Suroeste

0 1 2 3 4 5 Kilometers

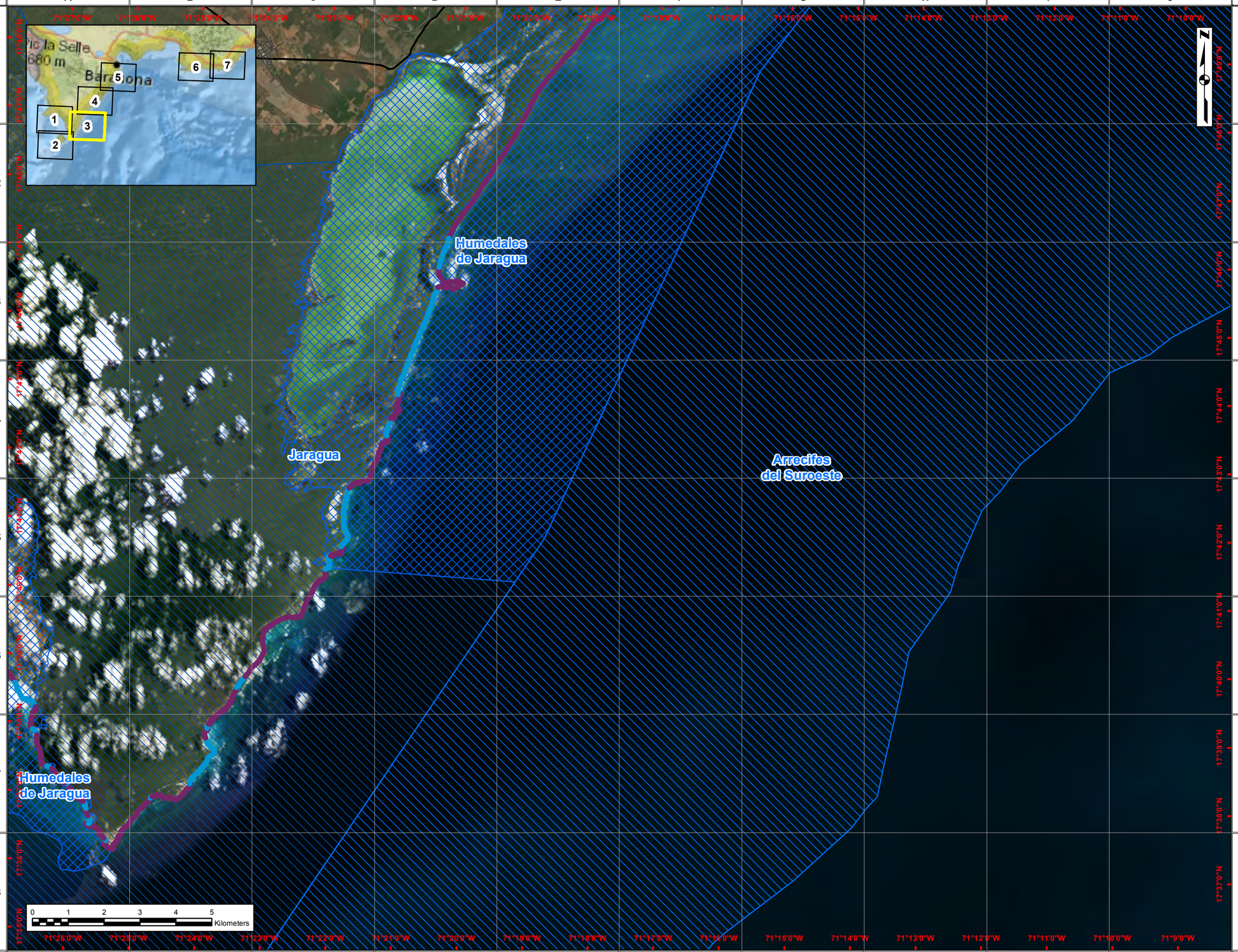
Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 2 of 7
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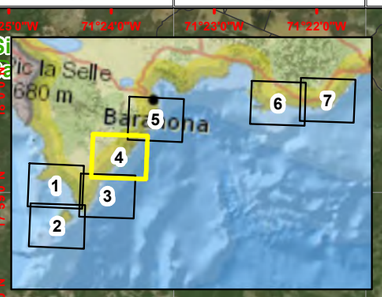
Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Secondary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
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Mirador del Paraíso

Arrecifes del Suroeste

Humedales de Jaragua

Jaragua

0 1 2 3 4 5 Kilometers

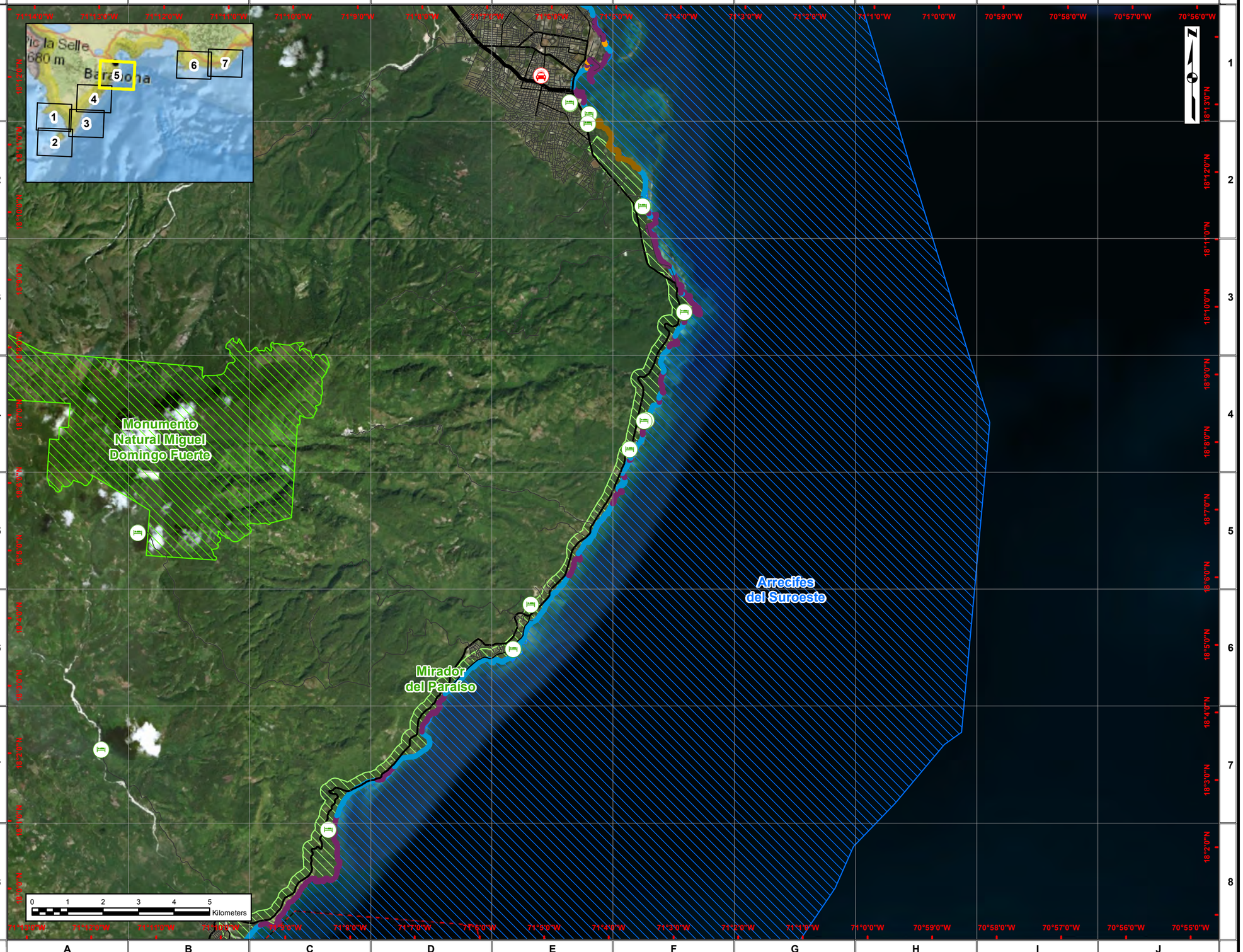
Legend

- International Marine Protected Area
- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 9B - Vegetated low banks
- 10D - Mangroves
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Hazardous Areas

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 4 of 7
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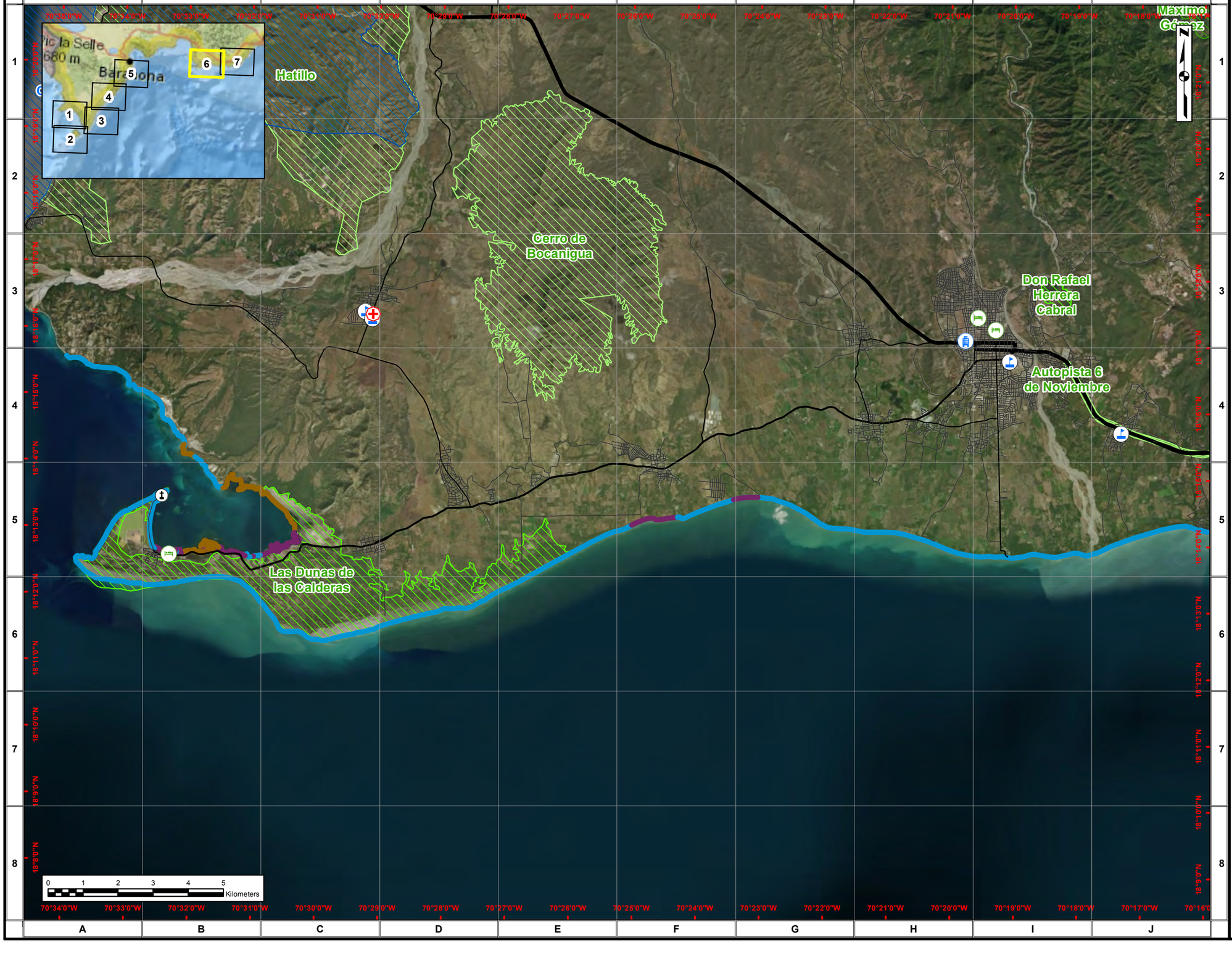
Legend

- IUCN Category III, IV
- IUCN Category III, IV
- IUCN Category V, VI
- Police Stations
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 5 of 7
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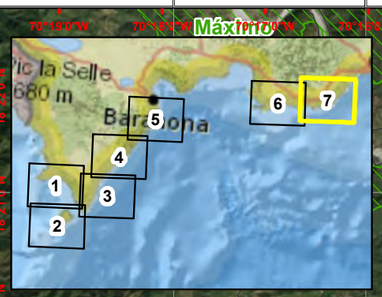
Legend

- IUCN Category I, II
- IUCN Category III, IV
- IUCN Category V, VI
- Hospitals
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 6 of 7
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Legend

- IUCN Category V, VI
- IUCN Category I, II
- IUCN Category V, VI
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Boca de Nigua

Don Rafael Herrera Cabral

Autopista 6 de Noviembre

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Dominican Republic
Map 7 of 7
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Haiti

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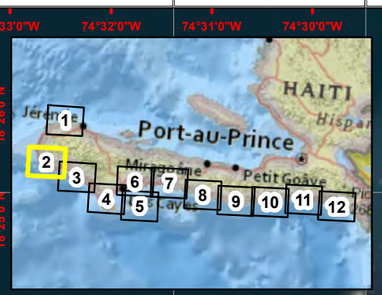
Legend

- Hospitals
- Police Stations
- School
- College
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 9B - Vegetated low banks
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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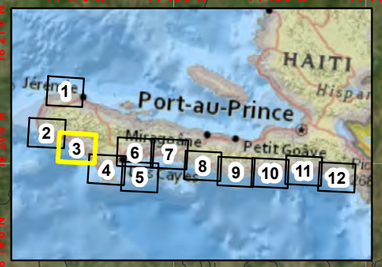
- Hospitals
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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0 1 2 3 4 5 Kilometers

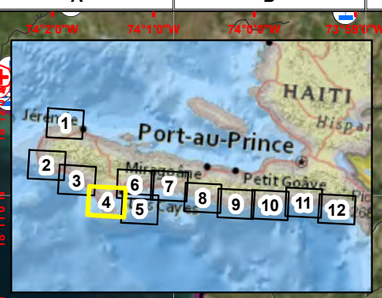
Legend

- IUCN Category I, II
- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 9A - Sheltered tidal flats
- 10D - Mangroves
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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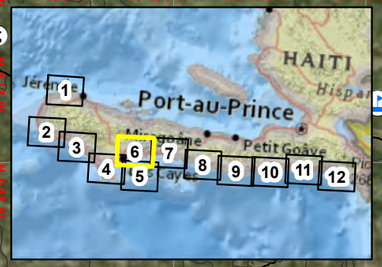
Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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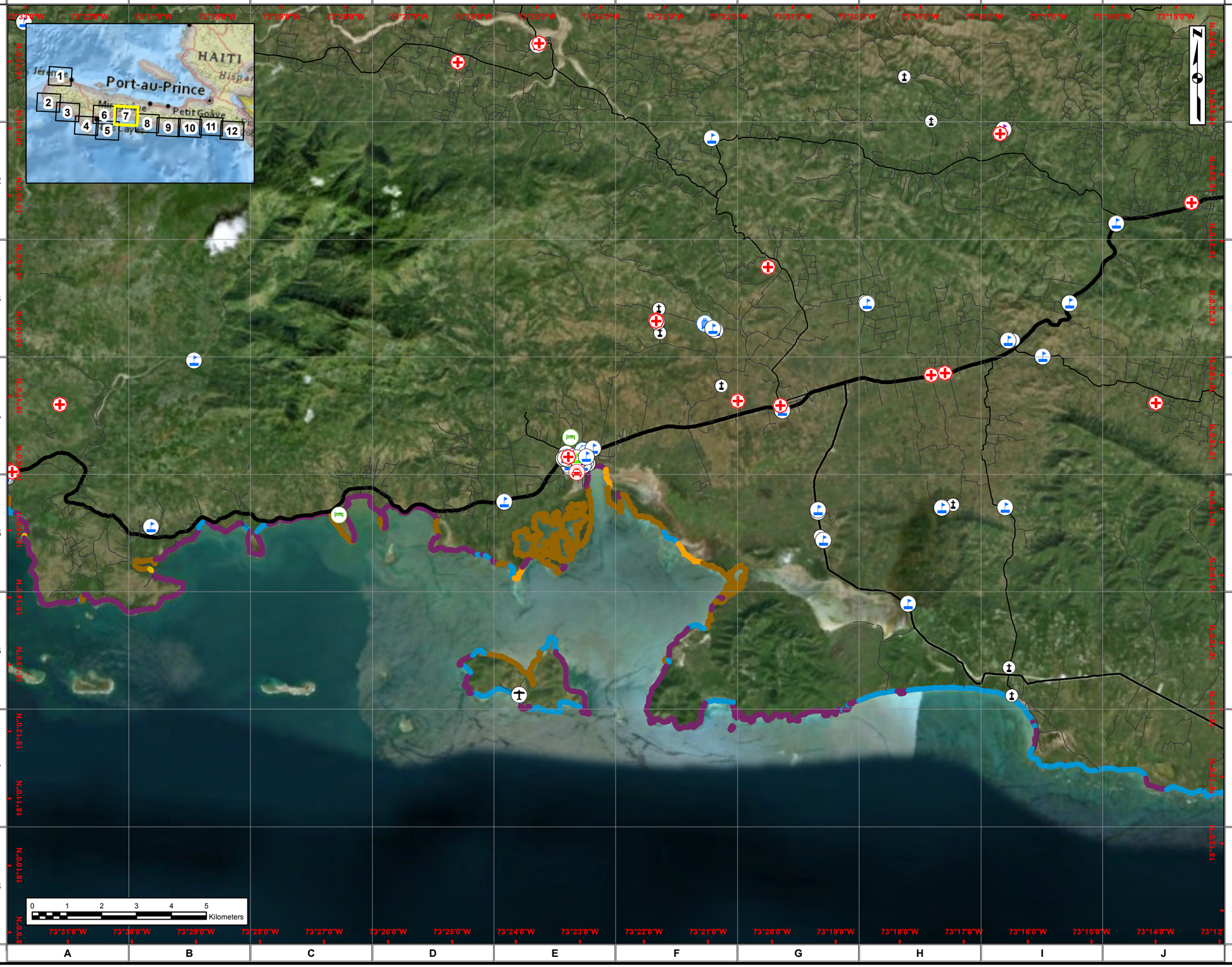
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 7 - Exposed tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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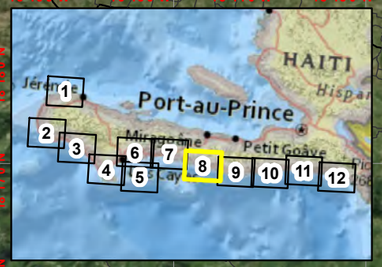
Legend

- Hospitals
- Police Stations
- Kindergarten
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 7 - Exposed tidal flats
- 9A - Sheltered tidal flats
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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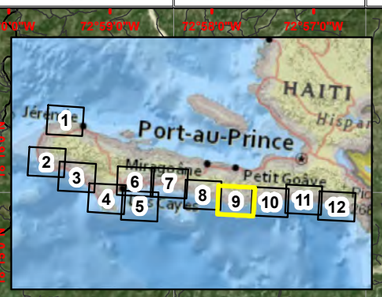
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- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
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- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 8 of 12
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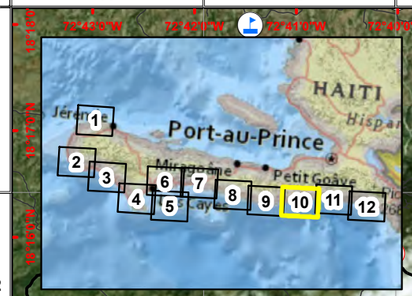
Legend

- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
Map 9 of 12
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27 June 2019

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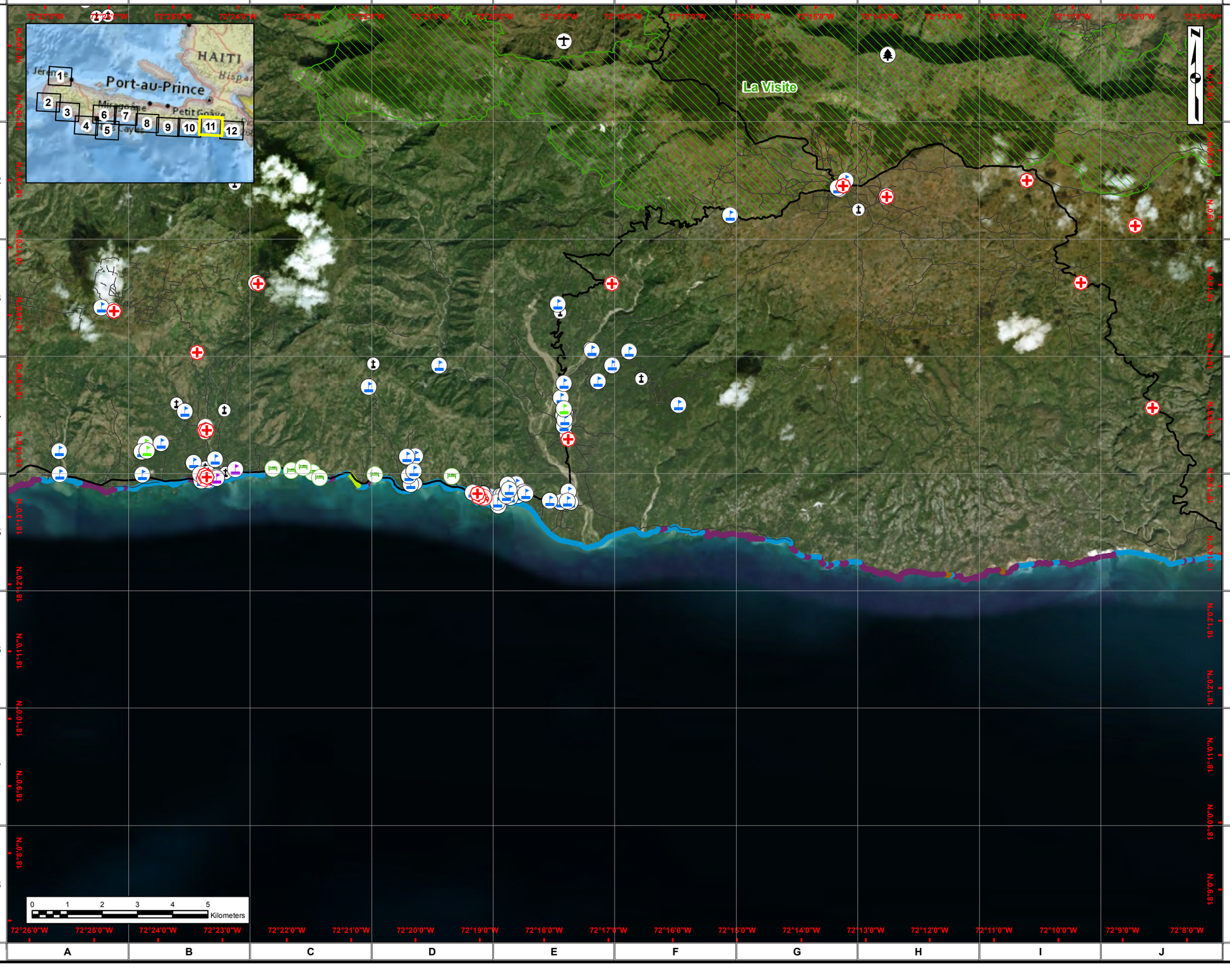
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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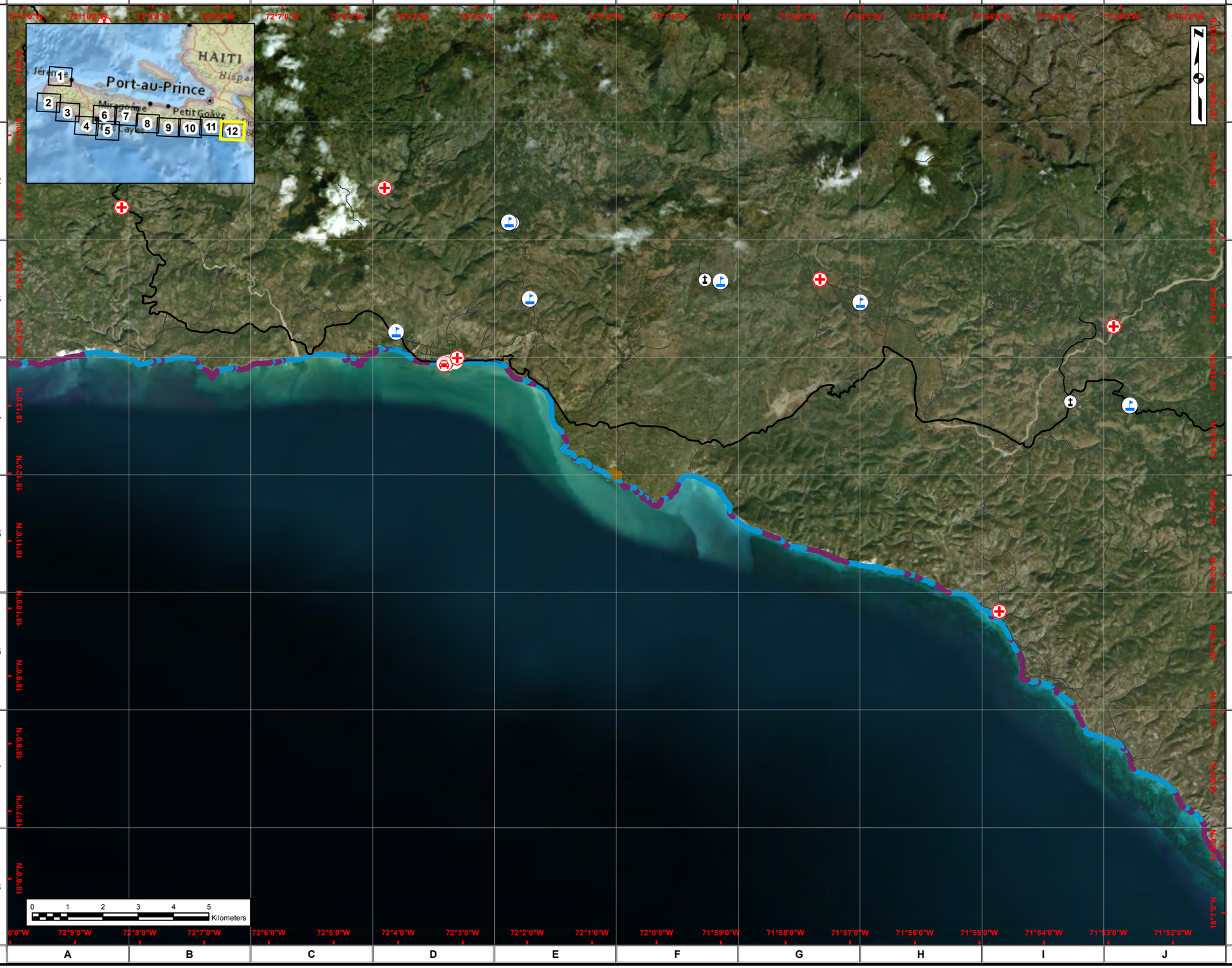
Onshore National Protected Areas

- IUCN Category Not Reported
- IUCN Category I, II
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 6B - Riprap structures and gravel beaches (cobbles and boulders)
- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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Legend

- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

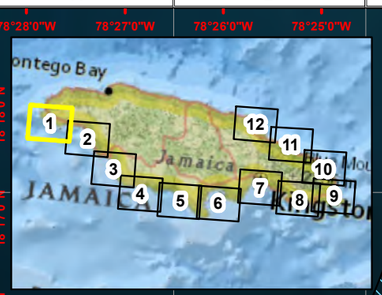
Coastal Sensitivity and Spill Response
Shoreline Access
Haiti
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Jamaica

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Negril

Negril Great Morass

Camp Savannah

Spring Garden

Geneva Mountain

0 1 2 3 4 5 Kilometers

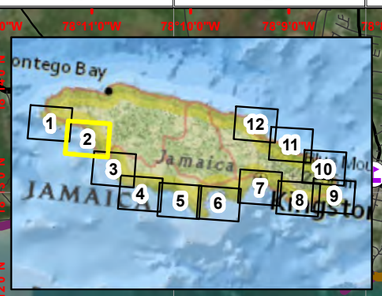
Legend

- IUCN Category Not Reported
- IUCN Category V, VI
- IUCN Category Not Reported
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Deans Valley

Bluefields Bay

Bog

Petersville

Croydon

Black River Lower Morass

0 1 2 3 4 5 Kilometers

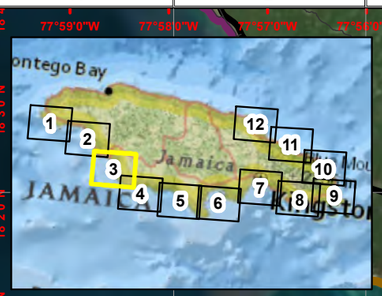
Legend

- IUCN Category III, IV
- IUCN Category V, VI
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Galleon - Black River

Black River Lower Morass

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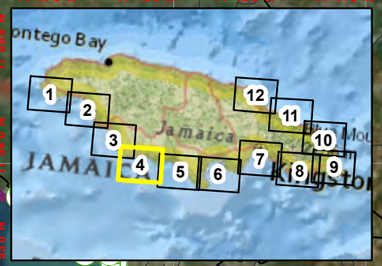
- IUCN Category III, IV
- International Onshore Protected Area
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Reefs

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Lovers Leap

New Forest

Alligator Pond/Gut River/Canoe Valley

0 1 2 3 4 5 Kilometers

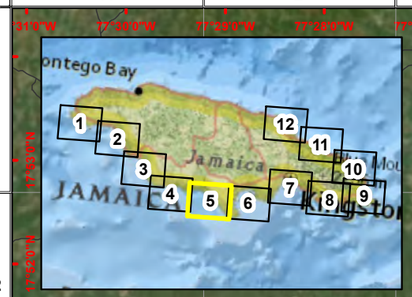
Legend

- IUCN Category Not Reported
- IUCN Category V, VI
- Hospitals
- Police Stations
- Kindergarten
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- Places of Worship
- Hotels
- Tertiary Roads
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Alligator Pond/Gut River/Canoe Valley

Portland Bight Wetlands and Cays

Portland Bight

Peak Bay

N

0 1 2 3 4 5 Kilometers

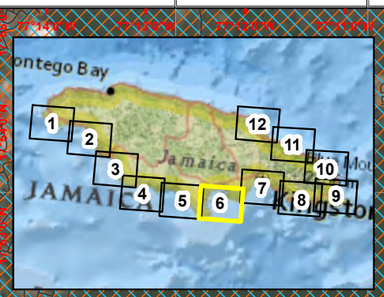
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- IUCN Category V, VI
- IUCN Category Not Reported
- International Onshore Protected Area
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Tertiary Roads
- Access Roads and Tracks
- Rock
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Portland Bight Wetlands and Cays

Salt Harbour (revised)

Galleon Harbour

Healthshire

Three Bay Area

Salt Harbour (revised)

Peak Bay

Peak Bay

Peak Bay

Portland Bight

0 1 2 3 4 5 Kilometers

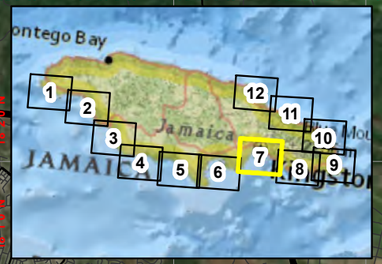
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- IUCN Category III, IV
- IUCN Category V, VI
- International Onshore Protected Area
- IUCN Category V, VI
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Wreck
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Hermitage
Blue Mountain Forest Reserve
Hope River Stream
Newton
Blue and John Crow Mountains
Petersfield
Trumpet Tree
Chesterfield
Flamstead
Orchard
Elleston Run (Dallas Mountain)
Good Hope
Rockfort
Palisadoes
Palisadoes - Port Royal
Portland Bight Wetlands and Cays
Healthshire
Portland Bight

0 1 2 3 4 5 Kilometers

Legend

- International Marine Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- Police Stations
- Kindergarten
- School
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
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- 10D - Mangroves
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Flamstead
Orchard
Blue and John Crow Mountains
Blue and John Crow Mountains
Blue Mountain Forest Reserve
Spring Estate
Spring Pen
Norris
Lloyds
Citron Valley
Montego Bay
Jamaica
JAMAICA
1
2
3
4
5
6
7
8
9
10
11
12
N
0 1 2 3 4 5 Kilometers

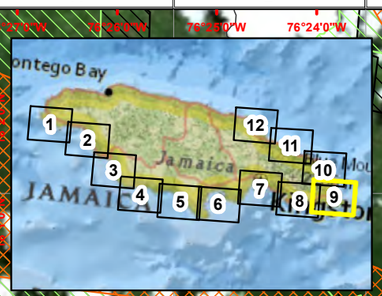
Legend

- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- Police Stations
- Kindergarten
- School
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- Places of Worship
- Government Facilities
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Blue Mountain (Ecclesdown Addition)

Ecclesdown

Blue and John Crow Mountains

Blue Mountain Forest Reserve

Grange Hill

Citron Valley

0 1 2 3 4 5 Kilometers

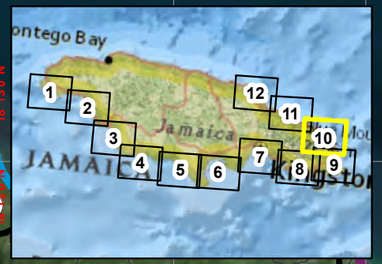
Legend

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- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- Police Stations
- School
- 1A - Exposed rocky shore
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- Places of Worship
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Fellowship

Cambridge Back Lands

Windsor and Seaman's Valley

Blue and John Crow Mountains

Blue Mountain Forest Reserve

Blue and John Crow Mountains

Blue Mountain (Ecclesdown Addition)

Ecclesdown

0 1 2 3 4 5 Kilometers

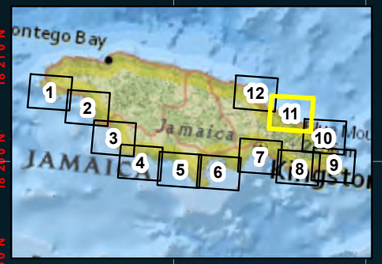
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- International Onshore Protected Area
- IUCN Category V, VI
- IUCN Category Not Reported
- Hospitals
- School
- College
- Fishing Dock or Landing
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Places of Worship
- Hotels
- Primary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Legend

- IUCN Category V, VI
- IUCN Category Not Reported
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Hotels
- Primary Roads
- Secondary Roads
- Access Roads and Tracks

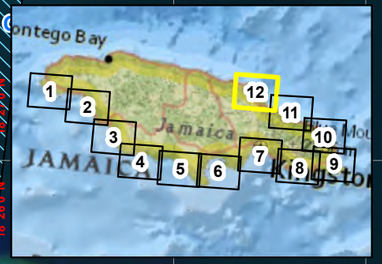
Dover
Fort George
Haycock Hill
Fort Stewart
Kildare
Caenwood
Chepstowe
Blue Mountain Forest Reserve
Airy
Blue and John Crow Mountains

0 1 2 3 4 5 Kilometers

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Oracabessa
Fish

Nutfield

Tremolesworth

0 1 2 3 4 5 Kilometers

Legend

- IUCN Category III, IV
- IUCN Category V, VI
- College
- 1A - Exposed rocky shore
- 1B - Exposed, solid man-made structures
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Hotels
- Primary Roads
- Secondary Roads
- Tertiary Roads
- Access Roads and Tracks

Coastal Sensitivity and Spill Response
Shoreline Access
Jamaica
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Colombia

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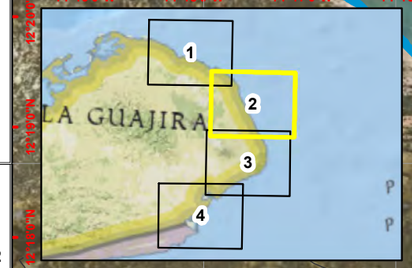
Legend

- School
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Access Roads and Tracks
- Wreck
- Rock
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 1 of 4
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Macuira

0 1 2 3 4 5 Kilometers

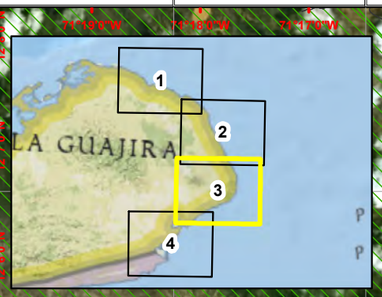
Legend

- IUCN Category I, II
- Hospitals
- College
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Hotels
- Access Roads and Tracks
- Seabed Cables

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 2 of 4
EEPGL
27 June 2019

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Macuira

0 1 2 3 4 5 Kilometers

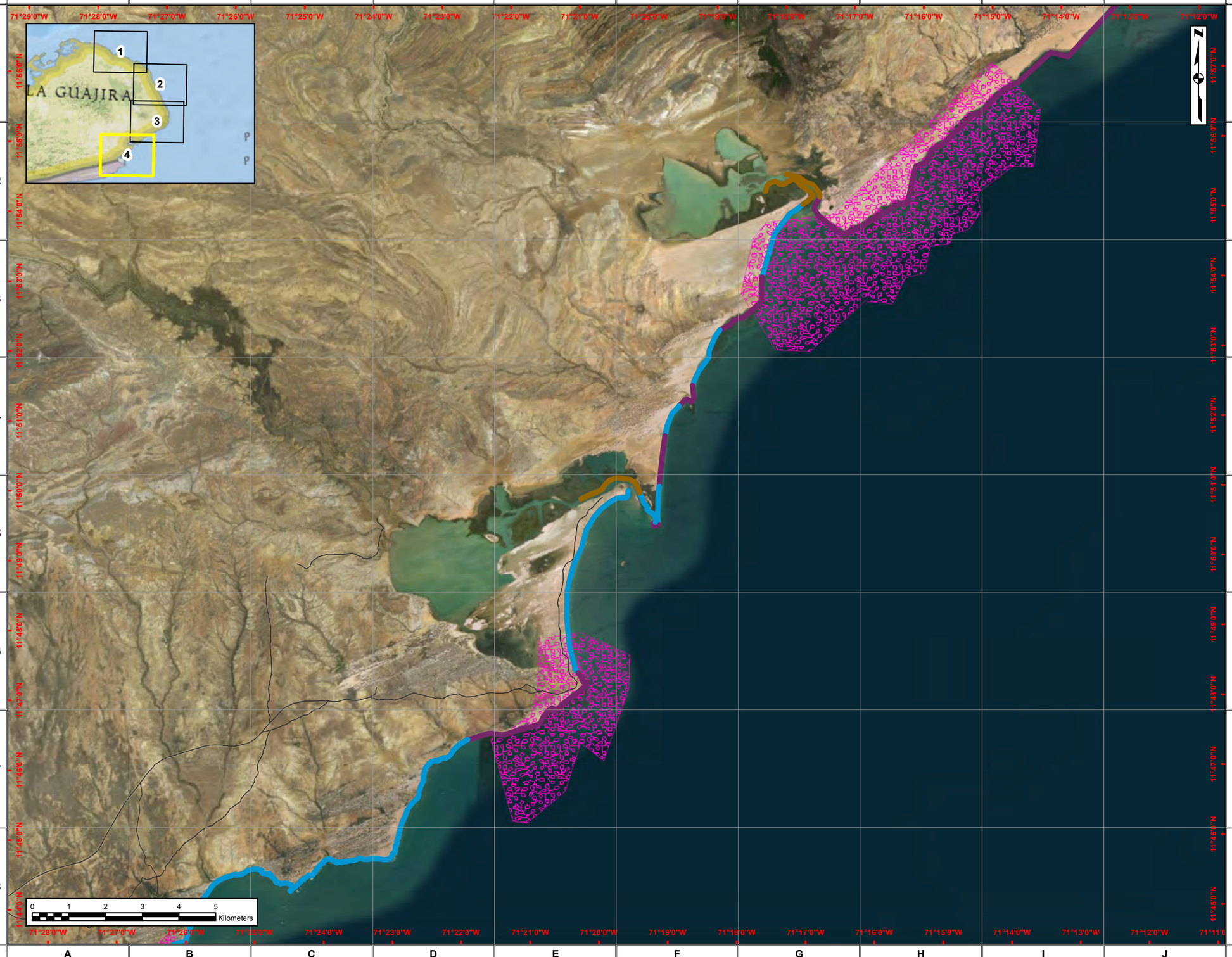
Legend

- IUCN Category I, II
- School
- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 3 of 4
EEPGL
27 June 2019

ERM

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Legend

- 1A - Exposed rocky shore
- 3A - Fine to medium-grained sand beaches
- 10D - Mangroves
- Access Roads and Tracks
- Reefs

Coastal Sensitivity and Spill Response
Shoreline Access
Colombia - La Guajira Peninsula
Map 4 of 4
EEPGL
27 June 2019

ERM

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APPENDIX Q

Flora and Fauna of Shell Beach

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APPENDIX IV. BIODIVERSITY

Source: *Guyana Marine Turtle Conservation Society (GMTCS) (2011). Shell Beach Protected Area Process. Report on the Proposed Shell Beach Protected Area Delineation Process (SBPA). Final Report. Appendix IV: Biodiversity*[1]

List of Biodiversity found within the Shell Beach Area

Appendix IVa: Avifauna of Shell Beach

Source: *Mendonca, Sean, Michelle Kalamandeen, and Robin S. McCall (2006). A Bird's Eye View: Coastal Birds of Shell Beach. Proceedings of International Conference on the Status of Biological Sciences in Caribbean and Latin American Societies.*

Scientific Name	Common Name
Actitis macularia	Spotted Sandpiper
Agelaius icterocephalus	Yellow-hooded Blackbird
Amazilia chionopectus	White-Chested Emerald
Amazilia fimbriata	Glittering-throat Emerald
Amazilia spp.	Amazilia Hummingbird
Amazona amazonica	Orange-winged Parrot
Amazona ochrocephala	Yellow-crowned Parrot
Anhinga anhinga	Anhinga
Ara ararauna	Blue & Gold Macaw
Ara chloropterus	Red & Green Macaw
Ara manilata	Red-bellied Macaw
Ara nobilis	Red-shouldered Macaw
Aramides cajanea	Gray-necked Woodrail
Ardea alba	Great Egret
Ardea cocoi	Cocoi Heron
Ardei cocoi	White-necked Heron
Arenaria interpres	Ruddy Turnstone
Arundinicola leucocephala	White-headed Marsh Tyrant
Asturina nitida	Gray Hawk
Attila spadiceus	Bright-rumped Attila
Bubo virginianus	Great Horned Owl
Bubulcus ibis	Cattle Egret
Busarellus nigricollis	Black-collared Hawk
Buteo magnirostris	Roadside Hawk
Buteogallus aequinoctialis	Rufous Crab-hawk
Buteogallus anthracinus	Common Black Hawk
Butorides striatus	Striated Heron

[1] In instances where either scientific or common names were not included in the source document, they have been included where possible.

Scientific Name	Common Name
Cacicus cela	Yellow-rumped Cacique
Cacicus haemorrhous	Red-rumped Cacique
Cairina moshata	Muscovy Duck
Calidris minutilla	Least Sandpiper
Calidris pusilla	Semipalmated Sandpiper
Camptostoma obsoletum	Southern beardless Tyrannulet
Campylopterus largipennis	Gray-breasted Sabrewing
Cathartes aura	Turkey Vulture
Cathartes burrovianus	Yellow-headed Vulture
Celeus flavus	Cream-colored Woodpecker
Cercomacra spp	Slaty Antwren
Cercomacra tyrannina	Dusky Antshrike
Certhiaxis cinnamomea	Yellow-throated Spinetail
Certhiaxis cinnamomea	Yellow-chinned Spinetail
Ceryle torquata	Ringed Kingfisher
Charadrius collaris	Collared Plover
Charadrius wilsonia	Wilson's Plover
Chelidoptera tenebrosa	Swallow-wing Puffbird
Chlorestes notatus	Blue-chinned Sapphire
Chloroceryle aenea	American Pygmy Kingfisher
Chloroceryle aenea	Pygmy Kingfisher
Chloroceryle amazona	Amazon Kingfisher
Chloroceryle americana	Green Kingfisher
Chloroceryle inda	Green & Rufous Kingfisher
Chlorophanes spiza	Green Honeycreeper
Ciconia maguari	Maguari Stork
Circus buffoni	Long-winged Harrier
Cissopis leveriana	Magpie Tanager
Claravis prestiosa	Blue Ground-dove
Coccyzus melacoryphus	Dark-billed Cuckoo
Cochlearius cochlearius	Boat-billed Heron
Coereba flaveola	Bananaquit
Columba plumbea	Plumbeous Pigeon
Columba subvinacea	Ruddy Pigeon
Columbina talpacoti	Ruddy Ground-dove
Conirostrum bicolor	Bicolored Conebill
Conirostrum leucogenys	White-eared Conebill
Coragyps atratus	Black Vulture
Crotophaga ani	Smooth-billed Ani
Crotophaga major	Greater Ani
Cyanocorax cayanus	Cayenne Jay
Cymbilaimus lineatus	Fasciated Antshrike

Scientific Name	Common Name
Daptrius ater	Black Caracara
Dendrocyna autumnalis	Black-bellied Whistling-duck
Dendrocyna longicauda	Long-tailed Woodcreeper
Dendroica aestiva	Yellow Warbler
Dryocopus lineatus	Lineated Woodpecker
Egretta caerulea	Little Blue Heron
Egretta thula	Snowy Egret
Egretta tricolor	Tricolored Heron
Elaenia flavogaster	Yellow-bellied Elaenia
Elanoides forficatus	Swallow-tailed Kite
Elanus leucurus	White-tailed Hawk
Eudocimus ruber	Scarlet Ibis
Euphonia violacea	Violaceous Euphonia
Eurypga helias	Sunbittern
Falco peregrinus	Peregrine Falcon
Falco rufigularis	Bat Falcon
Falco sparverius	American Kestrel
Fluvicola pica	Pied Water-tyrant
Formicarius analis	Black-faced Ant-thrush
Frederickena viridis	Black-throated Antshrike
Fregata magnificens	Magnificent Frigatebird
Galbula albirostris	Yellow-billed Jacamar
Geranospiza caerulescens	Crane Hawk
Glaucis hirsuta	Rufous-breasted Hermit
Glyphorynchus spirurus	Wedge-billed wood creeper
Harpia harpyja	Harpy Eagle
Heliornis fulica	Sun Grebe
Herpetotheres cachinnans	Laughing Falcon
Hirundo rustica	Barn Swallow
Hoploxypterus cayanus	Pied Plover
Ibycter americanus	Red-throated Caracara
Icterus chrysocephalus	Moriche Oriole
Icterus nigrogularis	Yellow Oriole
Jacana jacana	Wattled Jacana
Larus atricilla	Laughing Gull
Leptotila rufaxilla	Gray-fronted Dove
Leptotila verreauxi	White-tipped Dove
Lipaugus vociferans	Screaming Piha
Lophotriccus galeatus	Helmeted Pygmy-tyrant
Manacus manacus	White-bearded Manakin
Megarynchus pitangua	Boat-billed Flycatcher
Melanerpes cruentatus	Yellow-tufted Woodpecker

Scientific Name	Common Name
Mesembrinibis cayennensis	Green Ibis
Micrastur ruficollis	Barred Forest-falcon
Milvago chimachima	Yellow-headed Caracara
Momotus momota	Blue-crowned Motmot
Morphnus guianensis	Crested Eagle
Myiarchus ferox	Short-crested Flycatcher
Myiarchus swainsoni	Swainson's Flycatcher
Myiodynastes maculatus	Streaked Flycatcher
Myiopagis gaimardi	Forest Elaenia
Myiozetetes cayanensis	Rusty-margined Flycatcher
Myrmceciza atrothorax	Black-throated Antbird
Myrmornis torquata	Wing-banded Antbird
Myrmotherula brachyura	Pygmy Antwren
Numenius phaeopus	Whimbrel
Nyctanassa violacea	Yellow-crowned Night-heron
Nyctibius grandis	Great Pootoo
Nycticorax nycticorax	Black-crowned Night-heron
Nyctidromus albicollis	Common Paraque
Odontophorus gujanensis	Marbled Woodquail
Ortalis motmot	Little Chacalaca
Oryzoborus angolensis	Chestnut-bellied Seedeater
Otus choliba	Tropical Screech-owl
Pandion haliaetus	Osprey
Pelecanus occidentalis	Brown Pelican
Penelope jacquacu	Spix's Guan
Phaeothlypis flaveola	River Warbler
Phaethornis superciliosus	Longtailed Hermit
Phaetusa simplex	Large-billed Tern
Phalacrocorax brasilianus	Neotropical Cormorant
Philohydor lictor	Lesser Kiskadee
Phoenicopterus ruber	American Flamingo
Piaya cayana	Squirrel Cuckoo
Piaya melanogaster	Black-bellied Cuckoo
Piaya minuta	Little Cuckoo
Picumus spp	Piculet
Pionus menstruus	Blue-headed Parrot
Pipile pipile	Common Piping-guan
Pipra aureola	Crimson-hooded Manakin
Pitangus sulphuratus	Greater Kiskadee
Pitylus spp	Grosbeak
Porzana carolina	Sora Crake
Progne chalybea	Gray-breasted Martin

Scientific Name	Common Name
Psarocolius decumanus	Crested Oropendula
Psarocolius viridis	Green Oropendula
Pteroglossus aracari	Black-necked Aracari
Pulsatrix perspicillata	Spectacled Owl
Querula purpurata	Purple-throated Fruitcrow
Quiscalus lugubris	Carib Grackle
Ramphastos tucanus	Red-billed Toucan
Ramphastos vitellinus	Channel-billed Toucan
Ramphocelus carbo	Silver-beaked Tanager
Rostrhamus sociabilis	Snail Kite
Rynchops niger	Black Skimmer
Sakesphorus canadensis	Black-crested Antshrike
Saltator coerulescens	Grayish Saltator
Sarcoramphus papa	King Vulture
Scaphidura oryzivora	Giant Cowbird
Seiurus noveboracensis	Northern Waterthrush
Sterna anaethetus	Bridled Tern
Sterna antillarum	Least Tern
Sterna maxima	Royal Tern
Sterna nilotica	Gull-billed Tern
Sterna superciliaris	Yellow-billed Tern
Sturnella militaris	Red-breasted Blackbird
Sublegatus arenarum	Northern Scrub-flycatcher
Tachornis squamata	Fork-tailed Palm-swift
Tachycineta albiventer	White-winged Swallow
Tachyphonus rufus	White-lined Tanager
Tangara mexicana	Turquoise Tanager
Tapera naevia	Striped Cuckoo
Thamnophilus doliatus	Barred Antshrike
Thamnophilus murinus	Mouse-coloured Antshrike
Thraupis episcopus	Blue-gray Tanager
Thraupis palmarum	Palm Tanager
Thryothorus coraya	Coraya Wren
Thryothorus leucotis	Buff-breasted Wren
Tiaris obscura	Dull-colored Grassquit
Tigrisoma lineatum	Rufescent Tiger Heron
Tinamus major	Great Tinamou
Todirostrum cinereum	Common Tody Flycatcher
Todirostrum maculatum	Spotted Tody Flycatcher
Tringa flavipes	Lesser Yellowlegs
Tringa melanoleuca	Greater Yellowlegs
Tringa solitaria	Solitary Sandpiper

Scientific Name	Common Name
Troglodytes aedon	Southern House Wren
Trogon viridis	White-tailed Trogon
Turdus leucomelas	Pale-breasted Thrush
Tyrannus dominicensis	Gray Kingbird
Tyrannus melancholicus	Tropical Kingbird
Tyrannus savana	Fork-tailed Flycatcher
Vanellus chilensis	Southern Lapwing
Vireo olivaceus	Red-eyed Vireo
Volatinia jacarina	Blue-black Grassquit
Xiphorhynchus guttatus	Buff-throated Woodcreeper

Appendix IVb: Herpetofauna of Shell Beach

Sources: *(1) Kalamandeen, Michelle and Phillip DaSilva (2005). A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.*
(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques (2004). Shell Beach Biodiversity Assessment: a Summary Report.

Reptiles

Scientific Name	Common Name
Ameiva ameiva	Ameiva Lizard
Anolis sp.	Anolis Lizard
Bothrops atrox	Labaria
Caiman crocodilus	Spectacled Caiman
Chelonia mydas	Green Turtle
Cnemidophorus gramivagus	Whiptail Lizard
Cnemidorphous lemniscatus	Rainbow Whiptail Lizard
Constrictor constrictor	Boa Constrictor
Corallus hortulanus	Cook's Tree-boa
Dermochelys coriacea	Leatherback Turtle
Drymarchon corais	Tiger Snake
Eretmochelys imbricata	Hawksbill Turtle
Eunectus marinus	Anaconda
Gonatodes humeralis	Trinidad Gecko
Gonatodes sp.	Gecko
Helicops angulatus	Water Labaria
Hydropis sp.	Sea Snake
Iguana iguana	Green Iguana
Kentropyx calcarata	Striped Forest Whiptail
Kinosternon scropiodes	Mud Turtle
Leptotyphlops sp.	Blind Snake
Liophis cobella	Water Snake
Mabuya mabuya	Mabuya
Plica plica	Tree Lizard
Rhinoclemmys punctularia	Labaria Turtle
Thecadactylus rapicauda	Turnip-tailed Gecko
Tupinambis negropunctatus	Tegu

Amphibians

Scientific Name	Common Name
Dendrosophus marmorata	Marbled Treefrog
Dendrosophus minuta	Lesser Treefrog
Hyla crepitans	Emerald-eyed Treefrog
Hyla spp1	Treefrog sp.
Hyla spp2	Treefrog sp.
Hyla spp3	Treefrog sp.
Hyla spp4	Treefrog sp.
Leptodactylus mystaceus	Basin White-lipped Frog
Leptodactylus sp.	White-lipped Frog sp.
Pipa pipa	Suriname Toad
Psuedes paradox	Paradox Frog
Rhinella marina	Cane Toad
Scinax ruber	Red-snouted Treefrog

Appendix IVc: Mammals of Shell Beach

Sources: *(1) Kalamandeen, Michelle and Phillip DaSilva (2005). A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.*
(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques (2004). Shell Beach Biodiversity Assessment: a Summary Report

Scientific Name	Common Name
Alouatta seniculus	Red Howler Monkey
Artibeus obscurus	Dark Fruit-eating Bat
Artibeus sp.	Neotropical Fruit Bat sp.
Artibeus spp 2	Neotropical Fruit Bat sp.
Ateles paniscus	Spider Monkey
Bradypus tridactylus	Three-toed Sloth
Cebus olivaceus	Wedge-capped capuchin
Cebus paella	Brown Capuchin
Dasyprocta agouti	Agouti
Eira Barbara	Tayra
Glossophaga soricina	Common long-tongued Bat
Inia geoffrensis	Porpoise
Lontra longicaudis	Southern River Otter
Nasua nasua	Coati
Noctilio leporinus	Bulldog Bat
Panthera onca	Jaguar
Pithecia pithecia	White-face Saki
Procyon cancrivorus	Raccoon
Pteronura brasiliensis	Giant River Otter
Saccopteryx bilineata	Two-lined Riverside Bat
Saimiri sciureus	Squirrel Monkey
Tamandua tetradactyla	Southern Tamandua
Trichechus manatus	Manatee
Unidentified genera	Deer
Unidentified genera	Long-nosed Bat
Unidentified genera	Rat
Uroderma bilobatum	Common Tent-making Bat

Appendix IVd: Fishes of Shell Beach

Sources: *(1) Kalamandeen, Michelle and Phillip DaSilva (2005). A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.*
(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques (2004). Shell Beach Biodiversity Assessment: a Summary Report

Scientific Name	Common Name
Anableps anableps	Foureye
Anableps sp[2]	Blinker
Bagre marinus	Catfish
Batrachoides surinamensis	Pacu
Bothus ocellatus	Flounder
Boulengerella cuvieri	Swordfish
Brycon falcatus	Curimai
Caranx hippos	Couvalli
Cathorops spixii	Spring Courass
Centropomus undecimalis	Snook
Chaetodipterus sp.	Spadefish
Cichla ocellaris	Lukanani
Cichlasoma sp.	Patwa
Crenicichla sp.	Sunfish
Cynoscion ocoupa	Grey Snapper
Cynoscion virescens	Trout
Rhinoptera bonasus	Cownose Stingray
Dasyatis sp.	Stingray
Diapterus rhombeus	Sea Patwa
Epinephelus itajara	Jewfish
Genyatremus luteus	Annafoke
Heptranchias perlo	Sharpnose Sevengill Shark
Sciades parkeri	Gillbacker
Hexanematichthys proops	Kokwari
Hoplerythrinus unitaeniatus	Yarrow
Hoplias malabaricus	Houri
Hoplosternum sp.	Hassa
Hypophthalmus edentatus	Highwater
Hypostomus sp	Seahassa
Lobotes surinamensis	Paggie
Lutjanus campechanus	Red Snapper
Lutjanus griseus	Gray Snapper
Macrodon ancylodon	Bangamary

[2] Presumed to be of the Anableps genus

Scientific Name	Common Name
Manta birostris	Manta Ray
Megalops atlanticus	Cuffum
Mugil cephalus	Mullet
Mugil liza	Quamina
Myleus rubripinnis	Katabac
Nebris microps[3]	Butterhead
Notarius grandicassis	Tampocker
Oncorhynchus mykiss	Rainbow Trout
Paralonchurus brasiliensis	Banded Croaker
Parauchenipterus galeatus	Imeri
Pimelodus blochii	Cassi
Plagioscion sp	Basha
Plagioscion squamosissimus	Crocrer Basha
Poecilia reticulata	Guppy
Pomacanthus arcuatus	Grey Anglefish
Pseudodoras (Oxydoras) niger	Yadaro
Pygocentrus niger	Black Pirai
Sciades herzbergii	Gillbacker
Sciades passany	Cuma Cuma/Black Cuirass[4]
Sciades proops	Hardhead Cuirass
Scomberomorus brasiliensis	Mackerel
Stellifer rastrifer	Rockhead
Unidentified genera	Cock-a-net
Unidentified genera	Wabaru

[3] Presumed to be butterfish
[4] Presumed to possibly be Mud Cuirass

Appendix IVe: Plants of Shell Beach

Sources: *(1) Kalamandeen, Michelle and Phillip DaSilva (2005). A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.*
(2) Prince, Waldyke, Michael Patterson, Floria Francis, Romeo De Freitas, and David Rodriques (2004). Shell Beach Biodiversity Assessment: a Summary Report

Scientific Name	Common Name
Avicennia germinans	Black Mangrove
Canavalia rosea	Bay Bean/Horse Bean/Sea Bean
Carapa guianensis	Crab-wood
Carica papaya	Papaya
Cecropia sp.	Cecropias sp.
Ceiba pentandra	Kapok
Chrysobalanus sp.	Kaunta
Cissus verticillatus	Grapevine sp.
Cocos nucifera	Coconut
Cucurbita moschata	Squash
Cuscuta umbellata	Flatglobe Dodder
Cyperus sp.	Flatsedge/Nutsedge sp.
Eperu falcata	Soft Wallaba
Eschiwella sp.	Kakaralli
Euterpe sp.	Manicole
Goupia glabra	Kabukalli
Guilandina bonduc	Grey Nicker/Nickar Bean
Hibiscus pernambucensis	Sea Hibiscus
Ipomoea pes-caprae	Beach Morning Glory
Jatropha gossypiifolia	Bellyache-bush/Black Physicnut
Languncularia racemose	White Mangrove
Manihot esculenta	Cassava
Mauritia flexuosa	Ite Palm
Mora excelsa	Mora
Morindra citrifolia	Noni
Parahancornia sp.	Dukalli
Pterocarpus sp.	Corkwood
Rhizophora mangle	Red Mangrove
Sesuvium portulacastum	Shoreline Purslane
Terminalia catappa	Almond
Thespesia populnea	Portia Tree

Appendix IVf: Macroinvertebrates of Shell Beach

Source: *Kalamandeen, Michelle and Phillip DaSilva (2005). A Preliminary Survey of the Herpetofauna of Shell Beach. Biodiversity and Conservation Studies in Guyana: Volume 2.*

Scientific Name	Common Name
Aratus pisonii	Tree Crab
Atta sp.	Machusi Ant
Avicularia sp.	Tarantula
Cardisoma guanhumi	Bundari Crab
Danaus plexipus	Monarch Butterfly
Euedes sp.	Butterfly
Euptichia sp.	Buttefrly
Eurema sp.	Butterfly
Morpho menelaus	Blue Morpho Butterfly
Ocypode quadrata	Ghost Crab
Parides sp.	Butterfly
Thelpusa sp.	Grasshopper
Uca rapax	Fiddler Crab
Unidentified genera	Ladybug
Unidentified genera	Millipede
Unidentified genera	Mosquito
Unidentified genera	Roach
Unidentified genera	Sand Wasp
Unidentified genera	Scorpion
Unidentified genera	Spider
Unidentified genera	Bee
Unidentified genera	Field Cricket
Unidentified genera	Fly
Unidentified genera	Centipede
Unidentified genera	Coconut Worm
Unidentified genera	Dragonfly

Appendix Q (Supplement 1): Additional Avifauna Documented during 3-13 April 2018 Coastal Bird Survey in Region 1 and 24-25 January 2019 Nearshore Bird Survey in Region 1

Additional bird species (other than those listed in the above table *Appendix IVa: Avifauna of Shell Beach*) were observed during an April 2018 coastal bird survey conducted in Region 1 that was conducted in coordination with coastal mapping and ecosystem services work and a January 2019 nearshore bird survey conducted within 5 kilometers of the shoreline in Region 1 up to the mouth of the Waini River. The April 2018 and January 2019 surveys did not replicate the survey that produced the observations in the table above (*Appendix IVa: Avifauna of Shell Beach*) in terms of survey area or level of effort. In addition, some of the observations reflected in the April 2018 survey were made some distance inland of Shell Beach. However, as all observations from the April 2018 and January 2019 surveys were collected within 20 kilometers from the coastline of Shell Beach, it is considered reasonably possible that these species could be present at times within the Shell Beach Protected Area.

Scientific Name	Common Name
Arremon taciturnus	Pectoral Sparrow
Atalotriccus pilaris	Pale-eyed Pygmy-tyrant
Attila cinnamomeus	Cinnamon Attila
Buteo nitidus	Grey-lined Hawk
Buteogallus urubitinga	Great Black Hawk
Caracara cheriway	Crested Caracara
Cathartes burrovianus	Lesser Yellow-headed Vulture
Cathartus melambrotus	Greater Yellow-headed Vulture
Celeus elegans	Chestnut Woodpecker
Chaetura cinereiventris	Gray-rumped Swift
Columba livia domestica	Rock Pigeon
Columbina passerina	Common Ground-Dove
Diopsittaca nobilis	Northern Red-shouldered Macaw
Euphonia finschi	Finsch's Euphonia
Eupsittula pertinax	Brown-throated Parakeet
Geothlypis aequinoctialis	Masked Yellowthroat
Glabula galbula	Green-tailed Jacamar
Hylophilus pectoralis	Ashy-headed Greenlet
Hylophilus thoracicus	Lemon-chested Greenlet
Hypocnemoides melanopogon	Black-chinned Antbird
Ictinia plumbea	Plumbeous Kite
Legatus leucophaius	Piratic Flycatcher
Leptodon cayanensis	Gray-headed Kite
Lophornis ornatus	Tufted Cocquette
Mimus gilvus	Tropical Mockingbird
Molothrus bonariensis	Shiny Cowbird

Scientific Name	Common Name
Mycteria americana	American Woodstork
Myiarchus tyrannulus	Brown-crested Flycatcher
Myiothlypis rivularis	Riverbank Warbler
Myrmotherula axillaris	White-flanked Antwren
Myrmoborus leucophrys	White-browed Antbird
Patagioenas cayennensis	Pale-vented Pigeon
Phaeomyias murina	Mouse-colored Tyrannulet
Phaethornis ruber	Reddish Hermit
Rhamphastus tucanus	White-throated Toucan
Rhytipterna simplex	Grayish Mourner
Rupornis magnirostris	Zone-tailed Hawk
Sclateria naevia	Silvered Antbird
Sporophila lineola	Lined Seedeater
Sporophila minuta	Ruddy-breasted Seedeater
Sterna sandvicensis	Sandwich Tern
Synallaxis albescens	Pale-breasted Spinetail
Tachornis squamata	Neotropical Palm-swift
Tachyphonus luctuosus	White-shouldered Tanager
Thalurania furcata	Fork-tailed Woodnymph
Tityra cayana	Black-tailed Tityra
Tyrannulus elatus	Yellow-crowned Tyrannulet
Zimmerius acer	Guianan Tyrannulet

Appendix Q (Supplement 2): Additional Fish Species Documented During 24-25 January 2019 Nearshore Fish Survey of Region 1

Additional fish species (other than those listed in the above table *Appendix IVd: Fishes of Shell Beach*) were recorded during a nearshore fish survey conducted in the nearshore zone (within 5 kilometers of the shoreline) of Region 1 in January 2019.

Scientific Name	Common Name
Albula vulpes	Bonefish
Amphiarius rugispinis	Softhead Sea Catfish
Anchoa spinifer	Spicule Anchovy
Anchoa sp.	Unidentified Anchovy
Bagre bagre	Coco Sea Catfish
Cathorops arenatus	White Spring Cariss
Centropomus ensiferus	Swordspine Snook
Micropogonias furnieri	Bashaw
Pseudauchenipterus nodosus	Cocosoda Catfish
Sciades couma	Sciades Sea Catfish

APPENDIX R

Turtle Telemetry Tracking Report

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Prepared by:
Catherine McClellan, Ph.D. -
The Ocean Foundation (Sea Turtle Census Initiative) / Chelonian Research Institute

ERM Guyana, Inc.
210 New Market Street
Georgetown, Guyana

Final Analysis Report — 2018 Shell Beach Sea Turtle Tracking Project

Liza Phase 1—Post-Permit Studies

Esso Exploration and Production Guyana Limited

28 January 2019

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ACRONYMS AND ABBREVIATIONS

EEPGL	Esso Exploration and Production Guyana Limited
EEZ	Guyana Exclusive Economic Zone
EIA	Environmental Impact Assessment
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
GIS	Geographic information system
GPS	Global positioning system
PAC	Protected Areas Commission
SBPA	Shell Beach Protected Area
SD	Standard deviation
SSH	Sea surface height

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EXECUTIVE SUMMARY

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorization for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On 1 June 2017, the EPA approved the Environmental Impact Assessment (EIA) submitted as part of the Application for Environmental Authorization and issued an Environmental Permit for the Liza Phase 1 Development Project. As a condition of the Environmental Permit, the Guyana EPA required EEPGL to "work with appropriate sea turtle conservation organizations and/or academia in Guyana and the region to expand existing sea turtle telemetry programs where practicable."

Since the early 1960s, four species of sea turtles have been documented nesting seasonally along the remote shores of Shell Beach. This important terrestrial habitat is now protected under Guyanese law (Protected Areas Act 2011) that, together with legislation protecting the turtles at sea (Fisheries Act 2002), strengthens conservation actions aimed at ensuring species survival. However, little information exists to date on Guyana's marine turtle populations at sea. Environmental Resources Management (ERM), EEPGL's environmental consultant, enlisted the assistance of The Ocean Foundation (specifically the Sea Turtle Census Initiative program) and Environmental Management Consultants to consult with the Chelonian Research Institute and develop a scope of study, engage with appropriate entities, and conduct the field work for a sea turtle tracking and telemetry program to satisfy the above-referenced Environmental Permit condition. The methodology for the program (referred to herein as the 2018 Turtle Tagging and Telemetry Program) was developed in partnership with local entities to build on prior work conducted in Guyana and elsewhere in the Caribbean region. It represents current best practice in terms of minimizing stress to turtles, minimizing potential disruption of their reproductive behaviors, and supporting data acquisition objectives. The goal of this study was to obtain empirical data focused on characterizing the turtles' inter-nesting phenological and movement behaviors in both the horizontal (spatial) and vertical (depth) dimensions, with the potential for capturing their migrations to foraging grounds.

The program included two mobilizations to the Shell Beach Protected Area (SBPA). The first deployment was undertaken from 21 to 27 March 2018; all field work was permitted through the Guyana Protected Areas Commission (PAC) and all conditions detailed in the PAC's "Letter of No Objection to ERM Conducting Turtle Telemetry Study in the Shell Beach Protected Area" dated 19 March 2018 were strictly followed. The second deployment was undertaken from 8 to 14 June 2018, for which all field work was conducted in accordance with the permit conditions detailed in the PAC's "No Objection to ERM Conducting 2nd Turtle Telemetry Study in the Shell Beach Protected Area" letter dated 31 May 2018. The field teams worked in close collaboration with PAC Rangers and local community members during field activities in the SBPA.

Pursuant to the permits issued by the PAC, the details of the March and June 2018 deployments, along with preliminary analysis of the telemetry data for four green turtles

(*Chelonia mydas*) and three leatherback turtles (*Dermochelys coriacea*), were submitted to the PAC in separate reports in May 2018 and July 2018, respectively. This report provides an expanded analysis of the tracking data obtained through early October 2018, when the last transmitter (of the four green and three leatherback turtles that had been tagged) ceased operating.

Methodology, Data Acquisition, Processing, and Analyses

During the studies, nightly patrols of the northern-most section of Shell Beach, known as Almond Beach, were carried out by PAC rangers to monitor the beach for sea turtle nesting. When a turtle was encountered, the rangers notified the rest of the awaiting team to approach. Rangers measured the turtle and checked for flipper tags, noting any scars or unique physical attributes. If no flipper tag was present, an Inconel tag was applied to the left front flipper to uniquely identify the turtle in future nesting events. Between 21 and 27 March 2018, four adult, female green turtles were tagged with satellite transmitters immediately after they had finished laying their eggs. Similarly, between 9 and 14 June 2018, three adult, female leatherback turtles were tagged with satellite transmitters, but attachment was done during egg deposition when the turtle was in a calm, trance-like state rather than upon completion of its nest. Wildlife Computers model MK10 SPLASH® satellite transmitters were used to track sea turtles in this study and were programmed with species-specific behavioral configurations prior to going into the field. All tags were programmed to transmit continuously (i.e. at all hours, days, and months) and to produce Argos locations and haul-out information. Half of the tags also transmitted locations derived using Fastloc® GPS (global positioning system) technology for greater location accuracy. The other half of the tags transmitted dive information that provided depth (meters), duration (minutes), and temperature (degrees Celsius, °C) data.

The information collected by the satellite tag was transmitted as encoded, fixed-frequency radio signals each time the turtle surfaced to breathe. Raw sensor data, such as dive profiles and Fastloc® GPS locations, were also transmitted through the Argos System, but required additional processing to decode the data. Processed and filtered data were then analyzed in the Albers Equal Area coordinate system using geographic information system (ArcGIS®) and statistical (R®) software programs.

Tag Performance

The quantity and quality of data received during satellite tracking is strongly influenced by the animal's behavior and this was evident among the seven turtles in this study. Given the satellite coverage at Guyana's low latitude, data reception from all seven transmitters exceeded expectations. Variability in data acquisition appeared to be related to movement behavior, producing similar numbers of locations, sensor data messages, and tag durations among green turtles (165 +/- 18 days). Leatherback data was more variable among individuals and likely to be directly related to tag duration (65 +/- 44 days).

The number of Fastloc® GPS locations retained after filtering was similar between green and leatherback turtles (76.0 +/- 4.2 percent and 73.5 +/- 9.2 percent) reflecting the static availability

of GPS satellites across the globe. Ultimately, movement metrics based on the filtered Argos locations were only slightly greater than those based on Fastloc® GPS locations. Dive sensor information was received for a minimum of 76 percent of the data-days possible and included daily histogram summaries for depth and temperature, hourly summaries of the percent dry time, and time-series of dive and temperature profiles. Haul-out information was received for three out of four green turtles and all three leatherback turtles in either haul-out or status messages; this was a critical parameter for determining re-nesting events.

The tracking duration of all tag models was shorter than projected by battery life and programming alone. This could be due to a variety of factors, not limited to: animal behavior, biofouling, predation, incidental capture, antenna damage, discharged battery, or attachment failure. Incidental capture can probably be ruled out, as there was no sudden increase in a series of high quality locations that are typically associated with an animal being on land or in a boat.

Inter-nesting Period

While all individuals showed strong nesting-site fidelity to their capture locations throughout this period, three different inter-nesting movement behaviors were identified:

A. Remained in the immediate vicinity of Almond Beach, making small near-shore loops;

B. Moved moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops; and

C. Moved large distances, making small near-shore loops in the vicinity of Almond Beach and offshore loops between Venezuela, Trinidad, and Guyana.

Turtles returned to nest between two and six times, exclusively on Almond Beach, in approximately 12-day intervals, with the exception of one green turtle (Violet), who also nested across the Barima-Waini river mouth and nested at longer time intervals than the other turtles. All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements among nests. With respect to the size of the area used by the turtles during the inter-nesting period, there were no significant differences between species or among individuals; however, the leatherback turtles occupied waters at a farther distance from shore than the green turtles.

The leatherback turtles occupied deeper water (34.9 +/- 35.8 meters) than did the green turtles (6.8 +/- 7.2 meters) in the inter-nesting period. The greatest density of green turtle locations occurred in less than 5 meters of water, with dives up to 16.7 meters; the greatest density of leatherback turtle locations occurred in less than 10 meters of water, with dives up to 134.5 meters.

Generally, the turtles' inter-nesting habitat use was concentrated within the territorial seas of Guyana within the direct vicinity of Almond Beach, but also included the territorial seas of Venezuela and Trinidad. The three leatherbacks, and one of the greens, demonstrated more itinerant movement behaviors. Karin, a green turtle, exhibited the farthest movements during her inter-nesting period, extending along 261.7 kilometers of coastline, venturing 50 kilometers

offshore of the Orinoco River Delta in Venezuela on one of her loops, and reaching the Port of Galeota on the Trinidad coastline on another. Julie was the only leatherback with a flipper tag scar, and so was likely not a neophyte nester. She displayed the most moderate offshore movements (54 kilometers) among the leatherback turtles during the nesting season, traveling along 104.9 kilometers of coastline between Guyana and Venezuela and staying within the 50 meter bathymetric contour. Denise, a leatherback turtle, moved the farthest distance from shore (111 kilometers), crossing the 100 meter bathymetric contour during three inter-nesting loops that spanned 120.4 kilometers of shoreline including both Guyana and Venezuela.

Migration Period

The study was able to capture the onset, partial, or complete migration of turtles from the Shell Beach nesting site to their foraging grounds for all of the tagged turtles. All the green turtles in this study headed southeast to Brazil, following a near-shore corridor across an average distance of 2,485 kilometers; all the leatherback turtles initially headed directly out to sea in a northeasterly direction. Both green and leatherback turtles used deeper waters during their migration periods, as compared to the water depths used during other tracking periods. Both green turtles fitted with dive-sensors displayed deep dives of up to 60 meters before or after major river mouths (i.e., the Essequibo River, Guyana; the Corentyne River, Suriname; the Amazon and Pará Rivers, the Mearima River/Arraial Bay, and the Parnaíba River, Brazil).

The first leatherback to start her migration was Arleen, covering a remarkable distance of 4,634 kilometers over 96 days before her transmissions ceased. It appeared as though she was heading for the Laurentian Channel when her tag stopped transmitting. Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have been previously described as critical foraging habitat for leatherback turtles.

Dive data collected from Denise indicated that a week after she began migrating, she started making deep dives every two or three days, the deepest of which (560.5 meters) was the day before her last transmission, where she was in water depths exceeding 5,000 meters.

To examine the influence of ocean currents on the turtles' movements, their tracks were overlaid on monthly-averaged geostrophic current (altimetry) imagery, which included sea surface height (SSH) and velocity. When looking at the green turtle migrations superimposed on the altimetry data, the turtles appear to remain in a very narrow band close to the shore, where current magnitudes are relatively low and where SSHs are lowest, except around the major river mouths in Brazil where SSH is elevated. Leatherback turtles initiated migrations in early to mid-July, when altimetry indicated onshore movement of the Guiana Current near Shell Beach and a large divergent zone forming approximately 200 kilometers offshore.

Foraging Period

Three green turtles in this study were tracked to their ultimate destination, determined to be foraging grounds in the State of Ceará, Brazil. Two of these three turtles overlapped geographically in area, adjacent to the Mundaú River Estuary Environmental Protection Area. These three green turtles displayed similar foraging habitat use (area) and movements

(dispersal from foraging centroid) among individuals, and their locations were at similar distances from shore as during the inter-nesting period, although water depths in the foraging area were slightly deeper. The fourth green turtle and none of the leatherbacks did not reach the foraging grounds during their tracking periods.

Conclusions

The results of this study provided a wealth of new information about Guyana's nesting sea turtles. Although sample sizes were small, they provided the first look into the at-sea behaviors of green and leatherback turtles in this region. Shell Beach is an important yet under-described nesting area for green and leatherback sea turtles that migrate to disparate foraging grounds in Brazil and Canada, respectively. The study shows that turtles may remain in the inter-nesting zone for one to more than three months, venturing northwest into the territorial seas of Venezuela and Trinidad, laying multiple clutches of eggs, and displaying strong site fidelity. During this period, turtles remained primarily in the upper 10 meters of the water column near to shore, but made occasional forays within the continental shelf between nests. After nesting, green turtles followed a narrow migration corridor along the coastline, avoiding the effects of the opposing Guiana and North Brazil western boundary currents. Leatherback turtles dispersed into the high seas after nesting, taking an initial northeasterly course. Figures ES-1 and ES-2 show the recorded paths for green and leatherback turtles during the study, respectively, focused on the area adjacent to Guyana’s shoreline.

Transmitter life was the primary limitation in this study; while significant efforts were made to maximize tag retention and life (as well as data quality and quantity), additional preparation of all tags with a coat of a more reliable anti-fouling product prior to future deployments may help extend transmitter durations.

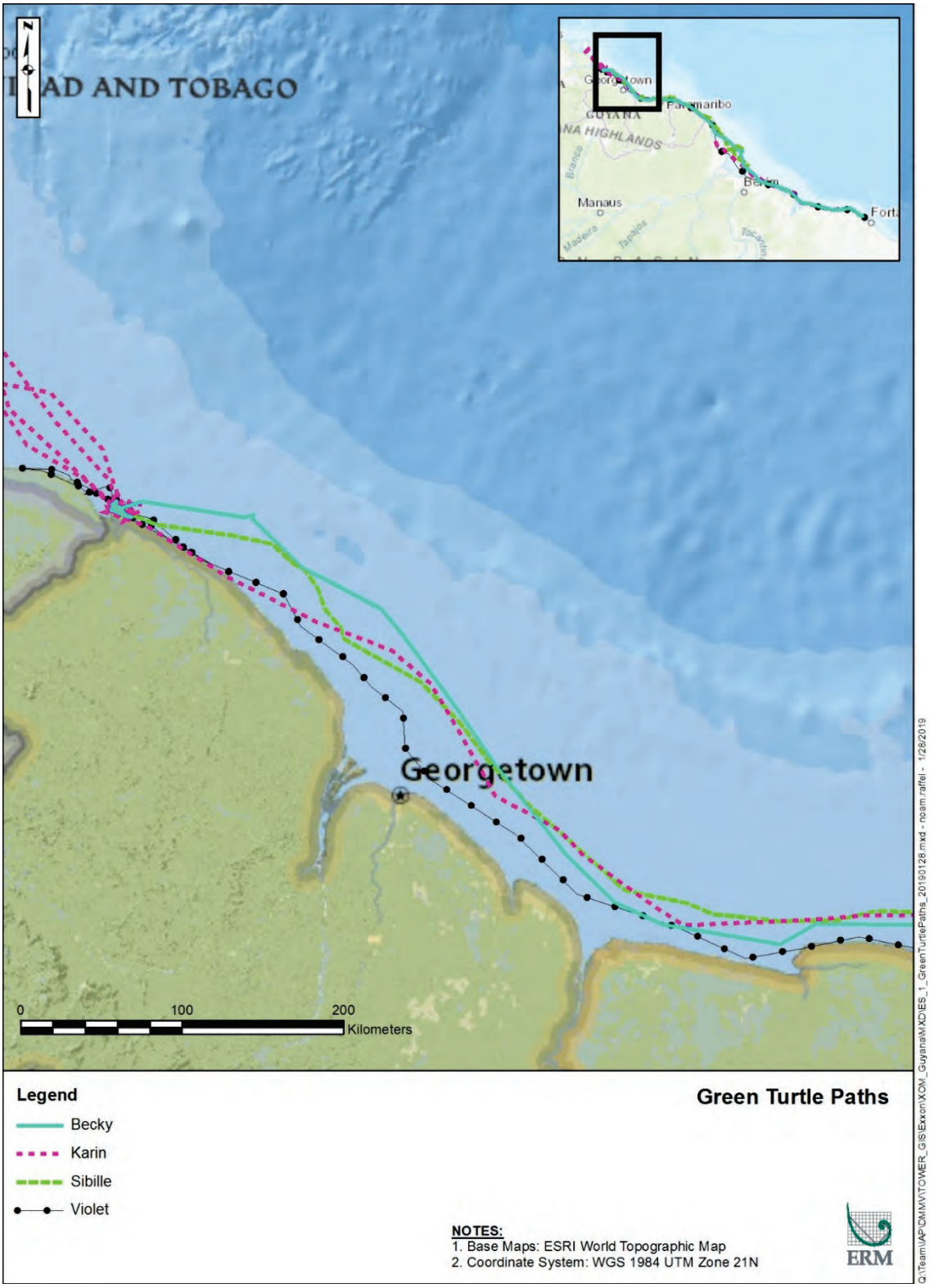


FIGURE ES-1: GREEN TURTLE PATHS

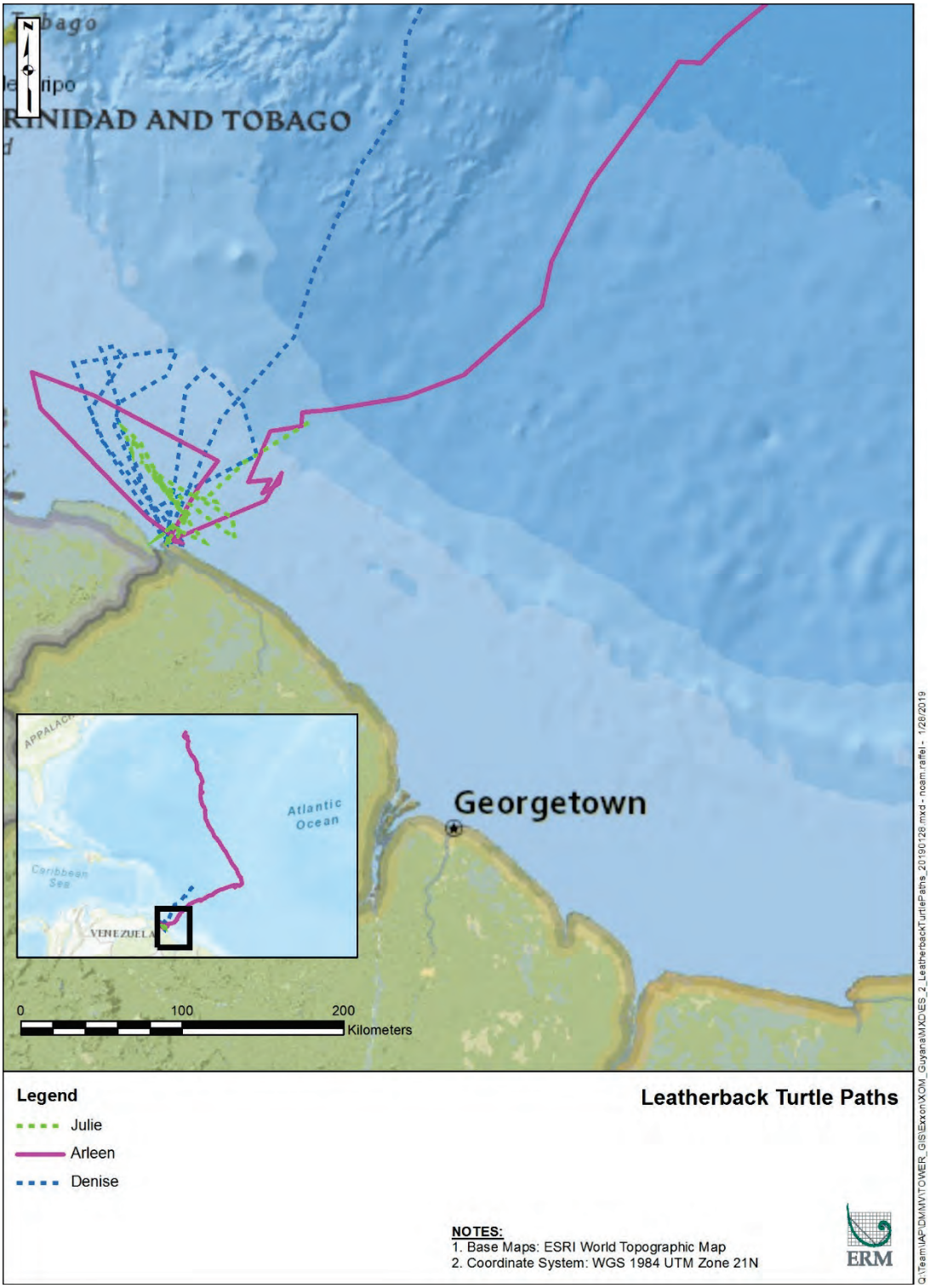


FIGURE ES-2: LEATHERBACK TURTLE PATHS

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OVERVIEW

In March and June 2018, ExxonMobil's Guyana affiliate Esso Exploration and Production Guyana Limited (EEPGL) retained a team of marine scientists, local experts, and environmental managers to conduct two research expeditions in Region 1 of Guyana to study the inter-nesting and at-sea behaviors of sea turtles at Shell Beach.

Sea turtles nest on land and exhibit natal philopatry[1], making this the most understood part of their life cycle. Since the early 1960s, under the pioneering field studies of Dr. Peter Pritchard—Chelonian Research Institute, four species of sea turtles have been documented to nest seasonally along the remote shores of Shell Beach, including leatherback (*Dermochelys coriacea*), green (*Chelonia mydas*), hawksbill (*Eretmochelys imbricata*), and olive ridley (*Lepidochelys olivacea*) turtles. This important terrestrial habitat is now protected under Guyanese law (Protected Areas Act 2011) that, together with legislation protecting the turtles at sea (Fisheries Act 2002), strengthens conservation actions aimed at ensuring species survival. However, little information exists to date on Guyana's marine turtle populations at sea.

The goal of this study was to provide empirical data on a cryptic aspect of these animals' lives. Specifically, the research design focused on characterizing the turtles' inter-nesting phenological[2] and movement behaviors in both the horizontal (spatial) and vertical (depth) dimensions, with the potential for tracking their migrations to foraging grounds. Due to turtles' exceptional dispersal capabilities and the unpredictability of encountering them at sea, the only way to gain such information was by deploying autonomous data tracking devices on wild animals. At present, this can be done at the only time and place when human beings can reliably expect to encounter them in any number: when they come ashore to dig a nest and lay their eggs.

[1] The tendency to return to their birthplace to breed
[2] Of or related to the timing of growth and breeding events.

BACKGROUND

In 2016, EEPGL applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorization for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On 1 June 2017, the EPA approved the Environmental Impact Assessment (EIA) submitted as part of the Application for Environmental Authorization and issued an Environmental Permit for the Liza Phase 1 Development Project. As a condition of the Environmental Permit, the EPA required EEPGL to "work with appropriate sea turtle conservation organizations and/or academia in Guyana and the region to expand existing sea turtle telemetry programs where practicable." Environmental Resources Management (ERM), EEPGL's environmental consultant, enlisted the assistance of The Ocean Foundation (specifically the Sea Turtle Census Initiative program) and Environmental Management Consultants to consult with the Chelonian Research Institute and develop a scope of study, engage with appropriate entities, and conduct the field work for a sea turtle tracking and telemetry program. The methodology for the program (referred to herein as the 2018 Turtle Tagging and Telemetry Program) was developed in partnership with local entities to build on prior work conducted in Guyana and elsewhere in the Caribbean region. It represents current best practice in terms of minimizing stress to turtles, minimizing potential disruption of their reproductive behaviors, and supporting data acquisition objectives to satisfy the above-referenced Environmental Permit condition.

The program included two mobilizations to the Shell Beach Protected Area (SBPA). The first deployment was undertaken from 21 to 27 March 2018; all field work was permitted through the Guyana Protected Areas Commission (PAC) and all conditions detailed in the PAC's "Letter of No Objection to ERM Conducting Turtle Telemetry Study in the Shell Beach Protected Area" dated 19 March 2018 were strictly followed. The second deployment was undertaken from 8 to 14 June 2018, for which all field work was conducted in accordance with the permit conditions detailed in the PAC's "No Objection to ERM Conducting 2nd Turtle Telemetry Study in the Shell Beach Protected Area" letter dated 31 May 2018. The field teams worked in close collaboration with PAC Rangers and local community members during field activities in the SBPA.

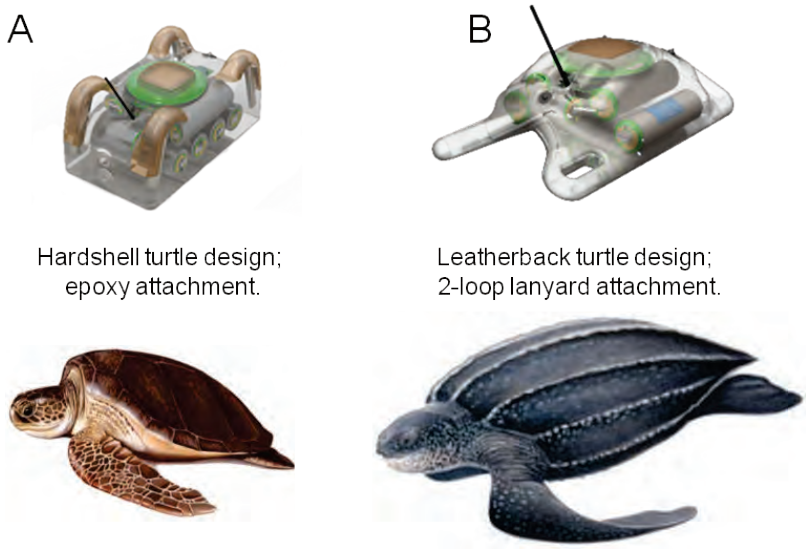
Pursuant to the permits issued by the PAC, the details of the March and June 2018 deployments, along with preliminary analysis of the telemetry data for four green turtles (*Chelonia mydas*) and three leatherback turtles (*Dermochelys coriacea*), were submitted to the PAC in separate reports in May 2018 and July 2018, respectively. This report provides an expanded analysis of the tracking data obtained through early October 2018, when the last transmitter (of the four green and three leatherback turtles that had been tagged) ceased operating.

METHODOLOGY

Tracking Sample Design

Wildlife Computers model MK10 SPLASH® satellite transmitters were used to track sea turtles in this study and were programmed with species-specific behavioral configurations prior to going into the field. Satellite tag models were specific to species' attachment methodologies and dictated the number and size of batteries encased in the mold (Figure 1). Furthermore, because there is a limit to the volume and frequency of data that can be transmitted through the Argos satellite system, the sampling rate of tags was set to balance the tradeoffs between successful transmissions, data acquisition, and battery life. All tags were programmed to transmit continuously (i.e., at all hours, days, and months) and to produce Argos locations and haul-out[3] information. Half of the tags also transmitted locations derived using Fastloc® GPS (global positioning system) technology, which has greater location accuracy but requires greater surface time to establish a location fix. The Fastloc® tags were set to reattempt GPS fixes at 3-hour intervals. The other half of the purchased tags transmitted dive information that was sampled at 10-second intervals and summarized into species-specific histogram bins over a 24-hour period, including depth (meters), duration (minutes), and temperature (degrees Celsius, °C). These “dive-enabled” tags also transmitted hourly summaries of the percent dry time (i.e., surface intervals) every 24 hours, as well as time-series information that were summarized into 10-minute intervals.

FIGURE 1: WILDLIFE COMPUTER SATELLITE TRANSMITTER DESIGNS



Wildlife Computers satellite transmitters were designed to accommodate sea turtle species' carapace morphologies and attachment methodologies. A. Green turtle design MK10-BF-334 for epoxy attachment; mass 980 g; 6 x lithium AA batteries. B. Leatherback turtle design MK10-BF-295 for 2-loop lanyard attachment; mass 233 g; 4 x lithium AA batteries.

[3] Defined as greater than 10 consecutive minutes dry (i.e., representing nesting, resting, or capture events)

Field Expeditions

Nightly patrols (19:00 hours–05:00 hours) of the northern-most portion of the SBPA, locally known as Almond Beach, were carried out by PAC rangers to monitor the beach for sea turtle nesting. When a turtle was encountered, the rangers notified the rest of the awaiting team with light signals to approach. During the June expedition, rangers were accompanied during their patrols by at least one member of the tagging team who were equipped with hand-held radios to relay information to the waiting team members. Every effort was made to limit disturbance of wildlife and habitat during these patrols.

Between 21 and 27 March 2018, four adult, female green turtles were tagged with satellite transmitters immediately after they had finished laying their eggs (Figures 2A, 2B). A wooden box was assembled around the turtle after it had finished nesting to keep it on the beach during the lengthy transmitter attachment process, and a wet towel was placed over the animal's eyes to keep it calm. Rangers measured the turtle and checked for flipper tags, noting any scars or unique physical attributes. If no flipper tag was present, an Inconel tag was applied to the left front flipper to uniquely identify the turtle in future nesting events. The carapace was prepared for the transmitter attachment by washing it with fresh water and a scrub pad, removing epibionts,[4] sanding away any rough patches on the scute margins, and wiping it down with acetone. Two thin layers of cool-setting, two-part epoxy (Quickrete® or Superbond®) were then used to affix the transmitter to the two anterior vertebral scutes. The pretreated transmitter and dried epoxy were then painted with antifouling paint (Torginol®) before releasing the turtle. The entire process, from encounter to return to the water, took an average of 4.7 hours (+/- 0.3 hours) between the hours of 20:00 hours and 09:30 hours.

[4] Living organisms attached to the turtles, such as barnacles, bryzoans, algae, etc. These organisms must be removed in order to ensure secure attachment of the transmitters.

FIGURE 2: PICTORIAL SUMMARY OF THE SEA TURTLE TAGGING UNDERTAKEN AT SHELL BEACH, GUYANA



A. After nesting, green turtles were restricted to a wooden box during the multi-stage tag attachment procedure and shaded if the process extended past sunrise; B. Once the attachment was completed, the box was removed and the turtles were free to move down the beach; C. Leatherback turtles were tagged during nesting by threading wire lanyards through the dorsal ridge of the carapace; D. Attachment was complete before the turtle had begun covering the nest. Photos by CMM, KRS, and DC.

Similarly, between 9 and 14 June 2018, three adult, female leatherback turtles were tagged with satellite transmitters, but attachment was done during egg deposition when the turtle was in a calm, trance-like state rather than upon completion of its nest (Figures 2C and 2D). Leatherbacks are far too large and powerful to be held on the beach in a box and epoxies do not adhere well to their "leathery" expandable carapace; therefore, rapid and direct attachment methods were required. As before, rangers intercepted and measured the turtles, and checked for existing tags or scars; no flipper tags were identified. While the turtle was digging the egg chamber, the dorsal ridge of the carapace was cleaned and sanitized with Vetericyn® spray. Following the deposition of 3 to 4 eggs, two 4.5 millimeter holes were drilled through the dorsal

ridge at approximately two-thirds of the way posterior on the carapace using a cordless drill fitted with a sterile orthopedic drill bit. Sterile plastic-coated wire lanyards were threaded through silicone Tygon® tubing sheaths and inserted through the holes in the carapace. Equinox®35 fast-set silicone molding putty was mixed by hand and formed into a cushion that was placed between the dorsal ridge and the satellite transmitter. The wire lanyards were then threaded through the transmitter fittings, tightened, and secured with a metal crimp. The entire process, from encounter to attachment completion, took an average of 0.8 hours (+/- 0.5 hours) between the hours of 21:40 hours and 01:00 hours. In the case of the leatherbacks, the team did not wait to observe the turtle going back into the water because they moved on to the next patrol and several turtles were encountered in rapid succession on the same night.

Data Acquisition, Processing, and Analyses

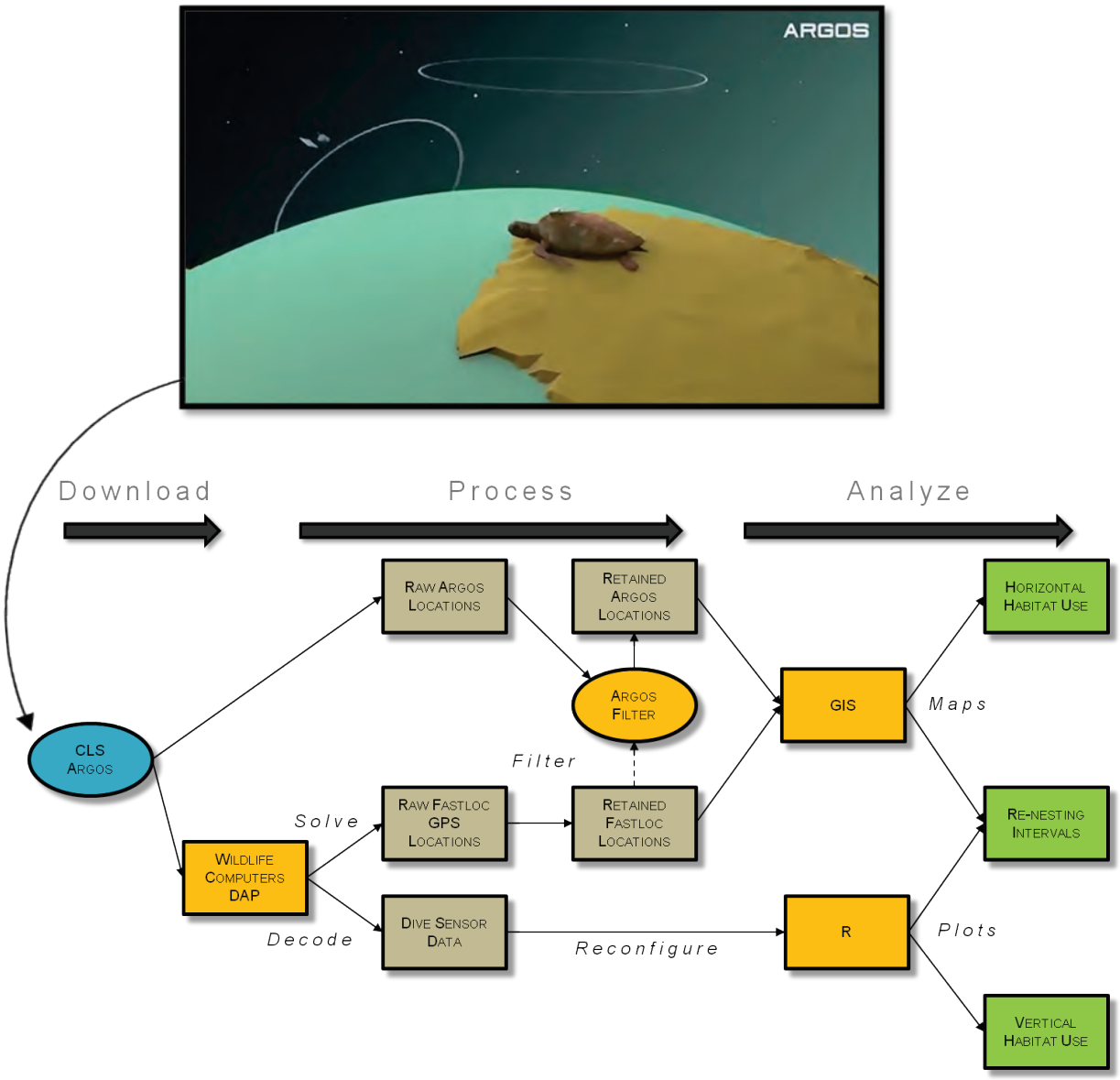
The satellite tracking and data relay system is operated by CLS Argos. The information collected by the satellite tag was transmitted as encoded, fixed-frequency radio signals each time the turtle surfaced to breathe. Data were only received if one of the polar-orbiting satellites equipped to receive Argos messages was passing overhead during this narrow window of time. Unlike GPS, which employs a constellation of fixed satellite positions to determine location, the Argos system uses Doppler Shift (i.e., the change in sound frequency) to calculate the estimated location of the signal. The Argos method resolves positions faster, but it is not without measurement error, resulting in varying levels of accuracy. Raw sensor data, such as dive profiles and Fastloc® GPS locations, were also transmitted through the Argos System, but required additional processing through tag-manufacturer-specific software to decode the data (Figure 3). The best practices for wildlife tracking require filtering the raw location estimates through statistical algorithms before further analysis to remove implausible positions based on movement rates and turning angles. In this case, the high-precision GPS data were used to calculate site- and species-specific movement thresholds for setting the Argos location filtering algorithm. Fastloc® GPS data were first filtered to remove locations derived from fewer than 6 satellites and with high residual errors (>20). The hybrid Douglas Argos-Filter (Douglas et al. 2012) was then used on Argos locations, which optimally retains locations based on maximum redundancy thresholds (5 kilometers) and speed (5 kilometers per hour) and turning angle thresholds (25°) for migratory animals. Argos location estimates with error classes 2 and 3[5] were always retained, as well as the first and last locations, and default parameter values were used for the hybrid method. Data were then analyzed in the Albers Equal Area coordinate system using geographic information system (ArcGIS®) and statistical (R®) software programs (Figure 3). Monthly mean ocean altimetry images[6] from the Global Ocean 1/12° Physics

[5] CLS Argos uses location class error codes that classify location estimates within a given distance from the true location. Location classes 2 and 3 have the highest estimated accuracy (<500 m).

[6] SSH, meridional (U), and zonal (V) velocity

Analysis and Forecast dataset were downloaded from the Copernicus Marine Environment Monitoring Service website to evaluate movements in context with geostrophic[7] ocean currents.

FIGURE 3: A PICTOGRAM OF THE FLOW AND TREATMENT OF SEA TURTLE SATELLITE TRACKING DATA FOR ADDRESSING SPECIFIC RESEARCH OBJECTIVES



[7] Currents resulting from a balance between pressure gradients and Coriolis forces. Coriolis forces pertain to the rotation of currents that are deflected to the right in the northern hemisphere and to the left in the southern hemisphere.

RESULTS

Tag Performance

The quantity and quality of data received during satellite tracking is strongly influenced by the animal's behavior. For example, individual sea turtles undergoing long-distance forays spend more time at the surface due to physiological requirements, and they typically produce more frequent and higher quality location fixes than those individuals remaining within a restricted area, who spend more time making vertical dives. This pattern was evident among the seven turtles in this study (Tables 1 and 2).

Given the satellite coverage at Guyana's low latitude, data reception from all seven transmitters exceeded expectations. Variability in data acquisition appeared to be related to movement behavior, producing similar numbers of locations (Table 1), sensor data messages (Table 2), and tag durations (165 +/- 18 days [mean +/- 1 standard deviation (SD)]; Tables 1 and 3) among green turtles. Leatherback data were more variable among individuals (Tables 1 and 2) and likely to be directly related to tag duration (65 +/- 44 days [mean +/- 1 SD]; Tables 1 and 3).

Green turtle transmissions produced an average of 14.1 +/- 0.7 (mean +/- 1 SD) Argos location estimates and 6.4 +/- 0.3 (mean +/- 1 SD) Fastloc® GPS locations per day per turtle (Table 1) over the study period. Only 9 percent of green turtle Argos positions were classified as high quality (i.e., location classes 1, 2, or 3); however, most Argos locations were retained after the filtering process due to a less-conservative hybrid algorithm (95.3 +/- 0.5 percent [mean +/- 1 SD]). For leatherback turtles, there were an average of 11.5 +/- 2.6 (mean +/- 1 SD) Argos location estimates and 4.7 +/- 0.1 (mean +/- 1 SD) Fastloc® GPS locations received per day per turtle (Table 1) over the study period. Leatherback Argos positions had a greater proportion of high-quality locations (16 percent), but fewer Argos locations were retained after the filtering process (62.3 +/- 31.0 % [mean +/- 1 SD]). The difference between the Argos locations received and retained by the filter between species is likely due to the animals' movement behaviors and the number of satellites available by latitude (more at higher latitudes, fewer at lower latitudes). The number of Fastloc® GPS locations retained after filtering was similar between green and leatherback turtles (76.0 +/- 4.2 percent and 73.5 +/- 9.2 percent [mean +/- 1 SD], respectively), reflecting the static availability of GPS satellites across the globe. Ultimately, movement metrics based on the filtered Argos locations were only slightly greater than those based on Fastloc® GPS locations (Table 1).

Dive sensor information was received for a minimum of 76 percent of the data-days possible and included daily histogram summaries for depth and temperature, hourly summaries of percent dry time, and time-series of dive and temperature profiles (Table 2). Haul-out information was received for three out of four green turtles and all three leatherback turtles via either haul-out or status messages; this was a critical parameter for determining re-nesting events.

TABLE 1: TURTLE LOCATION DATA AND MOVEMENT SUMMARY STATISTICS FOR COMPARISON AMONG INDIVIDUALS AND BETWEEN LOCATION ESTIMATION METHODOLOGIES (I.E., ARGOS VERSUS FASTLOC® GPS)

Turtle ID	Days of Tracking Data	Location Estimation Method	Total # of Locations Received	% of Locations Filtered Out	Convex Hull of Retained Locations (km^2)	Total Distance Traveled (km)*	Maximum Displacement (km)	Maximum Offshore Distance (km)
Green Turtles								
173290 Sibille	137	Argos Fast-GPS	2043 898	5 27	196,774.4 176,853.8	2211.2 1794.2	1536.0 1416.7	149.6 120.1
173293 Violet	164	Argos	2250	4	533,866.6	3487.6	2597.6	77.3
173291 Becky	180	Argos Fast-GPS	2454 1011	5 21	456,993.2 446,367.4	3248.7 3130.1	2579.6 2576.2	152.7 149.6
173294 Karin	172	Argos	2422	5	477,219.0	3801.3	2497.0	95.4
Leatherback Turtles								
173284 Julie	24	Argos Fast-GPS	350 111	15 20	6551.3 2781.4	622.0 517.7	116.6 79.9	111.6 51.1
173288 Denise	47	Argos	464	25	76,414.9	1900.7	939.7	515.6
173285 Arleen	110	Argos Fast-GPS	1120 526	27 33	2,388,788.8 1,836,887.3	5138.1 4315.8	3597.0 3019.1	1310.2 1304.4

* indicates a standardized calculation based on a subset of the data (i.e., one location per day)
km = kilometers; km^2 = square kilometers

TABLE 2: DIVE AND FASTLOC® GPS DATA COLLECTED IN PREDEFINED SAMPLING INTERVALS AND RELAYED THROUGH THE ARGOS SYSTEM

		Number of Messages Received for Various Data Files							
Turtle ID	**Tag Type**	**Status**	**Time-Series**	**Time-at-Temperature**	**Time-at-Depth**	**Haul Outs**	**% Dry Time**	**Dive Depth**	**Dive Duration**
Green Turtles									
173290 Sibille	GPS	74	-	122	-	1	-	-	-
173293 Violet	Dive	111	470	143	151	-	142	142	149
173291 Becky	GPS	106	-	169	-	1	-	-	-
173294 Karin	Dive	139	409	145	140	-	131	152	147
Leatherback Turtles									
173284 Julie	GPS	15	-	23	-	1	-	-	-
173288 Denise	Dive	32	129	40	44	-	40	42	39
173285 Arleen	GPS	54	-	103	-	1	-	-	-

Columns represent the reconstructed data files that were generated during the decoding process with respect to tag type (see Figure 3). Values indicate the number of messages received.

TABLE 3. SUMMARY OF TURTLE BEHAVIORAL INTERVALS DETERMINED FROM SATELLITE TRACKING DATA[8]

Turtle ID	Tracking Dates	Inter-nesting			Migrating		Foraging[9]		Method Used
		Clutches	Days	km Countries	Days	km Countries	Days	km Countries	
Green Turtles									
173290 Sibille	23 Mar–11 Aug 2018	7	72	16.7 GY	69	1697.9 GY, SR, GF, BR	-	-	Haul-Out, GIS
173293 Violet	24 Mar–4 Sep 2018	3	36	106.5 GY, VE	91	2746.8 GY, SR, GF, BR	38	29.9 BR	Haul-Out, % Dry, Time Series, GIS
173291 Becky	24 Mar–22 Sep 2018	5	55	17.8 GY	78	2781.0 GY, SR, GF, BR	50	52.6 BR	Haul-Out, GIS
173294 Karin	25 Mar–14 Sep 2018	6	70	261.7 GY, VE, TT	62	2719.6 GY, SR, GF, BR	41	15.2 BR	Haul-Out, % Dry, Time Series, GIS
Leatherback Turtles									
173284 Julie	14 Jun–11 Jul 2018	3	26	104.9 GY, VE	1	-	-	-	Haul-Out, GIS
173288 Denise	14 Jun–8 Aug 2018	4	30	120.4 GY, VE	26	-	-	-	Haul-Out, % Dry, Time Series, GIS
173285 Arleen	14 Jun–5 Oct 2018	2	17	204.6 GY, VE	96	-	-	-	Haul-Out, GIS

Clutches indicate the total number of nests laid. Days indicate the number of days during inter-nesting, migrating, and foraging periods that made up the track. Km (kilometers) indicate the approximate distance of coastline that was covered during the period and the countries whose territorial waters were involved.

BR = Brazil; GF = French Guiana; GY = Guyana; km = kilometer; SR = Surinam; TT = Trinidad; VE = Venezuela.

[8] Behavioral intervals were characterized by a change in heading and movement rates calculated from tracking data.

[9] It should be noted that one of the greens and all of the leatherbacks did not reach the foraging grounds during their tracking periods. It is generally believed that turtles do not feed during inter-nesting and migration periods.

Tracking durations in this study are within the range of those published in the scientific literature, but were shorter than what was projected by battery life and programming alone for both tag models. This could be due to a variety of factors, not limited to: animal behavior, biofouling, predation, incidental capture, antenna damage, discharged battery, or attachment failure. It is impossible to positively identify the root cause of tag failure in each case; however, the data provided were examined in the status messages over the lives of the tags and the manufacturer was consulted to try to identify indications or rule out potential causes of the shorter-than-anticipated tracking durations. Examination of the data revealed no degradation in battery voltage, power of signal strength, or number of GPS satellite fixes in any of the tags, and all tags had made fewer than half of the total transmissions possible, allowing those issues to be ruled out.

There was some evidence from the wet/dry sensors that biofouling might have occurred, especially for Arleen, but perhaps also for Becky and Karin. Tags and epoxy affixed to green turtles were coated with anti-fouling paint during the attachment process. Leatherback tags were not painted because they typically swim faster and range farther offshore than green turtles, which tends to result in less biofouling in leatherbacks compared to green turtles. Sometimes, in cases of biofouling, a tag will stop transmitting for a period of time but then start up again when the fouling organism falls off or is scraped off on reefs, pilings, etc. However, none of the tags in this study started transmitting again once going offline.

All of the green turtle tags showed an increase over time in the minimum wet/dry sensor values, which has never been seen before by the tag manufacturer; they are currently consulting with the engineers for possible explanations. This did not occur in the leatherback tags.

Incidental capture can probably be ruled out, as there was no sudden increase in a series of high quality locations that are typically associated with an animal being on land or in a boat. There was an indication that one of the leatherback tags was having attachment issues, given by a PAC ranger (R. DeFreitas, personal communication). Apparently only one of the two lanyards was still attached when the turtle came to nest again, and an attempt was made to re-secure the tag at that time; however, we cannot be sure which animal it was since the leatherbacks were not flipper tagged. The first leatherback to stop transmitting was Julie, so it is reasonably likely that Julie was the turtle with the aforementioned attachment issues. More potential explanations associated with individual behavior are discussed below.

Inter-nesting Period

While all individuals showed strong nesting-site fidelity to their capture locations throughout this period (Table 3), three types of inter-nesting movement behaviors were identified (Figure 4, Table 1):

A. Remained in the immediate vicinity of Almond Beach, making small near-shore loops (Sibille and Becky);

B. Moved moderate distances up and down the Guyana-Venezuela coastline, making small near-shore loops (Violet); and

C. Moved large distances, making small near-shore loops in the vicinity of Almond Beach and offshore loops between Venezuela, Trinidad, and Guyana (Karin, Julie, Denise, and Arleen).

Turtles returned to nest between two and six times, exclusively on Almond Beach, in approximately 12-day intervals, with the exception of one animal (Violet), who also nested across the Barima-Waini river mouth and nested at longer time intervals than the other turtles (Figures 5, 6, and 7, Table 3). Green turtles (13.0 +/- 1.7 days [mean +/- 1 SD]) demonstrated longer re-nesting intervals than leatherback turtles (9.5 +/- 0.5 days [mean +/- 1 SD]) (χ^2= 12.492, df = 1, $p < 0.001$; Figure 7). The distance of green turtle nests from their initial capture locations ranged from 0 to 33.7 kilometers (Figure 7) with significant differences among individuals (χ^2= 33.017, df = 3, $p < 0.001$). Most of this variability stemmed from Violet and Karin; if their nests are removed from the data set, the remaining nests were all within 1 kilometer of the original capture location. Leatherback turtle nests were within 1.9 kilometers (Figure 7), but also showed individual differences in nest dispersal (χ^2= 7.593, df = 2, p = 0.022), driven by Denise's slightly more diffuse nesting than that of Julie or Arleen. All turtles demonstrated remarkable nesting-site fidelity irrespective of their maximum displacements among nests (Table 1). With respect to the size of the area used by the turtles during the inter-nesting period, there were no significant differences between species or among individuals; however, leatherback turtles occupied waters at a farther distance from shore than did the green turtles (χ^2= 4.500, df = 1, p = 0.034; Figure 7).

FIGURE 4: SPATIAL FOOTPRINTS OF GREEN AND LEATHERBACK TURTLE INTER-NESTING MOVEMENTS FROM ALMOND BEACH

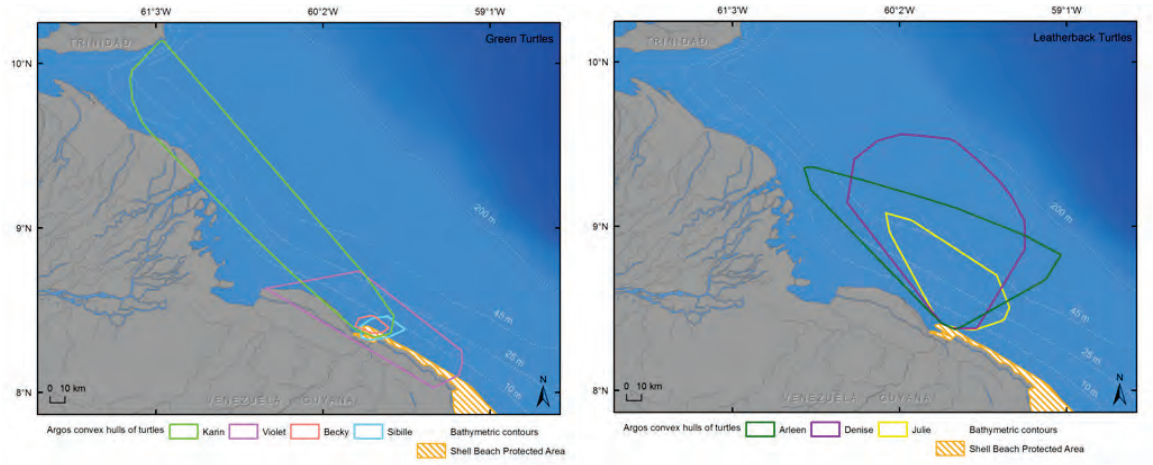


FIGURE 5: RE-NESTING LOCATIONS AND SPATIAL FOOTPRINTS OF GREEN TURTLES DURING INTER-NESTING

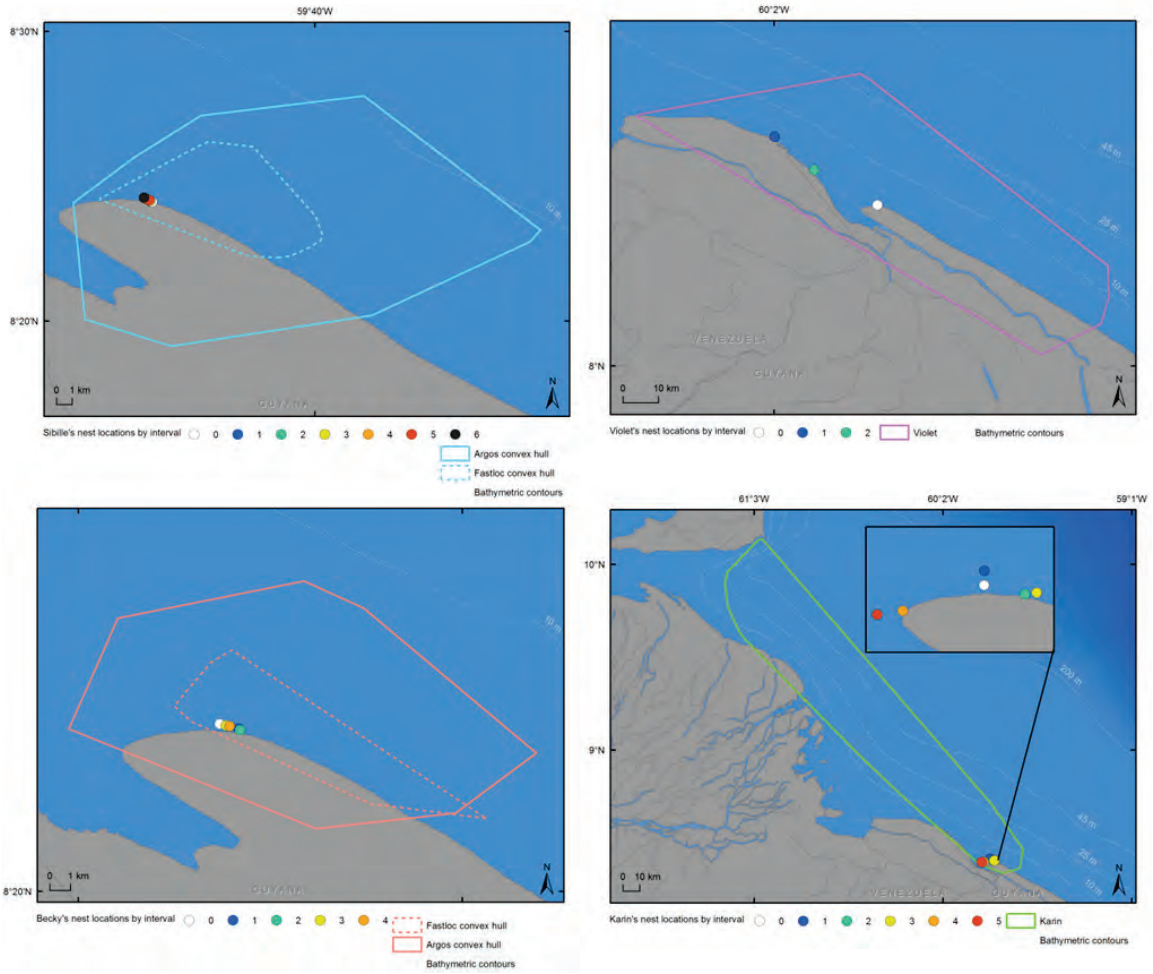
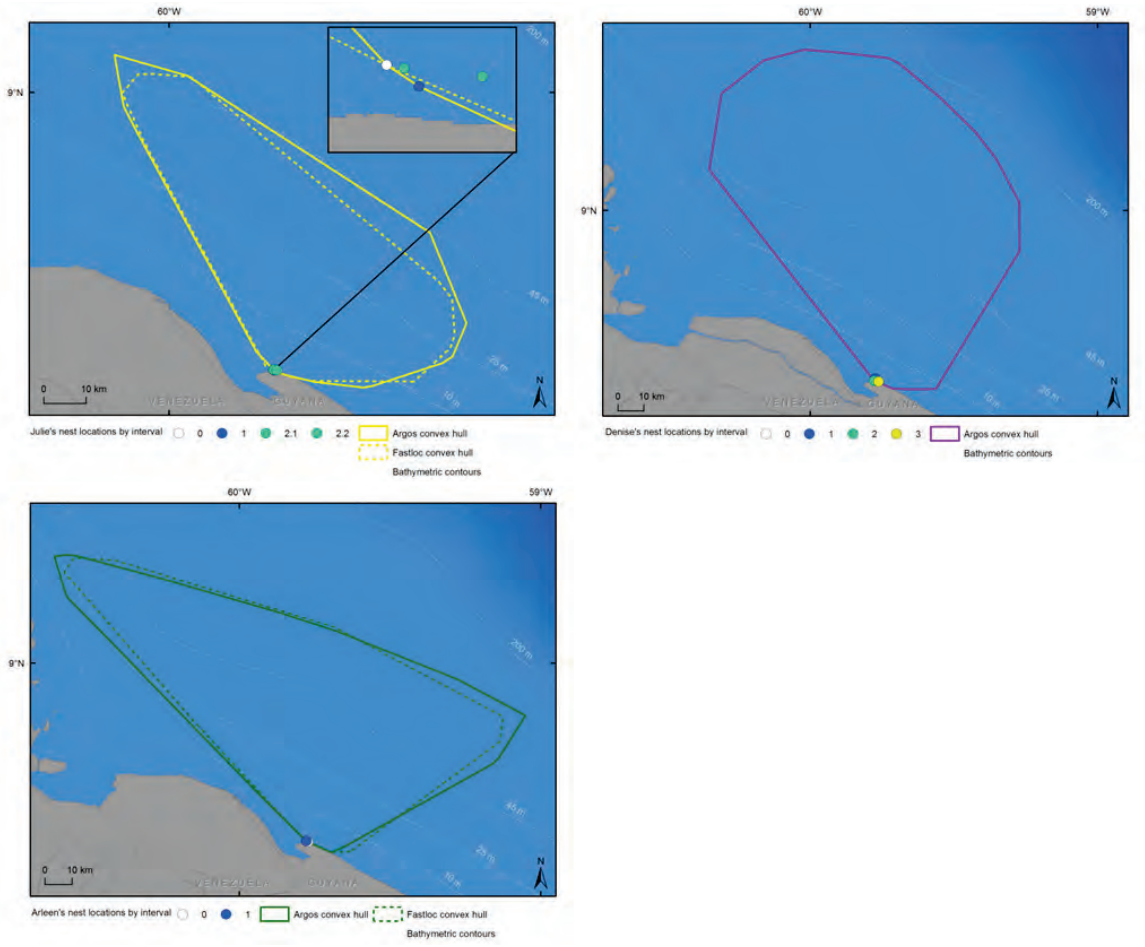
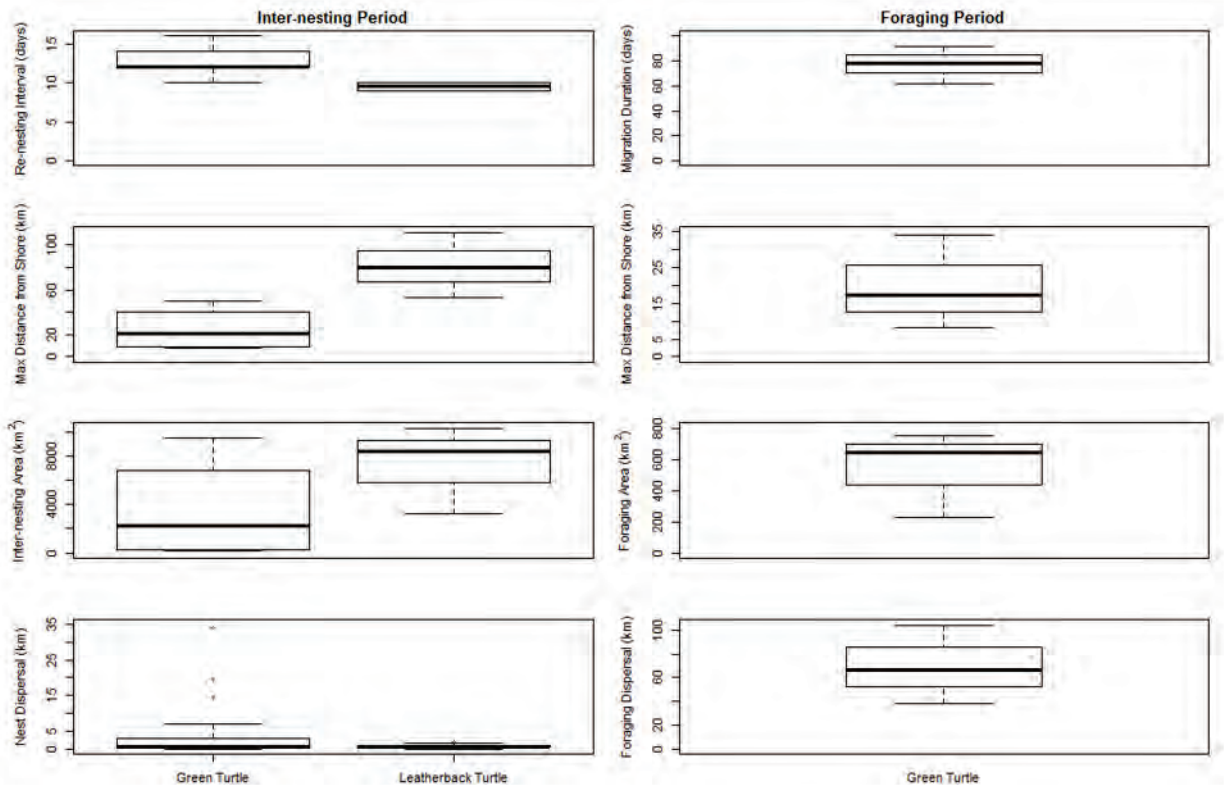


FIGURE 6: RE-NESTING LOCATIONS AND SPATIAL FOOTPRINTS OF LEATHERBACK TURTLES DURING INTER-NESTING



Re-nesting periods with more than one point (same color symbols, with decimal labels) represent multiple attempts (i.e., false crawl) as indicated by the haul-out or percent dry time data

FIGURE 7: BOX AND WHISKER DIAGRAMS COMPARING HABITAT USE METRICS BETWEEN SPECIES AND BETWEEN INTER-NESTING AND FORAGING PERIODS



The thick line represents the median value, the box shows the values between the upper and lower quartiles, the whiskers indicate the range, and the points show outliers.

Leatherback turtles occupied deeper water (34.9 +/- 35.8 meters [mean +/- 1 SD]) than green turtles (6.8 +/- 7.2 meters [mean +/- 1 SD]) during the inter-nesting period ($F_{1,234} = 93.174$, $p < 0.001$; Figure 8). The greatest density of green turtle locations occurred in less than 5 meters of water (Figure 9); The greatest density of leatherback turtle locations occurred in less than 10 meters of water (Figure 10). There were individual differences in depth use during this period for both green turtles ($F_{3,160} = 7.222$, $p < 0.001$) and leatherback turtles ($F_{2,69} = 5.215$, $p = 0.008$). The two green turtles with depth sensors (who incidentally also occupied a wider range of water depths) recorded maximum dives of 16.7 meters during this period, but data indicated that the majority of their dives were within the upper 5 meters of the water column (Figures 11A and 12A). The one leatherback turtle with a depth sensor tag recorded maximum dives of 134.5 m during the inter-nesting period, but data indicated that most dives were within the upper 10 meters of the water column (Figure 13A). Details on the vertical habitat use of turtles during their entire tracking period are summarized in Table 4 and Figures 14, 15, and 16.

TABLE 4: TURTLE DAILY VERTICAL HABITAT USE

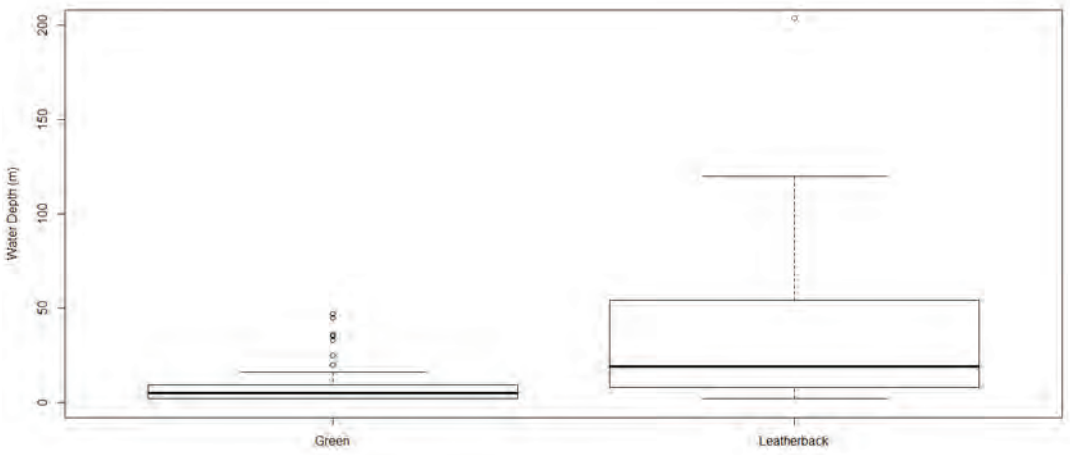
Turtle ID	Water Depth (m)		Turtle Depth (m)		Maximum Dive Depth (m)[10]	
	Mean (SD)	Range	Mean (SD)	Range	Mean (SD)	Range
Green Turtles						
173290 Sibille	10.5 (9.1)	1.0–42.0	-	-	-	-
173293 Violet	9.9 (6.9)	1.0–42.0	6.9 (5.4)	0.0–34.0	12.5 (6.1)	1.8–33.8
173291 Becky	12.2 (11.1)	1.0–69.0	-	-	-	-
173294 Karin	9.1 (9.1)	1.0–48.0	6.0 (5.1)	0.5 - 37.0	10.3 (6.8)	2.8–37.0
Leatherback Turtles						
173284 Julie	58.9 (198.4)	1.0–1065.0	-	-	-	-
173288 Denise	1400.9 (1961.8)	1.0–5437.0	22.7 (33.5)	0.5–560.5	108.3 (100.0)	7.3–560.5
173285 Arleen	3909.9 (1932.3)	1.0–5963.0	-	-	-	-

Turtle daily vertical habitat use (i.e., depth) was inferred from sampling bathymetric maps (see Figures 9 and 10) and from dive data collected by the turtle tags. Sibille, Becky, Julie, and Arleen were not equipped with dive recorders.

m = meters

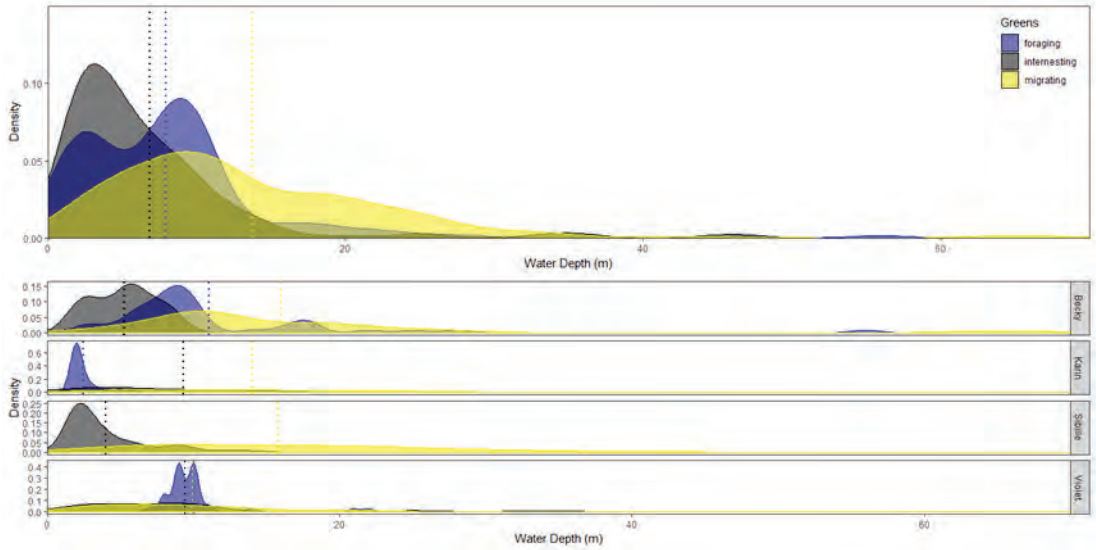
[10] Note: This table shows the mean and standard deviation as well as the range. For example, the maximum depth of a given dive was on average 10 - 13 m for green turtles. Maximum dives of 30-40 m were rare but are captured in the range column of the table. The same logic applies to leatherbacks.

FIGURE 8: BOX AND WHISKER DIAGRAM SHOWING WATER DEPTH USE FOR GREEN AND LEATHERBACK TURTLES DURING THE INTER-NESTING PERIOD



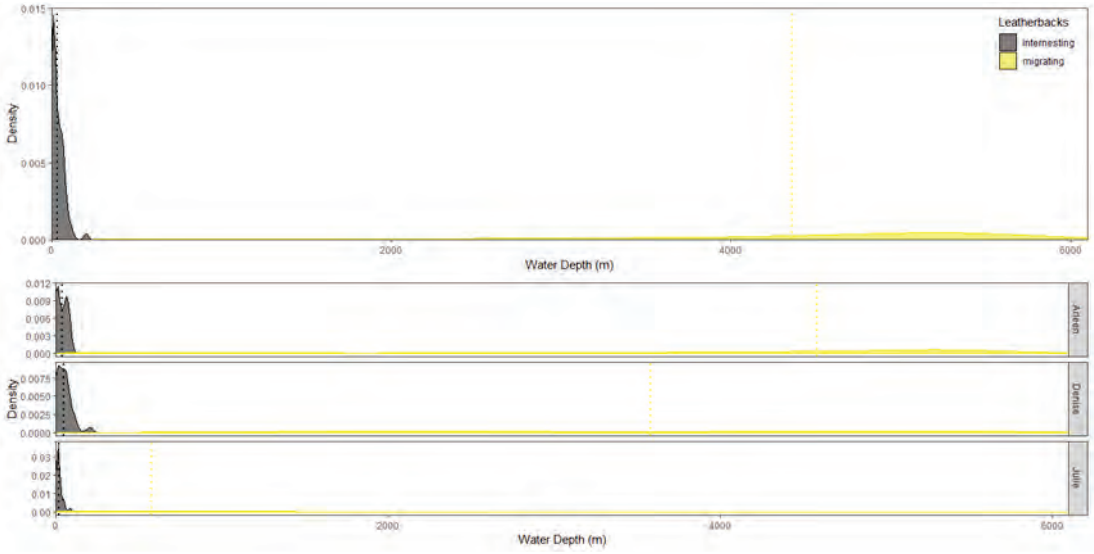
The thick line represents the median value, the box shows the values between the upper and lower quartiles, the whiskers indicate the range, and the points show outliers.

FIGURE 9: DENSITY DISTRIBUTION OF WATER DEPTHS OCCUPIED BY GREEN TURTLES COMBINED TOGETHER (TOP PANEL) AND INDIVIDUALLY (BOTTOM PANELS) DURING DIFFERENT TRACKING PERIODS (INDICATED BY COLOR)



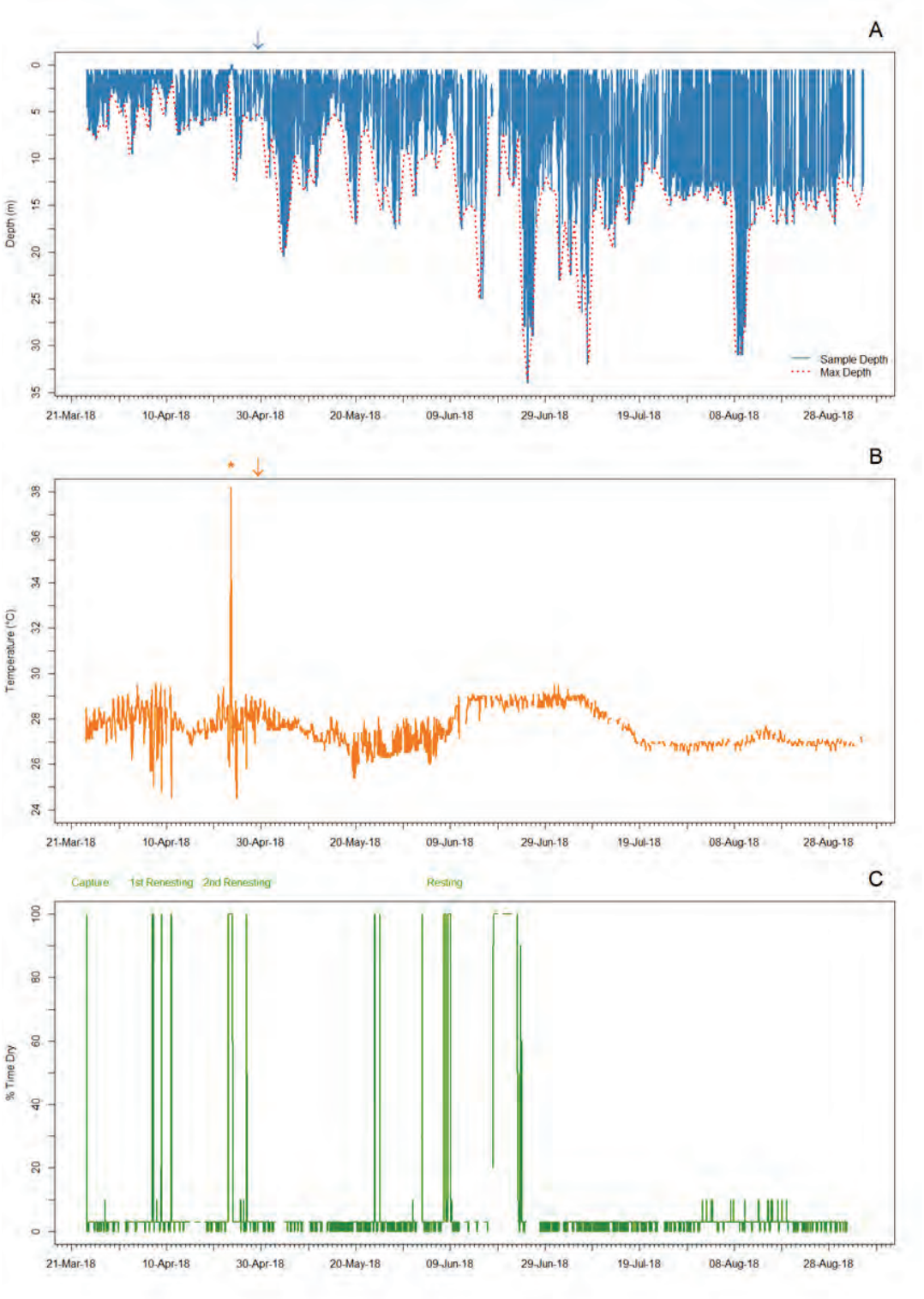
Mean values for the sampling period are indicated by a vertical dotted line. Water depth values were extracted from a GEBCO-14 global bathymetry raster at the single best Argos location per day in a GIS to facilitate comparisons among animals. Points falling on land were excluded from this analysis.

FIGURE 10: DENSITY DISTRIBUTION OF WATER DEPTHS OCCUPIED BY LEATHERBACK TURTLES COMBINED TOGETHER (TOP PANEL) AND INDIVIDUALLY (BOTTOM PANELS) DURING DIFFERENT TRACKING PERIODS (INDICATED BY COLOR)



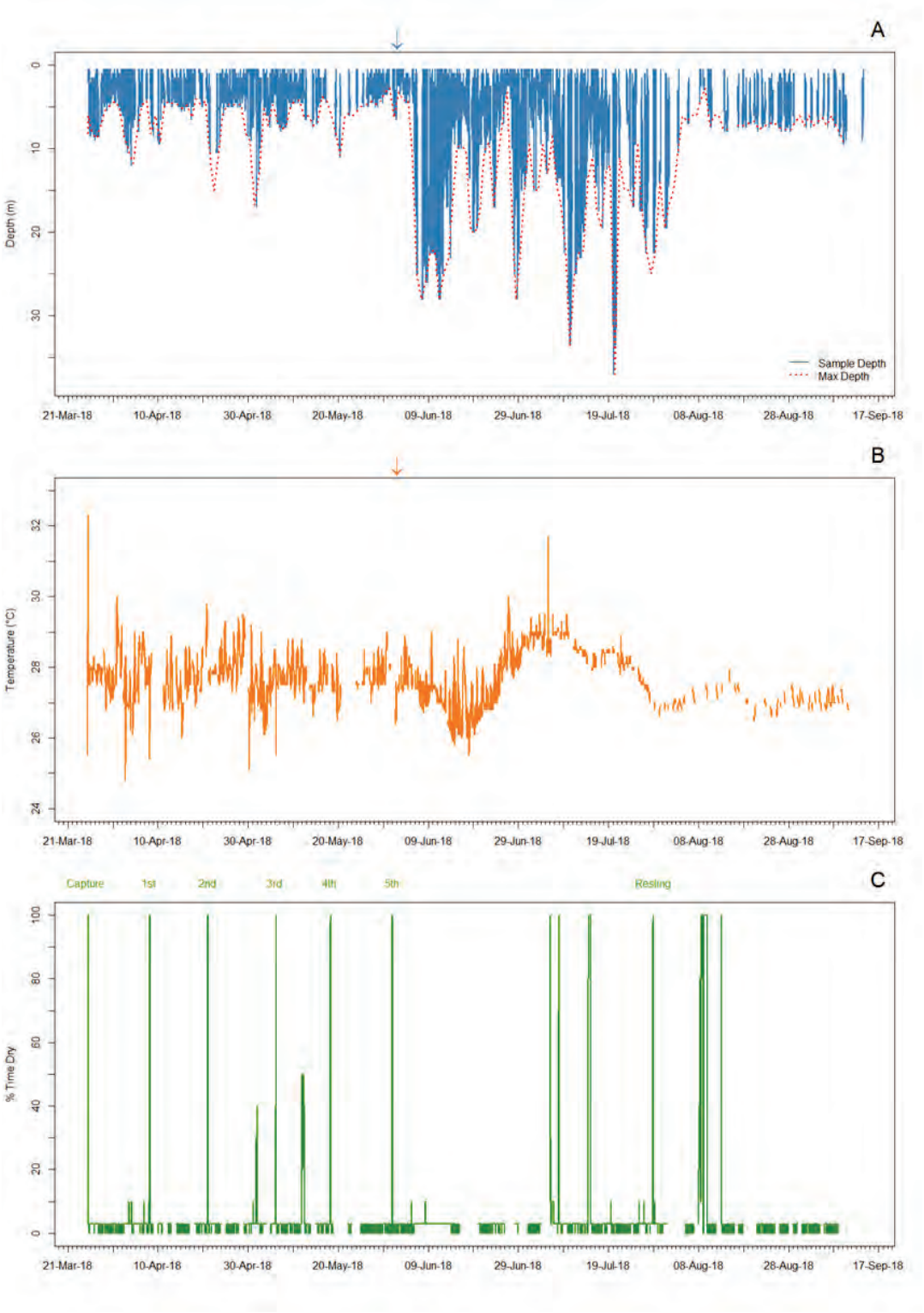
Mean values for the sampling period are indicated by a vertical dotted line. Water depth values were extracted from a GEBCO-14 global bathymetry raster at the single best Argos location per day in a GIS to facilitate comparisons among animals. Points falling on land were excluded from this analysis.

FIGURE 11: TIME-SERIES PLOTS OF (GREEN TURTLE) VIOLET'S DIVE DATA



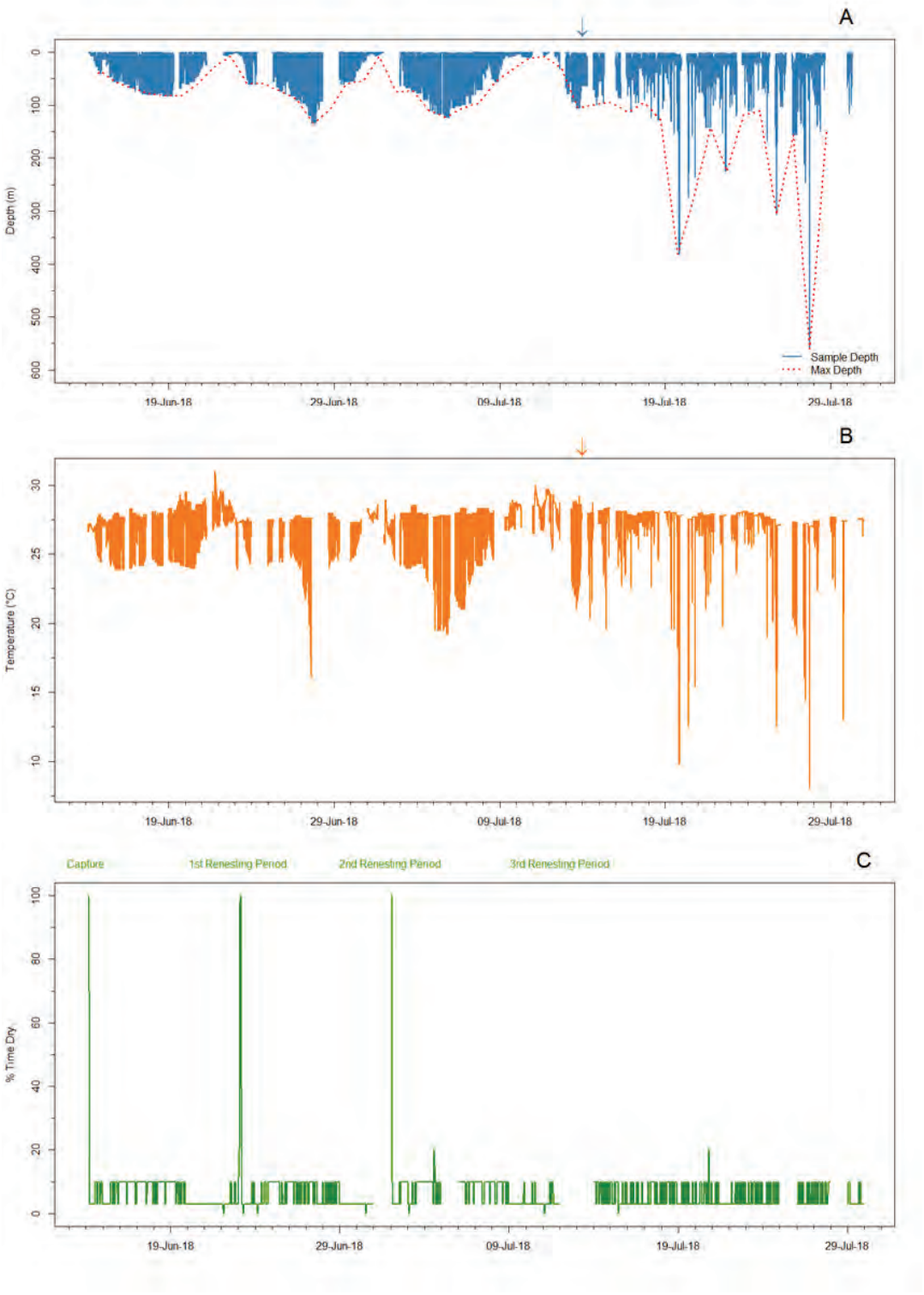
A) depth; B) temperature; C) percent dry time. Arrows indicate the start of Violet's migration period. The orange asterisk indicates a "stranding" event from 23 to 24 April 2018. Note the asynchronous 100 percent dry times over a period of 5 days within individual re-nesting periods and again during the migration period; these are probable resting periods at the surface.

FIGURE 12: TIME-SERIES PLOT OF (GREEN TURTLE) KARIN'S DIVE DATA



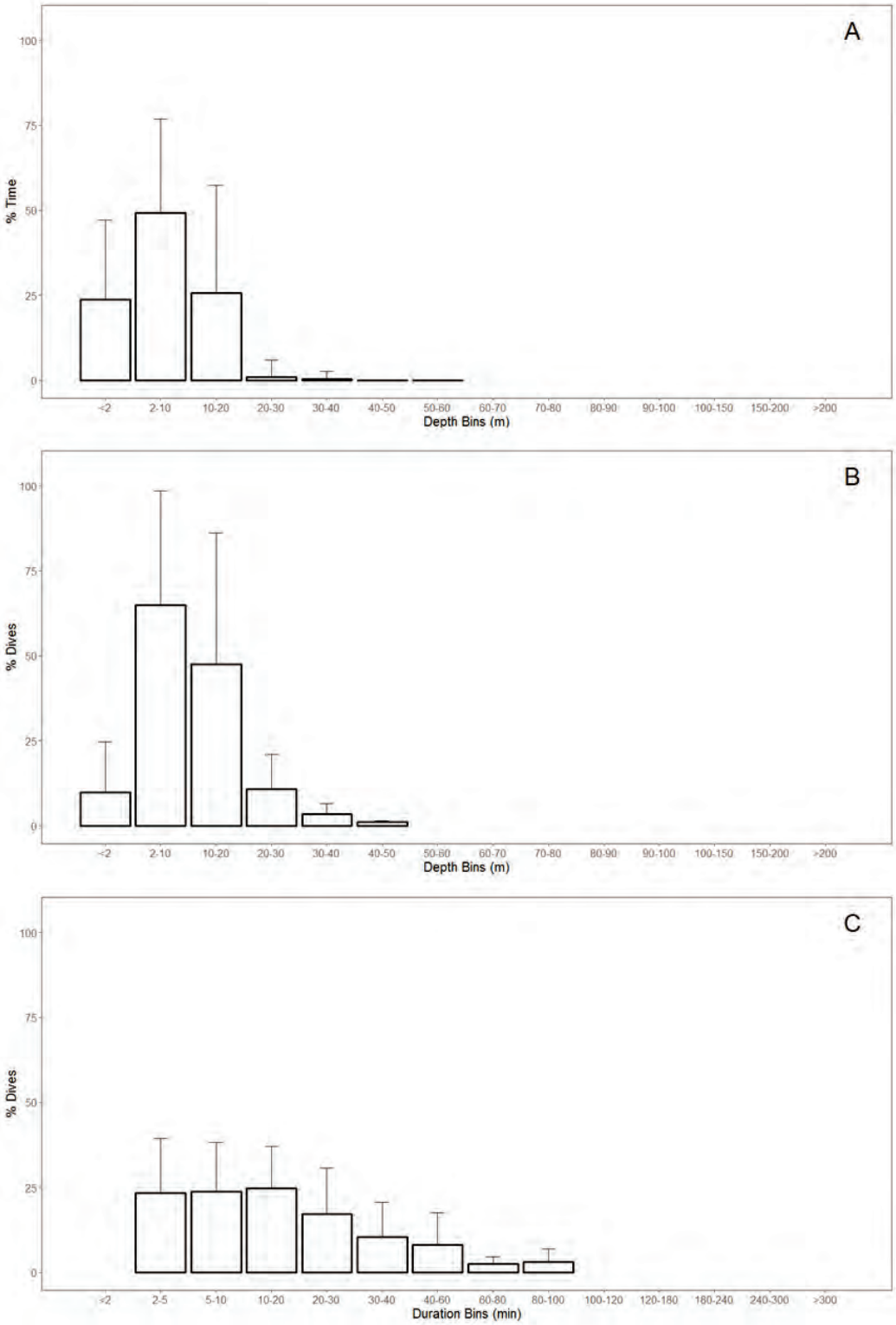
A) depth; B) temperature; C) percent dry time. Arrows indicate the start of Karin's migration period. Note the synchronous 100 percent dry times marking individual re-nesting periods and the asynchronous 100 percent dry times during the migration period; the latter are probable resting periods at the surface.

FIGURE 13: TIME-SERIES PLOT OF (LEATHERBACK TURTLE) DENISE'S DIVE DATA



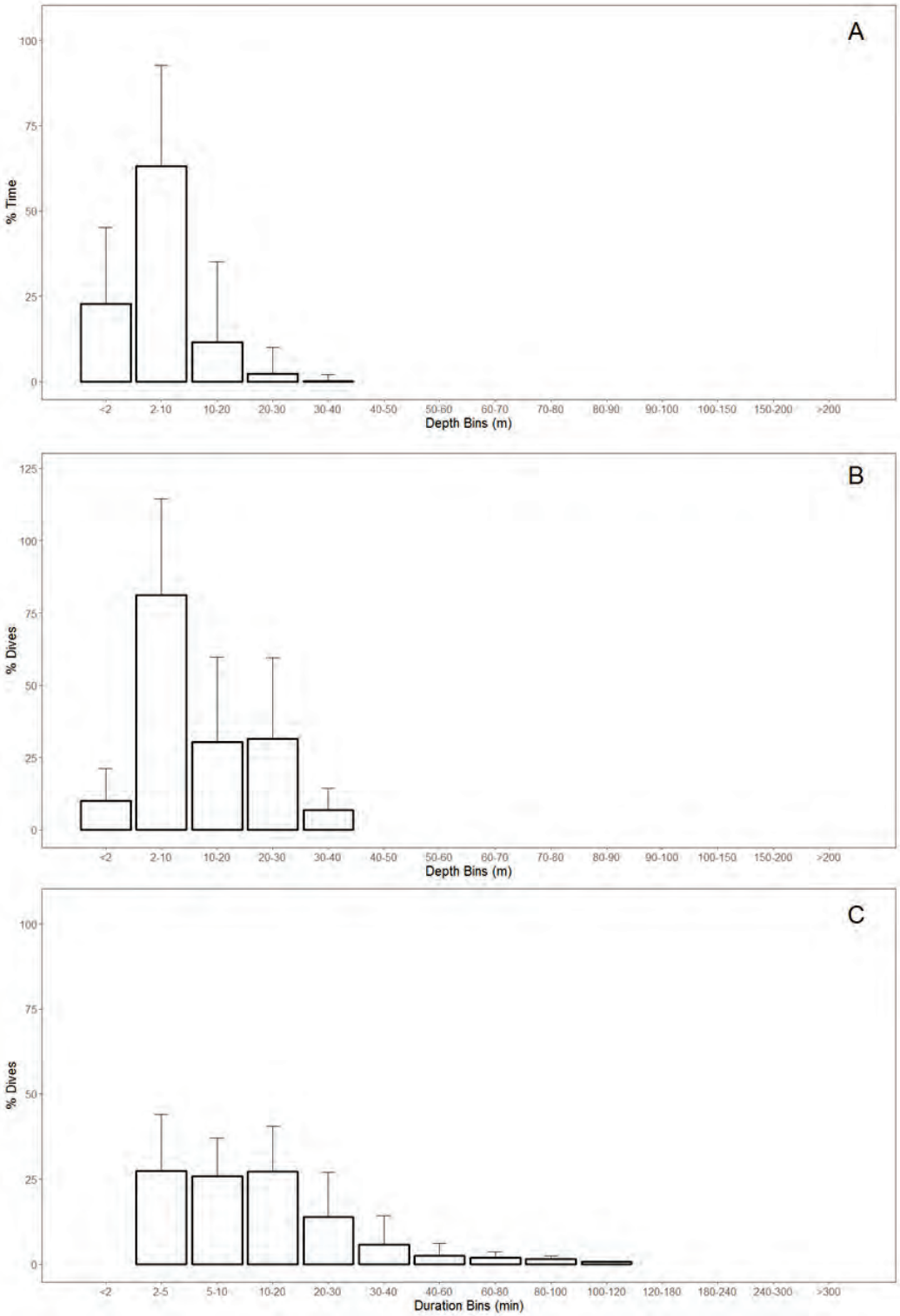
A) depth; B) temperature; C) percent dry time. Arrows indicate the start of Denise's migration. Note the synchronous 100 percent dry times marking two individual re-nesting periods, but a gap in the data that misses the third re-nesting event, which was determined by location data.

FIGURE 14: FREQUENCY HISTOGRAMS OF (GREEN TURTLE) VIOLET'S DIVE DATA DURING THE ENTIRE STUDY PERIOD



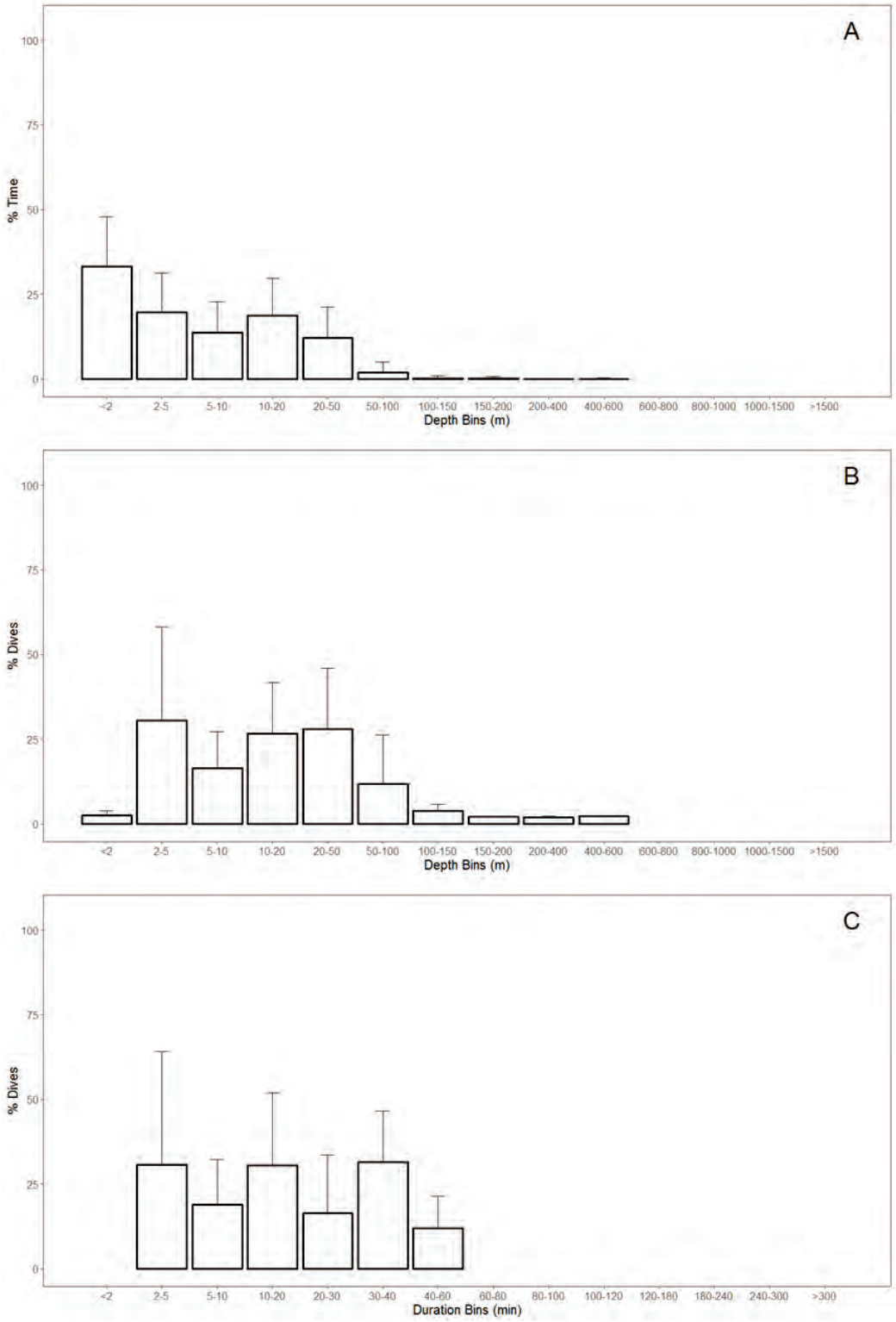
A) Time at depth intervals; B) percent of dives at depth intervals; C) percent of dives at duration intervals; Boxes represent mean daily values and whiskers represent standard deviations

FIGURE 15: FREQUENCY HISTOGRAMS OF (GREEN TURTLE) KARIN'S DIVE DATA DURING THE ENTIRE STUDY PERIOD



A) time at depth intervals; B) percent of dives at depth intervals; C) percent of dives at duration intervals; Boxes represent mean daily values and whiskers represent standard deviations

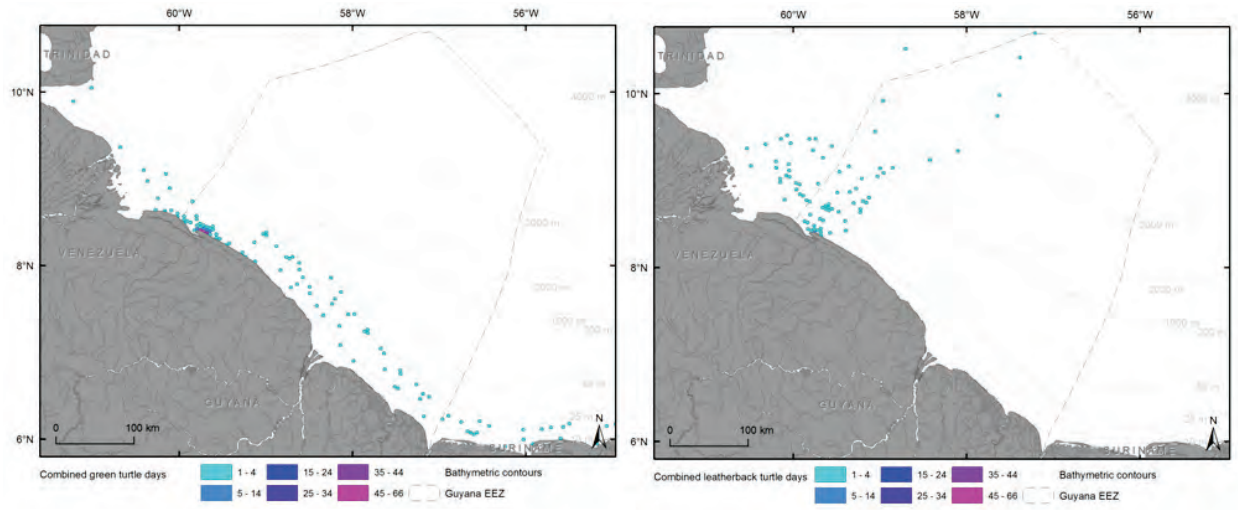
FIGURE 16: FREQUENCY HISTOGRAMS OF (LEATHERBACK TURTLE) DENISE'S DIVE DATA DURING THE ENTIRE STUDY PERIOD



A) time at depth intervals; B) percent of dives at depth intervals; C) percent of dives at duration intervals; Boxes represent mean daily values and whiskers represent standard deviations

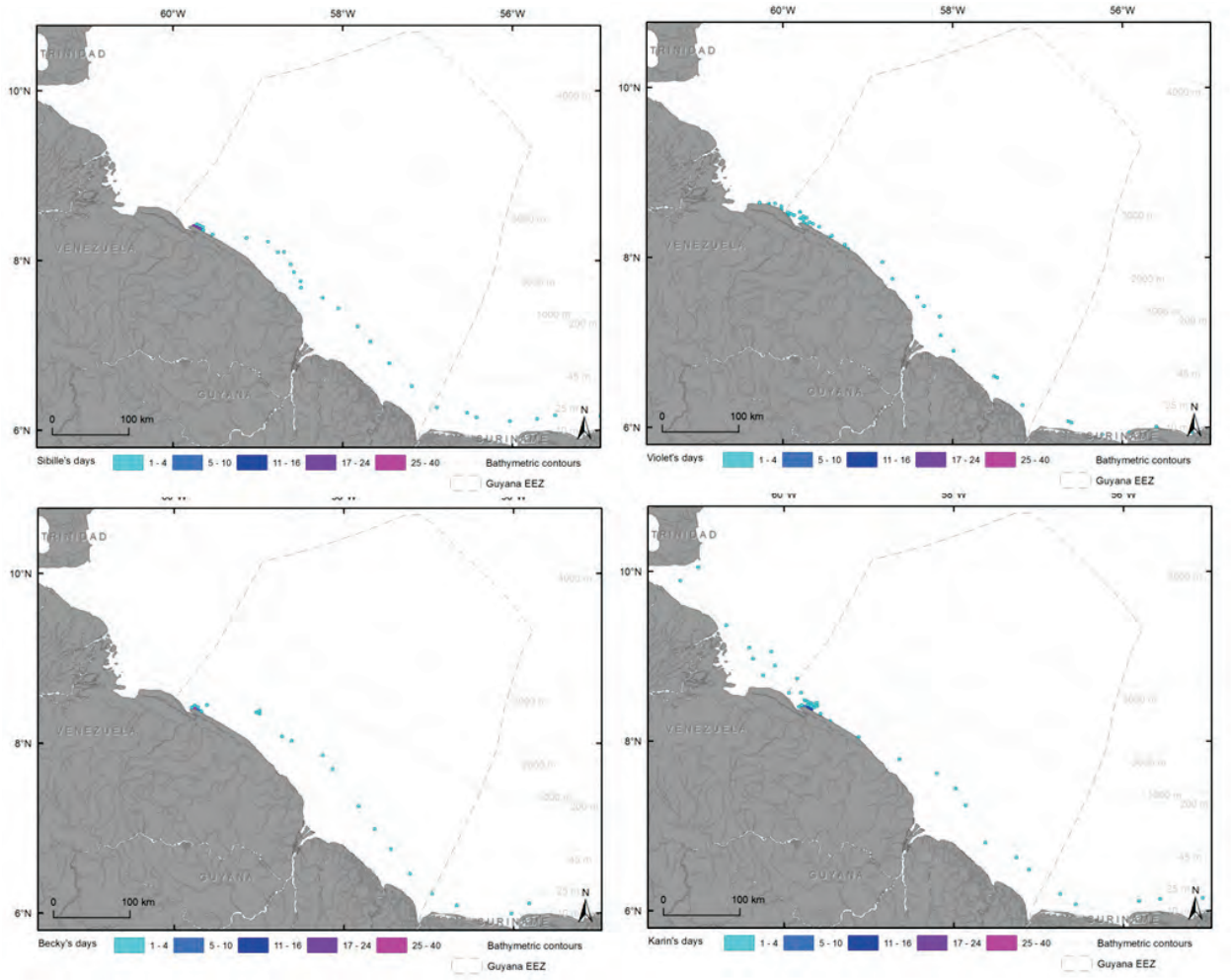
As highlighted above, three types of inter-nesting movement behaviors were characterized among the tagged turtles; despite these differences, the center of inter-nesting activity for all turtles was immediately adjacent to the nesting beach (Figure 4). Generally, the turtles' inter-nesting habitat use was concentrated within the territorial seas of Guyana - within the direct vicinity of Almond Beach (Figure 4, Figure 17), but also included the territorial seas of Venezuela and Trinidad (Table 3). Sibille and Becky (Figure 5, Figure 18) remained near their capture locations, spanning 16.7 kilometers and 17.8 kilometers of coastline, respectively, circling within the 10-meter bathymetric contour, and never traveling more than 11 kilometers from shore. Both of these animals' tags were equipped with Fastloc® GPS capability. While there is some variability in the appearance in their tracks generated from Argos and Fastloc® GPS data, both demonstrate similar patterns, with Fastloc® data falling within the Argos convex hulls (Figure 5).

FIGURE 17: SYNOPSIS OF HABITAT USE OF TURTLES CENTERED WITHIN GUYANA'S EXCLUSIVE ECONOMIC ZONE (EEZ)



A synopsis of habitat use of turtles centered within Guyana's EEZ presented as the number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers. This encompassed the turtles' inter-nesting periods and part of their migration period.

FIGURE 18: SYNOPSIS OF HABITAT USE OF INDIVIDUAL GREEN TURTLES CENTERED WITHIN GUYANA'S EEZ

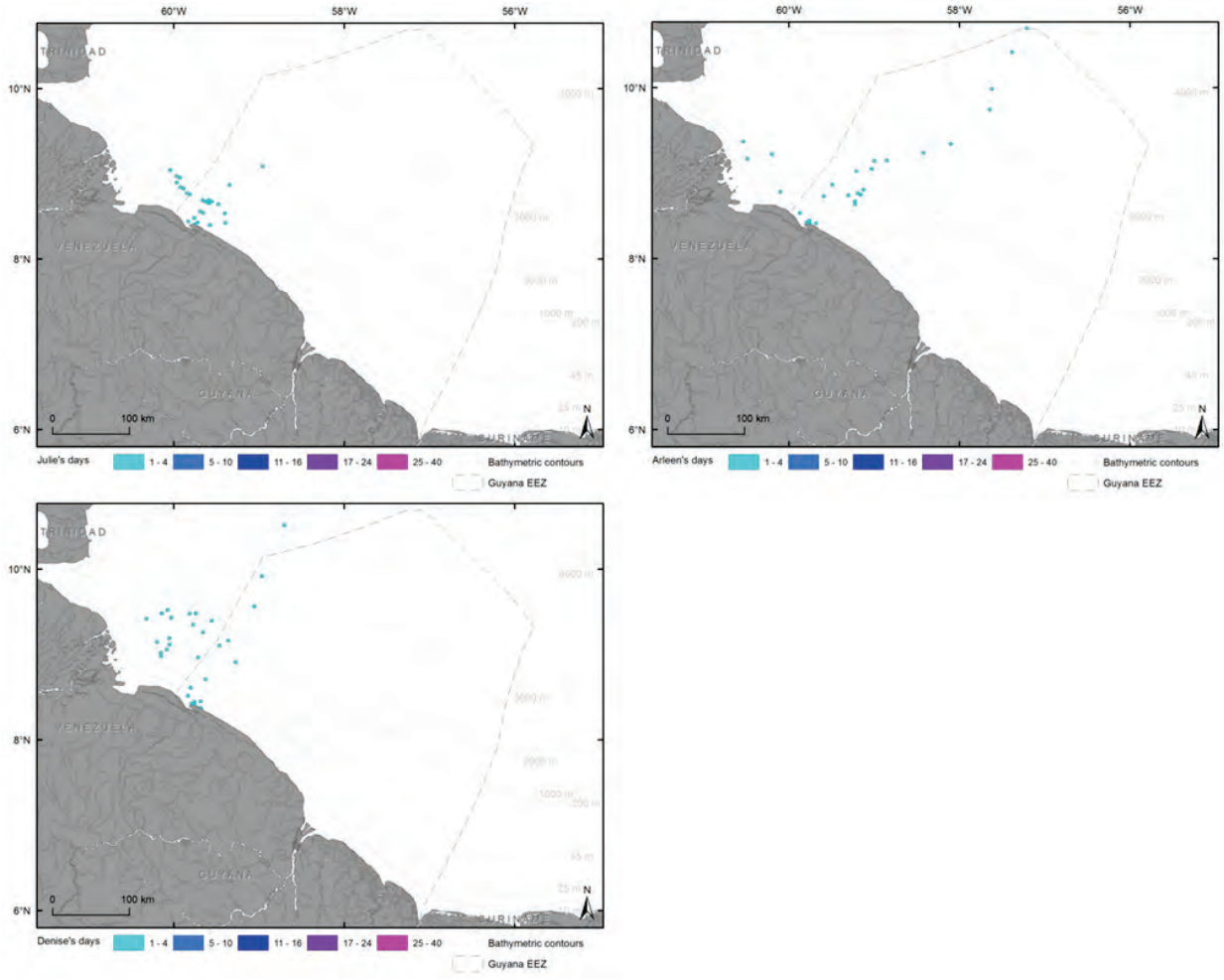


A synopsis of habitat use of individual green turtles centered within Guyana's EEZ presented as number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers. This encompassed the turtles' inter-nesting periods and part of their migration period.

Violet and Karin (Figure 18) and the three leatherbacks, Julie, Denise, and Arleen (Figure 19), demonstrated more itinerant movement behaviors, as compared to Sibille and Becky. Violet's movements extended 106.5 kilometers laterally northwest and southeast along the coastline, where she made similar but more extensive loops offshore, primarily within the 10-meter bathymetric contour (Figures 5 and 18) and within 30 kilometers of Guyana and Venezuela (Figures 5 and 18, Table 3). This turtle was identified as a new nester at Shell Beach (not already having flipper tags at capture). Her elaborate forays, disparate nesting attempts, and extended inter-nesting intervals may reflect her inexperience in selecting a nest site. Violet presented an interesting example of unusual inter-nesting behavior (Figure 11C). During her second re-nesting period, she was apparently stranded on the Venezuela shoreline for a nearly 22-hour period. This area is characterized entirely by mud banks (R. DeFreitas, personal communication), so when the turtle came up to nest, she apparently got stuck in the mud and was unable to return until the tide came in and released her. This stranding event is visible in

the data by looking at the combined characteristics of the time-series graphs: (a) a positive depth, (b) a maximum temperature peak of 38°C, and (c) a wide peak in the 100 percent dry time (Figure 11). The event occurred across the channel from the SBPA, where she was not visible to rangers conducting nightly patrols (Figure 4), but fortunately she was eventually able to re-enter the water and successfully started her migration southward just days later. She was the first to leave Shell Beach (Table 3).

FIGURE 19: SYNOPSIS OF HABITAT USE OF INDIVIDUAL LEATHERBACK TURTLES CENTERED WITHIN GUYANA'S EEZ



A synopsis of habitat use of individual leatherback turtles centered within Guyana's EEZ presented as number of days that turtles occupied individual hexagons of approximately 16.25 square kilometers.

Karin exhibited the farthest movements during her inter-nesting period, extending along 261.7 kilometers of coastline, venturing 50 kilometers offshore of the Orinoco River Delta, Venezuela on one of her loops, and reaching the Port of Galeota on the Trinidad coastline on another (Figures 5 and 18, Table 3). She also made five shorter loops within the 10-meter bathymetric contour. This turtle had previously nested on Shell Beach (already possessing flipper tags) and the precision of her returns after forays may demonstrate her previous experience nesting at this area. Karin also presented an interesting example of what first

appeared to be an unusually high number of erroneous points on land on the east end of Almond Beach between the 8th and 29th of May (Figure 20). Upon close inspection in Google Earth for more recent shoreline profiles, the points still seemed unlikely, albeit some are in swampland and several are with high quality location classes. More recent photos from the air (see Figure 20) (R. DeFreitas March 2018) illustrate clearly that extreme coastal erosion had facilitated seawater intrusions across the beach and into the large swampland behind. Increased erosion was observed in June, making parts of Almond Beach inaccessible at high tides. Evidently, Karin swam into the swamp area and either had difficulties finding her way out, or was content to go back and forth between the ocean and swamp during the 10-day period. Karin and Sibille were the last to leave Shell Beach, only one day apart (Table 3).

FIGURE 20: SATELLITE VIEW OF KARIN'S LOCATIONS BETWEEN 8 AND 29 MAY, 2018



Photos by R. DeFreitas

A satellite view of Karin's locations between 8 and 29 May 2018 showing an unusual concentration of high-quality positions falling in series on land. Low quality positions are colored in black and high quality positions are in red. Photos of the area from the air in March 2018 show that due to large amounts of coastal erosion, the sea had breached the shore in several places, making the swamp in the background accessible. The turtle was therefore determined to indeed be inhabiting these "inland" regions for a 10-day period.

Julie was the only leatherback with a flipper tag scar, and so was not a neophyte nester. She displayed the most moderate offshore movements (54 kilometers) among the leatherback turtles during the nesting season, traveling 104.9 kilometers of coastline between Guyana and Venezuela and staying within the 50-meter bathymetric contour (Figures 6 and 19, Table 3). This turtle most likely made a false crawl on her second re-nesting attempt. There were several false crawls during the second expedition, presumably due to the large amount of debris covering the nesting beach during this part of the season (Figure 21).

FIGURE 21: EXTENSIVE DEBRIS PRESENT ON ALMOND BEACH IN JUNE 2018



Photo by C. McClellan

Denise moved the farthest distance from shore (111 kilometers) crossing the 100-meter bathymetric contour during three inter-nesting loops (Figures 6 and 19) that spanned 120.4 kilometers of shoreline including both Guyana and Venezuela (Table 3). It was these highly visible and equally timed loops that indicated Denise's third re-nesting event, which was not captured in the time-series or haul-out records (Figure 13C).

Arleen made only one offshore inter-nesting loop into 50 meters of water before being the first of the tagged leatherback turtles to leave Shell Beach (Figures 6 and 19, Table 3). This movement stretched across the Orinoco River Delta approximately 80 kilometers from land, comprising a total span of 204.6 kilometers along the coast.

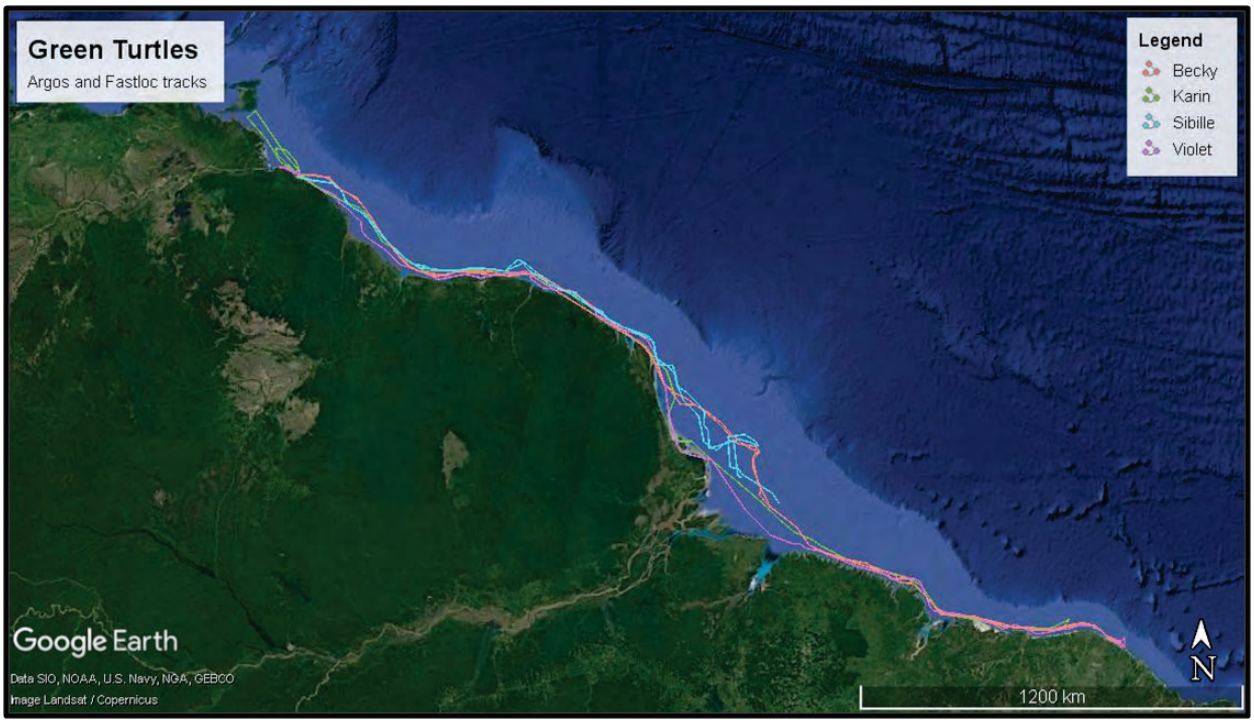
Time-series information was useful for visualizing vertical movements and identifying re-nesting events for animals that (with little exception) displayed complicated horizontal movements. Lower temperatures occurred during deeper dives, while the highest temperatures typically occurred during periods when the animals were hauled-out on land to nest (Figures 11B, 12B, and 13B), but occasionally also when they hit warm water masses (see Figure 12B and below). Similarly, the 100 percent dry times coincided with zero-depths and changes in temperature (Figures 11, 12, and 13). Karin's discrete re-nesting periods were readily visible when looking at these time-series graphs together (Figure 12), for example, even though they were less obvious in the horizontal movement data.

Migration Period

The study was able to capture the onset of (N = 1), partial (N = 4), or complete (N = 3) migration of turtles from the Shell Beach nesting site to their foraging grounds for all turtles in this study. These movements were characterized by a consistent heading and an increase in movement rates. All the green turtles in this study headed southeast to Brazil, following a near-shore corridor across an average distance of 2,485 +/- 526 kilometers (mean +/- 1 SD) (Figure 22, Table 3). All the leatherback turtles initially headed directly out to sea in a northeasterly direction (Figure 23, Table 3). However, the tracking durations once they left the nesting beach were

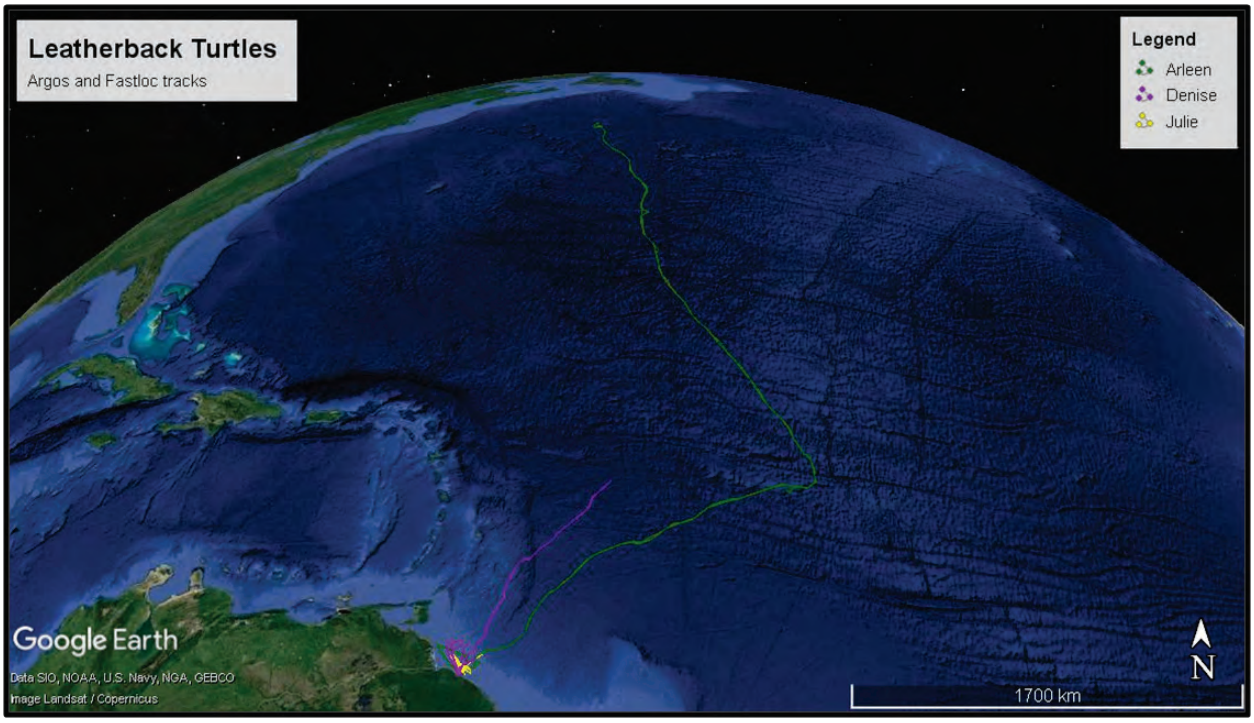
highly dissimilar and none of the leatherbacks had definitively arrived at their foraging grounds (which would have been indicated by a change in movement parameters) before their transmissions ceased. Both green and leatherback turtles used deeper waters during their migration period as compared to water depths used in other tracking periods ($F_{2,575} = 39.625$, $p < 0.001$; $F_{1,187} = 755.040$, $p < 0.001$, respectively), and leatherbacks used significantly deeper waters than green turtles, the latter remaining on the continental shelf ($F_{1,765} = 764.6$, $p < 0.001$) (Figures 9 and 10).

FIGURE 22: MIGRATION ROUTES OF GREEN TURTLES TRACKED FROM SHELL BEACH



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc® location data. In most cases the difference is unapparent.

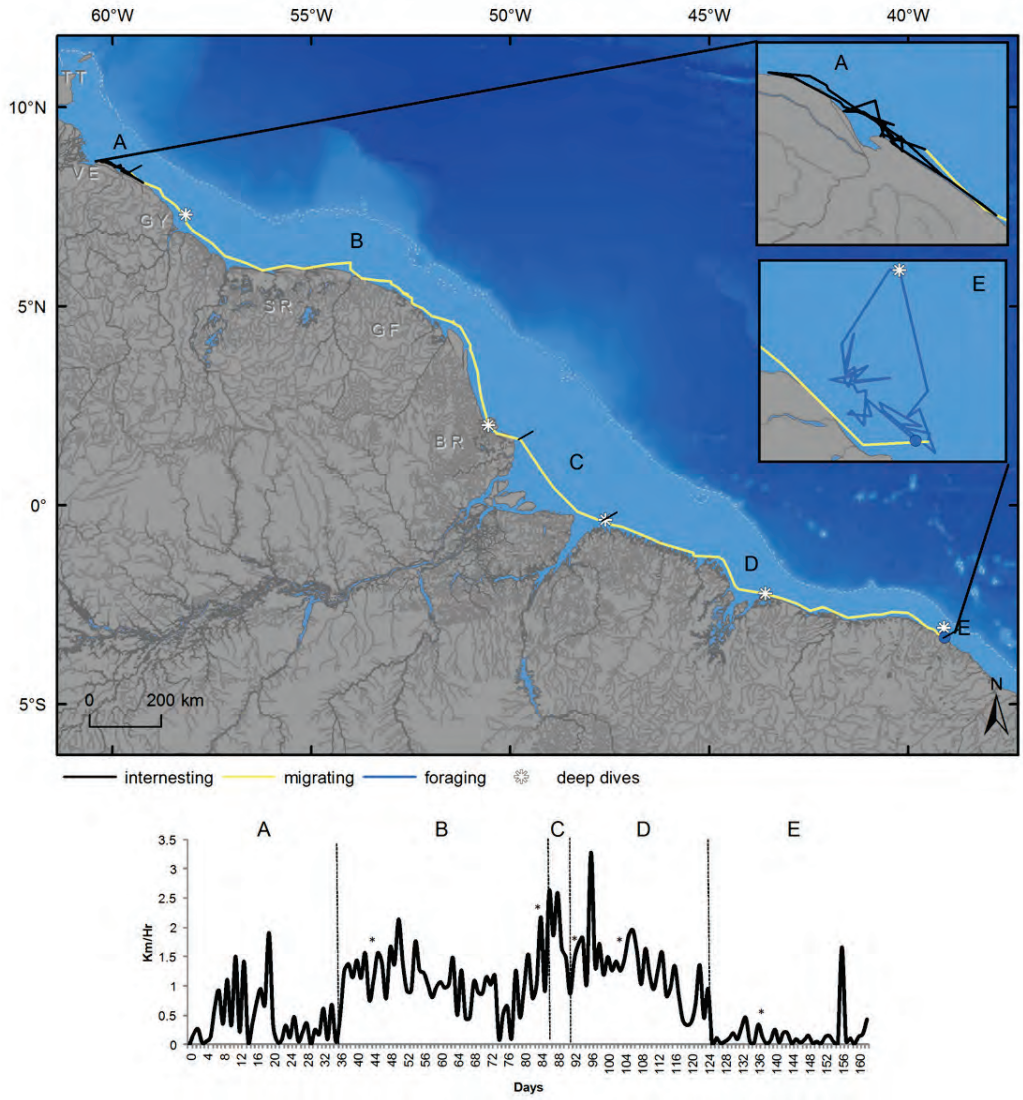
FIGURE 23: MIGRATION ROUTES OF LEATHERBACK TURTLES TRACKED FROM SHELL BEACH



Where double lines appear for a given turtle, this indicates deviations between the tracks derived from Argos and Fastloc® location data. In most cases the difference is unapparent.

Violet was the first green turtle to start her migration, on 28 April 2018, and took the longest to complete it (91 days; Table 3). Figure 24 shows the different behavioral periods of Violet's journey and the associated changes in speed. It appears that Violet's deepest dives occurred in the vicinity of (prior to or after crossing) major river mouths (i.e., the Essequibo River, Guyana; the Amazon and Pará rivers and the Mearima River/Arraial Bay, Brazil) (Figures 11A and 24), which may be an energetic strategy to avoid turbulence and current flows associated with these rivers. The turtle's speed steadily increased as it crossed into Brazil, passed inshore of Maracá Island, and traversed the mouths of the Amazon and Pará rivers (17 to 25 June 2018), and showed a brief spike at the mouth of the Mearima River, after which it declined. Although there are gaps in the time-series data, it appears that Violet rested at the surface on several occasions during her migration, but particularly during her crossing of the Amazon River between deep dives on either side (Figures 11A, 11C, and 24). The dive data indicated that Violet spent most of her time in the upper 10 meters of the water column and never went deeper than 60 meters (Figure 14A). More than 80 percent of her dives were less than 10 meters and all dives lasted under 1.6 hours with most being less than 20 minutes in duration (Figures 14B and 14C).

FIGURE 24: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR VIOLET, BY BEHAVIORAL INTERVALS

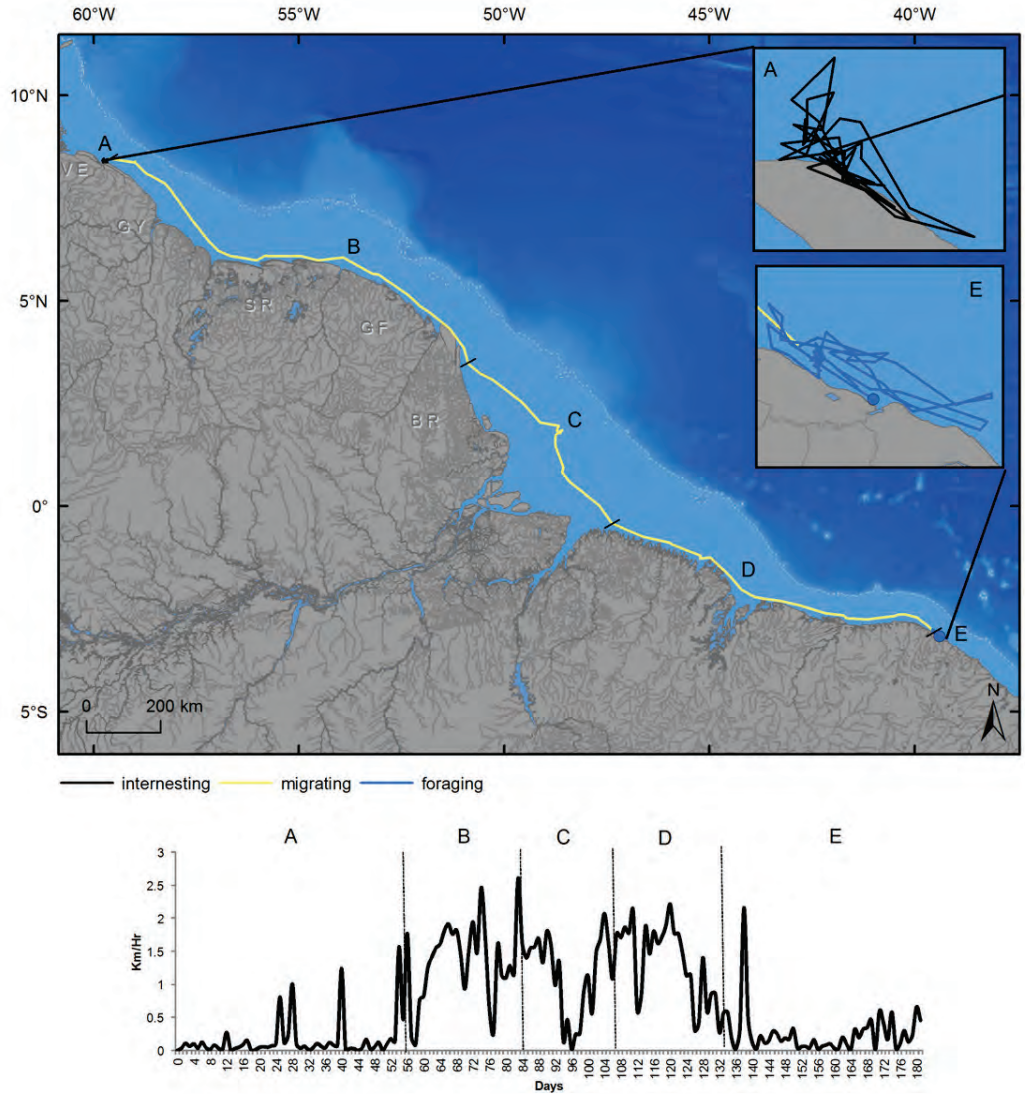


Approximate locations of deep dives are marked with an *. Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset boxes are a closer-up version of the inter-nesting and foraging areas.

Becky was the next green turtle to migrate from Shell Beach, beginning on 17 May 2018. She took 78 days to cover the distance between nesting and foraging sites (Table 3). As with the other green turtles, her journey was marked by changes in movement speeds, but these were even more marked than those of the other green turtles, with peaks and valleys that were likely related to changing currents encountered during her migration. There was a dip in movement rates just prior to her crossing from French Guiana into Brazil, and again prior to her crossing the Mearima River (Brazil) (Figure 25). She started her crossing of the Amazon and Pará river mouths just one day after Violet, but differed in that she moved directly across so that she was farther offshore and took longer to transit (18 June to 9 July 2018; Figures 22 and 25). As a result, she was farther away from the river plume, but closer to the edge of the swift-moving

North Brazil western boundary current. Becky's movement rates plummeted mid-crossing. There were no dive data associated with this tag to determine if she navigated this zone at depth or near the surface.

FIGURE 25: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR BECKY, BY BEHAVIORAL INTERVALS

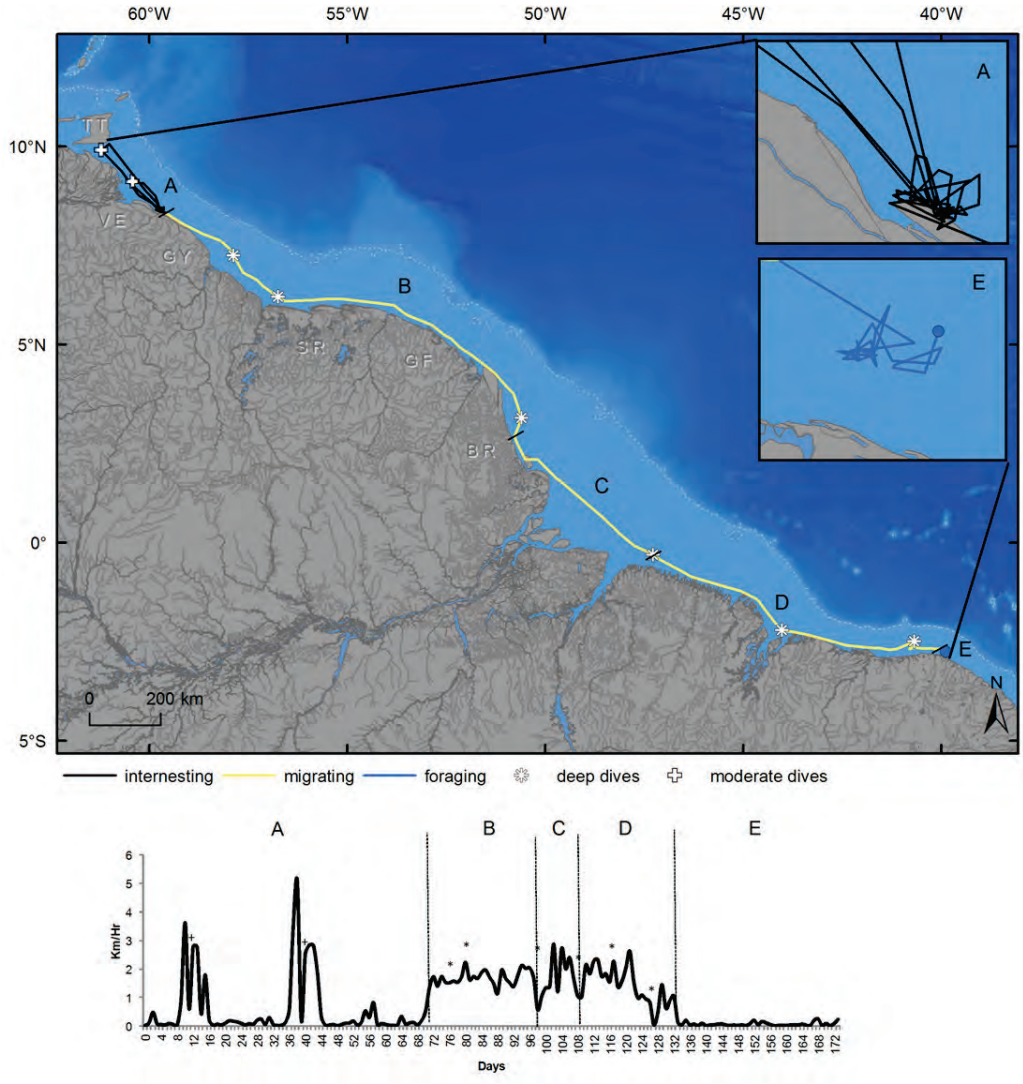


Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset boxes are a closer-up version of the inter-nesting and foraging areas.

Karin was the next green turtle to migrate, leaving Shell Beach on 2 June 2018, and making the fastest time in only 62 days (Table 3). Her journey and behavior is nearly identical to Violet's: she made deep dives before or after major river mouths (i.e., the Essequibo River, Guyana; the Corentyne River, Suriname; the Amazon and Pará rivers, the Mearima River/Arraial Bay, and the Parnaíba River, Brazil), and her speed increased as she crossed the Amazon and Pará river-mouths, then steadily declined (Figures 12A and 26). However, she crossed later than the

other turtles (30 June to 11 July 2018) and although she took the near-shore route, she traveled offshore of Maracá Island. Analogous to Violet's dive profiles, Karin demonstrated resting periods at the surface during and after the Amazon River crossing, as well as spikes in temperature of surface waters prior to entering and exiting the crossing, which may delineate the different water masses within the plume (Figures 12A, 12B, and 12C). Karin's dive record indicates that she spent most time in the upper 10 meters of the water column, never going deeper than 40 meters, and more than 80 percent of her dives were less than 10 meters (Figures 15A and 15B). All her dives were less than 2 hours in duration and most were less than 20 minutes (Figure 15C).

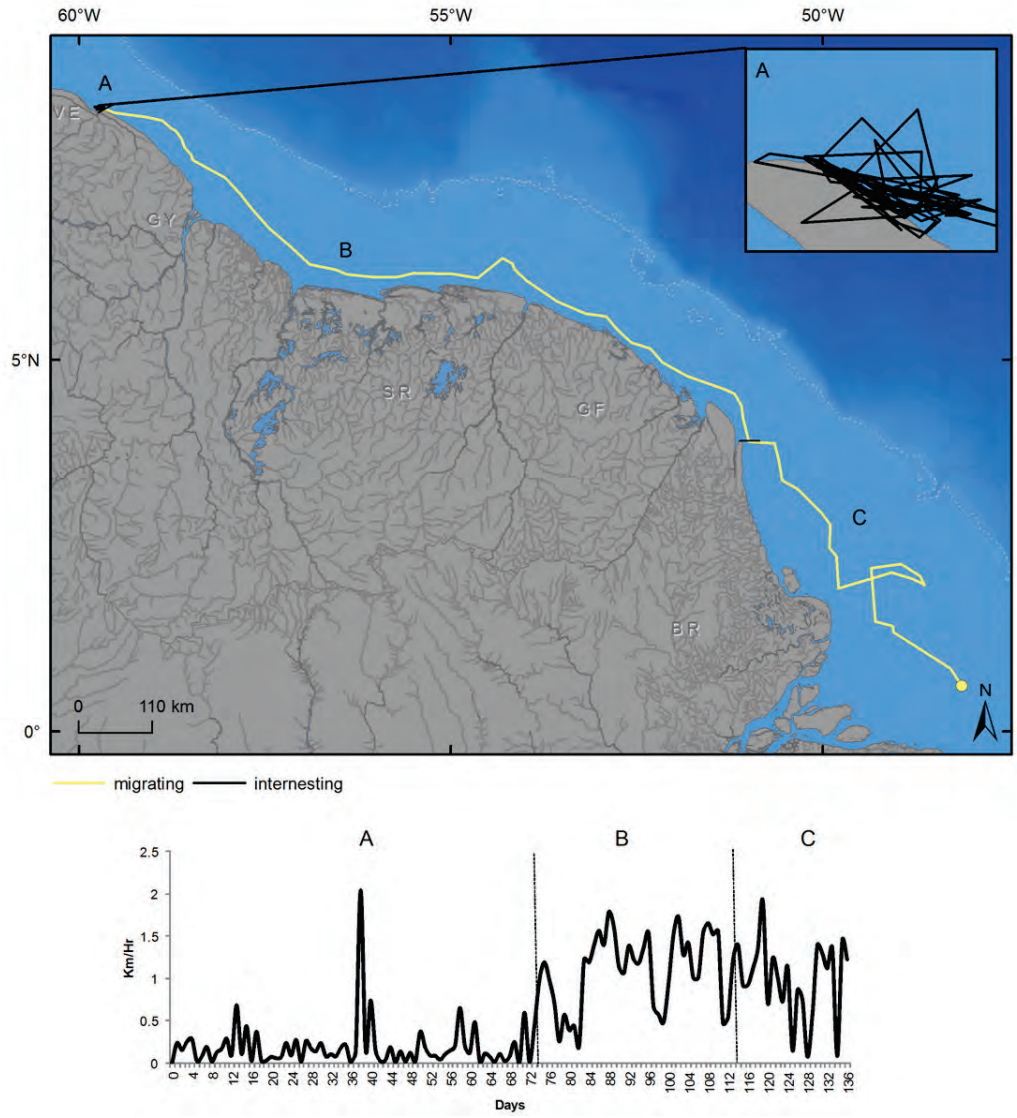
FIGURE 26: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR KARIN, BY BEHAVIORAL INTERVALS



Approximate locations of deep dives are marked with an *. Note the moderately deep dives occurring during the inter-nesting period are marked with a + and occurred at the outer limits of the two furthest inter-nesting loops and were flanked in peak movement rates. Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset boxes are a closer-up version of the inter-nesting and foraging areas.

Sibille was the last green turtle to leave the nesting beach, on 3 June 2018. She was tracked for 69 days during her migration to the foraging grounds, but her transmissions stopped before arriving (Table 3). Her route and movement characteristics were very similar to Becky's, with troughs and peaks in movement rates as she crossed into Brazil (Figure 27). On 28 July 18, Sibille also began crossing the Amazon farther offshore, but she veered inland and then turned back offshore, making a loop that was coincident with dips in the movement speed mid-way through. She continued on a straight course to the other shoreline, but transmissions ceased just as she was approaching the Pará River mouth. There were no dive data associated with this tag.

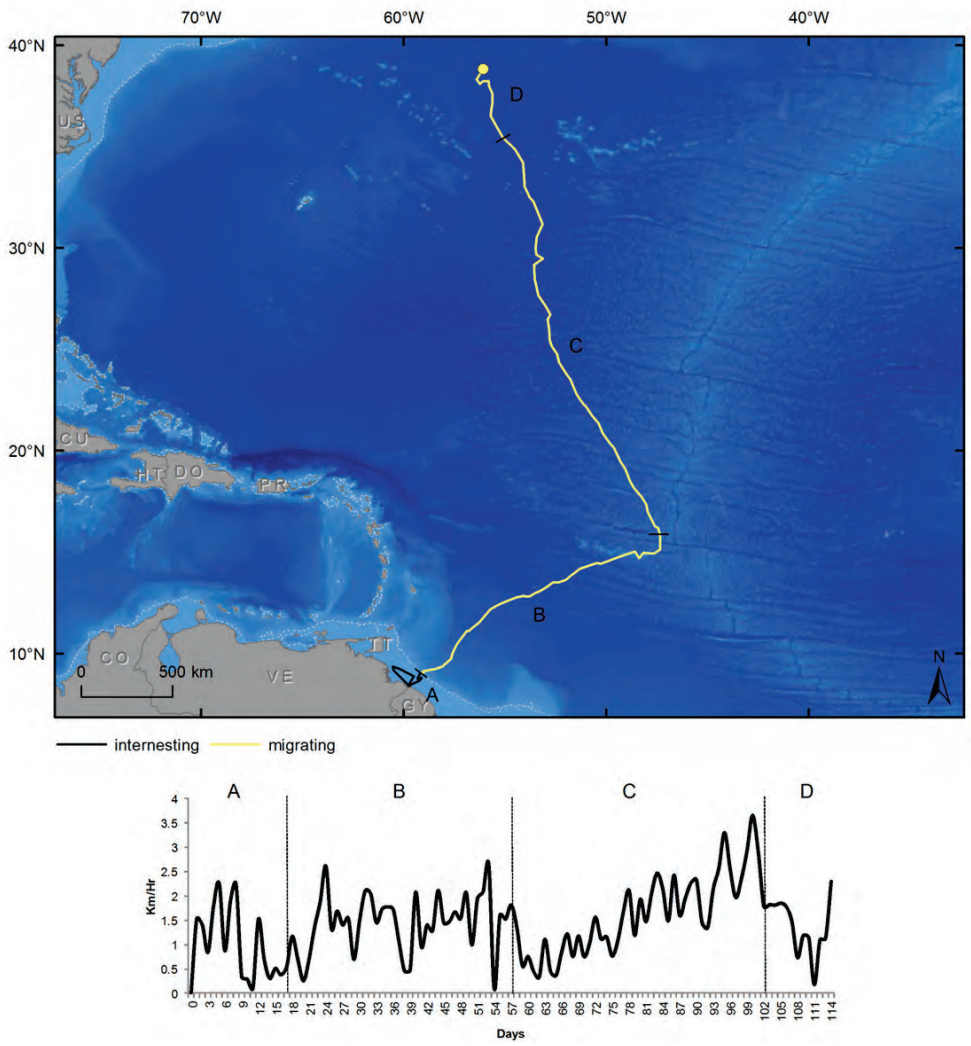
FIGURE 27: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR SIBILLE, BY BEHAVIORAL INTERVALS



Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph. The inset box is a closer-up version of the inter-nesting area.

The first leatherback to start her migration was Arleen. She left Shell Beach on 1 July 2018 and traveled for 96 days into the North Atlantic, covering a remarkable distance of 4,634 kilometers before her transmissions ceased (Figure 28, Table 3). Her migration path was divided into three behavioral intervals (movement rate and directional phases) (Figure 28). In interval B, she moved offshore to the northeast until reaching the Mid-Atlantic Ridge, after which she headed north-northwest (interval C), gradually gaining speed within the Sargasso Sea until she passed between the Corner Rise and New England Seamounts where her progress slowed (interval D). It appeared as though she was heading for the Laurentian Channel when her tag stopped transmitting. Canadian waters off Nova Scotia, Cape Breton, and Newfoundland have been previously described as critical foraging habitat for leatherback turtles (James et al. 2005, 2006) and indeed capture studies in this area have previously confirmed flipper tag recoveries from the Guianas (James et al. 2007).

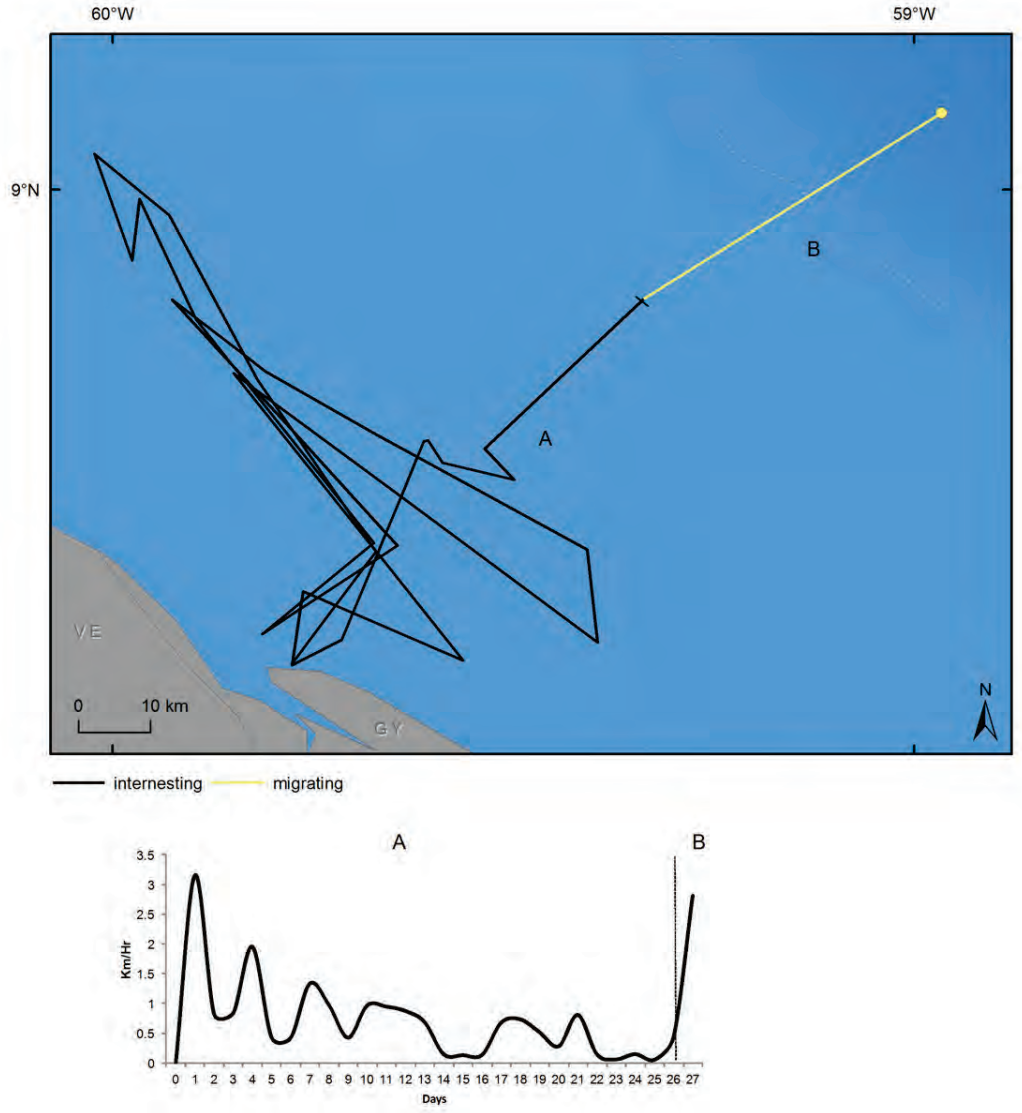
FIGURE 28: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR ARLEEN, BY BEHAVIORAL INTERVALS



Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph.

Julie was the second leatherback to leave the nesting beach, on 10 July 2018 (Table 3). Unfortunately, she ceased transmitting one day later, just as her movement rates increased (Figure 29).

FIGURE 29: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR JULIE, BY BEHAVIORAL INTERVALS

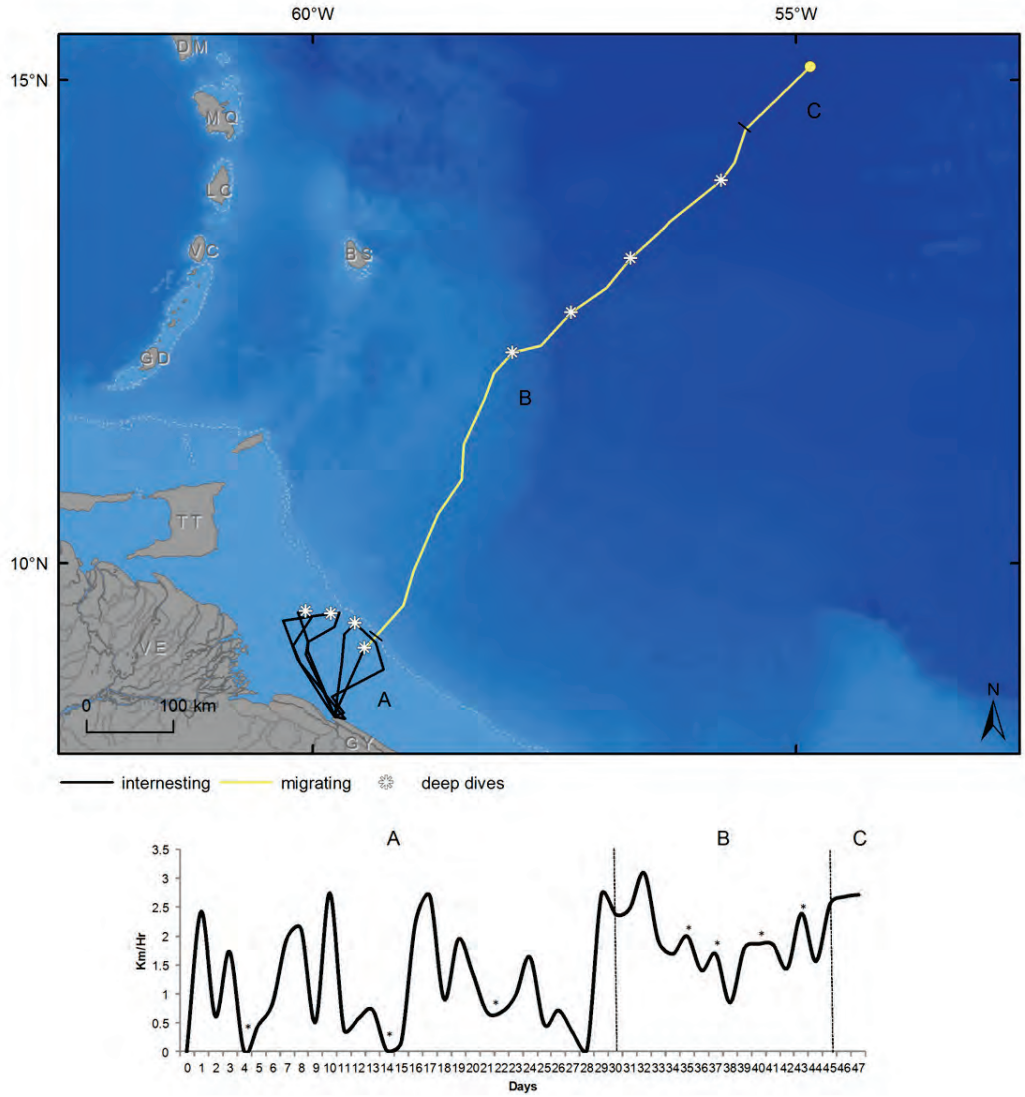


Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph.

Denise was the final turtle to leave Shell Beach during this study. She began migrating on 14 July 2018 and continued transmitting for 26 days, maintaining a northeasterly course offshore of Guyana (Figure 30, Table 3). A week after she began migrating, she started making deep dives every two or three days (Figure 30), the deepest of which (560.5 meters) was the day before her last transmission - where she was in water depths exceeding 5,000 meters (Figures 10 and 13A). Denise spent most of the time in the upper 20 meters of the water

column, making more than 75 percent of her dives within 50 meters and making few dives greater than 100 meters (Figures 16A and 16B). All of her dives were less than 1 hour in duration and most were less than 30 minutes (Figure 16C)

FIGURE 30: MAP OF THE RECONSTRUCTED MOVEMENT TRACK FOR DENISE, BY BEHAVIORAL INTERVALS



Approximate locations of deep dives are marked with an *. Note that deep dives also occurred during the inter-nesting period at the outer limits of the inter-nesting loops and were flanked in peak movement rates just like the green turtle, Karin. Changes in movement rates plotted below the map indicate behavioral intervals along the movement track and are denoted with letters in both the map and graph.

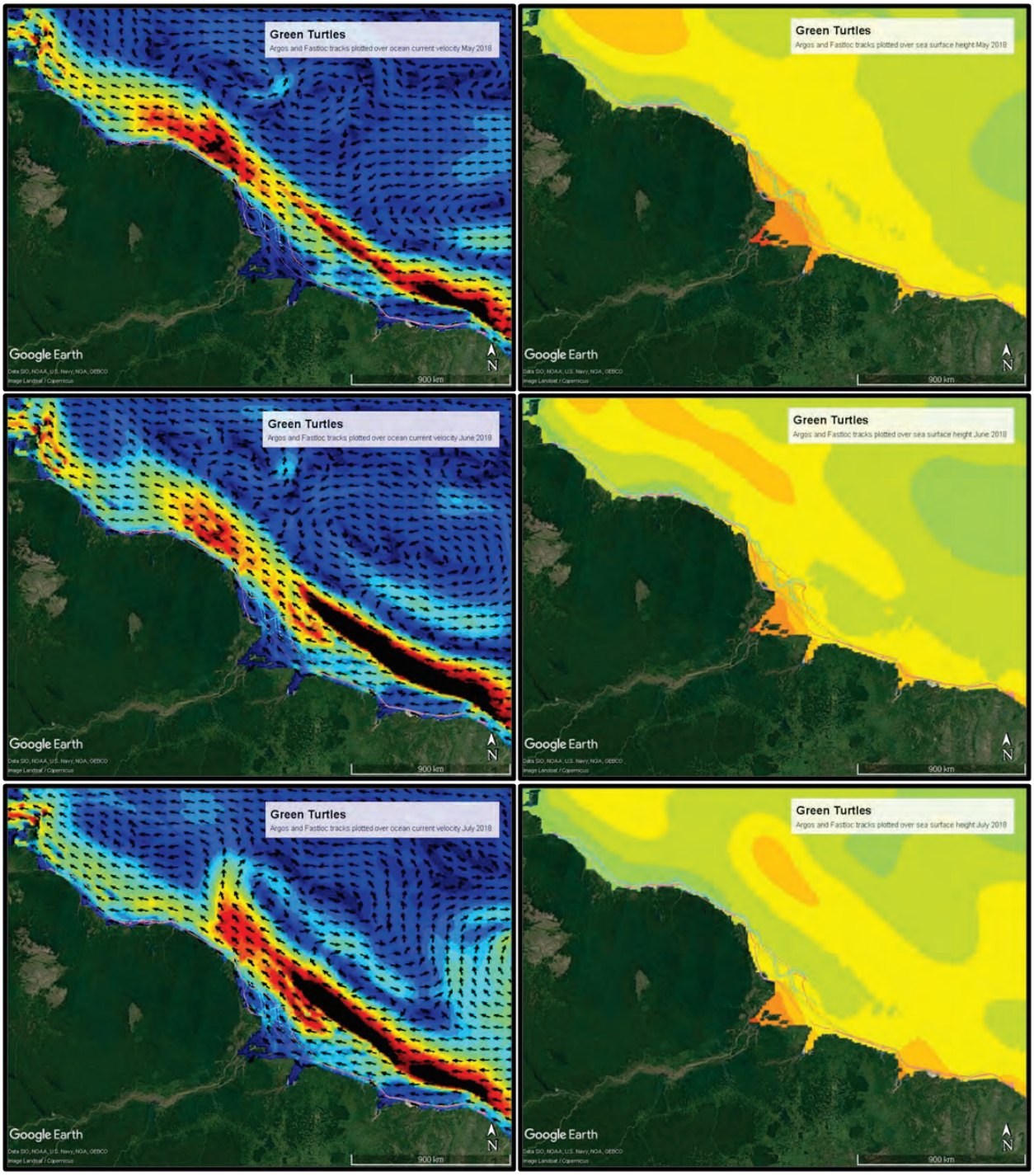
A key consideration in the analysis of tracking marine species is the effect that oceanography plays in their movements. Both green and leatherback turtles are strong swimmers, with specific habitat requirements related to physiology and foraging behaviors. Adult green turtles are neritic[11] and typically remain within the continental shelf (i.e., 200 meters) of the tropics and Equator unless they are migrating from oceanic islands to the mainland, as is the case for Ascension Island turtles (Hays et al 2003). Leatherback turtles are generally oceanic and may cross entire ocean basins between nesting grounds in tropical waters and their foraging grounds in the temperate and subarctic waters. They are also deep diving specialists that can behaviorally—and physiologically—regulate environmental conditions.

To examine the influence of ocean currents on their movements, the turtles' tracks were overlaid on monthly-averaged geostrophic current imagery, which included SSH and velocity. The North Brazil Current and the Guiana Current are regional components of the South Equatorial Current near shore, forming strong northward flow along the South America coastline that can be seen in satellite altimetry data. This is counter-directional to the movements of the green turtle migrations. Similarly, the North Atlantic Gyre is readily visible as a mound in the SSH data and Northern Equatorial and Gulf Stream Currents in the velocity data, which leatherback turtles would have to cross in order to migrate to northern foraging zones. In each case, there is the potential for large energetic costs during migration.

Superimposing the green turtle migrations on the altimetry data suggests that the turtles remain in a very narrow band close to the shore, where current magnitudes are relatively low and where SSHs are lowest, except around the major river mouths in Brazil - where SSH is elevated (Figure 31). This effect was strongest and most extensive in May and weakened in June and July when the turtles crossed these zones. Baudouin et al. (2015) illustrated this narrow migratory corridor for post-nesting green turtles traveling from Suriname and French Guiana to Brazil. Similarly, Chambault et al. (2015) described the Amazon River plume as most turbulent in the upper surface layers and suggested that a strategy of short, deep dives would help green turtles that are migrating south to avoid the energetic costs of navigating those forces. Their study found the same two spatial patterns used by green turtles crossing the Amazon River that this study has, either close to shore or farther offshore, and suggested that animals that crossed farther offshore would initiate foraging sooner than those that crossed near to shore. These scenarios, with respect to depth or distance to foraging site, were not found to be the case within the small sample size of this study.

[11] Relating to the shallow part of the sea near the coast and overlying the continental shelf.

FIGURE 31: OVERLAY OF GREEN TURTLE MIGRATION TRACKS AND ALTIMETRY DATA



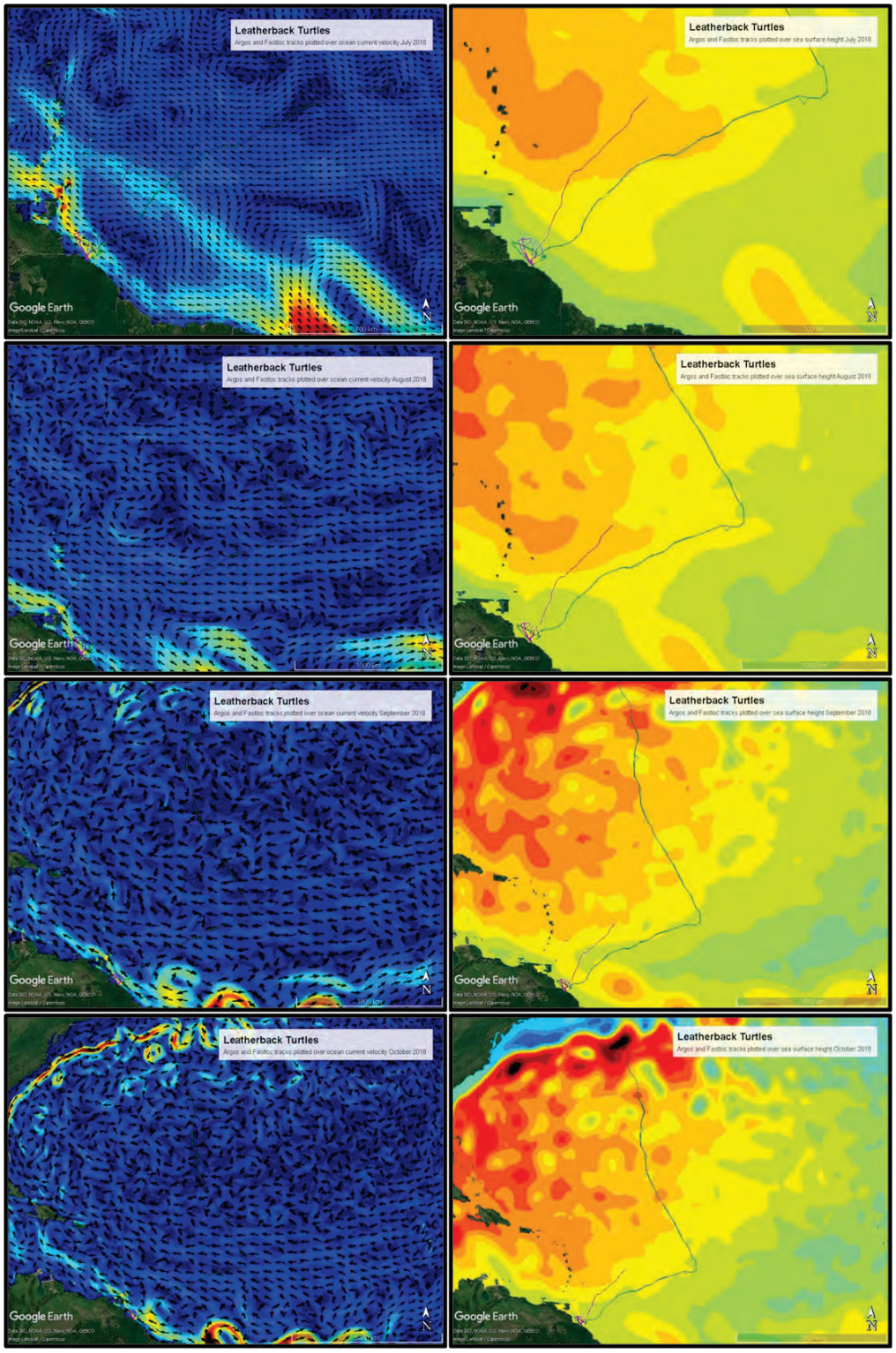
Combined green turtle migration tracks, superimposed over mean-monthly ocean altimetry data, where geostrophic current vectors are displayed in the left hand panels and SSH is displayed in the right hand panels for May through July 2018 (top to bottom). Warmer colors indicate higher magnitude or height, respectively.

Leatherback turtles initiated migrations in early to mid-July, when altimetry indicated onshore movement of the Guiana Current near Shell Beach and a large divergent zone forming approximately 200 kilometers offshore (Figure 32). The slightly spatially and temporally offset, but nearly identical, tracks of Arleen and Denise indicated that they may have been traveling along the edge of a convergent zone. Leatherbacks have been documented to maintain remarkably consistent headings traveling through the North Atlantic subtropical gyre, with negligible drift associated with ocean currents (Dodge et al. 2015). Arleen showed similar consistency and essentially swam “uphill” into the North Atlantic toward Canada. It is interesting to note that she stopped transmitting just as she headed into the meandering Gulf Stream Current at a point of strong convergence. It is possible that the forces created by strong western boundary currents and pressure forces experienced in leatherback deep dives were too great for the lanyard attachments of the satellite transmitters.

Foraging Period

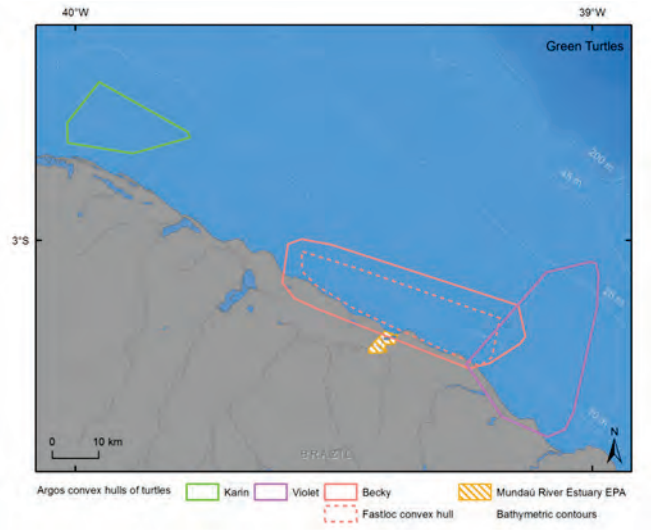
Three green turtles in this study were tracked to their ultimate destination, the foraging grounds in the State of Ceará, Brazil. This region was first described as a green turtle foraging area by Pritchard in 1976 based on tag returns of turtles from the Guianas. Since that time, molecular techniques and satellite tracking have provided further evidence supporting a well-established, mixed-stock foraging aggregation of green turtles at Almofala, Brazil (Nario-Maciel et al. 2007, Godley et al. 2003), which attracts animals from Ascension Island and the lower Caribbean. As far as is known by the authors of this report, no satellite tagging study has been published documenting the foraging grounds of green turtles from Guyana. The turtles in this study did indeed settle into the vicinity of Almofala, Brazil and were tracked for an average of 43 +/- 6.2 days (mean +/- 1 SD) (Figures 24, 25, and 26, Table 3). Two of the three turtles overlapped geographically in area, adjacent to the Mundaú River Estuary Environmental Protection Area (Figure 33). The three green turtles displayed similar habitat use (area) and movements (dispersal from foraging centroid) among individuals and their locations were at similar distances from shore as during the inter-nesting period (Figure 5). For all individuals except Karin, turtles used slightly deeper water depths than during the inter-nesting period (7.9 +/- 6.7 m [mean +/- 1 SD]) (Figure 9). The coastline between the Orinoco River in Venezuela and the Amazon River in Brazil is one of the world's muddiest due to high suspended-sediment discharge from the Amazon River being transported westward along shore as mud banks (Anthony et al. 2010). The region to the east is therefore the nearest habitat permitting the growth of seagrass, the primary food source for green turtles, which requires adequate light transmission to grow (Short et al. 2007).

FIGURE 32: OVERLAY OF LEATHERBACK TURTLE MIGRATION TRACKS AND ALTIMETRY DATA



Combined green turtle migration tracks, superimposed over mean-monthly ocean altimetry data, where geostrophic current vectors are displayed in the left hand panels and SSH are displayed in the right hand panels for July through October 2018 (top to bottom). Warmer colors indicate higher magnitude or height, respectively

FIGURE 33: SPATIAL FOOTPRINTS OF FORAGING GREEN TURTLES NEAR ALMOFALA, BRAZIL



CONCLUSION

The results of this study provided a wealth of new information about Guyana's nesting sea turtles. Although sample sizes were small, they provided the first look into the at-sea behaviors of green and leatherback turtles in this region. Shell Beach is an important yet under-described nesting area for green and leatherback sea turtles that migrate to disparate foraging grounds in Brazil and Canada, respectively. The study shows that turtles may remain in the inter-nesting zone for one to more than three months, venturing northwest into the territorial seas of Venezuela and Trinidad, laying multiple clutches of eggs, and displaying strong site fidelity. During this period, turtles remained primarily in the upper 10 meters of the water column near to shore, but made occasional forays within the continental shelf between nests. After nesting, green turtles followed a narrow migration corridor along the coastline, avoiding the effects of the opposing Guiana and North Brazil western boundary currents. Leatherback turtles dispersed into the high seas after nesting, taking an initial northeasterly course.

Transmitter life was the primary limitation in this study; while significant efforts were made to maximize tag retention and life (as well as data quality and quantity), it is hypothesized that preparing all tags with a coat of high quality anti-fouling product prior to future deployments may help preserve tags' structural integrity and extend transmitter life.

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APPENDIX S

List of Marine Fishes in Guyana

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Scientific Name
Acanthostracion quadricornis
Acanthurus hepatus
Achirus achirus
Albula vulpes
Alutera monoceros
Alutera schoepfi
Alutera ventralis
Amphiarius phrygiatus
Amphiarius rugispinis
Anableps anableps
Anchoa spinifer
Anchovia clupeoides
Anchovia surinamensis
Anchoviella lepidentostole
Anisotremus virginicus
Antennarius scaber
Antigonia capros
Apionichthys dumerili
Archosargus rhomboidalis
Aspistor quadriscutis
Aspredinichthys filamentosus
Aspredo aspredo
Bagre bagre
Bagre marinus
Bairdiella ronchus
Balistes capriscus
Balistes carolinensis
Balistes vetula
Bathystoma aurolineatum
Bathystoma rimator
Bathystoma striatum
Batrachoides surinamensis
Brachyplatystoma filamentosum
Brachyplatystoma vaillantii
Bellator militaris
Brachyplatystoma vaillantii
Calamus pennatula
Calamus proridens
Carcharhinus brevipinna
Caulolatilus guppyi
Chaetodon bimaculatus
Carcharhinus acronatus
Cathorops arenatus
Cathorops melanopus
Cathorops spixii
Centropomus ensiferus
Centropomus pectinatus
Centropomus unidecimalis
Chaetodon ocellatus
Chaetodipterus faber
Chilomycterus antillarum
Chloroscombrus chrysurus

Scientific Name
Coloconger meadi
Colomesus psitacus
Conodon nobilis
Coryphaena hippurus
Ctenosciaena gracilicirrhus
Cyclopsetta fimbriata
Cynoponticus savanna
Cynoscion acoupa
Cynoscion arenarius
Cynoscion jamaicensis
Cynoscion nothus
Cynoscion similis
Cynoscion steindachneri
Cynoscion virescens
Dactylopterus volitans
Decapterus punctatus
Decapturus macarellus
Diapterus rhombeus
Diplectrum formosum
Diplectrum radiale
Echeneis naucrates
Elops saurus
Eqeus lanceolatus
Eucinostomus gula
Fistularia petimba
Fontitrygon geijskesi
Genyatremus luteus
Gymnothorax ocellatus
Gymnura micrura
Haemulon carbonarium
Haemulon melanurum
Haemulon sciurus
Haemulon steindachneri
Halieutichthys aculeatus
Harengula clupeola
Harengula jaguana
Hippocampus longirostris
Holocanthus tricolor
Holocentrus ascensionis
Holocentrus bullisi
Hoplias malabaricus
Hypanus guttatus
Hypopthalmus edentatus
Hypostomus plecostomus
Lactophrys tricornis
Lagocephalus laevigatus
Larimus breviceps
Lobotes surinamensis
Lonchurus elegans
Lonchurus lanceolatus
Lutjanus analis
Lutjanus aya

Scientific Name
Lutjanus purpureus
Lutjanus synagris
Lycengraulis batesii
Lycengraulis grossidens
Macrodon anciclos
Macrodon ancylodon
Micropogonias furnieri
Monocanthus ciliatus
Monocanthus hispidus
Mugil curema
Mugil incilis
Mugil liza
Mustelus higmani
Myliobatis goodie
Myxine c.f. robinsorum
Nebris microps
Nematopalaemon schmitti
Odontognathus mucronatus
Ogocephalus vespertilio
Opisthonema oglinum
Orthopristis ruber
Paralonchurus brasiliensis
Pareques acuminatus
Peprilus paru
Pimelodus blochii
Plagioscion squamosissimus
Plagioscion surinamensis
Polydactylus oligodon
Polydactylus virginicus
Pomacanthus arcuatus
Pomacanthus paru
Priacanthus arenatus
Prionodes phoebe
Prionotus beanii
Prionotus punctatus
Pristipomoides aquilonaris
Pseudauchenipterus nodosus
Pseudobatos percellens
Pterengraulis atherinoides
Pterois lunulata
Pterois volitans
Rachycentron canadum
Remora brachyptera
Rhinobatos percellens
Rhinoptera bonasus
Rhomboplites aurorubens
Saurida normani
Sciades couma
Sciades herzbergii
Sciades parkeri
Sciades passany
Sciades proops

Scientific Name
Scoliodon terrae-novae
Scomberomorus brasiliensis
Scomberomorus cavalla
Scorpaena agassizii
Scorpaena brasiliensis
Scorpaena plumieri
Selar crumenophthalmus
Selene setapinnis
Selene vomer
Spariosoma aqualidum
Sphoeroides dorsalis
Sphoeroides marmoratus
Sphoeroides testudineus
Sphyraena guachancho
Stellifer brasilensis
Stellifer chaoi
Stellifer microps
Stellifer rastrifer
Syacium papillosum
Symphurus plagusia
Symphurus tessellatus
Synodus foetens
Synodus intermedius
Synodus poeyi
Trachinocephalus myops
Trachinotus carolinus
Trachinotus cayennensis
Trachurus lathami
Upeneus maculatus
Trichiurus lepturus
Trinectes paulistanus
Upeneus parvus

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APPENDIX T

Participatory Fishing Survey Quarterly Report

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Esso Exploration and Production Guyana Limited

Participatory Fishing Study Quarterly Report

First Quarter 2019

June 2019

Project No.: 0491147

The business of sustainability

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Signature Page

June 2019

Participatory Fishing Study Quarterly Report

First Quarter 2019



Todd Hall
Partner



Shyam Nokta
Principal

ERM Guyana, Inc.
210 New Market Street,
Georgetown, Guyana

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ACRONYMS AND ABBREVIATIONS

Name	Description
EEPGL	Esso Exploration and Production Guyana Limited
EIA	Environmental Impact Assessment
EMC	Environmental Management Consultants
EPA	Guyana Environmental Protection Agency
ERM	Environmental Resources Management
GPS	Global Positioning System
GYD	Guyana Dollars
hp	horsepower
IUCN	International Union for Conservation of Nature
LC	Least Concern
NT	Near Threatened
PFS	Participatory Fishing Study
USD	U.S Dollars
RMBB	Riverview Mahaica Boat—Bangamary
RMBS	Riverview Mahaica Boat—Snapper
VU	Vulnerable

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1. INTRODUCTION

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorisation for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On 1 June 2017, the Guyana EPA approved the Environmental Impact Assessment (EIA) submitted as part of the Application for Environmental Authorisation and issued an Environmental Permit for the Phase 1 Development Project. As a condition of the Environmental Permit, the EPA required EEPGL to "conduct fishery-dependent studies in the nearshore zone augmented by fishery-independent studies in the nearshore and offshore zones...to develop a more complete understanding of the marine fish community outside the Liza Area of Interest." EEPGL complied with this requirement by conducting a year-long fish study, the first year of which was completed in 2018. To supplement the fishery-dependent information collected during the first year of study, EEPGL determined that a program focused primarily on engagement with the fishing community would be another beneficial approach to collecting baseline data.

EEPGL contracted with Environmental Resources Management (ERM) who has partnered with the local Guyanese firm Environmental Management Consultants (EMC) to collaboratively execute a Participatory Fishing Study (PFS) to characterize the nektonic community (with a focus on fisheries) and map the principal local fisheries activities offshore Guyana. The PFS is being executed by engaging with local fisherfolk who have agreed to participate on a volunteer basis (with a small stipend being offered to cover any expenses) and to provide data on their catch. The PFS has three primary components:

1. **Coastal Landing Site Assessment:** This component (referred to herein as Component 1) focuses on data and photos taken of overall daily catch and catch characteristics (number of species, sizes, weights, etc.) at various coastal landing sites. Six regional supervisors from different landing sites in all six of the coastal regions who also have experience in the area and knowledge of native species are participating in the study.
2. **Local Artisanal Fishing Activities Assessment:** This component (referred to herein as Component 2) focuses on data, Global Positioning System (GPS) information and photos of individual artisanal fishing activities, including daily catch, catch characteristics (number of species, sizes, weights, etc.), and routes to preferred fishing zones. Two onboard supervisors at different landing sites across all six coastal regions are participating in the study.
3. **Industrial Fishing Activity Assessment**: This component (referred to herein as Component 3) focuses on engagement and interviews with industrial fishing entities to gather information about their commercial catch.

This first quarterly report describes the progress in initiating and implementing Components 1 and 2 over the period from 31 January to 6 May 2019. It provides the initial findings of the first baseline data collection effort, which was conducted in January and February 2019 in conjunction with Year 2 of a Nearshore and Offshore Fisheries Study being conducted by ERM. The report also covers subsequent field efforts focused on identifying suitable regional and onboard supervisors, training the supervisors in properly utilizing the data sheets and related equipment (GPS and cameras), and commencing data collection. Preliminary analysis of data collected by the regional supervisors and one of the onboard supervisors in Region 4 is also included. It is anticipated that since the program is now fully operational and data is being collected across all six regions, the second Quarterly Report will provide a more thorough data analysis.

2. APPROACH

2.1 Selection of Landing Sites

The initial step in planning the PFS was the selection of landing sites. This selection process was informed by data collected on 20 landing sites evaluated in Year 1 of the Nearshore and Offshore Fisheries Study conducted by ERM in 2017 and 2018 (ERM 2018a), 98 landing sites visited during the Liza Phase 1 Ecosystem Services Study (ERM/EMC 2018), and the familiarity of the project team with other landing sites. The goal of the selection process was to ensure that landing sites included in the PFS constituted a representative sample of the fisheries activities in the six coastal regions based on the following key criteria:

- Gear type and vessels;
- Approximate number of vessels that utilize the landing site;
- Approximate duration of fishing trips by vessels at the site (daily versus weekly trips);
- Relevance of the site to any existing or future onshore activities; and
- Presence of active fisherfolk cooperatives/associations at the landing site.

By applying these criteria, 16 unique landing sites across Regions 1 to 6 were selected for Components 1 and/or 2 of the PFS, as shown in Table 1. A full justifiction for the selection of these landing sites is included in Attachement A, Justification of Selection of Landing Site for Components 1 and 2.

Table 1: Landing Sites Selected in Regions 1–6

Landing Sites Selected for Component 1	Landing Sites Selected for Component 2
Region 1—Smith's Creek	Region 1—Smith's Creek; Waramuri/Haimacobra
Region 2—Charity	Region 2—Lima; Hampton Court
Region 3—Zeeburg	Region 3—La Grange; Windsor Forest
Region 4—Riverview (Unity, Mahaica)	Region 4—Riverview (Unity, Mahaica); Ogle
Region 5—Mahaicony	Region 5—Rosignol; Bushlot
Region 6—Rose Hall	Region 6—Complex 66; Albion

2.2 Development of Assessment Protocol

The questionnaire/data sheet used in Year 1 of the Nearshore and Offshore Fisheries Study (2017–2018) (ERM 2018a) was adapted for the PFS to capture not only biological data but also socioeconomic aspects of fishery-related activities. Questions were also added to the data sheet regarding sightings of juvenile turtles to help inform other marine studies. A copy of the Data Sheet used for the PFS is provided in Attachement B, Copy of Data Sheet.

2.3 Initial Data Collection

The team first conducted a scouting exercise to seek advice from locals on the best time of day to meet fisherfolk at the landing sites. If fisherfolk were not present at the site during the scouting exercise, the team returned at more opportune times. The EMC team then worked jointly with the ERM Fisheries Study team from 31 January to 9 February 2019 in Regions 2 to 6 to collect the initial round of data through engagement. This happened in conjunction with ERM's efforts to collect biometric data as part of the Fisheries Study. A total of 71 one-on-one interviews were conducted at 14 visited landing sites. At this time, recommendations were also received from fisherfolk on individuals who could be considered as supervisors at landing sites in Region 2, 3, and 4.

2.4 Identification of Participants

EMC conducted the second field exercise between 12 and 28 March 2019 in Regions 2 to 6. The objective of this exercise was to identify appropriate individuals to volunteer as regional and onboard supervisors and thereafter introduce them to the PFS and their roles and responsibilities under the program. In advance of the second field exercise, the nominees previously identified were contacted by telephone to confirm their interest in participating in the PFS. Fishing cooperatives at Rosignol in Region 5 and Complex 66 in Region 6 were also contacted by telephone and briefed on the PFS and asked to nominate onboard supervisors from their organizations. For landing sites where no supervisor was identified prior to the second field exercise, nominations were requested from fisherfolk during the visit to the landing site. To the extent feasible, visits were planned to coincide with either launch or landing times of vessels at the landing sites in order to maximize participation and transparency in the nomination and selection process.

Following the identification of volunteers to act as regional and onboard supervisors at the landing sites in Regions 2 to 6, a Supervisor Selection Questionnaire was administered to verify that the selected individuals met the required competencies, including knowledge of the local fishing industry. When the questionnaire was successfully completed, the potential supervisors were guided through the terms of a Volunteer Agreement (which includes a small stipend to cover expenses) and introduced to the data collection methods, including data sheets and photography.

For Region 1, the first field missions to Smith's Creek and Waramuri were conducted on 18 March and 15 April 2019, respectively, as more planning in the remote areas and liaising with local leaders was required. Prior to the visits, EMC made contact with the village Toshaos (Indigenous Leaders) with assistance from the Regional Democratic Council of Region 1. An official correspondence was also sent to the villages. During the visits, the Toshao organized community meetings that included fisherfolk and were led by EMC stakeholder engagement specialists. Community members were provided with details of the PFS and the reasons for selecting the landing sites in these communities. In addition, EMC explained the roles and responsibilities of the regional and onboard supervisors. Following discussions, the community indicated their willingness to participate in the PFS. EMC subsequently conducted landing site assessments by interviewing three fisherfolk in Smith's Creek and eight in Waramuri.

2.5 Training of Participants

The third round of field visits to the landing sites in Regions 2 to 6 was conducted between 4 and 26 April 2019. These visits facilitated signature of the Volunteer Agreement, provision of equipment to supervisors (cameras, data sheets printed on Rite-in-Rain paper, scales, pencils, and sharpeners to all supervisors and additional GPS units to onboard supervisors), and training the supervisors in the use of equipment and completion of the data sheets. Once training was completed at a site, supervisors were encouraged to commence data collection activities. By 30 April 2019, supervisors at all landing sites in Regions 2 to 6 had signed the Volunteer Agreement and commenced data collection.

For Region 1, regional and onboard supervisors were identified for Smith's Creek on 6 May 2019 based on the recommendation of the Toshao, and the Volunteer Agreements were signed. Equipment was provided to these supervisors (cameras, data sheets printed on Rite-in-Rain paper, scales, pencils, and sharpeners to all Supervisors and GPS units to onboard supervisors) and they were subsequently trained on use of the equipment and completion of the data sheets. To ensure contact is maintained with the community during the PFS, a cellular phone was also provided to the Toshao. The selection and training of the onboard supervisor in Waramuri was completed in late-May with support from the local Toshao.

2.6 Schedule of Field Exercises

The schedule and purpose of the field visits conducted over from 31 January to 26 April 2019 is presented in Table 2 and the landing sites are depicted on a map in Figure 1.

Table 2: Schedule and Purpose of Field Visits

Date	Sites Visited	Purpose of Visit
31 January 2019	Region 3—La Grange	Landing Sites Assessments Scouting Missions
	Region 3—Windsor Forest	
	Region 3—Zeeburg	
	Region 4—Ogle	
2 February 2019	Region 4—Riverview (Unity, Mahaica)	
	Region 5—Mahaicony Bridge	
3 February 2019	Region 4—Riverview (Unity, Mahaica)	
3 February 2019	Region 5—Rosignol	
	Region 5—Bushlot	
4 February 2019	Region 6—Albion and Rose Hall	
5 February 2019	Region 6—Rose Hall	
	Region 6—Complex 66	
	Region 6—Albion	
7 February 2019	Region 2—Charity, Hampton Court, and Lima	
8 February 2019	Region 2—Hampton Court	
	Region 2—Charity	
	Region 2—Lima	
9 February 2019	Region 2—Lima	
	Region 2—Charity	
18 March 2019	Region 1—Smith's Creek	
15 April 2019	Region 1—Waramuri	
12 March 2019	Region 4—Ogle	Identification of regional and onboard supervisors, Introduction to the Participatory Fishing Study, signing Volunteer Agreement, and provision of data collection sheets
	Region 4—Riverview (Unity, Mahaica)	
	Region 5—Mahaicony Bridge	
13 March 2019	Region 5—Rosignol	
	Region 6—Rose Hall	
14 March 2019	Region 6—Complex 66	
	Region 6—Albion	
15 March 2019	Region 5—Bushlot	
16 March 2019	Region 2—Charity	
	Region 2—Lima	
22 March 2019	Region 4—Riverview (Unity, Mahaica)	
26 March 2019	Region 3—Zeeburg	
	Region 3—Windsor Forest	
	Region 3—La Grange	
28 March 2019	Region 2—Hampton Court	
	Region 2—Charity	

Date	Sites Visited	Purpose of Visit
10 April 10, 2019	Region 4—Ogle	Signature of the Volunteer Agreement, provision of equipment, training in use of equipment, and training in how data sheets should be completed. At some sites, there was also follow-up on the selection of onboard supervisors
11 April 2019	Region 4—Riverview (Unity, Mahaica)	
	Region 5—Mahaicony Bridge	
16 April 2019	Region 3—Zeeburg	
	Region 3—Windsor Forest	
	Region 3—La Grange	
18 April 2019	Region 2—Charity	
	Region 2—Lima	
	Region 2—Hampton Court	
24 April 2019	Region 5—Mahaicony Bridge	
	Region 5—Bushlot	
	Region 6—Rose Hall	
25 April 2019	Region 6—Albion	
	Region 6—Complex 66	
26 April 2019	Region 5—Rosignol	
	Region 4—Riverview (Unity, Mahaica)	
6 May 2019	Region 1—Smith's Creek	

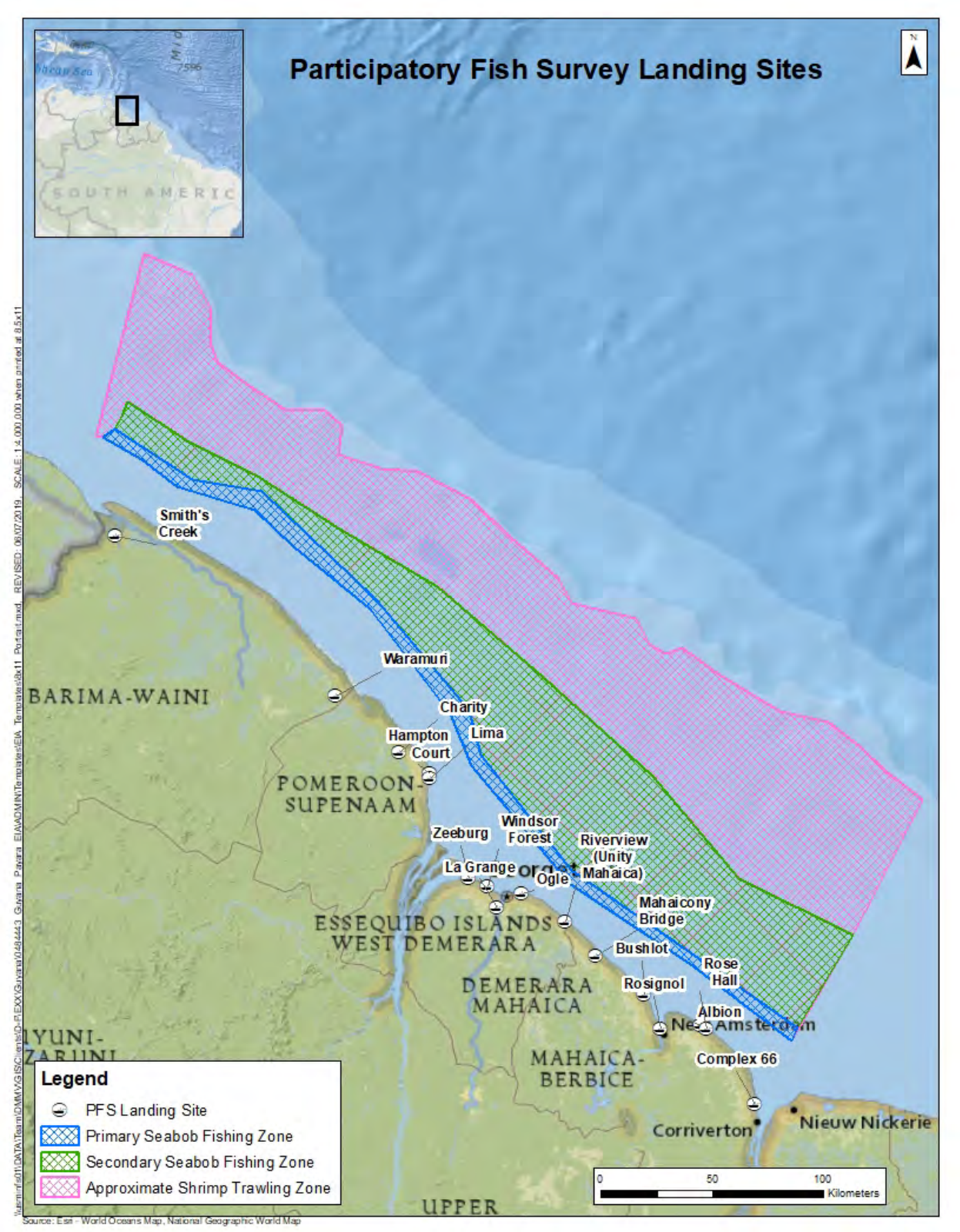


Figure 1: Locations of Landing Sites Visited between Regions 1–6

2.7 Observations

During the first field exercise, the team comprised of EMC and ERM fisheries specialists observed that a variety of measurement units (baskets, tubs, buckets, and pounds) were being used across landing sites in the various regions. During the second and third field exercises, the team comprised of EMC fisheries and stakeholder engagement specialists observed the weighing of filled baskets of bangamary (*Macrodon ancylodon* and *Cynoscion* sp.) and butterfish (*Nebris microps*) using scales provided by ice trucks that visit the landing sites in Riverview in Region 4 and Mahaicony Bridge in Region 5 to purchase catch (see Figure 2). The weights of these baskets averaged approximately 36.2 kilograms.

Common names for fish species are often utilized in the Guyanese context and are represented throughout this report. Table 3 provides a table of the common names and their species designation.



Figure 2: Weight of a Basket of Bangamary at the Riverview Landing Site, Region 4

Table 3: Common Finfish Names and Species Designation

Species Name	Common Name
Micropogonias furnieri	basher, basha [a]
Cynoscion acoupa	grey snapper
Cynoscion virescens	trout
Nebris microps	butterfish / butterhead
Carcharhinus limbatus	blacktip shark [b]
Chaetodipterus faber	spadefish / donkey fish
Sciades proops	kukawri [c]
Batrachoides surinamensis	pacu
Macrodon ancylodon	bangamary [d]
Stellifer rastrifer	rockhead
Scomberomorus cavalla	mackerel
Xiphopenaeus kroyeri	coarse shrimp/seabob
Cynoscion sp.	bangamary [d]
Odontognathus mucronatus	netly
Trichiurus lepturus	silverbelt
Lonchurus elegans	Chinese butterfish
Nematopalaemon schmitti	white belly shrimp
Achirus achirus and *Symphurus plagusia*	flounder
Centropomus undecimalis	snook
Farfantepenaeus sp. and *Litopenaeus* sp.	prawns [e]
Bagre bagre	sea catfish
Lobotes surinamensis	paggie
Cathorops spixii	spring cuirass
Cathorops sp. *and Sciades* sp.	cuirass
Sciades herzbergii	gillbacker / spring cuirass/mud cuirass
Megalops atlanticus	cuffum / tarpon
Genyatremus luteus	annafoke
Myleus rubripinnis	katabac
Mugil cephalus	Suriname mullet
Anchoa spinifer	small herring
Elops saurus	long john
Diapterus rhombeus	sea patwa
Pomatomus saltatrix	salmon

[a] Basha and basher are used in different regions of Guyana and both refer to *Micropogonias furnieri*.
[b] All photos collected during the showed *C. limbatus*, but the data could have small numbers of other shark species included.
[c] Kukawri is used to refer to *Sciades proops* in this report but the species is also known as kokwari and hard head cuirass in Guyana.
[d] Bangamary is used in Guyana to refer to both *Macrodon ancylodon* and *Cynoscion* sp.
[e] In Guyana, prawn is a blanket term used for both *Farfantepenaeus* sp. and *Litopenaeus* sp.

3. INITIAL BASELINE DATA COLLECTION RESULTS

The first field exercise in Regions 2 to 6 occurred during the off-peak season for fishing activities along the coastline. As a result, at some of the larger sites, only a small number of fisherfolk who normally use the landing site were present to participate in the baseline data collection survey. Although the primary purpose of this initial field exercise was to validate the selection of landing sites to be included in the PFS, the concurrent baseline data collection is still important to the overall knowledge of fisheries activities and therefore is captured as such in this section.

As discussed in Section 2.4, the Region 1 initial field exercise (which combined identification of supervisors and validation of landing site selection) occurred in March and April 2019 and also included a component of initial baseline data collection.

This section outlines the findings by region of the initial baseline data collection efforts at the various landing sites selected for the PFS program.

3.1 Region 1

3.1.1 Smith's Creek

At this landing site, three fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Smith's Creek is an Amerindian community located on the left bank of the Barima River. The primary livelihood activity is fishing. Fisherfolk estimate that approximately 6 artisanal vessels operate out of this site, although up to 20 vessels from both Smith's Creek and the neighboring community of Morawhanna dock at both sites at any one time (the regional supervisor will monitor and report on both sites in the future). All vessels are equipped with outboard engines ranging in size from 15 to 48 horsepower (hp). Drift seines are used by the two vessels with engine sizes of more than 40 hp. Mesh sizes range from 5 to 18 centimeters (2 to 7 inches). Vessels operating the 15-hp engines use pole seines with mesh sizes of 9 centimeters and 20 centimeters (3.5 and 7.9 inches).
- **Fishing Practices**: Vessels with engines of more than 40 hp generally make one trip per week, spending 5 to 6 days at sea per trip. Fishing occurs at 11 meters (36.1 feet) depth with soak time for fishing activities lasting approximately 3 to 5 hours. The 15-hp vessel also makes one trip per week spending up to 5 days fishing in the Waini Region.
- **Marketing**: Commercial species caught at this site include bangamary, trout, cuirass (*Cathorops* sp. and *Sciades* sp.), snook (*Centropomus undecimalis*), and gillbacker (*Cynoscion acoupa*). Larger vessels generally yield about 90 to 230 kilograms (198.4 to 507.1 pounds). The fishes are mainly sold at the Kumaka landing in Mabaruma. Most fishes are sold at $400 Guyanese dollars (GYD) or $1.92 U.S. Dollars (USD) per kilogram; however, gillbacker is sold at $600 GYD ($2.88 USD) per kilogram. On occasion, fishes are sold to trawlers docked at Morawhanna (the community opposite to Smith's Creek).
- **Challenges**: Fisherfolk at this location indicated that they are affected by pirates from Venezuela and allegedly are victims of theft.

3.1.2 Waramuri

At this landing site, eight fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Waramuri is an Amerindian Community located on the left bank of the Moruca River. Fisherfolk estimate that approximately

20 vessels, all equipped with outboard engines ranging from 5 to 48 hp, normally operate at this landing site. Cadell (demersal long line) and drift seines with mesh sizes of 5 to 12 centimeters (2 to 4.7 inches) are the principal fishing gear used at this site.

- **Fishing Practices**: Fisherfolk at this site use fishing grounds in several locations throughout Region 1 and 2 including Kamwatta, Moruca mouth, Pomeroon mouth, Iron Punt, Charo Beach, and Danfore. Engine size and fishing gear do not determine fishing practices, as both small and large vessels use either longline or drift seines and fish once per month, spending up to 14 days at sea per trip. However, one of the small vessels makes daily trips twice per week to the Moruca mouth for fishing. Fishes caught by fisherfolk from this community are dried/smoked during fishing trips since ice is unavailable for cold storage. Boats usually dock daily at beaches along the coastline where the drying/smoking is done. The duration of a fishing trip also includes this time spent to dry/smoke the fishes caught.
- **Marketing**: Species caught by fisherfolk at this site include bangamary, trout, cuirass, snook, sea catfish (*Bagre bagre*), and gillbacker. The larger vessels generally yield about 50 to 680 kilograms (110.2 to 1499.1 pounds) per trip. The fishes are sold at the Kumaka landing at Santa Rosa in Moruca. Most fishes are sold at $400 to $600 GYD ($1.92 to $2.88 USD) per kilogram. In this particular landing site, it was observed that women play a leading role in drying and smoking fishes for sale, more so than in other landing sites.
- **Challenges**: Cadell fisherfolk indicated that trawlers and the lack of bait are the main factors affecting them. Drift seine fisherfolk indicated that seaweed (referred to specifically as Sargassum) is the main challenge affecting them. Drift seine vessels have also reported conflicts with other drift seine vessels.

3.2 Region 2

3.2.1 Charity

During the first field exercise, a representative artisanal vessel fleet of ten was observed. However, most fisherfolk present were reluctant to participate in the survey and, ultimately, only four were interviewed. The key findings from the interviews were as follows:

- **Characterization of the landing site and artisanal vessel fleet:** Charity is the main port in Region 2, with commercial passenger vessels, produce vessels, and artisanal fishing vessels all using it as an embarkation/disembarkation site. Fisherfolk indicated that an artisanal vessel fleet of up to 100 vessels uses the site. However, at the time of the survey, only 10 vessels were in use because it was the off-peak season. Both inboard- and outboard-powered vessels operate from this port. The main fishing methods at this site are the drift seine with mesh sizes between 10 and 20 centimeters (3.9 to 7.9 inches), and Chinese seine[1]. Fisherfolk who use Chinese seines were not present at the site and therefore were not engaged. Fishing by vessels at this landing site occurs along the Essequibo Coast (Region 2), and northwest from Charity to the Waini River (Region 1).
- **Fishing practices**: Vessels typically fish between 3.2 and 16.1 kilometers (2 and 10 miles) from the coastline and at a depth of 8 meters (26.2 feet). Vessels with inboard engines spend about 18 days at sea per trip with soak time for fishing activity lasting 7 hours per day. Outboard-powered vessels with more than 40-hp engines spend 7 to 18 days at sea per trip with soak times ranging from 5 to 12 hours. Due to the extended number of days spent at sea, fishes are usually de-gutted before vessels land at Charity. This practice may hinder future biometric measurements at this landing site.

[1] A Chinese seine is a common term in Guyana used to describe a fyke net.

- **Marketing**: A diverse range of species are caught at this location including cuirass, grey snapper, gillbacker (*Sciades herzbergii*), snook, cuffum (*Megalops atlanticus*), bangamary, trout (*Cynoscion virescens*), and catfish[2]. All fisherfolk interviewed indicated that their catch is sold at the Charity Fishing Complex for prices ranging from $300 to $400 GYD ($1.44 to $1.92 USD) per pound depending on species. Their main expenses are ice (some indicated ice shortages) and fuel.
- **Challenges**: The main challenges fisherfolk encounter at this landing site include conflicts with trawlers cutting seines, conflicts among fisherfolk who use different fishing gear types, Venezuelan vessels fishing in Guyanese waters without permission, and piracy. Some fisherfolk also reported that seaweed in the mouth of the Pomeroon River and flowing up to the Waini River also affects their fishing activities.

3.2.2 Lima

At this landing site, three fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Up to 15 vessels utilize the Lima landing site. All vessels are outfitted with small outboard engines ranging from 10 to 15 hp. The main fishing methods are drift seines with mesh sizes ranging from 8 to 15 centimeters (3.1 to 5.9 inches) and Chinese seines.
- **Fishing Practices**: Fishing trips from this site usually range from 1 to 8 days at sea with soak times of 2 to 8 hours. These smaller vessels usually go approximately 2 to 3 kilometers (1.2 to 1.7 miles) from the coastline at depths of 4 meters (13.1 feet).
- **Marketing**: Fisherfolk usually catch 1 to 6 baskets of mixed fish. Species caught at this site include cuirass, bangamary, shrimp,[3] sea patwa (*Diapterus rhombeus*), annafoke (*Genyatremus luteus*), gillbacker, trout, and katabac (*Myleus rubripinnis*). Produce is sold both at the landing site and in surrounding villages. Prices range from $220 to $440 GYD ($1.06 to $2.11 USD) per kilogram.
- **Challenges**: The principal challenges encountered are with piracy and anchor seine/trawler vessels.

3.2.3 Hampton Court

At this landing site, six fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Approximately 25 to 30 vessels use the Hampton Court landing site. All vessels are powered with outboard engines ranging from 15 to 60 hp. Vessels with engine sizes of 40 hp or greater use drift seines with mesh sizes of 13 to 20 centimeters (5.1 to 7.9 inches), whereas vessels with engine sizes of 40 hp or less use Chinese seines with mesh sizes of 13 to 14 centimeters (5.1 to 5.5 inches).
- **Fishing Practices**: Fisherfolk at this site usually fish between 2 and 16 kilometers (1.2 and 9.9 miles) from the coastline at up to 15.24 meters (50 feet) in depth. Larger vessels (engines more than 40 hp) travel further from the coastline and spend 2 to 6 days at sea with soak times of 4 to 6 hours. Smaller vessels make daily trips and also have soak times of 4 to 6 hours.
- **Marketing**: Species caught at this site include cuirass, grey snapper, bangamary, shrimp, gillbacker, and trout. During this season, larger vessels report catch of 450 to 680 kilograms (992 to 1,499 pounds), while smaller vessels report an average catch of 1 basket of shrimp. Produce is mostly sold to trucks at the landing site. However, some fisherfolk sell their catch in nearby villages or to fish

[2] Undetermined species

[3] In Guyana, “shrimp” is a blanket term used for both *Xiphopenaeus kroyeri* and *Nematopalaemon schmitti*.

vendors for $220 GYD ($1.06 USD) per kilogram of shrimp and $440 GYD ($2.11 USD) per kilogram of fish.

- **Challenges**: The principal challenges encountered are boats fishing out of boundaries, trawlers, seaweed, piracy, ice shortages, and theft. There are frequent conflicts between the fisherfolk at the Hampton Court landing site who use drift and Chinese seines with fisherfolk from out of the area who practice anchor seine fishing.

3.3 Region 3

3.3.1 Zeeburg

At this landing site, four fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Fisherfolk estimate that there are over 30 vessels with 15-hp outboard engines that use this site. Chinese seines use gear ranging from 1.27 to 10 centimeters (0.5 to 3.9 inches) in mesh sizes.
- **Fishing Practices**: At this site, fisherfolk make one or two trips per day with soak times ranging from 4 to 15 hours. These fisherfolk prefer to fish around Leguan Island at the Mouth of the Essequibo River at distances of 5 to 32 kilometers (3.1 to 19.9 miles) from the landing site and at 5 to 31 meters (16.4 to 101.7 feet) depth.
- **Marketing**: The main catch at Zeeburg is white belly shrimp (*Nematopalaemon schmitti*). Depending on their soak times, one trip could yield 3 to 20 baskets of shrimp. Trucks come to the landing site to purchase the shrimp for about $3,000 GYD ($14.40 USD) per basket. The main expense is fuel.
- **Challenges**: Fisherfolk at this location encounter challenges with theft and piracy.

3.3.2 La Grange

At this landing site, eight fisherfolk were interviewed. It should be noted that at the time of the visit, there were only a few fisherfolk at the site and they volunteered to summon other fisherfolk to participate in the survey. In general, fisherfolk were enthusiastic about the survey at this site. The following were the key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Fisherfolk indicated that there are six to eight vessels that use Cadell at this site. This is one of the only landing sites in Guyana where most fisherfolk still use Cadell for commercial fishing (as seine fishing is now more prevalent). Although the landing site is more inland that the other landing sites surveyed, fisherfolk traverse the Demerara River to fish along the Region 3 coastline. Most vessels are equipped with 15-hp outboard engines.
- **Fishing Practices**: Fisherfolk make daily trips with soak times ranging from 2 to 16 hours per day. Fisherfolk in La Grange fish about 2 to 24 kilometers (1.2 to 14.9 miles) offshore at depths of 7 to 27 meters (23 to 88.6 feet).
- **Marketing**: The main species caught by fisherfolk at this landing site include catfish[4], cuirass, grey snapper, trout, and shark. Yield is typically 2 to 4 tubs of fish that could be sold for $1500 to $3000 GYD ($7.20 to $14.40 USD) per tub depending on the species. Produce is sold at the Meadow Bank Wharf, Stabroek Market, or to vendors in the community. The main expenses are fuel and fishing bait.

[4] Undetermined species

- **Challenges**: The main challenges encountered at this site are problems with fisherfolk using drift seine and lack of markets. Fisherfolk have also indicated that variable weather patterns, including changes in season, which they state are associated with climate change, are negatively impacting their activities.

3.3.3 Windsor Forest

At this landing site, one fisherfolk was interviewed with the following key findings:

- **Characterization of landing site and artisanal vessel fleet**: Approximately 12 vessels use this landing site. All vessels are equipped with 15-hp outboard engines. In addition, all use Chinese seines with mesh sizes ranging from 3 to 20 centimeters (1.2 to 7.9 inches).
- **Fishing Practices**: Fisherfolk make daily trips with an average soak time of 6 hours. Fishing occurs 24 kilometers (14.9 miles) offshore at depths of 5 meters (16.4 feet).
- **Marketing**: The average catch in the present season is 2 baskets of fish and one basket of shrimp per trip. A basket of mixed fishes (bangamary, netly [*Odontognathus mucronatus*], Suriname mullet [*Mugil cephalus*], small herring [*Anchoa spinifer*]) is sold for approximately $5,000 GYD ($24 USD) at the landing site to trucks or other vendors.
- **Challenges**: The main challenge encountered by the fisherfolk interviewed at this site is with trawlers.

3.4 Region 4

3.4.1 Riverview (Unity, Mahaica)

At this landing site, six fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Fisherfolk estimate that approximately 30 vessels that are all equipped with outboard engines ranging from 5 to 48 hp normally operate at this landing site. Drift seines with mesh sizes of 7 centimeters (2.8 inches) are used for catching bangamary and mesh sizes of 10 centimeters (3.9 inches) are used for grey snapper.
- **Fishing Practices**: Vessels with engines of more than 40 hp make one trip per day and have soak times ranging from 2.5 to 3 hours. These vessels fish at an approximate distance of 2 to 24 kilometers (1.2 to 14.9 miles) from the coastline and 2 to 28 meters (6.6 to 91.9 feet) of depth. Vessels with engines of less than 40 hp have soak times of 3 to 12 hours. Vessels from this site fish along the coast of Regions 4 and 5.
- **Marketing**: The main catch at this landing site includes cuirass, pacu (*Batrachoides surinamensis*), bangamary, butterfish, and sea catfish. Large vessels have yields of approximately 1 to 5 baskets while smaller vessels have yields of 0.5 to 2 baskets. Produce is sold to trucks at the landing site and in nearby villages at a price of $132 to $882 GYD ($0.63 to $4.23 USD) per kilogram. The main expense is fuel.
- **Challenges**: Fisherfolk at this location have challenges with sharks destroying seines, rough seas, and trawlers.

3.4.2 Ogle

At this landing site, six fisherfolk were interviewed with the following key findings:

- **Characterization of landing site and artisanal vessel fleet**: Fisherfolk indicated that there are 20 to 30 vessels at this site, all of which are outfitted with outboard cruisers with 15-hp engines. All vessels use Chinese seine with mesh sizes of 3 to 13 centimeters (1.2 to 5.1 inches).
- **Fishing Practices**: Fisherfolk make one to two trips per day travelling about 5 to 8 kilometers (3.1 to 5 miles) off the shore between Ogle and the mouth of the Demerara River. Fishing occurs at depths of 5 to 7 meters (16.4 to 23 feet) with soak times of 2 to 6 hours.
- **Marketing**: Species caught at this site are characterized as mixed fishes comprising bangamary, basha (*Micropogonias furnieri*), gillbacker, cuirass, sea catfish, and shrimp. At this time of year, catch averages 0.25 to 2 baskets of mixed fishes and shrimp. A basket of mixed fishes sells for $4,000 to $6,000 GYD ($19.20 to $28.80 USD) and is generally sold to trucks at the landing site or other vendors. The main expenses are fuel and ice.
- **Challenges**: The main challenges at this location are channels not being cleared/dug and inconsistent catch. Fisherfolk also indicated that climate change is adversely affecting their operations due to changes in seasons.

3.5 Region 5

3.5.1 Mahaicony Bridge

At this landing site, four fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** Fisherfolk estimate that approximately 15 vessels operate at this landing site and that all are powered by outboard engines of 40 hp or greater. Vessels were further grouped as bangamary and snapper vessels, with the former using drift seines with mesh sizes of 6 centimeters (2.4 inches) and the latter using drift seines with mesh sizes of 13 to 20 centimeters (5.1 to 7.9 inches).
- **Fishing Practices**: Vessels make one trip per day and have soak times of 3 to 5 hours. These fisherfolk travel about 13 to 19 kilometers (8.1 to 11.9 miles) off the coast at depths of 13 to 22 meters (42.6 to 72.2 feet). Fisherfolk at this site fish along the coast of Region 5.
- **Marketing**: During the present season, characterized by lower yields, fisherfolk indicated that their catch is approximately 2 to 5 baskets of bangamary, trout, sea catfish, and butterfish per trip. The product is sold to refrigerated trucks that visit the landing site for approximately $220 GYD ($1.06 USD) per kilogram. The main expense is fuel.
- **Challenges**: Fisherfolk indicated that their main challenge is trawlers cutting their seines when fishing.

3.5.2 Rosignol

At this landing site, six fisherfolk were interviewed with the following key findings:

- **Characterization of landing site and artisanal vessel fleet**: Fisherfolk indicated that there are more than 40 vessels at this site, all of which are outfitted with outboard engines of 40 to 60 hp. All vessels use a variety of gear: Chinese seines with mesh sizes ranging from 3 to 20 centimeters (1.2 to 7.9 inches), cat guts seines with mesh sizes of 6 to 11 centimeters (2.4 to 4.3 inches), gill nets with 19 centimeters (7.5 inches) mesh size, and Cadell boats. This landing site is managed by the Fishermen's Association.

- **Fishing Practices**: Fishing trips by large vessels with 60-hp engines are at a distance of about 24 kilometers (14.9 miles) from the coastline and 27 meters (88.6 feet) of depth. These larger vessels may spend up to 2 weeks at sea. Smaller vessels usually fish at a distance between 5 kilometers (3.1 miles) from the coastline and at 5 meters (16.4 feet) depth and generally have daily trips. Fisherfolk reported soak times of 2 to 6 hours.
- **Marketing**: Species caught at this site are characterized as mixed fishes including bangamary, trout, basha, gillbacker, grey snapper, and shark. Larger vessels have yields of up to 450 kilograms (992 pounds), which is sold at the landing site for $792 to $1,760 GYD ($3.80 to $8.45 USD) per kilogram. The main expense is fuel.
- **Challenges**: The main challenges are trawlers destroying fisherfolks' seines, piracy, and overfishing.

3.5.3 Bushlot

At this landing site, four fisherfolk were interviewed with the following key findings:

- **Characterization of landing site and artisanal vessel fleet**: Only 20 vessels were operational at this landing site during the visit. However, fisherfolk indicate that approximately 40 vessels use the landing site during peak season. Most vessels observed were sailboats, although some were fitted with small outboard engines of 5 hp. Fisherfolk use drift seines of 6 to 10 centimeters (2.4 to 3.9 inches).
- **Fishing Practices**: Fisherfolk at this landing site fish approximately 2 to 3 kilometers (1.2 to 1.9 miles) off the Bushlot beach at depths of about 1 to 4 meters (3.3 to 13.1 feet). They have soak times ranging from 2 to 6 hours. Typical yield during the off-peak season is 0.5 to 2 baskets per trip.
- **Marketing**: The main species at this site are cuirass, bangamary, trout, and butterfish, which are sold as mixed fishes per basket for $4,000 to $8,000 GYD ($19.20 to $38.40 USD).
- **Challenges**: Previously, catch was sold to trucks that came to the site to purchase. However, the access road to the landing site is in a significantly deteriorated state and fisherfolk now have to transport their catch to the villages for sale. Fisherfolk also shared challenges arising from a higher than usual abundance of mud at the landing site, and rough seas.

3.6 Region 6

3.6.1 Rose Hall

At this landing site, three fisherfolk were interviewed with the following key findings:

- **Characterization of the landing site and artisanal vessel fleet:** At the time of the visit, four vessels were observed at the landing site. Three of these vessels utilize a 3 to 4-centimeter (1.2 to 1.6-inch) pin seine and one vessel uses a drift seine.
- **Fishing Practices**: Fisherfolk who utilize pin seines make trips to check their nets at 12-hour intervals depending on the tide. The pin seines are set less than 2 kilometers (1.2 miles) from the Rose Hall beach.
- **Marketing**: The main species caught at this landing site are butterfish, bangamary, cuirass, shrimp, and Suriname mullet. Pin seine fisherfolk typically catch 1 to 2 baskets of fishes per trip which are sold at markets. One basket of fish is sold for $10,000 GYD ($48 USD) or parcels of about 10 fish are sold for $500 to $1,000 ($2.40 to $4.80 USD) depending on the species.
- **Challenges**: Fisherfolk indicated that their main challenge is lack of available markets to sell their produce and the rough seas they encounter.

3.6.2 Complex 66

At this landing site, nine fisherfolk were interviewed with the following key findings:

- **Characterization of landing site and artisanal vessel fleet**: During the visit, a vessel fleet of 140 vessels was observed at the landing site. However, fisherfolk indicated that at the peak season more than 200 vessels operate at this site. Vessels are fitted with outboard engines of 40 to 60 hp. The main gear used is drift seines with mesh sizes of 13 to 20 centimeters (5.1 to 7.9 inches).
- **Fishing Practices**: Some vessels at this landing site fish along the Suriname and Guyana coast at a depth of 26 meters (85.3 feet). These vessels spend 10 to 16 days at sea per trip with soak times of 6 to 12 hours.
- **Marketing**: The main species at this site are grey snapper, trout, and gillbacker. Catch averages 45 to 2,273 kilograms (99.2 to 5011.1 pounds) depending on the duration of the trip. Prices range from $572 to $880 GYD ($2.75 to $4.22 USD) per kilogram depending on the species being sold. The main expense is fuel.
- **Challenges**: At this location piracy, cat guts fishing (sometimes improper disposal of seine in seas contributes to reduced stock), and the fact that some vessels need licenses from Suriname (as they fish in those waters) are the major challenges encountered.

3.6.3 Albion

Eight fisherfolk were interviewed at this landing site, with the following key findings:

- **Characterization of landing site and artisanal vessel fleet:** Fisherfolk indicated that 40 to 70 vessels use the landing site at Albion. All vessels are fitted with outboard cruisers with engine sizes ranging from 15 to 50 hp. Vessels are characterized as either bangamary vessels that use drift seines with mesh sizes of 3 to 8 centimeter (1.2 to 3.1 inches), or trout vessels that use drift seines and till seines. Bangamary vessels are the main fishing method at this site.
- **Fishing Practices:** Fisherfolk at this site make daily trips with soak times of 2 to 4 hours. The fisherfolk at Albion travel between the Berbice River and Whim along the coast. The fisherfolk fish approximately 2 to 21 kilometers (1.2 to 13 miles) offshore at a depth of 10 to 33 meters (32.8 to 108.3 feet).
- **Marketing:** The main species at this site are bangamary, butterfish, trout, and sea catfish. Catch averages 45 to 136 kilograms (99.2 to 299.2 pounds) and is sold to trucks at the landing site and/or to markets in surrounding villages. Prices range from $176 to $550 GYD ($0.84 to $2.64 USD) per kilogram depending on the species being sold. The main expense is fuel.
- **Challenges:** All fisherfolk interviewed at this location indicated that trawler vessels are a challenge because they frequently pass over and damage seines, causing the fisherfolk to lose catch and requiring seine repairs.

4. ANALYSIS OF DATA COLLECTED BY SUPERVISORS

As noted previously, the majority of the first quarter of PFS programming was dedicated to landing site selection and onboarding and training of participants. Therefore, the data collected by the regional supervisors and onboard supervisors through the end of this reporting period is limited to two landing sites in Region 4. The data collected has been analyzed and is presented below. It is envisioned that the data presented in subsequent Quarterly Reports will follow this structure and be presented by region. Figure 3 presents a photolog of the site assessment and training of regional and onboard supervisors.



Landing Site Assessment at Waramuri



Training of Regional Supervisor to Measure Fish Weights at Charity



Training of Onboard Supervisor in Use of the GPS at La Grange



Training the Onboard Supervisor at Windsor Forest



Training of the Regional Supervisor at Riverview (Unity, Mahaica)



Training of the Regional Supervisor at Mahaicony Bridge



Training the Onboard Supervisor at Rose Hall

Figure 3: Photolog of Initial Landing Site Assessments and Training of Regional and Onboard Supervisors

4.1 Socioeconomic Data and Analysis

4.1.1 Region 4, Riverview (Unity, Mahaica)—Analysis of Data Collected by the Regional Supervisor

The regional supervisor at this site completed nine data collection sheets from 11 to 30 April 2019. Over that period, data were collected from 22 vessels that use the landing site and comprise both "snapper boats" and "bangamary boats." [5] Four of these vessels were Riverview Mahaica Boat—Snapper (RMBS) vessels utilizing drift seines with mesh sizes of 10 to 12 centimeters (3.9 to 4.7 inches). These mesh sizes are designed to catch larger species of fishes as smaller species tend to move easily through the seine. This also has an ecological benefit of supporting regeneration of the fish stock as it allows younger fishes the opportunity to mature and reproduce. Three of the RMBS vessels (referred to as RMBS2, RMBS3, and RMBS4 in Figure 4 below) are large and have engine sizes ranging from 40 to 48 hp. These vessels

[5] For the purposes of this analysis, "snapper boats" at this landing site are referred to as Riverview Mahaica Boat—Snapper (RMBS) and "bangamary boats" as Riverview Mahaica Boat—Bangamary (RMBB).

fish in depths of at least 9 meters (29.5 feet) and fishing trips typically last for 2 to 6 days. The fourth RMBS (referred to as RMBS1) uses the same type of seine but it has a smaller 15-hp engine. Fishing trips typically last for 1 day and the vessel stays relatively close to the shoreline with fishing occurring at depths of approximately 2.7 meters (8.9 feet). The species caught by RMBS1 are less diverse than the catch of the other three vessels. It may be considered that RMBS1 targets pacu, which is more frequently caught close to the shore, whereas the catch from the larger vessels are more diverse. Figure 4 shows the total quantity and composition of catch for one trip for each of the four RMBSs.

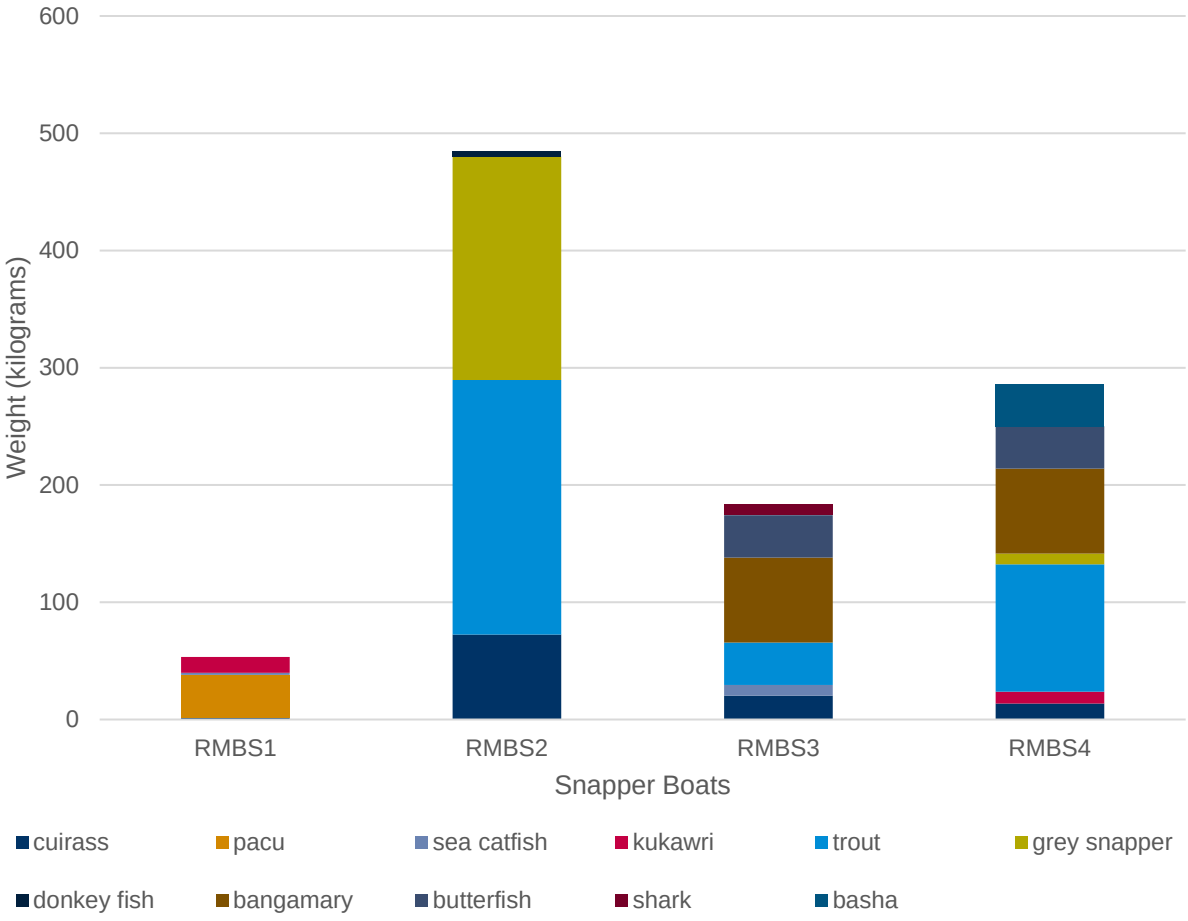


Figure 4: Total Quantity and Composition from "Snapper Boats"

In addition, data were collected from 18 bangamary boats, some of which made multiple trips during the reporting period. These vessels all use drift seines with mesh sizes of 7 centimeters (2.7 inches). As anticipated, the composition of the catch from vessels using the smaller mesh sizes shows greater species diversity as compared to larger mesh sizes. The lowest daily catch was recorded by Riverview Mahaica Boat—Bangamary (RMBB) 2, which brought in 36 kilograms (79.4 pounds) of bangamary on its first trip for which data were captured. The second lowest daily catch was also recorded by RMBB2-1, with a catch of basha and cuirass during the second trip for which data were recorded. The largest haul of 878 kilograms (1935.6 pounds), predominantly trout, bangamary, and butterfish, was recorded by RMBB1-3 on the third trip during which data were captured. However, these differences can be attributed to different fishing practices. RMBB1 spends approximately 2 days at sea and soaks its seines more, up to 5 times, whereas during its first trip RMBB2 soaked its seines once and spent 10 hours at sea. Fishing

grounds also differed as RMBB1 fished along the Region 4 coastline while RMBB2 stayed in the vicinity of the landing site. Most other trips routinely yielded more than 300 kilograms (661.4 pounds). Figure 5 shows the total quantity and composition of catch for trips of the RMBBs.

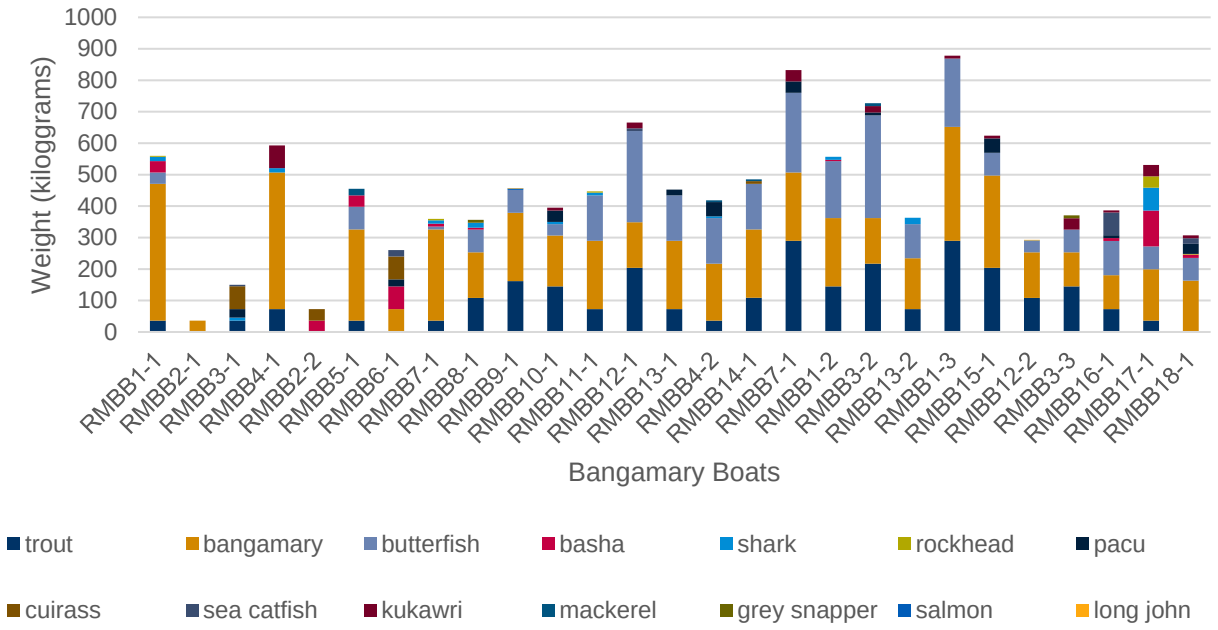


Figure 5: Quantity and Composition of Fishing Trips from "Bangamary Boats"

Bangamary, trout, grey snapper, and butterfish are the species that are caught in the largest quantities and sold for commercial purposes at Riverview. Catches of bangamary from the 7 centimeters (2.7 inches) "bangamary seines" far exceed the quantities of other species of fishes caught with this seine. This can be attributed to the specialization of the mesh size of the seine to capture this species. Other commercial species from this landing site include basha, kukawri (*Sciades proops*), pacu, shark, cuirass, and sea catfish. Catch also includes mackerel (*Scomberomorus cavalla*), rockhead (*Stellifer rastrifer*), donkey fish (*Chaetodipterus faber*), salmon (*Pomatomus saltatrix*), and long john (*Elops saurus*) but these are not considered commercial species because of the limited quantities that are caught. In addition, rockhead fish are rarely caught at commercially viable sizes. As a consequence, commercially viable species are determined by species abundance, size, and level of effort required to catch. Figure 6 provides a photolog of various catch.



butterfish (*Nebris microps*)



grey snapper (*Cynoscion acoupa*)



trout (*Cynoscion virescens*)



bangamary (*Macrodon ancylodon*)

Figure 6: Photolog of Catch

Gross earnings per trip is significantly dependent on the species caught and the prevailing market prices. For example, trout is sold for at least $660 GYD ($3.17 USD) per kilogram, shark $748 GYD ($3.59 USD) per kilogram, and grey snapper $880 GYD ($4.22 USD) per kilogram. RMBS2 caught 485 kilograms (1069.2 pounds), with 217.2 kilograms (478.9 pounds) of trout and 190.5 kilograms (420 pounds) of grey snapper and had gross earnings of $63,465 GYD ($304.63 USD). By contrast, RMBB1-3 had a haul of 878 kilograms (1935.7 pounds), almost twice the size of RBBS2's catch, comprising of 362 kilograms (798 pounds) of bangamary, 217 kilograms (478.4 pounds) of butterfish and 290 kilograms (639.3 pounds) of trout among other species. However, gross earnings were $69,946 GYD ($335.74 USD). Figure 7 shows gross earnings per vessel per trip which landed at Riverview.

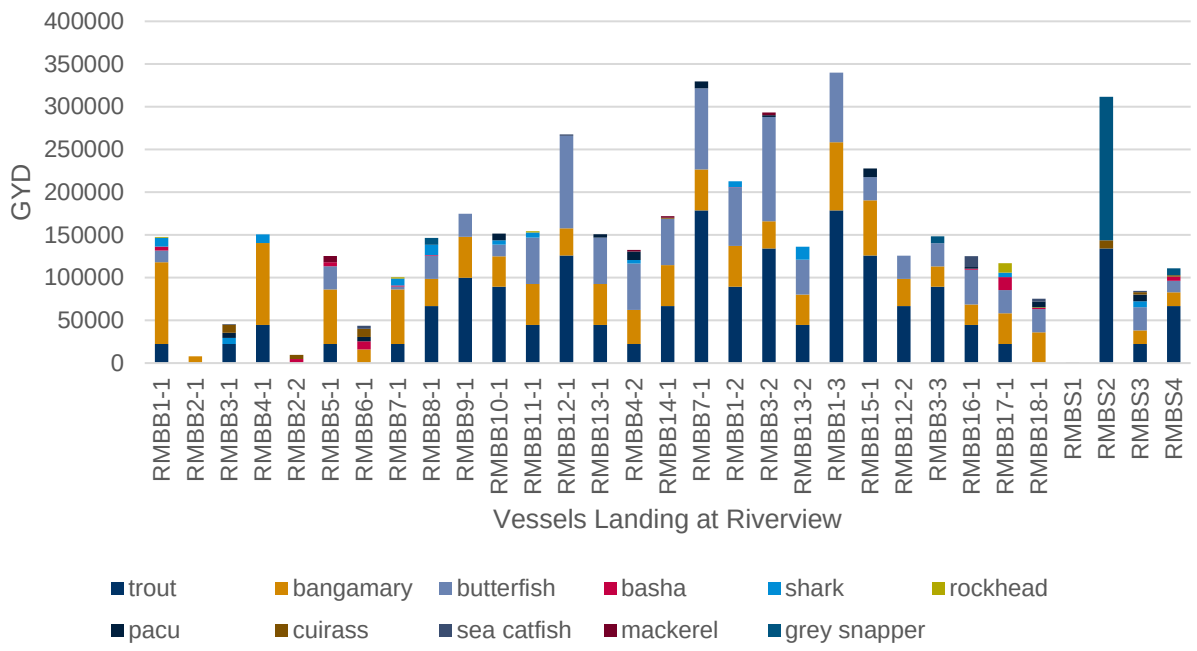


Figure 7: Gross Earnings per Vessel per Trip landed at Riverview (Unity, Mahaica)

4.1.2 Region 4, Ogle—Analysis of Data Collected by the Onboard Supervisor

The onboard supervisor selected at this site is the owner of a small fishing vessel that operates with a 30-hp engine. The vessel makes daily trips with a crew of three, including the supervisor. Each trip lasts 4 to 6 hours. The vessel uses Chinese seine to fish and three different pen locations have been established at 2 kilometers (1.2 mile), 3.85 kilometers (2.4 miles), and 4.13 kilometers (2.6 miles) offshore from the landing site. Chinese seines are used to catch shrimp and small fishes are also caught in the nets (see Figure 8). During the reporting period of 10 to 29 April 2019, 16 fishing trips were undertaken and a data sheet was completed for each trip. Over that time, 21 commercially viable species were caught by the vessel. More than 70 percent of the total catch is represented was coarse shrimp (*coarse shrimp*) and white belly shrimp (Figure 9).



Figure 8: Catch from the Onboard Supervisor at Ogle

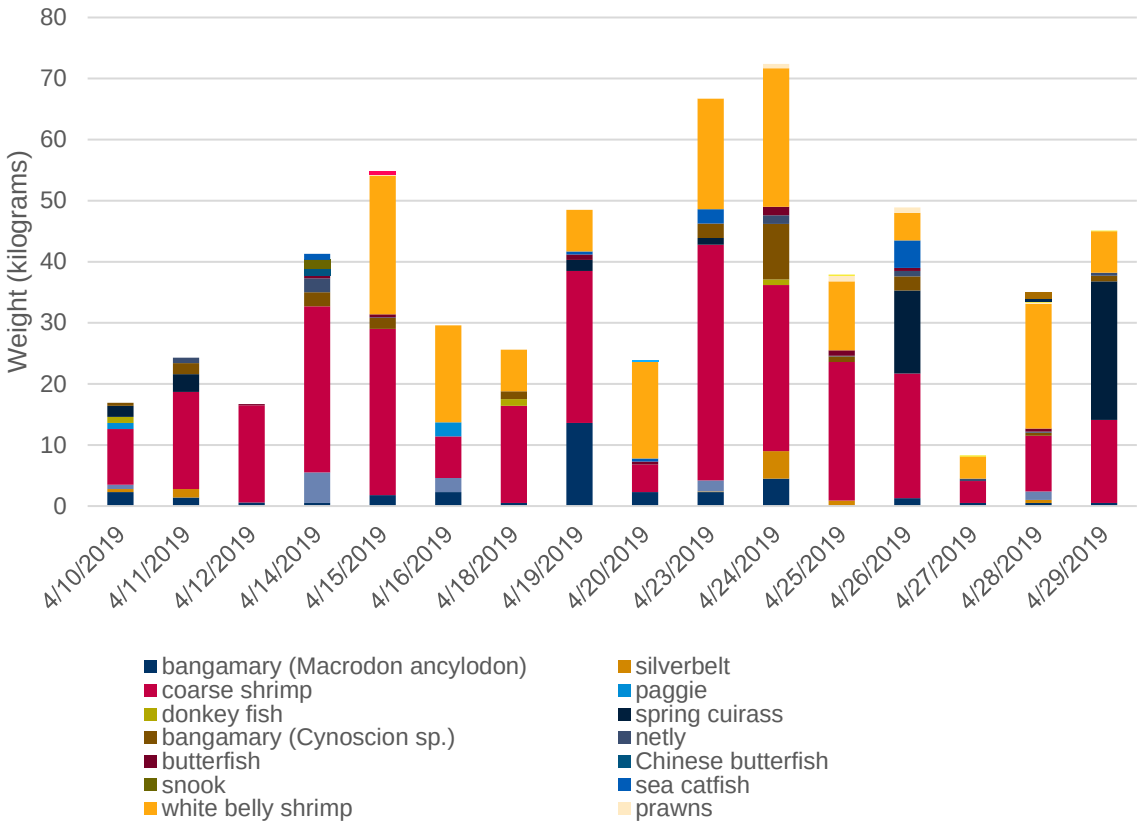


Figure 9: Catch Composition per Fishing Trip

The supervisor reported that the proliferation of sargassum is significantly affecting his operations. In fact, sargassum accounted for as much as 45.3 kilograms (99.9 pounds) of bycatch from one of the fishing trips where total bycatch was 51 kilograms (112 pounds). Figure 10 shows the quantity of sargassum that was pulled up in the seine during a fishing trip on 11 April 2019.



Figure 10: Sargassum Pulled Up in a Seine

4.2 Biological Data and Analysis

Biological data on the length and weight of fishes are important indicators of health of the catch and may also inform conclusions of how the fish stock is being managed. At each of the landing sites, supervisors are expected to randomly sample one commercially viable fish of each species represented in a vessel's total catch. These fish will be measured and weighed to build a comprehensive baseline of any changes in species size by season, landing site, and gear used. In this section, measurements of length and weight which were submitted by the regional supervisor at Riverview in Region 4 are presented, since these are the only data collected within this reporting period.

4.2.1 Biological Data of Commercially Viable Species at Riverview (Unity, Mahaica) in Region 4

For each data sheet completed at the landing site, the regional supervisor randomly selected one fish from each of the commercially viable species and measured its length (centimeters) and weight (grams). Figure 11 below shows the average weight and lengths of trout, bangamary, butterfish, cuirass, shark, basha, sea catfish, and pacu that were randomly selected for measurement.

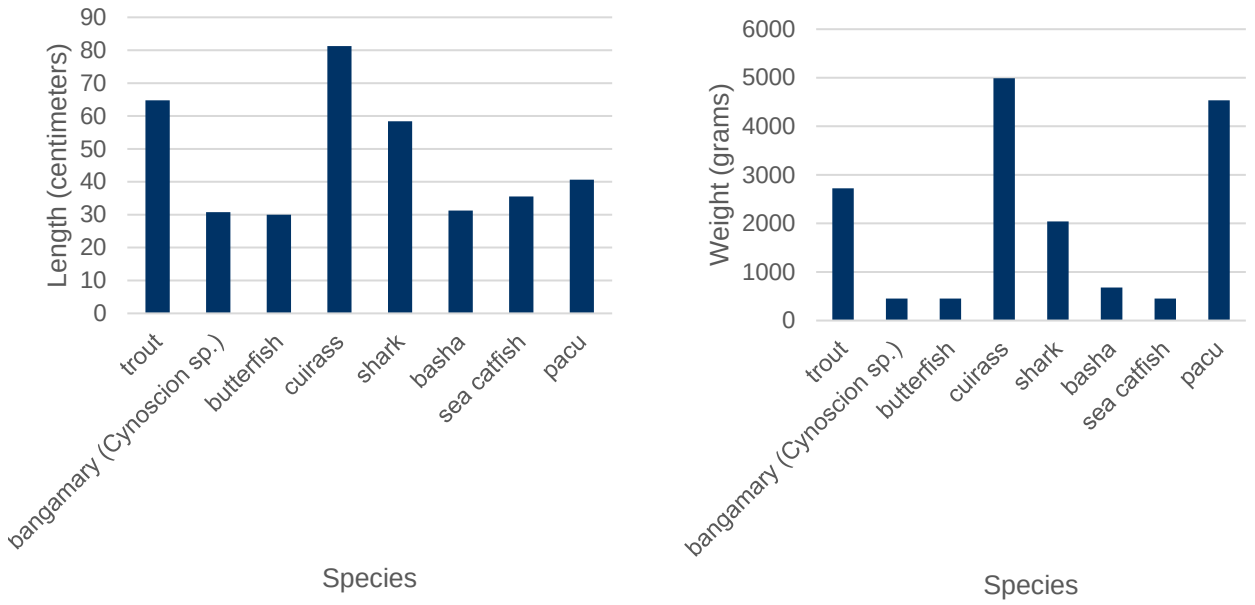


Figure 11: Length (left) and Weight (right) of Commercially Viable Species at Riverview

4.2.2 Biological Data of Commercially Viable Species at Ogle in Region 4

The vessel at the Ogle landing site primarily caught shrimp and small fish. No biometric data were collected for shrimp and the onboard supervisor reported that a significant quantity of the fish catch is not sufficiently heavy for their weight to be registered on the scale which was provided. This is likely due to the fact that fishing is close to shore and therefore the fish caught have not reached sexual maturity. As a consequence, only length measurements were submitted by the onboard supervisor at Ogle. For each data sheet completed at the landing site, the regional supervisor randomly selected one fish from each of the commercially viable species and measured its length (centimeters). Figure 12 shows the average lengths of the species that were randomly selected for measurement.

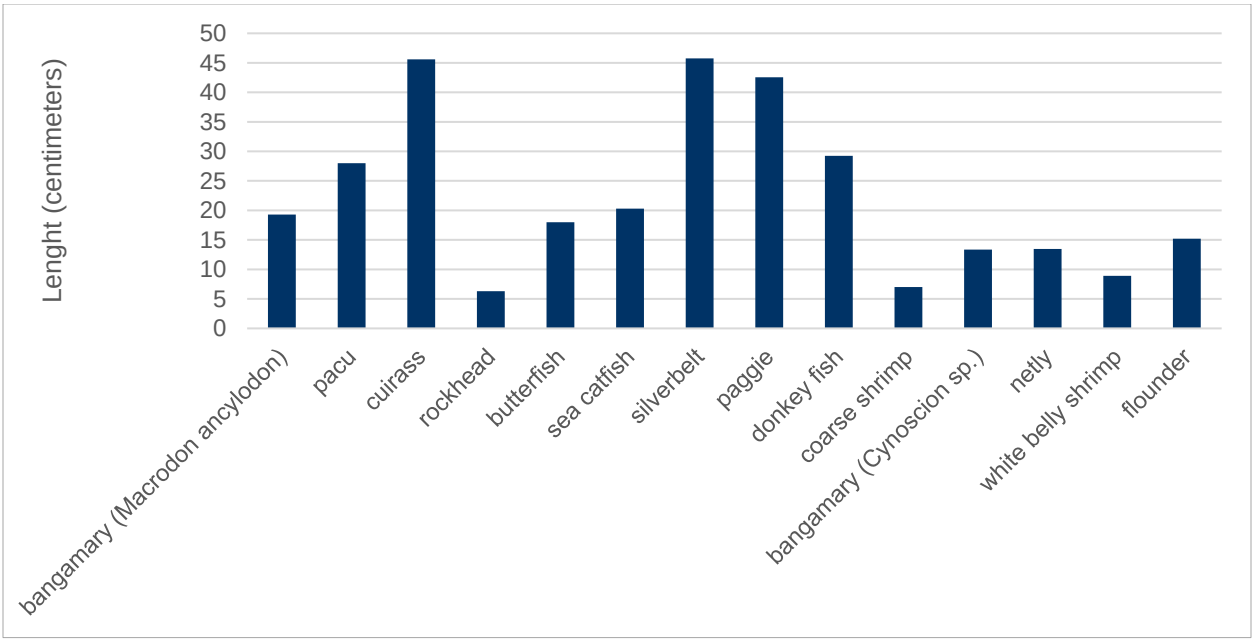


Figure 12: Length of Commercially Viable Species at Ogle

4.2.3 Comparison of Biological Data at Region 4

When comparing the average lenghts of the same species measured by the regional supervisor at Riverview and the onboard supervisor in Ogle, a significant difference can be observed in the average size of the catch as represented by length. This is attributed primarily to the different fishing gears that were used—drift seines versus Chinese seines. The larger mesh sizes of the drift seines only allow large fishes to be caught. By comparison, only smaller fish of the same species are caught by the Chinese seines. Figure 13 shows the comparable lengths.

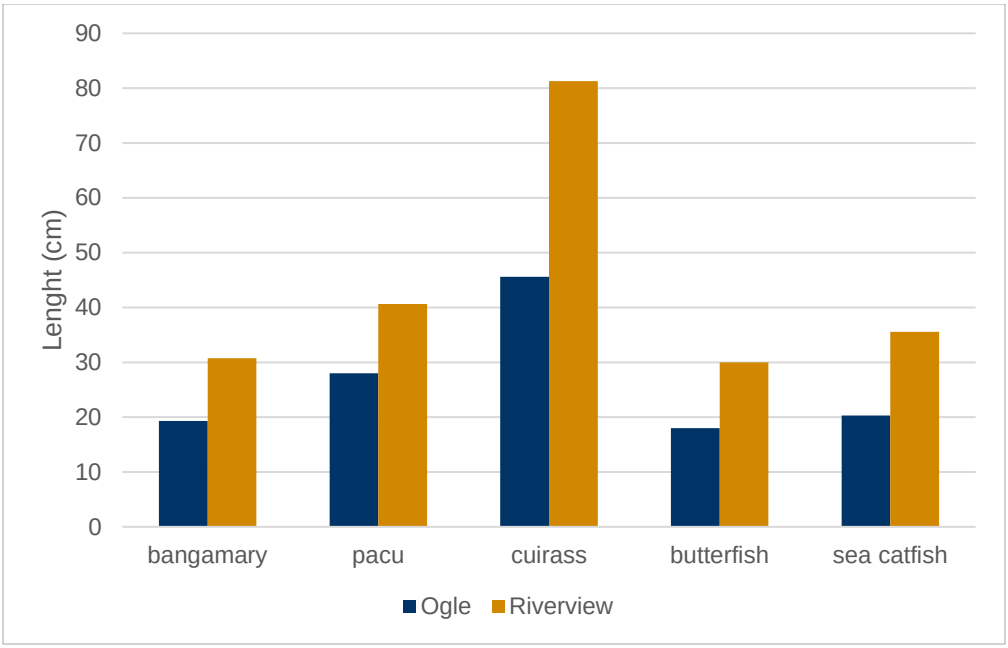


Figure 13: Comparison of Average Lengths of Fishes at Ogle and Riverview, Region 4

5. ADDITIONAL INFORMATION COLLECTED FROM FISHERFOLK

During the field exercises, additional information was collected from interlocutors related to juvenile turtles.

The following are key points related to juvenile turtles:

- Fisherfolk have religious and superstitious beliefs about turtles and for this reason all fisherfolk reported that they release any turtles that become captured in their seines. Fisherfolk have also reported great sympathy for “turtle tears” which are observed when these animals are captured. For these reasons, Hindu fisherfolk would not be willing to participate in any turtle capture and release as part of any turtle research study.
- Fisherfolk along the Berbice coast have indicated numerous sightings and captures of leatherback turtles. Some also reported sightings of juvenile leatherbacks. No specific locations were provided.
- Fisherfolk at the landing site in Riverview (Unity, Mahaica) in Region 4 reported observing an attempted nesting on the sand banks of the landing site several years ago. Attempted nestings were also reporting at the landing site at Lima in Region 2. However, the beach area has changed from sandy to muddy during this time as a result of mangroves planting programs and as such, turtle nesting attempts are no longer observed.
- The fisherfolk at Region 2 indicated that they have been coming into contact with seaweed just off the Pomeroon River which has been affecting them. This could be interpreted as anecdotal evidence of foraging grounds as several turtle sightings in this area were reported.
- Almost all fisherfolk interviewed in Region 1 reported sightings of turtles during their fishing activities. Several also indicated that turtles have become caught in their seines and were released. The sightings and encounters were reported to occur for all four species of marine turtles known to nest in Guyana. Some of the fisherfolk in Waramuri fish in the vicinity of Shell Beach and have reported frequent encounters. Similarly, fisherfolk from Smith’s Creek report that marine turtles are frequently encountered.
- During the visit to the Rose Hall landing site in Region 6 on 13 March 2019, fisherfolk reported that a dead adult leatherback turtle washed up onto the shore of their landing site during the week of 4 March 2019.

6. LIMITATIONS AND CONSIDERATIONS FOR FUTURE WORK

The following are the key limitations encountered during this reporting period along with considerations and recommendations for future work:

- Landing site assessments for Regions 2 to 6 were conducted during off-peak seasons at all landing sites. Fisherfolk indicated that peak season is mid-year, as warmer temperatures and less rainfall are considered contributing factors to greater yield. During the first field exercise, greater quality of findings was observed at sites where more fisherfolk participated. Therefore, in order to ensure that a representative sample of fisherfolk and fishing activity is captured at the landing sites, the socioeconomic aspects of quality assurance/quality control activities should be scheduled between May and August.

  There was a significant variety in units of measurement (buckets, baskets, tubs, pounds) across landing sites in different regions. This is anticipated to create challenges in quantitatively analyzing catch. Therefore, in subsequent field visits, EMC will measure baskets and tubs of fish of various species at different landing sites to enhance understanding of the average weight of the units of measurements used.

- There was reluctance among some fisherfolk at two landing sites in Region 4 and Region 3 to participate. As this is a voluntary program, there could be similar issues in the future which could limit the data collected in pre-determined important landing sites.

It is anticipated that EMC will continue making bi-monthly visits to landing sites in Regions 2 to 6 to continue to collect data sheets and engage with participants. EMC will also continue to work with the Toshao and community in Waramuri in Region 1 so that an onboard supervisor can be selected as soon as possible. Monthly visits to landing sites in Region 1 to collect data sheets will also continue.

7. CONCLUSION

Significant progress was achieved over this reporting period. During the first field exercise, 82 one-on-one interviews were conducted with fisherfolk as part of the initial baseline data collection effort at 16 landing sites in Regions 1 to 6. Fisherfolk reported facing several challenges in their daily routines, foremost of which was piracy, which affected fisherfolk at all landing sites. Piracy resulted in loss of vessels, equipment, and catch. Some fisherfolk also reported personal harm from piracy including violence on their person and being thrown overboard. In addition, there have been reports of conflicts between fishing vessels, in particular where different types of fishing gear (dragnets, drift seines, and Cadell/long lines) become entangled. Lastly, the intrusion of Sargassum weed into Guyana's waters has hampered fishing activities as it takes up a large quantity of bycatch.

At most of these landing sites, vessels have outboard cruisers with some larger sites having inboard cruisers. However, sailboats also operate at Bushlot landing site in Region 5. The boats have engines ranging from 5 hp to 130 hp. A variety of gear types and fishing practices were also captured. Regional and/or onboard supervisors were identified at 15 of these landing sites, all of whom have commenced data collection. Efforts are progressing to secure an onboard supervisor at the Waramuri landing site in Region 1. Preliminary analysis of the data suggests that fisherfolk who utilize fishing gear with relatively small mesh sizes and fish in the near-shore catch smaller fish of the same species. Further analysis of average fish lengths will help to determine whether these smaller fishes are juvenile. Finally, as data collection continues, GPS data from onboard supervisors will be used to generate maps of "hotspots" of fishing activity along Guyana's coastline.

8. REFERENCES

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ATTACHMENT A JUSTIFICATION OF SELECTION OF LANDING SITES FOR COMPONENTS 1 AND 2

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Landing Sites Selected for Component 1

Selected Landing Sites	Justification
Region 1 Smith's Creek	Smith's Creek is one of the main fishing villages in Region 1 and almost all of the men in the community are involved in fishing. There are 15 to 20 small vessels that include daily trips to Waini Point. In addition, there are 3 large vessels that travel to the area between Waini Point and Iron Punt twice monthly, spending 8 to 10 days at sea each time. The Village Council will be the principal point of contact and is expected to support the selection of suitable supervisors to support data collection.
Region 2 Charity	Charity is one of the two main disembarkation points for all vessel types in Region 2. Fisherfolk conduct daily trips (6 hours per day, 7 days per week) and longer trips spending up to 18 days at sea. Different types of fishing gear are used at this site, including gillnets, drift seines, and Chinese seines. Fishing occurs mainly in the ocean between Pomeroon-Waini and at the Pomeroon River mouth. Therefore, selection of this site will provide data from a diverse selection of vessel types, fishing gear, and fishing zones.
Region 3 Zeeburg	Zeeburg is the second largest landing site in Region 3 and approximately 30 to 50 fish and shrimp vessels land there. Activities at this site focus mainly on shrimping and will enhance understanding of this sub-sector.
Region 4 Riverview (Unity, Mahaica)	There are 2 landing sites at Riverview (Unity, Mahaica) at which there are approximately 60 to 80 fish and shrimp vessels. Additional information on this landing site was not collected in the Nearshore and Offshore Fisheries Study (2017–2018) (ERM 2018) but the Ecosystem Services Study (ERM/EMC 2018) identified it as an important site in the region.
Region 5 Mahaicony Bridge	This landing site has about 30 boats. This site is focused largely on commercial fishing at sea. However, there are also a few small boats that fish in the Mahaicony River. It is the third largest drift seine location in Guyana.
Region 6 Rose Hall	This is the largest pin seine location in the country. It has about 8 to 12 boats that fish for both subsistence and commercial use. Pin seine fishing is done along the shoreline and data collected from this site will improve understanding of small-scale pin seine fishing.

Landing Sites Selected for Component 2

Selected Landing Sites	Justification
Region 1 Waramuri/Haimacobra	This is the main fishing community within the Moruca Sub-Region. Haimacobra is a satellite community of Waramuri. Most of the men in the community are involved in fishing. Fishing occurs at both sides of the Moruca River mouth between Iron Punt and Cozier Canal. The Village Council will be the principal point of contact and is expected to support the selection of suitable supervisors to support data collection.
Region 1 Smith's Creek	Smith's Creek is one of the main fishing villages in Region 1 and almost all of the men in the community are involved in fishing. There are 15 to 20 small vessels that include daily trips to Waini Point. In addition, there are 3 large vessels that travel to the area between Waini Point and Iron Punt twice monthly spending 8 to 10 days at sea each time. The Village Council will be the principal point of contact and is expected to support the selection of suitable supervisors to support data collection. This site was also selected for Component 1.
Region 2 Lima	A variety of fishing gear is used at Lima including drift seines, Chinese seines, and pin seines. Some fisherfolk at this site make daily trips while others make longer trips lasting 2 to 6 days. There is commercial fishing activity along the Essequibo Coast from Lima to Charity and the Pomeroon River Mouth. In addition, there is also fishing for subsistence use in areas around the Anna Regina.
Region 2 Hampton Court	Fisherfolk use several types of fishing gear at this site including gill nets, Chinese seines, and drift seines. The fisherfolk here generally fish along the Essequibo Coast.

Selected Landing Sites	Justification
Region 3 La Grange	There are two distinguishing features of the site. Firstly, it is unique in that most of the vessels that land there use longline (Cadell) as their primary fishing gear. In addition, the site is located further from the coastline than any other site identified for the PFS. Fisherfolk access their preferred fishing zones of the coastline of Region 3 and 4 by traversing the Demerara River and passing the Guyana Shore Base Inc. in the process.
Region 3 Windsor Forrest	There are approximately 15 vessels that use Chinese seines at this landing site. Fisherfolk from this site generally fish along the Region 3 coastline.
Region 4 Ogle	There are more than 20 vessels operating at this site that all use Chinese seines. At this site there is also some pin seine fishing along the coast. A few people reportedly come to the site to fish for subsistence fishing using hand lines and cast nets.
Region 4 Riverview (Unity, Mahaica)	There are 2 landing sites at Riverview (Unity, Mahaica), which approximately 60 to 80 fish and shrimp vessels use. Additional information on this landing site was not collected in either the Nearshore and Offshore Fisheries Study (2017–2018) (ERM 2018) or the Ecosystem Services Study (ERM/EMC 2018). This site was also selected for Component 1.
Region 5 Rosignol	Rosignol is the largest landing site in Region 5 and has about 80 vessels. In general, there is significant diversity in the types of fishing gear and fishing practices at this site. There is a fisherfolk cooperative/association at this site that was engaged to support the process of selecting the vessel to participate in the study.
Region 5 Bushlot	Bushlot one of the largest landing sites in the region. The Ecosystem Services Study (ERM/EMC 2018) reports that more than 100 vessels use this site to land and that it is the second largest landing site in this region. It contains a significant amount of drift seine fisherfolk.
Region 6 Complex 66	This is the largest landing site in the Region 6 with over 300 boats involved in nearshore and deep-sea fishing. In addition, 6 to 8 boats use pin seines along the shore and, 10 to 30 persons catch shrimp and fish on the shore using hand seine daily. It is one of the largest drift seine locations in the country. There is a fisherfolk cooperative/association at this site that was engaged to support the process of selecting the vessel to participate in the study.
Region 6 Albion	Albion is the second largest fish landing site in Region 6 with approximately 150 vessels.

ATTACHMENT B COPY OF DATA SHEETS

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Data Collection Sheets for Regional Supervisors

Name: _____ **Landing Site:** _____
Date: _____ **Start Time:** _____ **End Time:** _____

Name of the Boat/ Captain's name	Type of engine + HP	Seine Type and mesh size	Fishing area	Time spent at sea	No. of times seine was soaked	Type of fish	Quantity (lb, kg, basket, bucket)	Price ($/lb, kg, basket, bucket)	Observations

Data Collection Sheets for Onboard Supervisors

Name:_____ Name of the boat:_____ Date:

Landing site :_____ _____

Name of Co-op, if any:_____ Start time:_____ End time:_____ Type of Engine: _____ HP: _____

No. of Soakings	Time of Soakings	Fishing area (GPS coordinates) at deployed area		No. of crew	Seine Type	Time of Shake/ Pull-up	Type of fish	Quantity (lb, kg, basket)	Observations and By-catch quantity

Data Collection Sheets for Biological Data

No.	Common name	Standard Length (cm)	Total Weight (g)	Code/Date of the photograph
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
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17				
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APPENDIX U

Traffic Impact Assessment

Resubmitted without changes

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Traffic Impact Assessment

ESSO EXPLORATION AND PRODUCTION GUYANA LIMITED

Guyana, 2019



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Executive Summary

Caribbean Transportation Consultancy Services (CARITRANS) Company Limited was contracted by Environmental Resources Management (ERM) on behalf of Esso Exploration and Production Guyana Limited (EEPGL) to undertake a Traffic Impact Assessment (TIA) for 47 intersections around six key points in the Georgetown area.

To conduct a TIA, base data are needed to calibrate a model of existing conditions from which the assessment can be made. Turning Movement Counts (TMCs) at intersections that were deemed to potentially be affected by EEPGL-related vehicle trips were collected between May 9 and 12, 2019. The road network was then analysed for specific future years, namely 2021 and 2023, as selected by EEPGL to represent different stages of activity for EEPGL's proposed developments. The scenarios analysed for these years included "with development" and "without development." VISSIM microsimulation software was used to develop and analyse these scenarios through simulation.

Future base traffic volumes for the 2021 and 2023 scenarios were obtained by "growing" the May 2019 measured base model volumes using an annual growth rate of 5%. Outputs from the VISSIM model included predicted traffic queues and delays, the latter used to determine the Level of Service (LOS) for each approach at the study intersections.

Generally, the bulk of the existing intersections were found to be operating at **LOS A** (free-flowing of operations) under base traffic conditions. However, of the 47 intersections for which base condition LOS modelling was conducted, it was found that some individual approaches and, in most instances, individual movements (right, left, or through) were found to be experiencing unsatisfactory LOS (i.e., an **LOS E** or **LOS F**) under base conditions. Specifically, of the 322 approaches analysed across all of the intersections, 51 (approximately 16%) were found to be operating at unsatisfactory LOS in the AM peak period under base conditions, and 48 (approximately 15%) were found to operate at unsatisfactory LOS in the PM peak period under base conditions. These typically occurred at signalized intersections, those with high intercity connectors, and around minibus stands. In such areas, development traffic would be better served through the consideration of alternative routes.

The additional trips associated with development are relatively low compared to current base and projected future traffic, resulting in projected negligible impact on the existing road network from the addition of development-related traffic.

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Introduction

Caribbean Transportation Consultancy Services (CARITRANS) Company Limited was contracted by Environmental Resources Management (ERM) on behalf of Esso Exploration and Production Guyana Limited (EEPGL) to undertake a Traffic Impact Assessment (TIA) for 47 intersections around six key points in the Georgetown area. The TIA was conducted to support an Environmental Impact Assessment (EIA) for EEGPL's proposed Payara Development Project, and involved assessment of the potential impacts from future projected EEPGL-related traffic at intersections that were deemed to potentially be affected by EEPGL-related vehicle trips (inclusive of traffic related to the Payara Development Project and other projected EEPGL-related activities; collectively referred to herein as "the development"). The intersections studied were generally clustered around six key locations in the Georgetown area (Figure 1).



Figure 1: Location plan of the six key locations around which study intersections were clustered

The TIA involved the analysis and assessment of conditions for the surrounding road network with the existing 2019 "base" traffic, and assessment of the potential impacts the proposed development would have on projected traffic conditions in 2021 and 2023.

Methodology

In order to assess the impact of the proposed development on the existing road network, the base or current year operating conditions were established. Base data were collected via Turning Movement Counts (TMCs) at fifty (50) intersections, grouped around six (6) key locations:

- *Marriott*
- *EEPGL Office Complex / Ogle*
- *Contractor Commercial Port A*
- *Contractor Inland Storage Yard*
- *Contractor Shorebase B*
- *Ramada Intersection*

The road network was then analysed for specific future years, namely 2021 and 2023, to represent different stages of activity for EEPGL's proposed development. A growth factor of five percent (5%) per annum was used to take the current year base data and project it to future years.

The trips generated by the proposed development were provided by ERM as daily volumes. The directional design hourly volume (DDHV) formula with general ranges of the 'K' (the proportion of daily traffic in the peak hour) and 'D' (the proportion of peak hour traffic travelling in the peak direction of flow) values were taken from the Institute of Transportation Engineers (ITE) Traffic Engineering Handbook 6th Edition, 2008 and used to calculate the volume of trips that occurred specifically during the morning and afternoon peak hours.

The analyses have been undertaken to assess traffic conditions for the noted future years for "without development" and "with development" scenarios. VISSIM microsimulation software was used to develop and analyse these models through simulation.

Capacity and Level of Service Analysis

Level of Service (LOS) is a key performance factor that is used to evaluate the operation of an intersection and is measured on a scale of A to F, A being the least congested and F being the most congested. It is a measure of the level of road-user comfort in traversing a roadway facility, usually taken as a measure of the delay experienced on/at the particular facility. The results of the TIA, presented by key location, are discussed below. The tables provided in the discussions (Tables 1-30) show the delays and queues calculated by the VISSIM analysis and the corresponding LOS for each approach at each study intersection.

For each of the key intersection's associated study intersections, separate tables are provided presenting results for the following analyses:

- *LOS for Base Model –AM Peak (2019)*
- *LOS for Projected Model – AM Peak (2021 and 2021 with projected development trips)*
- *LOS for Projected Model - AM Peak (2023 and 2023 with projected development trips)*
- *LOS for Base Model - PM Peak (2019)*
- *LOS for Projected Model – PM Peak (2021 and 2021 with projected development trips)*
- *LOS for Projected Model - PM Peak (2023 and 2023 with projected development trips)*

Marriott



Figure 2: Marriott location and corresponding study intersections

- *M1-Battery Road at Water Street*
- *M2-Battery Street at Fort Street*
- *M3-Battery Road at High Street*
- *M4-High Street at Wights Lane*
- *M5-High Street at Young Street*
- *M6-Fort Street at Wights Lane*
- *M7-Barrack Street at High Street*
- *M8-Fort Street at Barrack Street*
- *M9-Water Street at Barrack Street*
- *M10-Camp Street at Seawall Road*
- *M11-Camp Street at Carifesta Avenue and Young Street*

At the Marriott location, the morning peak indicates a general **LOS A**. However, at the M11 intersection the high delays indicate high congestion at the signalized intersections, as it was observed to have high queues that sometimes spilled over to other intersections. This was noted to occur because of the volumes heading into Georgetown; the reverse was seen to occur in the afternoon peak, as cars were leaving Georgetown. Police presence was commonplace at peak hours at the M11 intersection to assist with traffic flow.

LOS delay analysis indicates that there are no impacts on capacity at the Marriott location due to the additional projected development trips in both 2021 and 2023. Notably, the trips projected to be generated by the development are negligible compared to the existing traffic volumes, and do not result in deterioration of performance at the associated intersections. The results for the Marriott location are provided in Tables 1-6.

Table 1: Level of Service for Base Model - Marriott AM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
M1	SB	Right	0	27	44	1	A
		Left	0	27	4	1	A
		Through	0	27	168	2	A
	EB	Through	0	4	36	2	A
		Right	0	4	11	1	A
	WB	Right	0	25	68	3	A
		Through	0	25	192	2	A
		U-Turn	0	25	44	3	A
		Left	0	28	8	2	A
	NB	Through	0	7	11	1	A
		Right	0	7	46	1	A
		U-Turn	0	7	48	0	A
M2	EB	Through	2	21	128	10	A
	WB	Through	0	12	277	1	A
	NB	Left	4	29	36	18	C
		Right	4	30	75	20	C
M3	EB	Through	37	149	120	70	F
		Right	37	149	76	90	F
	WB	Through	17	152	136	21	C
		Left	17	152	305	22	C
	NB	Left	2	51	141	4	A
		Right	2	52	88	6	A
		U-Turn	2	51	5	40	E
M4	SB	Through	18	60	340	25	C
		Left	18	60	41	17	C
	NB	Through	0	21	74	4	A
		Left	1	22	44	7	A
	WB	Right	2	98	161	12	B
		Left	2	98	357	11	B
M5	SB	Right	0	31	49	2	A
		Through	0	35	647	0	A
	NB	Through	0	7	119	1	A
		Right	0	7	8	1	A
M6	NB	Through	2	15	56	18	C
	WB	Right	0	5	56	5	A
M7	NB	U-Turn	0	17	1	1	A
		Right	0	17	63	3	A
		Left	0	17	77	1	A
		Through	0	17	97	1	A
	WB	Left	1	39	136	3	A
		Through	1	39	124	6	A
		Right	1	39	13	4	A
	EB	Right	0	15	21	2	A
		Through	0	15	70	4	A
		Left	0	15	15	1	A
	SB	Through	1	52	520	4	A
		Left	1	51	75	3	A
		Right	1	51	47	4	A
		U-Turn	1	51	2	3	A
M8	NB	Through	0	4	8	1	A
		Right	0	4	7	1	A
		Left	0	4	2	0	A
	WB	Left	0	9	46	1	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
		Right	0	9	31	1	A
		U-Turn	0	9	5	1	A
		Through	0	9	165	1	A
	EB	Right	0	13	86	2	A
		Left	0	13	18	1	A
		Through	0	13	94	1	A
M9	NB	Through	0	26	54	0	A
		Right	0	4	180	1	A
	SB	Through	0	15	215	1	A
		Left	0	15	19	1	A
	WB	Left	0	10	116	1	A
		Right	0	10	51	3	A
M10	WB	Through	0	21	409	2	A
		Left	0	21	57	1	A
	EB	Through	0	16	151	1	A
		Right	0	16	56	3	A
	NB	Right	0	30	109	5	A
		Left	0	30	46	3	A
M11	NB	Right	12	63	31	47	D
		Through	12	63	114	48	D
		Left	5	52	64	8	A
	WB	Left	394	510	726	55	D
		Right	392	510	41	74	E
		Through	392	510	410	73	E
	SB	Through	6	37	23	45	D
		Left	6	37	33	43	D
		Right	6	37	54	44	D
	EB	Right	3	34	12	23	C
		Through	3	34	71	24	C
		Left	3	34	1	7	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)

Q_{max} = Maximum queue length (meters)

Vehicles = Number of vehicles (volume)

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

Table 2: Level of Service for Projected Model - Marriott AM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
M1	SB	Right	5	5	1	2	A	A
		Left	5	5	3	8	A	A
		Through	5	5	3	5	A	A
	EB	Through	19	18	4	13	A	B
		Right	19	18	2	4	A	A
	WB	Right	4	7	5	13	A	B
		Through	4	7	4	10	A	A
		U-Turn	4	7	7	20	A	C
		Left	4	8	4	3	A	A
	NB	Through	13	16	2	9	A	A
		Right	13	16	4	18	A	C
		U-Turn	13	16	1	12	A	B
M2	EB	Through	30	36	38	65	E	F
	WB	Through	4	8	5	13	A	B
	NB	Left	35	38	68	75	F	F
		Right	35	39	92	113	F	F
M3	EB	Through	109	115	126	162	F	F
		Right	109	115	152	181	F	F
	WB	Through	227	245	46	55	E	F
		Left	227	245	47	52	E	F
	NB	Left	17	19	4	9	A	A
		Right	18	20	7	11	A	B
		U-Turn	17	19	47	54	E	F
M4	SB	Through	31	32	28	29	D	D
		Left	31	32	18	23	C	C
	NB	Through	6	7	5	8	A	A
		Left	7	8	8	9	A	A
	WB	Right	144	145	15	19	B	C
		Left	144	145	13	18	B	C
M5	SB	Right	1	1	2	3	A	A
		Through	1	1	0	1	A	A
	NB	Through	59	59	3	6	A	A
		Right	59	59	1	3	A	A
M6	NB	Through	27	35	64	57	F	F
	WB	Right	14	19	60	86	F	F
M7	NB	U-Turn	35	31	3	3	A	A
		Right	35	31	2	4	A	A
		Left	35	31	1	2	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Through	35	31	1	1	A	A
	WB	Left	25	22	2	2	A	A
		Through	25	22	5	5	A	A
		Right	25	22	4	4	A	A
	EB	Right	18	19	2	3	A	A
		Through	18	19	3	3	A	A
		Left	18	19	1	1	A	A
	SB	Through	1	2	4	4	A	A
		Left	1	2	3	3	A	A
		Right	1	2	4	4	A	A
		U-Turn	1	2	3	3	A	A
M8	NB	Through	3	3	1	1	A	A
		Right	3	3	1	1	A	A
		Left	3	3	1	1	A	A
	WB	Left	0	0	1	1	A	A
		Right	0	0	1	2	A	A
		U-Turn	0	0	0	0	A	A
		Through	0	0	1	0	A	A
	EB	Right	9	9	1	1	A	A
		Left	9	9	1	1	A	A
		Through	9	9	1	1	A	A
M9	NB	Through	9	11	0	0	A	A
		Right	13	14	1	1	A	A
	SB	Through	0	8	1	1	A	A
		Left	0	8	1	1	A	A
	WB	Left	0	0	1	1	A	A
		Right	0	0	3	3	A	A
M10	WB	Through	100	97	3	4	A	A
		Left	100	97	2	5	A	A
	EB	Through	0	0	1	1	A	A
		Right	0	0	4	3	A	A
	NB	Right	16	23	5	6	A	A
		Left	16	23	4	4	A	A
M11	NB	Right	25	24	50	48	D	D
		Through	25	24	49	49	D	D
		Left	17	17	8	9	A	A
	WB	Left	429	432	53	55	D	D
		Right	428	431	74	74	E	E
		Through	428	431	72	73	E	E

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
	SB	Through	6	6	49	48	D	D
		Left	6	6	49	47	D	D
		Right	6	6	46	50	D	D
	EB	Right	5	5	36	33	D	C
		Through	5	5	35	34	C	C
		Left	5	5	6	17	A	B

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 3: Level of Service for Projected Model - Marriott AM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
M1	SB	Right	6	8	2	5	A	A
		Left	6	8	10	10	A	A
		Through	6	8	5	6	A	A
	EB	Through	28	39	14	24	B	C
		Right	28	39	6	33	A	D
	WB	Right	8	14	12	9	B	A
		Through	8	14	8	11	A	B
		U-Turn	8	14	17	8	C	A
		Left	9	15	4	10	A	A
	NB	Through	16	38	7	11	A	B
		Right	16	38	13	26	B	D
		U-Turn	16	38	11	17	B	C
M2	EB	Through	38	43	54	50	F	E
	WB	Through	8	19	8	11	A	B
	NB	Left	36	37	94	66	F	F
		Right	37	38	104	81	F	F
M3	EB	Through	119	123	141	151	F	F
		Right	119	123	169	175	F	F
	WB	Through	321	331	50	56	E	F
		Left	321	331	53	55	F	F
	NB	Left	23	28	7	10	A	A
		Right	24	29	9	12	A	B
		U-Turn	23	28	55	55	F	F
M4	SB	Through	33	33	28	28	D	D
		Left	33	33	18	18	C	C
	NB	Through	8	10	7	9	A	A
		Left	9	10	8	9	A	A
	WB	Right	184	236	19	23	C	C
		Left	184	236	17	23	C	C
M5	SB	Right	0	1	3	3	A	A
		Through	0	1	1	1	A	A
	NB	Through	75	95	5	11	A	B
		Right	75	95	2	5	A	A
M6	NB	Through	27	43	46	93	E	F
	WB	Right	15	17	88	63	F	F
M7	NB	U-Turn	46	56	3	2	A	A
		Right	46	56	2	2	A	A
		Left	46	56	1	1	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Through	46	56	1	1	A	A
	WB	Left	35	40	3	2	A	A
		Through	35	40	6	5	A	A
		Right	35	40	5	5	A	A
	EB	Right	27	32	2	3	A	A
		Through	27	32	3	3	A	A
		Left	27	32	1	1	A	A
	SB	Through	1	4	5	5	A	A
		Left	1	4	3	3	A	A
		Right	1	4	4	6	A	A
		U-Turn	1	4	3	2	A	A
M8	NB	Through	4	6	1	1	A	A
		Right	4	6	1	1	A	A
		Left	4	6	0	0	A	A
	WB	Left	0	1	1	1	A	A
		Right	0	1	2	2	A	A
		U-Turn	0	1	1	0	A	A
		Through	0	1	1	0	A	A
	EB	Right	15	20	1	1	A	A
		Left	15	20	1	1	A	A
		Through	15	20	1	1	A	A
M9	NB	Through	17	27	0	0	A	A
		Right	25	27	1	1	A	A
	SB	Through	11	13	1	1	A	A
		Left	11	13	1	1	A	A
	WB	Left	0	0	1	1	A	A
		Right	0	0	3	3	A	A
M10	WB	Through	168	196	8	9	A	A
		Left	168	196	7	9	A	A
	EB	Through	0	0	1	1	A	A
		Right	0	0	4	4	A	A
	NB	Right	47	49	7	7	A	A
		Left	47	49	5	6	A	A
M11	NB	Right	32	37	54	58	D	E
		Through	32	37	55	55	D	D
		Left	23	27	12	12	B	B
	WB	Left	442	445	54	54	D	D
		Right	442	444	73	75	E	E
		Through	442	444	73	75	E	E

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
	SB	Through	5	7	48	54	D	D
		Left	5	7	46	51	D	D
		Right	5	7	48	52	D	D
	EB	Right	5	5	37	42	D	D
		Through	5	5	35	36	C	D
		Left	5	5	8	19	A	B

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 4: Level of Service for Base Model - Marriott PM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
M1	SB	Right	17	27	4	1	A
		Left	17	27	32	1	A
		Through	17	27	5	2	A
	EB	Through	30	111	0	1	A
		Right	30	111	29	0	A
	WB	Right	1	13	11	3	A
		Through	1	13	16	2	A
		U-Turn	2	13	3	5	A
		Left	1	16	0	1	A
	NB	Through	157	256	0	0	A
		Right	157	256	16	3	A
		U-Turn	157	256	5	1	A
M2	EB	Through	68	84	41	9	A
	WB	Through	0	9	17	3	A
	NB	Left	60	78	14	9	A
		Right	61	80	36	9	A
M3	EB	Through	142	166	32	24	C
		Right	142	166	22	30	D
	WB	Through	380	503	5	8	A
		Left	380	503	30	12	B
	NB	Left	30	45	12	3	A
		Right	31	47	6	9	A
		U-Turn	30	45	1	26	D
M4	SB	Through	45	57	43	19	C
		Left	45	57	5	12	B
	NB	Through	10	18	8	2	A
		Left	11	19	13	3	A
	WB	Right	397	502	16	8	A
		Left	397	502	40	8	A
M5	SB	Right	13	30	69	1	A
		Through	15	34	12	0	A
	NB	Through	132	218	24	0	A
		Right	132	218	2	0	A
M6	NB	Through	47	90	3	4	A
	WB	Right	77	100	56	7	A
M7	NB	U-Turn	74	173	0	1	A
		Right	74	173	51	1	A
		Left	74	173	19	1	A
		Through	74	173	51	1	A
	WB	Left	46	127	97	1	A
		Through	46	127	60	2	A
		Right	46	127	2	3	A
	EB	Right	11	34	29	2	A
		Through	11	34	52	1	A
		Left	11	34	4	1	A
	SB	Through	0	5	9	2	A
		Left	0	4	3	1	A
		Right	0	4	1	4	A
		U-Turn	0	4	0	0	A
M8	NB	Through	0	2	9	0	A
		Right	0	2	2	1	A
		Left	0	2	5	0	A
	WB	Left	3	14	10	1	A
		Right	3	14	2	1	A
		U-Turn	3	14	1	0	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
		Through	3	14	64	0	A
	EB	Right	6	23	23	1	A
		Left	6	23	6	1	A
		Through	6	23	85	0	A
M9	NB	Through	56	171	36	0	A
		Right	56	174	108	0	A
	SB	Through	0	6	31	1	A
		Left	0	6	9	6	A
	WB	Left	13	42	40	1	A
		Right	13	42	24	2	A
M10	WB	Through	277	503	116	2	A
		Left	277	502	54	1	A
	EB	Through	0	12	26	1	A
		Right	0	12	11	3	A
	NB	Right	0	22	36	4	A
		Left	0	22	7	3	A
M11	NB	Right	64	98	3	40	D
		Through	64	98	28	45	D
		Left	54	86	27	8	A
	WB	Left	421	509	254	53	D
		Right	419	509	15	60	E
		Through	419	509	82	61	E
	SB	Through	81	120	10	89	F
		Left	81	120	7	64	E
		Right	81	120	30	84	F
	EB	Right	1	26	4	28	C
		Through	1	26	14	30	C
		Left	1	26	1	4	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)

Q_{max} = Maximum queue length (meters)

Vehicles = Number of vehicles (volume)

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

Table 5: Level of Service for Projected Model - Marriott PM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
M1	SB	Right	13	13	1	1	A	A
		Left	13	13	1	0	A	A
		Through	13	13	1	2	A	A
	EB	Through	22	24	3	3	A	A
		Right	22	24	1	1	A	A
	WB	Right	0	2	3	3	A	A
		Through	0	2	2	2	A	A
		U-Turn	0	2	3	3	A	A
		Left	0	2	2	1	A	A
	NB	Through	104	103	0	0	A	A
		Right	104	103	2	2	A	A
		U-Turn	104	103	1	1	A	A
M2	EB	Through	54	54	8	6	A	A
	WB	Through	0	0	3	3	A	A
	NB	Left	53	54	11	13	B	B
		Right	54	55	13	14	B	B
M3	EB	Through	126	126	31	32	D	D
		Right	126	126	35	36	D	E
	WB	Through	92	93	4	6	A	A
		Left	92	93	12	12	B	B
	NB	Left	13	26	10	8	A	A
		Right	13	27	9	12	A	B
		U-Turn	13	26	27	28	D	D
M4	SB	Through	40	41	39	40	E	E
		Left	40	41	21	16	C	C
	NB	Through	4	7	5	5	A	A
		Left	5	7	4	5	A	A
	WB	Right	328	335	17	26	C	D
		Left	328	335	17	23	C	C
M5	SB	Right	13	13	5	5	A	A
		Through	15	16	3	2	A	A
	NB	Through	141	138	3	5	A	A
		Right	141	138	2	5	A	A
M6	NB	Through	24	29	18	6	C	A
	WB	Right	79	68	10	14	A	B
M7	NB	U-Turn	99	96	2	3	A	A
		Right	99	96	3	3	A	A
		Left	99	96	2	3	A	A
		Through	99	96	3	4	A	A
	WB	Left	54	47	2	2	A	A
		Through	54	47	7	6	A	A
		Right	54	47	1	2	A	A
	EB	Right	32	28	2	3	A	A
		Through	32	28	3	5	A	A
		Left	32	28	2	1	A	A
	SB	Through	0	2	4	4	A	A
		Left	0	1	1	1	A	A
		Right	0	1	7	6	A	A
		U-Turn	0	1	0	0	A	A
M8	NB	Through	0	0	0	1	A	A
		Right	0	0	0	0	A	A
		Left	0	0	0	0	A	A
	WB	Left	1	0	1	1	A	A
		Right	1	0	1	1	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		U-Turn	1	0	0	0	A	A
		Through	1	0	0	0	A	A
	EB	Right	15	15	1	1	A	A
		Left	15	15	1	0	A	A
		Through	15	15	0	1	A	A
M9	NB	Through	41	44	0	0	A	A
		Right	37	40	1	1	A	A
	SB	Through	1	0	1	1	A	A
		Left	1	0	1	0	A	A
	WB	Left	3	3	1	1	A	A
		Right	3	3	2	2	A	A
M10	WB	Through	0	0	1	1	A	A
		Left	0	0	0	0	A	A
	EB	Through	0	0	0	1	A	A
		Right	0	0	1	1	A	A
	NB	Right	0	0	3	3	A	A
		Left	0	0	2	2	A	A
M11	NB	Right	54	54	46	44	D	D
		Through	54	54	47	46	D	D
		Left	45	45	9	8	A	A
	WB	Left	253	255	25	25	C	C
		Right	251	253	39	40	D	D
		Through	251	253	41	42	D	D
	SB	Through	19	21	45	52	D	D
		Left	19	21	45	47	D	D
		Right	19	21	47	50	D	D
	EB	Right	4	5	42	46	D	D
		Through	4	5	40	44	D	D
		Left	4	5	19	12	B	B

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 6: Level of Service for Projected Model - Marriott PM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length		Delay		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
M1	SB	Right	0	0	0	1	A	A
		Left	0	0	0	0	A	A
		Through	0	0	1	2	A	A
	EB	Through	0	0	2	3	A	A
		Right	0	0	1	1	A	A
	WB	Right	0	0	3	3	A	A
		Through	0	0	2	2	A	A
		U-Turn	0	0	3	3	A	A
		Left	0	0	2	1	A	A
	NB	Through	1	0	0	0	A	A
		Right	1	0	2	2	A	A
		U-Turn	1	0	1	1	A	A
M2	EB	Through	2	0	0	6	A	A
	WB	Through	0	0	1	3	A	A
	NB	Left	0	0	0	13	A	A
		Right	0	0	1	14	A	A
M3	EB	Through	8	2	5	32	A	A
		Right	8	2	8	36	A	A
	WB	Through	3	1	4	6	A	A
		Left	3	1	3	12	A	A
	NB	Left	3	0	2	8	A	A
		Right	3	1	4	12	A	A
		U-Turn	3	0	7	28	A	A
M4	SB	Thorugh	9	6	24	40	C	C
		Left	8	6	15	16	B	A
	NB	Through	1	41	3	5	A	A
		Left	2	1	4	5	A	A
	WB	Right	18	35	10	26	A	C
		Left	18	35	9	23	A	C
M5	SB	Right	1	2	3	5	A	A
		Through	1	2	0	2	A	A
	NB	Through	8	1	2	5	A	A
		Right	8	1	2	5	A	A
M6	NB	Through	0	0	1	6	A	A
	WB	Right	0	0	1	14	A	A
M7	NB	U-Turn	10	13	5	3	A	A
		Right	10	13	7	3	A	A
		Left	10	13	5	3	A	A
		Through	10	13	7	4	A	A
	WB	Left	5	6	5	2	A	A
		Through	5	7	16	6	C	C

Site	Direction	Movement	Queue Length		Delay		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Right	5	6	15	2	B	C
	EB	Right	7	8	16	3	C	C
		Through	7	8	27	5	D	D
		Left	7	8	18	1	C	C
	SB	Through	30	44	30	4	D	D
		Left	29	43	25	1	C	D
		Right	29	43	28	6	D	D
		U-Turn	29	43	31	0	D	C
M8	NB	Through	0	0	0	1	A	A
		Right	0	0	0	0	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	6	1	1	A	A
		Right	0	6	1	1	A	A
		U-Turn	0	6	1	0	A	A
		Through	0	6	0	0	A	A
	EB	Right	0	0	1	1	A	A
		Left	0	0	1	0	A	A
		Through	0	0	1	1	A	A
M9	NB	Through	0	10	0	0	A	A
		Right	0	9	0	1	A	A
	SB	Through	0	5	1	1	A	A
		Left	0	5	1	0	A	A
	WB	Left	0	5	1	1	A	A
		Right	0	5	2	2	A	A
M10	WB	Through	0	0	1	1	A	A
		Left	0	0	0	0	A	A
	EB	Through	0	0	0	1	A	A
		Right	0	0	1	1	A	A
	NB	Right	0	0	3	3	A	A
		Left	0	0	2	2	A	A
M11	NB	Right	14	14	47	44	D	D
		Through	14	14	47	46	D	D
		Left	7	7	9	8	A	A
	WB	Left	48	47	26	25	C	C
		Right	45	44	39	40	D	D
		Through	45	44	41	42	D	D
	SB	Through	6	7	45	52	D	D
		Left	6	7	45	47	D	D
		Right	6	7	47	50	D	D
	EB	Right	13	15	45	46	D	D
		Through	13	15	44	44	D	D
		Left	13	15	18	12	B	B

Table 7: Level of Service for Projected Model - Marriott PM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
M1	SB	Right	12	14	0	0	A	A
		Left	12	14	0	0	A	A
		Through	12	14	2	1	A	A
	EB	Through	16	26	2	2	A	A
		Right	16	26	1	1	A	A
	WB	Right	0	3	3	3	A	A
		Through	0	3	2	2	A	A
		U-Turn	0	3	3	2	A	A
		Left	0	3	2	2	A	A
	NB	Through	117	125	0	0	A	A
		Right	117	125	2	2	A	A
		U-Turn	116	125	1	1	A	A
M2	EB	Through	51	55	7	5	A	A
	WB	Through	4	1	3	3	A	A
	NB	Left	52	54	13	11	B	B
		Right	53	55	18	14	C	B
M3	EB	Through	121	125	33	29	D	D
		Right	121	125	37	30	E	D
	WB	Through	96	106	7	5	A	A
		Left	96	106	11	11	B	B
	NB	Left	14	23	3	3	A	A
		Right	14	24	10	9	A	A
		U-Turn	14	23	28	19	D	C
M4	SB	Through	39	41	35	35	D	D
		Left	39	41	28	23	D	C
	NB	Through	5	7	2	2	A	A
		Left	6	8	3	3	A	A
	WB	Right	312	332	14	12	B	B
		Left	312	332	13	13	B	B
M5	SB	Right	14	13	3	3	A	A
		Through	16	15	1	1	A	A
	NB	Through	101	122	1	1	A	A
		Right	101	122	1	3	A	A
M6	NB	Through	29	34	26	22	D	C
	WB	Right	82	76	16	12	C	B
M7	NB	U-Turn	49	67	1	1	A	A
		Right	49	67	3	1	A	A
		Left	49	67	3	1	A	A
		Through	49	67	1	2	A	A
	WB	Left	19	34	1	1	A	A
		Through	19	34	2	2	A	A
		Right	19	34	2	2	A	A
	EB	Right	10	19	2	2	A	A
		Through	10	19	2	1	A	A
		Left	10	19	1	1	A	A
	SB	Through	0	1	2	2	A	A
		Left	0	0	1	0	A	A
		Right	0	0	2	2	A	A
		U-Turn	0	0	0	1	A	A
M8	NB	Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	WB	Left	4	1	0	0	A	A
		Right	4	1	2	1	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		U-Turn	4	1	1	0	A	A
		Through	4	1	0	0	A	A
	EB	Right	5	5	1	1	A	A
		Left	5	5	1	1	A	A
		Through	5	5	1	1	A	A
M9	NB	Through	46	51	1	1	A	A
		Right	42	50	1	1	A	A
	SB	Through	3	0	1	1	A	A
		Left	3	0	0	1	A	A
	WB	Left	11	8	1	1	A	A
		Right	11	8	4	4	A	A
M10	WB	Through	0	0	1	1	A	A
		Left	0	0	0	0	A	A
	EB	Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A
	NB	Right	0	0	4	4	A	A
		Left	0	0	3	3	A	A
M11	NB	Right	55	58	57	56	E	E
		Through	55	58	51	51	D	D
		Left	46	48	11	11	B	B
	WB	Left	270	288	40	39	D	D
		Right	267	284	48	47	D	D
		Through	267	284	47	47	D	D
	SB	Through	20	24	52	53	D	D
		Left	20	24	50	45	D	D
		Right	20	24	50	48	D	D
	EB	Right	2	1	31	31	C	C
		Through	2	1	33	30	C	C
		Left	2	1	7	10	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 8: Level of Service for Projected Model - Marriott PM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length		Delay		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
M1	SB	Right	6	1	1	0	A	A
		Left	6	1	0	0	A	A
		Through	6	1	2	1	A	A
	EB	Through	8	1	2	2	A	A
		Right	8	1	1	1	A	A
	WB	Right	0	0	3	3	A	A
		Through	0	0	2	2	A	A
		U-Turn	0	0	3	3	A	A
		Left	0	0	2	2	A	A
	NB	Through	60	9	0	0	A	A
		Right	60	9	2	2	A	A
		U-Turn	60	9	1	1	A	A
M2	EB	Through	26	4	4	0	A	A
	WB	Through	2	0	2	1	A	A
	NB	Left	26	1	7	0	A	A
		Right	27	1	10	1	A	A
M3	EB	Through	64	11	19	4	C	A
		Right	64	11	22	7	C	A
	WB	Through	50	7	4	2	A	A
		Left	50	7	7	3	A	A
	NB	Left	8	4	2	2	A	A
		Right	8	4	7	4	A	A
		U-Turn	8	4	18	9	C	A
M4	SB	Thorugh	24	10	29	24	D	C
		Left	24	10	21	18	C	C
	NB	Through	3	1	2	2	A	A
		Left	3	1	3	3	A	A
	WB	Right	165	28	11	9	B	A
		Left	165	28	11	8	B	A
M5	SB	Right	7	0	2	1	A	A
		Through	8	0	1	0	A	A
	NB	Through	53	9	1	1	A	A
		Right	53	9	1	0	A	A
M6	NB	Through	15	0	13	1	B	A
	WB	Right	41	0	9	1	A	A
M7	NB	U-Turn	26	4	1	1	A	A
		Right	26	4	3	3	A	A
		Left	26	4	2	1	A	A
		Through	26	4	2	2	A	A
	WB	Left	9	3	1	1	A	A
		Through	9	3	3	4	A	A

Site	Direction	Movement	Queue Length		Delay		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Right	9	3	3	3	A	A
	EB	Right	5	1	2	4	A	A
		Through	5	2	3	6	A	A
		Left	5	1	2	2	A	A
	SB	Through	1	2	3	5	A	A
		Left	1	1	2	3	A	A
		Right	1	1	3	4	A	A
		U-Turn	1	1	5	3	A	A
M8	NB	Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	WB	Left	2	0	0	1	A	A
		Right	2	0	1	1	A	A
		U-Turn	2	0	1	1	A	A
		Through	2	0	0	0	A	A
	EB	Right	3	0	1	1	A	A
		Left	3	0	1	1	A	A
		Through	3	0	1	1	A	A
M9	NB	Through	23	3	0	0	A	A
		Right	21	3	1	1	A	A
	SB	Through	1	0	1	1	A	A
		Left	1	0	1	1	A	A
	WB	Left	6	0	1	1	A	A
		Right	6	0	4	3	A	A
M10	WB	Through	0	0	1	1	A	A
		Left	0	0	0	0	A	A
	EB	Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A
	NB	Right	0	0	4	4	A	A
		Left	0	0	3	2	A	A
M11	NB	Right	36	19	52	48	D	D
		Through	36	19	50	51	D	D
		Left	28	11	11	12	B	B
	WB	Left	196	147	42	47	D	D
		Right	191	141	49	53	D	D
		Through	191	141	49	52	D	D
	SB	Through	13	8	50	47	D	D
		Left	13	8	46	38	D	D
		Right	13	8	49	46	D	D
	EB	Right	3	4	30	32	C	C
		Through	3	4	33	33	C	C
		Left	3	4	7	11	A	B

EEPGL Office Complex / Ogle



Figure 3: EEPGL Office Complex / Ogle location and corresponding study intersections

- *OGL 1-Ogle Airstrip Road at unnamed Street*
- *OGL 2-Ogle Airstrip Road at Railway Embankment Road*
- *OGL 3-Ogle Airstrip Road at Rupert Craig Highway*
- *OGL 5-unnamed streets*
- *OGL 6-Railway Embankment Road at unnamed street*
- *GC-1-Grand Coastal Intersection at Rupert Craig Highway*

The LOS observed at most intersections is A. However, this location's operations are characterized by heavy east-west peak volumes, as it is one of the major conduits for traffic into and out of Georgetown from communities to the east. As such, OGL 2 and OGL 6 typically experience high delays. Police presence was commonplace at peak hours at the signalized intersection (OGL 3) to aid operations.

LOS delay analysis indicates that there are no impacts on capacity at the EEPGL Office Complex / Ogle location due to the additional projected development trips in both 2021 and 2023. Notably, the trips projected to be generated by the development are negligible compared to the existing traffic volumes, and do not result in deterioration of performance at the associated intersections. The results for the EEPGL Office Complex / Ogle location are provided in Tables 7-13.

Table 9: Level of Service for Base Model – EEPGL Office Complex / Ogle AM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
OGL 6	EB	Left	108	338	39	20	C
		Through	108	338	535	22	C
		Right	108	338	99	34	D
	WB	Right	105	500	96	23	C
		Through	105	500	720	16	C
		Left	105	500	43	15	B
	NB	Through	32	122	40	122	F
		Left	32	122	56	94	F
		Right	32	122	34	93	F
OGL 5	NB	Left	0	8	2	1	A
		Right	0	8	5	6	A
		Through	0	8	8	2	A
	EB	Right	0	9	31	1	A
		Through	0	8	197	1	A
		Left	0	8	55	1	A
	WB	Left	0	14	25	1	A
		Through	0	14	176	1	A
		Right	0	14	78	2	A
	SB	Through	0	22	25	4	A
		Right	0	22	33	4	A
		Left	0	22	81	2	A
OGL 1	NB	Right	0	10	33	2	A
		Left	0	10	37	1	A
	WB	Left	0	5	4	0	A
		Through	0	5	10	1	A
		Right	0	5	171	0	A
	SB	Left	0	18	22	3	A
		Right	0	18	74	3	A
	EB	Through	0	1	251	0	A
		Left	0	1	29	0	A
OGL 2	WB	Right	16	196	3	11	B
		Through	16	196	846	3	A
		Left	16	196	5	2	A
	SB	Left	10	69	38	37	E
		Right	10	69	21	51	F
		Through	10	69	89	40	E
	EB	Through	1	87	560	1	A
		Left	1	87	1	0	A
		Right	1	87	3	9	A
	NB	Right	2	23	12	35	D
		Through	2	23	13	26	D
		Left	2	23	14	17	C
OGL 3	SB	Right	88	120	10	252	F
		Through	88	120	145	262	F
		Left	88	120	2	271	F
	EB	Left	55	185	203	55	D
		Right	55	185	3	66	E
		Through	55	185	585	56	E
	NB	Through	1	18	15	50	D
		Left	1	18	2	12	B
	WB	Right	9	54	93	31	C
		Through	9	54	249	29	C
		Left	9	54	2	17	B
GC 1	SB	Through	0	8	2	2	A
		Left	0	8	6	0	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
		Right	0	8	13	4	A
	NB	Through	0	7	2	4	A
		Right	0	7	7	1	A
		Left	0	6	12	1	A
	WB	Right	0	21	53	3	A
		Left	0	21	73	1	A
		U-Turn	0	21	13	1	A
		Through	0	21	326	1	A
	EB	Left	0	28	28	1	A
		Right	0	28	66	3	A
		Through	0	28	436	1	A
		U-Turn	0	28	20	1	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)

Q_{max} = Maximum queue length (meters)

Vehicles = Number of vehicles (volume)

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

Table 10: Level of Service for Projected Model – EEPGL Office Complex / Ogle AM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
OGL 6	EB	Left	172	161	28	29	D	D
		Through	172	161	30	31	D	D
		Right	172	161	48	46	E	E
	WB	Right	149	215	27	36	D	E
		Through	149	215	19	23	C	C
		Left	149	215	19	27	C	D
	NB	Through	114	126	278	269	F	F
		Left	114	126	246	272	F	F
		Right	114	126	250	263	F	F
OGL 5	NB	Left	1	0	1	2	A	A
		Right	1	0	6	21	A	C
		Through	1	0	51	28	F	D
	EB	Right	5	5	11	8	B	A
		Through	5	5	7	6	A	A
		Left	5	5	12	10	B	A
	WB	Left	29	22	16	8	C	A
		Through	29	22	11	9	B	A
		Right	29	22	13	11	B	B
	SB	Through	3	3	12	11	B	B
		Right	3	3	14	10	B	A
		Left	3	3	8	6	A	A
OGL 1	NB	Right	0	0	2	2	A	A
		Left	0	0	2	1	A	A
	WB	Left	1	0	0	0	A	A
		Through	1	0	1	1	A	A
		Right	1	0	0	0	A	A
	SB	Left	1	1	4	3	A	A
		Right	1	1	4	4	A	A
	EB	Through	0	0	0	0	A	A
		Left	0	0	0	0	A	A
OGL 2	WB	Right	46	105	19	43	C	E
		Through	46	105	8	16	A	C
		Left	46	105	9	28	A	D
	SB	Left	29	57	81	147	F	F
		Right	29	57	106	181	F	F
		Through	29	57	83	158	F	F
	EB	Through	2	3	1	1	A	A
		Left	2	3	0	0	A	A
		Right	2	3	15	13	B	B
	NB	Right	3	5	51	79	F	F
		Through	3	5	44	68	E	F
		Left	3	5	43	63	E	F
OGL 3	SB	Right	94	96	268	282	F	F
		Through	94	96	277	292	F	F
		Left	94	96	279	172	F	F
	EB	Left	102	110	64	67	E	E
		Right	101	109	75	74	E	E
		Through	102	110	65	66	E	E
	NB	Through	1	1	53	46	D	D
		Left	1	1	4	6	A	A
	WB	Right	10	13	31	32	C	C
		Through	10	13	30	30	C	C

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Left	10	13	12	19	B	B
GC 1	SB	Through	0	0	3	3	A	A
		Left	0	0	0	1	A	A
		Right	0	0	3	3	A	A
	NB	Through	0	0	5	3	A	A
		Right	0	0	1	2	A	A
		Left	0	0	1	1	A	A
	WB	Right	0	0	3	3	A	A
		Left	0	0	1	1	A	A
		U-Turn	0	0	2	2	A	A
		Through	0	0	1	1	A	A
	EB	Left	0	0	1	1	A	A
		Right	0	0	3	3	A	A
		Through	0	0	1	1	A	A
		U-Turn	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 11: Level of Service for Projected Model – EEPGL Office Complex / Ogle AM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
OGL 6	EB	Left	183	179	26	31	D	D
		Through	183	179	34	32	D	D
		Right	183	179	51	48	F	E
	WB	Right	216	243	32	42	D	E
		Through	216	243	21	27	C	D
		Left	216	243	24	32	C	D
	NB	Through	173	173	360	359	F	F
		Left	173	173	345	369	F	F
		Right	173	173	333	348	F	F
OGL 5	NB	Left	1	4	38	1	E	A
		Right	1	4	7	58	A	F
		Through	1	4	65	63	F	F
	EB	Right	14	19	19	32	C	D
		Through	14	19	14	21	B	C
		Left	14	19	22	33	C	D
	WB	Left	66	84	23	26	C	D
		Through	66	84	30	35	D	D
		Right	66	84	32	40	D	E
	SB	Through	2	6	10	17	A	C
		Right	2	6	11	14	B	B
		Left	2	6	7	8	A	A
OGL 1	NB	Right	1	4	4	5	A	A
		Left	1	4	4	11	A	B
	WB	Left	1	2	0	0	A	A
		Through	1	2	3	4	A	A
		Right	1	2	1	2	A	A
	SB	Left	2	6	3	4	A	A
		Right	2	6	5	6	A	A
	EB	Through	0	0	0	1	A	A
		Left	0	0	1	1	A	A
OGL 2	WB	Right	124	154	22	26	C	D
		Through	124	154	16	24	C	C
		Left	124	154	14	54	B	F
	SB	Left	72	104	177	198	F	F
		Right	72	104	219	286	F	F
		Through	72	104	185	234	F	F
	EB	Through	4	8	1	2	A	A
		Left	4	8	1	1	A	A
		Right	4	8	21	26	C	D
	NB	Right	11	12	137	132	F	F
		Through	11	12	127	134	F	F
		Left	11	12	119	154	F	F
OGL 3	SB	Right	98	99	279	290	F	F
		Through	98	99	286	299	F	F
		Left	98	99	276	173	F	F
	EB	Left	254	270	85	87	F	F
		Right	254	270	99	87	F	F
		Through	254	270	79	80	E	E
	NB	Through	1	1	51	51	D	D
		Left	1	1	9	13	A	B
	WB	Right	11	14	31	34	C	C
		Through	11	14	29	28	C	C

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Left	11	14	27	17	C	B
GC 1	SB	Through	0	0	2	5	A	A
		Left	0	0	1	1	A	A
		Right	0	0	4	3	A	A
	NB	Through	0	0	2	4	A	A
		Right	0	0	1	1	A	A
		Left	0	0	1	2	A	A
	WB	Right	0	0	4	4	A	A
		Left	0	0	1	1	A	A
		U-Turn	0	0	1	1	A	A
		Through	0	0	1	1	A	A
	EB	Left	0	0	1	1	A	A
		Right	0	0	3	4	A	A
		Through	0	0	1	1	A	A
		U-Turn	0	0	2	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 12: Level of Service for Base Model – EEPGL Office Complex / Ogle PM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
OGL 6	EB	Left	118	338	58	17	C
		Through	118	338	470	20	C
		Right	118	338	82	33	D
	WB	Right	115	447	85	20	C
		Through	115	447	672	13	B
		Left	115	447	51	13	B
	NB	Through	10	45	11	32	D
		Left	10	45	19	20	C
		Right	10	45	10	23	C
OGL 5	NB	Left	0	11	8	2	A
		Right	0	11	10	3	A
		Through	0	11	24	2	A
	EB	Right	0	4	5	1	A
		Through	0	3	149	0	A
		Left	0	3	7	0	A
	WB	Left	0	4	4	0	A
		Through	0	4	205	0	A
		Right	0	4	16	1	A
	SB	Through	0	18	36	2	A
		Right	0	18	37	3	A
		Left	0	18	59	1	A
OGL 1	NB	Right	0	9	36	1	A
		Left	0	9	20	1	A
	WB	Left	0	6	4	0	A
		Through	0	6	16	0	A
		Right	0	6	150	0	A
	SB	Left	0	13	17	2	A
		Right	0	13	59	2	A
	EB	Through	0	3	185	0	A
		Left	0	3	31	0	A
OGL 2	WB	Right	36	212	9	6	A
		Through	37	212	808	2	A
		Left	36	212	4	2	A
	SB	Left	30	162	69	27	D
		Right	30	162	15	39	E
		Through	30	162	70	37	E
	EB	Through	0	28	473	1	A
		Left	0	27	4	1	A
		Right	0	28	2	6	A
	NB	Right	6	44	9	26	D
		Through	6	44	20	22	C
		Left	6	44	14	12	B
OGL 3	SB	Right	70	120	13	217	F
		Through	70	120	132	223	F
		Left	70	120	4	222	F
	EB	Left	82	229	208	65	E
		Right	82	229	25	80	E
		Through	82	229	622	64	E
	NB	Through	3	29	27	53	D
		Left	3	29	5	14	B
	WB	Right	10	61	87	31	C
		Through	11	61	296	29	C
		Left	10	61	14	20	B

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
GC 1	SB	Through	0	4	2	3	A
		Left	0	4	2	0	A
		Right	0	4	5	2	A
	NB	Through	0	8	16	4	A
		Right	0	8	15	1	A
		Left	0	8	19	1	A
	WB	Right	0	16	30	4	A
		Left	0	16	22	0	A
		U-Turn	0	16	9	1	A
		Through	0	16	377	1	A
	EB	Left	0	19	17	1	A
		Right	0	19	42	2	A
		Through	0	19	507	1	A
		U-Turn	0	19	23	1	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)

Q_{max} = Maximum queue length (meters)

Vehicles = Number of vehicles (volume)

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

Table 13: Level of Service for Projected Model – EEPGL Office Complex / Ogle PM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
OGL 6	EB	Left	87	88	19	18	C	C
		Through	87	88	18	20	C	C
		Right	87	88	31	35	D	D
	WB	Right	59	76	19	19	C	C
		Through	59	76	11	12	B	B
		Left	59	76	11	13	B	B
	NB	Through	2	3	33	46	D	E
		Left	2	3	25	29	C	D
		Right	2	3	25	30	C	D
OGL 5	NB	Left	0	0	2	2	A	A
		Right	0	0	3	2	A	A
		Through	0	0	2	1	A	A
	EB	Right	0	0	1	1	A	A
		Through	0	0	0	0	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	0	1	1	A	A
		Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A
	SB	Through	0	0	2	2	A	A
		Right	0	0	2	3	A	A
		Left	0	0	1	1	A	A
OGL 1	NB	Right	0	0	2	1	A	A
		Left	0	0	1	1	A	A
	WB	Left	0	0	0	0	A	A
		Through	0	0	1	1	A	A
		Right	0	0	0	0	A	A
	SB	Left	0	0	2	1	A	A
		Right	0	0	2	2	A	A
	EB	Through	0	0	0	0	A	A
		Left	0	0	0	0	A	A
OGL 2	WB	Right	7	13	6	5	A	A
		Through	7	13	2	3	A	A
		Left	7	13	1	2	A	A
	SB	Left	8	12	23	34	C	D
		Right	8	12	37	56	E	F
		Through	8	13	31	39	D	E
	EB	Through	0	0	1	1	A	A
		Left	0	0	1	1	A	A
		Right	0	0	9	8	A	A
	NB	Right	1	2	27	34	D	D
		Through	1	2	23	32	C	D
		Left	1	2	13	15	B	B
OGL 3	SB	Right	70	72	218	227	F	F
		Through	70	72	223	230	F	F
		Left	70	72	222	212	F	F
	EB	Left	88	86	66	67	E	E
		Right	87	86	80	81	E	F
		Through	88	86	64	64	E	E
	NB	Through	3	3	52	54	D	D
		Left	3	3	19	14	B	B
	WB	Right	10	11	31	31	C	C
		Through	10	11	29	29	C	C

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Left	10	11	19	21	B	C
GC 1	SB	Through	0	0	5	4	A	A
		Left	0	0	1	1	A	A
		Right	0	0	3	3	A	A
	NB	Through	0	0	4	4	A	A
		Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	WB	Right	0	0	3	4	A	A
		Left	0	0	0	0	A	A
		U-Turn	0	0	1	1	A	A
		Through	0	0	1	1	A	A
	EB	Left	0	0	1	1	A	A
		Right	0	0	2	2	A	A
		Through	0	0	1	1	A	A
		U-Turn	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 14: Level of Service for Projected Model – EEPGL Office Complex / Ogle PM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
OGL 6	EB	Left	206	204	32	39	D	E
		Through	206	204	39	38	E	E
		Right	206	204	69	58	F	F
	WB	Right	189	172	25	24	C	C
		Through	189	172	17	18	C	C
		Left	189	172	18	17	C	C
	NB	Through	17	5	84	55	F	F
		Left	17	5	90	57	F	F
		Right	17	5	77	44	F	E
OGL 5	NB	Left	0	0	1	1	A	A
		Right	0	0	3	3	A	A
		Through	0	0	2	2	A	A
	EB	Right	0	0	1	1	A	A
		Through	0	0	0	0	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	0	0	0	A	A
		Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A
	SB	Through	0	0	2	3	A	A
		Right	0	0	3	3	A	A
		Left	0	0	2	2	A	A
OGL 1	NB	Right	0	0	2	2	A	A
		Left	0	0	1	1	A	A
	WB	Left	0	0	0	0	A	A
		Through	0	0	1	1	A	A
		Right	0	0	0	0	A	A
	SB	Left	0	0	2	3	A	A
		Right	0	0	3	3	A	A
	EB	Through	0	0	0	0	A	A
		Left	0	0	0	0	A	A
OGL 2	WB	Right	115	90	9	16	A	C
		Through	115	90	12	12	B	B
		Left	115	90	7	12	A	B
	SB	Left	114	61	148	119	F	F
		Right	114	61	221	147	F	F
		Through	114	61	174	134	F	F
	EB	Through	1	4	1	1	A	A
		Left	1	4	1	3	A	A
		Right	1	4	7	17	A	C
	NB	Right	14	11	105	100	F	F
		Through	15	11	75	108	F	F
		Left	15	11	71	85	F	F
OGL 3	SB	Right	92	92	257	266	F	F
		Through	92	92	277	276	F	F
		Left	92	92	265	234	F	F
	EB	Left	331	337	84	82	F	F
		Right	331	336	94	100	F	F
		Through	331	337	80	81	E	F
	NB	Through	3	3	53	51	D	D
		Left	3	3	13	17	B	B
	WB	Right	13	13	31	31	C	C
		Through	13	13	29	29	C	C

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Left	13	13	27	26	C	C
Grand Coastal	SB	Through	0	0	2	2	A	A
		Left	0	0	0	0	A	A
		Right	0	0	3	2	A	A
	NB	Through	0	0	3	3	A	A
		Right	0	0	2	2	A	A
		Left	0	0	1	2	A	A
	WB	Right	0	0	4	4	A	A
		Left	0	0	1	0	A	A
		U-Turn	0	0	1	1	A	A
		Through	0	0	1	1	A	A
	EB	Left	0	0	1	1	A	A
		Right	0	0	2	2	A	A
		Through	0	0	1	1	A	A
		U-Turn	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Contractor Commercial Port A and Contractor Inland Storage Yard



Figure 4: Contractor Commercial Port and Contractor Inland Storage Yard locations and corresponding study intersections

Contractor Commercial Port A

- *JFL 1- Saffon Street at Mandela Avenue*
- *JFL 2- Saffon Street at First Street*
- *JFL 3-Saffon Street at unnamed street*
- *JFL 4-Saffon Street at Trench Street*

Contractor Inland Storage Yard

- *JF 1-Mandela Avenue at Hunter Street*
- *JF 2-Mandela Avenue at John Fernandes Container Terminal Road*
- *JF 3-Mandela Avenue at Plumbago Street*
- *JF 4-Mandela Avenue at Vessegen Road*
- *JF 6- Unnamed street intersection*
- *JF 7-Unnamed street intersection*

This location has one of the major connector roads for vehicles coming from East Bank Road into Georgetown. Consequently, the road is characterized by high traffic volumes and queues at the Mandela signalized intersection which spill over into the nearby intersections, especially during peak hours. Police presence was noted on both the morning and afternoon peaks to assist with operations. The resultant LOS at JF 1 was **LOS F** for both existing and projected future conditions, while at the other study intersections the LOS was generally **LOS A**.

LOS delay analysis indicates that there are no impacts on capacity at the Contractor Commercial Port A and Contractor Inland Storage Yard locations due to the additional projected development trips in both

2021 and 2023. The results for the Contractor Commercial Port A and Contractor Inland Storage Yard locations are provided in Tables 13-18.

Table 15: Level of Service for Base Model – Contractor Commercial Port A and Contractor Inland Storage Yard - AM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
JFL4	SB	Left	0	44	523	11	B
		Through	0	44	746	12	B
	NB	Through	0	0	111	0	A
JFL3	WB	Left	0	0	2	0	A
	NB	Through	0	0	111	0	A
	SB	Left	1	33	736	7	A
		Through	1	33	3	4	A
JFL2	WB	Right	0	6	112	1	A
		Left	0	6	176	1	A
	SB	Through	0	2	5	1	A
JFL1	NB	Right	0	35	21	7	A
		Left	0	35	573	5	A
	SB	Through	0	11	171	1	A
		Right	0	10	8	1	A
	WB	Left	1	29	57	3	A
		Through	1	29	46	17	C
	EB	Right	0	1	83	0	A
		Through	0	1	1	0	A
JF1	SB	Through	100	127	281	138	F
		Right	100	127	9	140	F
		Left	100	127	43	125	F
	NB	Through	8	45	14	41	D
		Left	3	43	5	4	A
		Right	8	45	116	40	D
	EB	Left	3	30	1	5	A
		Right	3	30	23	49	D
		Through	3	30	5	47	D
	WB	Right	20	240	14	32	C
		Left	31	245	620	24	C
		Through	20	240	89	35	C
JF2	NB	Right	0	0	3	0	A
	EB	Right	0	0	1	0	A
		Left	0	13	5	0	A
		Through	0	13	154	2	A
	SB	Right	0	8	15	4	A
		Left	0	8	18	0	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
	WB	Left	0	24	1	1	A
		Through	0	24	726	1	A
		Right	0	10	23	2	A
JF3	NB	Right	0	11	25	2	A
		Left	0	11	78	0	A
	WB	Left	1	55	38	2	A
		Through	1	55	677	3	A
	EB	Right	0	7	9	2	A
		Through	0	7	163	0	A
JF6	NB	Through	0	0	19	0	A
		Right	0	0	3	0	A
	SB	Left	0	0	46	0	A
	WB	Left	0	3	9	0	A
		Right	0	3	84	0	A
JF4	WB	Right	1	77	133	4	A
		Through	1	77	671	3	A
		Left	1	77	43	3	A
	EB	Left	1	38	50	3	A
		Through	1	38	133	6	A
		Right	1	38	5	4	A
	NB	Through	0	21	130	2	A
		Right	0	16	4	5	A
		Left	0	16	51	1	A
JF7	NB	Left	0	2	3	1	A
		Through	0	2	51	0	A
	WB	Left	0	7	11	1	A
		Through	0	7	79	0	A
		Right	0	7	129	1	A
	EB	Right	0	6	7	1	A
		Through	0	6	38	0	A
		Left	0	6	5	1	A
	SB	Through	0	7	14	1	A
		Left	0	7	21	0	A
		Right	0	7	12	1	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)
Q_{max} = Maximum queue length (meters)
Vehicles = Number of vehicles (volume)
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)

Table 16: Level of Service for Projected Model - Contractor Commercial Port A and Contractor Inland Storage Yard AM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
JFL4	SB	Left	0	0	11	11	B	B
		Through	0	0	13	13	B	B
	NB	Through	0	0	0	0	A	A
JFL3	WB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
	SB	Left	1	1	5	5	A	A
		Through	1	1	4	4	A	A
JFL2	WB	Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	1	1	A	A
JFL1	NB	Right	0	1	9	9	A	A
		Left	0	1	6	6	A	A
	SB	Through	0	0	2	2	A	A
		Right	0	0	2	1	A	A
	WB	Left	1	1	3	4	A	A
		Through	1	1	22	25	C	C
	EB	Right	0	0	0	0	A	A
		Through	0	0	0	0	A	A
JF1	SB	Through	100	101	140	144	F	F
		Right	100	101	143	146	F	F
		Left	100	101	126	128	F	F
	NB	Through	9	9	36	36	D	D
		Left	3	3	4	4	A	A
		Right	9	9	42	42	D	D
	EB	Left	3	4	5	4	A	A
		Right	3	4	48	50	D	D
		Through	3	4	42	44	D	D
	WB	Right	115	131	49	48	D	D
		Left	135	149	37	38	D	D
		Through	115	131	49	49	D	D
JF2	NB	Right	0	0	2	1	A	A
	EB	Right	0	0	1	2	A	A
		Left	0	0	0	0	A	A
		Through	0	0	3	4	C	A
	SB	Right	1	1	9	15	A	B
		Left	1	0	0	5	A	A
	WB	Left	3	7	0	0	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Through	3	7	2	3	A	A
		Right	2	6	2	3	A	A
JF3	NB	Right	0	0	1	2	A	A
		Left	0	0	0	0	A	A
	WB	Left	2	3	3	3	A	A
		Through	2	3	5	5	A	A
	EB	Right	0	0	2	2	A	A
		Through	0	0	0	0	A	A
JF6	NB	Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A
	SB	Left	0	0	0	0	A	A
	WB	Left	0	0	0	0	A	A
		Right	0	0	0	1	A	A
JF4	WB	Right	2	2	5	5	A	A
		Through	2	2	5	5	A	A
		Left	2	2	4	4	A	A
	EB	Left	1	1	3	4	A	A
		Through	1	2	7	8	A	A
		Right	1	1	9	6	A	A
	NB	Through	1	1	3	3	A	A
		Right	0	0	3	2	A	A
		Left	0	0	0	0	A	A
JF7	NB	Left	0	0	0	1	A	A
		Through	0	0	1	1	A	A
	WB	Left	0	0	0	1	A	A
		Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
	EB	Right	0	0	2	2	A	A
		Through	0	0	1	0	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	2	2	A	A
		Left	0	0	0	0	A	A
		Right	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 17: Level of Service for Projected Model - Contractor Commercial Port A and Contractor Inland Storage Yard AM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
JFL4	SB	Left	0	0	11	11	B	B
		Through	0	0	13	13	B	B
	NB	Through	0	0	0	0	A	A
JFL3	WB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
	SB	Left	1	1	5	5	A	A
		Through	1	1	4	4	A	A
JFL2	WB	Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	0	1	A	A
JFL1	NB	Right	1	1	11	11	B	B
		Left	1	1	8	8	A	A
	SB	Through	1	1	3	3	A	A
		Right	0	0	2	2	A	A
	WB	Left	2	3	8	13	A	B
		Through	2	3	41	45	E	E
	EB	Right	0	0	0	0	A	A
		Through	0	0	0	0	A	A
JF1	SB	Through	100	101	141	142	F	F
		Right	100	101	143	147	F	F
		Left	100	101	128	125	F	F
	NB	Through	10	10	42	42	D	D
		Left	4	4	4	4	A	A
		Right	10	10	42	42	D	D
	EB	Left	3	4	4	4	A	A
		Right	3	4	47	50	D	D
		Through	3	4	54	55	D	D
	WB	Right	266	295	54	52	D	D
		Left	282	310	43	44	D	D
		Through	266	295	54	55	D	D
JF2	NB	Right	0	0	4	4	A	A
	EB	Right	4	23	4	8	A	A
		Left	6	25	5	20	A	C
		Through	6	25	17	21	C	C
	SB	Right	5	7	104	125	F	F
		Left	5	7	29	35	D	D
	WB	Left	46	65	12	10	B	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Through	46	65	15	19	B	C
		Right	39	57	15	19	B	C
JF3	NB	Right	0	0	2	2	A	A
		Left	0	0	1	1	A	A
	WB	Left	35	47	9	13	A	B
		Through	35	47	12	15	B	B
	EB	Right	0	0	2	2	A	A
		Through	0	0	0	0	A	A
JF6	NB	Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
	SB	Left	0	0	0	0	A	A
	WB	Left	0	0	0	0	A	A
		Right	0	0	1	1	A	A
JF4	WB	Right	21	27	9	10	A	A
		Through	21	27	9	10	A	A
		Left	21	27	7	8	A	A
	EB	Left	3	2	7	6	A	A
		Through	3	2	11	10	B	A
		Right	3	2	10	9	A	A
	NB	Through	1	1	4	4	A	A
		Right	0	1	6	4	A	A
		Left	0	1	0	1	A	A
JF7	NB	Left	0	0	0	0	A	A
		Through	0	0	1	1	A	A
	WB	Left	0	0	0	0	A	A
		Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
	EB	Right	0	0	1	2	A	A
		Through	0	0	0	1	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	2	2	A	A
		Left	0	0	0	0	A	A
		Right	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 18: Level of Service for Base Model - Contractor Commercial Port A and Contractor Inland Storage Yard PM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
JFL4	SB	Left	0	32	559	12	B
		Through	0	32	677	13	B
	NB	Through	0	0	82	0	A
JFL3	WB	Left	0	0	2	0	A
	NB	Through	0	0	82	0	A
	SB	Left	1	31	671	5	A
		Through	1	31	2	2	A
JFL2	WB	Right	0	6	82	1	A
		Left	0	6	205	1	A
	SB	Through	0	2	4	1	A
JFL1	NB	Right	1	63	52	8	A
		Left	1	63	541	6	A
	SB	Through	0	13	206	3	A
		Right	0	13	0	0	A
	WB	Left	25	181	200	27	D
		Through	25	181	170	43	E
	EB	Right	0	1	77	0	A
		Through	0	1	7	0	A
JF1	SB	Through	99	127	34	139	F
		Right	99	127	287	133	F
		Left	99	127	21	124	F
	NB	Through	6	39	44	41	D
		Left	4	38	4	4	A
		Right	6	39	87	38	D
	EB	Left	5	35	1	5	A
		Right	5	35	47	50	D
		Through	5	35	9	52	D
	WB	Right	16	199	18	31	C
		Left	21	192	582	19	B
		Through	16	199	87	31	C
JF2	NB	Right	0	0	3	0	A
	EB	Right	0	0	0	0	A
		Left	0	12	3	1	A
		Through	0	12	111	2	A
	SB	Right	0	7	15	3	A
		Left	0	7	18	0	A
	WB	Left	0	16	2	1	A
		Through	0	16	683	0	A
		Right	0	1	6	0	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
JF3	NB	Right	0	7	14	2	A
		Left	0	7	40	0	A
	WB	Left	0	35	37	1	A
		Through	0	35	657	2	A
	EB	Right	0	7	7	2	A
		Through	0	7	122	0	A
JF6	NB	Through	0	0	21	0	A
		Right	0	0	2	0	A
	SB	Left	0	0	43	0	A
	WB	Left	0	1	28	0	A
		Right	0	1	34	0	A
JF4	WB	Right	1	64	215	4	A
		Through	1	64	629	4	A
		Left	1	64	2	2	A
	EB	Left	1	27	45	3	A
		Through	1	27	88	6	A
		Right	1	27	2	5	A
	NB	Through	0	28	110	2	A
		Right	0	23	28	4	A
		Left	0	23	70	1	A
JF7	NB	Left	0	3	5	1	A
		Through	0	3	50	1	A
	WB	Left	0	7	10	1	A
		Through	0	7	57	0	A
		Right	0	7	151	1	A
	EB	Right	0	6	3	1	A
		Through	0	6	33	0	A
		Left	0	6	8	1	A
	SB	Through	0	1	1	1	A
		Left	0	1	3	0	A
		Right	0	1	1	2	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)
Q_{max} = Maximum queue length (meters)
Vehicles = Number of vehicles (volume)
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)

Table 19: Level of Service for Projected Model - Contractor Commercial Port A and Contractor Inland Storage Yard PM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length		Delay		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
JFL4	SB	Left	0	0	11	11	B	B
		Through	0	0	13	13	B	B
	NB	Through	0	0	0	0	A	A
JFL3	WB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
	SB	Left	1	1	4	4	A	A
		Through	1	1	3	3	A	A
JFL2	WB	Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	1	1	A	A
JFL1	NB	Right	2	2	11	10	B	B
		Left	2	2	7	7	A	A
	SB	Through	1	1	4	6	A	A
		Right	1	1	2	1	A	A
	WB	Left	54	57	45	46	E	E
		Through	54	57	64	65	F	F
	EB	Right	0	0	0	0	A	A
		Through	0	0	0	0	A	A
JF1	SB	Through	99	100	135	136	F	F
		Right	99	100	133	135	F	F
		Left	99	100	122	118	F	F
	NB	Through	7	7	40	39	D	D
		Left	5	5	4	4	A	A
		Right	7	7	42	42	D	D
	EB	Left	5	6	4	4	A	A
		Right	5	6	52	54	D	D
		Through	5	6	55	50	D	D
	WB	Right	26	52	36	41	D	D
		Left	34	63	23	28	C	C
		Through	26	52	37	41	D	D
JF2	NB	Right	0	0	0	0	A	A
	EB	Right	0	0	0	0	A	A
		Left	0	0	0	0	A	A
		Through	0	0	2	2	A	A
	SB	Right	0	0	3	8	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	1	0	0	A	A
		Through	0	1	0	1	A	A

Site	Direction	Movement	Queue Length		Delay		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Right	0	1	1	1	A	A
JF3	NB	Right	0	0	1	1	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	0	2	2	A	A
		Through	0	0	2	2	A	A
	EB	Right	0	0	2	2	A	A
		Through	0	0	0	0	A	A
JF6	NB	Through	0	0	0	0	A	A
		Right	0	0	1	0	A	A
	SB	Left	0	0	0	0	A	A
	WB	Left	0	0	0	0	A	A
		Right	0	0	0	0	A	A
JF4	WB	Right	2	4	4	6	A	A
		Through	2	4	4	6	A	A
		Left	2	4	3	4	A	A
	EB	Left	1	1	2	3	A	A
		Through	1	1	7	7	A	A
		Right	1	1	7	9	A	A
	NB	Through	0	1	2	3	A	A
		Right	0	0	4	5	A	A
		Left	0	0	0	1	A	A
JF7	NB	Left	0	0	0	0	A	A
		Through	0	0	1	1	A	A
	WB	Left	0	0	0	1	A	A
		Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
	EB	Right	0	0	1	1	A	A
		Through	0	0	0	0	A	A
		Left	0	0	0	1	A	A
	SB	Through	0	0	1	3	A	A
		Left	0	0	0	0	A	A
		Right	0	0	1	0	A	A

Table 20: Level of Service for Projected Model - Contractor Commercial Port A and Contractor Inland Storage Yard PM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
JFL4	SB	Left	0	0	21	12	B	B
		Through	0	0	0	13	B	B
	NB	Through	0	0	0	0	A	A
JFL3	WB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
	SB	Left	1	1	0	5	A	A
		Through	1	1	0	3	A	A
JFL2	WB	Right	0	0	1	1	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	2	1	A	A
JFL1	NB	Right	2	2	11	11	B	B
		Left	2	2	7	8	A	A
	SB	Through	1	1	5	4	A	A
		Right	1	1	2	1	A	A
	WB	Left	46	66	40	47	E	E
		Through	46	66	60	66	F	F
	EB	Right	0	0	0	0	A	A
		Through	0	0	0	0	A	A
JF1	SB	Through	100	100	136	132	F	F
		Right	100	100	135	134	F	F
		Left	100	100	126	121	F	F
	NB	Through	7	7	39	39	D	D
		Left	5	5	4	5	A	A
		Right	7	7	42	42	D	D
	EB	Left	5	5	4	5	A	A
		Right	5	5	51	53	D	D
		Through	5	5	50	50	D	D
	WB	Right	32	35	40	37	D	D
		Left	43	46	27	27	C	C
		Through	32	35	41	39	D	D
JF2	NB	Right	0	0	0	0	A	A
	EB	Right	0	0	0	1	A	A
		Left	0	0	0	0	A	A
		Through	0	0	2	2	A	A
	SB	Right	0	0	4	5	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	0	0	0	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
JF3	NB	Right	0	0	2	2	A	A
		Left	0	0	0	0	A	A
	WB	Left	0	0	1	2	A	A
		Through	0	0	2	2	A	A
	EB	Right	0	0	2	2	A	A
		Through	0	0	0	0	A	A
JF6	NB	Through	0	0	0	0	A	A
		Right	0	0	1	0	A	A
	SB	Left	0	0	0	0	A	A
	WB	Left	0	0	0	0	A	A
		Right	0	0	0	0	A	A
JF4	WB	Right	4	3	5	6	A	A
		Through	4	3	6	6	A	A
		Left	4	3	3	4	A	A
	EB	Left	1	1	3	4	A	A
		Through	1	1	7	7	A	A
		Right	1	1	13	10	A	B
	NB	Through	1	1	3	3	A	A
		Right	0	0	4	5	A	A
		Left	0	0	1	1	A	A
JF7	NB	Left	0	0	1	1	A	A
		Through	0	0	1	1	A	A
	WB	Left	0	0	1	1	A	A
		Through	0	0	1	1	A	A
		Right	0	0	1	1	A	A
	EB	Right	0	0	1	1	A	A
		Through	0	0	0	0	A	A
		Left	0	0	1	1	A	A
	SB	Through	0	0	2	2	A	A
		Left	0	0	0	0	A	A
		Right	0	0	1	0	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Contractor Shorebase B



Figure 5: Contractor Shorebase B location and corresponding study intersections

- *JFS 1-Water Street at Hadfield Street*
- *JFS 2-Lombad Street at Hadfield Street*
- *JFS 3-Water Street at Brickdam*
- *JFS 4-Lombard/Cornhill at Brickdam*
- *JFS 5-Avenue of the Republic at Brickdam*
- *JFS 6-Croal Street at Water Street*
- *JFS 7- Croal Street at London Street*
- *JFS 8-Cornhill Street at Croal Street*
- *JFS 9-Avenue of the Republic at Croal Street*
- *JFS 10-Water Street at Commerce Street*
- *JFS 11-London Street and Hinck Street at Commerce Street*
- *JFS 12-Avenue of the Republic at Commerce Street*
- *JFS 13-Water Street at Robb Street*
- *JFS 14-Robb Street*
- *JFS 15-Robb Street at Avenue of the Republic*

This location includes the Stabroek Market as well as a concentration of government buildings and business places. It is therefore characterized by the following:

- High pedestrian volumes and movements that hinder vehicular traffic flows.
- Roadside vending and commercial activity that restrict capacity of the pavement and hinder traffic flows.
- Multiple minibus and taxi stands operations which interrupt the free flow of traffic.

Due to these activities, a few intersections in the immediate vicinity of the market experience high delays. Three out of the 15 study intersections experience at least one turning movement with an **LOS F**, characterized by long queues, standstill traffic and high delays. Aside from these intersections the intersections outside of the immediate market are predicted to operate at acceptable LOS, typically **LOS A**. Traffic police officers are frequently required to control operations at these intersections.

LOS delay analysis however, indicates that there are no impacts on capacity at the Contractor Shorebase B location due to the additional projected development trips in both 2021 and 2023. The results for the Contractor Shorebase B location are provided in Tables 19-24.

Table 21: Level of Service for Base Model – Contractor Shorebase B AM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
JFS5	NB	Right	202	221	4	171	F
		Left	202	221	10	321	F
		Through	202	221	179	263	F
	WB	Left	137	150	77	216	F
		U-Turn	137	150	1	303	F
		Through	137	150	109	319	F
		Right	137	150	43	328	F
	EB	Right	91	132	27	195	F
		Through	91	132	180	195	F
		Left	91	132	22	318	F
	SB	Through	28	90	95	58	E
		Left	28	90	89	45	D
		Right	28	90	23	44	D
JFS9	SB	Left	251	287	183	113	F
		Through	251	287	165	160	F
		Right	251	287	86	299	F
	WB	U-Turn	118	137	31	220	F
		Right	118	137	44	274	F
		Through	118	137	83	225	F
		Left	118	137	68	202	F
	NB	Right	118	137	50	262	F
		Through	66	93	188	126	F
JFS12	EB	Left	0	16	228	2	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
	NB	Through	0	8	94	1	A
JFS11	SB	Right	0	9	37	1	A
		Left	0	9	50	1	A
	EB	Through	0	0	179	0	A
JFS10	NB	Left	0	6	12	1	A
		Right	0	19	34	3	A
		Through	0	6	294	1	A
	SB	Left	1	15	251	1	A
JFS13	SB	Right	0	4	65	2	A
		Through	0	4	254	1	A
		Left	0	4	98	1	A
	EB	Left	0	6	20	1	A
		Through	0	14	44	3	A
	NB	Through	0	5	229	1	A
		Left	0	5	16	2	A
		Right	0	5	48	1	A
JFS14	EB	Left	0	14	33	2	A
		Through	0	14	156	1	A
JFS4	EB	Right	48	135	66	8	A
		Through	11	50	135	16	C
	WB	Left	0	38	142	6	A
	SB	Right	39	111	44	43	E
		Through	48	135	68	30	D
		Left	40	114	125	54	F
JFS3	EB	Through	3	26	197	5	A
		Left	4	32	66	3	A
	NB	Right	1	9	7	12	B
		Through	1	6	1	4	A
	WB	Right	0	11	44	1	A
JFS2	NB	Right	0	44	920	4	A
		Left	0	55	121	5	A
JFS8	EB	Left	1	15	104	2	A
		Through	1	15	179	1	A
	WB	Left	0	3	37	1	A
JFS7	WB	Left	51	123	253	45	E
		Through	51	123	115	54	F
	SB	Right	11	79	151	28	D
JFS6	NB	Through	0	15	111	2	A
	WB	Right	0	34	236	1	A
JFS1	WB	Left	0	0	25	0	A
		Through	0	0	148	0	A
		Right	0	0	9	1	A
JFS15	EB	Left	0	2	156	0	A
	NB	Through	0	8	253	0	A
		Right	0	8	69	1	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)

Q_{max} = Maximum queue length (meters)

Vehicles = Number of vehicles (volume)

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

Table 22: Level of Service for Projected Model - Contractor Shorebase B AM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
JFS5	NB	Right	204	203	244	188	F	F
		Left	204	203	361	271	F	F
		Through	204	203	280	260	F	F
	WB	Left	138	138	206	217	F	F
		U-Turn	138	138	490	465	F	F
		Through	138	138	317	309	F	F
		Right	138	138	327	314	F	F
	EB	Right	98	99	180	187	F	F
		Through	98	99	193	196	F	F
		Left	98	99	442	263	F	F
	SB	Through	14	24	58	57	E	E
		Left	14	24	44	41	D	D
		Right	14	24	55	75	D	E
JFS9	SB	Left	256	256	125	126	F	F
		Through	256	256	186	187	F	F
		Right	256	256	375	277	F	F
	WB	U-Turn	120	120	248	225	F	F
		Right	120	120	264	340	F	F
		Through	120	120	261	243	F	F
		Left	120	120	264	224	F	F
	NB	Right	120	120	263	328	F	F
		Through	67	70	143	138	F	F
JFS12	EB	Left	0	0	2	2	A	A
	NB	Through	0	0	1	1	A	A
JFS11	SB	Right	0	0	1	2	A	A
		Left	0	0	1	2	A	A
	EB	Through	0	0	1	1	A	A
JFS10	NB	Left	0	1	1	1	A	A
		Right	0	1	3	5	A	A
		Through	0	1	1	2	A	A
	SB	Left	1	3	1	4	A	A
JFS13	SB	Right	0	0	1	2	A	A
		Through	0	0	1	2	A	A
		Left	0	0	0	1	A	A
	EB	Left	0	0	0	0	A	A
		Through	0	0	3	3	A	A
	NB	Through	0	0	1	1	A	A
		Left	0	0	1	2	A	A
		Right	0	0	1	1	A	A
JFS14	EB	Left	0	0	2	2	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
		Through	0	0	2	1	A	A
JFS4	EB	Right	61	55	11	14	B	B
		Through	18	21	21	20	C	C
	WB	Left	0	0	6	5	A	A
	SB	Right	51	49	49	48	E	E
		Through	61	55	43	40	E	E
		Left	52	50	63	64	F	F
JFS3	EB	Through	6	8	9	10	A	A
		Left	8	10	5	7	A	A
	NB	Right	2	3	18	18	C	C
		Through	2	2	5	3	A	A
	WB	Right	0	0	1	1	A	A
JFS2	NB	Right	1	1	5	5	A	A
		Left	1	1	5	5	A	A
JFS8	EB	Left	2	2	0	2	A	A
		Through	2	2	1	4	A	A
	WB	Left	0	0	0	5	A	A
JFS7	WB	Left	67	74	63	55	F	F
		Through	67	74	110	85	F	F
	SB	Right	15	15	32	40	D	E
JFS6	NB	Through	0	0	2	2	A	A
	WB	Right	0	1	1	2	A	A
JFS1	WB	Left	0	0	0	0	A	A
		Through	0	0	0	0	A	A
		Right	0	0	0	0	A	A
JFS15	EB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 23: Level of Service for Projected Model - Contractor Shorebase B AM Peak (2023 and 2023 with proposed development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
JFS5	NB	Right	204	204	192	308	F	F
		Left	204	204	436	432	F	F
		Through	204	204	326	296	F	F
	WB	Left	138	138	221	199	F	F
		U-Turn	138	138	283	463	F	F
		Through	138	138	309	311	F	F
		Right	138	138	332	312	F	F
	EB	Right	99	103	202	213	F	F
		Through	99	103	205	211	F	F
		Left	99	103	398	327	F	F
	SB	Through	15	20	57	61	E	E
		Left	15	20	44	45	D	D
		Right	15	20	69	58	E	E
JFS9	SB	Left	259	259	106	117	F	F
		Through	259	259	163	185	F	F
		Right	259	259	392	334	F	F
	WB	U-Turn	122	122	306	232	F	F
		Right	122	122	308	265	F	F
		Through	122	122	306	286	F	F
		Left	122	122	300	256	F	F
	NB	Right	122	122	303	337	F	F
		Through	70	72	158	142	F	F
JFS12	EB	Left	0	0	2	2	A	A
	NB	Through	0	0	1	1	A	A
JFS11	SB	Right	3	3	7	5	A	A
		Left	3	3	5	3	A	A
	EB	Through	0	0	1	1	A	A
JFS10	NB	Left	4	3	2	1	A	A
		Right	5	3	4	3	A	A
		Through	4	3	1	1	A	A
	SB	Left	11	10	13	3	B	A
JFS13	SB	Right	3	3	4	2	A	A
		Through	3	3	5	2	A	A
		Left	3	3	4	1	A	A
	EB	Left	0	0	2	0	A	A
		Through	0	0	4	4	A	A
	NB	Through	0	0	1	1	A	A
		Left	0	0	2	1	A	A
		Right	0	0	1	1	A	A
JFS14	EB	Left	0	0	2	2	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Through	0	0	1	1	A	A
JFS4	EB	Right	65	64	18	16	C	C
		Through	21	24	23	26	C	D
	WB	Left	0	0	6	5	A	A
	SB	Right	54	53	62	53	F	F
		Through	65	64	55	49	F	E
		Left	55	55	82	82	F	F
JFS3	EB	Through	8	9	13	14	B	B
		Left	10	12	9	9	A	A
	NB	Right	3	5	25	25	C	C
		Through	2	5	3	8	A	A
	WB	Right	0	0	2	1	A	A
JFS2	NB	Right	1	1	7	7	A	A
		Left	1	1	8	7	A	A
JFS8	EB	Left	6	6	12	2	B	A
		Through	6	6	9	4	A	A
	WB	Left	1	1	14	9	B	A
JFS7	WB	Left	67	71	62	67	F	F
		Through	67	71	80	85	F	F
	SB	Right	23	23	58	44	F	E
JFS6	NB	Through	0	0	2	3	A	A
	WB	Right	2	1	1	1	A	A
JFS1	WB	Left	0	0	0	0	A	A
		Through	0	0	0	0	A	A
		Right	0	0	1	0	A	A
JFS15	EB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
		Right	0	0	1	1	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 24: Level of Service for Base Model - Contractor Shorebase B PM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
JFS5	NB	Right	204	221	15	238	F
		Left	204	221	10	495	F
		Through	204	221	148	365	F
	WB	Left	138	150	77	227	F
		U-Turn	138	150	1	344	F
		Through	138	150	110	351	F
		Right	138	150	46	362	F
	EB	Right	109	133	33	239	F
		Through	109	133	226	256	F
		Left	109	133	10	1002	F
	SB	Through	19	90	95	60	E
		Left	19	90	92	44	D
		Right	19	90	16	63	E
JFS9	SB	Left	261	286	22	243	F
		Through	261	286	174	312	F
		Right	261	286	55	524	F
	WB	U-Turn	122	135	48	364	F
		Right	122	135	32	325	F
		Through	122	135	58	381	F
		Left	122	135	41	338	F
	NB	Right	122	135	49	361	F
		Through	68	92	139	256	F
JFS12	EB	Left	0	14	189	1	A
	NB	Through	0	6	75	1	A
JFS11	SB	Right	0	6	20	1	A
		Left	0	8	42	0	A
	EB	Through	0	0	147	0	A
JFS10	NB	Left	0	0	17	1	A
		Right	0	8	16	2	A
		Through	0	0	173	1	A
	SB	Left	0	0	205	1	A
JFS13	SB	Right	0	2	23	1	A
		Through	0	2	206	1	A
		Left	0	2	106	0	A
	EB	Left	0	3	44	0	A
		Through	0	11	29	2	A
	NB	Through	0	1	144	0	A
		Left	0	1	4	1	A
		Right	0	1	25	1	A
JFS14	EB	Left	0	12	28	2	A
		Through	0	12	132	1	A

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
JFS4	EB	Right	84	137	114	25	C
		Through	30	52	237	37	E
	WB	Left	0	38	136	5	A
	SB	Right	68	112	11	170	F
		Through	84	137	37	191	F
		Left	70	115	74	244	F
JFS3	EB	Through	13	26	344	30	D
		Left	17	33	4	19	C
	NB	Right	0	6	8	35	D
		Through	0	3	1	2	A
	WB	Right	0	11	11	3	A
JFS2	NB	Right	0	29	779	3	A
		Left	0	40	99	3	A
JFS8	EB	Left	0	9	72	0	A
		Through	0	9	147	1	A
	WB	Left	0	0	20	0	A
JFS7	WB	Left	81	123	139	133	F
		Through	81	123	128	174	F
	SB	Right	7	78	101	22	C
JFS6	NB	Through	0	2	16	1	A
	WB	Right	0	23	197	0	A
JFS1	WB	Left	0	0	34	0	A
		Through	0	0	101	0	A
		Right	0	0	10	0	A
JFS15	EB	Left	0	3	132	0	A
	NB	Through	0	7	211	0	A
		Right	0	7	53	0	A

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)
Q_{max} = Maximum queue length (meters)
Vehicles = Number of vehicles (volume)
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)

Table 25: Level of Service for Projected Model - Contractor Shorebase B PM Peak (2021 and 2021 with proposed development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
JFS5	NB	Right	205	206	215	248	F	F
		Left	205	206	392	452	F	F
		Through	205	206	350	338	F	F
	WB	Left	138	138	212	221	F	F
		U-Turn	138	138	387	384	F	F
		Through	138	138	323	336	F	F
		Right	138	138	337	355	F	F
	EB	Right	110	109	277	268	F	F
		Through	110	109	276	268	F	F
		Left	110	109	972	709	F	F
	SB	Through	17	24	59	61	E	E
		Left	17	24	44	47	D	D
		Right	17	24	41	71	D	E
JFS9	SB	Left	263	263	292	242	F	F
		Through	263	263	325	325	F	F
		Right	263	263	497	438	F	F
	WB	U-Turn	123	122	361	309	F	F
		Right	123	122	354	301	F	F
		Through	123	122	400	353	F	F
		Left	123	122	358	336	F	F
	NB	Right	123	122	359	321	F	F
		Through	69	71	240	236	F	F
JFS12	EB	Left	0	0	2	2	A	A
	NB	Through	0	0	1	1	A	A
JFS11	SB	Right	0	0	1	5	A	A
		Left	0	0	1	3	A	A
	EB	Through	0	0	0	0	A	A
JFS10	NB	Left	3	3	1	2	A	A
		Right	4	3	4	4	A	A
		Through	3	3	2	1	A	A
	SB	Left	6	4	9	6	A	A
JFS13	SB	Right	2	1	2	1	A	A
		Through	2	1	3	2	A	A
		Left	2	1	2	1	A	A
	EB	Left	0	0	1	0	A	A
		Through	0	0	3	2	A	A
	NB	Through	0	0	1	0	A	A
		Left	0	0	1	2	A	A
		Right	0	0	1	1	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
JFS14	EB	Left	0	0	2	2	A	A
		Through	0	0	1	1	A	A
JFS4	EB	Right	85	82	27	26	D	D
		Through	31	31	39	40	E	E
	WB	Left	0	0	6	6	A	A
	SB	Right	69	67	199	204	F	F
		Through	85	82	199	202	F	F
		Left	71	69	263	254	F	F
JFS3	EB	Through	13	13	31	32	D	D
		Left	18	18	52	27	F	D
	NB	Right	1	0	32	43	D	E
		Through	1	0	1	4	A	A
	WB	Right	0	0	6	3	A	A
JFS2	NB	Right	0	0	4	4	A	A
		Left	0	0	4	4	A	A
JFS8	EB	Left	4	3	8	7	A	A
		Through	4	3	7	5	A	A
	WB	Left	1	1	20	9	C	A
JFS7	WB	Left	83	86	161	147	F	F
		Through	83	86	223	161	F	F
	SB	Right	18	12	79	49	F	E
JFS6	NB	Through	0	0	1	1	A	A
	WB	Right	1	1	0	0	A	A
JFS1	WB	Left	0	0	0	0	A	A
		Through	0	0	0	0	A	A
		Right	0	0	0	0	A	A
JFS15	EB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
		Right	0	0	1	0	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 26: Level of Service for Projected Model - Contractor Shorebase B PM Peak (2023 and 2023 with proposed development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
JFS5	NB	Right	206	206	241	321	F	F
		Left	206	206	347	308	F	F
		Through	206	206	450	352	F	F
	WB	Left	139	138	219	245	F	F
		U-Turn	139	138	0	511	A	F
		Through	139	138	394	347	F	F
		Right	139	138	396	381	F	F
	EB	Right	111	110	351	252	F	F
		Through	111	110	349	263	F	F
		Left	111	110	1073	895	F	F
	SB	Through	21	19	60	58	E	E
		Left	21	19	45	43	D	D
		Right	21	19	274	39	F	D
JFS9	SB	Left	265	264	367	257	F	F
		Through	265	264	341	303	F	F
		Right	265	264	544	532	F	F
	WB	U-Turn	124	123	387	326	F	F
		Right	124	123	286	290	F	F
		Through	124	123	512	385	F	F
		Left	124	123	361	343	F	F
	NB	Right	124	123	258	338	F	F
		Through	71	69	313	284	F	F
JFS12	EB	Left	0	0	1	2	A	A
	NB	Through	0	0	0	1	A	A
JFS11	SB	Right	0	0	1	2	A	A
		Left	0	0	2	1	A	A
	EB	Through	0	0	1	0	A	A
JFS10	NB	Left	0	7	1	1	A	A
		Right	0	8	3	3	A	A
		Through	0	7	1	1	A	A
	SB	Left	0	10	1	7	A	A
JFS13	SB	Right	0	2	1	1	A	A
		Through	0	2	1	1	A	A
		Left	0	2	0	1	A	A
	EB	Left	0	0	0	0	A	A
		Through	0	0	4	2	A	A
	NB	Through	0	0	1	1	A	A
		Left	0	0	1	1	A	A
		Right	0	0	0	0	A	A
JFS14	EB	Left	0	0	1	2	A	A

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
		Through	0	0	2	1	A	A
JFS4	EB	Right	107	89	47	26	E	D
		Through	34	32	55	37	F	E
	WB	Left	0	0	5	6	A	A
	SB	Right	82	74	232	190	F	F
		Through	107	89	200	193	F	F
		Left	84	76	244	249	F	F
JFS3	EB	Through	15	13	44	30	E	D
		Left	20	18	10	47	A	E
	NB	Right	0	2	23	37	C	E
		Through	0	1	2	2	A	A
	WB	Right	0	0	1	5	A	A
JFS2	NB	Right	0	0	4	4	A	A
		Left	1	0	3	5	A	A
JFS8	EB	Left	0	6	0	8	A	A
		Through	0	6	1	6	A	A
	WB	Left	0	1	1	10	A	A
JFS7	WB	Left	85	82	151	138	F	F
		Through	85	82	137	159	F	F
	SB	Right	3	18	17	46	C	E
JFS6	NB	Through	0	0	1	1	A	A
	WB	Right	0	3	0	0	A	A
JFS1	WB	Left	0	0	0	0	A	A
		Through	0	0	0	0	A	A
		Right	0	0	0	1	A	A
JFS15	EB	Left	0	0	0	0	A	A
	NB	Through	0	0	0	0	A	A
		Right	0	0	1	0	A	A

Queue Length = Distance (metres) of vehicles in queue behind the stop line

Delay = Vehicle Delay at the intersection (seconds)

LOS = Level of Service (A being the least congested and F being the most congested)

2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Ramada Intersection



Figure 6: Ramada Intersection location and corresponding study intersections

- *LP2 Point-Houston - East Bank Public Road at Houston Split*
- *LP2 Point-Eccles - East Bank Public Road at Eccles Intersection*
- *LP2 Point-DH Bridge - East Bank Public Road at the Demerara Harbour Bridge*
- *LP2 Point-Nandy Park - East Bank Public Road at Nandy Park Intersection*
- *LP2 Point-Massy - East Bank Public Road at Massy Intersection*

At the Ramada Intersection location, the morning peak featured the majority of vehicles heading into Georgetown, with increasingly higher delays experienced by northbound movements as they approached Georgetown. This is with the exception of LP2 Point - Nandy Park, which is a signalized intersection just after another signalized intersection, Eccles. The low delays experienced at LP2 Point - Nandy Park,

however, appear to be due to traffic metering by the signals at LP2 Point - Eccles, reducing the demand approaching LP2 Point - Nandy Park. Northbound vehicles soon re-join queues as they continue into Georgetown at LP2 Point - Houston. In essence, northbound movements experience queuing spillbacks and delays originating in Georgetown and reaching as far south as the Demerara Harbour Bridge in the morning peak period. This is reversed in the afternoon peak with southbound movements experiencing high delays from the Harbour Bridge, spilling back towards Georgetown.

LOS delay analysis indicates that there are no impacts on capacity at the Ramada Intersection location due to the additional projected development trips in both 2021 and 2023. The results for the Ramada Intersection location are provided in Tables 25-30.

Table 27: Level of Service for Base Model - Ramada Intersection AM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
LP2 Point Massy	NB	Through	0	11	816	0	A
		Right	0	21	18	4	A
		U-Turn	0	21	8	5	A
	SB	Left	0	13	33	2	A
		Through	0	1	376	1	A
	WB	Right	0	14	30	7	A
		U-Turn	0	3	4	1	A
		Left	0	13	14	2	A
LP2 Point DH Bridge	EB	Right	171	388	62	62	E
		Left	171	387	421	14	B
	NB	Through (Ln3)	8	128	281	9	A
		Left	5	110	25	6	A
		Through	83	405	539	4	A
	SB	Through	360	502	358	42	D
		Right	360	501	33	71	E
		U-Turn	360	501	30	73	E
LP2 Point Houston	SB	Through	13	156	541	3	A
	NB	Through (Ln3)	432	509	173	196	F
		Through	445	510	283	41	E
		Left	445	510	470	78	F
LP2 Point Nandy Park	NB	Through	0	15	796	1	A
		Right	1	34	55	5	A
	SB	U-Turn	0	15	38	2	A
		Through	0	2	377	0	A
		Left	0	14	7	2	A
	WB	Right	0	13	8	10	A
		Left	0	10	12	3	A
LP2 Point Eccles	SB	Through	14	115	252	16	B
		Left	14	115	69	36	D
	NB	Through (Ln3)	62	310	102	29	C
		Through	62	310	818	23	C
		Right	444	509	440	48	D
	WB	Left	57	255	9	58	E
		Right	68	268	140	62	E

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)
Q_{max} = Maximum queue length (meters)
Vehicles = Number of vehicles (volume)
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)

Table 28: Level of Service for Projected Model - Ramada Intersection AM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
LP2 Point Massy	NB	Through	9	32	3	1	A	A
		Right	10	33	7	5	A	A
		U-Turn	10	33	7	6	A	A
	SB	Left	0	0	3	3	A	A
		Through	0	0	1	1	A	A
	WB	Right	2	7	9	8	A	A
		U-Turn	1	6	1	2	A	A
		Left	2	7	2	3	A	A
LP2 Point DH Bridge	EB	Right	357	446	113	128	F	F
		Left	358	445	42	56	D	E
	NB	Through (Ln3)	71	75	18	16	B	B
		Left	64	68	20	21	B	C
		Through	203	226	22	20	C	B
	SB	Through	447	446	58	55	E	D
		Right	447	447	91	89	F	F
		U-Turn	447	447	122	118	F	F
LP2 Point Houston	SB	Through	297	275	41	35	E	D
	NB	Through (Ln3)	494	473	213	212	F	F
		Through	462	446	41	42	E	E
		Left	460	446	78	78	F	F
LP2 Point Nandy Park	NB	Through	65	64	12	10	B	A
		Right	71	70	15	12	B	B
	SB	U-Turn	1	1	9	9	A	A
		Through	0	0	1	1	A	A
		Left	0	0	2	2	A	A
	WB	Right	3	6	32	15	D	B
		Left	2	6	13	5	B	A
LP2 Point Eccles	SB	Through	31	46	30	34	C	C
		Left	31	46	46	50	D	D
	NB	Through (Ln3)	315	264	67	60	E	E
		Through	315	264	58	52	E	D
		Right	462	460	76	66	E	E
	WB	Left	277	269	181	167	F	F
		Right	285	277	196	186	F	F

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 29: Level of Service for Projected Model - Ramada Intersection AM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
LP2 Point Massy	NB	Through	87	143	13	15	B	B
		Right	89	145	16	19	C	C
		U-Turn	89	145	20	11	C	B
	SB	Left	0	0	3	3	A	A
		Through	0	0	1	1	A	A
	WB	Right	13	30	23	34	C	D
		U-Turn	10	26	1	23	A	C
		Left	12	29	18	29	C	D
LP2 Point DH Bridge	EB	Right	468	453	144	131	F	F
		Left	467	462	57	59	E	E
	NB	Through (Ln3)	112	126	22	23	C	C
		Left	104	119	36	36	D	D
		Through	259	264	34	38	C	D
	SB	Through	440	466	57	70	E	E
		Right	440	466	98	116	F	F
		U-Turn	440	466	118	143	F	F
LP2 Point Houston	SB	Through	421	401	58	64	F	F
	NB	Through (Ln3)	499	449	228	224	F	F
		Through	464	417	44	38	E	E
		Left	463	417	78	71	F	F
LP2 Point Nandy Park	NB	Through	154	202	27	31	D	D
		Right	163	214	29	32	D	D
	SB	U-Turn	2	1	14	17	B	C
		Through	1	0	2	1	A	A
		Left	2	1	2	2	A	A
	WB	Right	5	16	61	66	F	F
		Left	4	15	30	27	D	D
LP2 Point Eccles	SB	Through	55	45	49	42	D	D
		Left	54	45	56	50	E	D
	NB	Through (Ln3)	398	353	96	94	F	F
		Through	398	353	71	63	E	E
		Right	465	474	80	97	E	F
	WB	Left	374	372	216	209	F	F
		Right	380	378	222	219	F	F

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2023 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2023 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 30: Level of Service for Base Model - Ramada Intersection PM Peak (2019)

Site	Direction	Movement	Q_{95} (m)	Q_{max} (m)	Vehicles	Delay (s)	LOS
LP2 Point Massy	NB	Through	0	12	561	0	A
		Right	1	22	50	7	A
		U-Turn	0	23	6	5	A
	SB	Left	0	16	76	1	A
		Through	0	1	623	0	A
	WB	Right	1	26	42	9	A
		U-Turn	0	16	4	6	A
		Left	1	25	47	4	A
LP2 Point DH Bridge	EB	Right	147	235	81	21	C
		Left	305	464	227	1	A
	NB	Left	15	133	65	19	B
		Through	15	133	641	12	B
	SB	Through	433	510	671	13	B
		Right	437	510	254	286	F
		Through (Ln3)	16	134	642	3	A
LP2 Point Houston	SB	Through	1	40	1553	1	A
	NB	Through	0	0	454	0	A
		Left	0	0	538	0	A
LP2 Point Nandy Park	NB	Through	0	4	630	1	A
		U-Turn	0	23	0	0	A
		Right	1	23	32	0	A
	SB	U-Turn	0	26	53	10	A
		Through	0	11	689	3	A
		Left	0	26	16	1	A
	WB	Right	1	27	22	1	A
		Left	1	27	41	12	B
LP2 Point Eccles	NB	Through	227	506	847	15	B
		Right	227	506	13	45	E
	SB	Through	254	510	1094	76	F
		Left	0	0	62	24	C
	WB	Left	18	78	44	52	F
		Right	18	78	135	36	E

Q_{95} = 95th percentile queue (distance in metres of vehicles behind the stop line)
Q_{max} = Maximum queue length (meters)
Vehicles = Number of vehicles (volume)
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)

Table 31: Level of Service for Projected Model - Ramada Intersection PM Peak (2021 and 2021 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2021 Base	2021 + Trips	2021 Base	2021 + Trips	2021 Base	2021 + Trips
LP2 Point Massy	NB	Through	5	8	5	7	A	A
		Right	6	10	12	15	B	B
		U-Turn	6	10	12	16	B	C
	SB	Left	0	0	1	1	A	A
		Through	0	0	0	0	A	A
	WB	Right	10	10	32	31	D	D
		U-Turn	8	8	24	17	C	C
		Left	9	10	20	20	C	C
LP2 Point DH Bridge	EB	Right	154	163	106	83	F	F
		Left	147	154	9	7	A	A
	NB	Left	174	180	41	43	D	D
		Through	174	180	53	55	D	D
	SB	Through	490	488	18	16	B	B
		Right	491	490	354	334	F	F
		Through (Ln3)	175	181	6	6	A	A
LP2 Point Houston	SB	Through	162	144	30	26	D	D
	NB	Through	0	0	0	1	A	A
		Left	0	0	0	0	A	A
LP2 Point Nandy Park	NB	Through	112	143	17	15	C	B
		U-Turn	125	157	55	61	F	F
		Right	125	157	0	0	A	A
	SB	U-Turn	4	8	65	70	F	F
		Through	3	5	22	28	C	D
		Left	4	7	3	5	A	A
	WB	Right	31	43	2	3	A	A
		Left	31	43	217	269	F	F
LP2 Point Eccles	NB	Through	360	358	16	17	C	C
		Right	360	358	48	48	E	E
	SB	Through	415	402	132	125	F	F
		Left	0	0	47	41	E	E
	WB	Left	41	58	97	110	F	F
		Right	41	58	60	68	F	F

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2021 Base = Projected conditions “without development”, assuming a 5% per annum growth factor applied to 2019 measured conditions
2021 + Trips = Projected conditions “with development”, assuming a 5% per annum growth factor applied to 2019 measured conditions

Table 32: Level of Service for Projected Model - Ramada Intersection PM Peak (2023 and 2023 with projected development trips)

Site	Direction	Movement	Queue Length (m)		Delay (s)		LOS	
			2023 Base	2023 + Trips	2023 Base	2023 + Trips	2023 Base	2023 + Trips
LP2 Point Massy	NB	Through	98	82	37	33	E	D
		Right	102	86	42	37	E	E
		U-Turn	103	87	45	43	E	E
	SB	Left	0	0	1	1	A	A
		Through	0	0	0	0	A	A
	WB	Right	65	61	153	142	F	F
		U-Turn	60	56	72	110	F	F
		Left	64	61	106	113	F	F
LP2 Point DH Bridge	EB	Right	184	114	152	138	F	F
		Left	175	107	17	13	B	B
	NB	Left	204	210	46	46	D	D
		Through	204	210	61	60	E	E
	SB	Through	498	500	17	18	B	B
		Right	499	500	319	331	F	F
		Through (Ln3)	206	212	7	7	A	A
LP2 Point Houston	SB	Through	298	312	55	58	F	F
	NB	Through	0	0	0	1	A	A
		Left	0	0	0	1	A	A
LP2 Point Nandy Park	NB	Through	288	314	30	31	D	D
		U-Turn	306	333	92	95	F	F
		Right	305	333	0	0	A	A
	SB	U-Turn	15	8	104	103	F	F
		Through	12	5	50	40	E	E
		Left	15	7	7	4	A	A
	WB	Right	94	85	7	2	A	A
		Left	94	85	546	588	F	F
LP2 Point Eccles	NB	Through	360	359	16	17	C	C
		Right	360	358	47	48	E	E
	SB	Through	492	494	134	146	F	F
		Left	0	0	48	50	E	E
	WB	Left	63	61	110	109	F	F
		Right	63	61	70	72	F	F

Queue Length = Distance (metres) of vehicles in queue behind the stop line
Delay = Vehicle Delay at the intersection (seconds)
LOS = Level of Service (A being the least congested and F being the most congested)
2023 Base = Projected conditions "without development", assuming a 5% per annum growth factor applied to 2019 measured conditions
2023 + Trips = Projected conditions "with development", assuming a 5% per annum growth factor applied to 2019 measured conditions

Discussion

Comparison of modelled LOS values between the "without development" and "with development" scenarios indicated that the additional projected development trips in 2021 and 2023 will result in minimal changes to conditions on the existing road networks. This is due to the low percentage increase (relative to measured current conditions) associated with the additional projected development trips.

When undertaking analysis of a network of intersections where heavy flows occur in one main direction, it is expected that users of minor roads will experience poor LOS and high delays in attempting to traverse a common intersection. This is more so the case when dealing with unsignalized intersections. However, additional traffic on the major road segment may result in a reduction in vehicle flows and a slowing down of traffic at the intersection. There comes a point where the increased congestion creates more gaps in the traffic stream, allowing a greater volume of minor road users to access or cross the major road. Model analysis results of queue length, delay, and LOS may therefore appear to show improved flows and general operations for minor roads with the addition of vehicles to the intersection. However, this is to be taken into context of the entire intersection, where overall delay is increased.

This concept also applies to a dense, connected network of intersections, where vehicle spilling back into upstream intersections create gaps in the minor and/or opposite directions, given the appearance of improved operations. These issues were observed at the "Contractor Shorebase B" intersections, in particular.

Some of the existing road networks observed were characterised by less than ideal conditions, in particular the signalized intersections. It was observed that at all of the signalized intersections included in the study, police officers were present during peak periods to regulate traffic and alleviate congestion at the intersections. The high delays and **LOS F** ratings for these intersections indicate a need to optimise signal timings to allow for more efficient operations at the intersection and network levels. The following is therefore noted:

- The Contractor Shorebase B location is in an area where there is a high level of activity that directly affects traffic flows, resulting in substantial delays on the surrounding streets and spillover congestion into a number of major intersections.
- The Ramada Intersection location features high levels of northbound traffic into Georgetown in the morning and the reverse in the afternoon, resulting in significant delay and congestion (i.e., **LOS E** or **LOS F**).

- The EEPGL Office Complex / Ogle location shows high volumes of east-west traffic as vehicles go to and from Georgetown. The signalized intersection is observed to not efficiently handle the elevated volumes.
- Some of the high volumes from the EEPGL Office Complex / Ogle location lead into the Marriott location and result in excessive delay, especially at the signalized M11 intersection.

Conclusion

The additional projected development trips are not predicted to significantly impact traffic congestion on the existing roadway. One exception is in the vicinity of the EEPGL Office Complex / Ogle area, where LOS modelling indicates the addition of projected development traffic would result in a shift from an acceptable LOS (i.e., LOS A to LOS D) to an unacceptable LOS (i.e., LOS E or LOS F) for certain approach-movement combinations at two intersections off of the Railway Embankment Road (OGL 2 and OGL 6).

In general, the numbers of additional projected development trips at the study intersections are relatively small compared to measured base traffic volumes. The road network in the vicinity of some of the study intersections are characterized by high levels of base congestion due to limited road capacity, sub-optimal signal timing, and/or excessive vehicle demand. It is noted, however, that even in these areas, the additional projected development trips are not predicted to contribute significantly to worsening congestion. It is also noted that the analysis was based on a conservative assumption that the additional projected development trips were assumed to occur primarily during peak periods. It is more likely that a significant number of these trips will occur outside of peak hours, further reducing the (already negligible) predicted impacts on traffic congestion.

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CARITRANS

Caribbean Transportation Consultancy Services (CARITRANS) Company Limited
Address: Lot No. 5B Trincity Industrial Estate, Trinicity
Telphone: (868) 225 6926
Website:www.caritransltd.com

APPENDIX V

Enhanced Coastal Sensitivity Mapping—Ecosystem Services Final Reports

Submitted with Changes

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Prepared by:

Environmental Resources Management (ERM)
210 New Market Street
Georgetown, Guyana

Environmental Management Consultants (EMC)
60 Area H Ogle,
East Coast Demerara, Guyana

Enhanced Coastal Sensitivity Mapping—Ecosystem Services (Regions 1–4)—FINAL REPORT

Liza Phase 1 Development Project
Esso Exploration and Production Guyana Limited

April 2020

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EXECUTIVE SUMMARY

In 2016, ExxonMobil's affiliate Esso Exploration and Production Guyana Limited (EEPGL) applied to the Guyana Environmental Protection Agency (EPA) for an Environmental Authorisation for the Liza Phase 1 Development Project in the Stabroek Block, offshore Guyana. On June 1, 2017, the Guyana EPA approved the Environmental Impact Assessment (EIA) submitted as part of the Application for Environmental Authorisation and issued an Environmental Permit for the Phase 1 Development Project. As a condition of the Environmental Permit, the EPA required EEPGL to conduct field studies to verify (i.e., ground truth) selected shoreline and coastal habitat classifications contained in the coastal sensitivity maps provided in the approved EIA. The specific focus on ecosystem services was a direct request from the EPA during post-permit alignment meetings held in August 2017. Although oil spill modeling scenarios do not suggest the potential for impacts to shorelines along the coast of Guyana when standard response and mitigation measures are employed, EEPGL agreed to provide a baseline of ecosystem services for coastal communities for Regions 1–4.

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities and provide cultural fulfilment.

There are four standard categories of ecosystem services: *provisioning, regulating, cultural* and *supporting* services, defined as follows:

- **Provisioning services:** The goods or products obtained from an ecosystem such as food, freshwater, timber, fiber and other goods.
- **Regulating services:** The benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards.
- **Cultural services:** The non-material benefits obtained from an ecosystem such as recreation, spiritual values, and aesthetic enjoyment.
- **Supporting services:** The natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Despite the environmental importance of ecosystems and the biodiversity that underpins them, they are often undervalued and their importance underestimated in terms of the benefit they provide to human welfare. Therefore, in order to full understand the relationship between people and nature, it is critical to utilize a methodology that involves participation by the individuals who interact with the ecosystems under study.

In October 2017, a workshop was held by Environmental Resources Management (ERM) and Environmental Management Consultants (EMC) to discuss with key stakeholders (including Government, non-governmental organizations (NGOs), academics, indigenous community representatives, and civil society) the purpose of the ecosystem services study, the schedule,

and the proposed methodology for conducting the study. It was determined that a Community Based Participatory Research (CBPR) approach with local communities would be utilized in order to conduct a screening and scoping of ecosystem services. The CBPR approach is a partnership approach to research that equitably involves researchers, expert organizations, and community members in all aspects of a research process.

The methodology agreed upon using the CBPR approach comprised a data collection effort broken down into two parts. The first part was a screening exercise, through which local specialists from EMC, accompanied by an ERM socioeconomic expert, conducted stakeholder interviews with coastal community leadership and members to identify a comprehensive list of the ecosystem services that are potentially present along those coastal communities. The second part was a scoping exercise, involving field observations with representatives of the same group of community leadership and members who contributed to screening, with the objectives of establishing a complete list of ecosystem service beneficiaries; defining the value of ecosystem services to beneficiaries; identifying (through field verification) habitats and resources that provide ecosystem services; and assessing the existing condition and trends of these habitats and resources. The Study Area was defined as the coastal area throughout Regions 1 through 4, up to a distance of 500 meters from the shoreline.

After finalizing the screening and scoping protocols, in November and December 2017, the EMC/ERM specialists met with 25 coastal Neighborhood Democratic Councils (NDCs) and town councils in Regions 2, 3, and 4 to learn first-hand about their activities related to ecosystem services. Over 164 local community members participated in the meetings and many accompanied the team into the field after each meeting to help visually observe and map the ecosystem services. In April 2018, the same team of specialists met with 14 Community Development Councils (CDCs)/Village Councils (VCs)/Town Councils (TCs) in Region 1, during which 205 community members participated in the screening and scoping exercises. Given the high population of indigenous peoples throughout Region 1, a representative from the National Toshaos Council (NTC) participated in the entire exercise for Region 1. Each NDC/CDC/VC/TC interview and subsequent field engagement lasted for approximately one-half day.

The team entered data at each meeting and in the field directly into handheld tablets linked to the Liza Project Geographic Information System (GIS) database, and also took notes on general comments and observations. Based on the findings of the study, provisioning services were determined to be the primary service provided by the coastal ecosystem in Regions 1-4, accounting for 69 percent of the location-specific services identified in the four regions; cultural, regulating, and supporting services accounted for 20 percent, 9 percent, and 2 percent, respectively, of the location-specific services identified in the four regions. The detailed results of the study, including data at each NDC/CDC/VC/TC level are captured in this report, as well as in the Liza Project GIS database. The findings of the ecosystem services assessment were used primarily to: (1) validate assessments made in the Liza Phase 1 EIA; (2) provide baseline data for the Liza Phase 2 and Payara EIAs; and (3) provide detailed mapping for use in prioritizing oil spill response activities.

1. INTRODUCTION

1.1. Overview

This report provides an introduction to the concept and treatment of ecosystem services along the coastal communities in Regions 1, 2, 3, and 4 of Guyana. Ecosystem services are typically defined as the benefits that people obtain from the natural environment, as further defined and described in Section 1.2. The report was prepared by Environmental Resources Management (ERM) and Environmental Management Consultants (EMC). The work described herein corresponds with the Liza Phase 1 Post-Permit Studies requested by the Guyana Environmental Protection Agency (EPA) in the Environmental Permit issued to Esso Exploration and Production Guyana Ltd. (EEPGL) for its Liza Phase 1 Development Project[1].

Along with the **Enhanced Coastal Sensitivity Mapping—Biodiversity (Regions 1-4)** report and related geospatial mapping (submitted under separate cover), this report fulfils the Permit requirement in clause 1.5 to conduct field studies to verify (i.e., ground truth) selected shoreline and coastal habitat classifications contained in the coastal sensitivity maps provided in the approved Liza Phase 1 Development Project ("the Project") Environmental Impact Assessment (EIA). The focus on ecosystem services was a direct request from the EPA during post-permit alignment meetings held in August 2017. Although oil spill modeling scenarios do not suggest the potential for impacts to shorelines along the coast of Guyana when standard response and mitigation measures are employed, EEPGL agreed to provide a baseline of ecosystem services for coastal communities from Region 1 to Region 4.

The information presented in this report specifically provides for the screening, scoping, and validation of ecosystem services utilizing an internationally recognized ecosystem services methodology combined with geospatial analysis, as described in Section 2. The purpose is to further validate the ecosystem services findings in the Liza Phase 1 EIA, as well as provide specific details on coastal communities and their use of coastal resources to better inform EEPGL's oil spill response planning.

1.2. Scope Development

ERM and EMC held a coordination and planning workshop in October 2017 in Georgetown, with key stakeholders including Government, non-governmental organizations (NGOs), academics, indigenous community representatives, and other expert entities to discuss the purpose of the ecosystem services study, the applicability and the proposed methodology. It was determined that a Community Based Participatory Research (CBPR) approach with local communities would be utilized in order to conduct a screening and scoping of ecosystem services. The objective of the study was to provide data to establish a baseline of the relationship between coastal communities and the natural environment. The results of the study are captured in this report, as well as in the Liza Project Geographic Information System (GIS) database, and Liza

[1] Environmental Permit No. 20160705-EEDPF, dated June 1, 2017

Project Stakeholder Engagement Plan. The Study Area was defined as the immediate coastal area throughout Regions 1 through 4, up to a distance of 500 meters from the shoreline.

In November and December 2017, local specialists from EMC, accompanied by an ERM socioeconomic expert, conducted stakeholder meetings with 25 coastal Neighborhood Democratic Councils (NDCs) and town councils in Regions 2, 3, and 4 to learn first-hand about their activities related to ecosystem services. A total of 164 local community members participated in the meetings, and many from each NDC accompanied the team into the field after each meeting to help visually observe and map the activities.

In April 2018, the same team of specialists met with 14 Community Development Councils (CDCs)/Village Councils (VCs)/Town Councils (TCs) in Region 1, during which 205 community members participated in the meetings. Given the high population of indigenous peoples throughout Region 1, a representative from the National Toshaos Council (NTC) participated in the entire exercise. The NTC participation was to ensure all the engagements were fair and impartial and the concerns of the Indigenous communities were raised and addressed. The participation of the NTC was beneficial to the exercise, since communities were more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, had more confidence in the process and participated freely in the discussions.

The team entered data at each meeting directly into handheld tablets linked to the Liza Project GIS database, and also took notes on general comments and observations. The results of these meetings and field observations are described in this report, along with Ecosystem Service-specific maps for each NDC/CDC/VC/TC. Map books have been created from the GIS information contained in the database, and are provided under separate cover. Additionally, integrated map books (including both ecosystem service and biodiversity information) will be included in EEPGL's Oil Spill Response Plan.

During May to July 2019, following the screening, scoping, and assessment exercise, the same team of socioeconomic experts conducted a validation effort of the ecosystem services baseline data collected during the previous assessment phase. The team visited the same coastal NDCs, CDCs, VCs, and TCs (Haimokabra and Waramuri in Region 1 were visited simultaneously since Haimokabra is considered a satellite village of and shares leadership with Waramuri). This additional validation step enhances the accuracy of the original effort by allowing stakeholders to review and comment on the results of the screening, scoping, and assessment exercise. Any changes or additions to individual ecosystem services from the exercise were documented and larger trends that could have occurred over time as a result of specific ecosystem management interventions (e.g., mangrove programs) or extrinsic factors (e.g., population changes) were identified.

1.3. Definition of Ecosystem Services

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities and provide cultural fulfilment.

There are four standard categories of ecosystem services: *provisioning, regulating, cultural and supporting* services, defined as follows.[2]

- **Provisioning services:** The goods or products obtained from ecosystems such as food, freshwater, timber, fiber and other goods.
- **Regulating services:** The benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards.
- **Cultural services:** The non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment.
- **Supporting services:** The natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Additional details about the types of services under each category are provided in Appendix A.

[2] Millennium Ecosystem Assessment (MA). 2005. Synthesis Report. Island Press, Washington DC.

2. METHODOLOGY

2.1. Ecosystem Services Screening

A screening exercise was undertaken with the NDCs/CDCs/VCs/TCs prior to field observations in order to identify a comprehensive list of the ecosystem services that are potentially present along coastal communities in Regions 1, 2, 3, and 4. This step does not attempt to consider the importance of the services to beneficiaries or the likelihood of the Project impacting them in the event of an unplanned oil spill; it simply asks whether a service is likely to be present or not in each costal area.

For a service to be considered present, it must meet two criteria:

1. Habitats present in the Study Area are believed to provide this service or are similar to habitats elsewhere that provide this service; and
2. People are believed to benefit from the service, either at the local, national, or global level, and/or the Project is expected to benefit from this service.

Appendix A provides the screening checklist that was used by the team when interviewing. The table uses a standard list of ecosystem services adapted from internationally accredited sources.[3] All services identified as present or potentially present were then "screened in" to be considered when going into the field for observation, data collection, and mapping of the exact locations where such services exist.

For Region 1, the team supplemented the standard screening checklist with Region 1-specific questions derived from the Shell Beach Protected Area (SBPA) Management Plan[4], and questions developed by the Sea Turtle Census Initiative/Chelonian Research Institute turtle experts conducting the sea turtle telemetry work at Shell Beach Protected Area (also as part of the Liza Phase 1 Post-Permit Studies). These Region 1-specific topics are called out in the screening checklist.

[3] World Resources Institute (WRI). 2013. Weaving Ecosystem Services into Impact Assessment: A Step-by-Step Method. WRI, Washington, DC.
[4] PAC and EPA. 2014. Shell Beach Protected Area Management Plan 2015 – 2019 Volume 1, FINAL – DECEMBER 15, 2014

PHOTO 1: INTERVIEWS WITH VILLAGE LEADERS AND VILLAGERS (REGION 1)






BY ORDER OF MANAGEMENT









PHOTO 2: INTERVIEWS WITH NDC MEMBERS AND LOCAL COMMUNITY (REGIONS 2-4)





2.2. Ecosystem Services Scoping

Following completion of the screening exercise, the team and members of the local community used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This step aimed to:

- Establish a complete list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify the habitats and resources that provide ecosystem services in the Study Area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The descriptions and examples of "scoped-in" services for the Study Area, based on stakeholder input and field verification information, are provided in the scoping tables and broken down by NDC/CDC/VC/TC. During the engagements, the team, where appropriate, also asked for baseline data at the NDC/CDC/VC/TC level, including population statistics, numbers of beneficiaries utilizing each service or partaking in various livelihoods, incomes generated from livelihoods, and other socioeconomic baseline data. These data, when available, are captured in the overview of each Region, as well as in the detailed scoping tables. This information can also be found in the Liza Project GIS Database.

PHOTO 3: FIELD OBSERVATIONS WITH CDC/VC/TC MEMBERS AND LOCAL COMMUNITY (REGION 1)










PHOTO 4: FIELD OBSERVATIONS WITH NDC MEMBERS AND LOCAL COMMUNITY (REGIONS 2-4)





2.3. Ecosystem Services Prioritization

The ecosystem services prioritization has been designed to be consistent with international best practice, using the 2012 International Finance Corporation (IFC) Performance Standards (PS) as guidance. The prioritization process focuses on identifying services which that are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

a) **Importance of ecosystem services** to beneficiaries was assessed according to the following criteria and assigned a rating from low to essential based on:

- Intensity of use – e.g., daily, weekly or seasonal use; quantitative data were used if available and relevant;
- Scope of use – e.g., household versus community level, commercial use only, subsistence only or both;
- Degree of dependence – e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community; and
- The importance expressed by stakeholders and beneficiaries, including cultural and historical importance.

The weight given to each of these components varied slightly depending upon the service, but the importance to stakeholders and beneficiaries took precedence over other criteria with respect to the ultimate rating. Where a service was of greater or lesser importance to different stakeholder groups, two (or more) ratings were assigned so that impacts on these groups can be assessed individually.

b) **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The 'replaceability' of a service was assessed according to the following criteria and assigned a rating from high (many alternatives) to low (few or no alternatives):

- The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and man-made substitutes (e.g., availability of man-made items as an alternative to handicrafts);

- The accessibility, cost and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
- Preference / appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign a priority rating to the service (see Figure 2-1 below). **Ecosystem services *with high or critical* priority ratings are considered to be 'priority' ecosystem services.** As noted above, some services may have different importance ratings for different beneficiary groups, and therefore may be rated 'priority' services for some beneficiaries but not for others.

FIGURE 2-1: ASSIGNING A PRIORITY RATING TO ECOSYSTEM SERVICES

		Replaceability of Service		
		High *(many spatial alternatives)*	**Moderate** *(some spatial alternatives)*	**Low or Not Replaceable** *(few to no spatial alternatives)*
Importance of Service to Beneficiaries	**Essential**	*High*	*Critical*	*Critical*
	High	*Medium*	*High*	*Critical*
	Moderate	*Low*	*Medium*	*High*
	Low	*Low*	*Low*	*Medium*

2.4. Ecosystem Services Validation

Following completion of the above described steps, it was decided to revisit each of the NDCs, VCs, CDCs, and TCs to:

- Validate that the information compiled was correct;
- Verify that the Coastal Resources Maps were accurate;
- Collect any new data relating to ecosystems benefits since the previous engagements; and
- Collect updated socioeconomic data.

During the validation exercises, the team presented the findings and maps and asked the stakeholders a series of questions, as detailed below:

- Is the information presented for your district (NDC/TC/CDC/VC) correct?
- If not, what do we need to change/adjust?
- Are the locations for the various services presented on the map correct?

- Are the main economic activities/livelihoods in the area the same as one year ago? If not, what has changed?
- Has there been any notable growth or decline in any particular sector? What sector? What has changed?
- Has there been any increase in coastal resources over the past year? What purpose and where?
- Has there been any new use of coastal resources within the area over the past year? What purpose and where?
- Has there been any change to previous mapped points?
- What is the general description of the change?
- What is the current population estimate or trend (increased or decreased over past year)? What is contributing to the trend?
- Are there any other notable socioeconomic data that you wish to have documented?

The responses received during the validation exercise are incorporated below, presented by region. Raw data as it was recorded can be found in Appendix G: Validation Data Summary. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time elapsed between the 2017/2018 original data collection and the 2019 validation exercise.

3. ECOSYSTEM SERVICES FINDINGS AND PRELIMINARY CONCLUSIONS

3.1. Overview of Findings

Based on the findings of the assessment, provisioning services were the primary service provided by the coastal ecosystem in Regions 1-4, accounting for approximately 51.5 percent of the location-specific services identified in the four regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants;
- Traditional resource use in Region 1, including traditional medicine;
- Animals hunted primarily for food (recreational hunting is covered separately under cultural services);
- Aquatic transportation in remote areas where no alternative methods exist and commercial transportation facilities; and
- Income generators or services supporting income generation (e.g., boat building, repairs, transportation services).

Cultural services were the second most prevalent ecosystem service, representing approximately 35 percent of the location-specific services identified in the four regions. The most common cultural services identified include:

- Cultural value placed on traditional practices such as use of a location for prayer services;
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing; and
- Value placed on the aesthetics provided by landscapes and seascapes.

Regulating services were the third-most prevalent ecosystem services, representing approximately 8.5 percent of the location-specific services identified in the four regions. The most common regulating services identified include:

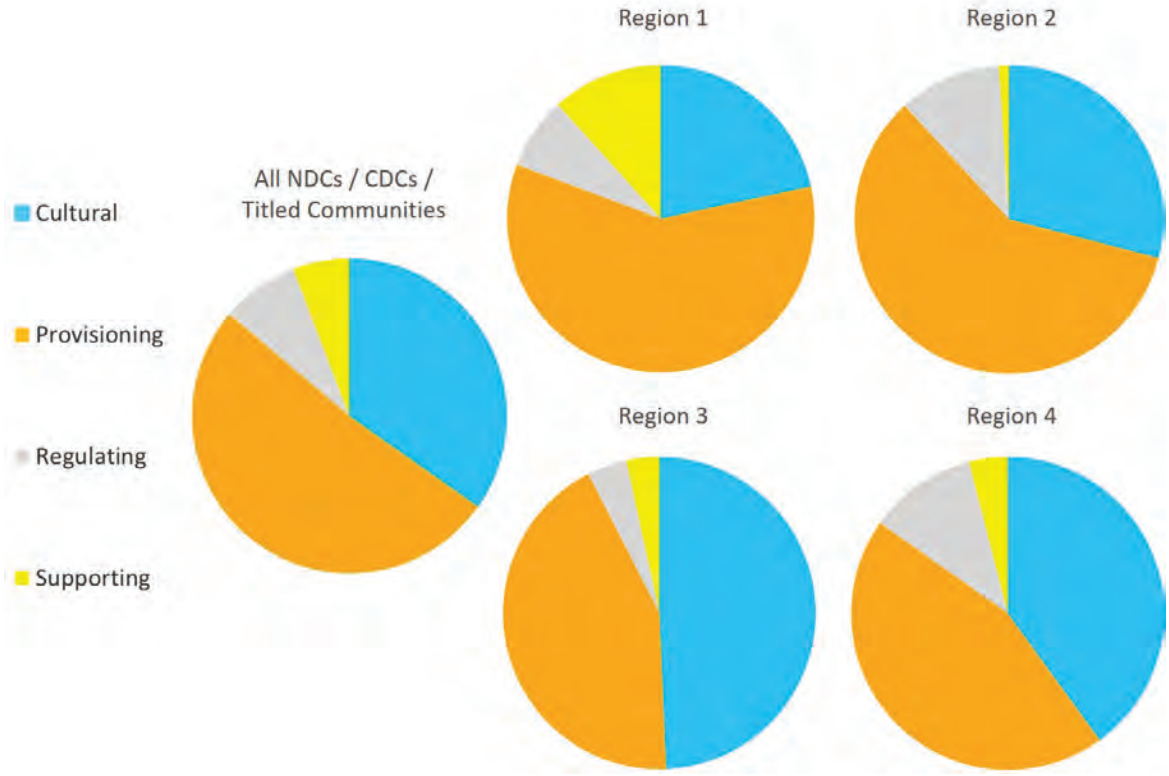
- Shoreline and riverbank protection and the role of mangroves in protecting crops, buildings, recreation areas from waves, wind and flooding; and
- Erosion protection and the role of vegetation in regulating erosion on slopes.

Supporting services are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. The service “Habitat Provision” is typically an exception, which is sometimes valued as an “end-use” service by stakeholders in addition to its supporting

role. Therefore, the relatively low prevalence of identified supporting services, representing approximately 5 percent of the location-specific services identified for the three regions, is not atypical; the services identified relate primarily to the fact that some stakeholders value mangroves for their maintenance of species populations and their ability to allow ecological communities to recover from disturbances, in addition to their regulating role of shoreline protection.

Figure 3-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories.

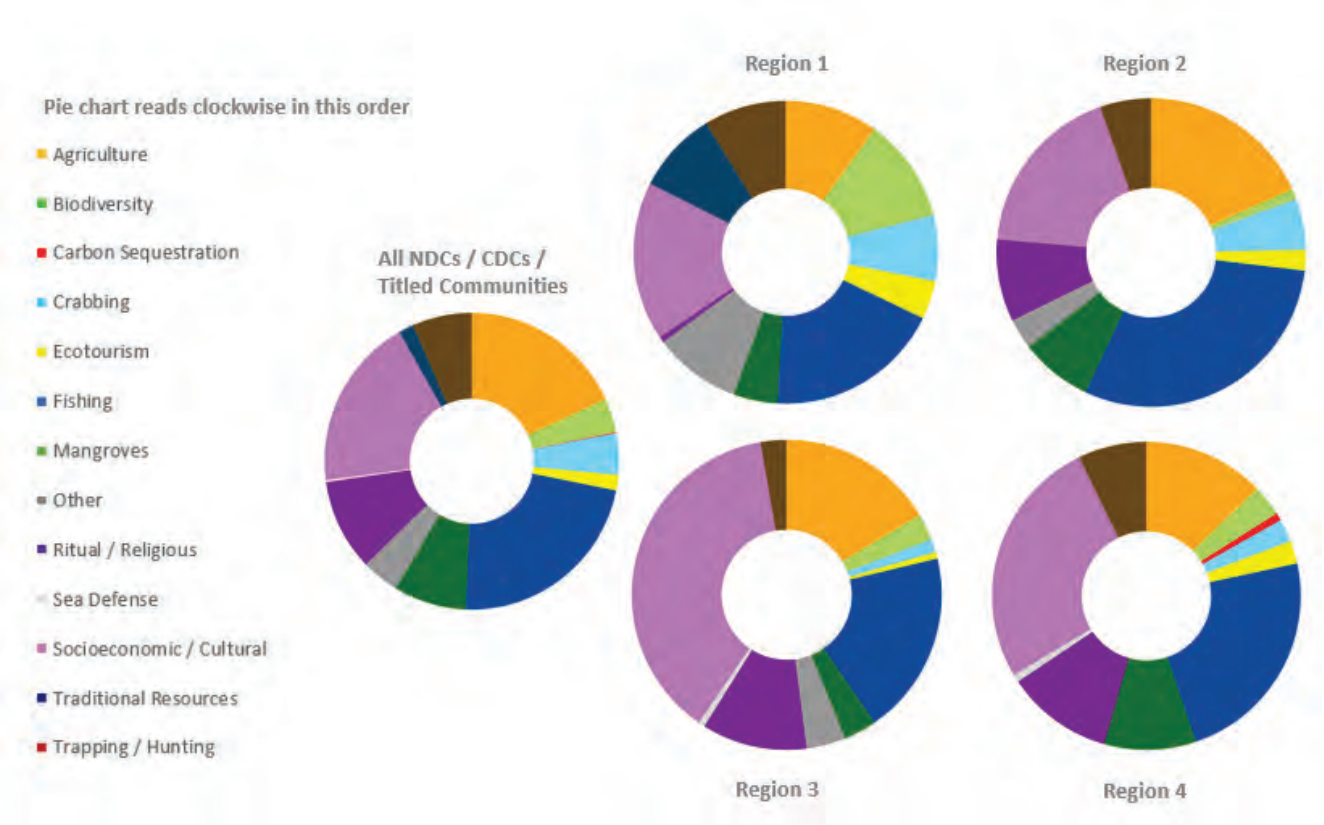
FIGURE 3-1: DISTRIBUTION OF ECOSYSTEM SERVICE CATEGORIES



NOTE: "All NDCs" pie chart includes Regions 1 through 6, which, when combined, indicates provisioning at 55.5 percent, cultural at 31 percent, regulating at 9.5 percent, and supporting at 4 percent.

Figure 3-2 summarizes the distribution of specific ecosystem service types across the categories. The service types match those used in the map books described herein.

FIGURE 3-2: DISTRIBUTION OF ECOSYSTEM SERVICE TYPES



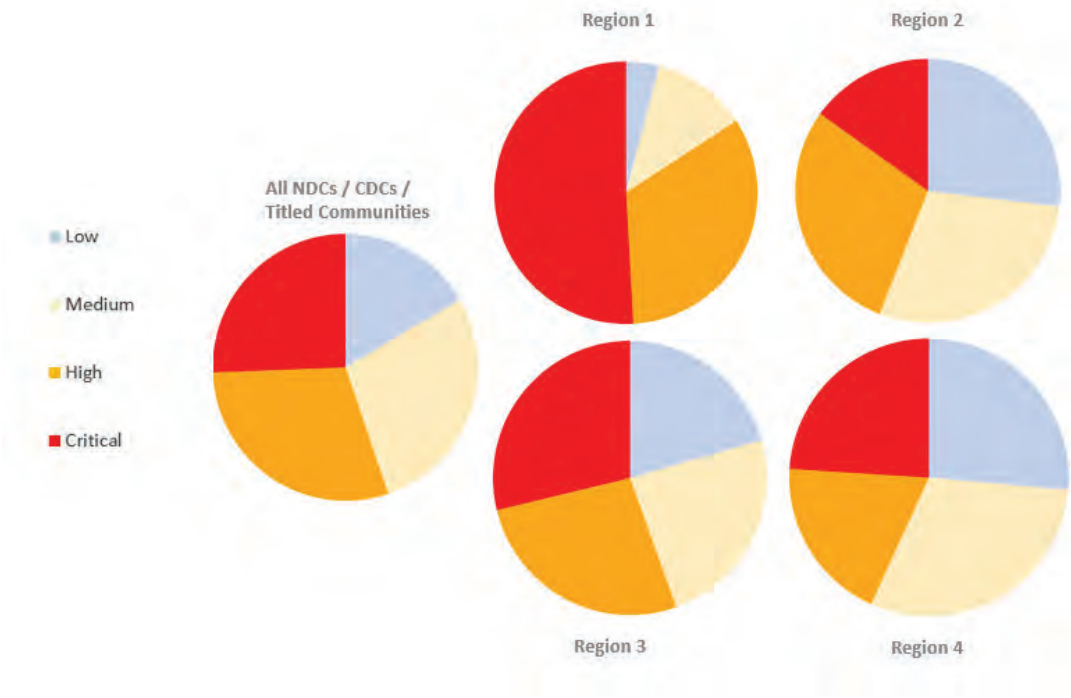
NOTE: "All NDCs" includes Regions 1 through 6 which, when combined, indicates fishing at 23 percent, socioeconomic/cultural at 19 percent, agriculture at 18 percent, ritual/religious at 10 percent, mangroves at 8 percent, trapping/hunting at 7 percent, crabbing at 5 percent, other at 4 percent, ecotourism and traditional resources each at 2 percent, and sea defense and carbon sequestration each at under 1 percent.

3.2. Summary of Findings by Region

Detailed findings for each identified ecosystem service, as well as priority ratings, are provided in Appendices B, C, D, and E and are summarized in Sections 4 to 7. As one of the primary goals of this study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 1-4, the ratings vary widely depending upon the responses from each NDC/CDC/VC/TC. For example, in one NDC in Region 2, livestock farming along the coastal wall was reported to be low priority, whereas in an adjacent NDC, the same service was considered a critical priority - since a larger number of families rely on the livestock and there are no other locations for livestock to graze. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figure 3-3 summarizes the distribution of priority ratings for the location-specific ecosystem services identified.

FIGURE 3-3: DISTRIBUTION OF ECOSYSTEM SERVICE PRIORITY RANKINGS



NOTE: "All NDCs" includes Regions 1 through 6, which, when combined, indicates critical at 26 percent, high at 28 percent, medium at 28 percent, and low at 18 percent.

For overview and general comparison purposes only, the **highest priority rating for each service in each Region is included in the table below.** As described in the methodology, services with *high* or *critical* priority ratings are considered to be 'priority' ecosystem services and would be a primary focus in the event of oil spill response. The overview table also helps to visualize which services did not feature as having importance to beneficiaries across the regions.

Table 3-1 summarizes the highest priority rating assigned in each region for each ecosystem service and Figure 3-4 shows a map of where all of the 'priority' (i.e., critical or high rating) ecosystem services are located, regardless of type or region.

TABLE 3-1: HIGHEST ECOSYSTEM SERVICE PRIORITY RATINGS FOR EACH REGION

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4
Provisioning Services				
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Critical	Critical	Critical	Critical
Cultivated crops	Critical	Critical	Critical	High
Livestock farming	High	High	High	High
Food: wild plants and honey	*	N/A	N/A	Medium
Food: wild meat	High	High	Low	Medium
Biomass fuel	*	N/A	N/A	N/A

Ecosystem Service Type	Region 1	Region 2	Region 3	Region 4
Timber and wood products	*	N/A	Low	N/A
Non-wood fibers and resins	*	N/A	Low	N/A
Traditional Resource Use/ Traditional Medicine	High	N/A	N/A	N/A
Freshwater for household use	Critical	N/A	High	N/A
Freshwater for irrigation use	N/A	N/A	Critical	N/A
Aquatic transportation/ports	Critical	Critical	Critical	Critical
Social/Economic commercial activity	Critical	Medium	Critical	Critical
Social/Housing	High	N/A	High	Critical
Regulating Services				
Global climate regulation	N/A	N/A	N/A	N/A
Regulation of water timing and flows	N/A	N/A	N/A	N/A
Flood regulation	N/A	N/A	N/A	N/A
Erosion regulation	Critical	Critical	Critical	Critical
Shoreline protection / Mangroves / River defense	Critical	High	Low	High
Pest regulation	N/A	N/A	N/A	N/A
Pollination	N/A	N/A	Medium	N/A
Disease regulation	N/A	N/A	N/A	N/A
Cultural Services				
Cultural, religious, or spiritual value	Low	Critical	Critical	Critical
Aesthetic value of natural landscapes, historical landmarks	N/A	Medium	Low	High
Tourism and recreation	High	High	Critical	Critical
Non-use value of biodiversity	N/A	N/A	N/A	N/A
Supporting Services				
Habitat provision, coastal protection	High	Critical	Critical	Medium
Primary production, biodiversity	Critical	N/A	N/A	Critical
Nutrient cycling	N/A	N/A	N/A	N/A
Water cycling	N/A	N/A	N/A	N/A
Soil formation	N/A	N/A	N/A	N/A

N/A – Not applicable; service not identified in the region
* - Service identified in the region but as part of Traditional Resource Use/Traditional Medicine

FIGURE 3-4: IDENTIFIED LOCATIONS OF CRITICAL AND HIGH PRIORITY ECOSYSTEM SERVICES – REGION 1

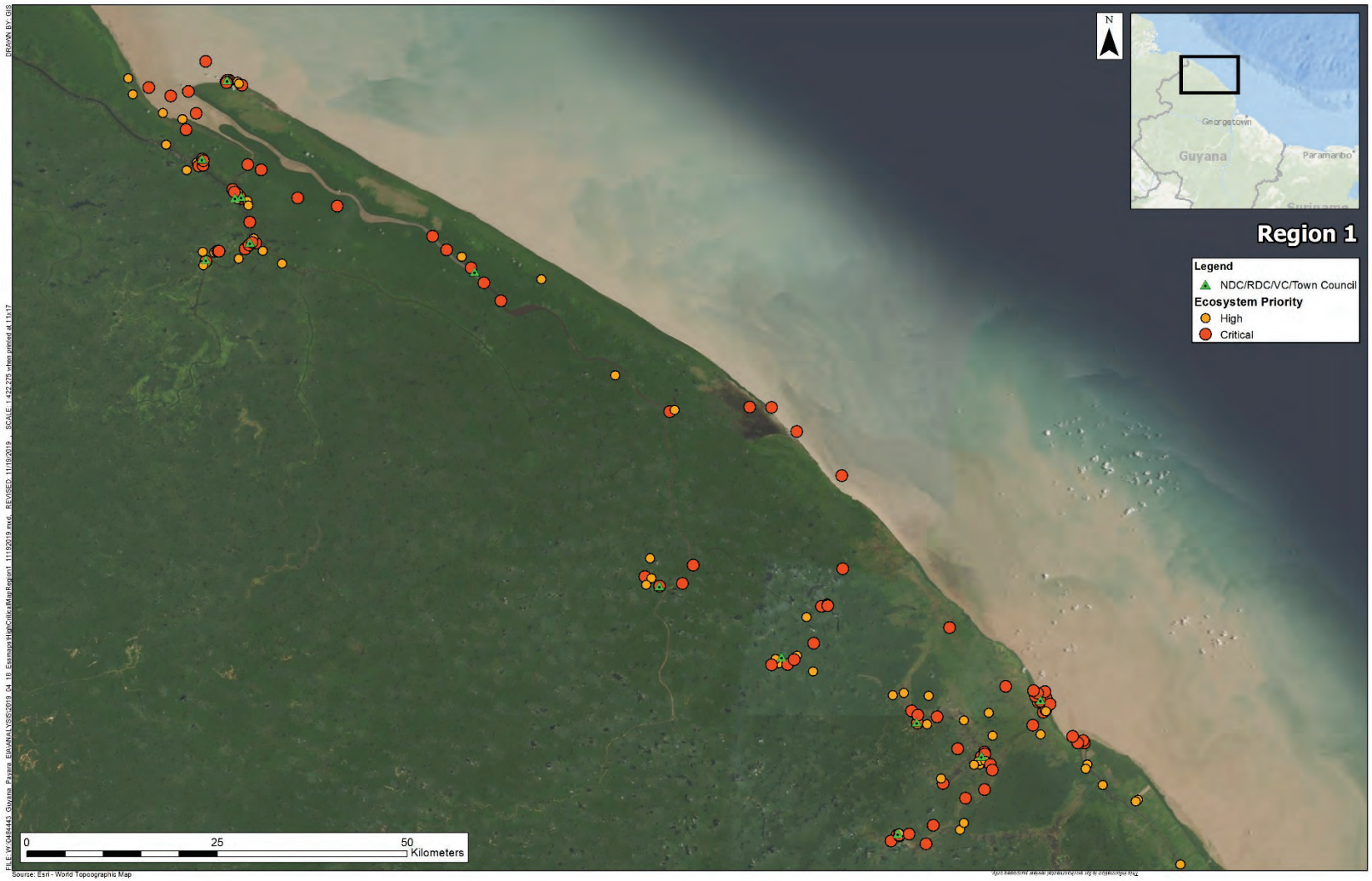


FIGURE 3-5: IDENTIFIED LOCATIONS OF CRITICAL AND HIGH PRIORITY ECOSYSTEM SERVICES – REGIONS 2-4



3.3. Use of Findings

The findings of the ecosystem services assessment will be used primarily to: (a) validate assessments made in the Liza Phase 1 EIA; and (b) provide detailed mapping for use in prioritizing oil spill response activities. In addition, the data can be leveraged for future EIAs and for ethnographic analysis, where understanding how stakeholders view their relationship with the natural environmental may be required.

The data described in the Liza Phase 1 EIA came from a variety of primary and secondary sources, including stakeholder engagement with government entities, fisherfolk, civil society, commercial businesses, NGOs, and academics. Based upon the data in hand at the time of the Liza Phase 1 EIA, it was determined that the Project's only potential impact on ecosystem services would be as a result of an unplanned event, where various environmental and socioeconomic resources could be negatively impacted in the event of a Tier III oil spill (and assuming no spill response and mitigation measures). The Liza Phase 1 EIA discusses various aspects of ecosystem services and related socioeconomic resources along the coastal communities, including:

- Mangroves are important providers of a number of ecological services upon which fish, wildlife, and humans rely (Section 7.4.3.2) and loss of such could weaken a critical component of the country's sea defense system and expose the coastal population to increased coastal flooding hazard (Section 7.4.4.7).
- Decreased fishery and agricultural yields as a result of an oil spill could potentially impact the fishery and agriculture sectors that currently account for a large part of the country's GDP (Section 7.4.4.1).
- Fishing, cultivation of traditional crops such as vegetables and fruits, crabbing, shrimping, and hunting of coastal game are important for subsistence and an oil spill could have a negative impact on food availability, and thus health, in coastal communities (Section 7.4.4.2).
- The coast is important for religious and traditional ceremonies for religious and ethnic groups in Guyana (Section 7.4.4.7).

As depicted in Table 3-1, the findings of the ecosystem services assessment are consistent with the assessment in the Liza Phase 1 EIA regarding potential resources that could be affected by an oil spill. Specifically, the findings corroborate that according to residents of the coastal communities, fishing, agriculture, farming, marine transport, marine related commercial activity, erosion regulation, mangrove protection, recreation, religious practices, and historical landmarks are priority services that should be accounted for when assessing potential impacts of an oil spill.

For Region 1 specifically, the findings also validate aspects of the SBPA Management Plan[5], specifically Section 2.3, which states, "Currently and historically, these communities have

[5] PAC and EPA. 2014. Shell Beach Protected Area Management Plan 2015 – 2019 Volume 1, FINAL – DECEMBER 15, 2014

utilized natural resources found in the area. Fishing, crabbing, hunting, manicole palm and timber harvesting are common among communities. Communities also engage in farming, mostly for subsistence to meet household needs but farm products may also be sold to others within the community."

The data in this report may also help the scientific community and government agencies fulfill some of the Shell Beach research needs as outlined by the PAC and EPA in Section 5 of the SBPA Management Plan, specifically:

- Baseline inventory of ecosystems (high priority need);
- Survey of impact of traditional resource uses within and at the periphery of SBPA (urgent priority need); and

Community inventory and mapping exercise to identify cultural aspects and places of importance and protection for Amerindian communities within and in areas surrounding the SBPA (high priority need). Additionally, the findings of the ecosystem services assessment provide an improved understanding of the specific locations where priority ecosystem services are present along the coast, and this information will be used to support the update of EEPGL's OSRP (i.e., with respect to prioritizing response activities in the event of an oil spill).

4. REGION 1 COASTAL ECOSYSTEM SERVICES FINDINGS

4.1. Population

Figure 4-1 shows the location of the communities in Region 1 with which the team engaged to perform the work.

FIGURE 4-1: AMERINDIAN COMMUNITIES IN REGION 1



Source: EMC

Population estimates for these communities are based upon data provided by the communities' leadership and community health workers during the ecosystem services-related engagements. Population was on the increase in almost all of the communities due to migration from Venezuela.

TABLE 4-1: POPULATION ESTIMATES - REGION 1

CDC/VC/TC Name	Population Estimate
Fathers Beach	23
Manawarin	2,000
Waramuri and Haimakabra	3,100
Santa Rosa	10,500

CDC/VC/TC Name	Population Estimate
Assakata	473
Warapoka	650
Three Brothers	120
Mabaruma Town Council	8,000
Aruka Mouth	300
Morawhanna	100
Smith's Creek	248
Imbotero	353
Almond Beach	51

4.2. Summary of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) services within the CDCs/VCs/TCs are summarized below:

TABLE 4-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE VCs/CDCs – REGION 1

CDC/VC/TC Name	Type of Service	Brief Description
Father's Beach	Regulating	Mangrove forest on the shoreline provides critical defense from the impacts of the sea and along the banks of the Moruca River.
	Provisioning	Farmers utilize land along the seashore in the mangroves and in some coastal areas for cash crop farming, including coconuts.
		Commercial and subsistence fishing conducted between the Pomeroon River Mouth and Father's Beach, including crabbing.
		Mangroves are used for crafting and construction. Many plants (including mangroves) are used for medicinal purposes. Shells are used in agriculture and for construction.
		Freshwater from wetlands is used for domestic purposes.
		The area supports commercial and other activities such as boat repairs, fuel sale, etc.
		Transportation is only by boats through a canal from the ocean.
Manawarin	Provisioning	There is an abundance of wildlife within the forests and rivers; hunting of wildlife is done for local use and some birds are caught for commercial purposes.
		All households engage in subsistence farming. Some produce is sold.
		Fishing in the sea between the Pomeroon Mouth and Father's Beach and at different locations in freshwater streams; most residents conduct crabbing.
		Freshwater from rivers and creeks is used for domestic purposes and drinking.
		Many plants are used for medicinal purposes, cooking, and crafting.
		Commercial activities and transportation services are located in the village landing area.
		Commercial activities including numerous small shops, fuel sales, and transportation services are located in the village landing area.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects the river banks from motor boats and water currents.

CDC/VC/TC Name	Type of Service	Brief Description
	Supporting	There is an abundance of wildlife in the forest and rivers including a feeding area for giant river otters feeding in the river.
Waramuri and Haimakabra	Provisioning	Commercial fishing on both sides of the Moruka River mouth between Iron Punt and Cozier Canal. Crabbing is done seasonally in the main crabbing areas of Father's Beach to east of Pomeroon Mouth. Villagers fish throughout the year in the creeks, savannas, and lagoons behind the beach.
		Numerous species of animals are found in the rivers and environment. A few people are involved in trapping for trade. Some hunting of wildlife and duck egg collection.
		Some timber species are harvested for lumber in the area.
		All households undertake subsistence and commercial farming.
		Freshwater from rivers and creeks is used for domestic purposes and drinking. The river network is critical for fishing and transportation.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects the river banks from motor boats and water currents.
Santa Rosa	Provisioning	Commercial fishing is done daily between the Pomeroon River and Iron Punt. And in the rivers at Dog Creek and Luri Creek. Almost all villagers seasonally catch crabs. A few people regularly do commercial crabbing.
		Cattle and some pigs are grazed in the savannas close to the village.
		Some hunting for sustenance is done at Luri Creek and Baramani Lake.
		Freshwater from creeks and rivers is used for domestic purposes and drinking. The rivers are critical for transportation.
		The village is the trading hub for the Moruca Sub District of Region 1.
		Traditional plants and resources are used for domestic and cultural purposes.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers, including mangrove forest at Moruca mouth, protects the river banks from motor boats and water currents.
	Supporting	The village and surrounding areas are populated by numerous species of birds, fishes, and mammals, including jaguars. Ite palms, which also provide habitats for birds, are found throughout the community.
Assakata	Provisioning	Fishing on at least a monthly basis by most residents. Commercial fishing is done along the shore at Iron Punt, and at Baramannie Lake and Luri Creek.
		Locals engage in cash crop farming and cultivation of cassava for sustenance.
		Community depends on freshwater from rivers and creeks for domestic use and drinking. Some villagers use groundwater from water wells.
		Some plants are used for medicinal purposes and forest resources are collected for household items.
		Many fishes and birds are found in the wetlands.
		Iguanas, tapirs, labba, deer powis, and wild ducks are caught on the seashore on fishing and hunting trips.

CDC/VC/TC Name	Type of Service	Brief Description
		Small businesses with people actively involved in the village cash economy.
		Access to the community is via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects banks from motor boats and water currents.
	Cultural	The village has a freshwater lake that can be used as a tourist attraction, along with some shell mounds.
Warapoka	Provisioning	All households engage in farming and some of the produce is sold.
		The village has numerous small businesses and a tourism center. There are also government/administrative facilities. These provide employment to people who contribute to the cash economy
		The villagers fish throughout the year in rivers, creeks, and lakes. Commercial fishing is done at Baramanni Lake and Luri Creek. Shrimp is caught in the rivers around the village.
		Some animals are caught on the seashore on fishing and hunting trips. Duck and other bird eggs are collected. Trapping and sale of wildlife is done.
		Many plants are used for medicinal purposes and honey is gathered from bees for sale. Cabbage sticks are cut in combination with fishing and other exercises.
		Access to the community is via boats through the river network.
	Regulating	Extensive vegetation covering the rivers protects the banks from boats and water currents.
	Supporting	Numerous species of birds, fishes, and mammals, including harpy eagles, river otters, tapir, deer, acouri and labba, are found in the rivers and environment.
Three Brothers	Provisioning	Fishing along the coast between Waini Point and Iron Point. Commercial fishing in Luri Creek and Baramini Lake. Sea turtles enter the river in the dry season.
		Numerous species of animals in the rivers and mangrove forests. Sea turtles, jaguars, giant otters, and harpy eagles are present in the area.
		All families have farms. Crops are grown for home use and sale.
		Mangrove is used for building and in farms. Medicinal plants are collected from the beach. Cabbage palm is cut and sold.
		Freshwater from creeks and rivers used for domestic purposes and drinking water. Waterways are used for transportation.
		Access to the community is only via boats through the river network.
	Regulating	Extensive vegetation covering rivers protects the river banks from boats and water currents.
	Supporting	Numerous species of birds, fishes, and mammals, including crabs, are found in the rivers and mangrove forests. There are plenty of ducks in the wetlands bordering with SBPA.
Mabaruma Town Council	Provisioning	The Kumaka waterfront and Mabaruma is used for transportation, commerce (including boat building) and administrative; it is the main transportation hub for the Region
		Shrimp is caught in a limited manner in the shrimp season. There are daily fishing trips to Waini point. There are several fishing sites. Crabs are also sold daily at the Kumaka waterfront.
		60% of people have farms and cultivate cassava, ground provision, and cash crops.

CDC/VC/TC Name	Type of Service	Brief Description
		Freshwater from rivers, creeks, and natural springs is used for domestic purposes and drinking by the outlying community. Water wells are also used.
		Cabbage sticks are cut for sale. Medicinal plants are harvest from beach. Mangroves are used in tanning, and construction.
		Iguanas, labba, agouti, and wild ducks are the main animals hunted. Many bird species, including toucan, macaws, parrots, and small rodents such as anteaters are also trapped.
		Sawmill, lumberyard, and boat building enterprise.
	Cultural	Shell mound within the town, and several hotels for tourists.
	Supporting	The town covers six villages and has a high diversity of flora and fauna, including rubber trees that line the main road. Numerous species of birds, fishes, and mammals are found in the rivers and inland environment.
Aruka Mouth	Provisioning	Fishing in the sea at Waini Point. Some people catch shrimp in the shrimp season. Fishing in the rivers and creeks on a daily basis. Freshwater fishes are found nearby in the rainy season when the waters are fresh.
		Numerous species of birds and fishes along with monkeys are found in the area. There are no wildlife traders in the village.
		Some families have farms that are impoldered[6]. Cassava, plantains, and ground provisions are the main crops.
		The crab catchers utilize forest products for the crab quakes. Mangrove is used for building, in farms and also for firewood.
		The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking.
		Access to the community is mainly via boats through the river network.
	Regulating	The rivers are protected by extensive mangroves growing on the river banks. The mangroves protect the river from the impacts of the motor boats and water current.
	Supporting	Numerous species of birds and fishes, along with monkeys, can be seen in the area.
Morawhanna	Provisioning	Most fish are caught in the sea. Most of the fresh catch is sold to vessels from Venezuela. Freshwater fish are caught in the river in the rainy season when the water is fresh. Fish are also found in the wetlands and creeks.
		The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. Bottled drinking water is purchased from Mabaruma.
		Wharf facilities provides a hub for trade in the area increasing economic activities to the settlement.
		Access to the community is mainly via boats through the river network.
	Regulating	The banks of the Barima River are covered by extensive mangroves protecting the banks from the impacts of the motor boats and water current.
	Supporting	The area has a roosting spot with scarlet ibises and egrets roosting for the night. Numerous species of other birds, fishes, mammals, and crabs are found in the rivers and mangrove forests.

[6] Made (an area of the seabed) into a piece of low-lying land by reclaiming it from the sea or a river

CDC/VC/TC Name	Type of Service	Brief Description
Smith's Creek	Provisioning	Villagers conduct commercial fishing along the coast and in the Barima River and Smith's Creek throughout the year. Crabbing popular at the markets on Tuesdays and Saturdays. Crabs are also sold to hucksters on the ferry to Georgetown
		Some households have farms for subsistence and local use.
		The community depends on freshwater from the rivers and creeks.
		Access to the community is mainly via boats through the river network.
	Regulating	The rivers are covered by mangroves protecting the banks from the impacts of the motor boats and water current. The mangroves also act as roosting habitats for many birds.
	Supporting	There are many species animals in the forests and lake. Many ducks and egrets are seen in the area but not hunted.
Imbotero	Provisioning	Each household has a boat that they can use with either with outboard engine or by paddling to the fishing ground.
		Some households have farms for subsistence and local use.
		The villagers fish throughout the year in the rivers, creeks, and lakes mainly for saltwater fishes.
		There are numerous species of animals including tapir, deer, acouri, and labba found in the rivers and forest.
		The village can facilitate tourism activities such visit to the border with Venezuela and Shell beach.
		Access to the community is mainly via boats through the river network.
	Regulating	The creeks and rivers are covered by extensive mangroves and palms protecting the banks from the impacts of the motor boats and water current.
	Supporting	There are numerous species of birds, fishes, and mammals including tapir, deer, acouri, and labba found in the rivers and forest. Jaguars and black caiman are also seen in the area.
Almond Beach	Provisioning	The entire community resides along the beach and all households have farms located on the beach which grow food for subsistence and commercial purposes.
		Commercial fishing done from Waini Mouth to Tiger Beach in the sea. Freshwater fish are caught in the wetlands beyond the beach throughout the year; hassar contributes significantly to fisherfolk income.
		Supports eco-tourism activities through collaboration with the PAC.
		There are numerous species of birds, fishes, and mammals including jaguars present in the area. Iguanas and some mammals are hunted for food.
		Access to the community is mainly via boats through the river network and ocean.
	Supporting	There are numerous species of birds, fishes, and mammals, including agouti, tapir, deer, acouri, and labba, found in the areas close to the beach. Leatherback turtles nest on the beach and harpy eagles are also sighted.

4.2.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 1 is fishing in the rivers and creeks, the ocean, and the mangroves of the riverine floodplains. Along the coast, fishing is

particularly active at the westernmost end of Shell Beach at the mouth of the Waini River, and easternmost end at the mouth of the Moruca River. However, most communities use an area along the Beach referred to as Iron Punt for these activities. This area can be accessed from the ocean, as well as from inland via the Luri Creek. By using Luri Creek, the communities also have access within this area to fish, birds, and crabs, particularly in the dry season, and some hunting in the wet season. The main commercial products from the ocean include many types of catfish, curass, gillbacker, snapper, bangamary, butterfish, mullet, snook, queriman, and trout. There is almost no shrimping in the region, as the waters are rough and only a handful of people have access to the type of equipment needed (Chinese seine). The long stretches of mangrove in the salty sections of the waterways provide an important nursery function for a number of commercial fish and shellfish species. The natural ponds and swamps, particularly those behind Shell Beach, collect seawater from the spring tide, catching the young shrimp and fish that are looking to migrate into lesser salty water until they mature into adulthood. The numerous rivers, creeks, and swampy areas throughout Region 1 have an abundance of freshwater fish including huri, yarrow, patwa, peacock bass, imary, casi, sunfish, wabrea, and many others that are caught and eaten on a regular basis and also sold in the local markets. The fish are caught with hooks and nets and also trapped in the vegetation that is pulled to the shore.

There are vast savannahs along the banks of many of the rivers and creeks which flood with the onset of the rainy seasons (May/June and November/December/January), so most daily freshwater fishing occurs in the dry season, when fish are in the rivers and not in the outlying savannahs. At the onset of the rainy seasons, many fisherfolk will burn the savannahs to ensure easier catching of fish as they migrate from the rivers to the bush islands[7]. The migrating fish are spotted in the shallow waters of the burned savannahs and are “chopped” with knives or caught by hand.

Crabbing is a significant activity for communities in Region 1. Crabbing in mangroves along the beach area is common, especially during the crab seasons. Residents from the coastal communities within the region, as well as from some areas of Region 2, venture to the beach during the crab season. Crabbing is done for both subsistence and small-scale commercial sale throughout the year. For some communities, especially those further north in the region, most adults (including women) are involved in crabbing throughout the year as a major economic activity.

A majority of the households in the region have multiple farms growing cassava as the main staple for daily subsistence, as well as other crops (such as ginger and coconuts) for sale in local markets. Cash crop cultivation is a main feature in this region, with much of the produce consumed by the family or sold to the local school or the local market. Some agricultural farming occurs directly on the coast at Father’s Beach and Almond Beach.

The communities depend on various types of wild meat (including iguana, labba, deer, turtle, wild ducks, etc.) for subsistence, which they hunt themselves. In some of the areas, the trapping of animals for trade is prohibited by the village or is not a popular activity. However,

[7] The bush islands refer to the high grounds in the flooded savannahs where families have their households and farms. Some of these islands have been occupied by the same family for over two hundred years.

hunting/trapping is prevalent in some communities, such as in the Luri Creek area, in the Baramani Lake, and within some communities' private lands.

Wood is collected for use as firewood by some households, particularly for the principal cooking tasks such as making of cassava bread or pepper pot. Driftwood is collected on the beach and from some of the river banks to be used for cooking. A small number of people use wood and non-wood fibers, including mangrove trees and coconut shell, for handicrafts and household items. A limited amount of mangrove bark is shipped to Georgetown by the ferry for use in tanning operations. The bark is also used for medicinal purposes by the Amerindians. Mangroves are used widely in the construction of houses and other household structures. Some mangrove poles are used by farmers to support their plantain trees and by fisherfolk as seine poles. In Region 1, mangroves are considered a community resource and are therefore legal for traditional community use.

Palms and vines, including Ite, Kufa, Nibbi, and Kufra, are utilized for making craft and household items. Manicole palm is harvested for commercial purposes by most communities and is sold to a factory based in the region. Medicinal plants, especially noni, are collected from the beach for use by the communities.

The communities depend on the waterways for potable and domestic water supply, and in most cases, they are the only form of transportation available.

Wild bees provide a critical service of pollination for the farmers. Wild bees are found in the mangroves and sometimes in the villages. While most locals avoid beehives, they are often raided by experienced individuals who can turn a good profit on honey sales at local markets.

A few people in some villages rear chickens and other birds in order to sell bird meat. However, there is generally a marked absence of livestock such as sheep, goats, and cattle in the villages, except for in the town of Mabaruma. It was reported that jaguars often feed on livestock and therefore livestock rearing is not popular. Attacks by jaguars on hunting dogs have also restricted the hunting capacity of many households.

4.2.2. Regulating Services

The entire shoreline of Region 1 is covered with mangroves with mudflats or shell deposits leading to the ocean. These mangroves contribute to erosion prevention along the shoreline by protecting it from waves, wind, and flooding. Mangroves are also found along the banks of the many coastal rivers within the region, thus also protecting the riverbanks from erosion. These were noted by stakeholders as critical services.

It should be noted that although many stakeholders commented that burning the savannahs assisted with pest control, they did not see this as a regulating service and so therefore, it was not captured as such in the data tables or on associated maps.

4.2.3. Cultural Services

The only cultural service observed on the beach is by a single Hindu family of Mabaruma that uses the Waini Beach a few times per year. The beach and coastlines are considered living

heritage by the Amerindians, but not for spiritual reasons. The local people, particularly of the Mabaruma Town Council, utilize Waini Point and Shell Beach for recreation, including kite flying and picnics, particularly at Easter.

Cultural heritage sites were also identified by local villagers, including shell mounds near Haimacobra Village, Waramuri Village, and Assakata Village, as well as a sacred site (200-year-old church) near Santa Rosa Village.

4.2.4. Supporting Services

The only supporting service identified through the engagement process was habitats for biodiversity. The region is rich in biodiversity, with villagers reporting numerous species of birds, fishes, and mammals. Leatherback turtles use the beach in the Almond Beach area for nesting. Harpy eagles are sighted in Almond Beach, and nesting areas for harpy eagles are located in Warapoka and Three Brothers villages. Jaguars are also common in some villages and black caiman have been sighted by villagers in Imbotero. In addition, there is a roosting area for scarlet ibises along the main rivers.

4.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by CDC/VC/TC and provided in the scoping tables located in Appendix B.

Figure 4-1 shows the ecosystem service locations, by type, identified by the Region 1 village leaders and villagers during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology outlined in Figure 2-1. Detailed maps by CDC/VC/TC are provided in the Coastal Mapping mapbook (separate from this report).

Figure 4-2 shows the ecosystem service “general areas,” by type, identified by Region 1 village leaders and villagers during the engagement process. This mapping to show general areas is provided for only Region 1 due to the fact that some areas identified by village leaders and villagers could not be field-verified (based on limitations to access along the SBPA and Region 1 coast). The general areas are intended to provide additional context for the location of ecosystem services in the region.

FIGURE 4-2: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES—REGION 1

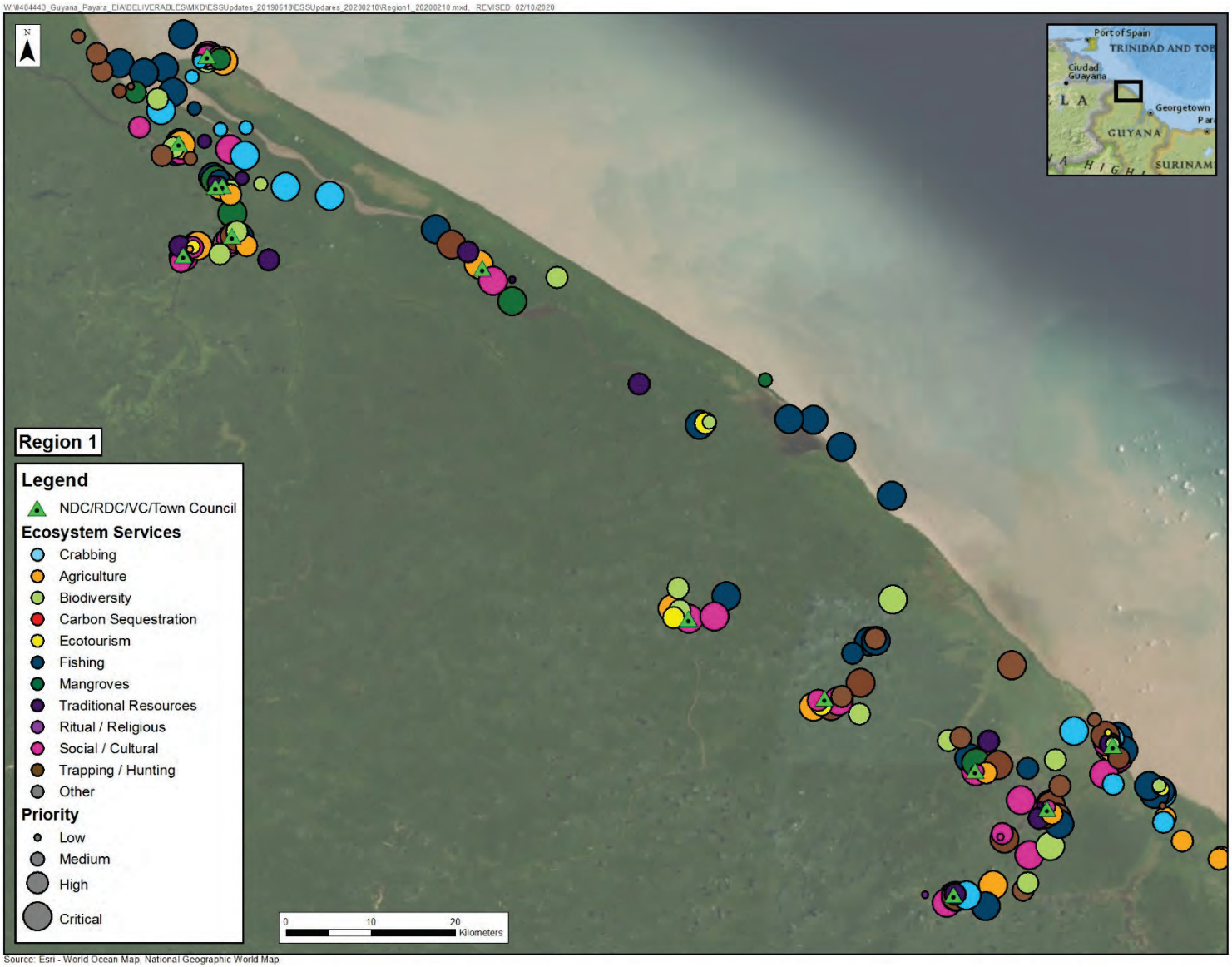
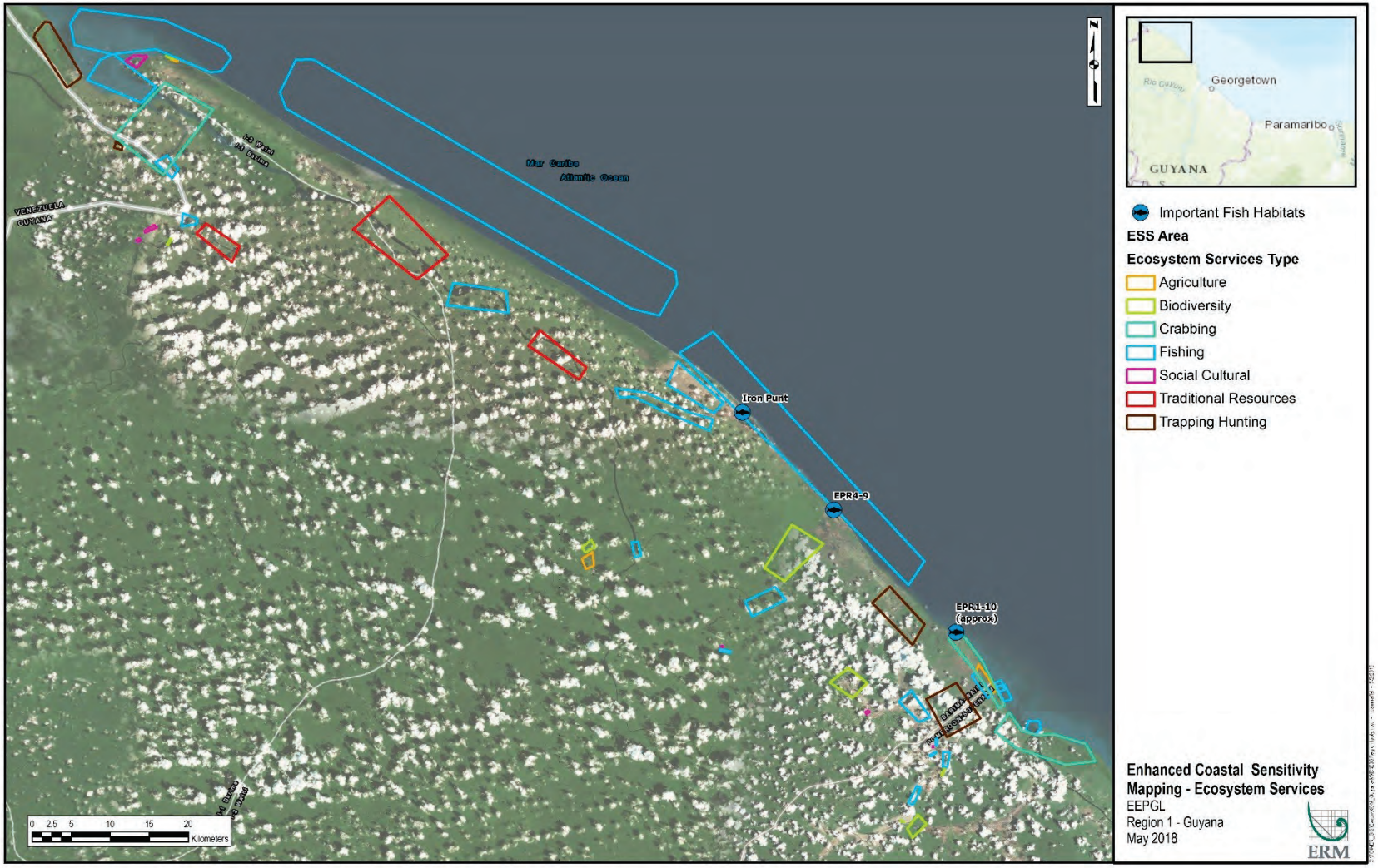


FIGURE 4-3: IDENTIFIED GENERAL AREAS OF ECOSYSTEM SERVICES TYPES—REGION 1



5. REGION 2 COASTAL ECOSYSTEM SERVICES FINDINGS

5.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 5-1: POPULATION ESTIMATES - REGION 2

NDC Name	Population Estimate	Other Details
Charity/Urasara	7,800	Population relatively stable
Evergreen/Paradise	7,500	High Hindu population
Aberdeen/Zorg-en-Vlygt	6,000	In Queenstown alone, which is largest village on coast
Anna Regina Town Council	22,000	Close to 50% Hindu population; population increasing due to Venezuelan migrants
Annandale/Riverstown	10,840	Population increasing due to Venezuelan migrants
Good Hope/Pomona	10,000	Population increasing due to Venezuelan migrants and Amerindians moving from inland areas of Region 2

5.2. Summary of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 5-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE NDCs – REGION 2

NDC Name	Type of Service	Brief Description
Charity/Urasara	Provisioning	Families and farmers utilize land along coast for crop cultivation
	Provisioning	Commercial fishing at mouth of and within Pomeroon River, especially crabbing
	Provisioning	The Big Bird Fish Complex is a major facility that serves as a landing for large-scale artisanal fishing and processes fish for export
	Supporting	Mangroves provide habitats for birds, crabs and other wildlife and protect the shoreline
Evergreen/Paradise	Provisioning	Families and farmers utilize land along seawall for cash crops and subsistence farming as well as livestock farming
	Provisioning	Commercial fishing at Andrews Koker, including crabbing
Aberdeen/Zorg-en-Vlygt	Provisioning	Commercial fishing at Capoey Koker, including crabbing and livestock farming along seawall
	Provisioning	Hunting of iguanas for meat and sale

NDC Name	Type of Service	Brief Description
	Regulating	New mangrove growth provides shoreline protection and a habitat for iguanas, crabs and birds
	Regulating	Bamboo groynes have been installed at various points along the shoreline
	Cultural	Recreation along the seawall and cremation site along the shoreline
Anna Regina Town Council	Provisioning	Farmers utilize land along the seawall for subsistence farming. Coconuts, bananas, plantains and cash crops are planted
	Provisioning	Commercial fishing landing sites in Hampton Court, Walton Hall, Lima, Sparta, and Anna Regina
	Cultural	Daily visits to a popular hotel close to the seashore for recreation, including softball cricket matches on the beach behind the hotel
Annandale/Riverstown	Provisioning	Main port is essential for access to other areas, including the islands; the ferry dock is used for businesses and trade
	Provisioning	Fishing landing sites at several locations including Abram Zuil
	Cultural	Religious activities along beach primarily at Golden Fleece temple
	Cultural	Recreation along the seawalls at Perseverance, Golden Fleece, Cullen Beach and Suddie
Good Hope/Pomona	Provisioning	Ports, wharfs and shipyards at Vilvoorden and Riverside are essential to commercial business; speedboat ferry at Supenaam is a major port
	Provisioning	Commercial fishing at Vilvoorden, Pomona, and Riverstown
	Provisioning	Large-scale cultivation of crops on Tiger Island
	Regulating	Tiger Island is a critical sea defense to erosion and flooding
	Cultural	Recreation on Tiger Island

5.2.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 2 is fishing. The main commercial products include catfish, snapper, snook, and crabs in the summer season. Some catching of shrimp also occurs. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. This is a priority service in Anna Regina, which is one of the only towns in Region 2.

Crop cultivation is present in many communities along the coast, and ranges in scale from subsistence farming of staple grains, including rice, to export-oriented farming of coconuts and watermelons.

The scale of livestock farming ranges considerably within communities in Region 2. Some households keep a few chickens, pigs, and cattle in their yards for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be

either dual purpose or specialize in dairy or beef. Beef is generally not consumed on a regular basis by the local population.

Some households in Region 2 collect wild plants, fruits, berries, mushrooms, other wild plants, honey, and nuts, primarily for subsistence use. This practice is limited in the Study Area and while mangroves provide the habitat for honey production, it is not common in Region 2 despite the fact that many people interviewed understood how honey production could be a major source of income.

A small number of households report depending on various types of meat (including iguana, etc.) for subsistence, whether they hunt it themselves or purchase it. Although hunting iguana is illegal, reports of hunting for meat increased during the validation exercise. Nonetheless, it is not likely a major source of food or income in the area.

Some wood and non-wood fibers, including mangrove trees and coconut husks, are used in handicrafts and household items in some of the coastal communities, although this is not extensive.

Potable water sources for communities include the Pomeroon River, rainwater, and groundwater. Households in larger communities are serviced by the national public water system. However, private wells are the most common source of potable water in the NDC. In rural areas, water is obtained from the lake or private wells excavated on household properties.

Region 2, especially in the northern coastal communities adjacent to the Pomeroon River, is significantly reliant on aquatic transport. Waste and pollution in the Pomeroon River and coastal habitats presents one of the biggest challenges for coastal communities.

Commercial activities abundant in these areas include those supporting the marine industry such as boat building, ship repairs, fuel services, and products needed by sailors and fisherfolk. It is quite evident that at almost all landing areas used by fisherfolk, including Supenaam, there are shops in close proximity selling alcohol and other consumable products.

5.2.2. Regulating Services

Shoreline protection is a major consideration along the entire Region 2 coastal area. Mangroves and coastal vegetation play a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. Mangroves along Region 2 are in various stages of growth, with many areas along NDC 1, 2, and 3 having undergone natural erosion cycles over the past 20 years.

The Ministry of Agriculture's National Agricultural Research & Extension Institute's (NAREI's) re-growth programs are most active in the Evergreen/Paradise NDC and Annandale/Riverstown NDC areas. The mangrove restoration projects in Walton Hall, Richmond, and Lima are reported by stakeholders to be doing considerably well. However, with all of the new mangrove plantings, there are now concerns over the nuisance of sand flies and mosquitoes as well as the noise from new species of birds in the area. This has been especially challenging in Anna Regina.

Natural shoreline protection services can be replaced by man-made engineering solutions, if needed. However, these are generally expensive to build and maintain over time.

Tiger Island is a critical ecosystem service in Good Hope/Pomona NDC to prevent erosion and flooding considering there is no other manmade or natural sea defense.

5.2.3. Cultural Services

Natural spaces or species with cultural, spiritual, or religious importance are considered "living heritage." The most prominent of these is the Hindu tradition of planting prayer flags at various points along the shoreline – most typically associated with shore access.

Locals utilize the areas along the seawalls for recreation, including walking, running, kite flying, and general recreation. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors.

5.2.4. Supporting Services

The natural processes of soil formation, nutrient recycling and accretion have contributed to ideal locations for commercial activities including, ports, wharfs, and dwelling places. The port at Supenaam is critical to the local economy, housing numerous ships offloading and loading their cargo. The primary wharves are at Paradise and Vilvoorden while other landing sites are used on the beaches where boats can land safely during the high tide.

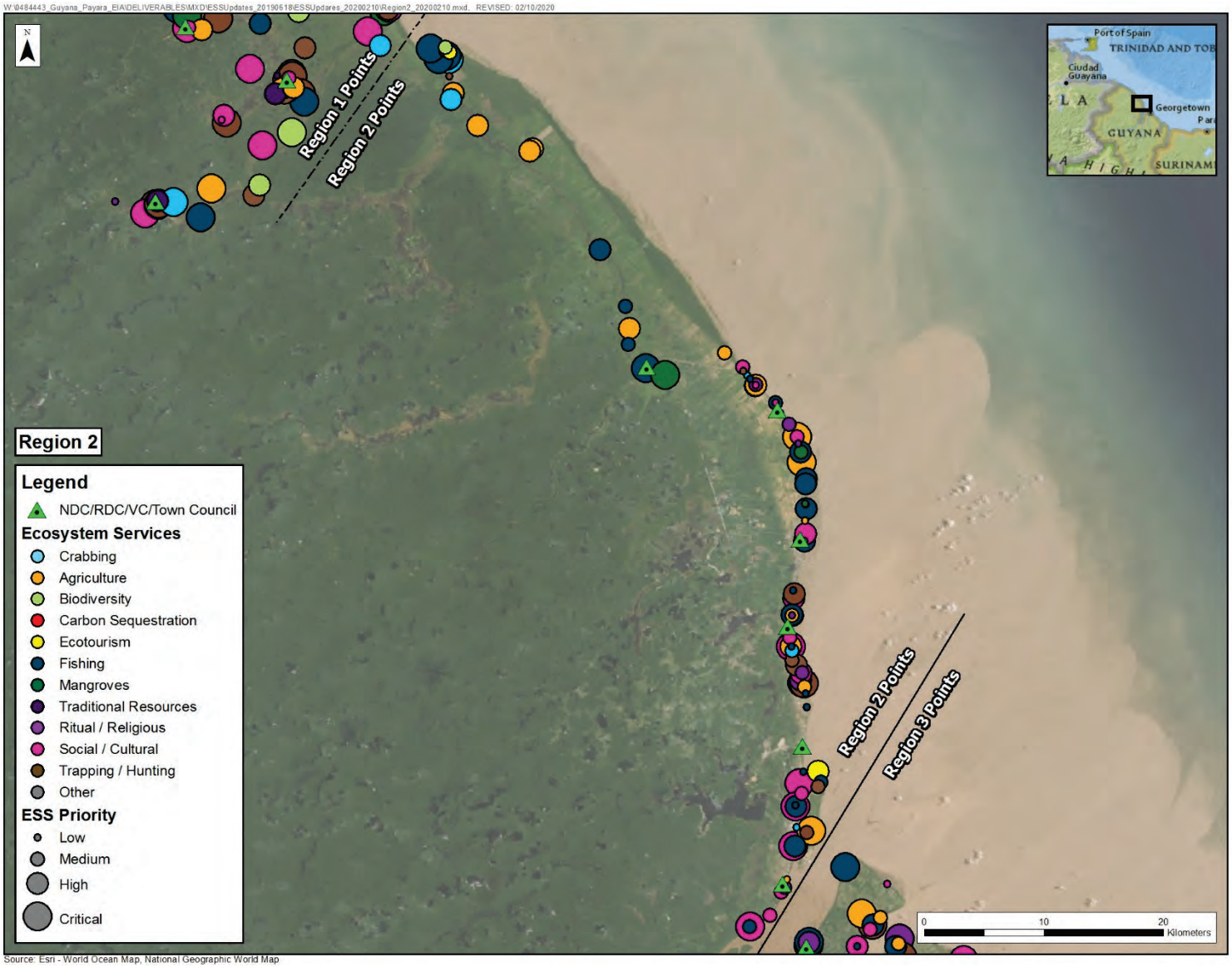
Along the Pomeroon River, mangroves provide habitat for biodiversity including scarlet ibis.

5.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix B.

Figure 5-1 shows the ecosystem service locations identified by the Region 2 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol) – critical, high, medium, or low – utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 5-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 2



6. REGION 3 COASTAL ECOSYSTEM SERVICES FINDINGS

6.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 6-1: POPULATION ESTIMATES - REGION 3

NDC Name	Population Estimate	Other Details
Wakenaam (island)	3,300	Decreasing due to migration
Leguan	2,700	Decreasing due to migration to Region 3 and North America
Mora/Parika	12,000	Growing due to migration to the NDC
Hydronie/Good Hope	4,200	Growing
Greenwich Park/Vergenoegen	2,600	
Tuschen/Uitvlugt	35,500	Increasing due to the growing housing schemes in several villages
Stewartville/Cornelia Ida	30,000	
Hague/Blankenburg	4,200	
La Jalousie/Nouvelle Flanders	5,500	Population increasing due to new housing schemes
Best/Klien/ Pouderoyen	25,000	Population increasing due to migration to the area

6.2. Summary of Findings

The services rated as “critical” or “high” priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 6-2: SERVICES RATED AS “CRITICAL” OR “HIGH” PRIORITY WITHIN THE NDCs – REGION 3

NDC Name	Type of Service	Brief Description
Wakenaam (island)	Provisioning	Commercial fishing at mouth of and within Essequibo River
	Provisioning	Freshwater from the Essequibo River is relied on island-wide for its irrigation of rice paddies and other crops during the dry season
	Provisioning	Crop cultivation is present in most areas of the island along the river dam and reserves
	Provisioning	Ports, wharfs, and shipyards, inclusive of boat building, on the river dam; commercial wharf at San Sousi for transport of fuels, rice, and other products that are shipped or imported to the island
	Provisioning	Speed boat landing site at Maria’s Pleasure for passenger transport to Parika and Leguan

NDC Name	Type of Service	Brief Description
Leguan	Provisioning	Transportation services to Parika and other areas
	Provisioning	Commercial fishing at Waterloo and Success
	Provisioning	The entire island depends on freshwater from the Essequibo River
	Cultural	Organized tours to historic sites including St. Peters Church
	Cultural	Hindu religious activities along the seashore and the presence of a cremation site
	Regulating	Erosion regulation as the island is at risk to erosion and much of the shore is not protected by manmade concrete defense
Mora/Parika	Supporting	Marine transport services and related economic activities at Parika stelling and saw mill
	Provisioning	Economic activity at fisheries wharf where boats load, refuel and discharge catch
	Provisioning	Residents squat along the river dam and use freshwater for domestic purposes
	Supporting	Biodiversity Reserve where locals protect two small islands that are roosting areas for hundreds of birds in the Essequibo River
	Cultural	Big Kiss temple on the river dam for worship activities
Hydronie/Good Hope	Provisioning	Economic activity from fishing at Ruby Koker and wharf supporting sea going vessels at Bushy Park, including ship repairs
	Provisioning	Livestock farming in the Ledestein to Good Hope area
	Provisioning	Two new wharfs established along the shoreline
	Cultural	Recreation at Bushy Park Beach, a popular tourist attraction for locals and people from other parts of the country
	Cultural	Hindu religious activities along the sea dam and the presence of a mosque at Ruby Koker
Greenwich Park/Vergenoegen	Provisioning	Fishing at Vergenoegen Outfall and cash crop cultivation along the coast
	Provisioning	Informal housing at Barnwell
	Cultural	Recreation at the seawall and Hindu religious activities along the shoreline
Tuschen/Uitvlugt	Provisioning	Fishing from the Zeeburg Seawall and Boeraserie Koker
	Provisioning	Shrimp processing at Zeeburg and Uitvlugt
	Supporting	Coastal protection from concrete sea defense
	Cultural	Recreation at Cinderella Park at Zeelugt Temple on the sea defense reserves at Uitvlugt
	Provisioning	Grazing of Animals at Zeelugt and Uitvlugt

NDC Name	Type of Service	Brief Description
Stewartville/Cornelia Ida	Provisioning	Fishing at Leonora boat landing area and farming along coast
	Supporting	Shrimp and fish processing on the Anna Catherina and Leonora seawall/reserve
	Supporting	Coastal protection from concrete sea defense
	Cultural	Religious practices at Cornelia Ida
	Provisioning	Informal housing at Anna Catherina sea defense reserves
Hague/Blankenburg	Provisioning	Fishing boat landing area at Hague seawall
	Provisioning	Crop cultivation and livestock farming along the sea shore
	Cultural	Recreation at the seawall and Hindu religious activities along the shoreline
La Jalousie/Nouvelle Flanders	Provisioning	Fishing from Windsor Forest Koker
	Cultural	Religious rituals at cremation site at Ruimzeigt and religious activity at La Jalousie
	Cultural	Recreation along seawall Windsor Forest
Best/Klien/ Pouderoyen	Provisioning	Transportation at Transport Wharf, GPL Wharf, Sawmill and Speedboat stelling; waterway used by boat builders
	Provisioning	Informal housing at Phoenix Park and Best Village
	Provisioning	Waterway is used by boat builders for access to launch boats built on the riverbank

6.2.1. Provisioning Services

The primary ecosystem services along the coastal zones in Region 3 are fishing and farming on the islands. The main commercial fish catch includes various types of catfish, snapper, bangamary, snook, mullet, and shrimp. The smaller boats catch shrimp and fish, while some boats change to catch shrimp in the season when it is abundant.

Crabs are caught during the period of July and August during spawning season. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. Some people catch crabs throughout the year by hunting them in the mangroves. The system of inland rivers is also critical to the growth of the rich biodiversity of the sea. Rivers provide spawning grounds, shelter, and nutrients for the rich aquatic life.

Crop cultivation is present in many communities along the coast, and ranges in scale from subsistence farming of staple grains, including rice, to export-oriented growing of coconuts and plantains on the islands. Cash crops are grown on the sea defense reserves by residents who live in the area adjacent to the reserves. Several people squat on the reserves and make ample use of the land for crops, fruits, and grazing grounds for livestock.

The intensity of livestock farming ranges considerably within the NDCs of Region 3. Generally, the communities have more sheep and goats, as this is consumed by a wider range of individuals than cows. Hindus do not eat beef but use cow's milk for many purposes including

religious activities. Some households keep a few chickens, pigs, and cattle in their yards for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be either dual purpose or specialize in dairy or beef.

Households in Region 3 rarely collect wild plants, fruits, and honey, for subsistence use or commercial use. While mangroves provide the habitat for honey production, it is not common in Region 3. One tanner uses the mangrove bark for his leatherwork on a limited basis. Some wood and non-wood fibers, including mangrove trees and coconut husks, are used in handicrafts and household items in some of the coastal communities, although this is not extensive.

Small groups of individuals will catch iguanas found living among the mangroves or thick vegetation of the sea dam. These reptiles are captured for sale and can attract G$6,000 for a large adult. Some people catch the birds on the seashore but on a limited basis. The shore is rapidly changing due to natural erosion and accretion and thus the bird population is constantly on the move. Since it is illegal to hunt some species of birds, hunting is likely underreported; in any case, it is likely not a major source of food or income in the region. The existence of various islands of large bird colonies where birds roost peacefully is testimony to the attitudes of the locals to the birds.

Potable water is available for communities from groundwater and many residents harvest rainwater. A few people rely on the fresh water from the river and irrigation canals for household purposes. The people squatting are more likely to use the seawater for some tasks. They have to fetch water some distance from their homes for drinking or cooking purposes. Transportation is mainly land based along the coast except for a few instances when the seacoast is used.

Commercial activities abundant in these areas include those supporting the marine industry, such as boat building, ship repairs, fuel services, and products needed by sailors and fisherfolk. It is quite evident that at almost all landing areas used by fisherfolk, there are shops in close proximity selling alcohol and other consumable products.

6.2.2. Regulating Services

Almost the entire shoreline is protected by rocks or concrete structures. Short lengths of earthen dams exist that are strengthened by rocks (riprap). Mangroves and coastal vegetation play a minor role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. The migrating mud flats are on the move and consequently areas rich in mangroves are being washed away while new beaches are built elsewhere.

The NAREI re-growth program was most active in the La Jalousie/Nouvelle Flanders NDC but those mangroves are now almost completely washed away. With all of the new mangrove plantings and natural growth in the Best/Klien/Pouderoyen NDC, there are now concerns over the nuisance of sand flies and mosquitoes. The new mangrove growth will provide allow for pollination, which is essential to the agricultural coastland.

The shallowness of the natural shoreline makes protection services susceptible to change and these must be replaced by man-made engineering solutions before the natural protection is washed away. However, these are generally expensive to build and maintain over time.

6.2.3. Cultural Services

Natural spaces or species with cultural, spiritual, or religious importance are considered "living heritage." The most prominent of these is the Hindu tradition of praying and the planting of prayer flags at various points along the shoreline – most typically associated with shore access. African religious practices are almost nonexistent in the area and are generally done in secret. In some areas, temples or temporary structures are built for the main worship days. On Sundays, many families visit the sea early in the morning to pray and swim.

Locals utilize the areas along the seawalls for recreation, including walking, running, kite flying, and general recreation. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors. There is a cremation site in the La Jalousie/Nouvelle Flanders NDC that is used daily by the Region 3 population.

6.2.4. Supporting Services

The sea and river dam, inclusive of the reserves, houses a number of commercial and household activities. The natural processes of soil formation, nutrient recycling and accretion have contributed to ideal locations for commercial activities including, ports, wharfs, and dwelling places. The port at Parika is critical to the local economy, housing numerous ships offloading and loading their cargo. The primary wharves are at Parika, Vreed-en-Hoop and other landing sites are used on the beaches where boats can land safely during the high tide.

6.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix C.

Figures 6-1 and 6-2 show the ecosystem service locations identified by the Region 3 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol) – critical, high, medium, or low – utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 6-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 3 (1 OF 2)

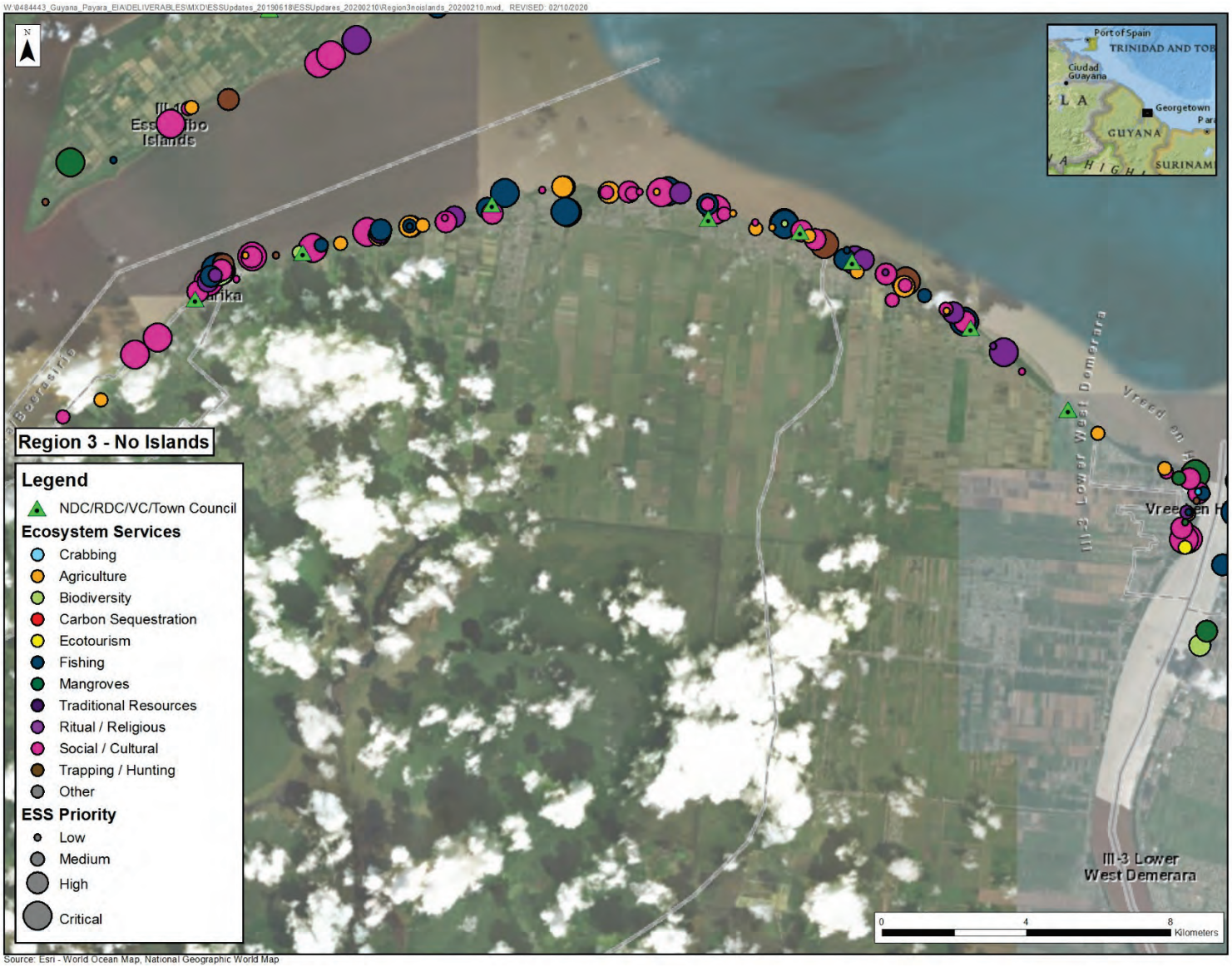
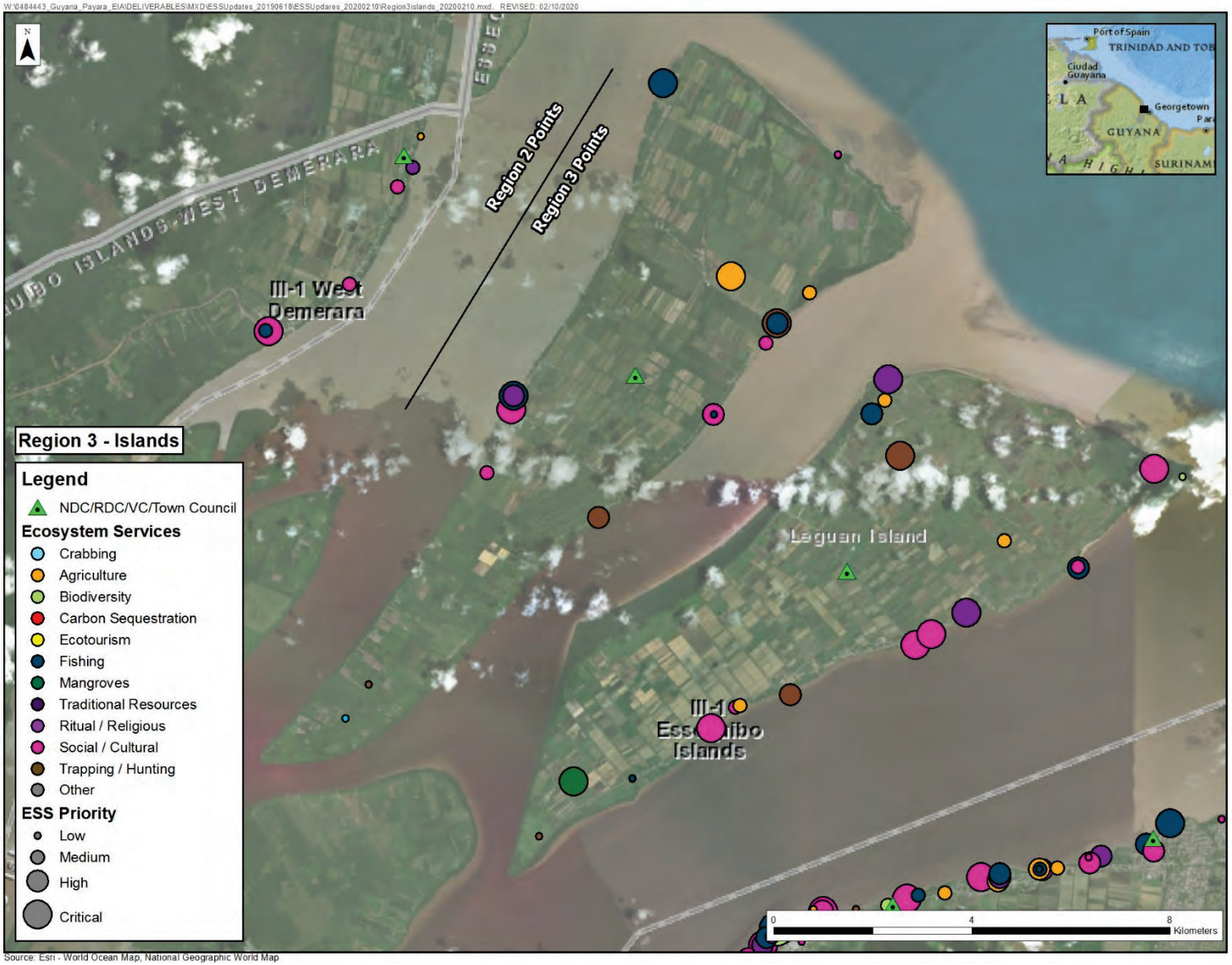


FIGURE 6-2: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 3 (2 OF 2)



7. REGION 4 COASTAL ECOSYSTEM SERVICES FINDINGS

7.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 7-1: POPULATION ESTIMATES - REGION 4

NDC Name	Population Estimate	Other Details
Georgetown City	132,000	Increasing in suburban housing areas
Industry/Plaisance	25,000	Should be increasing due to new housing schemes
Better Hope/ LBI	30,000	Increasing due to natural population growth
Beterverwagting/Triumph	7,000	
Mon Repos/ La Reconnaissance	40,000	Increasing
Buxton/Foulis	7,000	
Unity/Vereeniging	13,000	
Haslington/Grove	27,000	Population increasing due to new housing schemes
Enmore/Hope	8,000	

7.2. Summary of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 7-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE NDCs – REGION 4

NDC Name	Type of Service	Brief Description
Georgetown City	Supporting	Economic and social benefits from Port Georgetown and associated wharfs
	Provisioning	Commercial and subsistence fishing along the shore throughout the city
	Regulating	Erosion regulation as the coastland is at risk to erosion, although protected by concrete defense
	Cultural	Recreation from Kingstown along seawall
	Cultural	Tourism - two of the main hotels in Guyana are located on the sea shore
	Provisioning	Birds roost in the mangroves close to the Demerara Harbour Bridge
	Cultural	Religious activities at the Kingston shore/beach
Industry/Plaisance	Provisioning	Commercial fish landing site at Industry and Plaisance
	Cultural	Recreation, exercise and Hindu religious practices along the Cummings Lodge–UG Road area

NDC Name	Type of Service	Brief Description
Better Hope/ LBI	Provisioning	Fishing and salt fish drying from Montrose, Success and Better Hope
	Regulating	Erosion regulation as the coastland is at risk to erosion, although protected by concrete defense
	Provisioning	Locals utilize land along the sea wall at Better Hope for grazing livestock
Beterverwagting/Triumph	Provisioning	Fishing landing area in Triumph
	Cultural	Locals use the Triumph end of the NDC to exercise, recreate, or socialize.
Mon Repos/ La Reconnaissance	Provisioning	Fishing at fisheries landing areas in Mon Repos Koker and Lusignan Koker
	Cultural	Religious activities at Mon Repos
	Provisioning	Boat building & repairs
	Regulating	Mangrove cover is increasing and providing shoreline protection
Buxton/Foulis	Provisioning	Fishing at Stratsphey
	Provisioning	Informal housing at Bladen Hall in the mangroves
	Cultural	Recreation, exercise and Hindu religious activities at the Melanie to Non Pariel seawall
	Regulating	NAREI plots at Mon Repos and Vigilance for mangrove restoration.
Unity/Vereeniging	Provisioning	Fishing areas at Unity shoreline and Helena Koker, and wharfs in the Mahaica River supporting trade and the local economy
	Provisioning	Agriculture and grazing at Unity shoreline
	Supporting	Coastal defense, as the concrete sea defense is supported by natural vegetation including mangroves
	Cultural	Unity beach is frequented for recreation and aesthetic value of landscapes
	Cultural	Daily bird tours in the Mahaica River to spot numerous bird species
	Provisioning	Coconut estates encroach on the reserves along with some cash crops
	Cultural	Aesthetic value of natural landscapes throughout the area
Haslington/Grove	Provisioning	Fishing at landing areas Greenfield, Hope, Haslington and Victoria, including at mudflats
	Supporting	Mangrove Reserve supporting conservation, apiculture
	Cultural	Mangrove Reserve supporting ecotourism
	Cultural	Cove & John to Victoria seawalls for recreation and religious activities; Cove & John attracts thousands for the special religious days
	Provisioning	Grazing of animals at Hope Sea

NDC Name	Type of Service	Brief Description
Enmore/Hope	Provisioning	Fishing at the Enmore Koker
	Cultural	Enmore shoreline is a popular place for Hindu religious activities

7.2.1. Provisioning Services

The primary ecosystem service along the coastal zone of Region 4 is fishing. The main fish caught include various types of catfish, trout, paggy, snapper, bangamary, snook, mullet, and shark. Some fisherfolk catch shrimp, particularly those launching from the Demerara River and lower East Coast of Demerara. The fisherfolk from the coast switch to shrimp in the season when it is abundant.

Crabs are caught in the period July to August during their spawning season in areas where they are available. Some people catch crabs throughout the year by hunting them in the mangroves. The sea crabs are found in small puddles left on the mudflat when the water recedes. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. The system of rivers is also critical to the growth of the rich biodiversity of the sea. The Demerara and Mahaica Rivers provide spawning grounds, shelter, and nutrients for aquatic life.

Housing is the main activity on the coastland, followed by agriculture. Communities along the coast engage in subsistence farming of vegetables and fruits. Commercial farms grow sugarcane, staple grains (including rice), coconuts, and cash crops. Cash crops are also grown on the sea defense reserves by residents who live in the area adjacent to the reserves. A number of people who squat on the reserves make ample use of the land for crops, fruits, and grazing grounds for livestock. Mangroves are an important ecosystem service provider for the agricultural economy in this region as they house numerous pollinators.

The intensity of livestock farming increases as one leaves the city of Georgetown and progresses to the Mahaica area. Generally, the communities have more sheep and goats, as opposed to cows, as these are consumed by a wider range of individuals. Some households living in close proximity to the sea defense keeps a few chickens, pigs, and cattle in their yards for household consumption and sale.

Households in Region 4 rarely collect wild plants, fruits, berries, mushrooms, honey, and nuts, for subsistence use or commercial use mainly because they are in limited supply. This practice is limited in Region 4, although mangroves provide the habitat for honey production. Honey is known to be produced by two people using the mangroves on the coastland; these individuals agreed that honey production could be a major source of income. Honey is sold at G$3,500 per liter, and these individuals reportedly sell approximately four liters daily. Some wood and non-wood fibers, including mangrove trees and coconut husks, and driftwood are used in handicrafts and household items in some of the coastal communities, although this is not extensive.

Small groups of individuals will catch iguanas found living among the mangroves or thick vegetation of the sea dam. These reptiles are captured for sale and can attract G$6,000 for a

large adult. Some people shoot the birds on the seashore, but on a limited basis as the shotgun attracts police attention. It is illegal to hunt some species of birds, so hunting is not encouraged by the police. Birds do not constitute a major source of food or income in the region.

Potable water is available for communities from groundwater and many residents harvest rainwater. A few people rely on the canals for household purposes. The people squatting are more likely to use the salt water or water from the drainage canals for some tasks. The people squatting have to fetch water some distance from their homes for drinking or cooking purposes. Transportation is mainly land based along the coast except for a few instances when the seacoast is used.

Commercial activities dominate Georgetown, inclusive of fishing by commercial trawlers and large boats. Supporting services in the area offered to the industry include boat building, ship repairs, fuel services, entertainment and household products needed by sailors and fisherfolk. Specialized businesses offer services to the crews of visiting vessels, including food, beverages, transportation, and entertainment.

7.2.2. Regulating Services

Almost the entire shoreline is protected by rocks or concrete structures. Short lengths of earthen dams exist in a few NDCs that are strengthened by rocks (riprap). Mangroves and coastal vegetation play an increasing role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. The migrating mud flats are being deposited in this region and they provide substrate for new mangroves to thrive. The new mangrove growth will provide regulating services, of which pollination is essential to the agricultural coastland. The mangroves will also promote a more diverse biodiversity and increase in the abundance of fishes in the ocean.

The NAREI re-growth program was most active in Region 4 compared to Regions 2 and 3, although some replanted areas have now almost completely washed away. The new mangrove plantings in Better Hope/ LBI, Beterverwagting/Triumph, and Haslington/Grove NDCs and natural growth in Better Hope/ LBI, Beterverwagting/Triumph, Unity/Vereeniging, Haslington/Grove, and Enmore/Hope NDCs have increased concerns over the nuisance of sand flies and mosquitoes.

The mangroves help with flood regulation and sea defense on the shore. These services are essential to the coastal communities and the natural defense must be replaced by man-made engineering solutions before the natural protection is washed away.

7.2.3. Cultural Services

Natural spaces or species with cultural, spiritual, or religious importance are considered “living heritage.” These natural spaces are highly valued by the local communities, the most prominent of these being the Hindus. The believers practice the tradition of bathing, praying, and the planting of prayer flags at various points along the shoreline, particularly at the kokers. In some areas, temples or temporary structures are built for the main worship days. On Sundays, many

families visit the sea early in the morning to pray and swim. African religious practices are almost nonexistent in the area or are generally done in secret.

Locals utilize the areas along the seawalls for recreation, including walking, running, kite flying, and general recreation. At popular locations such as the Kitty Seawall in Georgetown, people from many other regions of Guyana visit for recreation purposes. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors. Birding tours are held daily in the Mahaica River for locals and overseas visitors. Mangrove Tours are held monthly in the Mangrove Reserves and as often as three times per day in the school tour season.

7.2.4. Supporting Services

Georgetown is the Capital City of Guyana and a historical port. The activities of the city based on the river and ocean systems are essential to the wellbeing of the nation. The sea defense and river dam, inclusive of the reserves, house a number of commercial and household activities. The natural processes of soil formation, nutrient recycling, and accretion have contributed to ideal locations for commercial activities including, ports, wharfs and commercial houses. The numerous wharves facilitate various services for ships, with docks utilized by passenger and fishing vessels. The mangroves are roosting areas for birds, with the area next to the Demerara Harbour Bridge being a particularly important site.

7.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix D.

Figure 7-1 shows the ecosystem service locations identified by the Region 4 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 7-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 4



APPENDIX A

Screening Checklist

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Ecosystem Service	Description, Examples
Provisioning Services	
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for harvesting
Food: wild plants, nuts, mushrooms, fruit, honey	Fruit, nuts, wild plants, etc. collected in natural areas for consumption or sale
Food: wild meat	Animals hunted primarily for food (recreational hunting is covered separately under cultural services); extent of wildlife trapping and trade (Region 1)
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale
Biomass for livestock production	Sedentary and nomadic livestock farming supported by native forage plants
Biomass fuel	Wood, dung and plant matter collected for charcoal or fuel
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp, paper – wood is used in house construction (importance varies by community)
Non-wood fibers and resins	For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber
Freshwater - household use	Freshwater for bathing, drinking, laundry, household use
Freshwater - irrigation & industry	Freshwater for irrigation or industrial use
Natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use
Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade
Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology
Transportation	In remote areas no alternative methods of transport; commercial transportation facilities such as wharfs, ferry stellings, etc.
Social / Economic	Income generators or services supporting income generation (e.g., boat building, repairs, transportation services)
Traditional Resource Use (Region 1)	Traditional medicine, manicole and morocut harvesting, logging, non-wood fibers and resins for sustenance and crafts, biomass for fuel, gathering wild plants and honey, turtle/wildlife trappings, and harvesting of shells
Regulating Services	
Regulation of air quality	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a “sink”) or emitting chemicals to the atmosphere (i.e., serving as a “source”)
Climate regulation: global	Vegetated areas sequester CO_2, with implications for global climate change
Climate regulation: local	Regulation of temperature, shade air, and quality by vegetated areas
Regulation of water timing and flows (including flood regulation)	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge
Water purification and waste treatment	Role played by vegetation in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds

Ecosystem Service	Description, Examples
Shoreline protection	Role of natural habitats (e.g., wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms
Fire regulation	Regulation of fire frequency and intensity (e.g., dense forest can provide firebreaks)
Pest regulation	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock
Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens
Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas
Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops
Cultural Services	
Spiritual or religious value	Natural spaces or species with spiritual or religious importance
Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources
Tourism and recreation	Use of natural spaces and resources for tourism or local recreation (e.g., swimming, boating, fishing); tourism potential and infrastructure needs (Region 1)
Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value
Cultural Services (Region 1)	Cultural aspects and places of importance and protection for Amerindian communities
Supporting Services [a]	
Habitat provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation
Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulfur, phosphorus, carbon) through ecosystems
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms.
Soil formation	Natural soil-forming processes throughout vegetated areas

[a] Supporting Services are intermediate ecological outcomes that are not directly used but rather support other ecosystem services. An exception is made for Habitat Provision, which is sometimes valued as an "end-use" service by stakeholders in addition to its supporting role.

APPENDIX B

Identified Ecosystem Services and Priority Ratings: Region 1 Coastal

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TABLE B-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 1 COASTAL

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
0101 Father's Beach - Population Estimate - 23 people							
Shoreline Protection; River Defense	Regulating Services	Extensive area of mangrove forest on the shore line protecting the sea shore from the impacts of the sea and along the banks of the Moruca River. The oldest coconut farms in the area (established in the 1950s) have been reclaimed by mangroves. There are mature mangroves and new mangrove growth in other areas. Erosion of mangroves is observed in some areas. There was a significant shell beach, which has eroded over the years. Shell is being used for construction in place of stone and is also used for landfilling and to provide nutrients for plants (fruit trees).	Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves **ES Linkages:** Agriculture, sea defense, settlements.	High	Low	Critical
Biodiversity - Habitats	Supporting Services	There are lots of animals within the mangroves including mammals, birds, crabs, fish, and reptiles. Jaguars are a common sighting and macaws and parrots are plentiful in the area eating the crops. Hunting is prohibited in the village and small animals are caught in the swamp for meat.	Mangroves, shoreline	Local people **ES Linkages:** Hunting, recreation	Moderate	Moderate	Medium
Food: Wild Meat	Provisioning Services	There are lots of birds, crabs, fish, and reptiles in the mangroves with crabs and fishes caught for commercial purposes. Some iguanas are caught on the seashore along with sea birds including curi and wild ducks for meat on a limited basis by a few people in the swamps behind the farms. Hunting by outsiders is banned.	Mangroves, shoreline	Local people	Moderate	Moderate	Medium
Agriculture, Cultivated Crops	Provisioning Services	Cash crops with coconuts, plantains, cassava, vegetables, and fruits are under cultivation in a stretch of twenty (20) acres along the sea shore in the mangroves. Some of the abandoned farmlands in the area have been reclaimed by the mangroves.	Sea dam, cultivated areas	Local farmers, residents	Essential	Moderate	Critical
Agriculture, Cultivated Crops	Provisioning Services	Coconut is the main crop grown by the community. A dry coconut sells for $ 45 and a water coconut sells for $ 50 at Charity. Copra sells for $45. Currently, coconut cockles are affecting the coconut grove.	Cultivated lands	Local communities (general population)	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Most people fish for food with three households who fish on a commercial basis in the sea between the Pomeroon River Mouth and Fathers Beach. They each sell about 200 lb. of fish on a weekly basis at $200-$300 per pound.	Marine habitat and Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabbing in mangroves along the beach area is common especially during the crab seasons. Residents from several villages, including as far as Pomeroon and Warapoka come into Fathers Beach to crab. Crap marching is disruptive to the community as the crabs tend to damage the dams which are critical for flood prevention and drainage. Other people catch crab throughout the year for both subsistence and commercial purposes.	Marine environment; Mangroves;	Local people	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Traditional Resource Use	Provisioning Services	Almost all plants including noni, mangroves, and others that are used by the locals for medicinal and spiritual purposes. These plants are plentiful on the beach. Mangroves are used for building construction plantain poles, seine poles, etc. Red mangrove is used to make craft and household items and buttonwood bark is used to make quake strings and shovel sticks. Residents also used the shell on the beach to provide nutrients for plants, use for construction of foundation for buildings, and use for fillings of yards. Shells are used for construction by the residents.	Biodiversity, Agriculture	Local people	Essential	High	High
Tourism and Recreation	Cultural Services	Community members and people from other areas use sections of the beach including Gwennie Beach, Papaya Beach and Bolton Area for recreation purposes.	Coastland	Local people	Low	Moderate	Low
Freshwater - Household Use	Provisioning Services	The community depends on rain water and some freshwater from the wetlands behind the farms. Water is used for bathing, washing, cooking, and drinking.	Coastal wetlands	Father's Beach	Essential	Moderate	Critical
Social/Economic Settlements	Provisioning Services	An entire community resides along the beach. Access to this community is from the beach only via a small channel in the high tide. This also supports commercial activities including fuel sales, boat building and repairs, engine repairs and the local bar is on the shore. People live on their farms in houses on stilts. In addition to the sale of fuel and conduct of boat repairs onshore, the community also provides these services offshore to stranded fisherfolk and other travelers. Persons in need of fuel or repairs can call and the personnel will respond.	Coastland	Father's Beach	Essential	Low	Critical
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Low	Critical
0102 Manawarin – Population Estimate 2,000 people							
Biodiversity- Habitat	Supporting Services	There is an abundance of wildlife within the forest and rivers. Giant river otters feeding area was observed in the river.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife – Hunting and Trapping	Provisioning Services	There are lots of birds, fish, mammals, and reptiles in the area with few birds caught for commercial purposes. Hunting and trapping is very limited in the area with more people focused on fishing and agriculture. However, about 25% of the population is engaged in some form of hunting. Species such as boas, anacondas, parrots, and macaws are caught and sold at Charity.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	All households have farms with plantains, cassava, vegetables, and fruits. Crops are for household use and some are sold to the school and other villages or in limited extent at Charity or Santa Rosa. More persons are farming but the market for the produce is lacking and it costs too much to transport the produce to Charity or Kumaka.	Forested areas, Bush Islands	Local farmers, residents	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	25% of the population fish in the sea between Pomeroon Mouth and Father's Beach targeting the Moruca Mouth area in seasons. Fishing has declined due to the lack of fishing vessels and supplies.	Marine habitat and Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Almost the entire village accesses the shoreline to catch crabs during the crab season. In addition, a few people catch crabs all year round and bring back to the village for sale.	Marine environment; Mangroves;	Local people	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers fish for food throughout the year at different locations following the movement of the fishes. In the dry season fishing is concentrated in the creeks and rivers.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. Some people harvest rainwater for domestic purposes and others use the groundwater from water wells. Freshwater in the creeks and rivers is used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	There are lots of plants including noni and others that are used by the locals for medicinal purposes. Some people cook the cabbage palm and also use the forests to gather materials for household items. Palms and vines including Ite, Kufa, Nibbi, and Kufra are utilized for making craft and household items. The community cuts wood for its internal construction and for sale. The current dispute with the village of Wakapao over the ownership of the resources has reduced the level of this activity.	Biodiversity, Cultural Heritage	Local people	Essential	High	High
Cultural Resources	Cultural Services	Rockstone is an old spiritual site that is far inland and away from the village. This site is used a few people in an infrequent manner.	Cultural	Locals	Low	Low	Low
Social/Economic	Provisioning Services	Commercial activities including numerous small shops, fuel sales, and transportation services are located in the village landing area used by more than 100 people daily.	Coastal wetlands, river ecosystems	Manawarin & Regions 1 & 2	Essential	Low	Critical
River Defense - Erosion Regulation	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the boats and water current.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Agriculture, sea defense	High	Low	Critical
Transportation	Provisioning Services	Access to the community is via boats through the river network entering the Moruka River and the Manawarin River. Numerous dirt road networks provide access from various points to the village.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0103 Haimakabra – Population estimate 600 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 50% of the male population is involved in fishing. 20 people catch fish in the sea on a fortnightly basis making two trips per month to catch snook, basha, bangamary, gillbacker, curass, etc., between Moruka Mouth to Iron Punt where they will camp. Fish is dried at the camps on the beach when ice is unavailable for storage.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally by almost everyone in the village, as well as regularly by a 10-12 people for sale at the weekly market at Santa Rosa.	Marine environment; Mangroves	Local people	Essential	High	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Biodiversity – Habitat Provision	Supporting Services	Numerous species of birds, fishes, mammals including manatees and river otters are found in the rivers. Giant river otters spotted in the area.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Hunting and Trapping	Provisioning Services	Several people in the village trap birds and other wildlife for trade. These are sold to a buyer who takes it to Charity for sale. Hunting of ducks and iguanas is done along the coast for meat by people who visit these areas. Timber species present in the area is utilized with lumbering prevalent, with about 20 chainsaws operating within the community. Each chainsaw operation employs about six people.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Cultivated Crops	Provisioning Services	Cassava is the main crop grown by the community for their staple. Fresh vegetables and fruits are grown for home use and for sale in the village. All households have multiple farms at different locations.	Cultivated lands	Local communities (general population)	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers fish for food throughout the year in areas close to their homes. In the dry season fishing is concentrated in the creeks and rivers. Special fishing trips are made to areas far from the village for commercial purposes.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Traditional resources are harvested in a limited manner and cabbage palm is only cut for cooking at home. Many people do not make traditional furniture or craft.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Social/Economic	Provisioning Services	The village in located on highland and is populated by houses, administrative buildings and village shops. The village has a sports ground.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks that are critical for fishing and transportation. Freshwater in the creeks and rivers is also used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Cultural Resources	Cultural Services	The village has a shell mound that can be used for tourist attraction in addition to its cultural value.	Cultural	Locals	Low	Moderate	Low
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Moderate	Critical
0104 Waramuri – Population estimate 2,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 30% of the males are commercial fisherfolk catching curass, snapper, gillbacker, highwater, cufum, and banga mainly on both sides of the Moruka River mouth between Iron Punt and Cozier Canal. Most of the fisherfolk lives in Haimakabra, a satellite of Waramuri.	Marine environment; Mangroves; river ecosystem	Local people	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabbing is done seasonally with every family making at least two trips to the main crabbing areas of Fathers Beach to east of Pomeroon Mouth.	Marine environment; Mangroves;	Waramuri villagers	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the creeks and savannas and lagoons behind the beach. In the dry season fishing is concentrated in the creeks and rivers with fishing trips to areas far from the village for commercial purposes. Some fish is sold fresh in the village. Some is dried and sold at Santa Rosa and Charity.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity – Habitat Provision	Supporting Services	Numerous species of birds, fishes, mammals including river otters, tapir, deer, and labba are found in the rivers and environment. Many ducks are seen but not caught. Many birds are seen in the savannas but not hunted.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Food: Wild Meat	Provisioning Services	A few people are involved in trapping. Along the beach wild animals are hunted including tapir, deer, iguana, wild ducks (muscovy), etc., with agouti and caiman caught. Snakes are caught and sold to visiting traders or sold at Charity. Duck eggs are also collected. Turtles were previously hunted but not anymore due to conservation efforts. Shore birds can be used for bait by the fisherfolk.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	Cassava is the main crop grown by the community for their staple by all households. Fresh vegetables and fruits are grown for home use and for sale to the school. Coconut cultivation is increasing in the village and water nuts are sold at Charity. Copra is sold at Pomeroon.	Cultivated lands	Local communities (general population)	Essential	High	High
Tourism and Recreation	Cultural Services	Shell mounds are located in the village that can be used for tourist attraction as a heritage site. This site is expected to be developed into a leading tourist attraction in the future as part of the village's plan to enhance eco-tourism activities.	Cultural	Locals	Moderate	Moderate	Medium
Traditional Resource Use	Provisioning Services	Traditional resources are harvested in a limited manner with the villagers embracing modernity. Most people cook with cooking gas using firewood in a limited manner. Noni is used for many medicinal remedies by villagers. Honey is gathered from wild bees along the beach and sells for 250 ml for $1000. Lumber is cut for domestic purposes and sometimes sold in the village. The ite palm is recognized by the village as the tree of life providing tibisiri for craft and hammocks, clothing, household items, roof material, fruit for drink making, and tacoma worm. The village has deposits of stone that are used in construction. Stone is mined and sold locally with some villagers selling to contractors in Santa Rosa.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	Moderate	High	Low
Social/Economic	Provisioning Services	The village in located on bush island (highland) and is populated by houses, administrative buildings, churches and over 20 village shops. The village has a sports ground and an internet service provider.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. The river network is critical for fishing and transportation. Freshwater in the creeks and rivers is also used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Shoreline Protection/River Defense	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the motor boats and water current. The shoreline area is preferred for farming since it is more fertile. However, large cultivated areas and the fisherfolk's camp were washed away. A lot of mangroves and other lands are also eroded from Shell Beach.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Transportation	Provisioning Services	Access to the community is via boats through the river network. Extensive networks of dirt roads exist connecting Waramuri and other settlements.	Rivers	Local People ES Linkages: Settlements, agriculture and socioeconomic	Essential	Low	Critical
0105 Santa Rosa – Population estimate 10,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	50 -100 people are fishing on a daily basis with some people making 2-3 trips per month. Fish is sold at $ 300 – 500 per pound at Moruca. One fisherfolk reports to sell over 1000 lb. of fish per trip making 2 trips per month. Fishing is done along the coast from Pomeroon River all the way to Waini Point, but mainly between the Pomeroon River and Iron Punt. Other fishing areas include Manawarin, Moruca, Baramanni, Biara, and Waini rivers. Dog Creek and Luri Creek are also visited in the dry season.	Marine habitat and Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally by almost everyone in the village, as well as regularly by a few people for sale. About 20 people catch crabs for the market on Tuesdays and Saturdays. Out of season crabs are sold at $100 for one.	Marine environment; Mangroves;	Local people	Essential	Moderate	Critical
Livestock Farming	Provisioning Services	A small group of <10 people have a few heads of cattle and some pigs. These are grazed in the savannas close to the village and do not reach the coastland.	Animal Husbandry	Local communities (general population)	Essential	High	High
Biodiversity - Habitats	Supporting Services	The village and its surrounding area are populated by numerous species of birds, fishes, mammals including numerous jaguars. Ite palms are found throughout the community and are used by the villagers. Ite palms also house numerous birds.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife – Trapping & Hunting	Provisioning Services	Wildlife trade is banned in the village but some people keep animals as pets. However, people hunt wildlife for sustenance. Luri Creek and Baramani Lake are important areas where villagers conduct hunting of animals for meat. There is a ban on all hunting within the village. Deer is scarce but iguanas are plentiful. Recently many saki monkey were trapped by a wildlife trader.	Coastal wetlands, Forested areas, Bush Islands	Local people	High	Moderate	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers fish for food throughout the year and more so in the dry season. Special fishing trips are made to Dog Creek and Luri Creek for commercial purposes.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Traditional resources are harvested in a limited manner and cabbage palm is only cut for cooking at home. Many people do not make traditional furniture or craft but rely on household items made exclusively from wood. Turtle shells are used for spiritual practices. The mangroves are part of the cultural heritage of the community and must be protected. The Moruca Mouth is part of the ancestral lands of the Amerindian people of Santa Rosa. Plants are gathered from the beach and throughout the community for medicinal and other purposes.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Social/Economic	Provisioning Services	The village in located on highland and is populated by houses, regional and village administrative buildings and numerous shops. The village has three sports ground used on a daily basis by the youths.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. The rivers are critical for transportation with 100 -200 people travelling on a daily basis to Charity or Mabaruma.	Coastal wetlands, river ecosystems	Local Communities ES Linkages: Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Cultural Resources; Tourism, and Recreation	Cultural Services	The village has a sacred site that can be used for tourist attraction in addition to its native culture. The village also has a 200 year old church that can be cites as a heritage site. There is an historical site call Lalancha along the Barabara River where there was a battle between the Indigenous communities and the Venezuelans. The Moruca River and its numerous waterways are used for swimming, cultural acts, fishing, recreation, sports, and some spiritual practices.	Cultural	Locals Villagers, Region 1, Guyana	Moderate	Moderate	Medium
Commercial, Social/Economic	Provisioning Services	The village in the trading hub for the Moruca Sub District of Region 1. Numerous boats and small vessels arrive in the village to ply their trade two times weekly. Over 100 people leave/arrive in the area daily.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
River Defense / Erosion Protection	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the motor boats and water current.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Shoreline Protection	Regulating Services	Extensive area of Mangrove forest at Moruca Mouth protecting the river banks and shoreline. The mangroves keep the banks of the river intact and the shoreline is constantly eroding and rebuilding.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	High	Moderate	High
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Moderate	Critical
0106 Assakata – Population Estimate 473 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	50 of the 57 households participate in fishing activities on at least a monthly basis. The fisherfolk use Biara and Bara Rivers, Luri Creek, and Dog Creek as their main fishing ground to catch many types of fishes for sale in the village and at Santa Rosa. Currently no boats fish in the ocean.	Marine environment; Mangroves; Rivers, Creeks & Lakes	Villagers **ES Linkages:** Commerce, transport	Essential	Moderate	Critical
Agriculture, Cultivated Crops	Provisioning Services	Cassava is the main crop used as the local staple along with fish for a daily meal. Cash crop includes bananas, coconuts, fruits, vegetables, and vine crops.	Bush Islands, Forests	Local farmers, residents	Essential	Moderate	Critical
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. Villagers harvest rainwater for domestic purposes and others use the groundwater from hand dug water wells. Freshwater in the creeks and rivers is used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Traditional Resource Use	Provisioning Services	About 30 villagers cut approximately 2500 cabbage sticks per trip making at least a trip per month. Noni and other plants are used by the locals for medicinal purposes. Some people cook the cabbage palm and also use the forests to gather materials for household items. Lumber is cut for household and community projects.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally along the rivers, shore, and beach by almost everyone in the village, as well as regularly by a few people for sale. Every family makes about 2 trips per season. A few people catch crabs on the fishing trips for food and sale.	Marine environment; Mangroves;	Local people	Moderate	Moderate	Medium
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the rivers, creeks, and lakes. In the dry season fishing is concentrated in the creeks and rivers with fishing trips to Baramanni Lake, and Luri Creek for commercial purposes. Some fish is sold fresh in the village. Some is dried and sold at Mabaruma, Santa Rosa, and Charity. Morocut is caught in the freshwater rivers for sale.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	Numerous species of birds, fishes, mammals including river otters, tapir, deer, acouri, and labba are found in the rivers and environment. Many ducks are seen but not caught. The rich biodiversity is known to be along Luri Creek.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Iguanas, tapirs, labba, deer powis, wild ducks are caught on the seashore on fishing and hunting trips, or along Luri Creek and Baramani Lake. Nobody from the village is a wildlife trader. Conservation efforts have paid off, with a reduction in wildlife trapping and trade within the community.	Mangroves, shoreline	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High
River Defense	Regulating Services	The rivers are covered by extensive vegetation protecting the banks from the impacts of the motor boats and water current. A lot of the vegetation has been burnt by the fisherfolk.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Tourism and Recreation	Cultural Services	The village has a freshwater lake that can be used as a tourist attraction along with some shell mounds in the village. The community will develop an ecotourism plan and seek funding from the government for the initiative.	Cultural	Locals Villagers, Region 1, Guyana	High	Moderate	High
Commercial, Social/Economic	Provisioning Services	The village has numerous small businesses with people actively involved in the cash economy. The village had its school and other government facilities that employ over ten people who contribute to the cash economy along with the pensioners.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the freshwater river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Low	Critical
0107 Warapoka – Population estimate 650 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are 20 people who fish in the sea at least two times per month. Catch includes queriman, bangamary, butterfish, curass, gillbacker, cufum, basha, and others. Shrimp is caught in the rivers around the village.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping & Crabbing	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Agriculture, Cultivated Crops	Provisioning Services	All households have farms located in the forests or on the bush islands. Small gardens are found at the homes of the villagers. Cassava is the main crop grown along with vegetables, fruits, and vine crops. Some of the food is sold locally to the school and the tourist center.	Forests, Bush Islands	Local farmers, residents **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Shoreline Protection	Regulating Services	Extensive area of mangrove forest at Iron Punt, Luri Beach, and Waini Point protecting the coast from the ravages of the sea. These area are used by the fisherfolk in different seasons.	Mangrove Forests	Local communities **ES Linkages:** Fishing, hunting, Erosion regulation, Pollination	High	Moderate	Medium
Cultural Resources	Cultural Services	The village has cultural sites used as tourist attraction along with key biodiversity sites. The tourism product of the village is developing and will grow with the success of the country.	Cultural	Locals Villagers, Region 1, Guyana	High	Moderate	Medium
Social/Economic/Commercial	Provisioning Services	The village has numerous small businesses including a growing tourism center with people actively involved in the cash economy. The village had its school and other government facilities that employ over fifteen people who contribute to the cash economy along with the pensioners.	Commercial, Administrative	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught seasonally to Waini Point and Moruca Mouth by almost everyone in the village, as well as regularly by a few people for sale.	Marine environment; Mangroves;	Local people	Moderate	Moderate	Medium
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the rivers, creeks, and lakes. Fishing trips to Baramanni Lake, and Luri Creek for commercial purposes with fish sold fresh in the village and at Mabaruma and Santa Rosa.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Low	Critical
Biodiversity	Supporting Services	Numerous species of birds, fishes, mammals including harpy eagles, river otters, tapir, deer, acouri, and labba are found in the rivers and environment. Many birds are seen but not hunted. The entire environment has rich biodiversity with numerous species. Four river turtles are found within the area (red neck, side neck, jumbie head, and black turtle). Manatees are also observed in Luri and Muribu Creeks. The village has two harpy eagles nesting sites, with once currently active.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Iguanas, tapirs, labba, deer, powis, wild ducks are caught on the seashore on fishing and hunting trips. Duck eggs are collected for use. Within the village birds eggs are collected seasonally (blue tiger bird and qak). Many people are involved in trapping of wildlife for sale. People will come to the village to purchase wildlife including snakes, parrots, macaws, turtles, etc. Prices fluctuates are generally around $1,000 for parrot, $10,000 for macaw and $2,500 for a Boa.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High
Tourism and Recreation - Ecotourism	Provisioning	The village has an ecotourism house that has six rooms and space for hammocks. Tourists can visit historic sites, experience the Amerindian culture, and see the Harpy eagle amongst many species of birds. The community hopes to develop sport fishing as an ecotourism option in the many fishing sites close to the village at Luri Creek. About 20 persons are now employed in the tourism activities, increasing from 10 in 2018.	Forests, River, Savannas	Local communities **ES Linkages:** Commerce, Agriculture, Guides	High	Moderate	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Traditional Resource Use	Provisioning Services	Approximately 20 households or 80 men cut cabbage sticks at least once in combination with fishing and other resource use exercises per month. Noni and many plants are used by the locals for medicinal purposes and are gathered from the beach. Morocut is caught in the freshwater rivers for sale. People gather honey from wild bees at the beach and honey is sold at $1,000 per liter. Beekeeping is done by one individual within the community.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	High	High
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture and socioeconomic	Essential	Low	Critical
0108 Three Brothers – Population estimate 120 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	More than 100 men from the three villages that make up the Three Brothers community catch fish in the sea making two trips per month to catch snook, basha, banga, gillbacker, curass, queriman etc. at Waini Point to Iron Punt. Some people use the Luri Creek to reach Iron Punt. The main fishing season for the sea is May-August.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Biodiversity	Supporting Services	Numerous species of birds, fishes, mammals including crabs are found in the rivers and mangrove forests. There are plenty of ducks in the wetlands bordering with SBPA. River dolphins were prevalent in the past but have not been sighted recently. This may be as a result of speed boats operating within the area and fuel spills in waterways. Both the neo-tropical and giant river otters are found within the area. There is a high presence of jaguars which take the dogs and livestock. Some sea turtles would also be observed up river. There are harpy eagle nesting sites within the area.	Coastal wetlands, Forested areas, Mangroves	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Food: Wild Meat	Provisioning Services	There are no wildlife traders in the village and no person from the village is involved in trapping but people from other villages will conduct this from time to time. Wild ducks and other birds are hunted for food. Iguanas and land turtles are utilized or sometimes sold. The dogs and chickens in the area are hunted by jaguars.	Coastal wetlands, Forested areas, Mangroves	Local people	Low	High	Low
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the season in the village by all households. There are crabs in the village that can be caught on a daily basis as some people do on occasions. People from outside the area are seen catching crabs at Waini Point on a weekly basis for the market.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Agriculture, Cultivated Crops	Provisioning Services	All families have farms that are impoldered. Cassava, plantains, and ground provisions are the main crops. Vegetables and fruits are also grown for home use and for sale in the village. The crabs can be a pest destroying the dams. There are a few commercial farms in the area but farming is generally on the decline, despite successes with ginger and other root crops.	Cultivated lands	Local communities (general population) **ES Linkages:** Transportation, Commerce	Essential	High	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	Fish is the main source of protein for the villagers who fish throughout the year in areas. Fishing trips are made to Luri Creek and Baraminni Lake for commercial purposes. Sea turtles enter the river in the dry season with the salt water as the fishes more inland.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Approximately 90% of the village cuts cabbage palm for sale to the company. Many people do not make traditional furniture or craft any longer. Mangrove is used for building and in the farms. Few people cook with firewood. Medicinal plants are collected from the beach.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. There are no groundwater wells in the area and people depend on rain as a safe source of drinking water. The waterways are also used for transportation of people and food.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Traditional Resource Use	Cultural Services	The village has a Crabwood Forest that is an important cultural resource and can be used for tourist attraction in addition to its native Warrau culture. This is being used to produce crabwood oil.	Cultural	Locals	Low	Moderate	Low
Mangroves River Defense – Erosion Protection	Regulating Services	The rivers are covered by extensive mangroves protecting the banks from the impacts of the motor boats and water current. The mangroves are quick to reclaim any lands not maintained by the community.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	Essential	Low	Critical
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0109 Mabaruma Town Council – Population estimate 8,000 people							
Socio/Economic: Transportation - Wharf facilities	Provisioning	The Kumaka waterfront is used for transportation, commerce, and administrative services by over 200 people daily. There were over 20 large vessels in the area docked. Main transportation hub for the Region	River	Local communities **ES Linkages:** Tourism, commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are over 20 fishing boats visiting the Kumaka market to sell their catch on a daily basis. Catch includes queriman bangamary, butterfish, curass, gillbacker, cufum, basha, and others. There are more than 100 fisherfolk within the Town living in the outlying district making at least weekly fishing trips lasting 3-5 days at sea. The smaller boats can do daily fishing trips to Waini Point. Shrimp is caught in a limited manner in the shrimp season (April – August) by less than 10 people. Fishing has increased due to the additional migrant fisherfolk now residents in the area.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping & Crabbing	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crab catching is done daily for sale at Kumaka and to hucksters working on the ferry to Georgetown. Blue crabs are found year round but red crabs are seasonal. Crab meat project initiated in some areas. Migrants also hunt for crabs for their sustenance.	Marine environment; Mangroves;	Local people, traders	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Agriculture, Cultivated Crops	Provisioning Services	Cassava and ground provision are the main crops used as the local staple along with fish for a daily meal. Cash crop includes bananas, coconuts, fruits, vegetables, and vine crops. About 60% of the people have farms particularly those living out of the urban center.	Bush Islands, Forests	Local farmers, residents	Essential	Moderate	Critical
Freshwater - Household Use	Provisioning Services	The outlying community depends on freshwater from the rivers, creeks, and natural springs. Some people harvest rainwater for domestic purposes and others use the groundwater from water wells provided by the government. Freshwater in the creeks and rivers is used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	Villagers in Smiths Creek, Wicabri, and Aruka Mouth cut cabbage sticks for sale. Traditional medicine is used by the locals in a limited manner. Morocut is caught in the freshwater rivers for sale at Mabaruma at $ 300 per lb. Medicinal plants are harvested from the beach area. Mangroves are utilized be people living in swampy areas as post for construction and for building foundation. Mangrove barks are also harvested to be used in tanning.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, Commerce	Essential	High	High
Biodiversity	Supporting Services	The town covers six villages and has a high diversity of flora and fauna. The rubber trees that line the main road are imported from Asia. Numerous species of birds, fishes, mammals are found in the rivers and inland environment. Many birds are in the area but not caught for food or trade. Many Iguanas are in the town and caught and sold. Parrots and macaws can be seen in the evening sky with a bird roosting area close to the town. Numerous monkeys are living in the town and are considered a pest by the farmers.	Coastal wetlands, Forested areas, Rivers	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Trapping and hunting are conducted mainly in the riverine areas. Iguanas, labba, agouti, and wild ducks are the main animals hunted. Many bird species are trapped including toucan, macaws, parrots, etc. Anteaters, small rodents, etc. are trapped. It is estimated that there are 100 trappers within the area and 3 traders based at Kumaka.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High
Agriculture, Livestock Farming	Provisioning Services	Grazing occurs throughout the Town with many heads of cattle seen roaming the roadways and in pastures. Pigs are also kept in pens by farmers who do not allow them to roam. Sheep and goats are more rare but present in small numbers in the town. The animals have no interaction with the coastland.	Mangroves, Sea Dam, Pastures	Local communities, private cattle farmers	Moderate	High	Low
Shoreline Protection, River defense	Regulating Services	Extensive area of Mangrove forest covering the banks of the main rivers and the coastline offering valuable protection and stability. Honey bees are found within the mangroves but seldom interfered with by the locals.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Erosion regulation, Beekeeping	Moderate	Moderate	Medium
Socioeconomic, Sawmill. Lumberyard, and Boat Building/Repairs	Provisioning Services	Sawmill and lumberyard located in Mabaruma. Boat building at Mabaruma, with repairs done to vessels and engines, is also done within the sawmill and lumberyard area.	Coastal	Local fisherfolk, boat owners	Essential	High	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Tourism and Recreation - Ecotourism	Provisioning	The town has a few hotels to house tourists who can visit historic sites, experience the Amerindian culture, and see the town. Sport fishing is optional in the many fishing sites close to the Town. Green Park was built for recreation and relaxing that can be utilized by tourists as well. Locals visit Waini Point and Shell Beach on Easter and on special occasions. There is a Shell Mound within the Town. Daily flights have increased to the town and so has tourism activities.	Forests, River, Savannas	Local communities **ES Linkages:** Commerce, Agriculture, Guides	Essential	High	High
0110 Aruka Mouth – Population estimate 300 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 80% of the households or about 60 men catch fish in the sea at Waini Point making weekly trips per month to catch snook, basha, bangamary, gillbacker, curass, queriman etc. at Waini Point. Some people catch shrimp in the shrimp season that is April – August.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Biodiversity	Supporting Services	Numerous species of birds and fishes along with monkeys can be seen in the area. There are no wildlife traders in the village but any animal caught can be sold to the traders at Mabaruma. There were river dolphins and otters in the area that have migrated because of the pollution in the water (primarily from oil and gasoline from boats). Significant roosting areas for birds along river.	Coastal wetlands, Forested areas, Mangroves	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the season in the village by all households. There are 15 persons that catch crabs for the markets on Tuesdays and Saturdays. Crabs are caught at Waini Point and in the riverine areas. Crabs are purchased by traders and taken to Georgetown	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Essential	Moderate	Critical
Agriculture, Cultivated Crops	Provisioning Services	A total of 20 families have farms that are impoldered and provide food for the household. Cassava, plantains, and ground provisions are the main crops. The water seems to be getting higher and flowing over the dams. The crabs can be a pest destroying the dams and serves to discourage villagers from farming. The farm produce is sold at Kumaka on Tuesdays and Saturdays.	Cultivated lands	Local communities (general population) **ES Linkages:** Transportation, Commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	All villagers can be found fishing in the rivers and creeks for different fishes on almost a daily basis. Freshwater fishes are found nearby in the rainy season when the waters are fresh. The Morocut will be found in the fresh river water during the rainy season at this location.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	2-5 households in the village cuts cabbage palm for sale to the company. The crab catchers utilize forest products for the crab quakes. Mangrove is used for building and in the farms and also for firewood.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Freshwater - Household Use	Provisioning Services	The village has a problem with access to safe drinking water. The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. There are no groundwater wells in the area and people depend on a spring that is located some distance from the river. The waterways are also used for transportation of people and food.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Mangroves, River Defense, and Erosion Protection	Regulating Services	The river banks are protected by extensive mangroves. The mangroves protect the river from the impacts of the motor boats and water current. The mangroves are quick to reclaim any lands not maintained by the community.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	Essential	Moderate	Critical
Food: Wild Meat	Provisioning Services	There are about ten persons from the community that hunt meat for sale at the Kumaka market. Wild birds are also caught in the season when they are plentiful.	Mangroves, shoreline, savannas, forest	Local people **ES Linkages:** Tourism, Commerce	High	High	Medium
Aquatic Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0111 Morawhanna – Population estimate 100 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	Approximately 30-40 men from Morawhanna catch fish in the sea making three trips per month to catch snapper, snook, basha, banga, gillbacker, curass, quereman, etc. at Waini Point to Iron Punt. Most of the fresh catch is sold to vessels from Venezuela.	Marine habitat and Mangrove Forests	Commercial fishing along the coast	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the season in the village by all households. There are 13-15 people who catch crabs for the markets on Tuesdays and Saturdays. Crabs are caught at Waini Point and in the riverine areas including Morawhanna.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Biodiversity	Supporting Services	The area has a roosting spot with scarlet ibises and egrets roosting for the night. Numerous species of other birds, fishes, mammals, and crabs are found in the rivers and mangrove forests. Hunting is not practiced by the villagers buys whistle birds from Venezuela.	Coastal wetlands, Forested areas, Mangroves	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	No farming currently done since all farmlands are flooded as the dams have been destroyed and people are discouraged to invest to empolder their lands. The crabs can be a pest destroying the dams in addition to the high tides affecting the area in the past three years.	Cultivated lands	Local communities (general population) **ES Linkages:** Transportation, Commerce	Essential	High	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	Freshwater fishes are caught in the river in the rainy season when the water is fresh. Fishes are also found in the wetlands and creeks that are more available in the dry season.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Traditional Resource Use	Provisioning Services	No one from the village cuts cabbage palm for sale to the company. The village is of mainly mixed ethnic origin and people rarely make traditional furniture or craft. Mangrove is used for construction of houses and few people cook with firewood. Some people use noni and fegosa for medical purposes.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium
Social/Economic - Commercial	Provisioning Services	The village has a few fuel suppliers selling to villagers and other people in the region. Many people have shops and carry numerous products for sale on the riverfront. About 40 boats from Venezuela are selling fuel in the area. The ice plant is now operational supplying ice to the fisherfolk. Food and other supplies are provided to the crew of the numerous ships on a daily basis.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Freshwater - Household Use	Provisioning Services	The entire community depends on freshwater from the rivers and creeks for bathing, washing, cooking, and drinking. There are no groundwater wells in the area and people depend on rain as a safe source of drinking water. Bottled drinking water is purchased from Mabaruma. A new well in the village had reduced the dependence on river water.	Coastal wetlands, river ecosystems	Local Communities **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0112 Smiths Creek – Population estimate 248 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	All males are fisherfolk with more than 100 men fishing in the Waini River and at Waini Point. The village has three large boats that make 2 trips per month each lasting 8-10 days at sea. Catch includes curass, snapper, gillbacker, highwater, cufum, and bangamary mainly at Waini Point to Iron Punt. The village also has 15-20 small boats that can make daily trips to Waini Point.	Marine environment; Mangroves; river ecosystem	Local people	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Everyone catches crabs for the markets on Tuesdays and Saturdays with a minimum 100 quakes supplied per market day valued at $1000 each. Crabs are also sold to hucksters on the ferry to Georgetown. Both blue and red crabs are sold (7-8 blue per quake and 10 red per quake). A crab processing facility is being established within the community with the support of the government.	Marine environment; Mangroves;	Waramuri villagers	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish in the Barima River and Smiths Creek throughout the year. In the rainy season freshwater fished including the morocut is caught in the area.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	There are many species of birds, fishes, and mammals including jaguars, tapir, deer, and labba are found in the rivers and forests. Many ducks and egrets are seen in the area but not hunted. One hunter traps birds at Macaw Point for sale to the traders (GYD$500 per pound).	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Agriculture, Cultivated Crops	Provisioning Services	Three people have farms in the area that is constantly flooded. Cassava and ground provisions are the staple crop for the households. Fresh vegetables and fruits are grown for home use and for sale in the village, to the school and at Mabaruma.	Cultivated lands	Local communities (general population)	Essential	High	High
Traditional Resource Use	Provisioning Services	Everyone is involved in the harvesting of manicole at different times with an average of 40 persons cutting per month. A family or crew can harvest 2500 sticks of manicole palms per trip, making a trip per month. Other traditional resources are harvested in a limited manner except materials related to crabbing. Most people cook with cooking gas using firewood in a limited manner. Noni, guava and mangroves is used for many medicinal remedies by villagers. Mangroves are utilized by people for construction and for building foundation and for firewood, fishing poles and medicinal uses.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	Moderate	Moderate	Medium

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Social/Economic	Provisioning Services	The village has a few fuel suppliers selling to villagers and other people in the region. Many people have shops and carry numerous products for sale on the riverfront.	Commercial, Administrative	Local people **ES Linkages:** Hunting, fishing, tourism	High	High	Medium
Freshwater - Household Use	Provisioning Services	The community depends on freshwater from the rivers and creeks. The river network is critical for fishing and transportation. Freshwater in the creeks and rivers is also used for bathing, washing, cooking, and drinking.	Coastal wetlands, river ecosystems	Local Communities ES Linkages: Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
River Defense, Erosion Protection	Regulating Services	The rivers are covered by mangroves protecting the banks from the impacts of the motor boats and water current. The mangroves also act as roosting habitats for many birds. There are a lot of mangrove being cut to construct new houses for the migrants and being cleared for their dwelling places along the Barima River.	Coastal wetlands, river ecosystems	Transportation **ES Linkages:** Fishing, transport	High	Low	Critical
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
Wildlife Trapping and Hunting	Provisioning Services	A few men hunt meat for food and trap animals for sale. Land turtles are hunted for meat and for sale to the trader at Kumaka.	Mangroves, shoreline, savannas, forest	Local people **ES Linkages:** Tourism, Commerce	High	High	Medium
0113 Imbotero – Population estimate 353 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are more than 100 men who fish. All men in the village are fisherfolk and some women also fish. Catch includes queriman bangamary, butterfish, curass, gillbacker, cufum, basha, and others. Each household has a boat that they can use with either with outboard engine or by paddling to the fishing ground.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping, Crabbing, commerce	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught in the crab season in the village by all households. There are also crabs in the village area caught on a daily basis. People from outside the area are seen catching crabs at Waini Point on a weekly basis for the market. The women of the village are reputed to be the better crab catchers catching 5–12 quakes per catching day.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Agriculture, Cultivated Crops	Provisioning Services	20 households have farms located in the savannas or forests that sometimes floods in the rainy season. Cassava is the main crop grown along with vegetables and fruits. Some of the food is sold locally to the school and in the village.	Forests, Bush Islands	Local farmers, residents **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical
Shoreline Protection	Regulating Services	Mangroves cover Waini Point and shell beach protecting the coast from the ravages of the sea. These areas are used by the fisherfolk in different seasons with some fishing camps onshore.	Mangrove Forests	Local communities **ES Linkages:** Fishing, hunting, Erosion regulation	High	Moderate	Medium

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Commercial, Social/Economic	Provisioning Services	The village has a school and that employs four teachers who contribute to the cash economy along with the pensioners. The trade in petroleum and some products from Venezuela boosts the local economy. The community now has a significant migrant population from Venezuela that has settled along the Barima River banks (Warraus settlement). The migrants have been given temporary status to live and utilize the village resources. As such, these have been an increased use of the same resources utilized by the community.	Human settlement, governance	Local people **ES Linkages:** Recreation, Administration	Essential	Low	Critical
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	The villagers fish throughout the year in the rivers, creeks, and lakes mainly for saltwater fishes. Fishing trips to Baramanni Lake and Luri Creek are made a few times per year. Freshwater fishes are caught more frequently from Lion Creek.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	There are numerous species of birds, fishes, and mammals including tapir, deer, acouri, and labba found in the rivers and forest. Many birds are seen but not hunted. The entire environment has rich biodiversity with numerous species. Many jaguars and black caimans are prowling the area with jaguars eating 30 hunting dogs from the village. The Warraus from Venezuela have cleared patches of mangrove and built houses along the river.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Moderate	High
Wildlife Trapping & Hunting	Provisioning Services	Iguanas and birds are plentiful but the ducks are difficult to catch. The iguanas are caught and eaten regularly. Some birds including parrots, macaws, black headed parrots, rainbow parrots are caught at Macaw Point and these can be sold to the wildlife trader visiting the area or at Kumaka.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	High	Medium
Tourism & Recreation	Provisioning Services	The village has no plans for ecotourism. They are confident that people visiting the area will wish to see the border with Venezuela and visit shell beach. This can be part of a package offered to tourists.	Forests, River, Savannas	Local communities ES Linkages: Commerce, Agriculture, Guides	Essential	High	High
Traditional Resource Use	Provisioning Services	Resources including noni, sweet broom, pear leaf, Indian tobacco, and others are used for medical purposes. The fisherfolk cut manicole palm in the dry season while on their fishing trips. Mangroves are utilized by people for construction and for building foundation and for firewood, fishing poles and medicinal uses.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, commerce	Moderate	High	Medium
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
0114 Almond Beach – Population estimate 51 people							
Agriculture, Cultivated Crops	Provisioning Services	All households have farms located on the beach and at risk of erosion. Cassava is the main food crop grown along with vegetables and fruits. Coconut is the main crop on the beach. Copra and both dried and water coconuts are sold at Kumaka. Erosion is still taking away mature and young trees as it washes the shell away every high tide. In general, farming has reduced due to a prolonged dry spell.	Forests, Bush Islands	Local farmers, residents **ES Linkages:** Fishing, Tourism, Transportation, Commerce	Essential	Moderate	Critical

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Shoreline Protection	Regulating Services	Mangroves cover most of the beach with a wide buffer of shells. The shells are the first wall of protection for most of the beach protecting the coast from the ravages of the sea. These areas are used by the fisherfolk in different seasons with some fishing camps onshore.	Mangrove Forests	Local communities **ES Linkages:** Fishing, hunting, Erosion regulation	High	Moderate	High
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning Services	There are three families who fish making two trips per month using from Waini Mouth to Tiger Beach in the sea. Catch includes queriman bangamary, butterfish, curass, gillbacker, cufum, basha, and others. Each household has a boat that they can use reach the fishing ground. Nobody catches shrimp and considers the shrimp seine to be inappropriate for the area. Fishing in the Atlantic Ocean depends on the catch, price, and cost of fuel. High gasoline prices have reduced fishing activities.	Marine environment; Mangroves; river ecosystem	Local people **ES Linkages:** Economic shrimping, Crabbing, commerce	Essential	Moderate	Critical
Food: aquaculture and wild-caught fish & shellfish: Crabs	Provisioning Services	Crabs are caught all year around by people from other areas. The villagers will catch some crabs when they are heading to Mabaruma on a market day. Crabs are caught in the crab season in the village by all households in their farms.	Marine environment; Mangroves;	Three Brothers, Imbotero, Smiths Creek, Mabaruma villagers	Moderate	Moderate	Medium
Tourism & Recreation - Ecotourism	Provisioning	The village has plans for ecotourism as they seek to collaborate with the PAC. Tourists were restricted in 2017 following the washing away of the beach with the tourism building. The rebuilding of the accommodations will see the return of tourists in the near future.	Forests, River, Savannas	Local communities **ES Linkages:** Commerce, Agriculture, Guides	Essential	High	High
Traditional Resource Use	Provisioning Services	Villagers use noni, pear leaf, wild mangrove, buttercup, and others for medical purposes. Villagers collect driftwood on the beach as their ancestors did for millennia. Turtle meat or eggs are no longer eaten by the villagers who are now strict turtle conservationists.	Biodiversity, Cultural Heritage	Local people **ES Linkages:** Fishing, Tourism, commerce	Essential	High	High
Food: aquaculture and wild-caught fish & shellfish: Freshwater	Provisioning Services	Freshwater fishes are caught in the wetlands beyond the beach throughout the year. Fishing trips to Baramanni Lake and Luri Creek are made a few times per year as the villagers make trips to Santa Rosa. Saltwater has intruded in much of this area and depleted fish like hassar that were once plentiful.	Inland freshwater ecosystems	Commercial and subsistence fishing along the rivers, creeks and savannas	Essential	Moderate	Critical
Biodiversity	Supporting Services	There are numerous species of birds, fishes, and mammals including agouti, tapir, deer, acouri, and labba found in the areas close to the beach. Many birds are seen but not hunted. Numerous iguanas are found on the beach and some are eaten by the villagers. Many jaguars are prowling the area with one killing a leatherback turtle two weeks prior to the visit to the beach. Several species of sea turtle nest on the beach. Harpy Eagle and armadillos are sometimes sighted.	Coastal wetlands, Forested areas, Bush Islands	Local people **ES Linkages:** Hunting, fishing, tourism	High	Low	Critical
Food: Wild Meat	Provisioning Services	Iguanas and some mammals are hunted and eaten regularly, along with crabs. Ducks, on the other hand, are difficult to catch, so only the duck eggs are typically consumed. There is no one catching birds or any animals for trade in the village.	Mangroves, shoreline, Savannas, Forest	Local people **ES Linkages:** Tourism, Commerce	High	Moderate	High

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Transportation	Provisioning Services	Access to the community is mainly via boats through the river network.	Rivers	Local People **ES Linkages:** Settlements, agriculture, and socioeconomic	Essential	Low	Critical
Social/Economic Settlements	Provisioning Services	An entire community resides along the beach. The PAC is also based within this community.	Coastland	Almond's Beach, PAC	High	Moderate	High

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APPENDIX C

Identified Ecosystem Services and Priority Ratings: Region 2 Coastal

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TABLE C-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 2 COASTAL

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 1 - Charity/ Urasara – Population estimate 7,800 people							
Marine aquaculture and wild-caught fish & shellfish, including crab (food)	Provisioning	• Crabbing is practiced by hundreds of persons in the NDC over the July, August, and September crabbing season. Approximately ten families in the NDC are engaged in crabbing as an everyday activity for their livelihoods. Some of these persons travel to the Pomeroon Mouth for crabbing. • Crabbing in the Pomeroon River at Providence.	Marine habitat and Mangrove Forests	a) Commercial and subsistence crabbing at mouth of river and along the coast b) Subsistence crabbing in Pomeroon River	a) Essential b) Moderate	a) Moderate b) Low	**a) Critical** **b) High**
	Provisioning	• 5-6 commercial fisherfolk in area and their supply chain (buyers, sellers etc.) of the Pomeroon River. • All fisherfolk come to mouth of river. A few times per week. Catfish catch is approximately 100 pounds over 3 days catch valued at USD 500. • Fishing site for pin seine and pole seine in Essequibo Coast, Pomeroon River, and Moruca. • Waste and pollution of river and coastal areas has been the biggest challenge for fisherfolk over the years.	Marine habitat and Mangrove Forests	a) Commercial fishing along the coast and in mangroves b) Commercial fisherfolk fishing in the mouth of the Pomeroon River c) Commercial and subsistence fishing	a) Essential b) Essential c) High	a) High b) Low c) High	**a) High** **b) Critical** **c) Medium**
	Provisioning	• The Big Bird Fish Complex at Charity is a major processing facility that processes large amounts of catch for export.	Marine habitat and Mangrove Forests	Commercial landing site and fish processing facility	Essential	Low	**Critical**
	Provisioning	• Most families in the area depend on fishing for sustenance.	Marine habitat and Mangrove Forests	a) Subsistence fishing along the coast and in mangroves b) Subsistence fishing along the river banks	a) High b) Moderate	a) High b) Moderate	**a) Medium** **b) Medium**
Cultivated Crops	Provisioning	• Crop cultivation is present in many communities along the coast, and ranges in scale from subsistence farming of staple grains, to export-oriented growing of coconuts and watermelons. • Staple grains, including rice, are also farmed for both commercial and subsistence use. • There are close to 50 families who farm along the Pomeroon River.	Cultivated lands	Local communities (general population)	Essential	High	**High**
Livestock Farming	Provisioning	• Grazing on the sea dam and the sea defenses throughout the NDC.	Pasturelands	Local communities	Moderate	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: wild meat	Provisioning	• Within certain mangrove areas, there are a few men who hunt birds and iguana to sell on the open market near Charity. This activity is on the decline in the NDC.	Mangrove Forests	Local communities (general population) near Charity **ES Linkages:** Fishing	Low	Moderate	**Low**
Tourism and Recreation	Cultural	• Biodiversity: Important Bird Area for Scarlet Ibis	Mangrove Forests	Local communities (general population) of Region 2 and visitors to the Pomeroon River **ES Linkages:** Mangroves, fishing, tourism	Moderate	Moderate	**Medium**
Habitat provision, coastal protection	Supporting	• Extensive mangrove forests have provided habitats for birds, crabs, and other wildlife. The mangroves also protected the shoreline of the NDC. • However, there has been significant erosion of the sea dam, mudflats and mangroves along the shoreline of the NDC with the result that habitats for wildlife, birds, and crabs are reduced. This is especially prevalent at along the coast of the NDC and in the Pomeroon River.	Marine habitat and Mangrove Forests	Local communities **ES Linkages:** Fishing, crabbing mangroves	Essential	Low	**Critical**
NDC 2 - Evergreen/Paradise – Population estimate 7,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Crabbing is common during the July to September crab season, and crabbers from other parts of Region 2 utilize the area. • More than ten persons from the NDC catch crabs in the Summerset & Berks mangroves on a weekly basis for sale.	Mangroves	Commercial and subsistence crabbing in mangroves	Low	High	**Low**
	Provisioning	• Approximately 10 boat owners from the local area with an average of 2-3 fisherfolk working each boat every 2-3 days; more than 30 people in the Andrews Koker area rely on fishing for livelihoods. • Two other primary dock areas in Paradise with less than 10 fishing boats per day. • Fishing landing area at Dartmouth and Westbury with three boats. • Fish landing site in Evergreen with five boats. • Fishing landing site in Perth with six boats	Marine environment; beach; Kokers	a) Commercial fishing at Andrews Koker, including crabbers b) Commercial and subsistence fishing in Paradise c) Commercial and subsistence fishing at Dartmouth and Westbury d) Commercial fishing at Evergreen e) Commercial fishing at Perth	a) High b) Moderate c) Moderate d) Moderate e) Moderate	a) Moderate b) Moderate c) Moderate d) High e) High	**a) High** **b) Medium** **c) Medium** **d) Low** **e) Low**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Cultivated Crops	Provisioning	• In Paradise, approximately 10 families utilize land along the coastal wall for crops and subsistence farming. There are very few other places/lands where they could cultivate crops.	Cultivated lands	Local communities (general population)	High	Low	**Critical**
Livestock farming	Provisioning	• Along the sea defense walls, approximately seven households utilize the land for grazing, primarily cows, for livelihoods in St. Andrews and Perth to Dartmouth. • Cows, sheep, and goats are grated in the Evergreen to La Resource area	Pasturelands	a) Local communities (general population) in St. Andrews and Perth to Dartmouth b) Local communities in Evergreen to La Resource	a) Low b) High	a) High b) Moderate	**a) Low** **b) High**
Tourism and recreation	Cultural	• Locals utilize Paradise Beach and Andrews area (approximately 10-15 people a day at each location) for recreation, kite flying, etc. • Approximately 50 users per day are at the seawall along the southern portion of the NDC. • Unity Park is also used for recreation although few people utilize this over the seawalls. • Recreation at the Dartmouth Seawall especially on Sundays when dominoes are played.	Coastal and Marine	a) Local communities in northern portion of coastal NDC; Unity Park users b) Local communities in southern portion of NDC **ES Linkages:** Sea Defense	a) Low b) Moderate	a) Moderate b) Moderate	**a) Low** **b) Medium**
Cultural, spiritual or religious value	Cultural	• The seashore areas at Paradise, Jib, Andrews, and Bounty Hall are used for religious activities. • Residents of Westbury and Perth use the seashore in Dartmouth. • Burial ground at Jib.	Coastal	a) Local Hindu communities along coastal areas from Bounty Hall to Dartmouth b) Local communities for burial at Jib c) Local Hindu communities at Paradise	a) High b) Low c) High	a) High b) Low c) High	**a) Medium** **b) Low** **c) Medium**
Food: wild meat	Provisioning	• Residents of the NDC hunt iguanas in the La Resource area for sustenance or but sometimes for sale. The iguanas are sold in the NDC or at popular restaurants in the region. Shore birds are also caught for both sustenance and sale. Some persons hunt large lizards (salipenters) for meat. • Anacondas are also caught for sale to traders.	Mangroves	Local communities	Low	Moderate	**Low**
NDC 3 - Aberdeen/Zorg-en-Vlygt – Population estimate 6,000 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are approximately 15 boats and 40 families engaged in fishing in the NDC. These boats use landing sites at La Union, Three Friends and Capoey Koker depending on the accessibility of these sites. • An average of 2-3 fisherfolk work on each boat every 2-3 days.	a) Marine environment; beach; Kokers b) Coastal areas	a) Commercial fishing at Capoey Koker, including crabbers b) Fishing landing site in La Union c) Fishing landing site in Three Friends	a) High b) Low c) Low	a) Moderate b) Moderate c) Moderate	**a) High** **b) Low** **c) Low**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
	Provisioning	• Crabs are caught daily throughout the NDC for subsistence and commercial use. They are sold to persons both within and outside the NDC.	Mangroves	Crabbing for subsistence and commercial use	High	High	**Medium**
Livestock farming	Provisioning	• Along the sea defense walls, approximately 15-20 households utilize the land for grazing, primarily goats and cows, for livelihoods; • There is a cattle rearing camp at the seashore at Hoff-Van-Aurich and La Union.	Pasturelands	a) Local communities (general population) from Aberdeen to Affiance b) Local communities in/around Hoff-Van-Aurich and La Union	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Shoreline protection / Mangroves / River defense	Regulating	• Mangroves have been growing in the NDC naturally with the buildup of mud and silt over the last 1.5 years. Mangroves are also growing near Bacchus Park. The new growth has resulted in iguanas, crabs, and new species of birds in the area. However, mangroves are also being degraded in some areas.	Ocean, mud flat	a) Coastal Communities (general population) of the NDC b) Coastal communities near Bacchus Park	a) High b) Moderate	a) Moderate b) Low	**a) High** **b) High**
Shoreline protection / Mangroves / River defense	Regulating	• Government has installed bamboo groynes at Columbia, Aberdeen, and Affiance which are helping to protect the shoreline and reduce erosion along the coast of these areas.	Ocean, mud flat	Coastal communities	High	Moderate	**High**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the coastal areas but typically mudflats prevent significant usage in the area • Cremation site at La Union is the only sanctioned site in the Region	Coastal areas; ocean	a) Local Hindu population b) Hindu population throughout Region 2 use the Cremation Site	a) Low b) Critical	a) High b) Critical	**a) Low** **b) Critical**
Recreation	Cultural	• Bacchus Park and the seawall both provide recreation on a daily basis for over 100 people; more active on weekends and holidays. • Many persons use the sea walls in Queenstown for recreation purposes.	Seawall	a) Local communities utilizing the seawall at Bacchus Park b) Local communities using the seawalls in Queenstown	a) Moderate b) Moderate	a) Low b) Moderate	**a) High** **b) Medium**
Food (wild meat)	Provisioning	• Iguanas are hunted in the fish pond areas by a small group of men who sell the meat on the market • Approximately 60–70 persons hunt iguanas daily for sale at prices ranging from GYD$3,000–5,000. Currently, there is no hunting of wild birds.	Biodiversity Mangroves	a) Local community in Zorg-en-Vlygt b) Local communities through the NDC	a) Low b) High	a) Low b) Moderate	**a) Medium** **b) High**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 4 - Anna Regina Town Council – Population estimate 19,000 people							
Mangroves & Carbon Sequestration	Regulating	• The mangroves grow naturally on the newly deposited mudflats, regulating man natural factors; they contribute to pollination of crops and add to carbon sequestration; they also cause nuisance such as bird singing at night, mosquitoes and sand flies (for first time in 20 years); • NAREI program in Reliance started a few years ago has been welcome and in some areas (near Lima Port) the importance to stakeholders is expected to grow over time.	Mangroves	a) Local community b) Local communities near new plantings **ES Linkages:** Fishing, Crabbing, biodiversity	a) High b) Low	a) High a) High	**a) Medium** **b) Low**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are several fishing landing sites in the municipality, including Anna Regina (15 boats); Windsor Castle (3 owners); Lima (6 owners); Walton Hall (10–12 boats); Lima (10–12 boats); Hampton Court (20 boats); Sparta (15 boats). • There is subsistence fishing at other locations, but on a small scale.	Marine environment; beach; mooring locations	Commercial fishing at coastal areas	High	Moderate	**High**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the coastal areas where they can get access	Coastal areas; ocean	Hindu population mainly	Low	High	**Low**
Tourism and recreation	Cultural	• Approximately 10 to 20 users per day are at the seawall for recreation • More than 50 persons visit the Henrietta Hotel on a daily basis for recreation. Softball cricket matches are also played on the beach behind the hotel.	Coastal	Local communities **ES Linkages:** Sea Defense	High	Moderate	**High**
Agriculture Cultivated Crops	Provisioning	• Farmers utilize land along the river defense wall for subsistence farming at Lima, Walton Hall, Anna Regina, and Devonshire Castle. Crops include coconuts, bananas, plantains, and cash crops are planted. • Areas near Lima Port are popular for rice paddies.	Cultivated lands	a) Local communities (general population) b) Local community near Lima Port	a) High b) Low	a) Low b) High	**a) Critical** **b) Low**
Livestock Farming	Provisioning	• Areas near Lima Port are popular for grazing.		Local community near Lima Port	Low	High	**Low**
NDC 5 - Annandale/Riverstown – Population estimate 9,400 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are fishing landing sites at: Golden Fleece (2 boats), Zorg (5 boats), Adventure (2 boats), Riverstown (1 boat), and Abrams Zuil with 20 boats including 2 new anchor seine boats.	Marine environment; beach; mooring locations	a) Commercial fishing at Adventure b) Commercial fishing at Golden Fleece c) Commercial fishing at Zorg d) Commercial fishing at Riverstown e) Commercial fishing and anchor seine fishing at Abraham Zuil	a) Low b) Low c) Moderate d) Low e) Essential	a) High b) High c) High d) High e) Moderate	**a) Low** **b) Low** **c) Low** **d) Low** **e) Critical**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Livestock farming	Provisioning	• Along the sea defense walls at Golden Fleece, some households utilize the land for grazing, cows goats and sheep	Pasturelands	Local communities (general population)	High	Moderate	**Medium**
Cultural, religious, or spiritual value	Cultural	• Hindus conduct religious activities along beach primarily at Golden Fleece where there is also a temple nearby; • Cullen Beach also very popular	Coastal areas; ocean	a) Hindu population throughout the NDC b) Hindu population at Cullen Beach	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Tourism and Recreation	Cultural	• More than 50 persons used seawalls for recreation purposes at Perseverance, Golden Fleece, Cullen Beach, and Suddie where there are cricket matches, football matches, and bar-be-ques on weekends.	Coastal areas	General population	High	Moderate	**High**
Aquatic transportation/ports	Provisioning	• Main port is essential for access to other areas, including the islands; the ferry used to dock here but it is now used for businesses and trade. • Big Pier, located in Abrams Zuil, is another commercial port where fuel, goods, cattle, etc., are transported.	Commercial areas at Port	a) Residents, local businessmen and islanders, farmers, fisherfolk, tourists who utilize the main port b) Residents, local businessmen, farmers, fisherfolk who utilize the Big Pier area	a) Essential b) High	a) Moderate b) Low	**a) Critical** **b) Critical**
NDC 6 - Good Hope/Pomona – Population estimate 1,500 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are fishing landing sites at: Pomona with 10–12 boats, Riverside Creek with 10–12 boats, Riverstown with 6 boats, and Vilvoordeen with 15 boats. Fishing boats also occasionally land at the Supenaam port. • Families who live close to the seashore often engage in near shore fishing and have their own small boats to conduct fishing activities. There are two boats at Good Hope which are used for this type of fishing. • Fishing is popular along the coasts at Tiger Island and in the Essequibo River using hooks, seines, and gillnets for catching high water; catfish; shrimp. Riverside fishing is also popular due to wharves.	Marine environment; wharf; mooring locations	a) Commercial fishing at Riverside b) Commercial fishing at Vilvoordeen c) Commercial fishing at Pomona and Riverstown d) Fishing at Tiger Island and Essequibo River	a) Moderate b) High c) Essential d) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Medium** **b) High** **c) High** **d) Medium**
		• Crabbing is popular during the July to September crabbing season.	Marine habitats and Mangrove Forests	Crabbing along the coasts of the NDC	Low	High	**Low**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Aquatic transportation/ports	Provisioning	• There are several wharfs in the NDC: three wharfs in Fairfield, one wharf in Good Hope, one wharf in Spring Garden, one wharf in Vilvoordeen and one wharf in Riverstown. These are essential to commercial business and livelihoods; cargo unloading area for fertilizer; gas plant equipment; quarry material; rice; cattle • Supenaam port is a major area for passenger transport and shipment with over 100 boats	Commercial areas on wharf	Residents, local businessmen and islanders, farmers, fisherfolk, tourists at: a) Fairfield b) Vilvoordeen c) Supenaam	a) Essential b) Essential c) Essential	a) Moderate b) Moderate c) Low	**a) Critical** **b) Critical** **c) Critical**
Social/Economic Commercial activity	Provisioning	• Sawmills utilize river defense area to transport logs to the mill	Commercial areas	Residents, local businessmen	Moderate	Moderate	**Medium**
Erosion Regulation	Regulating	• Tiger Island is a critical sea defense from the NDC to erosion and flooding since there is no manmade or natural mangroves protecting the coast	Coastal vegetation	Local businesses at Sawmill and Aurora	Essential	Low	**Critical**
Historical landmark	Cultural	• Dutch Chimney is an important landmark in Supenaam	Tourism	Tourists, Residents	Low	Low	**Medium**
Livestock farming	Provisioning	• There is grazing of animals along the seashore from Riverstown Creek throughout the NDC in vacant areas.	Pasturelands	Local communities (general population)	Moderate	High	**Low**
Cultivated Crops	Provisioning	• Large scale cash crop farming on Tiger Island.	Cultivated lands	Local communities	Essential	Low	**Critical**
Food (wild meat)	Provisioning	• Iguanas are hunted on Tiger Island as well as on the southern coast of the NDC within and outside the NDC area.	Biodiversity	Local community	Low	Low	**Medium**
Tourism and Recreation	Cultural	• Beaches are used for recreation purposes at Vilvoordeen, Aurora, Spring Garden, Good Hope, and Tiger Island.	Beaches	a) Local communities on Essequibo Coast b) Visitors to Tiger Island	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Cultural, Religious of Spiritual Value	Cultural	• There are religious activities on the seashore through the NDC. • The Spring Garden temple is located close to the shoreline.	Beaches, shoreline	Local communities who utilize the seashore and temple	Moderate	Moderate	**Medium**

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APPENDIX D

Identified Ecosystem Services and Priority Ratings: Region 3 Coastal

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TABLE D-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 3 COASTAL

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 07 – Wakenaam - Population 3,200 – on the decrease due to migration							
Food - aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fishing is done on both sides of the Island. Some boats are owned by persons from the Island while others come from the West Coast of Demerara. The fishing area is also shared with residents of Leguan. Approximately 20-30 boats and 40-60 commercial fisherfolk operate on the island fishing a few days per week. Many families on the island depend on fishing for sustenance and livelihoods. • Shrimp is dried on the sea defense by fisherfolk in the shrimp season occurring during the months of April to September. Shrimp mainly caught between Leguan and Wakenaam • Crabs are caught during the July to September period by many residents and by approximately 5 persons all year round in the mangroves abundant on the island.	Marine habitat, river habitat, mangrove forests and sea defense	a) Commercial fishing at mouth of Essequibo River b) Commercial and subsistence fishing along the coast and in mangroves c) Commercial fishing in the Essequibo River d) Crabbing in mangroves e) Drying of shrimp on sea defenses	a) Essential b) High c) High d) Moderate e) Moderate	a) Moderate b) Moderate c) Low d) High e) High	**a) Critical** **b) High** **c) Critical** **d) Low** **e) Low**
Agriculture - Cultivated Crops	Provisioning	• There is some planting on the sea defense reserves mainly by persons who have done their own empoldering and consider the lands their responsibility to maintain and farm. Islanders also farm on the other islands in the Essequibo River including Tiger Island, Hogg Island, Truli Island, and Karia. • The dominant crop on Wakenaam is plantains. • Rice is also farmed for both commercial and subsistence use. • There are more than 100 families who farm along the river dam bordering their land.	Cultivated lands	Local communities (general population)	Essential	Moderate	**Critical**
Livestock Grazing	Provisioning	• Along the river defense, households utilize the land for grazing of cows, goats, and sheep for livelihood. Animals are tied in the farming areas or graze freely in Palmyra, Zeelandia, or New Friendship.	River defense and mangroves	Local communities (general population)	Medium	Medium	**Medium**
Transportation - Ports, Wharf, Ferry Stelling	Provisioning	• Ports, wharfs, and shipyards, inclusive of boat building, on the river dam. Over 22 ships seen in dock at the wharfs. Farmers have their own boats to carry supplies and produce. • Wharf essential for access to the island. • Sawmill utilize river defense area to transport logs to the mill.	Commercial areas on river dam	Residents, local businessmen and islanders, farmers, fisherfolk, tourists	Essential	Medium	**Critical**
Religious/Ritual	Cultural	• Areas with good access to the river used by the Hindu population for daily and seasonal worship. There are many locations for use with a few more established sites, including a temple.	River, river defense	Hindu population	Moderate	Low	**High**
Food: wild meat and Materials	Provisioning	• Within certain mangrove areas, there are a few men who hunt birds and iguanas, “labba” and crabs to sell on the island or over at Parika. • In the July to September period while it is dry, iguanas are out and are caught for fun or meat. • Bamboo growing along the river defense is harvested for a variety of uses such as religious, construction material for sheds, fishing poles and in farming.	Mangroves coconuts and bamboo	Local communities (general population) near Charity	Low	High	**Low**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Freshwater – Household use	Provisioning	• Households use the freshwater for many household purposes including animal husbandry and gardening.	Freshwater	Local communities on the island	High	Moderate	**High**
Freshwater – Crop irrigation and other agricultural uses	Provisioning	• The entire island depends on freshwater from the Essequibo River for its irrigation of rice paddies and other crops during the dry season. • Animals also drink the water that flows in the irrigation channels. • Freshwater intake contributes to inland fishery whereby tilapia and hassar are caught in the wild for sale and subsistence use.	Freshwater	Island farming community	Essential	Moderate	**Critical**
Recreational	Cultural	• Beaches to the north of the island are utilized for recreational purpose by residents and visitors	Beaches and mangroves	a) Beach at Maria's Pleasure b) Beach at Wakenaam Point	a) Medium b) Moderate	a) Medium b) High	**a) Medium** **b) Low**
Mangroves & Carbon Sequestration	Regulating	• The mangroves grow naturally on the island, regulating many natural factors, contributing to pollination of crops and adding to carbon sequestration.	Mangroves	Local community **ES Linkages**: Fishing, Crabbing, Biodiversity	Moderate	High	**Low**
Aquatic transportation/ports	Provisioning	• Commercial wharf at San Sousi for transport of fuels, rice, and other products that are shipped or imported to the island. Ferry also lands at San Sousi. • Speedboat landing site at Maria's Pleasure. Speed boats to Parika and Leguan operate from this location. Six boats operate this route charging 1000 for a trip per passenger.	Sea shore, shoreline	a) Wharf at San Sousi b) Speedboat landing at Maria's Pleasure	a) Essential b) High	a)Low b) Moderate	**a)Critical** **b) High**
NDC 08 – Leguan - Population 2,500 – decreasing due to migration to Region 3 and North America.							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Approximately 25 fishing boats catch fish and shrimp using areas such as Waterloo, Success, Canefield, and other areas where they can dock their boats. • Shrimp mainly caught between Leguan and Wakenaam. • Crab fishing is common during the summer crab season with 2-3 people making a daily catch for sale.	Marine environment; beaches; kokers and mangroves	a) Commercial fishing at Waterloo, Success and Canefield b) Commercial and subsistence fishing in Essequibo River c) Commercial and subsistence crabbing in mangroves	a) High b) High c) Low	a) Moderate b) Moderate c) High	**a) High** **b) High** **c) Low**
Transportation and Commercial Services	Provisioning	• Approximately 20 boats offer transportation services to Parika and other areas. Most islanders have their own boat. The ferry at Enterprise offers three services daily to Parika. • Commercial wharfs and loading sites are used for shipping fuel and produce. • A new wharf was constructed at Belfield which facilitates shipping of construction materials.	River & river defense dam	a) Transportation Services b) Commercial wharfs on the island	a) Essential b) High	a) Moderate b) Low	**a) Critical** **b) Critical**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the river and on the river defense. Areas with good access to the river are preferred. There are many locations for use, with a few more established sites. • Cremation at Uniform is conducted on one of the beaches on the island.	River & river dam	a) Hindu population using the cremation site at Uniform b) Hindu religious activities along the river and river defense at Blenheim	a) Essential b) Essential	a) Moderate b) Moderate	**a) Critical** **b) Critical**
Cultivated Crops	Provisioning	• Farmers utilize land along the river defense wall for crops and subsistence farming. Coconuts, bananas, plantains, and cash crops are planted.	Cultivated lands	Local communities (general population) cultivating crops at: a) Richmond Hill b) Success	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Irrigation Water	Provisioning	• The entire island depends on freshwater from the Essequibo River for its irrigation of rice paddies and other crops during the dry season. • Animals also drink the water that flows in the irrigation channels.	Essequibo River	Crops and livestock farmers	Essential	High	**High**
Livestock Grazing	Provisioning	• Households utilize the land Better Hope to La Resource for grazing of cows, goats, and sheep for livelihood • Grazing has been constrained by the river defense works at Maryville, Success, and Thieres.	River defense and Mangroves	Local communities (general population)	Medium	Medium	**Medium**
Tourism and Recreation	Cultural	• Locals utilize Canefield Beach, Success Beach (approximately 10-15 people a day at each location) for recreation, swimming, etc. • Organized tours are done to Leguan to tour its historic sites including St. Peters Church	River, Coastal and Marine	Local communities in northern portion of NDC and tourists: a) Beach at Uniform b) Heritage Site at St. Peter's Church c) Beach at Canefield	a) Moderate b) Essential c) Moderate	a) Moderate b) Low c) Moderate	**a) Medium** **b) Critical** **c) Medium**
Habitat provision, coastal protection	Supporting	• The island has a large area covered by mangroves with rich biodiversity of birds and crabs.	Coastal Mangroves	Local communities	Low	High	**Low**
Food (wild meat)	Provisioning	• Iguanas, capybara, labba, and wild hogs are hunted in the cultivated areas. Wild ducks will visit this area in the planting season to feed on the rice paddies.	Biodiversity	Local residents, Region 3, wild meat tourism	Low	Moderate	**Low**
Cultural Practices	Cultural	• Hunting, harvesting and fishing continue to be practiced in some traditional fashion including the local craft made to hunt or fish.	Cultural Heritage	Local communities **ES Linkages:** Possibility for sport tourism	Low	Moderate	**Low**
Erosion Regulation	Regulating	• The island is at risk to erosion and much of the shore is not protected by manmade concrete defense. The mangroves and other vegetation help to defend the island against erosion.	Coastal vegetation	Local communities **ES Linkages:** Biodiversity, Fishing, hunting, socioeconomic	Essential	Low	**Critical**
NDC 09 - Mora/Parika - Population 10,000, growing due to migration to the NDC							
Transportation and Commercial Services	Provisioning	• Parika stelling has transportation services by ferry to Supenaam, Leguan, Bartica, and Wakenaam. Hundreds of people travel daily. • Over 100 passenger boats leave for various destinations daily to other parts of the country. • Ten private wharves facilitate transportation services daily. • There are seven boat houses in the NDC with two parking lots for vehicles. • Ship terminal serving as a hub for timber, stone, fuel and river transportation at the Parika koker. • This NDC is significantly reliant on marine transport services and related economic activities.	River	a) Parika Stelling users by ferry and boats from Regions 2, 3 and Essequibo Islands b) Local users of private wharfs c) Private docking and landing sites for passenger travel d) Parika Koker **ES Linkages:** Tourism, recreation and socioeconomic	a) Essential b) Essential c) Essential d) Essential	a) Low b) Moderate c) Moderate d) Low	**a) Critical** **b) Critical** **c) Critical** **d) Critical**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fisheries wharf, where more than 20 boats load, refuel, and discharge catch. • Outfall area, where more than 10 boats operate • Big Kiss wharf, where more than 10 deep water vessels operate	River	Fisherfolk using landing sites at: a) Parika Stelling b) Parika Outfall c) Big Kiss Wharf	a) Essential b) Essential c) High	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) Critical** **c) High**
Religious/ Ritual	Cultural	• Big Kiss has a temple on the river dam for worship activities for the general public.	River dam	a) Local Hindu Community using Big Kiss	a) Essential b) Moderate	a) High b) Moderate	**a) High** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Religious activities along the river defense. • The religious activities are about the same with the Hanuman Murti being a new feature at the riverside of the NDC		b) Local Hindu community using other sites			
Cultivated Crops	Provisioning	• Crops cultivated along the sea dam including, bananas, coconuts and fruits	River dam, mangroves and bamboos	Local Community	Low	High	**Low**
Livestock Farming	Provisioning	• Grazing of goats and cows in the Namryk – Hyde Park area of > 100 animals	River dam, mangroves and bamboos	Local communities	Medium	Medium	**Medium**
Social/Economics	Provisioning	• 10 saw mills in the NDC with access to the river dam where logs are discharged and processed • Boat building, boat docking and landing area	River dam	a) Local sawmillers and forest sector stakeholders using the river dam b) Local boat builders	a) Essential b) Essential	a) Moderate b) High	**a) Critical** **b) High**
Biodiversity Reserve	Supporting	• Locals protect two small islands that are roosting areas for hundreds of birds including scarlet ibis and wild ducks in the Essequibo River. The birds are not hunted due to the actions of the community.	Biodiversity, Culture	Biodiversity, local community **ES Linkages:** Tourism	Essential	Moderate	**Critical**
Freshwater – Household use	Provisioning	• Hundreds of residents squat in more than 200 buildings on the shore and along the sea defense reserves. They use the fresh water from the river for household purposes.	Freshwater	Local communities	Essential	High	**High**
Social/Housing	Provisioning	• Approximately 50 houses are squeezed into the sea defense and shore area.	Shoreline, beach, river defense reserves	Local communities **ES Linkages:** Freshwater, fishing	High	Moderate	**High**
Tourism and Recreation	Cultural	• Recreation for residents of the NDC and the region. Private developer charges a user fee for entrance to the area.	Shoreline	Local communities	Moderate	Moderate	**Medium**
NDC 10 - Hydronie/Good Hope - Population 4,000 and increasing.							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing at Ruby Koker with 10-15 boats daily with 2/3 mainly focusing on fish. • A few fishing boats also operate from the Orangestein Shore • Fishing along the shore line by nets, seine, lines	River, Ocean	a) Local communities and fisherfolk at Ruby Koker b) Fisherfolk along Orangestein Shore and other fisherfolk fishing along the shoreline	a) Essential b) Moderate	a) High b) Moderate	**a) High** **b) Medium**
Recreation	Cultural	• The Bushy Park Beach is a popular tourist attraction for locals and people from other parts of the country, with approximately 50 people visiting daily and hundreds on weekends and special occasions. • Orangestein Beach where people living in close proximity frequent.	River, Beach	Local communities, Regions 3 and 4 at Bushy Park and Orangestein beach	Essential	Low	**Critical**
Agriculture: Grazing and Crops	Provisioning	• Cattle and goats graze in the Ledestein–Good Hope area. • People in Orangestein graze cows on the sea dam.	Sea Dam, Vegetation	a) Local communities at Ledesteine-Good Hope b) Local communities at Orangestein	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Religious	Cultural	• Religious activities at Ruby Koker and Bushy Park. Mosque at Ruby Koker. • People living along the river dam use the beach for Hindu religious activities • Burial Ground at Farm	Sea dam, beach	a) Local communities at Ruby Koker and Bushy Park and Hindu communities using the sea dam b) Burial Ground	a) Essential b) High	a) High b) Low	**a) High** **b) Critical**
Social/Economic Commercial activity	Provisioning	• Industrial activity at Bushy Park by KARES Engineering	Sea Dam, beach	Commercial activity for Region 3 and 4 and local businesses at:	a) High b) Essential	a) High b) Low	**a) High** **b) Critical**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Two new wharves were established at Orangestein. Wharf supporting sea going vessels at Bushy Park, including ship repairs • Boat building and repairs on the seadam		a) Kares Engineering b) Wharf users c) Boat builders	c) Moderate	c) High	**c) Low**
Food (Wild Meat)	Provisioning	• A few people catch iguanas on a regular basis for sale in the area.	Sea dam vegetation	Local communities	Low	Moderate	**Low**
Biomass for Livestock	Provisioning	• Animals grazing on the sea dam, mangrove blossoms, bamboo shoots, grass, etc.	Sea dam vegetation	Local residents in proximity to vegetation	Moderate	Moderate	**Medium**
NDC 11 – Greenwich Park/Vergenoegen – Population – 2,500 people							
Food: Fishing, shrimp, crabs	Provisioning	• Vergenoegen Outfall and Philadelphia Koker, with more than 20 boats • Greenwich Park, with seven boats • Shrimp drying along concreted sea defense • 10–15 persons in the NDC dry fish for sale on a large scale of whom four have permission from the NDC • Some fisherfolk use the fishing grounds at Barnwell	Seashore, river, ocean, mangroves River defense	Local communities, Region 3 using: a) Vergenoegen Outfall and Philadelphia Koker b) Greenwich Park c) Shrimp and fish drying on the seawall d) Fishing grounds in Barnwell	a) Essential b) High c) High d) Low	a) Low b) Moderate c) High d) Moderate	**a) Critical** **b) High** **c) Medium** **d) Low**
Recreation	Provisioning	• Vergenoegen Seawall, which 10-20 people use daily to exercise, relax or socialize • Philadelphia Seawall, which 10-20 people use daily for recreation • Low tide beach at Philadelphia utilized for games such as cricket.	River defense	Local Communities using Vergenoegen and Philadelphia Seawalls	a) High	a) Moderate	**a) High**
Religious	Cultural	• Barnwell with access to the river. • Philadelphia with access and temple next to the river. • Religious activities also conducted at Greenwich Park	River bank	Mainly local Hindu community using Barnwell access, and Philadelphia access and temple	High	Moderate	**High**
Cultivated Crops	Provisioning	• Cash crops and fruits planted along the river defense reserves. Some gardens are fenced off.	River defense reserves	Local communities	Essential	High	**High**
Squatting	Provisioning	• Informal housing at Barnwell with over a dozen houses with 30-50 people in total.	Sea defense	Local communities	High	High	**High**
Biomass for livestock	Provisioning	• Grazing occurs on the natural vegetation by a reported >200 animals in the NDC. At Greenwich Park and Barnwell the dam is completely blocked off by the residents.	Natural vegetation	Local residents in proximity to grazing	Moderate	Moderate	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the river and its bank, are highly valued by local communities and visitors.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
NDC 12 – Tuschen/Uitvlugt - Population in excess of 30,000 due to the growing Tuschen Housing Scheme							
Food: Fishing, shrimp, crabs	Provisioning	• Zeeburg Seawall, with 30-50 fish/shrimp boats • Boeraserie Koker, with 20 boats • Uitvlugt Seawall, with 15-20 boats • Zeelugt Seawall, 25 boats • In addition, large scale shrimp processing occurs at Zeeburg with large scale fish processing occurring in Zeelugt, all on the sea walls or sea defense reserves.	Seashore, river & ocean	Fisherfolk, Region 3 using: a) Zeeburg seawall b) Boeraserie Koker c) Uitvlugt Seawall d) Zeelugt Seawall	a) Essential b) Essential c) Essential d) Essential	a) Moderate b) Moderate c) High d) Moderate	**a) Critical** **b) Critical** **c) High** **d) Critical**
Tourism and Recreation	Cultural	• Cinderella Park at Zeelugt is used by 10-20 people daily and >100 on weekends • Ocean View, Uitvlugt has approximately 20 people daily	Seawall, sea defense reserves	Local communities, Region 3 using: a) Cinderella Park b) Ocean View	a) High b) Moderate c) Low	a) Moderate b) Moderate c) High	**a) High** **b) Medium** **c) Low**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Kastev has about 10 people visiting daily		c) Kastev			
Religious/Ritual	Cultural	• Temple on the sea defense reserves at Uitvlugt. In addition, religious activities are held at the sea throughout the NDC	Seawall reserves, shore, beach	Local Communities, Region 3, 4 using the Uitvlugt Temple and coastal areas	Essential	High	**High**
Crop Cultivation	Provisioning	• Crops and fruits planted in Zeelugt and in Uitvlugt	Seawall reserves	Local Communities planting	Moderate	High	**Low**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC. The open areas are limited due to cash crop farming on the sea defense reserves in Zeelugt, Meten-meer-zorg, and De Willem. It is also affected by the shrimp and fish processers.	Seashore	Local communities grazing animals	High	Moderate	**High**
Social/Economic	Provisioning	• Fish Processing at Zeelugt and Uitvlugt • Shrimp Processing at Zeeburg and Uitvlugt, with 1kg selling for GYD$1,600	Seawall & reserves	a) Fish processors b) Shrimp processors	a) Moderate b) Essential	a) High b) Moderate	**a) Low** **b) Critical**
Coastal Protection	Supporting	• The concrete sea defense is supported by natural vegetation including mangroves, coconuts, fruits, and some cash crop plots.	Sea defense & reserves	Coastal region	High	Low	**Critical**
Social/ Housing	Provisioning	• Informal housing of about on the sea dam and beyond on the sea defense reserves. The persons use the sea water and also dump their refuse in the sea.	Sea defense & reserves	Coastal region	High	High	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore, are highly valued by local communities and visitors.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
NDC 13 - Stewartville/Cornelia Ida – Population – 30,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing boat landing area at Leonora used by 15 boats that catch fish and shrimp. • Fishing area at Anna Catherina used by 8 boats. • Landing site at Corneila Ida with 3 boats.	Seashore and ocean	Fisherfolk using landing sites at: a) Leonara b) Anna Catherina c) Cornelia Ida	a) Essential b) High c) Moderate	a) Low b) Moderate c) High	**a) Critical** **b) High** **c) Low**
Recreation	Cultural	• Stewartville seawalls are used by almost 20 people daily. • Leonora seawall is used by 10-20 people daily. • Anna Catherina seawall is used by more than 20 people daily, with >100 on weekends.	Seawall, beach	Local communities using seawalls: a) Stewartville and Leonora; b) Anna Catherina c) Groenveldt	a) Moderate b) High c) Moderate	a) High b) Moderate c) Moderate	**a) Low** **b) High** **c) Medium**
Religious	Cultural	• Stewartville seawalls are used by < 10 people daily. • Leonora seawall is used by < 10 people daily. • Anna Catherina seawall is used by more than 10 people daily. • Cornelia Ida Seawall and reserves are used by >20 people daily. A temple is located at this site.	Seawall, beach, reserves	Local Communities, Region 3 using seawalls for religious practices at: a) Stewartville, Leonora, Anna Catherina; b) Cornelia Ida	a) Moderate b) High	a) High b) Moderate	**a) Low** **b) High**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC with cows, goats, and sheep numbering 200-300. • Some people keep ducks and pigs on the sea defense reserves using the fish for food.	Sea defense reserves	Local communities: a) Stewartville b) Anna Catherina b) Leonora	a) Moderate b) Moderate c) High	a) High b) Moderate c) High	**a) Low** **b) Medium** **c) Medium**
Crop Cultivation	Provisioning	• A few people plant on the sea defense reserves at Leonora. Squatters plant fruits and crops at Anna Catherina.	Sea defense reserves	Local communities	Low	High	**Low**
Social/Housing	Provisioning	• Squatting at Anna Catherina sea defense reserves by 15-20 families.	Sea defense and reserves	Local Communities	High	High	**High**
Social/Economic (Shrimp Processing)	Provisioning	• Large scale fish and shrimp processing occurs at Leonora with large scale shrimp processing occurring in Anna	Sea wall	Local communities	Essential	Moderate	**Critical**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		Catherina, all on the sea walls or sea defense reserves. Some persons have built their own drying floors and storage facility on the sea defense reserves.					
Coastal Protection	Supporting	• The concrete seawall/defense is supported by natural vegetation including mangroves, coconuts, fruits, and some cash crop plots.	Sea defense and reserves	Coastal region	High	Low	**Critical**
Biodiversity	Regulating	• A small area on the shore with mangroves is occupied by birds for roosting. Fishes and crabs are found in the water below where people fish.	Sea defense and reserves	Local communities **ES Linkages:** Tourism	Low	Moderate	**Low**
NDC 14 - Hague/Blankenburg - Population - 4,200 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing boat landing area at Hague seawall used by 10-12 boats. There is a reduction in the number of boats due to the ban on catfish in the USA and also fears of piracy. • About 10-20 persons use hooks, lines, seines, cast nets, or use fishing rods to catch fish and shrimp on a daily basis at Den Amstel and Blankenburg.	Seawall, seashore	a) Local communities, Region 3 b) Landing site at Hague and fishing by hooks, lines, seines and caste nets at Den Amstel and Blankenburg	a) High b) Moderate	a)Low b) Moderate	**a) Critical** **b) Medium**
Recreation	Cultural	• Den Amstel seawall with > 20 people using the area on a daily basis to swim, relax, exercise, and socialize and about 200 persons on weekends. • Hague seawall is used by <10 people daily. • A small beach which is utilized for sports such as cricke.t	Seawall, beach, shore	Local communities using the seawall at: a) Den Amstel b) Blankenburg **ES Linkages:** Tourism	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Religious	Cultural	• Religious activities at Hague seashore. • Religious activities at Blankenburg sea dam. • Cemetery at Blankenburg with historical significance.	Beach, sea shore	Local communities	a) Moderate b) Essential Moderate	b)High b) Moderate c) Moderate	**a) Low** **b) Critical** **c) Medium**
Agriculture/Grazing	Provisioning	• Grazing at Hague of cows, horses, and goats. • Grazing of > 100 goats at Blankenburg. • Grazing of cows and goats at Den Amstel.	Sea dam, reserves, mangroves	Local communities: a) Grazing at Hague and Den Amstel; b) Grazing at Blankenburg	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
NDC 15 - La Jalousie/Nouvelle Flanders - Population - 4,480 people							
Food: Fishing, shrimp, crabs	Provisioning	• Twenty boats use the Windsor Forest Koker to dock and some fisherfolk sell their fish in that area. • There are three fish mongers selling the prized catfish (gillbacker) by the Windsor Forest koker on a daily basis.	Seashore, ocean and rivers	Local Communities	Essential	Moderate	**Critical**
Recreation	Cultural	• Windsor Forest seawall frequented by approximately 30 people daily and 100 on weekends. The previously existing beach is now completely eroded. • Recreation area and bar on the sea dam in La Jalousie has more than 20 visitors daily	Seawall, beach	Local Communities using: a) The Windsor Forest Seawall b) Recreation area and bar at La Jalousie sea dam	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Religious	Cultural	• Religious activity at La Jalousie with tent in place for worshipers. • Religious activities at Windsor Forest • Cremation site at Ruimzeigt utilized daily	Sea shore, sea dam, reserves	Local Communities, Region 3, 4 using religious sites at: a) La Jalouise b) Windsor Forest c) Ruimzeigt	a) High b) Low c) Essential	a) Moderate b) High c) Moderate	**a) High** **b) Low** **c) Critical**
Agriculture/Grazing	Provisioning	• Grazing occurs along the sea defense reserve from La Jalousie – Waller's Delight and Crane. However, it is not a significant activity.	Sea defense reserves	Local Communities in: a) La Jalousie to Waller's Delight b) Crane	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Tourism and Recreation/ Religious	Cultural	• New beach forming at Harlem	Sea shore	Local community	Low	Moderate	**Low**
NDC 16 - Best Klien/Pouderoyen – Population - 20,300 people							
Social/Economic: Transportation, Wharfs	Provisioning	• Transport Wharf, GPL Wharf, Sawmill • Speedboat stelling, with 75 speed boats registered to work at the crossing between Georgetown and Vreed en Hoop with fifty three (53) working on a daily basis.	River, river dam, reserves	Local Communities, Regions 3,4	Essential	Moderate	**Critical**
Food: Fishing, shrimp, crabs	Provisioning	• There are 11 fishing boats working in the NDC docking at Vreed en Hoop, Phoenix Park and the Jetty. • Mainly near shore fishing done in both the Demerara River and Atlantic Ocean. • Approximately five people catch crabs on a weekly basis for sale in the community. More persons join in the crab season.	Seashore, river and ocean	Fisherfolk operating from: a) Vreed-en-Hoop b) Phoenix Park c) Nearshore	a) Moderate b) High b) Low	a) High b) High b) Moderate	**a) Low** **b) Medium** **b) Low**
Mangroves	Provisioning	• Mangrove growth at Crane, Best Village, Vreed-en-Hoop, and Pouderoyen. Mangrove spread is increasing. • Lots of wildlife within mangroves including several species of birds, monkeys, raccoons, wild ducks, etc.	Mangroves	Local Communities: a) Plastic City b) Pouderoyen	a) Essential b) Low	a) Low b) Moderate	**a) Critical** **b) Low**
Grazing	Provisioning	• Grazing at Crane, Pouderoyen, and Best Villages by locals and squatters. Cows are tied and goats and sheep allowed to roam freely on the sea dam.	Sea dam, mangroves	Local Communities: a) Phoenix Park; Pouderoyen b) Best Village, Vreed-en-Hoop	a) Moderate b) High	a) Moderate b) High	**a) Medium** **b) Medium**
Social/Housing	Provisioning	• Squatting at Phoenix Park and Best Village. • Squatting in the mangroves at Plastic City.	Sea defense, mangroves	Squatters at: a) Phoenix Park b) Mangroves in Plastic City c) Best Village	a) Essential b) Essential c) High	a) High b) High c) High	**a) High** **b) High** **c) Medium**
Religious	Cultural	• Crane jetty and Cogland Dam Koker permits religious activities.	Sea, river, beach, reserve	Local Communities	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• A small number of people catch iguana for sale. • Shore birds such as “plawads” and “curry” are hunted. River turtles are caught but this is on a decline.	Mangroves forests	Local communities (general population)	Low	Moderate	**Low**
Aquatic transport	Provisioning	• Waterway is used by boat builders for access to launch boats built on the riverbank.	Drainage channel	Local communities	High	Moderate	**High**
Tourism	Cultural	• Bird watching is sometimes done in the mangrove area. • Historical sites along river bank including a monument and 1700’s Dutch koker serve as attractions	Coastal mangroves and shoreline	Local communities and tourists	Medium	Medium	**Medium**
Erosion Regulation	Regulating	• Mangrove vegetation assists in regulating erosion of the riverbanks. River bank is being built up naturally.	Mangrove Forest	Local communities **ES Linkages:** River defense	High	High	**Medium**
Pollination	Regulating	• Pollinators are abundant in the mangroves and increase crop productivity on the coastland farms.	Mangrove forests, biodiversity	Local communities, famers, national economy	High	High	**Medium**
Timber and wood products/ Non-wood fibers and resins	Provisioning	• A small percentage of households harvest mangroves, primarily for construction of fences and other structures in the squatting area.	Forests	Local communities (general population)	Low	High	**Low**

APPENDIX E

Identified Ecosystem Services and Priority Ratings: Region 4 Coastal

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TABLE E-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 4 COASTAL

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Georgetown City, Population 132,000, with increases in suburban housing areas							
Social/Commercial – Port & Wharfs	Provisioning	• The Port Georgetown is used by >30 ocean-going vessels daily, with others anchored in the river. • The wharfs are used by > 50 fishing vessels including trawlers for deep sea fishing • Thousands of passengers use the ferry stelling on a daily basis.	River & Sea	a) Regions 3, 4 and other communities using Port of Georgetown and ferry stelling b) fisherfolk at wharfs **ES Linkages:** Food, Tourism, Employment	a) Essential b) Essential	a) Low/ Moderate b) High	**a) Critical** **b) High**
Tourism/Hotels	Cultural	• Two of the main hotels in Guyana are located on the seashore, with hundreds of guests per week and >200 employees.	Seashore	Guyana	High	Moderate	**High**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• >20 fishing vessels use the seashore to fish or to access their fishing grounds in deeper waters. • Individuals use the area to fish with lines.	Ocean/ River	a) Commercial fisherfolk b) Recreational or subsistence fishing	a) Essential b) Low	a) Moderate b) Moderate	**a) Critical** **b) Low**
Recreation	Cultural	• >100 individuals use the stretch of Seawall from Kingstown – UG road daily. >1000 frequent the bandstand area on weekends and holidays.	Sea/river defense, beach	Georgetown, Guyana **ES Linkage:** Tourism	Essential	Low	**Critical**
Biodiversity	Provisioning	• Thousands of birds roost in the mangroves close to the Demerara Harbour Bridge. Birds feed on the mudflats of the river.	Sea/ River, Mangroves	Georgetown, Region 3, Guyana, International **ES Linkage:** Tourism	High	Moderate	**High**
Religious/Ritual	Cultural	• Religious activities at the Kingston shore/beach, with > 20 people daily • Religious activities at the UG Road seawall, with > 10 people daily	Seawall, shore, beach	Local communities using religious areas at: a) Kingston shore b) UG Road	a) High b) Moderate	a) Moderate b) High	**a) High** **b) Low**
Mangroves	Provisioning	• Mangroves grow on the banks of the Demerara River and on the Georgetown seashore	Sea/ River, Mangroves	Georgetown, Guyana	High	Moderate	**High**
Erosion Regulation	Regulating	• The coastland is at risk to erosion, although protected by concrete defense. The mangroves and other vegetation help to defend the coast against erosion. Beaches forming along the seawall are contributing to this effort.	Coastal vegetation	Local communities **ES Linkages:** Biodiversity, Fishing, hunting, socioeconomic	Essential	Low	**Critical**
NDC 17 – Industry/Plaisance - Population – 25,000 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fishing, including shrimp, caught by >20 boats for commercial purposes. • Pin seine fishing by a few people on the shore. Hand line and cast net fishing by a few people for sustenance. Most boats dock at the Ogle Koker.	Marine habitat, river habitat and mangrove forests	a) Commercial fishing in the ocean b) Pin seine fishing at Industry and Plaisance	a) Essential b) Moderate	a) Moderate b) High	**a) Critical** **b) Low**
Recreation	Cultural	• 40-50 people visit the Cummings Lodge–Ogle Road area for daily exercise. Some people walk/jog from Kingston to this area as part of their exercise routine. • 20-40 persons can visit the Turkeyen to Cummings Lodge seawall daily to relax, exercise and socialize	Sea wall, reserves	Local communities using seawalls in: a) Cummings Lodge to Ogle b) Turkeyen to Cummings Lodge c) Plaisance to Betterhope	a) High b) High c) Moderate	a) Moderate b) High c) Moderate	**a) High** **b) Medium** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Religious/Ritual	Cultural	• Cummings Lodge shore and sea defense is used for religious activities by >10 people daily. • Plaisance Koker is used for religious activities. • The Ogle Koker is used by Jordanites to conduct baptism and twice per year there are African Libation Ceremonies.	Sea defense, reserves	Local communities: a) Cummings Lodge to Ogle b) Plaisance	a) Essential b) Moderate	a) Moderate b) Moderate	**a) Critical** **b) Medium**
Food: Wild Meat	Provisioning	• Wild ducks and birds caught in summer season as they feed in the area. Birds hunted including the Scarlet Ibises in the summer months when the birds are plentiful in the area.	Seashore, mangroves	Local communities (especially boys)	Moderate	High	**Low**
Agriculture - Cultivated Crops	Provisioning	• A few people planted trees and cash crops (squatters) along the sea defense reserves. The dominant crop is coconuts.	Cultivated lands	Local communities (general population)	Low	High	**Low**
Mangroves & Carbon Sequestration	Regulating	• The mangroves grow naturally on the newly deposited mudflats, regulating many natural factors, contributing to pollination of crops and adding to carbon sequestration. New mangrove growth has covered shoreline between Ogle and Plaisance.	Mangroves	Local community. **ES Linkages:** Fishing, Crabbing, biodiversity	High	High	**Medium**
Shoreline Protection	Regulating	• Mangroves and coastal vegetation play a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms in Plaisance. Mangroves also offer shoreline protection helping the shells and mud to accumulate and build and further buffer the sea defense,	Mangroves Beaches	Coastal Communities **ES Linkages:** Tourism, biodiversity	High	High	**Medium**
Social/Cultural	Squatting	• Squatting occurring in close proximity to the sea defense at Plaisance	Shoreline, sea defense	Coastal Communities	Moderate	High	**Low**
NDC 18 – Better Hope/La Bonne Intention - Population - 50,000 – is increasing due to natural population growth							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Approximately 35 fishing boats catch fish and shrimp from Montrose, Success, and Better Hope. New mangrove growth are blocking of access to the sea which is affecting the fisherfolk. • Crab fishing is common during the summer crab season with about 12 people making a regular catch for sale. • There is salt fish drying along the seashore at Montrose.	a,b) Marine environment; beach; mangroves	a) Commercial fisherfolk at LBI and Chateau Margot b) Commercial fisherfolk at Montrose c) Salt Fish Drying at Montrose d) Crabbers	a) High b) High c) Essential d) Low	a) Moderate b) Moderate c) High d) Moderate	**a) High** **b) High** **c) Critical** **d) Low**
Shoreline protection / Mangroves / River defense	Regulating	• The coastland is at risk of erosion and much of the shore is protected by concrete defense. The mangroves and other vegetation helps to defend the coast against erosion. Mangrove is growing naturally at the seashore due to the increases in mud/silt deposits. • The NDC monitors the growth of the mangroves within the area and has observed that mangroves growth along the shoreline continues to increase.	Coastal vegetation	Local communities. **ES Linkages:** Biodiversity, Fishing, hunting , socioeconomic, tourism	Low	Moderate	**Low**
Religious/ Ritual	Cultural	• Hindus conduct religious activities along the sea and on the sea defense reserves at Ogle or Mon Repos	Sea & sea defense reserves	Local communities	Moderate	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Livestock Farming	Provisioning	• Locals utilize land along the sea wall for grazing of goats at Better Hope to Montrose. • Along the sea defense in the NDC, households utilize the land for grazing of cows and goats for livelihood. The animal pens are built on the reserves and also includes ducks and chickens.	Sea defense reserves, mangroves	Local communities (general population) in: a) Better Hope to Montrose b) LBI	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Primary production, biodiversity	Supporting	• The NDC has a large area covered by new growth mangroves with rich biodiversity of birds and crabs. People use this area for crabbing in season and out of season.	Coastal Mangroves	Local communities	Low	Moderate	**Low**
Food: wild meat	Provisioning	• Lulu, egrets, plover birds are caught by a few people in the NDC on the seashore.	Biodiversity	Local communities, NDC **ES Linkages:** Wild meat tourism	Low	Moderate	**Low**
Tourism and Recreation	Cultural	• 10–20 persons relax and exercise on the seawalls at Le Ressouvenir, LBI, and Chateau Margot. • More than 20 persons use the Montrose seawall daily for recreation including playing dominoes and exercise.		Local communities using the seawalls in: a) Le Ressouvenir, LBI and Chateau Margot b) Montrose	a) Moderate b) High	a) Moderate b) High	**a) Medium** **b) Medium**
NDC 19 – Beterverwagting/Triumph - Population - 7,000 people							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Fisheries landing area in Triumph where 15-20 boats load, refuel and discharge catch. • Mudflat where 10-15 catamarans operate using pin seine to fish.	Ocean, Mudflats, mangroves	a) Local Fisherfolk b) Local Communities	a) Essential b) High	a) Moderate b) High	**a) Critical** **b) Medium**
Recreation	Cultural	• >20 people use the Triumph end of the NDC to exercise, recreate, or socialize. Many people used to frequent the area before the mangroves began to increase. On weekends and holidays, there are a few families recreating in the area.	Sea wall, reserves	Local communities	Moderate	Moderate	**Medium**
Religious/ Ritual	Cultural	• Religious activities along the sea defense and at the koker at Triumph > 10 people daily.	Sea defense reserves, shore	Local Communities	Moderate	High	**Low**
Agriculture/Grazing	Provisioning	• Grazing of goats and cows in the NDC is limited as there is not much unoccupied or reserve land. • There has been a reduction of grazing along the shoreline. The NDC places high fines for stray cattle and many farmers have moved their animals to the backlands which is being developed by the Rural Agricultural Infrastructural Development Project for agriculture purposes.	Sea dam, Mangroves, reserves	Local communities	Low	Moderate	**Low**
Shoreline Protection	Regulating	• Mangroves and coastal vegetation at Beterverwagting play a critical role to maintain coastal stability and protect inland areas from waves, wind, and flooding from storms.	Mangroves Beaches	Coastal Communities **ES Linkages:** Tourism, biodiversity	Low	Moderate	**Low**
Coastal Protection	Supporting	• Mudflats are being built on the coast in the NDC that protect the sea defense structures. Mangroves has been growing in the NDC naturally with the buildup of mud and silt	Ocean, sea defense	Coastal communities	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: Wild Meat	Provisioning	• Wild ducks and shore birds are caught and eaten by few families in the summer when birds are plentiful in the area.	Seashore, mangroves	Local communities	Low	Moderate	**Low**
Social/Housing	Provisioning	• A housing scheme of 22 lots for residents is being developed Triumph North.		Residents in Triumph North	High	Low	**Critical**
NDC 20 – Mon Repos/La Reconnaissance - Population - 40,000 and increasing							
Food: Fishing, shrimp, crabs	Provisioning	• There are more than 100 fishing boats landing at Mon Repos Koker, Lusignan Koker and Annandale. Approximately 400–500 persons mainly from the villages of Mon Repos and Annandale. Mangroves have made it difficult for fisherfolk to access their landing areas. • < 10 people catch crab on a weekly basis for sale in the area.	Ocean & River ecosystems	a) Local fisherfolk at Mon Repos Koker and Lusignan Koker b) Annandale c) Local crabbers **ES Linkages:** Mangroves	a) Essential b) Essential b) Low	a) Low b) Low b) Moderate	**a) Critical** **b) Critical** **c) Low**
Recreation	Cultural	• Recreation at Lusignan and Annandale where people living in close proximity and others frequent. • The NDC has an abandoned play park in Annandale for recreational activities that is overgrown by vegetation. The NDC plans to refurbish the park for recreation and tourism purposes.	Sea wall, Beach	Local Communities using: a) Lusignan and Annandale b) community playground at Annandale	a) Moderate b) Low	a) High b) High	**a) Low** **b) Low**
Livestock Farming	Provisioning	• Cattle, sheep, and goats graze on the shoreline in the Lusignan area. Grazing is reduced due to stealing of animals.	Sea Dam, Vegetation	Local Communities	Moderate	Moderate	**Medium**
Religious	Cultural	• Religious activities with shrine built on the sea dam at Mon Repos • People living along the sea defense use the areas; accessible for religious activities at Annandale and Lusignan	Sea dam, beach	Local community using accessible areas at: a) Mon Repos b) Lusignan and Annandale	a) High b) Low	a) Moderate b) Moderate	**a) High** **b) Low**
Social/Economic Boat Building	Provisioning	• Boat building & repairs	Sea dam, beach	Local Community, Region 4	Essential	Moderate	**Critical**
Social/Economic - Tannery	Provisioning	• Mangrove barks are being utilized by three tanneries to color leather	Mangroves	Local leather tanner	High	High	**Medium**
Food: Wild Meat	Provisioning	• Wild ducks and shore birds are caught and eaten by few families in the summer when birds are plentiful in the area.	Sea shore, Mangroves	Local communities	Low	Moderate	**Low**
Social/Economic	Provisioning	• A heliport and a hotel are proposed for sea defense area at Lusignan, with the site already cleared for the construction to commence.	Sea Defenses	Private developers	Moderate	Moderate	**Medium**
Social/Economic	Provisioning	• A coconut processing center will be developed in close proximity to the shoreline at Annandale.	Sea shore	Private developers, Local communities	Moderate	High	**Low**
Social/Housing	Provisioning	• A new private housing scheme consisting of seventeen houses is being constructed close to the sea defense at Good Hope.	Sea dam	Private developers; Local communities	Moderate	Moderate	**Medium**
Shoreline protection / Mangroves / River defense	Regulating	• Mangroves cover the sea shore in Mon Repos and Annandale. In Mon Repos mangrove cover is increasing.	Mangroves	Local communities	High	Moderate	**High**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 21 – Buxton/Foulis – Population – 7,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing with six boats landing at Non Pariel as mud accumulation along the shoreline at Stratsphey made the landing site inaccessible • Fishing boats at Melanie and Paradise with pin seine • Some also catch shrimp	River, Ocean, mangroves	Local fisherfolk at: a) Non Pariel b) Melanie and Paradise	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Recreation	Provisioning	• Buxton/Friendship Seawall, which 10-20 people use daily to exercise, relax or socialize • Melanie/Non Pariel Seawall, which 10-20 people use daily for recreation	Sea defense, shore,	Local Communities at: a) Buxton / Friendship Seawall b) Melanie/Non Pariel Seawall	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Religious	Cultural	• Religious activity at Melanie with access to the sea. On Sundays, 20-30 families visit the area for religious activities.	Sea shore, sea dam	Local communities	Essential	Moderate	**Critical**
Livestock Farming	Provisioning	• Grazing of goats, sheep and cattle occurs on the natural vegetation by a reported few animals in the NDC	Natural vegetation	Local residents in proximity to grazing	Low	Moderate	**Low**
Habitat provision, coastal protection	Supporting	• Birds, insects, and some small mammals pollinate certain flora species, including some agricultural crops grown along the coast. The area has some tracts of mangrove and mixed vegetation that allows for such services.	Cultivated lands	Local communities **ES Linkages:** Crop cultivation	Low	Low	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore, are highly valued by local communities and visitors.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
Food: Wild Meat	Provisioning	• Wild ducks and shore birds are caught and eaten by few families in the summer when birds are plentiful in the area.	Sea shore, Mangroves	Local communities	Low	High	**Low**
Shoreline protection / Mangroves / River defense	Regulating	• NAREI plots at Mon Repos and Vigilance for mangroves. The growth of mangroves has created security issues for recreational users who are now avoiding these areas.	Sea shore, Mangroves	Local communities	High	Moderate	**High**
NDC 22 – Unity/Vereeniging - Population in excess of 9,000							
Food: Fishing, shrimp, crabs	Provisioning	• Unity shoreline has fewer than 20 fish/shrimp boats. • Riverview landing site at Unity at the Mahaica River mouth has approximately 50 boats. • Helena Koker, with approximately 25 boats. • There are over 150 fishing boats in the NDC of different types employing over 500 persons directly in fishing and an additional 500 persons in supporting services. • Crab catching done a lot, but seasonal.	River &sea	Local fisherfolk Region 4 a) Riverview landing site b) Unity Shoreline c) Landing sites at Beehive and Lowland d) Crabbing	a) Essential b) Moderate c) High d) Low	a) Low b) Moderate c) Moderate d) Moderate	**a) Critical** **b) Medium** **c) High** **d) Low**
Agriculture/Grazing	Provisioning	• Grazing at Unity shore for cows, horses, and goats. >200 animals graze in the pasture. Over 15 persons graze animals in the area.	Beach mangroves, vegetation; fishing	Local communities	Essential	Moderate	**Critical**
Recreation	Cultural	• Unity beach is frequented for swimming, exercise, recreation and socializing by 20-30 people daily.	Seawall, sea defense reserves	Local communities, Region 4	High	Moderate	**High**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Religious/Ritual	Cultural	• Religious activities held at the sea with access from the road throughout the NDC. • Unity Beach is the main area in the NDC for religious activity. 10-20 persons use this area daily for religious activities. Over 300 persons can be found on Sundays and thousands on Hindu religious days. • Crematorium at Unity Foreshore utilized regularly.	Seawall reserves, shore, beach	Local Communities, Region 4 using: a) Along coastal access areas b) Unity Beach and Crematorium	a) Essential b) Moderate	a) Moderate b) Moderate	**a) Critical** **b) Medium**
Ecotourism: Bird Tours	Cultural	• Daily bird tours in the Mahaica River to spot numerous bird species including the Canjie Pheasant	River ecosystem , Biodiversity	Local Guides, Tourists	High	Low	**Critical**
Cultivate Crops	Provisioning	• Crops and fruits planted on the sea and river defense reserves. • Coconut estates encroach on the reserves along with some cash crops.	Seawall reserves	a) Local Communities planting crops and fruits b) Coconut estate owners and workers	a) Moderate b) High	a) High b) Moderate	**a) Low** **b) High**
Food: Wild Meat	Provisioning	• Iguanas and some birds are increasingly caught in the shore and among the mangroves on a weekly basis for sale to wild meat enthusiasts.	Mangroves, Biodiversity	Local Boys	Moderate	Moderate	**Medium**
Social/Economic	Provisioning	• Wharfs in the Mahaica River supporting trade and the local economy. Numerous boats carry farm produce, goods, and passengers in the river.	Seawall & reserves	Local Communities	Moderate	Low	**High**
Coastal Protection	Supporting	• The concrete sea defense is supported by natural vegetation including mangroves, coconuts, fruits, and some cash crop plots.	Sea defense & reserves	Coastal region	High	Low	**Critical**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore, are highly valued by local communities and visitors. The Canjie Pheasant is highly valued and attracts daily tours to the area.	River, ocean, beach	Local communities **ES Linkages:** Tourism	Moderate	Low	**High**
Habitat provision, coastal protection	Supporting	• Birds, insects, and some small mammals pollinate certain flora species, including some agricultural crops grown along the coast. The area has some tracts of mangrove and mixed vegetation that allow for such services.	Cultivated lands	Local communities **ES Linkages:** Crop cultivation	High	High	**Medium**
Mangrove Materials	Provisioning	• Some harvesting of mangroves for firewood and poles, but this is limited.	Mangrove	Few local individuals	Moderate	High	**Low**
NDC 23 Haslington/Grove - Population - 22,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Fishing boat landing area at Greenfield >15 boats, mainly for fishing • Fishing boats landing area at Hope, with 10 boats. Fish are sold in the area. • Fishing boat landing area at Haslington, with 5 boats, and Victoria, with 3 boats • Fishing boat landing area with approximately 5 boats at Cove and John • Fishing done along the shoreline using seines and at kokers using cast net and lines. Catamarans used to access seine and lines via the mudflats.	Ocean, Mudflats, shore	Local fisherfolk , Region 4 at: a) Greenfield, b) Hope c) Cove and John d) Haslington e) Along other kokers; catamaran operators and users of cast nets and lines	a) Essential b) Essential c) High d) Moderate) e) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate e) Moderate	**a) Critical** **b) Critical** **c) High** **d) Medium** **e) Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• The locals catch much fishes in the swamps beyond the sea dam that is offered for sale in and out of the NDC.					
Primary production, biodiversity	Supporting	• This NDC has a Mangrove Reserve that facilitates mangrove conservation, apiculture, bird watching tours, and mangrove tours.	Mangrove Forest	a) Local Beekeeper, b) Coastal Communities c) Tourists	Essential	Moderate	**Critical**
Ecotourism	Cultural	• The mangrove reserve has over 70 species of birds that attract three tours daily in the school tour season and monthly tours from other markets including internationals.	Biodiversity, Mangroves	a) Local communities, b) Tour operators **ES Linkages:** Biodiversity	Essential	Moderate	**Critical**
Coastal Protection	Supporting	• Mudflats are naturally being built on the coast in the NDC that protects the sea defense structures and promotes the growth of mangroves. • Mangroves are monitored by 3 rangers; as such, there is no hunting of wildlife or harvesting on mangroves. • Mangroves on the increase due to planting and natural growth. • Previously Hope Beach was popular but now overgrown with mangrove. • Lots of awareness to protect mangroves	Ocean, sea defense	Coastal communities	Low	Moderate	**Low**
Recreation	Cultural	• Cove & John – Victoria seawalls is frequented by 20-40 people daily. • Haslington –Nootenzuil is used by 50 people daily to exercise, relax, or socialize. • Recreational area being constructed at Bel Field Seawall. • The NDC is in process of developing the beach at Victoria/Haslington for recreation and tourism purposes. There is a Regional Tourism Committee which is spearheading tourism development within the Region. • Weekend activities such as parties have increased along the seawall area.	Seawall, beach, shore	Local communities using: a) Cove and John Seawall b) Haslington –Nootenzuil **ES Linkages:** Tourism	a) Moderate b) Essential	a) Moderate b) Moderate	**a) Medium** **b) Critical**
Religious	Cultural	• Religious activities at Cove & John attracts thousands for the special religious days • Religious activities at Hope and Greenfield <10 people.	Beach, seashore	Local communities Guyana using: a) Cove & John b) Hope and Greenfield	a) Essential b) Moderate	a) Moderate b) High	**a) Critical** **b) Low**
Apiculture	Provisioning	• Beekeeping is done in the mangrove area, with about 4 liters of honey sold daily. Two persons are involved in Golden Grove.	Mangrove	Local beekeepers	High	Medium	**Medium**
Livestock Farming	Provisioning	• Grazing of cows at Hope sea dam and shore. • Grazing of cows at Hope – Golden Grove.	Sea dam, reserves, mangroves	Local communities	Moderate	Moderate	**Medium**
Food: Wild meat	Provisioning	• Iguanas are caught by a few people for own use. Tilapia is caught in the mangroves that grow in the flood basin.	Mangroves	Local communities **ES Linkages:** Biodiversity	Moderate	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Squatting	Provisioning	• Informal housing at Golden Grove and Nabaclis.	Sea defense, mangroves	Local communities	High	High	**Medium**
Cultivated Crops	Provisioning	• Crops and fruits planted on the sea and river defense reserves at Golden Grove and Nabaclis. • Coconut estate in Greenfield.	Sea defense reserves	a) Local farmers planting on sea and river defense reserves b) Coconut estate	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Habitat provision, coastal protection	Supporting	• Birds, insects, and some small mammals pollinate certain flora species, including some agricultural crops grown along the coast. The area has some tracts of mangrove and mixed vegetation that allow for such services.	Cultivated lands	Local communities **ES Linkages:** Crop cultivation	High	High	**Medium**
Aesthetic Value of Natural Landscapes	Cultural	• Views of natural landscapes and landscape features, including the ocean and its shore is highly valued by local communities and visitors.	Mangrove area	Local communities **ES Linkages:** Tourism	Moderate	High	**Low**
NDC 24 Enmore/Hope – Population – 2,000 people							
Food: Fishing, shrimp, crabs	Provisioning	• Twenty boats use the Enmore Koker to dock. People fish with line and nets in the area. • Pin seine fishing is also practices by 2 to 3 persons using catamaran to access to fishing grounds. • Shrimp is caught by persons dragging seine along the shoreline. • Tilapia is caught in the flood reservoir within mangroves • The area is under much economic depression due to the closure of the sugar estates. There is more demand on the fishing resources offshore and in the canals and wetlands within mangroves. • The fisherfolk have good access to their landing area as the access was upgraded by the National Drainage and Irrigation Authority. The improved access is also used by the pin seine fisherfolk.	Ocean, reservoir	a) Local commercial fisherfolk b) Pin seine fishing and shrimping along the shoreline c) Fishing in mangroves	a) Essential b) Moderate c) Moderate	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) Medium** **c) Medium**
Recreation	Cultural	• Enmore seawall was a popular spot but now is only frequented by >10 people daily. Most people use the community center.	Seawall, beach	Local Communities	Moderate	High	**Low**
Religious	Cultural	• Enmore shoreline is a popular place for worshipers.	Seashore, sea dam, reserves	Local Communities	High	Moderate	**High**
Livestock Farming	Provisioning	• Grazing occurs along the sea defense reserve from Enmore – Hope. The amount is decreasing due to stealing of animals.	Sea defense reserves	Local Communities	Moderate	Moderate	**Medium**
Cultivate Crops	Provisioning	• Crops and fruits planted on the sea and river defense reserves at Haslington by one person.	Sea defense reserves	Local farmers	Low	Moderate	**Low**
Ecosystem, Mangroves	Provisioning	• The NDC has an area covered by mangroves with rich biodiversity of birds, fishes, and crabs. New mangrove growth on the shore is increasing and contributing to carbon sequestration. Mangroves are increasing within the NDC shoreline, which has resulted in less persons exercising due to security fears.	Coastal Mangroves	Local communities **ES Linkages:** Carbon Sequestration	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on stakeholder input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Coastal Protection	Supporting	• Mudflats are being built on the coast in the NDC that protect the sea defense structures and promote the growth of mangroves	Ocean, sea defense	Coastal communities	High	High	**Medium**
Food: wild meat	Provisioning	• Some birds such as the plover birds are caught using wire along the shoreline.	Mangroves	Local communities	Low	High	**Low**

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APPENDIX F

Meeting Schedule

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REGION 1 VCs/CDCs/TCs

Name of VC/CDC/TC	Date and Time (2018)		Date and Time (2019)	
Father's Beach	Wed, April 4	9:30 AM	Mon, June 10	8:30 AM
Manawarin	Thur, April 5	9:00 AM	Mon, June 10	1:00 PM
Haimakabra	Thur, April 5	2:00 PM	Tues, June 11	8:30 AM
Waramuri	Fri, April 6	9:00 AM	Tues, June 11	8:30 AM
Santa Rosa	Fri, April 6	2:00 PM	Tue, June 11	2:00 PM
Assakata	Sat, April 7	9:00 AM	Wed, June 12	1:00 PM
Warapoka	Sat, April 7	2:00 PM	Thu, June 13	8:30 AM
Three Brothers	Mon, April 9	11:00 AM	Thu, June 13*	1:00 PM
Mabaruma Town Council	Tue, April 10	9:00 AM	Fri, June 14	8:30 AM
Aruka Mouth	Tue, April 10	2:00 PM	Fri, June 14	11:00 AM
Morawhanna	Wed, April 11	9:00 AM	Fri, June 14	1:00 PM
Smith's Creek	Wed, April 11	11:00 AM	Fri, June 14	3:00 PM
Imbotero	Wed, April 11	2:30 PM	Sat, June 15	9:00 AM
Almond Beach	Thur, April 12	9:00 AM	Sat, June 15	2:00 PM

* Meeting not held due to unavailability of village.

REGION 2 NDCs

Name of NDC	Date and Time (2017)		Date and Time (2019)	
Charity/Urasara	Wed, Nov. 15	10:00 AM	Tue, May 28	8:30 AM
Evergreen/Paradise	Thu, Nov. 16	9:00 AM	Tue, May 28	11:00 AM
Aberdeen/Zorg-en-Vlygt	Thu, Nov. 16	1:00 PM	Wed, May 29	8:30 AM
Anna Regina Town Council	Fri, Nov. 17	8:00 AM	Tue, May 28	2:00 PM
Annandale/Riverstown	Fri, Nov. 17	10:00 AM	Wed, May 29	11:00 AM
Good Hope/Pomona	Fri, Nov. 17	1:00 PM	Wed, May 29	2:00 PM

REGION 3 NDCs

Name of NDC (Coastal)	Date and Time (2017)		Date and Time (2019)	
Wakenaam (island)	Mon, Nov. 20	9:00 AM	Tues, July 9	9:00 AM
Leguan	Tue, Nov.21	9:00 AM	Tues, July 9	2:00 PM
Mora/Parika	Wed, Nov.22	9:00 AM	Wed, July 10	8:30 AM
Hydronie/Good Hope	Wed, Nov.22	1:00 PM	Wed, July 10	11:00 AM
Greenwich Park/ Vergenoegen	Thu, Nov. 23	9:00 AM	Wed, July 10	2:00 PM
Tuschen/Uitvlugt	Thu, Nov.23	1:00 PM	Thur, July 11	8:30 AM
Stewartville/Cornelia Ida	Fri, Nov. 24	9:00 AM	Thur, July 11	11:00 AM
Hague/Blankenburg	Fri, Nov. 24	1:00 PM	Thur, July 11	2:00 PM
La Jalousie/Nouvelle Flanders	Mon, Nov. 27	9:00 AM	Fri, July 12	8:30 AM

Name of NDC (Coastal)	Date and Time (2017)		Date and Time (2019)	
Best/Klien/ Pouderoyen	Mon, Nov. 27	1:00 PM	Fri, July 12	11:00 AM

REGION 4 NDCs

Name of NDC (Coastal)	Date and Time (2017)		Date and Time (2019)	
Georgetown City	Tue, Dec. 5	9:00 AM	---	---
Industry/Plaisance	Tue, Nov. 28	9:00 AM	Wed, May 8	8:30 AM
Better Hope/ LBI	Tue, Nov. 28	1:00 PM	Wed, May 8	11:00 AM
Beterverwagting/Triumph	Wed, Nov. 29	9:00 AM	Wed, May 8	2:00 PM
Mon Repos/ La Reconnaissance	Wed, Nov. 29	1:00 PM	Thu, May 9	8:30 AM
Buxton/Foulis	Thu, Nov. 30	9:00 AM	Thu, May 9	11:00 AM
Enmore/Hope	Mon, Dec. 4	1:00 PM	Thu, May 9	2:00 PM
Unity/Vereeniging	Thu, Nov. 30	1:00 PM	Fri, May 10	11:00 AM
Haslington/Grove	Mon, Dec. 4	9:00 AM	Fri, May 10	8:30 AM

--- Location not revisited during validation exercise.

APPENDIX G

Validation Data Summary

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ACRONYMS

CDC	Community Development Councils
EEPGL	Esso Exploration and Production Guyana Limited
GIS	Geographic Information System
NAREI	National Agricultural Research and Extension Institute
NDC	Neighbourhood Democratic Council
NGO	non-governmental organization
NTC	National Toshaos Council
SBPA	Shell Beach Protected Area
TC	Town Council
VC	Village Council

1. INTRODUCTION

As detailed in Section 1.2, after documenting the findings and analysis, the final phase in the process was to validate the compiled data and verify that the associated detailed mapping was accurate. An ecosystem services validation exercise commenced in May 2019 and concluded in July 2019. As described in Section 2.4, in addition to validating previously recorded information, the validation exercise allows for the collection of any new data relating to ecosystem services functions and values since the previous engagements, while also providing the opportunity to collect updated socioeconomic data at the community level.

The information presented in this Validation Data Summary appendix is limited to the feedback obtained from stakeholders during the validation stage whereby the socioeconomic and biodiversity experts presented the findings of the ecosystem services study and the coastal sensitivity maps on which the results of the ecosystem services study were displayed. These were presented to 62 of the original 64 Neighbourhood Democratic Councils (NDCs), Town Councils (TCs), Village Councils (VCs), and Community Development Councils (CDCs) in the coastal area of Regions 1, 2, 3, 4, 5, and 6.

The responses received during the validation exercise are detailed below, presented by region and stakeholder group. Feedback regarding additional or changed ecosystem services data is reflected under the “Ecosystem Services Survey” heading. Issues not directly related to ecosystem services functions or values, but related generally to socioeconomic status, are also noted under “Other data collected” headings for the purpose of documentation. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time which has lapsed since the 2017/2018 original data were collected and the 2019 validation exercise. In some cases, there are specific notes regarding changes that will be made within the Liza Project Geographic Information System (GIS) database. These are captured within the responses in order to maintain accuracy in the reporting and subsequent mapping efforts. The findings outlined in this appendix are provided in detail within the Detailed Findings Sections of the report.

Some minor changes and updates were recommended as indicated by individual focus groups. These minor updates relate mainly to adjustments in the quantitative data for some ecosystem services presented, as well as location of some activities. In a few instances, additional uses/services in some areas were recommended to be included. The spatial adjustments of locations and inclusion of new uses have been updated in the Liza GIS Database.

Additional socioeconomic data at the NDC, CDC, VC, and TC level were also collected, including updated population figures.

The NDCs, CDCs, VCs, and TCs generally expressed gratitude for the information shared and the opportunity to participate in the original screening and scoping process, and subsequent validation exercise. At their request, finalized maps of their area depicting the ecosystems services within their area as well as the summarized analysis was provided to each of the participating NDCs, CDCs, VCs, and TCs and Regional Councils in December 2019.

1.1. Region 1

This section presents the feedback from the ecosystem services validation exercise within Region 1. Engagements with the following CDCs, VCs, and TC within Region 1 were conducted during the period June 10 to June 15, 2019:

- Father's Beach
- Manawarin
- Waramuri
- Santa Rosa
- Assakata
- Warapoka
- Three Brothers
- Mabaruma Town Council
- Aruka Mouth
- Smith's Creek
- Morawhanna
- Almond Beach
- Imbotero

As noted above, Haimokabra and Waramuri in Region 1, which were visited separately in 2017/2018, were visited simultaneously during the validation exercise since Haimokabra is considered a satellite village of and shares leadership with Waramuri. A representative from the National Toshaos Council (NTC) participated in the entire Region 1 exercise. The NTC participation was to ensure all the engagements were fair and impartial and the concerns of the Indigenous communities were raised and addressed. The participation of the NTC was beneficial to the exercise, since communities were more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, had more confidence in the process and participated freely in the discussions. A representative from the non-governmental organization (NGO) Guyana Marine Conservation Society, who is also affiliated with the University of Guyana, attended the meetings in Region 1 to verify that engagement with Indigenous communities was performed in a matter that meets community expectations. Two of Esso Exploration and Production Guyana Limited's (EEPGL's) community and socioeconomic experts also attended the engagements at Father's Beach, Manwarin, and Waramuri.

1.1.1. Father's Beach Village Council

Ecosystem Services Survey

- Coconut palms on the shore, which are protected by the mangroves and earthen barriers, also function as dams. Cassava, fruits, vegetables, and other crops are planted on the farms with some of the produce sold in Pomeroon or at Charity. Coconut cockles are currently affecting the coconut grove. Coconut cockles attack the heart of the coconut palm, which eventually leads to the death of the tree. This is not isolated to Region 1 and is a known pest to coconut plantations in other parts of the coast of Guyana.

- Plants with medicinal and spiritual values are abundant on the beach and almost all plants found in the area are used for medicinal and other purposes.
- Mangroves, in addition to offering protection from erosion, also serve as a buffer between crops and the ocean, preventing the salt water spray from reaching the crops. In some areas there are mature mangroves and in others there is mangrove regrowth.
- There has been significant beach erosion over the years. Shells are being used for construction in place of stone and also used for landfill and to provide nutrients for plants (e.g., fruit trees).
- Fuel and boat repair services are provided onshore and offshore. Persons in need of fuel or repairs offshore can call and service is provided by residents. (Note: This service was added as 50_130 to the GIS dataset.)
- Hunting of wild animals or birds is limited in the area, and hunting by outsiders is banned. Some persons do catch iguanas but not on a regular basis. There are small animals caught for meat that can be found in the swamp beyond the farms.
- Crab meat is an important source of food for the households. Persons from other areas also catch crabs at Father's Beach. Crabs damage the dams and cassava crops.

Other Data Collected

- The village population is declining and currently stands at 23 persons. When there were significant activities on the beach, the population was in excess of 300 persons. Some have signaled their intention to return but have not done so.
- Father's Beach was well occupied with large cultivated farms some 60 years ago. From that time onwards, the beach has been slowly eroding with many of the farms washed away and the people migrating inland or to the Pomeroon River. On long stretches of the beach, the mangroves have completely eroded.
- The school was closed and most children now attend school at Waramuri. The medical center no longer functions and medical services are sought at Charity.
- The local people are prohibited by law from using turtle shells, which is important in one of their traditional religious practices. They claim that the village did not agree to these restrictions during the Shell Beach Protected Area (SBPA) consultation process. The community is awaiting the revision of the rules of the SBPA by the Government of Guyana to better reflect Indigenous people's culture.
- The community is not willing to discuss its spiritual practices with outsiders.
- Savannah burning is still a concern since it burns the dams that protect the community.

1.1.2. Manawarin Village Council

Ecosystem Services Survey

- Fishing along the sea coast has decreased because residents do not have the necessary boats and engines.

- Crabbing is an important cultural activity that the entire community participates in at some level.
- The Manawarin River is not the only form of access to the village. There are numerous tracks and dirt roads that provide access to the community from various points.
- Many species of animals are trapped for trading at Charity, including the emerald boa, rainbow boa, anaconda, and parrots. Seabirds are rarely caught, as people do not frequent the shore apart from during the crab season.
- The community cuts wood for internal construction and for sale commercially. The current dispute with the village of Wakapoa (an adjacent Amerindian village in Region 2 but not located within the coastal area) over the ownership of the resources has reduced the level of this activity.
- People have increasingly planted small-scale, cash-crop farms (e.g., vegetables, cassava) but the market for the produce is lacking and the costs for transport to Charity or Kumaka are prohibitive.
- A giant river otter feeding area was observed during the exercise. (Note: This service was added as 50_131 to the map dataset.)

Other Data Collected

- The population is in excess of 2,000 and is increasing.
- The area referred to as Rockstone is disputed but it is a spiritual site and has the potential to be a tourist attraction. It belongs to Manawarin since they previously occupied it. Trees planted by residents exist there today.

1.1.3. Waramuri Village Council

Ecosystem Services Survey

- According to the village Toshao, Waramuri houses the world's 27th shell mound to be discovered (although this has yet to be internationally verified). The expectation is for this site to be developed into a leading tourist attraction in the future as part of the village's plan to enhance ecotourism activities.
- The number of people involved in fishing is the same with most living in Haimokabra. Iron Punt area is used for fishing camps. Fish are caught and dried along the beach since ice is not available.
- Shorebirds are not hunted by the fisherfolk visiting the shore, but are sometimes used as bait for fishing.
- Wildlife is hunted on the shore with the assistance of dogs. Ducks, iguanas, deer, labba, agouti, and alligator are caught onshore. Snakes are caught and sold to trappers visiting the village or sold in Charity. Duck eggs are also collected.
- The shoreline area is preferred for farming since it is more fertile. However, large cultivated areas were washed away, as well as the fisherfolks' camp. Significant stands of mangroves and other lands are also eroded from Shell Beach.

- The village has deposits of stone that are used in construction. Stone is mined and sold locally and to contractors in Santa Rosa.
- Coconut cultivation is increasing within the community. Coconuts are sold at Pomeroon. Copra is also made and sold at Pomeroon.
- Lumbering is performed mainly for domestic construction. This activity is managed by the VC. However, no inventory of the forest within the community has been completed. SBPA management has indicated that it will assist the village in completing its forest resources inventory. Once completed, the village will use this information when developing its own management plan.
- The ite palm (an indigenous type of palm) is recognized by the village as the tree of life. The palm provides tibisiri[8], food, roof material, fruit for drink making, other construction material, and the tacoma worm[9].
- In addition to the river network, there is land access to the village from different onshore areas.

Other Data Collected

- The population is approximately 2,500 and is increasing.
- Economic activities within the community are also on the rise.
- Boats from Charity selling various commodities visit the community on a regular basis.
- The community plans to pursue tourism development. Some of the possible attractions/activities include crab catching, nature trails, historical remnants (such as Dutch bottles), the Shell Mound, and a nature creek. There are also plans to construct a guest house.
- Mangroves along the river banks sometimes fall into the river, which affects navigation. The village, given its location, often receives requests to remove the fallen trees.
- There has been a notable decrease in fishing within the Moruca River in recent years.
- The village has changed its construction methods and materials with the new designs being more modern and better for the households.

1.1.4. Santa Rosa Village Council

Ecosystem Services Survey

- Ite palms are found throughout the community, and residents can easily access and gather forest materials for multiple purpose use. People have chosen to build with modern materials but tibisiri is still used for many crafts.

[8] Tibisiri is made from the fiber from the leaves of the palm and is used to make hammocks, thatch roof, furniture, baskets, and carpets.
[9] Tacoma worm, also known as the beetle larvae (Rhynchophorus palmarum), feeds on old ite trees that have fallen to the ground. These beetles are full of fat and are considered a delicacy and a good source of nutrients by the indigenous communities that consume them.

- The Moruca River and its numerous waterways are used for swimming, cultural acts, fishing, recreation, sports, and some spiritual practices. (Note: This service was added as point 50_132 to the GIS dataset in order to identify cultural uses of the rivers.)
- Turtle shells are used by persons in their homes for spiritual practices.
- Some hunting/trapping of wildlife still occurs even though there is zero tolerance of this activity within the community. Deer are scarce in the savannas due to overhunting but iguanas are plentiful. Recently, many saki monkeys were trapped by a wildlife trader.
- The mangroves at the mouth of the Moruca River are part of the cultural heritage of Santa Rosa and should be carefully preserved while cleared to accommodate the safe movement of boats. The Moruca River mouth is part of the ancestral lands of the Amerindian people of Santa Rosa.
- The village has more than 100 fisherfolk who fish in both freshwater rivers and in the ocean. Fishing areas include Manawarin River, Moruca River, Baramanni River, Biara River, Dog Creek, Luri Creek, Baramanni Lake, Waini River, Waini Point, Iron Punt, and Father's Beach.
- Plants are gathered from the beach and throughout the community for medicinal and other purposes.

Other Data Collected

- The population is approximately 10,500 and is increasing. There are many returning Guyanese from Venezuela who have ties to the community.
- Economic activities are increasing. There is a new shopping mall under construction near the community that will be opened in the near future.

1.1.5. Assakata Village Council

Ecosystem Services Survey

- Lumbering is performed for domestic use and community projects.
- The village has no boats that fish in the ocean. The popular fishing areas include Baramanni Lake, Luri Creek, and Dog Creek.
- Crabs are caught in season, as the fisherfolk do not venture into the crab breeding area on a regular basis.
- The community plans to develop the Village Lake into a tourist attraction and combine it with the shell mound also found in their village. The community will develop an ecotourism plan and seek funding from the government as well as private sources.
- Members of the community are not involved in the trapping of animals for trade. Wild dogs are hunted. Occasionally, iguanas are also hunted for their meat. Conservation efforts have paid off with a reduction in wildlife trapping and trade within the community.
- About 30 persons are involved in the cutting of cabbage sticks for sale.

Other Data Collected

- The village population is 473 and increasing.
- Most persons from the community engage in farming.

1.1.6. Warapoka Village Council

Ecosystem Services Survey

- Warapoka is making strategic investments to become a major ecotourism destination, with visitor counts on the rise over the past several years due in part to government-sponsored ecotourism programs. The guest house has been renovated and plans to bridge the wetland leading to harpy eagle nests are being considered for the dry season. The community is also developing its sport fishing product at Luri Creek with help from Rewa village (North Rupununi). About 20 people are employed in tourism activities, an increase from 10 in 2018. Visitors, primarily consisting of local tourists, have increased over the past year as well. Attractions and activities include village tours, bird watching, cave visits, visits to harpy eagle nesting sites, cultural presentations and sport fishing. [Note: Two points were added to the GIS dataset: 50_133 identifying the Shell mound at Warapoka, and 50_134 for the sports fishing at Luri Creek.]
- The community does not fish in the Atlantic Ocean at this time, but sometimes fishing occurs along the beach, which is accessed through Luri Creek and Baramanni River. The fisherfolk currently fish in the rivers as far as Waini Point.
- Crabs are caught at Waini Point and Moruca River Mouth during the crabbing season.
- The community rarely traps animals for trade, but some community members hunt meat for food. The community gathers eggs from the tiger birds seasonally. Ducks and cranes that lay eggs by the thousands are found in the ite palm forest.
- Approximately 80 men cut cabbage (heart of palm) for sale commercially on a weekly basis during the dry periods of the year.
- Some persons within the community are engaged in craft making.

Other Data Collected

- The population is 650 and is increasing. Guyanese persons from Venezuela with ties to the community are returning. Forty such people have returned to date. However, there are also about 40 other Venezuelan migrants without any ties to the community who have also moved into the community.

1.1.7. Three Brothers Village Council

Ecosystem Services Survey

- Fishing remains the main sustenance and economic activity.
- Some villagers are still involved in the cutting of cabbage palm.

- There are a few commercial-scale farms in the area, but farming is generally in decline despite successes with ginger and other root crops.
- The village dogs continue to be attacked by jaguars, which is affecting hunting activities.

Other Data Collected

- The village population is 120 and is in decline as people continue to migrate to more populated areas like Mabaruma.
- The economic situation is declining more rapidly due to the fuel crisis, which has driven up the price of fuel that villagers depend on to travel in the Waini River and to Mabaruma.
- The villagers expressed discontent with the SBPA management and regulations.

1.1.8. Mabaruma Town Council

Ecosystem Services Survey

- The resource use in the township generally remains the same from the last year. There is a small increase in fishing from the migrant community, but the quantity remains unknown. The migrants also hunt for crabs for their sustenance, mainly in the areas close to their temporary homes.
- There is a small growth in the tourism sector, although there was significant growth in the number of people flying to Mabaruma.
- The township has three sawmills that provide dressed lumber for the town and other communities. The owners have timber concessions and also purchase timber from the Amerindian communities. There is a current boost in the building sector that sustains the three sawmills. These are not affected by the shortage of gasoline. [Note: A new point 50_134 was added to the GIS dataset to show the sawmill and lumber yard that supplies dressed lumber to the town and other communities.]
- The township has embraced the Green State Development Strategy and has built a “Green Park” at Hosororo and planted more than a thousand trees in the town. It also has a solar farm that generates power for the electric grid. There are plans to install a wind farm as well.

Other Data Collected

- The current population is estimated at 8,000.
- There has been in excess of 4,000 migrants (the vast majority Venezuelan and the rest Guyanese people with links to these communities) passing through the community recently, with more than 1,000 remaining. Most of these are residing in an area referred to as Khan’s Hill.
- The local people of the town are not responding in a positive manner to the presence of the migrants who are suspected of taking jobs, spreading diseases, conducting unsanitary practices, and occupying open spaces. There are also numerous cases of migrants being taken advantage

of by local people, which are not reported or given legal consideration due to lack of enforcement.

- There is a small increase in economic activities due to the presence of the migrants.
- The town needs a dedicated site for the disposal of garbage. The current site is not adequate and the migrants at Khan's Hill are seen rummaging through the garbage.

1.1.9. Aruka Mouth Community Development Council

Ecosystem Services Survey

- The community has about 60 men who fish on a regular basis, mainly in the Waini River Mouth.
- In addition to the fisherfolk who also have farms, there are approximately 20 farmers who rely mainly on farming as a means of sustenance. Produce is sold at Kumaka market on Tuesdays and Saturdays.
- Approximately 15 persons catch crabs and sell them on Tuesdays and Saturdays at the Kumaka market. Crabs are purchased by traders and taken to Georgetown.
- The community has about ten persons who hunt. The meat is used domestically and sold at the market. A few people hunt seabirds when they are plentiful.

Other Data Collected

- The population is approximately 300 and is increasing.
- The Warraus from Venezuela visit the community on the way to the Kumaka market and trade with a few willing people. Hammocks, craft, and dried fish are the main items that are in demand in Aruka Mouth.

1.1.10. Smith's Creek Community Development Council

Ecosystem Services Survey

- More than 100 people fish in the Waini River and at Waini Point heading further west along the Venezuelan Coast.
- Approximately 40 people cut cabbage palm during the dry season. A crew of ten men average 1,500 sticks, which occurs twice a month.
- Some men hunt for food but few trap any animals for sale. Land turtles are a favorite.
- There are many mangroves being cut and cleared to construct new houses for the migrants along the Barima River.
- Crab catching remains a significant activity. A crab processing facility is being established within the community with the support of the government.

Other Data Collected

- The population is 248 and increasing.
- There are migrants present within the community, mainly comprising of the same Warrau tribe of the community. At one time there were as many as 80 migrants present. Currently there are ten migrant families who have established dwellings within the community.
- Commercial activities relating to the fuel trade have increased at nearby Morawhanna on the opposite bank of the river. Fuel spills and leaks in the waterways are affecting the community as fuel washes up on the shore. Also, there has been a decline in fish caught within the river.
- The community needs an alternative source of water since the river is often contaminated by fuel, and during the dry season the creek that provides water is usually dry.

1.1.11. Morawhanna Community Development Council

Ecosystem Services Survey

- There has been an increase in economic activity due to the fuel trade. Boats from Venezuela bring fuel to sell to local vessels. There can be as many as 40 vessels docking in the Barima River in proximity to Morawhanna.
- The ice plant is now operational and numerous fishing boats come to purchase fuel.
- The area is mainly a commercial hub with the community taking advantage of its wharf and the increased trading. Food and other supplies are provided daily to the crews of the numerous ships.
- The community floods regularly so people have given up on planting crops.
- There are no hunters in the area who trap animals for trade or meat.
- Everyone fishes in the river for fresh fish on nearly a daily basis. The presence of numerous fish affirms for the villagers that their waters are not polluted due to fuel spills.
- There is now a water well within the community, which has significantly reduced the use of the river as a water source.

Other Data Collected

- The current population is approximately 100 persons.
- The community houses the Coast Guard, the Guyana Revenue Authority, and Immigration authorities.

1.1.12. Almond Beach Community Development Council

Ecosystem Services Survey

- Coconut is the main crop on the beach. Copra, dried coconuts, and water coconuts are sold at Kumaka market. Erosion is still taking away mature and young trees as it washes the shells away during high tide.
- Farming has been reduced due to the prolonged dry spell.
- Salt water has taken over the swamp, driving the freshwater fish away, including the hassar that was recently caught by the thousands.
- Fishing in the Atlantic Ocean is the same with small variations, positive and negative, depending on the catch, price, and cost of fuel. Current gasoline prices have reduced fishing activities.
- Ecotourism is nonexistent, as the community has had no recent visitors due to the lengthy and burdensome process prescribed by the SBPA authority. The SBPA authority also forbids visitors to walk on the beach in order to observe turtles. There have been fewer turtles observed on the beach since 2016, but the reduction in sightings may be as a result of reduced monitoring.
- Rain water is harvested for drinking and shell ponds are constructed to provide water for bathing and domestic chores.
- [Note: A new point 50_135 was added to the GIS dataset to show the SBPA Field Station on Almond Beach.]

Other Data Collected

- The village population is 51 persons.
- There are seven students currently attending the school on the beach.
- Erosion continues to affect the beach and livelihood activities. A comprehensive approach from the community, the Regional Democratic Council, and the Protected Area Commission is needed to address this issue.
- The community may need to be relocated further inland. This was previously proposed for an area inland but there has been no feedback on this plan.
- The community would like to re-introduce ecotourism but the SBPA authority restrictions are affecting this and other activities. There were previous awareness activities being conducted in relation to the sea turtle program, targeting schools, etc., but these are no longer being done.

1.1.13. Imbotero Community Development Council

Ecosystem Services Survey

- Almost everyone fishes in the Imbotero Creek and Barima River for daily catch. The community fisherfolk are not currently venturing out to Waini Point to fish, as they are afraid of having their outboard engine stolen by pirates.

- All hunting and fishing is done in proximity to the community, which has abundant resources. Building materials are also abundant in close proximity including mangroves for house building.
- Some villagers trap birds, reptiles, and small animals for sale to the wildlife traders or at Kumaka market. Some animals are caught for their meat especially in the dry season.
- The community now has a significant migrant population from Venezuela that has settled along the Barima River banks. [Note: Point 50_136 was added to the GIS dataset to show the Warraus settlement.] The migrants have been given temporary status to live and use the village resources. As such, there has been an increased use of the community's resources.

Other Data Collected

- The community currently has a population of 353 persons.
- The community currently has 153 Warraus migrants from Venezuela and is trying to cope with the influx of the migrants who are arriving with very little resources and materials.
- The government is currently providing some assistance to the migrants but this is not properly coordinated with the community. Also, this is causing tensions within the community since no assistance is being provided to the residents.
- The Warraus bring fish, hammocks, crafts, and household items for sale in the village and at Kumaka market.

1.2. Region 2

This section presents the feedback from the ecosystem services validation exercise within Region 2. Engagements with the following NDCs and TC within Region 2 were conducted during the period 28 May to 29 May 2019:

- Charity/Usara
- Evergreen/Paradise
- Aberdeen/Zorg-en-Vlygt
- Anna Regina Town Council
- Annandale/Riverstown
- Good Hope/Pomona

1.2.1. Charity/Usara NDC

Ecosystem Services Survey

- Approximately ten families in the NDC area are engaged in daily crabbing for their livelihoods. Some of these people travel to the Pomeroon River Mouth for crabbing. Crabs are in-season from July through September. During this time, there is an increase in the number of people crabbing.

- There has never been much hunting of wild animals in the area. However, hunting of wild birds has declined. In addition, some people catch iguanas, but not on a regular basis.
- The Big Bird Fish Complex at Charity is a major processing facility that processes large amounts of catch for export.
- There is significant erosion of the sea dam, mudflats, and mangroves along the shoreline of the NDC, which reduces the habitats for wildlife, birds, and crabs. This is especially prevalent along the coast of the NDC and in the Pomeroon River. Additional manmade sea defense structures like groins can be constructed to assist in capturing sediments by reducing the power of the washing waves.
- There is cash-crop farming and grazing on the sea dam and the sea defenses. There is more grazing when the rice lands are under cultivation. The cultivated areas are not adequately irrigated and need urgent investment in order for the land to reach its full potential for agricultural production.

Other Data Collected

- The population within the NDC area is 7,800 and has been stable.
- There is large-scale rice cultivation, which is water intensive in the NDC area. However, the Tapacuma Reservoir was not designed to provide irrigation for rice cultivation but for farming cash crops only. Incomes are higher in rice cultivation and this incentivizes farmers to cultivate rice in the NDC area. As a consequence, farmers have a shortage of fresh water for all crops particularly during the dry seasons.

1.2.2. Evergreen/Paradise NDC

Ecosystem Services Survey

- More than ten people from the NDC hunt crabs in the Summerset and Berks mangroves on a weekly basis for commercial purposes.
- Residents of the NDC hunt iguanas in the La Resource area for sustenance, and occasionally for commercial purposes. The iguanas are sold in the NDC for popular restaurants in the region. Shorebirds are also caught for both sustenance and sale. Some people hunt large lizards (salipenters) for meat and anacondas to sell to traders.
- There is an increase in fishing activity in the NDC mainly due to decreased rice cultivation. There are more fisherfolk at the Andrews Koker than previously reported. In addition, there are five boats in Evergreen and six at Perth. Castle is not located in the NDC area.
- Many cows graze in the Perth, Dartmouth, and Andrews areas. In addition, cows, sheep, and goats are grazed in the Better Hope to La Resource areas.
- The seashore areas at Paradise, Jib, Andrews, and Bounty Hall are used for religious activities. Residents of Westbury and Perth use the seashore in Dartmouth.

- Recreation activities are found at the Dartmouth Seawall, especially on Sundays when dominoes are played.
- Trees along the sea dam from Evergreen to Better Hope are being cut down, which is contributing to erosion.

Other Data Collected

- The population in the NDC area is 7,500.
- There has been a decline in rice cultivation in the NDC area due to lower rainfall and saline intrusion into the drainage and irrigation system. This has led to more mixed farming with multiple crops being grown, including an increase in red peas in Dartmouth.
- Grazing of animals in the NDC area has increased.

1.2.3. Aberdeen/ Zorg-en-Vlygt NDC

Ecosystem Services Survey

- There are approximately 15 boats and 40 families engaged in fishing in the NDC. These boats use landing sites at La Union, Three Friends, and Capoey Koker depending on the accessibility of these sites.
- There is a new growth of mangroves in the NDC, which has resulted in iguanas, crabs, and new species of birds in the area. Crabs are caught and sold daily from persons both within and outside the NDC. In addition, approximately 60 to 70 persons hunt iguanas daily for sale at prices ranging from $3,000 to $5,000 GYD (approximately $14.35 to $23.92 USD). Currently, there is no hunting of wild birds.
- Mangroves are washing away at Columbia. At this locale, the government has installed bamboo groins at Columbia, Aberdeen, and Affiance, which help to protect the shoreline and reduce erosion along the coast of the NDC.
- There is a rearing camp for cattle at the seashore at Hoff-Van-Aurich and La Union.
- Many persons graze their animals on the sea dam and over the seashore. There has been a small increase in the amount of cattle present in the NDC.
- There is a cremation site at La Union that is used by the entire Essequibo coast.
- Many persons use the sea wall in Queenstown for recreation purposes.

Other Data Collected

- There are significantly more mosquitoes in the NDC area due to the regrowth of mangroves.
- Coconuts have been growing wildly along the seashore beyond the rip raps, particularly in Queenstown. This is aided by the accretion of mud in the NDC area. However, there is no large-scale cultivation of coconuts in the NDC.

1.2.4. Anna Regina Town Council

Ecosystem Services Survey

- There has been significant regrowth of mangroves in the municipality and mangrove growth continues to increase. This has resulted in negative impacts for residents including:
  - Increasing mosquitoes that deter people from visiting the seawall. There are also more mosquitoes in residential areas within the municipality.
  - The accumulation of mud and sediments on the seashore that blocks the channel. In some instances, grazing animals become stuck in the mud and die. In addition, sometimes fishing boats become stuck in the mud and dead fish are dumped into the mud. These create odors and also act as breeding grounds for mosquitoes.
  - The beach at Anna Regina has been lost due to the accretion of mud. At Easter, which is the biggest day for recreation activities at the seawall and beach, there was a lower turnout than in previous years and those that visited left early. In addition, people can no longer access the seashore to conduct religious activities.
- There are landing sites at Sparta with 15 boats, Hampton Court with 20 boats, Anna Regina with 15 boats, Walton Hall with 10 to 12 boats, and Lima with 10 to 12 boats. Overall, fishing activities have declined in the municipality; this is partly attributed to the ban on exports of the gillbacker.
- More than 50 people visit the Henrietta seawall on a daily basis, particularly to access the open Wi-Fi hotspot supplied by the government. Softball cricket matches are also played on the beach.
- There is crop cultivation on the government reserves at Lima, Walton Hall, Anna Regina, and Devonshire Castle.

Other Data Collected

- There are approximately 22,000 persons in the municipality. In addition, the boundaries of the township were expanded since the last visit to include Lima Sands.
- There are approximately 5,000 persons from Venezuela scattered throughout the township comprising both returning Guyanese and native Venezuelans.
- Rice cultivation has declined in the municipality due to declining rainfall and a paddy bug infestation.
- There are two excavators on pontoons in the channel leading to the koker in Anna Regina that keep the channel clear due to the accretion of drift mud.

1.2.5. Annandale/Riverstown NDC

Ecosystem Services Survey

- There are fishing landing sites at: Golden Fleece with 2 boats, Zorg with 5 boats, Adventure with 2 boats, Riverstown with 1 boat, and Abraham Zuil with 20 boats, including 2 new anchor seine boats.
- Fishing activities have increased in the NDC area because other employment options are limited.
- Grazing of cows has increased on the seawall and sea dams.
- Religious activities are conducted throughout the NDC but mostly at Golden Fleece.
- There are recreational activities at the seawalls at Perseverance, Golden Fleece, and Suddie, where there are cricket matches, football matches, and barbecues on weekends.
- The beach at Cullen is popular but needs upgrading to facilitate tourism activities. The NDC is seeking to build stands and washroom facilities that will improve the services offered at the beach. Dumping of garbage on the seashore should also be reduced.

Other Data Collected

- There are 10,840 persons in the NDC. This count was completed in 2018 and includes Venezuelan migrants.
- The Venezuela migrants include returning Guyanese and native Venezuelans. It is alleged that many of the migrant women engage in prostitution, which causes significant, negative impacts to the local population.

1.2.6. Good Hope/Pomona NDC

Ecosystem Services Survey

- There are fishing landing sites at: Pomona with 10 to 12 boats, Riverside Creek with 10 to 12 boats, Riverstown with 6 boats, and Vilvoordeen with 15 boats. Fishing boats also occasionally land at Supenaam. There has been an increase in fishing in the NDC area due to declines in other economic sectors, such as rice and livestock.
- Families who live close to the seashore often engage in nearshore fishing and have their own small boats to conduct fishing activities. There are two boats at Good Hope which are used for this type of fishing.
- There are wharves to facilitate shipping of raw materials for construction, commercial products, and exports. There are three wharfs in Fairfield, one in Good Hope, one in Spring Garden, one in Vilvoordeen, and one in Riverstown.
- There is grazing of animals along the seashore starting from Riverstown Creek.
- Hunting of iguanas has increased and is done by persons from both within and outside the NDC area.

- There are beaches for recreation purposes at Vilvoordeen, Aurora, Spring Garden, and Good Hope.
- There are religious activities on the seashore throughout the NDC. The Spring Garden temple is located close to the shoreline.
- There is significant erosion along the coastline of the NDC. Tiger Island is helping to slow the rate of erosion. Currently, revetments are being installed at Aurora. Similar sea defense measures are needed at other locations in the NDC.
- The landing area at Supenaam is being enhanced.
- [Note: The GIS datasets should include the label "Itribisi Lake" at the point 6_15 as a portion of this lake falls within the NDC; remove "West Demerara" from the points at 6_10 and 6_11; clarify the Tiger Island is under management of Region 2.]

Other Data Collected

- There are approximately 10,000 persons in the NDC and the population is increasing. This includes previous residents returning to the NDC area, migrants from Venezuela, and Amerindians moving from inland areas of Region 2.
- There are several new houses in the NDC.

1.3. Region 3

This section presents the feedback from the ESS Validation Exercise within Region 3. Engagements with the following NDCs within Region 3 were conducted during the period of 9 to 12 July 2019:

- Wakenaam
- Leguan
- Mora/ Parika
- Hydronie/ Good Hope
- Greenwich Park/Vergenoegen
- Tuschen/ Uitvlugt
- Stewartville/Cornelia Ida
- Hague/ Blankenburg
- La Jalousie/Nouvelle Flanders
- Best/ Klien/Pouderoyen

1.3.1. Wakenaam NDC

Ecosystem Services Survey

- Fishing is done on both sides of the island. Some boats are owned by persons from the island, while other boats come from the West Coast of Demerara. The fishing area is shared with residents of Leguan and approximately 20 to 30 boats operate in the area.
- Many residents catch crabs from July to September, but a few residents catch crabs all year in the mangroves on the island.

- During April to September, fisherfolk catch shrimp during the shrimp season and dry it on the sea defense wall.
- During the dry season in July to September, residents catch iguanas for recreation and sustenance.
- By empoldering, some people plant/farm on the sea defense reserves and consider upkeep of farms along the Essequibo and on Tiger Island, Hogg Island, Truli Island, and Karia Karia their responsibility.
- Animal grazing is not a challenge—animals are either tied in the farming areas to graze or graze freely in Palmaria, Zeelandia, or New Friendship.
- The beach at Zeelandia has significantly eroded over the years.
- There are 46 kokers around the island, which provide drainage and irrigation.
- There is a pending proposal to construct and operate a solar farm on the island.

Other Data Collected

- At its peak, the population of the island was 18,000 but is now 3,300. This is likely due to the fact that there are not many jobs on the island and islanders seek employment elsewhere and the majority of current residents are self-employed.
- There is an increase in the presence of Amerindians from various areas of the country and many of these Amerindians are seeking employment.
- The plantain chip factory that was constructed in 2014 is not yet operational, but is expected to bring about 30 jobs to the island.
- Plantain production has been increasing recently. It is estimated that the island exports five boats, each with approximately 15,000 pounds of plantains, every day.
- The island does not have a landfill site or garbage collection system, which results in dumping in waterways.

1.3.2. Leguan NDC

Ecosystem Services Survey

- Residents hunt iguanas (which are plentiful on the island) for recreation, sustenance, and sale.
- Several residents from the island catch and sell crabs from the mangroves on a weekly basis.
- Fishing has increased in the NDC mainly due to the decreased rice cultivation. There are around 25 fish and shrimp boats on the island.
- There is significant grazing in the NDC, which is concentrated between Better Hope and La Resource. Grazing has been constrained by the river defense works at Maryville, Success, and Thieres.

- Shorebirds are rarely caught for their meat and only in the summer months. Grassland birds are caught and kept in cages to become pets, with some sold at Parika.
- Recreation activities often occur at Canefield and Success beaches, especially on weekends when many games are played.
- Guyana Energy Agency is looking to set up a wind farm at Dauntless Point on the island.
- The island is considered by residents to be rich in natural gas, with pockets reportedly visibly flowing out of the ground in Belfield and Richmond. One resident traps the gas and uses it for cooking.
- A new wharf was recently constructed at Belfield. It facilitates shipping of construction materials.
- Farming has declined along the shoreline as a result of construction of the sea defense.

Other Data Collected

- The population on the island was 10,000 at its peak, but is currently 2,700.
- There are not many jobs on the island and the majority of the residents are self-employed.
- Economic activities on the island fluctuate, depending on rice cultivation and price.
- There are about 20 speed boats providing transportation to Parika.
- The island is challenged by the absence of a landfill site or garbage collection system, which results in dumping along the shoreline and in trenches.

1.3.3. Mora/ Parika NDC

Ecosystem Services Survey

- Within the Essequibo River, Parika remains the hub of river transportation with speed boat services, shipping, ferry, etc.
- There are a few fishing boats operating in the NDC at Kent and Hyde Park. The boats move around the NDC tracking the catch. In general, the deep sea trawlers are found at Big Kiss and Shairaz wharfs.
- Grazing has significantly declined as a result of the sea defense works and theft.
- There are seven house boats in the NDC and two associated parking lots.
- There are five dockyards for ship repairs in the NDC.
- There are 10 wharves within the NDC—two being recently constructed.
- Squatting along the shoreline remains a big challenge for the NDC, with more persons migrating to the NDC and seeking low-cost housing.
- The religious activities are about the same, with the Hanuman Murti being a new feature at the riverside of the NDC.
- Residents of Bird Island are protecting the island as a safe haven for birds.

- Mangroves are sparse within the NDC, with mainly boulders as the sea defense. The sea defense is currently being rebuilt between Grove and Hyde Park.

Other Data Collected

- The population within the NDC is currently 12,000 and is increasing due to an influx of people from other areas of the country seeking employment.
- There is some squatting inland by Guyanese nationals who have recently returned from Venezuela.
- There has been an increase in economic activities related to small business and service providers.
- The NDC is a major hub for commercial activities within Region 3.

1.3.4. Good Hope/Hydronie NDC

Ecosystem Services Survey

- The sawmill at Bushy Park is now closed; however, there are other economic activities in place such as the pre-casting concrete plant.
- Crops are still being planted along the shoreline.
- In addition to Ruby Koker, there are a few fishing boats operating from the Orangestein Shore.
- The Orangestein beach is used a landing site for large vessels.
- Two new wharves were built at Orangestein.
- There are two burial grounds along the sea dam in the NDC at Good Hope and Ruby.

Other Data Collected

- The population within the NDC is currently 4,200.

1.3.5. Greenwich Park/ Vergenoegen

Ecosystem Services Survey

- There are seven fishing boats, although they are also used to catch shrimp, at Greenwich Park along the sea dam, while there are approximately 25 more fishing boats at the Vergenoegen Outfall.
- Approximately 10 to 15 NDC residents dry fish for sale on a large scale, only four of whom have permits to do so.
- There is an increase in recreational use of the seawall and, aligned with this, the government is interested in building up the seawall area at Vergenoegen for recreational use.
- There is grazing along the sea dam at Greenwich Park and Barnwell. This area is completely blocked off by the residents.

- Religious activities are also conducted mainly in Barnwell, Philadelphia, and Greenwich Park in the NDC.
- Residents continue to use the sea defense reserve for farming.
- There are some squatters on the sea defense reserve.
- Most of the mangroves from are now gone.

Other Data Collected

- The population within the NDC is currently 2,600.
- There are about 75 Venezuelan migrants within the NDC.
- There has been an increase in small businesses such as supermarkets and wash bays.
- Illegally dumping waste in public spaces is a common issue in the NDC.

1.3.6. Tuschen/ Uitvlugt NDC

Ecosystem Services Survey

- There are 25 fishing boats at each of the sites Zeelugt, Zeeburg, and Uitylugt, respectively.
- Large scale shrimp processing occurs at Zeeburg, while large scale fish processing occurs at Zeelugt. All of this occurs on the sea walls or sea defense reserves.
- Grazing occurs in open areas in Zeelugt, Uitvlugt, and Tuchen; however, these areas are limited because of cash crop farming on the sea defense reserves and the shrimp and fish processers.
- Residents utilize the seawall for exercise and recreation, although some residents are deterred from using this space because there is significant garbage along the shore that distracts from quality time along the seawall.
- The NDC has a number of schools and parks in close proximity to the sea defense.
- Squatting along the shoreline area has increased since the previous engagement. This is occurring at several areas in the NDC.

Other Data Collected

- The population within the NDC is currently 35,500. There are new housing accommodations at Zeelugt, Tuschen, De Williem, Zeeburg, and Uitvlugt. It is expected that the population will continue to increase as a result of these accommodations.
- There is a significant migrant population within the NDC, which includes Guyanese nationals returning from Venezuela.

1.3.7. Stewartville/ Cornelia Ida NDC

Ecosystem Services Survey

- There are 15 fishing boats at Leonora, 8 boats at Anna Catherina, and 3 boats at Cornelia Ida.
- Large scale fish and shrimp processing occurs at Leonora; large scale shrimp processing occurs in Anna Catherina. All of this processing occurs, on the seawalls or sea defense reserves. Some residents have built their own drying floors and storage facilities on the sea defense reserves.
- Ducks and pigs are reared on the sea defense reserves, being drawn by the fish disposed by the fisherfolk.
- Grazing occurs in open areas throughout the NDC; however, this area is limited by squatters in Anna Catherina and Stewartville.
- The sea walls at Stewartville, Leonora, and Anna Catherina are used for recreation and religious practices on a daily basis.

Other Data Collected

- The population within the NDC is currently 30,000.
- It is estimated that there are 200 to 300 Venezuelan migrants within the NDC, consisting primarily of returning Guyanese nationals.
- There has been an increase in small businesses within the NDC.

1.3.8. Hague/ Blankenburg NDC

Ecosystem Services Survey

- There are approximately 10 fishing boats operating at Hague in the NDC, which is less than previous counts. This is likely due to the US embargo on catfish and heightened fears of piracy.
- Grazing has increased on the sea defense and shore, as the owners avoid the public road where thieves monitor.
- Recreation activities have been reduced with the rehabilitation of the sea defense and the erosion of the beach; however, many residents—upwards of 200 on weekends—continue to visit the Den Amstel sea walls for recreation and exercise. Recreation activities have also likely been reduced as a result of the significant amount of garbage that washes up along the shoreline.
- Approximately 20 residents use hooks, lines, seines, cast nets, or fishing rods to catch fish and shrimp on a daily basis at Den Amstel and Blankenburg.
- There are mangroves beyond the sea defense where birds roost.
- The religious activities are about the same within the NDC as they were in 2017.
- Shrimp drying no longer occurs, as the seawall—which was historically used—has been updated as part of sea defense works.

Other Data Collected

- The NDC population remains 4,200.
- There has been an increase in small businesses within the NDC such as wash bays, taxi services, and supermarkets.

1.3.9. La Jalousie/ Nouvelle Flanders NDC

Ecosystem Services Survey

- The mangroves in the NDC have been completely eroded. The wildlife has migrated east to the mangroves in the neighboring NDC.
- There are approximately 20 fishing boats in the NDC. There are three fish mongers who sell prized catfish (gillbacker) daily by the Windsor Forest koker.
- The main areas for religious activities are at Blankenburg, Windsor Forest, and the Cremation Site.
- The Cremation Site continues to be one on the most used site in the country, with as many as three cremations per day.
- Grazing is not a significant activity on the reserves anymore. Some animal graze on the sea defense reserves or graze freely; however, more animals graze in the burial grounds inland, south of the shore.
- There is almost no hunting of shorebirds. There is no other biodiversity inhabiting the shoreline within the NDC.
- During the weekdays, approximately 30 residents exercise or recreationally use the Windsor Forest sea wall daily, while during the weekends more than 100 residents exercise or recreational use this area. The previously existing beach is now completely eroded.

Other Data Collected

- The population within the NDC is approximately 5,500 and is increasing due to three new housing accommodations. Guyanese nationals returning from Venezuela are also contributing to an increase in the NDC's population.
- There has been a small increase in small businesses within the NDC such as supermarkets.

1.3.10. Best/ Klien/ Pouderoyen NDC

Ecosystem Services Survey

- There are 75 speed boats registered to work at the crossing between Georgetown and Vreed en Hoop, with 53 working on a daily basis.
- There are 11 fishing boats docking at Vreed en Hoop, Phoenix Park, and the Jetty.

- Grazing mostly occurs in the Best Village and Pouderoyen area. Cows are tied and goats and sheep are allowed to roam freely.
- The NDC's mangroves are increasing, but are under threat from squatters who are clearing them and using the trees and shrubs for building materials.
- A few residents catch crabs on a daily basis as their livelihood, and more residents participate in the industry during crab season.
- Little hunting—mainly iguanas—occurs in the area.
- Tourists, primarily bird watchers, visit the NDC as part of tours organized by operators located in Georgetown.
- The shoreline is being actively considered for the development of shore-based facilities.

Other Data Collected

- The population within the NDC is approximately 25,000 and is increasing due to migration. Guyanese from the hinterlands and other rural areas move to the area, as well as Venezuelan migrants.
- There has been an increase in small businesses within the NDC.

1.4. Region 4

This section presents the feedback from the ecosystem services validation exercise within Region 4. Engagements with the following NDCs within Region 4 were conducted during the period 8 May to 10 May 2019:

- Industry/Plaisance
- Better Hope/La Bonne Intention
- Beterverwagting/Triumph
- Mon Repos/La Reconnaissance
- Buxton/ Foulis
- Enmore/Hope
- Haslington/Golden Grove
- Unity/Vereegining

1.4.1. Industry/Plaisance NDC

Ecosystem Services Survey

- The mangroves are now more prevalent along the shoreline within the NDC and are taking over parts of the shore completely, especially between Ogle and Plaisance. The mangroves offer shoreline protection by helping the shells and mud to accumulate and build, which further buffers the sea defense.

- The locals hunt sea birds, including the Scarlet Ibis on occasion, mainly in the summer months when the birds are plentiful in the area. The birds avoid the areas near the shore, feeding in shallow mud a few hundred meters from the seawall, thus making it additionally challenging for hunters to get close enough to catch them.
- In addition to worshipping at the seashore by Hindus, the Jordanites (a religious group within Guyana) conduct baptisms at the Ogle Koker and there are African Libation Ceremonies twice per year.
- There is squatting occurring in close proximity to the sea defense at Plaisance.
- [Note: Recreation areas should be changed in the GIS dataset from Cummings Lodge–UG Road to Cummings Lodge – Ogle.]

Other Data Collected

- The population within the NDC area is approximately 25,000 and should be increasing given that there are new housing schemes within the area.
- The NDC has seen the growth of small businesses in recent times, including an influx of migrants who work mainly in the bars.
- The major challenge in the NDC is the illegal dumping of garbage along the shore that ends up in the mangroves. A youth group in Plaisance is actively cleaning up the shoreline on a regular basis, but its efforts are not enough to address the garbage problem.
- The increasing use of the Ogle Koker by fisherfolk has decreased its aesthetics with the build-up of shacks and the odor of decaying fish.

1.4.2. Betterhope/LBI NDC

Ecosystem Services Survey

- The NDC monitors the growth of the mangroves within the area and has observed that mangrove growth along the shoreline continues to increase. This has resulted in:
  - An increase in mosquitos that has limited the use of the shoreline for recreation and religious practices. Religious activities have moved to Ogle or Mon Repos, where there is better access and less sand flies and mosquitoes.
  - An increase in garbage dumping within the mangrove area, which is challenging to clean.
  - Blocking access to the sea which affects the fisherfolk.
- There has been a reduction in grazing of animals on the shoreline and adjacent areas.
- There is salt fish drying along the seashore at Montrose.
- There was no new activity within the NDC along the seashore.

Other Data Collected

- The estimated population is 30,000; the population is increasing.
- There was a report of mangrove destruction at Pigeon Island.

1.4.3. Beterverwagting/Triumph NDC

Ecosystem Services Survey

- A new housing area is changing the land use. The NDC is building a housing scheme of 22 lots for residents at Triumph North. The project has reduced the area available for grazing animals.
- There has been a reduction of grazing along the shoreline. The NDC places high fines for stray cattle and many farmers have moved their animals to the back lands which are being developed by the Rural Agricultural Infrastructural Development Project for agriculture purposes.
- There is not much change in the mangrove cover despite the rapid growth in other NDCs.
- There are new businesses in the NDC over the last year, including Chinese supermarkets.

Other Data Collected

- The population is approximately 7,000.

1.4.4. Mon Repos/La Reconnaissance NDC

Ecosystem Services Survey

- A heliport and a hotel are proposed for the sea defense area at Lusignan, with the site already cleared for the construction to commence.
- An application for a coconut processing center in close proximity to the shoreline at Annandale is currently being reviewed by the NDC.
- A new private housing scheme consisting of 17 houses is being constructed close to the sea defense at Good Hope. Eight of the houses are already constructed.
- In Mon Repos, mangrove growth has increased. This has resulted in:
  - The fisherfolk experiencing difficulties in accessing the landing area along the shore.
  - An increase in mosquitoes. The NDC has a fogging machine to help with the mosquitoes, but has not used it due to the lack of knowledge in mixing the chemicals and operating the machine.
  - An increase in garbage within the mangroves.
- There are more than 100 fishing boats within the NDC employing approximately 400 to 500 people, mainly from the villages of Mon Repos and Annandale.
- The NDC has a mangrove plot with an abandoned play park for recreational activities that is overgrown by vegetation. The NDC plans to refurbish the park for recreation and tourism purposes.

Other Data Collected

- The population is approximately 40,000.
- The NDC has an influx of migrants (Guyanese returning from Venezuela as well as Venezuelan citizens), but they are mainly employed in various businesses and are not squatting on the NDC reserves.

1.4.5. Buxton/Foulis NDC

Ecosystem Services Survey

- There is no new mangrove growth within the NDC except for the National Agricultural Research and Extension Institute (NAREI) plots at Mon Repos and Vigilance. However, the growth of mangroves has created security issues for recreational users who are now avoiding these areas.
- There are some changes to the fish landing sites within the NDC as a result of mud accumulating along the shoreline. Boats are now landing at Non Pariel.
- There is less grazing in the NDC as more animals were lost to thieves preying on the animals in the bushes.
- The local squatters vacated the area at the Buxton sea dam on their own accord.
- There is seasonal hunting of the birds on the shore by a few individuals.

Other Data Collected

- The population is approximately 7,000.
- There are new businesses in the NDC, including three Chinese supermarkets.
- More people are involved in fishing as a means of supplementing their incomes since the closure of the Enmore Sugar Estate.
- A group of Venezuelan migrants with Guyanese family members is now squatting at Non Pariel.

1.4.6. Enmore/Hope NDC

Ecosystem Services Survey

- The area is under economic depression due to the closure of the sugar estates. There is more demand on the fishing resources offshore, in the canals and wetlands, and within the mangroves. The wetland is an important source of tilapia that is caught for sale by many residents of the NDC.
- The fisherfolk have good access to their landing area as the access was upgraded by the National Drainage and Irrigation Authority. The improved access is also used by the pin seine fisherfolk.
- There are two to three persons who conduct pin seine fishing using catamarans to access to fishing ground.

- Shrimp is caught by persons dragging seines along the shoreline.
- The mangroves are increasing within the NDC shoreline, which has reduced recreation in the area.
- Some birds, such as the plovers, are caught using wire along the shoreline.

Other Data Collected

- The population is approximately 8,000.

1.4.7. Haslington–Golden Grove NDC

Ecosystem Services Survey

- The NDC is developing the beach at Victoria/Haslington for recreation and tourism purposes. There is a Regional Tourism Committee that is spearheading tourism development within the Region.
- There is an increase in the number of fishing boats within the NDC, which is directly employing more local people. The number of catamaran fisherfolk has decreased as the mud flats have moved beyond the boundary of the NDC.
- The level of grazing within the NDC has decreased with many of the animals moved to the back lands where there are more grazing grounds.
- Two persons in the NDC engage in bee keeping at Golden Grove.
- The locals catch fish in the swamps beyond the sea dam. The catch is offered for sale in and out of the NDC.
- There is a minor increase in squatting near the sea defense.
- Weekend activities such as parties have increased along the seawall area.

Other Data Collected

- The population is approximately 27,000 and is increasing due to new housing schemes within the NDC.
- An old coconut estate is being cleared and prepared for rice cultivation.

1.4.8. Unity/Vereeniging NDC

Ecosystem Services Survey

- More boats are now docking on the Mahaica River due to security concerns arising from the previous docking areas, especially the Helena Landing Site, which now has about 25 boats. There are more than 150 fishing boats in the NDC of different types employing more than 500 people directly in fishing and an additional 500 people in supporting services.
- The fish landing site at the old Mahaica River Bridge falls within the Woodlands–Farm NDC and not within this NDC. This site has about 15 to 20 boats.

- The two landing sites at Unity should be separated, with the Riverview site at the Mahaica River mouth having about 50 boats, while the landing site at the Unity shoreline has fewer boats (less than 20 boats).
- Grazing within the NDC remains the same; however, the changing land use is detrimental to grazing animals.
- Mangrove growth remains the same and the wood is used by farmers and fisherfolk.
- There is an increasing number of people who hunt iguanas and wild birds on a weekly basis for sale to wild meat enthusiasts.
- The wharf facilities remain the same but there are plans to expand the wharf to facilitate additional development in the area.

Other Data Collected

- The population is approximately 13,000.

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ATTACHMENT A: REGISTRATION SHEET

Attachment A1: Region 1

Name	Designation	Contact Information
Father's Beach VC		
B. Boyer	Farmer	
Steve Goddette		
Romario James		
Celine Van Sluytman	Councillor	On file
Genevieve Van Sluytman	Toshao	On file
Manawarin VC		
Rekem Lyte		On file
Ameir Miller		
Tenessa Miller		
Conan John		
Roland Tobin		
Roxanne Henry		On file
Wanita Lyle		
Menelva Roberts		
Merona Fredericks		
Ian Singh	Teacher	On file
Anika James	Teacher	On file
Taren	Student	On file
Mazema	Student	
Meshella	Student	
Nicola	Student	
Selia	Student	
Lona	Student	
Maritta	Student	
Brinton	Student	
Simon	Student	
Charwayne	Student	
Lewis Miller		
Christopher James	Community Health Worker	On file
L. Lall		
Dwain Vieira		
Ted Fredreicks		

Name	Designation	Contact Information
Reuben Lyte	Farmer	On file
Roy Miller	Farmer	On file
Golin Shew	Teacher	On file
Heidi Martinez	Teacher	On file
Elisha George	Teacher	On file
George	Teacher	On file
Nedera George	Teacher	On file
Violet Samuels	Teacher	On file
Edna James	Cook	
Shermine John	Cook	
Genith Roberts	Teacher	On file
Louyann Henry	Teacher	On file
Melindia Henry	Teacher	On file
Phillip Williams	Teacher	On file
Lovern Williams	Shop Keeper	On file
Waramuri VC		
Learmond Emmanuel	Toshao	On file
Ivan Holmes	Villager	On file
Sharmayne De la Cruz	Councillor	On file
Ernest Boyal		
Derick Henry	Councillor	On file
Santa Rosa VC		
Mary De Silva	CDO	On file
Whanita Phillips	Toshao	On file
Michael Anthony	Councillor	On file
Alopius Daniels	Councillor	On file
Murphy Rodrigues	Councillor	On file
J. Shawn Atkinson	Councillor	On file
Mebach Atkinson	Resident	On file
Tracy Bhojedat- Hetsberger	Councillor	On file
Assakata VC		
Eugene Daniels	Farmer	On file
Henry	Teacher	On file
Margery Jacobs	Farmer	On file
Melissa Richards		On file
Canace Bloomhart		On file
Francine Domingo		On file
Eyon Lucas	Farmer	On file
Donna Charles		

Name	Designation	Contact Information
Mariette Henry		On file
Reno Williams	Logging	
Fazeela Joseph		
Levi Daniels		
Shermela Bloomhunt	Farmer	On file
Sharon Daniels	Farmer	
Rockesha Henry		
Terrence Henry	Farmer	
Mitzi Daniels	Health Worker	On file
Cynthia Conyers	Housewife	
Karen Daniels		On file
Clinton Anthony	Farmer	
Clifton Henry	Farmer	
Alban Cyroms	Farmer	
Cyri Joseph	Farmer	
William Henry	Farmer	
William Conyers		
Warapoka VC		
Nalini Wilson	Teacher	On file
Pamela Williams		
Deon Henry	Farmer	
Marcus Boyal	Farmer	
Duncan Henry	Farmer	On file
Michelle Welcome	Farmer	
Grace Henry	Farmer	
Dave		
Dolly Henry		
Neil Thornhill		
Leroy Henry		
Victor Welcome	Farmer	
Carlene Wilson	Manager	On file
Joseph Boyal	School Teacher	On file
Malini Pierre		
Vashty Rodrigues		On file
Terrence Welcome		
Levi Lucas		
Annika Lucas		

Name	Designation	Contact Information
Three Friends VC		
	Toshao	
Mabaruma Town Council		
Celestine Chacon	Secretary	On file
Maria Basheer	Town Clerk	On file
Egbert Dubrg	Supt. of Works	On file
Chris Phang	Mayor	On file
Aruka Mouth CDC		
Malissa Pritchand	CDC Chairperson	On file
Mario Mc Lennon	Farmer	On file
Elton O' Neil	Fisherman	On file
Shane Yipson	Fisherman	On file
Manuel Rodrigues	Fisherman	
Norris Joseph	Fisherman	On file
Elion Allicock	Fisherman	On file
Randy Webber	Fisherman	
Warell David	Fisherman	
Desmond Joseph	Fisherman	On file
Randolph Webber	Farmer	
Sharmin Joseph	HM (ag)	On file
Smith's Creek CDC		
Leolie Borin	Farmer	
Stanley Sam	Farmer	
Augustine Lockan	Fisherman	
Reynold Santiago	Fisherman	
Jousu Lakan	Fisherman	
Mario Williams	Fisherman	
Clemet Borin	Fisherman	
Wendy Borin	Farmer	
Elizabeth Sam	Crab Catcher	
Celia Lewis	Housewife	
Jermey Bumbury		
Junita Sam		
Elizabeth Lewis		
Lucy Williams		
Ingrid Williams		
Sherman Lewis	CDC	On file
Boodwah Sookdeo		On file

Name	Designation	Contact Information
Morawhanna CDC		
Marlon Smilther	Businessman	On file
Andre Roberts		
Rebecca Roberts		
Melrose Pritchard	Teacher	On file
Susanna Phillips	School Cook	On file
Terrence Rufino	CDC	On file
Sylvia Roberts	Health Worker	On file
Rianna Jaggernath		
Ruben Solomon		
Shanaaz Rufino	Teacher	
Akeem Marks		
Zaheer Khan		
Almond Beach CDC		
Ricardo Thomas	Farmer	On file
Arnold Benjamin	CDC Chair	On file
Alicia France	Teacher	On file
Kistow Augustus	Teacher	On file
Myles Pierre	PAC employee	On file
Ken Joseph	Monitor	On file
Timothy Andrews	Ranger/ Tour Guide	On file
A. Campbell	Ranger	On file
Violet James	Housewife	
Imbotero CDC		
Ashton Williams	Farming	
Patrick Sam	Farming	On file
Jeanette Jack	Poultry Farming	
Mary Anastacio	Housewife	
Indra Harris	Poultry Farming	
Georgia Marley Morphy		
Josephine Martin		
Dolores Anselmo		
Susan Raseo		
Morcoline Martin		
Julio Valenzuela		
Raul Marquez		
Miser Marquez		
Mariani Raseo		
Lisandra Raseo		

Name	Designation	Contact Information
Trecia Jerome		
Norma Santagio		

Attachment A2: Region 2

Name	Designation	Contact Information
Charity/Urasara NDC		
Rameez P. Baksh	Assistant Overseer	On file
Peter Pammoogan	Labourer	On file
Carita Perreira	Market Clerk	On file
Gregory Ryan Van Sluytman	Manager	On file
Tamesh Kishore	Chairman	On file
Samuel Sooklall	Overseer	On file
Deleep Singh	Businessman	On file
Evergreen/ Paradise NDC		
Edmund Price	Checker	On file
Keith Bellfield	Supervisor	On file
Gweneth Mc Farlane		On file
Lionel Boodhram	Chairman	On file
Inez Grant		
Mohamed Ahmad		On file
Kissoonlall Jawakoorlall		On file
Kira Sukhnandan	E.H.A	On file
Wazim Ramdin	E.H.A	On file
Savita Deochan	Overseer E/P NDC	On file
Aldrin Shepherd	Teacher	On file
Yvette Ramnaught	C.E.T.L	On file
Anna Regina Town Council NDC		
Jewan Persaud	Rice Farmer	On file
Rajendra Prabhulall	Mayor	On file
Esther Alves	Environmental Health Asst.	On file
Ravindra Persaud	Environmental Health Asst.	On file
Radika Narish Lall	Municipal Treasurer	On file
Muhammad Rafeeq	Security Guard	On file
Chandanie Kissoon	C/ Secretary	On file
Diane Critchlow	Town Clerk	On file
Bissoon Lalltoo	Ranger	On file

Name	Designation	Contact Information
Rajkumarie Deonarine	Finance Clerk	On file
Rudolph C.G Williams	Deputy Mayor	On file
Dew an Persaud	Councillor	On file
Wazeer Dhanraj	Market Clerk	On file
Aberdeen/ Zorg-en-Vlygt NDC		
Jayashree Persaud	Chairperson	On file
Stephon Vaughn	Councillor	On file
Cromw ell Mentis	Councillor	On file
Sharmen Henry	Councillor	On file
Danieram Singh	Overseer	On file
Hansranie Ow eri Jodhan	Councillor	On file
Kumar Rambo	Furniture Manufacturer	On file
Deodat Persaud	Ranger/ COR	On file
Ghansham Persaud	Councillor	On file
Safeek Mohamed	Councillor	On file
Annandale/ Riverstow n NDC		
Soorsattie Sankar		On file
Marva S. Chappelle		On file
Charran Sarabjeet	NDC Chairman	On file
Esther Connelly	Environmental Health Asst.	On file
Heamw ant Narine	Public Health Inspector	
Seerojanie Singh	Vice Chairperson	On file
Balw ant Singh	G. Fleece	On file
P. Rupnarayan	Market Clerk	On file
T. Daniels	Assistant Overseer	On file
Rockel Williams		On file
Ramkew an Dass		On file
Good Hope/ Pomona NDC		
Andy E. Ramnarine	Teaching (NDC Chair)	On file
Deona Dean	EHA	On file
Yograj Bhow an	CETL (CIIP)	On file
Purandai Rupnarayan	Environmental Health Officer	On file
Rovin Doolara	Ranger Ch/P NDC	On file
Misha Persaud	Overseer Ch/P NDC	On file
Arnold Adams	Vice Chairman	On file

Attachment A3: Region 3

Name	Designation	Contact Information
Wakenaam NDC		
Jeanette Harrylall	Vice Chairperson	On file
S. Saaed Ahmad	Chairman	On file
Yogita Thakur	Overseer	On file
Sabita Persaud	Typist Clerk	On file
Yuyul Chaula	Superintendent of work	On file
Luasieann Whyte	Student	On file
Afera Zafull	Student	On file
Ackbar Alli	Councillor	On file
Lynnell Graham	Environmental Health Asst.	On file
Leguan NDC		
Mahindra Ganpat		On file
Lachhman Dwarkha		On file
Sheik Ayube		On file
M. Phaghu		On file
E. Ayube		On file
E. Ramroop		On file
Fazia Ali		On file
Tuslie R. Singh	Overseer	On file
Jainarine Singh		On file
Balgobin Magon		On file
Mustapha Zaman	Field Foreman N.D&IA	On file
Mora/ Parika NDC		
Phillip France	Councillor	On file
Aleassa Peters	Overseer	On file
Siddique Jameil	Environmental Health Asst.	On file
Resay Rodrigues	Student	On file
Raywatti Outar	Vice Chairperson	On file
Y. Khan	Councillor	On file
Jaideo Sooklal	Farmer/ Cman	On file
Melita Chaitram	Student	On file
Donald Nauth	Councillor	On file
Hydronie/ Good Hope NDC		

Name	Designation	Contact Information
Viola Vaughn	Housewife	On file
Nafleem Phillips	Housewife	On file
Felisha Coleman	Housewife	On file
Yugisthir Hemrup	Farmer	On file
LP Ramotar	Farmer	On file
A. Ragnauth	Farmer	On file
S. Singh	Housewife	On file
Moses Ramjohn	Labourer	
Perasram Persaud	Contractor	On file
Bibi Khadija McLennan	Councillor	On file
Greenwich Park/Vergenoegen NDC		
Steaphen Ramdas	Self Employed	On file
Rameshwar Bajnauth	Asst. Overseer	On file
Mahendra Lall	Joiner/ Councillor	On file
Melecia Washington Wellington	Overseer	On file
Simone Osborne	Environmental Health Asst.	On file
Mickhel McKend	Work Study Student	On file
Michael Adams	Work Study Student	On file
Francis Wright	Councillor	On file
Shavon George		On file
Ann Zelena Ally		On file
Tuschen/Uitvlugt NDC		
Sheldon Alexander	Self Employed	On file
Uma Devi Gajraj	Assistant Overseer	On file
Bibi S. Ambedkar	Overseer	On file
Vishal Ambedkar	Chairman/ Teacher	On file
B. S Nath	Councillor	On file
Samuel Oudhoo	Work Study Student	On file
Karen Persaud	Work Study Student	On file
Revaldo Smith	Work Study Student	On file
Roopnarine Singh	Councillor/ Accountant	On file
Dinesh Prashad		On file
Sue Ann Melville	Environmental Health Asst.	On file

Name	Designation	Contact Information
Shameeza Azad	Environmental Health Asst.	On file
Salima Ali	Councillor	On file
Leotha Greene Watson	Councillor	On file
Stewartville/ Cornelia Ida NDC		
Noel Waithe	Councillor	On file
P. Hinds	Councillor	On file
Oneil A. Dayne	Councillor	On file
Rashree Premnath	Councillor	On file
Lionel Rasul	Councillor	On file
Savitri Gopaul	Overseer	On file
Jainarine Narine	Chairman	On file
Shaneeza Yacoob	Assistant Overseer	On file
Beesham Basdeo	Councillor	On file
Yassim Ali	Councillor	On file
Kocwrilia Persaud	Councillor	On file
Sheik Samad	Councillor	On file
Denesh Narine	Environmental Health Personnel	On file
Hague/ Blankenburg NDC		
John Crawford	Councillor	On file
Marjorie Eversley	Councillor	On file
Vincent Boucher	Councillor	On file
Sandrene McKend	Councillor	On file
Delon Grandison	Councillor	On file
Kamrul Hasan	Councillor	On file
Chaitram Surujpal	Councillor	On file
Ceceline Crighton	Overseer	On file
Deon Dublin	Health Officer	On file
George Langevine	Councillor	On file
Sakeria Henriques	Student	On file
Lois Dash	Assistant Overseer	On file
Kenton Hilliman	Chairman	On file
La Jalousie/ Nouvelle Flanders NDC		
Stacy Deoraj	Typist	On file
Karran Walter	Assistant Overseer	On file

Name	Designation	Contact Information
Rajish Kadarnauth	Chairman	On file
Latchman Khamraj	Overseer	On file
Best Klien/ Pouderoyen NDC		
M.R. Sudama	Farmer/ Councillor	On file
M. Ragnauth	Retired PR	On file
S. Chanballi	Housewife	On file
Rehon Bhair	Vice Chairman	On file
U. Balram	Chairman	On file
V. Yearwood	Housewife	On file
M. Lokhnauth	Housewife	On file
R. Archer	Councillor/ Pastor	On file
Chand	Councillor	On file
S. A. Churaman	Overseer	On file
Aisha Trim	Work Study Student	On file
La Cosy Mason	Work Study Student	On file
N. Subhan	Assistant Overseer	On file
S. Harripersaud	Typist Clerk/ Collector of Rates	On file
Kay Low Koon	Retiree	On file
Suraj Narine	Youth Community Development Officer	On file

Attachment A4: Region 4

Name	Designation	Contact Information
Industry/ Plaisance NDC		
Cloyde Abel	NDC Councillor	On file
R. Ramdass	NDC Councillor/Logistics Manager	On file
Rodwell Lewis	NDC Chairman	On file
Deborah McDowell	Overseer	On file
Monesa Hughes	Asst. Overseer	On file
Rev. Basil Roberts	Superintendent of Works	On file
Dawn Johnson	NDC Councillor	On file
Better Hope/ La Bonne Intention NDC		
Zaman Shaw	Medical Doctor/NDC Chairman	On file
Ramkaran Budhram	NDC Councillor	On file

Name	Designation	Contact Information
Abdool M Razack	NDC Councillor	On file
Leonie Ramnarine	NDC Councillor	On file
S Ramcharan	NDC Councillor	On file
Sheik Samsail	NDC Councillor/Businessman	On file
Beterverwagting/ Triumph NDC		
Nykeen Critchlow	Superintendent of Works	On file
Jimmaul Bagot	NDC Chairman	On file
Mon Repos/ La Reconnaissance NDC		
Ayube Mohammed	Businessman/Chairman	On file
Parisram Ramkisson	Overseer	On file
M.S Baksh	NDC Councillor/Construction Worker	On file
Bisrounai Persaud	NDC Councillor	On file
Sachin Shiwdas	NDC Councillor/Businessman	On file
Sherry Deos	NDC Councillor/Activist	On file
Buxton/ Foulis NDC		
Neirpaul Purai	NDC Chairman	On file
Chetram Dowlatram	NDC Councillor	On file
Chandrawattie Singh	NDC Councillor	On file
Petal Telford	NDC Vice Chairperson	On file
Jackdeep Singh	NDC Councillor	On file
Roger Evelyn	NDC Councillor	On file
Enmore/ Hope NDC		
Aarti Persaud Ugraj	NDC Councillor	On file
Somawattie Mahae	Typist/clerk	On file
Jaydesh Dumay	CIIP Foreman	On file
Ramnarase Tewari	NDC Chairman	On file
Anand Persaud	NDC Councillor	On file
C.B Singh	NDC Councillor	On file
Seogopaul Basdeo	NDC Councillor	On file
Mohadeo Panday	NDC Councillor	On file
H. Persaud	P.R	On file
Mahendra Sharma	NDC Councillor	On file
Haslington/ Grove NDC		
Ingrid Holder	NDC Councillor	On file
Charlotte De Jesus	NDC Councillor	On file
Akesha Layne	NDC Staff	On file
Sandra Sukhu	NDC Councillor	On file
Steve Martins	NDC Councillor	On file
Shaquille Adonis	NDC Councillor	On file

Name	Designation	Contact Information
R. Chanderpaul	NDC Councillor	On file
Maureen Philadelphia	NDC Chairw oman	On file
Avnel Woode	NDC Councillor	On file
Samuel Sandy	NDC Councillor	On file
Yonette Jervis	Overseer (Ag)	On file
Corw in Harry	NDC Councillor	On file
Joy Morgan-Lew is	NDC Councillor	On file
Unity/ Vereeniging NDC		
Atamdeo Persaud	NDC Chairman	On file
Lallbachand Debi	NDC Councillor	On file
Basmattie Singh	NDC Councillor	On file
Natasha Dhaniran	NDC Councillor	On file
Dw arka Roopnarain	NDC Councillor	On file
Rushana Walters	E.H.A	On file
Lemuel Lynch	E.H.A	On file
Diodat Haridat	Overseer	On file

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ATTACHMENT B: IMAGES

Attachment B1: Region 1

Father's Beach VC





Manawarin VC





Waramuri VC





Santa Rosa VC





Assakata VC





Warapoka VC





Mabaruma Town Council





Aruka Mouth CDC





Smith's Creek CDC





Morawhanna CDC



Almond Beach CDC





Imbotero CDC





Attachment B2: Region 2

Charity-Urasara NDC





Evergreen-Paradise NDC





Anna Regina Town Council





Aberdeen-Zorg-en-Vlygt NDC





Annandale-Riverstown NDC





Good Hope-Pomona NDC





Attachment B3: Region 3

Wakenaam NDC





Leguan NDC





Mora-Parika NDC





Hydronie-Good Hope NDC





Greenwich Park-Vergenoegen NDC





Tuschen-Uitvlugt NDC





Stewartville-Cornelia Ida NDC





Hague-Blankenburg NDC





La Jalousie-Nouvelle Flanders NDC





Best-Klien-Pouderoyen NDC





Attachment B4: Region 4

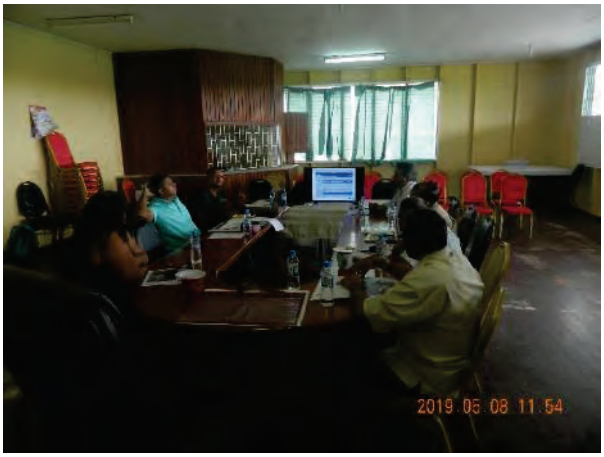
Industry-Plaisance NDC





Better Hope-La Bonne Intention NDC





Beterverwagting-Triumph NDC





Mon Repos-La Reconnaissance NDC





Buxton-Foulis NDC





Enmore-Hope NDC





Haslington-Grove NDC





Unity-Vereeniging NDC





Prepared by:

Environmental Resources Management (ERM)
210 New Market Street
Georgetown, Guyana

Environmental Management Consultants (EMC)
60 Area H Ogle
East Coast Demerara, Guyana

Enhanced Coastal Sensitivity Mapping – Ecosystem Services (Regions 5 and 6) – FINAL REPORT

Esso Exploration and Production Guyana Limited

April 2020

The business of sustainability

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B: Identified Ecosystem Services and Priority Ratings: Region 5 Coastal
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D: NDC Meeting Schedule
E: Validation Data Summary

1. INTRODUCTION

1.1. Overview

This report provides an introduction to the concept and treatment of ecosystem services along the coastal communities in Regions 5 and 6 of Guyana. Ecosystem services are typically defined as the benefits that people obtain from the natural environment as further defined and described in Section 1.2. The report was prepared by Environmental Resources Management (ERM) and Environmental Management Consultants (EMC). The work described herein is supplemental to the Liza Phase 1 Post-Permit Studies for Regions 1-4 requested by the Guyana Environmental Protection Agency (EPA) in the Environmental Permit issued to Esso Exploration and Production Guyana Ltd. (EEPGL) for its Liza Phase 1 Development Project[1].

Along with the Enhanced Coastal Sensitivity Mapping – Biodiversity report and related geospatial mapping (submitted under separate cover), this report is a summary of field studies conducted to verify (i.e., ground truth) selected shoreline and coastal habitat classifications in Regions 5 and 6. The information presented in this report specifically provides for the screening and scoping of ecosystem services utilizing an internationally recognized ecosystem services methodology combined with geospatial analysis, as described in Section 2. The purpose is to provide specific details on coastal communities and their use of coastal resources to better inform EEPGL's oil spill response planning, as well as to provide information for use in future project Environmental Impact Assessments (EIAs).

The information presented in this report is limited to Regions 5 and 6. A similar report for Regions 1-4 has been prepared under separate cover for submission to the EPA as a regulatory requirement. This report covering Regions 5 and 6 is for EEPGL's internal use only.

1.2. Scope Development

ERM and EMC held a coordination and planning workshop in October 2017 in Georgetown, with key stakeholders including Government, non-governmental organizations (NGOs), academics, indigenous community representatives, and other expert entities to discuss the purpose of the Region 1-4 ecosystem services study, its applicability and the proposed methodology. It was determined that a Community Based Participatory Research (CBPR) approach with local communities would be utilized in order to conduct a screening and scoping of ecosystem services. The objective of the study was to provide data to establish a baseline of the relationship between coastal communities and the natural environment. The results of the study are captured in this report, as well as in the Liza Project Geographic Information System (GIS) database, and Liza Project Stakeholder Engagement Plan. The Study Area was defined as the immediate coastal area, up to a distance of 500 meters from the shoreline.

The first phase of the exercise was conducted in November and December 2017 in Regions 2, 3, and 4. The second phase of the exercise for Region 5 and 6 was conducted in January and

[1] Environmental Permit No. 20160705-EEDPF, dated June 1, 2017

February 2018. Local specialists from EMC accompanied by an ERM socioeconomic expert conducted stakeholder meetings with 24 coastal Neighborhood Democratic Councils (NDCs) in Regions 5 and 6 to learn first-hand about their activities related to ecosystem services. Over 168 local community members participated in the meetings, and many from each NDC accompanied the team into the field after each meeting to help visually observe and map the activities.

The team entered data at each meeting directly into handheld tablets linked to the Liza Project GIS database, and also took notes on general comments and observations. The results of these Region 5 and 6 meetings and field observations are described in this report, along with Ecosystem Service-specific maps for each NDC. Map books have been created from the GIS information contained in the database, and are appended to this report. Additionally, integrated map books (including both ecosystem service and biodiversity information) will be included in EEPGL's Oil Spill Response Plan, where necessary.

During May to July 2019, following the screening, scoping, and assessment exercise, the same team of socioeconomic experts conducted a validation effort of the ecosystem services baseline data collected during the previous assessment phase. The team visited the same coastal NDCs, CDCs, VCs, and TCs (the Black Bush Polder NDC in Region 6 was not revisited due to its distance from the coastal zone). This additional validation step enhances the accuracy of the original effort by allowing stakeholders to review and comment on the results of the screening, scoping, and assessment exercise. Any changes or additions to individual ecosystem services from the exercise were documented and larger trends that could have occurred over time as a result of specific ecosystem management interventions (e.g., mangrove programs) or extrinsic factors (e.g., population changes) were identified.

1.3. Collaboration with NAREI

The participation of four officers from the Mangrove Restoration and Management Department of the National Agriculture Research & Extension Institute (NAREI) Mangrove Department ("the Department") for a total of nine days in the ESS work was beneficial to both the ESS Team and the Department, as well as the Local Authorities (NDCs and Town Councils). The ESS Team was able to access information on activities occurring within the mangroves areas of these regions, as well as the concerns of the Department in relation to these activities. Information was also obtained on areas where the Department is/was involved in activities, including monitoring and restoration. The ESS engagement also provided an opportunity for the Local Authorities to identify and discuss issues and concerns relating to the mangroves within their districts. Other benefits included the following:

- The ESS engagements with the Local Authorities provided a forum for NAREI to discuss issues relating to mangroves within districts. For many of the NDCs/Town Councils this was their first direct engagement with NAREI.
- NAREI was able to collect information on mangroves within each district, including mangrove distribution, uses of the mangrove forest, activities being conducted within the mangrove forest, and issues and concerns regarding mangroves.

- The verification exercise provided the opportunity for NAREI to interact with some users of mangrove areas, especially persons involved in fishing and construction and operation of fish ponds within mangrove areas.
- NAREI was able to share information with the Local Authorities relating to mangrove management, including the importance of mangroves, the status of mangroves as protected species, activities which are allowed within mangrove forests, activities which are prohibited and are detrimental to mangroves, and potential economic activities which can be conducted within mangroves forest. Importantly, recommendations on addressing some of the current issues and concerns such as grazing within mangrove forest and clearing of mangrove vegetation were shared. There was good dialogue and sharing of ideas between the Department and the Local Authorities on these areas.
- NAREI was able to share its plans for improvement in mangrove management along coastal areas, especially through more public awareness and information sharing now that there is a dedicated Community Development Officer.
- The communities recognized the importance of mangroves and their legal status as a protected species. There was a call for a balance between enforcement and sustainable use issues for the rural people who have been historically utilizing its many ecosystem services.
- The shrimp farmers of Region 6 agreed to organize themselves into a formal group that could be better engaged by NAREI for the mangrove management and sustainable use of the coastal resources.

1.4. Definition of Ecosystem Services

Ecosystem services are typically defined as the benefits that people obtain from the natural environment, including natural resources that underpin basic human health and survival needs, support economic activities and provide cultural fulfilment.

There are four standard categories of ecosystem services: *provisioning, regulating, cultural and supporting* services, defined as follows.[2]

- **Provisioning services:** The goods or products obtained from ecosystems such as food, freshwater, timber, fiber and other goods.
- **Regulating services:** The benefits obtained from an ecosystem's control of natural processes such as climate, water flow, disease regulation, pollination, and protection from natural hazards.
- **Cultural services:** The non-material benefits obtained from ecosystems such as recreation, spiritual values, and aesthetic enjoyment.
- **Supporting services:** The natural processes such as erosion control, soil formation, nutrient cycling, and primary productivity that maintain other services.

Additional details about the types of services under each category are provided in Appendix A.

[2] Millennium Ecosystem Assessment (MA). 2005. Synthesis Report. Island Press, Washington DC.

2. METHODOLOGY

2.1. Ecosystem Services Screening

A screening exercise was undertaken with the NDCs prior to field observations in order to identify a comprehensive list of the ecosystem services that are potentially present along coastal communities in Regions 5 and 6. This step does not attempt to consider the importance of the services to beneficiaries or the likelihood of the Project impacting them in the event of an unplanned oil spill; it simply asks whether a service is likely to be present or not in each costal area.

For a service to be considered present, it must meet two criteria:

1. Habitats present in the Study Area are believed to provide this service or are similar to habitats elsewhere that provide this service; and
2. People are believed to benefit from the service, either at the local, national, or global level, and/or the Project is expected to benefit from this service.

Appendix A provides the screening checklist that was used by the team when interviewing the NDCs. The table uses a standard list of ecosystem services adapted from internationally accredited sources.[3] All services identified as present or potentially present were then "screened in" to be considered when going into the field for observation, data collection, and mapping of the exact locations where such services exist.

PHOTO 1: INTERVIEWS WITH NDC MEMBERS AND LOCAL COMMUNITY



[3] World Resources Institute (WRI). 2013. Weaving Ecosystem Services into Impact Assessment: A Step-by-Step Method. WRI, Washington, DC.





2.2. Ecosystem Services Scoping

Following completion of the screening exercise, the team and members of the local community used the ecosystem services that were identified as present or potentially present as a guide for the field observations. This step aimed to:

- Establish a complete list of ecosystem service beneficiaries;
- Establish the value of ecosystem services to beneficiaries;
- Identify the habitats and resources that provide ecosystem services in the Study Area; and
- Identify the existing condition and trends of natural resources providing ecosystem services.

The descriptions and examples of "scoped-in" services for the Study Area, based on stakeholder input and field verification information, are provided in the scoping tables and broken down by NDC. During the engagements, the team, where appropriate, also asked for baseline data at the NDC level, including population statistics, numbers of beneficiaries utilizing each service or partaking in various livelihoods, incomes generated from livelihoods, and other socioeconomic baseline data. These data, when available, are captured in the overview of each Region, as well as in the detailed scoping tables. This information can also be found in the Liza Project GIS Database.

PHOTO 2: FIELD OBSERVATIONS WITH NDC MEMBERS, NAREI TEAM, AND LOCAL COMMUNITY



2.3. Ecosystem Services Prioritization

The ecosystem services prioritization has been designed to be consistent with international best practice, using the 2012 International Finance Corporation (IFC) Performance Standards (PS) as guidance. The prioritization process focuses on identifying services which are important to local stakeholders and difficult to replace, where loss or degradation of the service could adversely affect local communities. The prioritization process considered the following criteria:

a) **Importance of ecosystem services** to beneficiaries was assessed according to the following criteria and assigned a rating from low to essential based on:
   - Intensity of use – e.g., daily, weekly or seasonal use; quantitative data were used if available and relevant;
   - Scope of use – e.g., household versus community level, commercial use only, subsistence only or both;
   - Degree of dependence – e.g., contribution of fish to total protein in the diet; contribution of fishing to employment in the community; and
   - The importance expressed by stakeholders and beneficiaries, including cultural and historical importance.

The weight given to each of these components varied slightly depending upon the service, but the importance to stakeholders and beneficiaries take precedence over other criteria where the rating is not clear. Where a service was of greater or lesser importance to different stakeholder groups, two (or more) ratings were assigned so that impacts on these groups can be assessed individually.

b) **Availability of alternatives (replaceability):** Understanding the availability of spatial alternatives is critical to assessing the extent to which a community will be adversely impacted if that service declines due to Project activities. The 'replaceability' of a service was assessed according to the following criteria and assigned a rating from high (many alternatives) to low (few or no alternatives):
   - The existence of spatial alternatives, including both natural replacements (e.g., the replacement of one type of wild food with another) and man-made substitutes (e.g., availability of man-made items as an alternative to handicrafts);
   - The accessibility, cost and sustainability of potential alternatives, including a consideration of other users and the existing status and threats to the resource(s) providing natural alternatives to the service; and
   - Preference / appetite for and cultural appropriateness of alternative services.

After compiling information on the importance and replaceability of each service, these ratings were combined to assign a priority rating to the service (see Figure 2-1 below). **Ecosystem services *with high* or *critical* priority ratings are considered to be 'priority' ecosystem services.** As noted above, some services may have different importance ratings for different

beneficiary groups, and therefore may be rated 'priority' services for some beneficiaries but not for others.

FIGURE 2-1: ASSIGNING A PRIORITY RATING TO ECOSYSTEM SERVICES

		Replaceability of Service		
		High *(many spatial alternatives)*	**Moderate** *(some spatial alternatives)*	**Low or Not Replaceable** *(few to no spatial alternatives)*
Importance of Service to Beneficiaries	**Essential**	*High*	*Critical*	*Critical*
	High	*Medium*	*High*	*Critical*
	Moderate	*Low*	*Medium*	*High*
	Low	*Low*	*Low*	*Medium*

2.4. Ecosystem Services Validation

Following completion of the above described steps, it was decided to revisit each of the NDCs, VCs, CDCs, and TCs to:

- Validate that the information compiled was correct;
- Verify that the Coastal Resources Maps were accurate;
- Collect any new data relating to ecosystems benefits since the previous engagements; and
- Collect updated socioeconomic data.

During the validation exercises, the team presented the findings and maps and asked the stakeholders a series of questions, as detailed below:

- Is the information presented for your district (NDC/TC/CDC/VC) correct?
- If not, what do we need to change/adjust?
- Are the locations for the various services presented on the map correct?
- Are the main economic activities/livelihoods in the area the same as one year ago? If not, what has changed?
- Has there been any notable growth or decline in any particular sector? What sector? What has changed?
- Has there been any increase in coastal resources over the past year? What purpose and where?
- Has there been any new use of coastal resources within the area over the past year? What purpose and where?
- Has there been any change to previous mapped points?

- What is the general description of the change?
- What is the current population estimate or trend (increased or decreased over past year)? What is contributing to the trend?
- Are there any other notable socioeconomic data that you wish to have documented?

The responses received during the validation exercise are incorporated below, presented by region. Raw data as it was recorded can be found in Appendix E: Validation Data Summary. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time elapsed between the 2017/2018 original data collection and the 2019 validation exercise.

3. ECOSYSTEM SERVICES FINDINGS AND PRELIMINARY CONCLUSIONS

3.1. Overview of Findings

Based on the findings of the assessment, provisioning services were the primary service provided by the coastal ecosystem in Regions 5 and 6, accounting for 63.6 percent of the location-specific services identified in the two regions. The most common provisioning services identified include:

- Fish, shrimp, and crabs caught for subsistence or commercial sale;
- Annual and permanent cultivated crops grown for subsistence use and commercial sale;
- Agricultural and grazing, including livestock farming supported by coastal grassland and plants; and
- Animals hunted primarily for food (recreational hunting is covered separately under cultural services).

Cultural services were the second most prevalent ecosystem service, representing approximately 23.3 percent of the location-specific services identified in the three regions. The most common cultural services identified include:

- Cultural value placed on traditional practices such as use of a location for prayer services; and
- Use of natural spaces and resources for local tourism or local recreation, such as use of coastal walls for walking, coastal parks for relaxing, and beaches for recreational fishing;

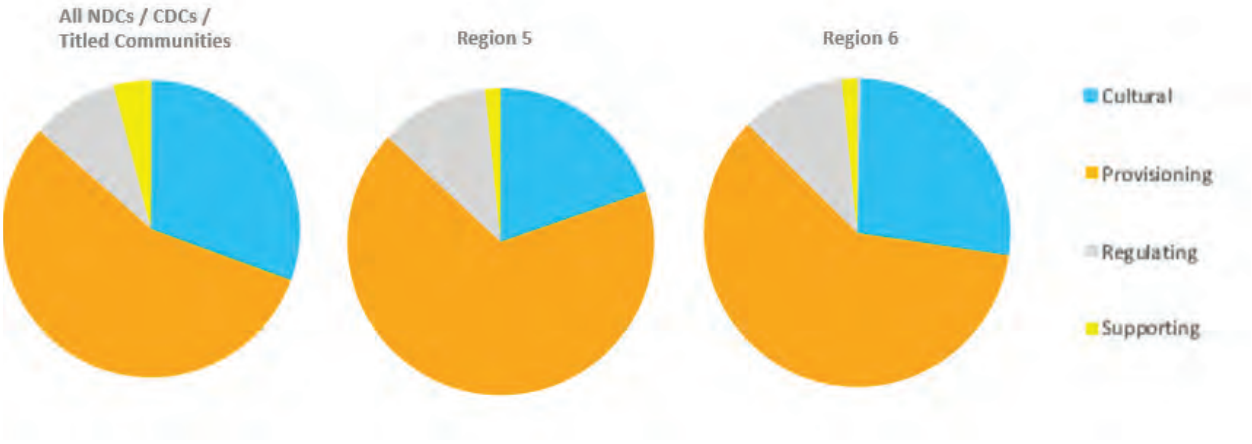
Regulating services were the least prevalent ecosystem services, representing approximately 11.3 percent of the location-specific services identified in the three regions. The most common regulating services identified include:

- Shoreline protection and the role of mangroves in protecting crops, buildings, recreation areas from waves, wind and flooding; and
- Shoreline protection along rivers.

Supporting services, which represented less than 2 percent, are intermediate ecological outcomes that are not directly used, but rather support other ecosystem services. The service “Habitat Provision” is typically an exception, which is sometimes valued as an “end-use” service by stakeholders in addition to its supporting role. Therefore, lack of identified supporting services is not atypical.

Figure 3-1 summarizes the distribution of identified ecosystem services across the four ecosystem service categories for Regions 5 and 6, as well as for all NDCs (including Regions 2 through 6).

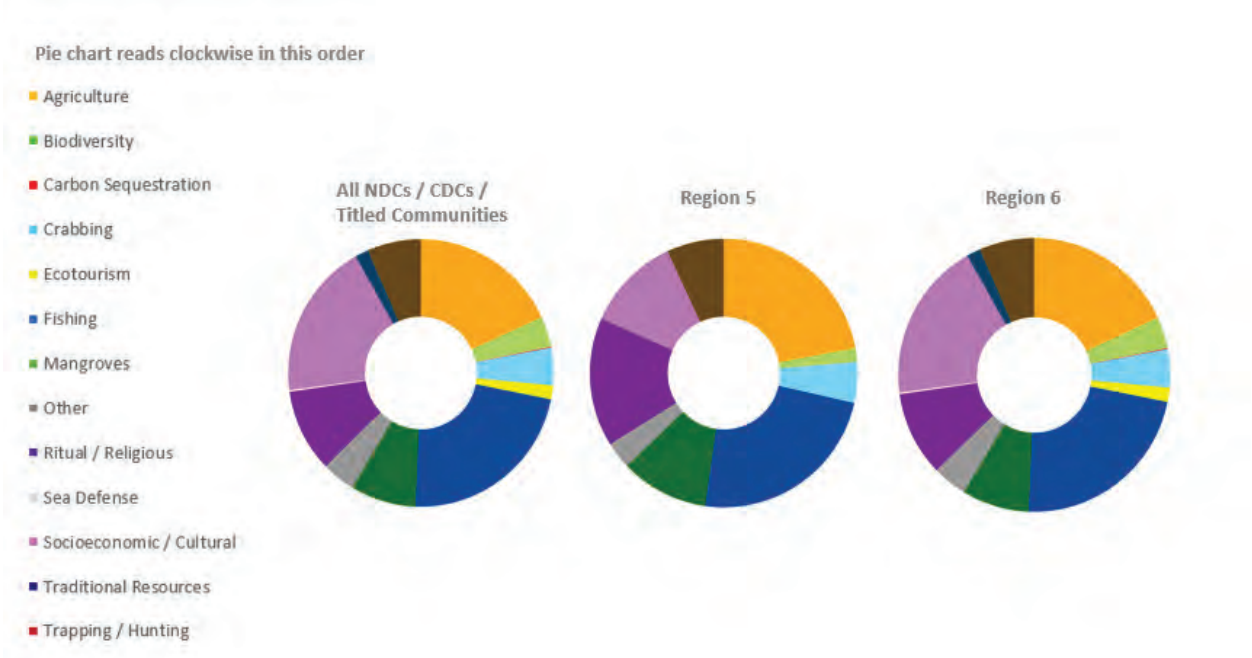
FIGURE 3-1: DISTRIBUTION OF ECOSYSTEM SERVICE CATEGORIES



NOTE: "All NDCs" pie chart includes Regions 1 through 6, which, when combined, indicates provisioning at 55.5 percent, cultural at 31 percent, regulating at 9.5 percent, and supporting at 4 percent.

Figure 3-2 summarizes the distribution of specific ecosystem service types across the categories. The service types match those used in the map books described herein.

FIGURE 3-2: DISTRIBUTION OF ECOSYSTEM SERVICE TYPES



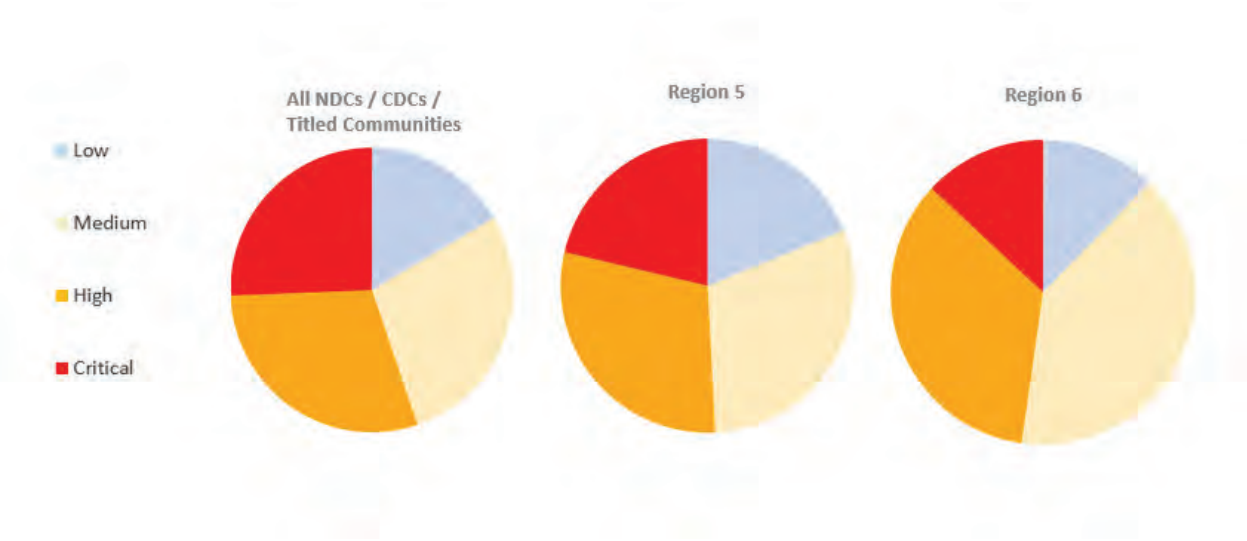
NOTE: "All NDCs" includes Regions 1 through 6, which, when combined, indicates fishing at 23 percent, socioeconomic/cultural at 19 percent, agriculture at 18 percent, ritual/religious at 10 percent, mangroves at 8 percent, trapping/hunting at 7 percent, crabbing at 5 percent, other at 4 percent, ecotourism and traditional resources each at 2 percent, and sea defense and carbon sequestration each at under 1 percent.

3.2. Summary of Findings by Region

Detailed findings for each identified ecosystem service, as well as priority ratings, are provided in Appendices B and C, and are summarized in Sections 4 and 5. As one of the primary goals of this study was to understand the relationship between coastal communities and the natural environment along the entire coast in Regions 5 and 6, the ratings vary widely depending upon the responses from each NDC. For example, in one NDC in Region 6, livestock farming along the coastal wall was reported to be medium priority, whereas in the same NDC at another location, the same service was considered a critical priority. Furthermore, some services may have different importance ratings for different beneficiary groups, and therefore may be rated as high priority services for some beneficiaries but not for others.

Figure 3-3 summarizes the distribution of priority ratings for the location-specific ecosystem services identified.

FIGURE 3-3: DISTRIBUTION OF ECOSYSTEM SERVICE PRIORITY RANKINGS



NOTE: "All NDCs" includes Regions 2 through 6, which, when combined, indicates critical at 26 percent, high at 28 percent, medium at 28 percent, and low at 18 percent.

For overview and general comparison purposes only, the **highest priority rating for each service in each region is included in the table below.** As described in the methodology, services with *high* or *critical* priority ratings are considered to be 'priority' ecosystem services and would be a primary focus in the event of oil spill response. The overview table also helps to visualize which services did not feature as having importance to beneficiaries across the regions.

Table 3-1 summarizes the highest priority rating assigned in each region for each ecosystem service and Figure 3-4 shows a map of where all of the 'priority' (i.e., critical or high rating) ecosystem services are located, regardless of type or region.

TABLE 3-1: HIGHEST ECOSYSTEM SERVICE PRIORITY RATINGS FOR EACH REGION

Ecosystem Service Type	Region 5	Region 6
Provisioning Services		
Marine aquaculture and wild-caught fish & shellfish (food)	Critical	Critical
Cultivated crops	High	High
Livestock farming	Critical	Critical
Food: wild plants and honey	Medium	Low
Food: wild meat	Medium	High
Biomass fuel	N/A	N/A
Timber and wood products	N/A	N/A
Non-wood fibers and resins	N/A	N/A
Traditional medicine	N/A	N/A
Freshwater for household use	N/A	N/A
Freshwater for irrigation use	N/A	Medium
Aquatic transportation/ports	Critical	Critical
Social/Economic Commercial activity	Critical	Critical
Social/Housing	Low	High
Regulating Services		
Global climate regulation	N/A	N/A
Regulation of water timing and flows	N/A	N/A
Flood regulation	Critical	High
Erosion regulation	N/A	N/A
Shoreline protection / Mangrove	Critical	High
Pest regulation	N/A	N/A
Pollination	N/A	N/A
Disease regulation	N/A	N/A
Cultural Services		
Cultural, religious, or spiritual value	Critical	Critical
Aesthetic value of natural landscapes, historical landmarks	N/A	N/A
Tourism and recreation	Critical	Critical
Non-use value of biodiversity	N/A	N/A
Supporting Services		
Habitat provision, coastal protection	N/A	High
Primary production, biodiversity	N/A	N/A
Nutrient cycling	N/A	N/A
Water cycling	N/A	N/A
Soil formation	N/A	N/A

N/A – Not applicable; service not identified in the region

FIGURE 3-4: IDENTIFIED LOCATIONS OF CRITICAL AND HIGH PRIORITY ECOSYSTEM SERVICES – REGIONS 5-6



3.3. Use of Findings

The services rated as "critical" or "high" priority (which constitute Priority Services) priority services within the NDCs are summarized below:

TABLE 3-2: SERVICES RATED AS "CRITICAL" OR "HIGH" PRIORITY WITHIN THE NDCs—REGION 5

NDC Name	Type of Service	Brief Description
Woodlands/Farm	Provisioning	Commercial and subsistence fishing along the coast and in mangroves
	Provisioning	Grazing of livestock Fairfield to Bath, and High Dam to Drill
	Cultural	New beach at Taymouth Manor used for recreational purposes
Hamlet/Chance	Provisioning	Fishing and fisheries landing at the Mahaicony River (Old Bridge); shrimping and crabbing in the mangroves and swamps
	Provisioning	Cultivation of cash crops and fruits throughout the NDC
	Regulating	Shoreline protection with mangrove forest protecting from the impacts of the Mahaicony River
Mahaicony/Abary	Cultural	There is a large beach at Good Faith that is frequented by persons from throughout Region 5 for recreational and religious purposes.
	Provisioning	Commercial and subsistence fishing, shrimping, and crabbing along the coast and in mangroves with fishery landing site at Abary River Mouth
	Provisioning	Grazing of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands.
	Regulating	Extensive area of mangrove forest on the shoreline
Profit/Rising Sun	Cultural	Locals from throughout the West Berbice area utilize the Belladrum Beach to relax, swim, exercise, and socialize daily. More persons visit on weekends including Hindus for religious purposes.
	Cultural	A crematorium at Weldaad is used by the residents of the NDC and Region.
	Provisioning	Boat landings at Belladrum, Profit, and Foulis are used by many fisherfolk.
	Provisioning	Grazing of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands
	Regulating	Existing and new growth of mangroves protecting the shoreline from the impacts of the sea
Seafield/Tempie	Provisioning	Fisherfolk use the fishing landing sites at Jacoba and Seafield and local communities fishing and shrimping in mangroves and swamps
	Provisioning	Grazing of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands
Union/Naarstigheid	Cultural	Locals utilize Onverwagt, Bush Lot and Hopetown for recreational and religious purposes. Bush Lot has a horse racing track close to the shore that is

NDC Name	Type of Service	Brief Description
		used by thousands of persons at least each quarter.
	Provisioning	Commercial and subsistence fishing along the coast and in mangroves with fishery landing site at Bush Lot
	Regulating	Existing and new growth of mangroves protecting the shoreline from the impacts of the sea and drainage pump at Trafalgar aids in flood prevention
Bath/Woodley Park	Provisioning	Fishing and fisheries landing at the No. 12 Village outfall; fishing, shrimping, and crabbing in mangroves and swamps
	Provisioning	Cash crop cultivation in close proximity to the sea dam and on the façade throughout the NDC; animals are also grazed along the shoreline and in mangroves throughout the NDC
	Cultural	Local Hindu religious activities are practiced at Bath, Experiment, and No. 11 & 12
Woodlands/Bel Air	Provisioning	Cash crop cultivation in close proximity to the sea dam and on the façade throughout the NDC
	Provisioning	Cows, goats, and sheep on the shore in the mangroves and on adjacent lands
Zeelugt/Rosignol	Cultural	Religious activities held at three temples located at the shore at Rosignol and No. 2 Village
	Provisioning	Processing facility at Rosignol that processes Manicole Palm for export
	Provisioning	Commercial and subsistence fishing along the coast and in mangroves with fishery landing sites at Rosignol, De Edward, Victory Dam, and Bennet Dam
	Provisioning	Processing facility at Rosignol that processes much of the landed fish catch for export
	Provisioning	Boat building at Victory Dam and De Edward
	Provisioning	Cows, goats, donkeys, and sheep are grazed along the shoreline and in the mangroves
	Provisioning	River transportation wharf used by more than 1,000 persons daily and Berbice River Bridge used by thousands of Guyanese daily

3.3.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 5 is fishing in the sea and in the mangroves along the coast. The main commercial products from the sea include many types of catfish, snapper, bangamary, butterfish, mullet, snook, and trout. Some shrimping also occurs in selected areas, sometimes close to the shore. Mangroves provide an important nursery function and provide habitat for a number of commercial fish and shellfish species. The natural ponds and drainage channels receive ocean water during the spring tide, which contains young shrimp and fish species that are looking to migrate into less salty water until they mature into adulthood. These are harvested by persons for both commercial and subsistence purposes.

Crab catching is also done in the mangrove areas. Crabs are caught in the period July to August during their spawning season in areas where they are available. Some persons catch crabs throughout the year by hunting them in the mangroves. The sea crabs are found in small puddles left on the mudflat when the water recedes. The system of rivers is also critical to the growth of the rich biodiversity of the sea. The Mahaica, Mahaicony, Abary, and Berbice rivers provide spawning grounds, shelter, and nutrients for aquatic life.

Housing is the main activity on the coastland, followed by agriculture. Communities along the coast engage in subsistence farming of vegetables and fruits. Commercial farms grow sugarcane, staple grains (including rice), coconuts, and cash crops. Some of the cash crop farming occurs along the sea defense area.

The scale of livestock farming ranges considerably across communities in Region 5, depending on the level of crop cultivation - since this restricts grazing grounds. Some households keep a few chickens, pigs, sheep, goats, and cattle for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be either dual purpose or specialize in dairy or beef. There is also large-scale rearing of sheep and goats, which primarily graze at the shoreline areas.

A limited number of residents in Region 5 are engaged in honey production. While mangroves provide the habitat for honey production, it is not common in Region 5 despite the fact that many people interviewed understood how honey production could be a major source of income. The bees provide a critical service of pollination for the cash crop farmers whose produce is highly valued in the economy. However, there is only one large producer and a few smaller ones who are making use of this service.

A small number of households utilize various types of meat (including iguana, etc.) for subsistence, whether they hunt it themselves or purchase it. Persons are engaged in hunting of wild animals which are sold throughout the region. Bird hunting is common by wire, shotgun, or nets and is a major source of food or income in the area, with birds sold openly in local markets.

Some wood and non-wood fibers, including mangrove trees and coconut husks, are used in handicrafts and household items in some of the coastal communities, although this is not extensive. Mangrove bark is used in a limited amount for tanning. The buttonwood tree of the mangrove forests is used by the cash crop farmers as a prop for vines and fence posts. Fisherfolk use the white mangrove for fish poles, which they refer to as “cedar.”

Potable water is available for communities from groundwater and many residents harvest rainwater. A few persons rely on the canals for household purposes. Transportation is mainly land-based along the coast, except for a few instances when the sea coast is used.

3.3.2. Regulating Services

The majority of the shoreline of Region 5 is a mixture of mud or sand/shells. This shoreline has a first line defense of mangroves to buffer the wave action of the sea. Mangroves play a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. Short tracks of riprap sea defense exist in a few of the NDCs.

The NAREI mangrove re-growth program has resulted in significant mangrove population in the Bel Air – Mon Choisi area. However, these have increased concerns over the nuisance of sand flies and mosquitoes. Residents are aware of the importance of mangrove in coastal protection and report that they have reduced activities that can negatively affect growth.

Natural shoreline protection services can be replaced by man-made engineering solutions, if needed. However, these are generally expensive to build and maintain over time.

3.3.3. Cultural Services

The Hindu population visits the shoreline for their traditional daily or weekly early morning prayers. More recently, daily visits have been reduced for the majority, with most persons conducting prayers on Fridays or Sundays at the places with beaches or access to the shoreline. The Hindu tradition of planting prayer flags at various points along the shoreline, typically associated with shore access, is a significant practice. On occasions, the beaches will be used by Christians for baptism services. These natural spaces with cultural, spiritual or religious importance are considered “living heritage,” particularly for Hindus.

There are a few areas along the shoreline which locals utilize for recreation, including walking, running, kite flying, and general recreation. Some persons will venture out of the NDC or will have visits from other NDCs, depending on the shoreline or beach in the area. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors.

3.3.4. Supporting Services

The natural processes such as soil formation, nutrient cycling, erosion control, and primary productivity are likely in the region. This is evidenced by the excessive expanse of natural sea defense supported by mangroves. The processes of soil formation and nutrition cycling are constant in the region, as areas are constantly being eroded or built up by sediments. The mangrove growth rapidly follows the buildup of sediments giving further protection to the natural shore. However, it should be noted that during the engagement, the existence of these supporting services was not reported.

3.4. Use of Findings

The findings of the ecosystem services assessment provide an improved understanding of the specific locations where priority ecosystem services are present along the coast, and this information can be used to support the update of EEPGL’s OSRP (i.e., with respect to prioritizing response activities in the event of an oil spill) to include Regions 5 and 6, if necessary. In addition, the data can be leveraged for future EIAs and for ethnographic analysis, where understanding how stakeholders view their relationship with the natural environmental may be required.

4. REGION 5 COASTAL ECOSYSTEM SERVICES FINDINGS

4.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 4-1: POPULATION ESTIMATES - REGION 5

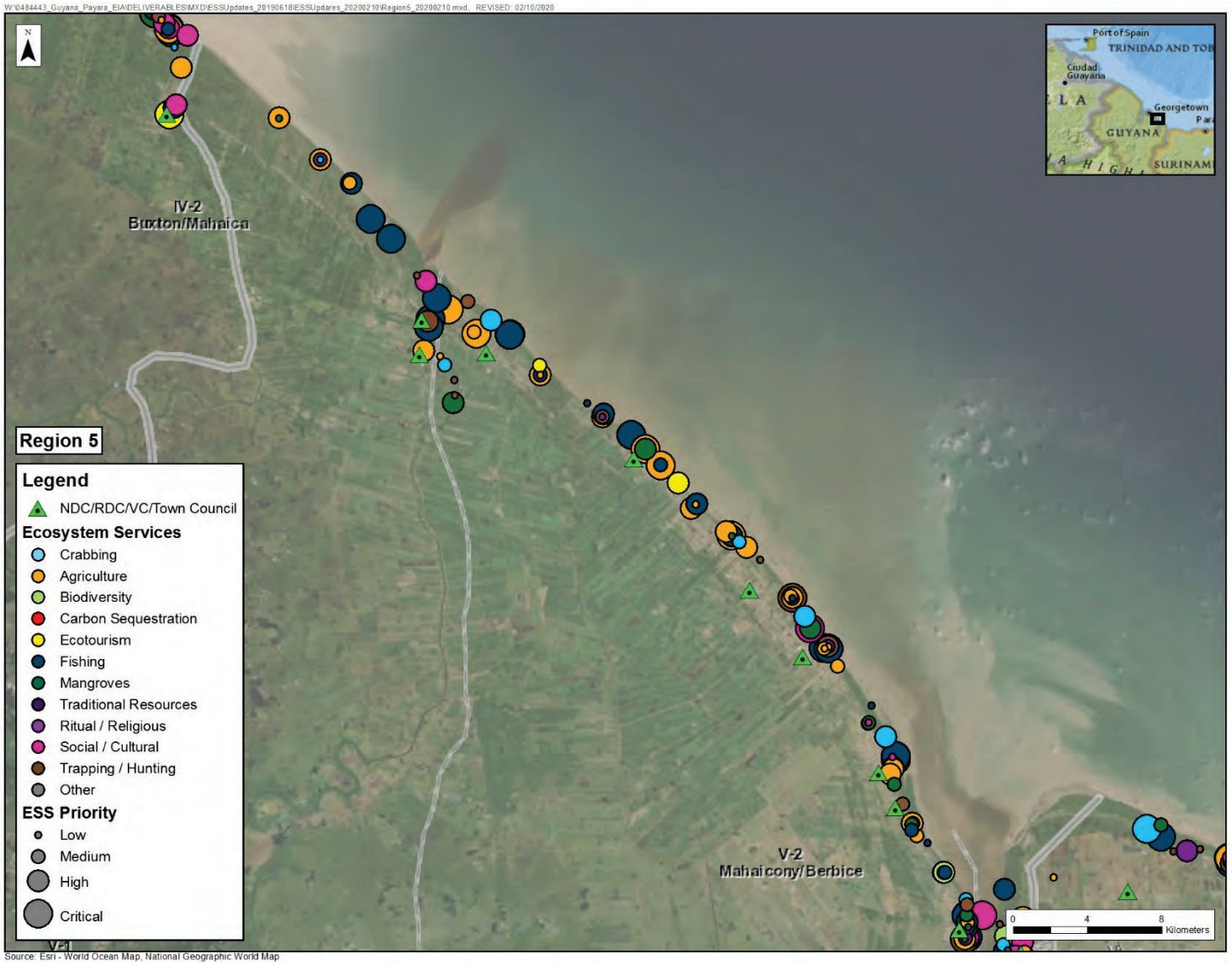
NDC Name	Population Estimate
Woodlands/Farm	20,000
Hamlet/Chance	1,500
Profit/Rising Sun	7,500
Mahaicony/Abary	8,000
Union/Naarstigheid	15,000
Seafield/Tempie	5,000
Bath/Woodley Park	18,000
Woodlands/Bel Air	1,200
Zeelugt/Rosignol	2,000

4.2. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix B.

Figure 4-1 shows the shows the ecosystem service locations identified by the Region 5 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol)—critical, high, medium, or low—utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 4-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 5



5. REGION 6 COASTAL ECOSYSTEM SERVICES FINDINGS

5.1. Population

Population estimates are based upon data provided by NDC leadership during the ecosystem services-related engagements.

TABLE 5-1: POPULATION ESTIMATES—REGION 6

NDC Name	Population Estimate
Ordinance/Fort Lands	8,500
Kintyre/No.37	1,000
Gibraltar/Fyrish	5,600
Kilcoy/Hampshire	25,000
Rose Hall Town Council	15,000
Port Mourant/John	16,000
Bloomfield/Whim	4,000
Lancaster/Hogstye	2,500
Black Bush Polder	4,500
Good Hope/No.51	2,354
Macedonia/Joppa	3,535
Bushlot/Adventure	6,000
Maida/Tarlogie	3,500
No. 52/No. 74	20,000
Corriverton Town Council	18,000

5.2. Summary of Findings

The services rated as “critical” or “high” priority (which constitute Priority Services) within the NDCs are summarized below:

TABLE 5-2: SERVICES RATED AS “CRITICAL” OR “HIGH” PRIORITY WITHIN THE NDCs—REGION 6

NDC Name	Type of Service	Brief Description
Ordinance/Fort Lands	Provisioning	Wharf at Canje Bridge facilitating transport of building supplies (stone, steel and sand) and boat repairs, sawmill at Sheet Anchor
	Provisioning	Fishing and fisheries landing at Sheet Anchor, Cumberland and Seawell
	Provisioning	Significant livestock population grazing along the shore area
	Provisioning	Informal housing at Sheet Anchor and Cumberland

NDC Name	Type of Service	Brief Description
	Supporting	Mangroves provide habitats for wild bees, birds, crabs, fish, and shrimp
Kintyre/No.37	Provisioning	Numerous ponds both natural and man-made being used for shrimp and fish including tilapia and mullet
	Provisioning	Significant crab catching throughout the year
	Provisioning	Significant grazing of livestock along the shore area
	Provisioning	CXG Shorebase in Seawall and Wharf on Crab Island
	Provisioning	Clay along shore area harvested for clay brick making
	Regulating	Extensive area of mangrove forest used as shoreline and coastal protection; drainage pumps are installed at Borlam Dam
	Cultural	Cemetery located in close proximity to the seashore
Gibraltar/Fyrish	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
	Provisioning	Animal grazing pastures in mangroves and in pasturelands in the NDC
Kilcoy/Hampshire	Provisioning	Significant crab catching throughout the year
	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC
	Provisioning	Large landing site at Albion for commercial artisanal fishing boats
	Provisioning	Large-scale poultry farms along the sea shore at Kilcoy and Chesney; cattle also grazed along the seashore and in mangroves
	Provisioning	Cultivation of cash crops and fruits along the shoreline
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
Rose Hall Town Council	Cultural	The Rose Hall beach is utilized for recreational and religious purposes by hundreds of persons on a daily basis
	Cultural	The religious activities of the Hindus are held at the beach, which provides space and privacy
	Provisioning	Beach used as landing site for fishing boats
	Provisioning	Pin seine fishing conducted along shoreline area by locals
Port Mourant/John	Provisioning	Significant livestock population grazing along the shore area
	Provisioning	A large poultry farm exists at John with over 5,000 chickens
	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC with

NDC Name	Type of Service	Brief Description
		a fishing landing site at the Port Mourant Outfall
	Cultural	Babu John Crematorium at Tain has national significance
Bloomfield/Whim	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC and boats dock along coast
	Provisioning	Cash crop cultivation in close proximity to the sea dam at Whim & Letter Kenny
	Provisioning	A Guyana Water Incorporated (GWI) water well and pump system is located in Letter Kenny in close proximity to the seashore
	Regulating	Mangrove forest covers most of the shore with new growth in some areas
	Cultural	Religious activities are held at Whim to Letter Kenny, including a cemetery
Lancaster/ Hogstye	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC and fishing boats use Hogstye/Adventure outfall
	Provisioning	Cash crop cultivation in close proximity to the sea dam throughout the NDC
Black Bush Polder	Regulating	Two drainage outlets at No. 43 and at Adventure
Good Hope/No.51	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC
	Provisioning	Catching of crabs, fish and shrimp in the mangrove forest on a weekly basis
	Provisioning	Hunting of iguanas in mangroves for meat and for sale by persons from the NDC and wider Region 6
	Regulating	Mangrove coverage is increasing throughout and is important to protecting the shoreline
Macedonia/Joppa	Provisioning	Significant boat building at No. 43
	Provisioning	Livestock grazing along the shore area throughout the NDC
	Provisioning	Fishing and fisheries landing at No. 43 and Eversham, and fishing and crabbing in mangroves and fish ponds
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
Bushlot/Adventure	Regulating	Two drainage outlets at No. 43 and at Adventure
	Provisioning	Cash crop cultivation in close proximity to the sea dam on private lands and on reserves at Bushlot–Friendship
	Provisioning	Fishing and crabbing in mangroves, swamps, and communal fish ponds; privately owned shrimp ponds and landing sites for commercial artisanal fishing boats at Adventure and Bushlot/Kildonan

NDC Name	Type of Service	Brief Description
	Cultural	Recreation and religious activities at the Bushlot beach by hundreds of persons on a weekly basis
Maida/Tarlogie	Provisioning	Natural and man-made shrimp/fish ponds on the shore area throughout the NDC; crabbing in the mangroves for sustenance and recreation
	Regulating	Extensive area of Mangrove forest used as shoreline and coastal protection
	Provisioning	Grazing of more than 1,000 animals on the dam and in the mangroves at Ellington Park, Philippi and Kilmarnock; there are also small farms adjacent to the sea dam where cash crops and fruits are planted
	Provisioning	Boats landing at Tarlogie, Maida and Kilmarnock
No. 52/No. 74	Provisioning	Significant commercial fishing and fisheries landing at No. 66 and No. 65 and catching fish, shrimp, and crabs in mangroves and along the shoreline
	Provisioning	Construction of a fish processing plant approximately 10 meters from the No. 65 Outfall
	Provisioning	Cash crop cultivation along most areas of the shore and on sea dam on private lands with coconuts and other crops
	Provisioning	Significant boat building activities at No. 66
	Cultural	Significant recreational activities at the No. 63 beach—the most popular and widely used beach in the country—as well as at No. 69 and No. 70 beaches
	Cultural	Religious activities along the shoreline of the NDC, especially at No. 63 and No. 73 villages
Corriverton Town Council	Provisioning	Wharves facilitate the movement of people and cargo between Guyana and Suriname daily, as well as between the Region and other parts of Guyana
	Provisioning	Significant livestock population grazing along the shore area
	Provisioning	The shoreline at the central area of the Township (No. 78 Village) is utilized for recreational purposes.
	Provisioning	Significant fishing and fisheries landing, and boat building, at No. 79 and other areas
	Provisioning	Informal housing (squatting) along the shoreline of Line Path, Dukestown, Scottsburg, and No. 78 and No. 79 villages
	Cultural	Religious activities held in the area at Line Path, Scottsburg, and Spring Garden

NDC Name	Type of Service	Brief Description
	Cultural	Tour operators who provide trips along the Corentyne River with fishing options

5.2.1. Provisioning Services

The primary ecosystem service along the coastal zones in Region 6 is fishing in the sea and along the shore in close proximity to the coastal mangroves. The main commercial products from the sea include many types of catfish, snapper, bangamary, butterfish, mullet, snook, trout, and 'sardines'[4]. There are almost 1,000 fishing boats in the region, making the fishing occupation a critical one for the economy. The sardines are caught in the Corentyne River in seasons. The fisherfolk utilized the Chinese seine for shrimping in the Ocean. Coastal shrimping is done by the use of small seines pulled by two persons on the near shore where sandy beaches occur.

The abundant mangrove forest provides an important nursery function and habitat for a number of commercial fish and shellfish species including tilapia, mullet, shrimp, and the sherriga. A widespread practice is allowing seawater to flow into ponds, where it is kept for the growth of black belly shrimp and some fish species. Ponds are both natural and man-made and the species harvested are in much demand by the local people. This practice is dominant throughout the region.

Crab catching is also done in the mangrove areas. Crabs are caught in the period July to August during their spawning season in areas where they are available. Some persons catch crabs throughout the year by hunting them in the mangroves. The sea crabs are found in small puddles left on the mudflat when the water recedes. The system of rivers is also critical to the growth of the rich biodiversity of the sea. The Mahaica, Mahaicony, Abary, and Berbice Rivers provide spawning grounds, shelter, and nutrients for aquatic life.

Region 6 is a major agricultural production hub, with its farmlands extending to the shoreline with cultivation of cash crops, fruits, and coconuts. Agriculture plays a dominant role in the economy, with much of the produce taken to Georgetown. Many farmers also keep livestock including pigs, sheep, goats, chickens, and ducks. Some households keep a few of these animals in their yards for household consumption and sale of any excess product. Larger operations can have dozens of heads of cattle and may be either dual purpose or specialize in dairy or beef. A lot of grazing occurs along the shoreline area, especially by sheep and goats. Some farmers graze their animals in the backlands during the out of crop period for rice, but once cultivation recommences, these are returned to the shore.

In this region, only a small group of people take advantage of the numerous benefits of the mangroves. Many persons are afraid of the bees and keep away from them. The bees provide a critical service of pollination for the cash crop farmers, whose produce is highly valued in the economy but undervalued in the community.

[4] The species is referred to as sardine by the locals but may not be the sardine species.

Many persons in the various NDCs hunt iguanas and other form of wildlife. In Corriverton, rabbits are hunted for their meat, along with other small mammals that move to the shoreline from the sugar cultivation areas. The hunting of shorebirds with nets, wire, and shotgun is a significant activity for locals. The bird meat is normally sold in the market and is in high demand, especially from overseas-based Guyanese returning home. However, this activity is treated as illegal in the No. 63 Beach area and hunters can be arrested. Bird hunting is more prevalent on remote mudflats where birds gather to feed. Some birds are also captured at the fish ponds, where they feed on the fish and shrimp.

5.2.2. Regulating Services

For most of the region, there is a naturally-built sea defense consisting of a mixture of clay or sand/shells. Most of this shoreline has as a first line of defense in the form of the mangroves - to buffer wave action. The large expanse of mangroves plays a critical role in maintaining coastal stability and protecting inland areas from waves, wind, and flooding from storms. The shoreline is being eroded in some areas while accretion is evident in others, bolstered by new mangrove growth. Short tracks of concrete and riprap sea defense exist in a few NDCs, where the wave action would have broken down the natural sea defense.

The NAREI mangrove re-growth programs are active in a few of the NDCS of Region 6, in areas such as Wellington Park. Some re-growth areas are being affected by erosion within this region. There are plans for extending mangrove restoration activities within the region and the mangrove restoration project has been well received by the NDCs and accepted by many locals; as such, activities which could be detrimental to mangroves have been drastically reduced.

5.2.3. Cultural Services

The region has the most popular beach in the country, the No. 63 Beach, which is utilized daily and especially on weekend for recreational purposes. It is frequented by thousands of persons from throughout the country on Easter and other holidays. It is also utilized by Hindus and Christians for various spiritual and recreational purposes. There are many other locations that are frequented by the Hindu population for their traditional daily early morning prayers and religious functions. Most persons frequent the sea or areas close to the sea on Fridays or Sundays. In a few of the NDCs, there are temples in close proximity to the sea that are frequented on a regular basis. These natural spaces with cultural, spiritual or religious importance are considered “living heritage,” particularly for Hindus. The most prominent of these is the Hindu tradition of planting prayer flags at various points along the shoreline – most typically associated with shore access.

The community recognizes the value of their beaches and shoreline areas within their NDCs which are used for recreation, including walking, running, kite flying, and general socialization. Many persons will visit areas outside of their NDC to locations that provide better access to the shoreline with beaches for their own purposes. Views of natural landscapes and landscape features, including river and ocean views, are highly valued by local communities and visitors. The Town Council of Rose Hall Town has plans to invest in its beach that is a popular spot for

recreational activities. The Town Council of Corriverton has plans to erect a boardwalk along a portion of its sea defense to promote tourism in the town. Further improvements to facilitate tourism are planned for the No. 63 Beach.

5.2.4. Supporting Services

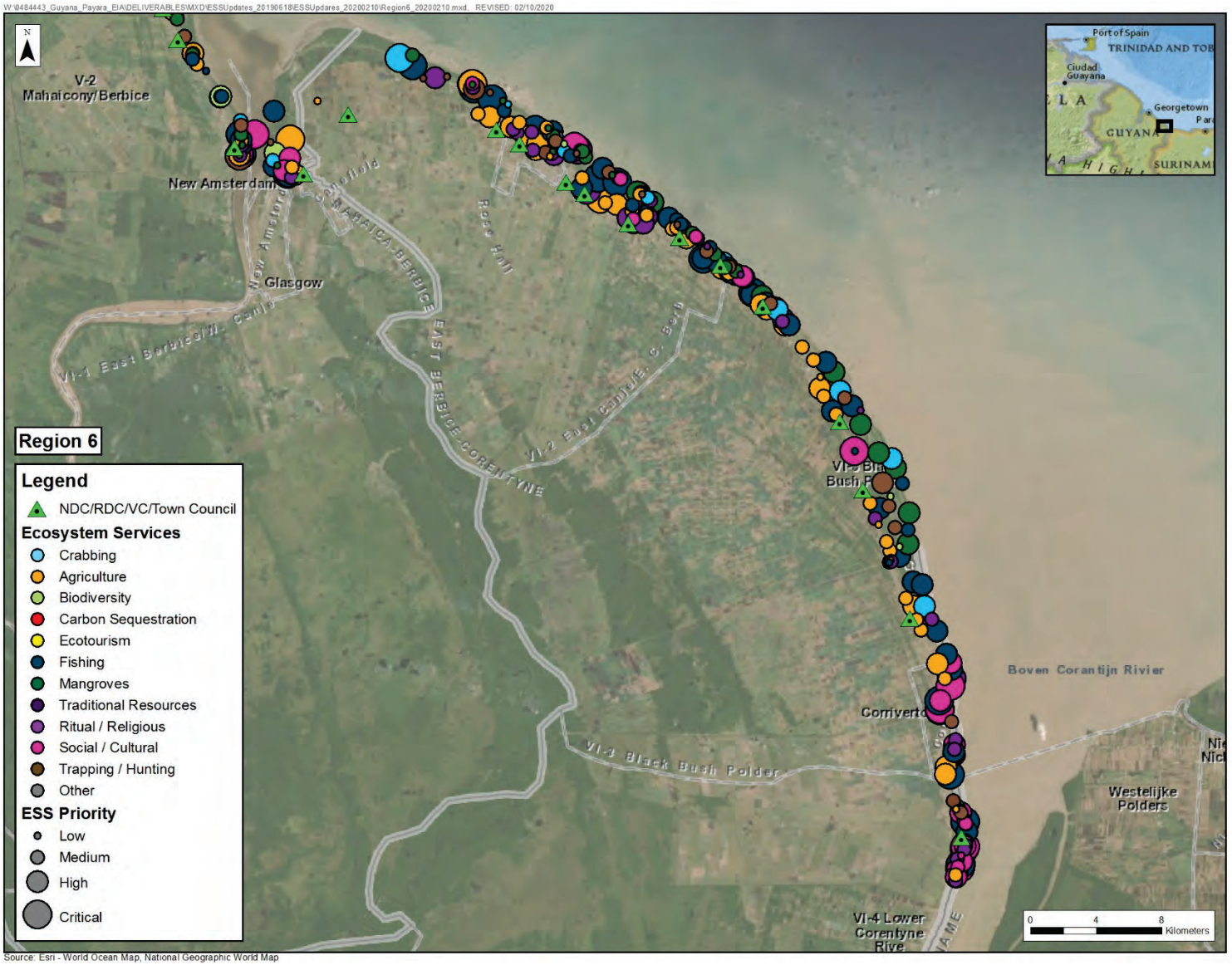
The natural processes such as soil formation, nutrient cycling, erosion control, and primary productivity are likely in the region. This is evident by the excessive expanse of natural sea defense supported by mangroves. The processes of soil formation and nutrition cycling are constant in the region, as areas are constantly being eroded or built up by sediments. The mangrove growth rapidly follows the buildup of sediments, giving further protection to the natural shore. However, it should be noted that during the engagement, the existence of these supporting services was not reported.

5.3. Detailed Findings

Detailed information on all ecosystem services scoped in for the Study Area are listed by NDC and provided in the scoping tables located in Appendix C.

Figure 5-1 shows the ecosystem service locations identified by the Region 6 NDC members and local communities during the engagement process and which were mapped during the field observations. They are displayed by ecosystem service (color of symbol) and priority (size of symbol) – critical, high, medium, or low – utilizing the methodology outlined in Figure 2-1. Detailed maps by NDC are provided in the ecosystem services map book (appended to this report).

FIGURE 5-1: IDENTIFIED LOCATIONS OF ECOSYSTEM SERVICES – REGION 6



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APPENDIX A

Screening Checklist

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Ecosystem Service	Description, Examples
Provisioning Services	
Food: wild-caught fish and shellfish & aquaculture	Fish caught for subsistence or commercial sale; Fish, shellfish, and/or plants that are bred and reared in ponds, enclosures, and other forms of freshwater or saltwater confinement for harvesting
Food: wild plants, nuts, mushrooms, fruit, honey	Fruit, nuts, wild plants, etc. collected in natural areas for consumption or sale
Food: wild meat	Animals hunted primarily for food (recreational hunting is covered separately under cultural services)
Food: cultivated crops	Annual and permanent crops grown for subsistence use and commercial sale
Biomass for livestock production	Sedentary and nomadic livestock farming supported by native forage plants
Biomass fuel	Wood, dung and plant matter collected for charcoal or fuel
Timber and wood products	Wood collected for local use or for sale as timber, wood pulp, paper – wood is used in house construction (importance varies by community)
Non-wood fibres and resins	For example, cane, palm, straw, cotton, hemp, twine and rope, natural rubber
Freshwater - household use	Freshwater for bathing, drinking, laundry, household use
Freshwater - irrigation & industry	Freshwater for irrigation or industrial use
Natural medicines, pharmaceuticals	Natural medicines, biocides, food additives, pharmaceuticals and other biological material for commercial or domestic use
Ornamental resources	For example, pelts, carved or decorative animal products, live animal trade
Genetic resources	Genes and genetic information used for animal breeding, plant improvement, and biotechnology
Regulating Services	
Regulation of air quality	The influence ecosystems have on air quality by extracting chemicals from the atmosphere (i.e., serving as a “sink”) or emitting chemicals to the atmosphere (i.e., serving as a “source”)
Climate regulation: global	Vegetated areas sequester CO_2, with implications for global climate change
Climate regulation: local	Regulation of temperature, shade air, and quality by vegetated areas
Regulation of water timing and flows (including flood regulation)	Influence ecosystems have on the timing and magnitude of water runoff, flooding, and aquifer recharge
Water purification and waste treatment	Role played by vegetation in the filtration and decomposition of organic wastes and pollutants and the assimilation and detoxification of compounds
Shoreline protection	Role of natural habitats (e.g., wetlands, beaches, reefs) in protecting crops, buildings, recreation areas from waves, wind and flooding from coastal storms
Fire regulation	Regulation of fire frequency and intensity (e.g., dense forest can provide firebreaks)

Ecosystem Service	Description, Examples
Pest regulation	Predators from forests, grassland areas, etc. may control pests attacking crops or livestock
Disease regulation	Influence ecosystems have on the incidence and abundance of human pathogens
Erosion regulation	Role of vegetation in regulating erosion on slopes and riparian areas
Pollination	Birds, insects and some small mammals pollinate certain flora species, including some agricultural crops
Cultural Services	
Spiritual or religious value	Natural spaces or species with spiritual or religious importance
Traditional practices	Cultural value placed on traditional practices such as hunting, fishing, crafts and use of natural resources
Tourism and recreation	Use of natural spaces and resources for tourism or local recreation (e.g., swimming, boating, fishing)
Aesthetic value	Cultural value placed on the aesthetic value provided by landscapes, natural landmarks
Educational and inspirational values	Information derived from ecosystems used for intellectual development, culture, art, design, and innovation
Non-use value of biodiversity (e.g. existence, bequest value)	Species and areas valued globally as of high conservation value
Supporting Services[5]	
Habitat provision	Natural spaces that maintain species populations and protect the capacity of ecological communities to recover from disturbances
Primary production	Formation of biological material by plants through photosynthesis and nutrient assimilation
Nutrient cycling	Flow of nutrients (e.g., nitrogen, sulphur, phosphorus, carbon) through ecosystems
Water cycling	Flow of water through ecosystems in its solid, liquid, or gaseous forms.
Soil formation	Natural soil-forming processes throughout vegetated areas

[5] Supporting Services are intermediate ecological outcomes that are not directly used but rather support other ecosystem services. An exception is made for Habitat Provision, which is sometimes valued as an "end-use" service by stakeholders in addition to its supporting role.

APPENDIX B

Identified Ecosystem Services and Priority Ratings: Region 5 Coastal

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TABLE B-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 5 COASTAL

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 26 – Woodlands/Farm							
Shoreline Protection	Regulating	• Extensive area of mangrove forest on the shore line protecting the sea shore from the impacts of the sea. There are lots of birds, crabs, fish and shrimp in the mangroves with crabs and shrimp caught for commercial purposes at De Kindren to Drill area. Mangroves also protect the river defense in the Mahaica River. The sea defense is under threat, with erosion taking place in some sections, particularly Fairfield seashore. • There is beekeeping within the NDC, but not at the shoreline. However, the bees might be feeding within the mangroves at the shoreline.	Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves **ES Linkages:** Agriculture, sea defense	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• Less than 10 persons with over 200 heads of cattle in the area on lands beyond the sea dam and approximately 20 sheep at Fairfield/Bath. • Over 300 heads of cattle grazing at High Dam to Drill with a private farm at Drill.	Sea Dam, Pastures	Local communities, private cattle farmers Agriculture	High	Moderate	**High**
Cultivated Crops	Provisioning	• Rice cultivation close to the sea dam in a few areas. Other crop cultivation in close proximity to the sea dam on private lands and on reserves. Grazing is done on the lands in this area not under cultivation.	Sea dam, cultivated areas	Local farmers, residents Private developers	High	High	**Medium**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Swamp shrimp caught for commercial purposes between De Kindren to Drill area in the drainage canals and sold locally @ 10,000 per bucket. Tilapia, mullet, and other species caught in this area as well with approximately 50 persons weekly visiting the area to harvest. • There is much fishing within the Bellamy Canal that is behind the sea dam. More than 10 persons visit this canal daily during the dry season to catch fish and shrimp. • Fish Landing Site at Mahaica River at Old Bridge, with 10-15 boats. • Some persons also catch crabs in the mangroves.	Marine Habitat and Mangrove Forests	Fisherfolk engaged in: a) Commercial and subsistence fishing along the coast, canal, and in mangroves b) Fishing at the Mahaica River Old Bridge c) Crabbing	a) Essential b) High c) Low	a) Moderate b) Low c) High	**a) Critical** **b) Critical** **c) Low**
Cultural, Religious	Cultural	• Religious activity along the dams leading to the sea shore and on the sea shore where access is provided and the area is clear or with a beach.	Seashore; Sea Dam	Local Hindus	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Many persons hunt along the shoreline for iguanas, labba, and wild birds for subsistence use and sale.	Mangroves, seashore	Local communities	Moderate	High	**Low**
Tourism and Recreation	Cultural	• A new beach at Taymouth Manor is being used for recreational activities. Access to the area is currently a challenge but the NDC is hoping to put the necessary infrastructure in place.	Seashore	Local communities	Moderate	Low	**High**
NDC 27 – Hamlet/Chance							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 30 boats which dock at the Mahaicony River that do commercial fishing at sea. The area also has a few small boats that fish in the river. • Tilapia and mullet are caught in the mangroves by a few persons for sale in the community. • Crabs are caught in the July-August season.	Marine environment; Mangroves; River ecosystem	Local communities and fisherfolk who: a) Utilize the landing site and fishing in the Mahaicony River b) Fish in the mangroves	a) Essential b) Essential c) Moderate	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) Critical** **c) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Fish is caught by lines and nets in the Mahaicony River by more than ten persons daily for subsistence.		c) Crab in the mangroves			
Wildlife: wild meat and song birds	Provisioning	• Iguanas are caught on the seashore and along the banks of the Mahaicony River for sale with each adult going for GYD$3,000–5,000. • Sea birds including curi curi and storks are caught for meat. • Song birds are caught for trade. Birds caught along the shore and river banks include Twa Twa, Grasie, Canary, Red, and Love birds.	Mangroves	a) Local communities who hunt iguanas and sea birds for meat and for sale b) Local communities who catch song birds for trade	a) Low b) Low	a) Moderate b) Moderate	**a) Low** **b) Low**
Cultural, Religious	Cultural	• Religious activity mainly done outside of NDC or along the river with good access.	Seashore; sea dam	Local communities	Low	Moderate	**Low**
Shoreline Protection	Regulating	• Extensive area of mangrove forest protects the local communities from the impacts of the Mahaicony River.	Mangrove Forests	Local communities **ES Linkages:** River Defense	High	Moderate	**High**
Livestock Farming	Provisioning	• A few head of cattle are grazed within the NDC but the main stocks are kept at the backlands where there are pastures.	Pastureland	Local communities	Low	High	**Low**
Cultivated Crops	Provisioning	• Farming of household crops for consumption; banana trees, bora, etc., throughout the NDC	Cultivated Lands	Local communities	Moderate	Low	**High**
NDC 28 – Mahaicony/Abary							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 60 boats in the Abary River that commercially fish in the sea employing over 200 persons. Catch includes bangamary, butterfish, trout, and some shrimp. The number of boats fluctuates with the fish season with more persons putting their boats to work in the summer when the catch is plentiful. The sargassum is a constant bother to the fisherfolk, affecting their nets and their ability to catch fish. There are also numerous wrecks in the area that affect the fisherfolk when the nets get tangled in the wrecks. Drift mud also affects fishing activities • Pin seine fishing done by almost 50 persons on a daily basis along the shore in the NDC. • Hundreds of persons from Regions 4 & 5 catch shrimp and crabs in the mangroves and swamps when in season.	Marine environment; Mangroves; River Ecosystem	Local communities and fisherfolk who: a) Utilize the Abary landing site b) Fish using pin seines c) Shrimping and crabbing in the mangroves **ES Linkages:** Economic shrimping & Crabbing	a) Essential b) High c) High	a) Moderate b) High c) Moderate	**a) Critical** **b) Medium** **c) High**
Agriculture: Apiculture	Provisioning	• Beekeeping in the mangroves with three sets of active hives of about 20 in total observed in Huntley and Airy Hall.	Mangrove Forest	Local communities	High	High	**Medium**
Shoreline Protection	Regulating	• Extensive area of mangrove forest on the shoreline protecting the seashore from the impacts of the sea. Mangroves also protect the river defense along the Abary River. Mangroves are in the increase in the NDC due to natural growth.	Mangrove Forests	Commercial and subsistence fishing along the coast and in mangroves **ES Linkages:** Agriculture, Apiculture, Grazing Fishing Sea & River defense	Essential	Moderate	**Critical**
Tourism and Recreation	Cultural	• There is a large beach within the NDC at Good Faith that is frequented by persons from throughout Region 5 and is used by approximately 50-100 persons per	Coastal and Marine	Local communities in NDC and Region 5 using the beaches in:	a) Essential b) Moderate	a) Moderate b) Moderate	**a) Critical** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		day and more than 50 families on holidays and weekends. This beach is used increasingly as beaches in other NDCs are being covered by mud and taken over by mangroves. • There is a small beach at Abary that is used by several persons in the area.		a) Good Faith b) Abary **ES Linkages:** Religious activity, Fishing			
Religious Activities	Cultural	• More than 10 persons daily and 100 on weekends and religious days used the Good Faith Beach for worshipping. There is also a cremation site at the beach.	Coastal	Local Hindu communities	High	Low	**Critical**
Livestock Farming	Provisioning	• Approximately fifty people graze over 1,000 heads of cows, goats, and sheep and pigs on the shore in the mangroves and on adjacent lands.	Coastal, Pasturelands	Local communities grazing cattle in: a) Abary b) Huntley c) Good Faith	a) High b) Essential c) Essential	a) Moderate b) Moderate c) Moderate	**a) High** **b) Critical** **c) Critical**
Cultivated Crops	Provisioning	• There are a few persons who farm on the sea m and on adjacent lands with mainly cash crops and fruits in Abary.	Coastal, Pasturelands	Local communities	Low	Moderate	**Low**
Wildlife: wild meat and song birds	Provisioning	• Sea birds including curi curi, plover and egrets are caught for meat • Songbirds are caught during the summer months when they are plentiful on the shore and river banks.	Mangroves	Local people	Moderate	Moderate	**Medium**
NDC 29 - Profit/Rising Sun							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 12 boats landing at Belladrum, Profit, and Foulis employing approximately almost 40 persons. Catch includes catfish, bangamary, butterfish, trout, mullet, and some shrimp. The fishing boats move according to the migration of the fish to different fishing grounds. • Fishing and shrimping with 3-5 boats at Weldaad. • Pin seine fishing done by 6 persons on a daily basis along the shore in the NDC.	Marine environment; Mangroves; river ecosystem	Fisherfolk who: a) Utilize the fishing landing site in the Belladrum, b) Utilize the landing site in Profit Foulis c) Utilize the landing site in Weldaad d) Practice pin seine fishing along the shoreline	a) Essential b) High c) High d) Moderate	a) Moderate b) Moderate c) High d) High	**a) Critical** **b) High** **c) Medium** **d) Low**
Food: wild meat	Provisioning	• Iguanas are caught on the seashore along with sea birds including curi curi and wild ducks for meat on a limited basis by a few persons.	Mangroves, shoreline	Local people	High	High	**Medium**
Cultural: Religious	Cultural	• The NDC has a few sites throughout used for religious purposes. A crematorium at Weldaad is used by the residents of the NDC and Region.	Coastal	Hindu rituals at: a) Sea dam in Profit/Foulis b) Sea dam in Weldaad	a) Low b) Moderate	a) Moderate b) Moderate	**a) Low** **b) Medium**
Livestock Farming	Provisioning	• There are more than 100 persons who graze more than 2,000 animals on the shore, in the mangroves, and on adjacent lands with a growing population due to natural increase. • However, there is a reported high rate of thievery of livestock.	Coastal, Pasturelands	Local Communities grazing animals in: a) Profit/Foulis b) Belladrum c) Weldaad	a) High b) Essential c) Essential	a) Moderate b) Moderate c) Moderate	**a) High** **b) Critical** **c) Critical**
Tourism and Recreation	Cultural	• Locals utilize Belladrum Beach with approximately 50 persons per day to relax, swim, exercise, and socialize. More persons visit on weekends including Hindus for religious purposes. The beach is used by many persons and expected to be used by more as a bridge and a new road will be built to access the beach.	Coastal and Marine	a) Local communities using the sea front at Belladrum b) Birdwatching by locals and tourists	a) High b) Moderate	a) Moderate b) Low	**a) High** **b) High**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• There is an increase in bird watching in the area by tourists promoted by the Georgetown-based bird watching groups. Species include curi curi, pellew, and duckla. There are thousands of duckla in the area in the afternoons when the tide is low.					
Shoreline Protection	Regulating	• Extensive area of Mangrove forest at Weldaad shore protecting the sea shore from the impacts of the sea. New mangrove growth is noted in the area. Grazing of animals occurs in the mangroves and may affect the new plants.	Mangrove Forests	Local communities **ES Linkages:** Agriculture, fishing, grazing	High	Moderate	**High**
NDC 30 – Seafield/Tempie							
Food: wild meat	Provisioning	• A few mammals and iguanas are caught on the seashore. Many plover birds are caught using wire along with curi curi and wild ducks for meat.	Mangroves, shoreline	Local people	Low	Moderate	**Low**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are landing sites for fishing boats at Jacoba and Seafield. Catch includes catfish, bangamary, butterfish, trout, mullet, and some shrimp. The mangroves have reduced at Jacoba and more fishing boats are now in the area as the mud is washing away. • In addition, approximately 10 persons catch shrimp, tilapia, coo coo belly, and cufum in the swamp ponds or drainage canals. • Crabs are caught in the season by a numerous persons locally.	Marine environment; Mangroves ecosystem	Local people using the: a) Fishing landing site at Jacoba b) Fishing and shrimping in swamp ponds, mangroves and drainage canals c) Fishing landing site in Seafield d) Mangroves and shoreline area for crabbing	a) High b) Moderate c) High d) High	a) Moderate b) Low c) Moderate d) High	**a) High** **b) High** **c) High** **d) Moderate**
Cultivated Crops	Provisioning	• There are approximately 20 persons in Seafield-Litchfield with cash crop farms on the sea dam and on adjacent lands with mainly cash crops and fruits. Cash crop cultivation is increasing along the sea defense. • Coconut plantations are found beyond the sea dam.	Coastal lands	Local communities	Moderate	High	**Low**
Shoreline Protection	Regulating	• Erosion has significantly reduced the shoreline within the NDC over the years. The area has old sluices that are in the sea approximately 1 km from the present shoreline. • The farmers are fearful of the salt water intruding onto their farms as some persons are cutting the mangroves for their own purposes in No. 42 and No. 37 villages.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation	Moderate	High	**Low**
Livestock Farming	Provisioning	• There are many persons who graze more than 1,500 animals on the shore, in the mangroves, and on adjacent lands. Mainly sheep and goats graze along the shoreline area and the number of animals in the NDC is increasing. Grazing has increased at Ross, Seafield, and Tempie.	Coastal Pasturelands	Local communities grazing animals in: a) No. 37 Village b) Lichfield c) Kingelly d) Seafield	a) Essential b) High c) High d) High	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Critical** **b) High** **c) High** **d) High**
NDC 31 – Union/Naarstigheid							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There is a fishing landing site at Bushlot. Fishing has increased within the NDC with more boats at Bushlot. Catch includes various catfishes, bangamary, butterfish, trout, and mullet. A number of smaller boats catch shrimp. • More than thirty persons are involved in the on land fishing of tilapia and shrimp for commercial purposes.	Marine environment; Mangroves; Drainage canals; Natural ponds	Local people within the NDC who: a) Utilize the landing site at Bush Lot b) Utilize the landing site at No. 29 Village	a) Essential b) Moderate c) High d) High	a) Moderate b) High c) Low d) Moderate	**a) Critical** **b) Low** **c) Critical** **d) High**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		Approximately 10 persons catch shrimp, tilapia, coo coo belly, and cufum daily in the natural swamps, ponds, or drainage canals at Bush Lot, Hopetown, and Lovely Lass. • Crabs are caught in the season and on a regular basis by locals.		c) Fish in the swamps and drainage canals d) Engage in crabbing			
Shoreline Protection	Regulating	• Extensive area of Mangrove forest at Bushlot, Hopetown, and Naarstigheid and new growth at Onverwagt. There is an increase in mangroves, especially at Onverwagt. The extensive coverage of mangroves deters the residents of the NDC from making full use of the sea shore.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Essential	High	**High**
Agriculture: Apiculture	Provisioning	• Beekeeping in the mangroves at Bush Lot, Naarstigheid, Hopetown, and No. 29 Village. • Beekeeping is done Union, Lovely Lass, Onderneeming, Hopetown and No. 29.	**Mangrove Forest**	Local communities engaged in apiculture in: a) Bush Lot b) Hopetown **ES Linkages:** Pollination, Pest control, Mangroves	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
Agriculture, Grazing	Provisioning	• Grazing occurs in many places in the NDC but is more predominant at No. 29 Village and Hopetown with grazing of cattle and other animals. • There are more animals grazing now in the NDC than in 2018. The animals compete with the cash crop farmers for space on the sea dam and reserves.	Mangroves, Sea Dam, Pastures	Local communities, Private cattle farmers who graze animals in: a) No. 29 Village b) Hopetown c) Bushlot **ES Linkages:** Cultivated crops	a) High b) High c) Moderate	a) Moderate b) Moderate c) High	**a) Medium** **b) Medium** **c) Low**
Agriculture, Farming	Provisioning	• Cash crop cultivation in close proximity to the sea dam at Bush Lot, No. 29 & No. 30 villages. Crops include bananas, coconuts, fruits, vegetables, and vine crops.	Sea dam, cultivated areas	Local farmers, Residents	Moderate	Moderate	**Medium**
Religious activities	Cultural	• The religious activities of the Hindus are held at Onverwagt and Bush Lot. A crematorium at Bush Lot is used by the residents of the NDC.	Coastal	Local Hindu communities in: a) Bushlot b) Onverwagt	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Tourism and recreation	Cultural	• Locals utilize Bush Lot, Union, Bel Air, Lovely Lass, and Hope Town Community Centre for recreational purposes. The areas are used by approximately 10-50 persons per day and more on holidays and weekends. Bush Lot has a horse racing track that is used by thousands of persons at least each quarter.	Coastal and Marine, Sand Reef	Local communities in NDC and Region 5 **ES Linkages:** Religious activity, Horse Racing	Essential	Moderate	**Critical**
Wildlife Trapping & Hunting	Provisioning	• Iguanas are caught on the seashore in the August season. Many plover birds are caught using wire in addition to curi curi, stork, egrets, and wild ducks for meat to sell in the market.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Essential	Moderate	**High**
Flood Regulation	Regulating	• Drainage pump installed at Trafalgar/No. 29 Village			Essential	Low	**Critical**
NDC 32 – Bath/Woodley Park							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There is a landing site at the No. 12 Village outfall for boats that engage in commercial fishing in the sea employing over 20 persons. Catch includes queriman, bangamary, butterfish, and some shrimp.	Marine environment; Mangroves ecosystem	Fisherfolk who: a) Utilize the landing site at the No. 12 outfall	a) High b) Essential c) Essential d) Low	a) Low b) Moderate c) High d) High	**a) Critical** **b) Critical** **c) High** **d) Low**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Many persons are fishing in the swamps and the near shore during the out-of-crop season of the sugar estates. It is estimated that 10 persons conduct this activity regularly while during out-of-crop periods it can range from 30-50 persons. Catch shrimp and tilapia daily. • In the summer crabbing seasons, hundreds of persons catch crabs. • One fisherfolk used pin seine along the mudflats for his daily catch.		b) Fish and shrimping in the ponds and swamps c) Crab d) Use pin seines for fishing **ES Linkages:** Economic shrimping & Crabbing			
Religious activities	Cultural	• The religious activities of the Hindus are held at Bath, Experiment, No. 11 & 12 villages along the shore and along the main canal in other areas.	Coastal	Local Hindu communities in: a) No. 12 Village b) Experiment	a) High b) Moderate	a) Moderate b) High	**a) High** **b) Low**
Agriculture: Grazing	Provisioning	• Grazing occurs throughout the NDC and across the shoreline and mangroves with many residents owning animals.	Mangroves, Sea Dam, Pastures	Local communities, private farmers	Moderate	Low	**High**
Cultivated Crops	Provisioning	• Cash crop cultivation in close proximity to the sea dam and on the façade throughout the NDC. Crops include plantains, bananas, coconuts, fruits, vegetables, and vine crops. Some farmers have chickens and ducks.	Sea dam, cultivated areas	Local farmers, residents at: a) No. 12 Village b) Hope	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Shoreline Protection	Regulating	• Extensive area of mangrove forest throughout the NDC. The mangrove protects the mud dams erected for sea defense. Mangroves have been reduced by erosion in some areas in the NDC.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Pollination	Moderate	Moderate	**Medium**
Socioeconomic: Squatting	Provisioning	• Persons squatting along the reserves bordering the sea dam from Bath, Experiment, and Hope mainly due to economic reasons taking advantage of the opportunity to plant crops and keep animals. • There is a lot of squatting along the façade canal throughout the NDC, with the persons engaged in crop farming.	Coastal Habitat	Local persons	Moderate	High	**Low**
Tourism and Recreation	Cultural	• Possible site for picnics in the No. 12 Village.	Shoreline	Local communities	Low	Moderate	**Low**
NDC 33 Woodlands/Bel Air							
Religious Activities	Cultural	• The religious activities of the Hindus are held at No. 6 and 7 and other villages along the main canal bordering the shore.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Agriculture: Farming	Provisioning	• Cash crop cultivation in close proximity to the sea dam and reserves throughout the NDC, except in No. 10 Village, by persons living in close proximity. Crops include peppers, bananas, coconuts, fruits, tomatoes, and carilla. Some farmers have chickens and ducks for home use and sale.	Sea dam; Cultivated areas	Local farmers; Residents	High	Moderate	**High**
Shoreline Protection, Mangroves	Regulating	• Extensive area of mangrove forest throughout the NDC that protects the mud dams erected for sea defense. Grazing occurs in the mangroves and sea dam despite actions taken by NAREI to protect the mangroves. Mangroves were replanted in the area at No. 6 & 7 villages. Some beekeeping is done within	Mangrove Forests	Local communities; Farmers; Beekeepers **ES Linkages:** Fishing, Grazing, Pollination, Beekeeping	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		mangrove at No. 10 Village. Crabs are caught seasonally within mangroves. • There is now mangrove growth throughout the NDC shoreline which has reduced religious and recreational activities along the shoreline. The No. 6 beach is taken over by mangroves and the local people have to travel further to find a beach for recreation.					
Food: wild meat	Provisioning	• Birds are hunted with shotguns by a few hunters on an irregular basis including curi curi, egrets, and wild ducks for meat. Plover birds are caught using wire.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• There are more than 100 persons who graze over 1,000 heads of cows, goats, and sheep on the shore in the mangroves and on adjacent lands. The number of grazing animals in the NDC has reduced due to actions by NAREI.	Coastal, Pasturelands	Local communities in: a) No. 6 Village b) No. 7 Village	a) Moderate b) Moderate	a) Moderate b) High	**a) Medium** **b) Low**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Two fishing boats dock at No. 9. • Numerous persons catch fish and shrimp in the swamps and drainage canals using nets or long seines.	Shoreline, mangroves	a) Fishing boats at No. 9 Village b) Fishing and shrimping in swamps and canals	a) Low b) High	a) High b) High	**a) Low** **b) Medium**
NDC 34 Zeelugt/Rosignol							
Cultural: Religious	Cultural	• Religious activities held at three temples at Rosignol, Victory Dam, and No. 2 Village. • There are 6 Hindu temples at De Edward, Cotton Tree, No. 3, Bennett Dam, Victory Dam and along the main canal	Coastal	Local Hindu communities in: a) Rosignol b) No. 2 Village c) Victory Dam d) Bennet Dam	a) Moderate b) High c) Moderate d) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Medium** **b) High** **c) Medium** **d) Medium**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 90 boats using the Rosignol wharf for commercial fishing. Catch includes queriman, bangamary, butterfish, and some shrimp. • 75 boats using the De Edward port for fishing with a few shrimp boats. • 25 fishing boats use other landing areas along the river daily. • Shrimp is abundant in the swamps. • Crabs are practiced during the summer crabbing season.	Marine environment; Mangroves; River ecosystem	Fisherfolk using the landing sites at: a) Rosignol b) De Edward c) Victory Dam d) Bennet Dam e) Local communities shrimping in the swamp f) Local communities crabbing in the mangroves and swamps **ES Linkages:** Economic shrimping & Crabbing, Fish/Shrimp Processing	a) Essential b) Essential c) High d) High e) Moderate f) Moderate	a) Moderate b) Moderate c) Moderate d) Moderate e) Moderate f) Moderate	**a) Critical** **b) Critical** **c) High** **d) High** **e) Medium** **f) Medium**
Socioeconomic: Wharf Facilities	Provisioning	• River transportation wharf used by over 1,000 persons daily for river launch crossing.	River	Local communities **ES Linkages:** Tourism	Essential	High	**High**
Socioeconomic: Fish/Shrimp Processing	Provisioning	• Processing facility at Rosignol that processes much of the landed fish catch for export.	Coastal	Local fisherfolk, Export market	Essential	Moderate	**Critical**
Livestock Farming	Provisioning	• Grazing occurs throughout shore of the NDC with many residents owning animals. There are more than 400 pigs grazing in Rosignol. A few persons graze	Mangroves; Sea Dam; Pastures	Local communities, private cattle farmers in: a) Victory Dam	a) Moderate b) Moderate c) Essential	a) Moderate b) Moderate c) High	**a) Medium** **b) Medium** **c) High**

Service	Type of Service	Description and Examples in the Study Area Based on Stakeholder Input	Relevant Land Use / Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low- Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		over 100 cows, goats, donkeys, and sheep in Rosignol on the sea dam. Much grazing occurs at Bel Air, Zeelust, and Cotton Tree with over 300 goats, sheep, and cows on the dams and in the mangroves.		b) No. 2 Village c) Zeelugt/Rosignol			
Socioeconomic: Palm Processing Facility	Provisioning	• Processing Facility at Rosignol for processing of Manicole Palm for export.	Coastal	Local harvesters from riverine communities including Amerindians, Export market	Essential	Moderate	**Critical**
Shoreline Protection	Regulating	• Extensive area of Mangrove forest from Zee Zeight to De Edward with ponds in the forest. Mangroves covering the banks of the Berbice River at most locations. Grazing occurs in the mangroves and sea dam at each location. Honey bees are kept at No. 3 Village by one family.	Mangrove Forests	Mangrove in: a) De Edward b) No. 2 Village c) Zeelugt/Rosignol d) Bennet Dam **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination, Beekeeping	a) Moderate c) Moderate d) Moderate	a) Moderate b) High c) High	**a) Medium** **b) Low** **c) Low**
Food: Mangrove Forest	Provisioning	• Crabs, fish, and shrimp caught in ponds in the mangrove forest. Pin seine is used for fishing beside the mangroves in the river.	Mangrove Forests, River Ecosystem	Local communities	High	Moderate	**High**
Food: wild meat	Provisioning	• Iguanas are caught daily in the mangroves by fewer than 50 hunters. • Many plover birds are caught using wire for a trap. Curi curi is not hunted regularly. • Cage birds are caught along the shore.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Socioeconomic: Boat Building	Provisioning	• Boat building at Victory Dam and De Edward with an average of two boats per month with the 35-foot boat selling for GYD$780,000.	Coastal	Local fisherfolk	Moderate	Moderate	**Medium**
Socioeconomic	Provisioning	• The Berbice River Bridge is used by thousands of persons daily and the Berbice River launch transports almost 1000 school children and Government workers on weekdays between Rosignol and New Amsterdam.	Coastal	Local communities (general population)	Essential	Low	**Critical**
Cultivated Crops	Provisioning	• Planting of fruits and cash crops in De Edward and No. 2 Village	Cultivated lands	Local communities	Moderate	Moderate	**Medium**

APPENDIX C

Identified Ecosystem Services and Priority Ratings: Region 6 Coastal

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TABLE C-1: IDENTIFIED ECOSYSTEM SERVICES AND PRIORITY RATINGS: REGION 6 COASTAL

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
NDC 35 – Ordinance/Fort Lands							
Socioeconomic: Sawmilling	Provisioning	• Sawmill at Sheet Anchor employing 10-50 persons on a part time basis. Use Canje River to transport logs to mill.	Coastal	Local community	High	Moderate	**High**
Socioeconomic, Wharf, Building Materials Depot	Provisioning	• Wharves at Canje Bridge facilitating transport of building supplies (stone, steel, and sand) and boat repairs used by approximately 100 persons daily.	Coastal	Local community, Hardware suppliers, Construction sector, Boat owners	Essential	Moderate	**Critical**
Socioeconomic	Provisioning	• Two crab meat processing plants are located within the NDC.	Sea shore	Local community; crabbers	High	High	**Medium**
Shoreline Protection, River defense	Regulating	• Extensive area of mangrove forest on the riverbanks protecting the land from the Berbice and Canje Rivers.	Mangrove Forests	**ES Linkages:** Agriculture, fishing river defense	Moderate	High	**Low**
Habitat provision, coastal protection	Supporting	• Mangroves provide habitats for wild bees, birds, crabs, fish and shrimp in the mangroves.	Mangrove Forests	Local community	High	Moderate	**High**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• Approximately 50 boats docking at Sheet Anchor, Cumberland, and Seawell. The boats catch both fish and shrimp. • Approximately 100 persons catch shrimp and fish in the mangroves and canals using nets and seine for daily use and sale. The downturn of the sugar industry has resulted in approximately 50–60 persons seeking employment in fishing, especially within the swamps along the shoreline areas. Catch is sold within and outside of the NDC. • Crab catching done throughout the year supplying two crab meat processing operations.	Marine habitat and Mangrove Forests	a) Fishing boats landing at Sheet Anchor b) Fishing boats landing at Sheet Anchor Wharf c) Commercial and subsistence fishing in the mangroves d) Crabbing	a) Essential b) Essential c) High d) High	a) Moderate b) Moderate c) Moderate d) High	**a) Critical** **b) Critical** **c) High** **d) Medium**
Livestock Farming	Provisioning	• More than 2,000 head of cattle graze in the Cumberland, Fort Ordinance, Palmyra, and No. 2 area. • Grazing at Sheet Anchor of more than 100 head of cow, goats, and sheep.	Sea Dam, Pastures	Local communities, private cattle farmers that graze animals in: a) Fort Ordinance b) Sheet Anchor c) Cane Field	a) Essential b) High c) Moderate	a) Moderate b) Moderate c) Moderate	**a) Critical** **b) High** **c) Medium**
Cultivated Crops	Provisioning	• Cash crop cultivation in close proximity to the sea dam on private lands and on reserves. Grazing is also done on the lands in this area not under cultivation.	Sea dam; Cultivated areas	Local farmers; Residents	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Religious activity along the dams leading to the Canje River at Sheet Anchor and Cane Field used by less than 10 persons daily and more on religious days.	Seashore, sea dam,	Local Hindus	Moderate	Moderate	**Medium**
Socioeconomic: Informal Housing	Provisioning	• Squatting at Sheet Anchor and Cumberland by 10-20 households. Squatting has increased by 1 or 2 households.	Coastal	Local community, Fisherfolk	High	Moderate	**High**
Food: wild meat	Provisioning	• Sea birds including curi curi, plover, and wisi wisi ducks are caught for meat by a few locals.	Coastal Mangroves	Local people	Moderate	High	**Low**
NDC 36 – Kintyre/No. 37							
Food: aquaculture and wild-caught fish & shellfish: Marine & Coastal	Provisioning	• There are numerous ponds in the area used for shrimp and fish including tilapia and mullet. Persons from throughout the Corentyne Coast benefit from these resources. • Over 1,000 crabs are caught daily by different crews of 4-6 persons. 20 crabs sell for GYD$1,000 locally and in Georgetown. Catches are more significant during the crab marching season. More persons are involved in crabbing.	Coastal environment; Mangroves; River ecosystems	a) Fish and shrimp ponds b) Crabbing, fishing and shrimping at Borlam Dam **ES Linkages:** Tourism, Trapping	a) Essential b) Essential	a) Moderate b) Moderate	**a) Critical** **b) Critical**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Food: wild meat	Provisioning	• Approximately 10 persons are involved in the daily capture of sea birds including curi curi, plover and wisi wisi ducks are caught for meat at the shoreline and by the ponds.	Mangroves	Local people **ES Linkages:** Tourism	Low	Moderate	**Low**
Cultural: Religious	Cultural	• Religious activity at Seawell and Borlam Dam, with daily and weekly use by the Hindu religious community. • There is a cemetery located in close proximity to the seashore in Bohemia.	Seashore; Sea dam	a) Hindu religious activities b) Cemetery in Bohemia	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Shoreline Protection	Regulating	• Extensive area of mangrove forest protects the local communities from the impacts of the sea. Crabs, fish, shrimp, and birds are abundant.	Mangrove Forests	Mangroves in: a) Borlam Dam b) Bohemia and Warren **ES Linkages:** Fishing, crabbing	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
Flood Regulation	Regulating	• Extensive area of the coast covered by housing and other economic activities are drained by drainage pumps installed at Borlam.	Mangrove Forests	Local communities **ES Linkages:** Fishing, crabbing	High	Moderate	**High**
Livestock Cultivation	Provisioning	• Grazing of more than 1,000 heads of cattle, goats, and sheep.	Coastal, Pasturelands	Local communities in: a) Bohemia/Warren b) Seawell	a) Essential b) Moderate	a) Moderate b) High	**b) Critical** **b) Low**
Tourism and Recreation	Cultural	• Locals utilize Crab Island and Borlam Beach for recreational purposes.	Coastal and Marine	Tourism and recreation	Moderate	Moderate	**Medium**
Socioeconomic	Provisioning	• There is brick making from the burning of clay in lands adjacent to the shoreline. It was reported that the operation has been disrupting the cemetery which is in proximity and reports have been made to the Regional Health Officer. Concerns were raised that brick making increases erosion risk due to the extraction of soil and excavation is moving in the direction of the shoreline.	Coastal	Cemetery; Mangroves; Grazing	Low	Moderate	**Low**
Socioeconomic	Provisioning	Presence of CGX shore base in Seawell and wharf on Crab Island.	Coastal, Mangroves	Businesses; Local communities	Moderate	Low	**High**
NDC 37 – Gibraltar/Fyrish							
Food: aquaculture and wild-caught fish & shellfish: Coastal Mangroves	Provisioning	• There are about 12 shrimp ponds in the NDC with the majority on the seashore. Each pond can earn GYD$200,000 per crop/month in shrimp. • There are a few persons who catch crabs for sale in the NDC at GYD$50 for each adult crab. • Catching crabs, fish, and shrimp for subsistence use has increased.	Marine environment; Mangroves; Crab grass	a) Fishing and shrimping in the ponds for subsistence use and sale b) Crabbing for sale and subsistence use	a) Essential b) Moderate	a) Low b) High	**a) Critical** **b) Low**
Shoreline Protection	Regulating	• Extensive area of mangrove forest on the shore line protecting the coast from the impacts of the sea. Mangroves are in the increase in the NDC due to natural growth but there is some erosion at No.1 Village. The seas defense is being breached to allow for sea water into the shrimp ponds.	Mangrove Forests	a) Local communities protected by mangroves throughout the NDC b) Business persons who breach mangrove for shrimp pond in No. 1 Village/Courtland **ES Linkages:** Agriculture, fishing Sea & River defense	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
Livestock Farming	Provisioning	• There are grazing pastures at Gibraltar and Portland with cows, goats, and sheep and pigs in pasturelands and in the mangroves on the coast.	Coastal Pasturelands	Local communities that graze animals in: a) No. 1/ Courtland b) Fyrish c) Gibraltar	a) Moderate b) High c) High	a) Moderate b) Moderate c) Moderate	**a) Medium** **b) High** **c) High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Religious Activities; Burial Ground	Cultural	• Hindu religious activities are practiced along the shoreline in areas where there is access such as the eastern section of Fyrish and the No. 1 Village. • There is a cemetery in Fyrish that is used for burials by all religions.	Coastal	Local communities using: a) The Fyrish and No. 1 shoreline b) The cemetery in Fyrish	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Food: wild meat	Provisioning	• Sea birds including curi curi, plover, and wisi wisi ducks are caught for meat by a few locals. The number of persons involved in this activity has increased.	Coastal Mangroves	Local people	Low	Moderate	**Low**
NDC 38 - Kilcoy/Hampshire							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There is a large landing site for commercial artisanal fishing vessels Albion. Approximately 450–475 persons from the NDC are employed in fishing. Catch includes catfish, bangamary, butterfish, trout, mullet, and white belly and fat shrimp. • There are about 40 ponds in the NDC used for shrimp farming with each pond reaping an average of 20 buckets of shrimp per month that can sell for GYD$160,000–200,000. • In addition, there are several persons involved in cast net and drag net fishing along the seashore for subsistence purposes. During the out-of-crop sugar seasons, more persons are involved in these types of subsistence fishing. • There are 10-50 persons from the NDC and the Region who catch crabs weekly for sale at GYD $50 for each adult crab. Crab catching is also considered a recreational activity and the crabs caught in this way are for subsistence use.	Marine environment; Mangroves;	a) Local fisherfolk using the landing site at Albion b) Persons using shrimp ponds c) Local communities engaged in crabbing d) Subsistence fishing along the sea shore	a) Essential b) Essential c) Moderate d) High	a) Moderate b) Moderate c) Moderate d) Moderate	**a) Critical** **b) Critical** **c) Medium** **d) High**
Food: wild meat	Provisioning	• Iguanas are caught on the seashore along with sea birds including plovers, egret, curi curi, stork, and wild ducks for meat by a few persons and sold in the local market at 10-40 for GYD$1,000.	Mangroves; shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Primary production, biodiversity	Supporting	• Wild bees are found in the mangroves with hives at Hampshire.	Mangrove Forest	Local communities **ES Linkages:** Pollination, Pest control	Low	Moderate	**Low**
Livestock Farming	Provisioning	• The poultry farm located in Kilcoy and Chesney comprises five large multi-storey chicken pens with each pen containing approximately 20,000 chickens.	Coastal	Local communities Local Businesses	High	Moderate	**High**
Cultural: Religious	Cultural	• Hindu temples are in close proximity to the seashore at Chesney, Hampshire, Nigg, No. 4 Village, and two temples are located in Belvedere. • Hindu religious activities are also conducted on the sea dam in No. 4 Village. • The NDC has a burial ground at the foreshore of No. 4 Village where burial is done for all religions.	Coastal	Local Hindu Community using: a) temples at Chesney and No. 4 b) temples at Belvedere and Hampshire c) temple at Nigg d) Burial Ground in No. 4 Village	a) Moderate b) Moderate c) Moderate d) Moderate	a) High b) Moderate c) Moderate c) Low	**a) Low** **b) Medium** **c) Medium** **d) High**
Cultivated Crops	Provisioning	• A few persons farm on the sea dam and on adjacent lands with mainly cash crops and fruits for subsistence and sale in the community. Mainly done at Nigg, Kilcoy, and Chesney.	Cultivated lands	Local communities	Moderate	Low	**High**
Livestock Farming	Provisioning	• Grazing of cattle in Nigg and Hampshire	Pasturelands	Local communities grazing animals at: a) Hampshire b) Nigg	a) Moderate b) High	a) Moderate b) Moderate	**a) Medium** **b) High**
Shoreline Protection	Regulating	• Extensive area of Mangrove forest on the shore line protecting the coast from the impacts of the sea. Mangroves are in the increase in the NDC	Mangrove Forests	Mangroves offering shoreline protection at:	a) Moderate b) Low	a) High b) High	**a) Low** **b) Low**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		due to natural growth but there is some erosion at No.1 Village. The seas defense is being breached to allow for sea water into the shrimp ponds. Mangrove cover has increased.		a) Hampshire b) Albion c) Nigg **ES Linkages:** Agriculture, fishing Sea & River defense	c) Moderate	c) Moderate	**c) Medium**
Socio-Economic	Provisioning	• Land in Hampshire close to the seashore has been earmarked for the establishment of a new industrial site	Sea shore; shoreline	Local business communities	Low	Low	**Medium**
NDC 39 – Rose Hall Town							
Tourism and Recreation	Cultural	• There is a long stretch of beach within the Town Council that is used by the wider community and is frequented by over hundreds persons daily and approximately 500 on weekends. In 2019, there were a comparable number of persons on the beaches at Rose Hall and No. 63 beach during the Easter holidays.	Coastal and Marine	Local communities in NDC and Region 6 **ES Linkages:** Fishing, Grazing	Essential	Low	**Critical**
Shoreline Protection	Regulating	• Extensive area of mangrove forest at the shore protecting the town from the impacts of the sea. Animals graze within mangrove area and the extent of mangrove coverage in the municipality has declined. However, mangroves are still harvested for use as firewood, in construction and to be used as fishing rods. Mangroves are being monitored.	Mangrove Forests	Local communities **ES Linkages:** Fishing, grazing	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Many plover birds are caught using wire for sale at the local market.	Mangroves, shoreline	Local communities	Low	High	**Low**
Cultural: Religious	Cultural	• The Hindu religious activities are held at the Rose Hall beach, which provides space and privacy. Religious activities by Hindus on the Rose Hall beach has increased and approximately 200 persons use the area on a weekly basis, with more on Sundays and Tuesdays. Thousands of persons use the area on special days of worship for Hindus.	Coastal	Local Hindu communities	Essential	Low	**Critical**
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There is a landing site for fishing boats at Rose Hall. Pin seine fisherfolk also use this site for catching fish for subsistence and for sale. Fishes include bangamary, butterfish, trout, and mullet. • Fish pond for locals to catch fish, shrimp and crabs in Williamsburg	Marine environment; Mangroves;	a) Local fisherfolk using the Rose Hall site b) Local communities using the fish pond	a) Moderate b) High	a) Moderate b) High	**a) Medium** **b) Medium**
Livestock Farming	Provisioning	• There are approximately 100 animals grazing on the shore and near shore areas.	Coastal; Pasturelands	Local communities	High	High	**Medium**
Cultivated Crops	Provisioning	• There are small farms on the sea dam and on adjacent lands used by persons living in proximity planting fruits and cash crops. Farming on the sea dam and on adjacent lands has decreased due to saline intrusion.	Coastal, Pasturelands	Local communities	Moderate	High	**Low**
NDC 40 – Port Mourant/John							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are 9 boats using the Port Mourant outfall employing 33–40 persons, as a landing area for fish and shrimp. Fishing is considered a second job for sugar workers during out-of-crop seasons on the sugar estates. • Approximately 20–25 persons catch shrimp, tilapia, coo coo belly, and cufum in the swamp or drainage canals along the sea dam on a daily basis. During out-of-crop seasons, up to 100 persons catch fish and shrimp in swamps and drainage canals for subsistence use and for sale. • There are approximately 100 shrimp and fish ponds in the NDC owned by 40 persons in the NDC. Ponds have been expanded and there are different sections for species. In addition, areas formerly used for rice cultivation have been converted to shrimp and fish ponds. The ponds in Babu John have been rehabilitated and are currently in use. All ponds in the NDC are privately owned.	Marine environment; Mangroves; river ecosystem	a) Fisherfolk using the Port Mourant outfall b) Owners of private fish and shrimp ponds c) Local people fishing in swamps and drainage canals	a) High b) Essential c) High	a) Moderate b) Moderate c) Moderate	**a) High** **b) Critical** **c) High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Livestock Farming	Provisioning	• A farm at John has five large multi-story pens with approximately 5,000 chickens per pen; it employs more than 20 persons full time. • More than 8,000 animals graze on the shore, in the mangroves, and on adjacent pastures. More than 1,000 animals graze in Tain. The number of animals in the NDC is increasing. • There is a ranch at Babu John with 400-500 animals. The NDC has no established pasture.	Coastal	Local communities, Local Businesses: a) Operating poultry farms b) Grazing animals in Tain c) Grazing animals in Port Mourant	a) High b) Essential c) High	a) Moderate b) Moderate c) High	**a) High** **b) Critical** **c) Medium**
Shoreline Protection	Regulating	• Mangrove forest at the shore aids in capturing the sediments as the shore is built. There is no monitoring of mangrove cover and mangroves are reported by the NDC to be cut by shrimp farmers to access the water for ponds and to create ponds. Some persons collect dried mangrove roots for use in their kitchen gardens and as firewood.	Mangrove Forests, Coastal	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation	Moderate	High	**Low**
Food: wild meat	Provisioning	• Shore birds including plover and spika are caught using wire for sale at the local market at GYD$1,500–2,000 per string of about 20 birds. Curi curi and carrow are sold at 2 for GYD$1,000–1,500. Although a few persons routinely catch these birds, there are peak numbers of persons involved on a seasonal basis.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• The religious activities of the Hindus are held at Port Mourant and Tain. Prayers and daily worship are held at the Port Mourant beach extending from Rose Hall. • Religious activities are held at Port Mourant. In addition, the main cremation site at Babu John is dedicated to late President Cheddi Jagan. There is also a cemetery at Babu John.	Coastal	a) Local Hindu communities at Port Mourant b) Babu John Crematorium in Tain	a) Moderate b) High	a) Moderate b) Low	**a) Medium** **b) Critical**
Tourism and recreation	Cultural	• Locals utilize the Port Mourant beach from the Rose Hall entrance for recreational purposes.	Coastal and Marine	Local communities in NDC and Region 6	Moderate	Moderate	**Medium**
NDC 41 – Bloomfield/Whim							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• The outfalls at Letter Kenny and Whim are used as landing sites for fishing boats. They are not frequently used, as the channels are heavily silted making access to the landing sites difficult. However, approximately 28 fishing boats are owned by persons from the NDC who use landing sites at Adventure and Complex 66. In addition, more than 100 persons in the NDC are employed as fisherfolk on boats at different landing sites throughout the Corentyne Coast. Catch various catfishes, bangamary, butterfish, trout, and mullet. • Approximately 15 persons catch crabs on a regular basis for sale. The number of persons engaged in crabbing increases during the summer crab season. • Approximately 30 ponds in the area for shrimp farming which are owned by 10–15 people. One bucket valued at GYD$10,000. • Approximately 15 persons fish along the shoreline using pin seines and cast nets.	Marine environment; Mangroves; Drainage canals; Natural ponds	a) Fisherfolk using the landing site at Letter Kenny b) Fisherfolk using the landing site at Whim c) Owners of shrimp ponds in the NDC d) Persons engaged in crabbing **ES Linkages:** Fishing, Grazing, Erosion regulation, Tourism	a) High b) High c) High d) Moderate	a) High b) High c) Moderate d) Moderate	**a) Medium** **b) Medium** **c) High** **d) Medium**
Shoreline Protection	Regulating	• Mangrove forest covers most of the shore with new growth in some areas as the silt washes ashore and is trapped. Cows and goats are found grazing in the mangroves.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	High	Moderate	**High**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC but is more predominant at Whim to Letter Kenny, with hundreds of heads of cattle, goats, and sheep. Grazing along the sea dams and shoreline has increased; this is attributed to former sugar workers seeking alternative employment.	Mangroves; Sea Dam; Pastures	Local communities; Private cattle farmers	High	High	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
Cultivated crops	Provisioning	• Cash crop cultivation in close proximity to the sea dam at Whim and Letter Kenny. Crops include watermelon, muskmelon, cucumbers, bora, tomatoes, and eggplant. Cultivation of cash crops and fruit in close proximity to the sea dams increases during the wet seasons when freshwater is easily available.	Sea dam; Cultivated areas	Local farmers; Residents; Businessmen in: a) Letter Kenny and Whim	a) Moderate	a) Moderate	**a) Medium**
Cultural: Religious	Cultural	• The religious activities of the Hindus are held from Bloomfield to Letter Kenny. Persons from within and outside of the NDC come to these areas for worship. • There are three Hindu temples located in close proximity to the shoreline at Letter Kenny and Whim. • There are cemeteries at Letter Kenny and Whim which are used by all religions.	Coastal	a) Local Hindu communities using shoreline between Bloomfield and Letter Kenny b) Local Hindu communities using the temples c) Cemeteries at Letter Kenny and Whim	a) High b) High c) Moderate	a) High b) Moderate c) Low	**a) Medium** **b) High** **c) High**
Food: wild meat	Provisioning	• Shore birds including egret, curi curi, dukla, plover, wisi wisi, and spika are caught for meat or sale in the market.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	High	**Low**
Social	Provisioning	• There is a nursery school located in close proximity to the seashore in Letter Kenny.	Mangroves; Shoreline	Local children; local communities	High	High	**Medium**
Socio-economic	Provisioning	• A water well and pump system was installed by Guyana Water Incorporated (GWI) Letter Kenny and provides water to Whim, Bloomfield, Letter Kenny and Auchlyne.	Mangroves; Shoreline	Local communities	Essential	Moderate	**Critical**
NDC 42 – Lancaster/Hogstye							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are 12 boats that use the Hogstye/Adventure outfall for fishing. The number of large fishing boats landing at the Hogstye/Adventure outfall has increased as there is easy access and the landing site at Complex 66 is crowded. None of the boats at the outfall are owned by persons from the NDC. However, persons from the NDC, mostly from Lancaster, work on fishing boats that land at various sites along the Corentyne Coast. • Persons throughout the NDC utilize pin seines and cast nets for fishing along the shoreline. • There is one shrimp pond and one tilapia pond in Lancaster occupying 198 acres of land close to the seashore. Two persons own these ponds.	Marine environment; Mangroves;	a) Fisherfolk using the landing site at Hogstye/Adventure b) Local fisherfolk fishing with pin seines and cast nets along the shoreline c) Local persons who own the shrimp and fish ponds	a) High b) High c) High	a) Moderate b) High c) Moderate	**a) High** **b) Medium** **c) High**
Food: wild meat	Provisioning	• Iguanas are hunted daily for meat and for sale by young persons in the NDC who are unemployed. There is limited hunting of birds in the NDC.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	High	**Low**
Cultural: Religious	Cultural	• The religious activities of the Hindus are held mainly at Manchester and Alness where sand beaches facilitate these activities. These activities are increasing because access to the beaches has improved.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• Grazing occurs throughout the NDC and across the shore with many residents owning more than 5000 cows, goats, sheep, pigs, and horses.	Mangroves, Sea Dam, Pastures	Local communities, private cattle farmers	Moderate	Moderate	**Medium**
Shoreline Protection	Regulating	• Mangrove forest exists throughout the NDC on the shore and is reported to be destroyed by the shrimp farmers. Grazing occurs in the mangroves and on the sea dam. Natural regrowth of mangroves is continuing.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Pollination, Bird hunting	High	Moderate	**Medium**
Cultivated Crops	Provisioning	• Cultivation of cash crops and fruits along the shoreline throughout the NDC. These activities are increasing and more crops are planted during the wet seasons. Crops include watermelon, bora, tomatoes, muskmelon, etc.	Sea dam, cultivated areas	Local farmers, residents	High	Moderate	**High**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• In Lancaster there are conflicts for land between the farmers and the owners of the fish and shrimp ponds. In addition, there are complaints from some residents of the NDC that spraying pesticides on the crops cultivated on the seashore adversely impacts their lives.					
Tourism and Recreation	Cultural Services	• Locals utilize the Manchester and Alness beaches for recreational purposes with over 100 persons on weekends. These activities are increasing because access to the beaches has improved.	Coastal and Marine	Local communities in NDC and Region 6	High	Moderate	**Medium**
NDC 43 Black Bush Polder							
Drainage	Regulating	• The agricultural settlement has two drainage outlets at No. 43 and at Adventure, with drainage pumps to drain the excess water.	Coastal; cultivated areas	Local farmers, residents	Essential	High	**High**
Religious Activities	Cultural	• The religious activities some residents are held at Adventure beach for special ceremonies.	Coastal	Local Hindus	Moderate	Moderate	**Medium**
Wildlife Trapping & Hunting	Provisioning	• Birds are hunted with shotguns by a few persons on an irregular basis including curi curi, egrets, and wild ducks for meat. Other persons buy the birds at the market.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Low	Moderate	**Low**
Food: aquaculture and wild-caught fish & shellfish: Coastal & mangroves	Provisioning	• A small group of persons visit the mangroves on the coast at No. 43–47 villages to catch crabs in season and on occasion out of season. • Black belly shrimp from the shrimp ponds are sold in the NDC on a daily basis by vendors from the coast.	Marine environment; Mangroves	Local people **ES Linkages:** Economic shrimping & Crabbing	a) Low b) High	a) High b) High	**a) Low** **b) Medium**
NDC 44 Good Hope/No. 51							
Shoreline Protection	Regulating	• Extensive area of mangrove forest from No. 47–49 villages. Mangrove coverage throughout the NDC is increasing throughout the NDC and the Council is actively trying to stop the harvesting of mangroves because of its importance to protecting the shoreline of the NDC.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	High	Moderate	**High**
Primary production; biodiversity	Supporting	• Wild bees are present in the mangroves in No. 45, No. 47, No. 48, No. 50, and No. 51. Honey is harvested from these hives for subsistence use. However, the numbers of bees are increasing and there have been complaints of bees swarming residences in these areas. • Birds and crabs are abundant. Grazing also occurs in the mangroves and on the sea dam.	Mangrove Forests	Local communities	Low	Moderate	**Low**
Livestock Farming	Provisioning	• One person grazes goats on the sea dam and in the mangroves at No. 49 Village. • In addition, several other persons graze cows, goats and sheep at No. 45, No. 47, No. 48, No. 50, and No. 51 villages.	Mangroves, Sea Dam, Pastures	Local communities; Private cattle farmers who graze animals in: a) No. 49 Village b) Other villages in the NDC	a) Moderate b) High	a) High b) High	**a) Low** **b) Medium**
Cultural: Religious	Cultural	• Religious activities are held in No. 49 and No. 51 villages with the most persons on Fridays and Sundays. There is easy access to the shoreline at No. 49 Village.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Hunting of iguanas has increased significantly in the mangroves throughout the NDC. Persons from throughout the Corentyne Coast including New Amsterdam visit the NDC to catch iguanas for sale. • Hunting of shore birds has increased and is done daily at No. 45, No. 48, No. 50, and No. 51 villages. • In addition, cage birds/finches are caught for sale and training in the NDC at No. 45, No. 48, No. 50 and No. 51 villages.	Mangroves, shoreline	People who hunt: a) Iguanas b) Shore birds for meat and sale, and cage birds for sale **ES Linkages:** Tourism	a) High b) Moderate	a) Moderate b) Moderate	**a) High** **b) Medium**
Food: aquaculture and wild-caught fish &	Provisioning	• A few boats use the landing site at No. 51 Village. The boats mainly fish including bangamary, butterfish, trout, and mullet.	Marine environment; Mangroves	Local fisherfolk Local people who:	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
shellfish: Marine and Coastal		• Persons fish along the shoreline using pin seines and cast nets daily throughout the NDC. • There are four large shrimp ponds in the No. 49 Village which are all privately owned. • In the No. 51 Village, there is a swamp area where persons through the NDC catch fish and shrimp for subsistence use. This area is also used by persons from the No. 52 Village, located outside of the NDC. • Approximately 30–40 persons from within and outside of the NDC catch crabs in the mangrove forests in the NDC. In addition, catch is sold both within and outside the NDC.		a) Use the landing site at located in No. 51 Village b) Fish along the shoreline c) Own private shrimp ponds d) Fish in the communal ponds e) Catch crabs	c) High d) High e) High	c) Moderate d) Moderate e) Moderate	**c) High** **d) High** **e) High**
Socioeconomic: Brick burning	Provisioning	• Brick burning by 4-8 persons on the sea dams using dried mangrove and lumber as fuel.	Coastal	Local communities	Moderate	Moderate	**Medium**
Cultivated Crops	Provisioning	• Cultivation of cash crops and fruits including coconuts on the sea dam and adjacent lands in No. 47 Village has stopped due to significant saltwater intrusion where the dam was eroded and there were breaches in the mangroves. • Farming is continuing on the sea dams on No. 50 and No. 51 villages.	Coastal; Pasturelands	a) Local communities farming on the sea dams b) Local communities planting coconuts on the sea dams	a) Moderate b) Moderate	a) High b) Moderate	**a) Low** **b) Medium**
NDC 45 Macedonia/Joppa							
Shoreline Protection	Regulating	• Extensive forest of mangroves in the NDC. Grazing occurs in the mangroves and on sea dam. Shrimp and fish ponds in the mangroves used by locals. Mangroves are reduced due to erosion of the shore. • There is extensive mangrove cover in the NDC and the mangrove stand has been increasing.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Moderate	Moderate	**High**
Livestock Farming	Provisioning	• Cows, goats, and sheep graze throughout the NDC in Bengal, Joppa, Brighton, Eversham, Kiltaira, and No. 35 Village. The least amount of grazing occurs in Eversham. • In between the rice crops, some animals are taken to the rice fields to graze.	Coastal, Mangroves, Sea Dam, Pastures	Local communities, Cattle farmers who graze animals in: a) No. 35 Village b) Brighton c) Kiltaira d) Eversham	a) Moderate b) High c) Moderate d) Moderate	a) Moderate b) Moderate c) Moderate d) High	**a) Medium** **b) High** **c) Medium** **d) Low**
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• Fishing boats that use the outfall in No. 43 Village has declined and larger boats use the landing at Complex 66. 5 boats use the Eversham outfall. Catch of bangamary, mullet, catfish, etc. • Persons fish along the shoreline using pin seines and cast nets. • There are 5 privately owned shrimp ponds on the sea dams of Bengal, Kiltyre, and No. 36 Village. • Approximately 100 persons catch shrimp, tilapia, and hassar in the mangroves, canals, and along the shoreline using pin seines and cast nets daily for subsistence use. If there is excess catch, then it is sold within the NDC. Turtles are sometimes caught in the mangroves for meat. • Crabbing is a significant activity in the NDC and during the crab season persons from Canje visit the NDC to catch crabs for sale.	Marine environment; Mangroves;	Local fisherfolk and local people: a) Fishing boats at the No. 43 Village b) Fishing boats at Eversham c) Privately owned shrimp ponds d) Fishing along the shoreline; and in mangroves, swamps and canals e) Crabbing	a) Low b) High c) High d) High e) High	a) High b) Moderate c) Moderate d) Moderate e) Moderate	**a) Low** **b) High** **c) High** **d) High** **e) High**
Cultivated Crops	Provisioning	• Cultivation of cash crops, fruits, and coconuts is continuing on the government reserves in the Brighton Canal, Kiltyre, and Eversham. However, there are challenges with saltwater intrusion and high water levels close to the mangroves. Cultivation of cash crops and fruits increases during the wet seasons which fresh water is available.	Sea dam, cultivated areas	Local farmers, residents	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Hindu religious activities occur at the shoreline in No. 43 Village. Most persons use the No. 63 beach.	Seashore, sea dam	Local Hindus	Low	High	**Low**
Socioeconomic: Boat Building	Provisioning	• Boat building at No. 43 outfall. There is also boat maintenance and seine mending at the No. 43 outfall.	Coastal	Local fisherfolk, Boat builders, Lumber dealers	Essential	Moderate	**Critical**

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Food: wild meat	Provisioning	• A few persons catch plover using wire or seine. Curi curi and wild ducks are shot for meat.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
NDC 46 Bushlot/Adventure							
Food: aquaculture and wild-caught fish & shellfish: Marine	Provisioning	• There are 6 boats using Bushlot/Kildonan outfall for docking. • 12 boats use the Adventure outfall for docking. A total of 20-25 persons work these boats. • Persons fish along the shoreline using pin seines and cast nets. Shrimp caught on the shore with seine by locals daily. The number of persons who fish along the shoreline using pin seines and cast nets is increasing. These persons are generally seeking alternative sources of employment following the closure of sugar estates. • A small group of persons visit the mangroves on the coast regularly to catch crabs and more persons in season. • There are three shrimp ponds in the NDC. Two are in Bushlot Farm and are privately owned by two persons. A communal pond is in Bushlot.	Marine environment; Mangroves; Drainage canals;	Fisherfolk and local people who: a) Bushlot/Kildonan landing site b) Adventure landing site c) Fish along the shoreline d) Private Shrimp ponds e) Communal pond and fishing in mangroves and swamps f) Catch crabs **ES Linkages:** Fishing, erosion regulation, Tourism	a) High b) Essential c) High d) High e) High f) High	a) Moderate b) Moderate c) High d) Moderate e) Moderate f) Moderate	**a) High** **b) Critical** **c) Medium** **d) High** **e) High** **f) High**
Food: wild meat	Provisioning	• Shore is highly populated by thousands of birds. A few persons, mainly in Bushlot, catch plover using wire or seine. Curi curi and wild ducks are shot for meat for sale. A few persons also catch iguanas. This is mostly done by young people who have completed secondary school and are unemployed.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Hindu religious activities are mainly conducted on the Bushlot beach for Hindu religious activities from other areas as far east as Hampshire use the beach for religious purposes.	Seashore, sea dam,	Local Hindus using: a) Bushlot beach b) other areas in the NDC	a) Moderate b) Moderate	a) Low b) High	**a) High** **b) Low**
Tourism and Recreation	Cultural	• Approximately 100 persons use the Bushlot Beach on a weekly basis for recreation purposes. There are several hundred persons on special holidays like Easter weekend.	Coastal and Marine	Local communities in NDC and Region 6	High	Moderate	**High**
Cultivated Crops	Provisioning	• Cultivation of cash crops and fruits in continuing near the sea dam from Bushlot–Adventure. Cultivation has increased and this is also linked to higher levels of unemployment resulting from the closure of the sugar estates. There is no farming on private lands.	Sea dam; Cultivated areas	Local farmers, residents	High	Moderate	**High**
Shoreline Protection	Regulating	• Extensive area of Mangrove forest in the NDC protecting the mud or sand sea defense. Birds and crabs are abundant and used by locals. Grazing in the mangroves and sea dam particularly by residents living in proximity. • Mangrove cover at Kildonan has been increasing. Persons from the NDC use dried mangroves in their kitchen gardens and sometimes as firewood.	Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• Grazing of goats and sheep along the seashore in Kildonan.	Mangroves	Local communities	Moderate	Moderate	**Medium**
NDC 47 Maida/Tarlogie							
Shoreline Protection	Regulating	• Mangrove forest covers the entire shore protecting the fragile mud sea defense. In 2018, NAREI established a mangrove restoration plot in Wellington Park. These mangrove seedlings have died. However, there are mangroves on other areas in the NDC and new natural growth is continuing in Kilmarnock.	Coastal, Mangrove Forests	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Essential	High	**High**

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Agriculture: Grazing	Provisioning	• More than 1,000 cows and sheep graze along the shoreline throughout the NDC. The owners of these animals reside in Wellington Park, Philippi, and Kilmarnock.	Mangroves; Sea Dam; Pastures	Local communities; Private cattle farmers	High	Moderate	**High**
Religious Activities	Cultural	• Religious activities held in areas with access to the sea at Wellington Park, Kilmarnock, Maida, and Tarlogie.	Coastal	Local Hindu communities	Moderate	Moderate	**Medium**
Food: wild meat	Provisioning	• Curi curi, flamingo, duckla, wisi wisi, and plover birds are hunted regularly for meat or sale. • Hunting of iguanas and sea birds for meat and sale in the mangroves is increasing and approximately 20–25 persons do this daily.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Food: aquaculture and wild-caught fish & shellfish: Marine and coastal	Provisioning	• 14 boats landing at Maida, Kilmarnock, and Wellington Park depending on the ease of traversing the channels to access the sites. Approximately 60 persons are employed in these boats. Catch includes catfish, bangamary, butterfish, trout, mullet, snook, basha, etc. • Persons fish along the shoreline using pin seines and cast nets. • Crabbing is also an important source of livelihoods throughout the year in the NDC. Crab catching is also done by several persons for recreation. • There are canals and swamp basins in Tarlogie that are open for communal catch of fish and shrimp. • Large area in the NDC with shrimp ponds harvesting approximately 125 buckets of shrimp monthly valued at GYD$1,000,000. Additional privately owned shrimp ponds have been created on Wellington Park, Maida, and Kilmarnock. Approximately 8–10 persons own the ponds in the NDC.	Marine environment; Mangroves;	Local fisherfolk Local people who: a) Utilize the landing sites at Maida, Kilmarnock, and Wellington Park. b) Catch fish and shrimps in swamps and fish along the shoreline c) Own private shrimp ponds d) Catch crabs	a) High b) High c) Essential d) High	a) Moderate b) Moderate c) Moderate d) Moderate	**a) High** **b) High** **c) Critical** **d) High**
Cultivated Crops	Provisioning	• There are small farms on the sea dam and on adjacent lands at Maida, Tarlogie, and Wellington Park planting fruits and cash crops.	Coastal, Pasturelands	Local communities	High	Moderate	**High**
NDC 48 No. 52/74 Villages							
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are more than 400 boats at No. 66 Village outfall for nearshore and deep sea fishing. Fishing boats from Regions 4 and 5 and along the Corentyne Coast use this landing site. • 100 boats use the No. 65 Village outfall for fishing activities with shrimp. • At No. 63 Village, there are approximately 20 small boats that use pin seines to fish along the shoreline. In total, there are approximately 60–75 small boats in the NDC that practice pin seine fishing along the shoreline for sale. • 10-30 persons daily catch shrimp and fish on the shore by the beach using hand seine. Shrimp, mullet, and sardines are caught for sale. • Erosion of mangroves has significantly reduced crabbing activities and crabs are only caught during crab marching seasons. In crab season more than 50 persons daily catch crabs. • Approximately 4,000 persons are directly indirectly employed in the fishing sector in this NDC.	Marine environment; Mangroves; Drainage canals;	Fisherfolk who: a) Use the landing site at No. 66 Village b) Use the outfall at No. 65 Village c) Conduct pin seine fishing and fish along the shoreline d) Catch crabs **ES Linkages:** Fishing, Fish mongering, Boat Building; Mangroves	a) Essential b) Essential c) Essential d) High	a) Low b) Moderate c) High c) Moderate	**a) Critical** **b) Critical** **c) High** **d) High**
Socio/economic	Provisioning	• Approximately 10 meters from the No. 65 outfall, construction of a fish processing plant has commenced. The owner of this processing plant is has also purchased 45 new fishing boats, which may eventually land at the processing plan. Approximately 500 persons are expected to be employed at the fishing processing plant.	Mangroves, outfall, shoreline	Local business persons, fisherfolk, local communities	High	Moderate	**High**
Food: wild meat	Provisioning	• Many iguanas are caught and sold for GYD$4,000-5,000 each. Few birds are caught using nets or wire though the practice is illegal at the No. 63 beach.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Shoreline Protection	Regulating	• Mangrove forest covers most of the NDC offering protection and aids in capturing the sediments as the shore is built. There is significant to complete erosion of mangroves in No. 52–No. 63, No. 67, No. 69,	Mangrove Forests, Coastal	Local communities	High	Moderate	**Medium**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		No. 70, No. 73, and No. 74 villages. There is no cutting of mangroves and it is likely that these are natural deaths due to the age of the stand.		**ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination			
Livestock Farming	Provisioning	• Previously, thousands of animals grazed throughout shoreline areas of the NDC. Grazing of animals along the shoreline has decreased significantly. Due to the erosion of the mangrove forests, grazing lands have been lost to the sea and available lands are not private property. As a result, grazing has shifted largely to the back-dam areas. At present, more persons are involved in cattle rearing but there are fewer livestock overall in the NDC.	Mangroves, Sea Dam, Pastures	Local communities, Private cattle farmers who graze animals at No. 61 and No. 63 villages	High	Moderate	**Medium**
Cultural: Religious	Cultural	• Religious activities held in the area at No. 63 beach with 20-50 persons daily and hundreds on weekends. • Religious activities at No. 73 beach with 20 persons daily and more than 200 on weekends. • In general, religious activities are held throughout the NDC where there is easy access to the shoreline including No. 69, No. 70, and No. 71 villages.	Coastal	Local Hindu communities Christians (baptisms/ outings) Muslims (Outings) with: a) Religious activities at No. 63 beach b) Religious activities at No. 73 beach c) Other locations in the NDC	a) Essential b) High c) Moderate	a) Low b) Moderate c) Moderate	**a) Critical** **b) High** **c) Moderate**
Socioeconomic: Boat Building	Provisioning	• Boat building occurs on both sides of the dam at Complex 66. Surinamese fisherfolk also order fishing boats at the boat building sites at Complex 66 due to the quality of wood used in Guyana and the skills of the boat builders. • A boat construction facility has also been opened adjacent to the new fish process plant at No. 65 Village.	Coastal	Local fisherfolk, boat builders, lumber dealers	Essential	Moderate	**Critical**
Tourism and Recreation	Cultural	• 50-100 persons use the No. 63 beach daily for recreational purposes with hundreds of persons on weekends and thousands on Easter and August weekends. • No. 69–No. 70 beach is used by 20-50 persons daily and over 100 on weekends and holidays.	Coastal and Marine	Local communities in NDC, Region 6 and other areas of the Country using: a) No. 63 beach b) No. 69 to 70 beach and other beaches, recreational sites in the NDC	a) Essential b) High	a) Low b) Moderate	**a) Critical** **b) High**
Cultivated Crops	Provisioning	• Cash crop cultivation along most areas of the shore and on sea dam on private lands with coconuts and other crops. Peeled dried coconuts sells at GYD$4,000–6,000 per hundred. Cash crop cultivation along the shoreline has also decreased due loss of lands as a result of mangrove erosion.	Sea dam, cultivated areas	Local farmers, residents	High	Moderate	**High**
NDC 49 Corriverton Town Council							
Socioeconomic: Renewal Energy	Provisioning	• Private company has installed a wind turbine of 275 KVA capacity on the riverbank, but it is not yet operational. The business is awaiting permission from the Government of Guyana before it can be used.	Coastal	Local businessmen Township	Moderate	High	**Low**
Socioeconomic: Wharf for Passengers & Cargo	Provisioning	• The wharf located at Line Path is used by farmers and loggers for transport of their produce from Orealla and Siparuta to Corriverton. • Passengers use the 'backtrack route' at No. 78 Village to access the speedboat service to Suriname. When in operation, the ferry to Suriname lands at Moleson Creek, which is not located in the municipality.	Coastal; River	Local boatmen, Businessmen; locals; Guyanese, Surinamese using: a) Wharf in Line Path b) Speedboat service to Suriname	a) Essential b) Essential	a) Moderate b) Moderate	**a) Critical** **b) Critical**
Food: aquaculture and wild-caught fish & shellfish: Marine and Coastal	Provisioning	• There are more than 40 boats at No. 79 Village seawall for fishing in the Corentyne River and catch fish and shrimp. • Nine fishing boats docked for fishing activities in the river and the sea including sardines.	Marine environment; Mangroves; Drainage canals;	Fisherfolk and locals who: a) Utilize the landing site at No. 79 Village b) Fish along the shoreline	a) High b) Essential	a) Low b) Moderate	**a) Critical** **b) Critical**

Service	Type of Service	Description and Examples in the Study Area based on Stakeholder Input	Relevant Land Use/ Habitat Categories	Beneficiaries and ES Linkages	Importance to Beneficiaries (Low-Essential)	Replaceability (Low-High)	Priority Rating (Importance x Replaceability)
		• Approximately 10–50 persons are engaged in daily use of seines and cast nets for catching mullet and shrimp. • Catching sardines is seasonal and more than 100 persons are engaged in using seines to catch sardines when in season. When in season, catching sardines is also considered a recreational activity.		**ES Linkages:** Fishing, Fish mongering, Boat Building, Shrimping			
Socioeconomic: Boat Building	Provisioning	• Boat building at No. 84 Village outfall with 2 boats under construction by a crew of 4 persons. • Boat building at Line Path Skeldon by a crew of 6 persons. • Speed boat construction is done at the No. 78 Village.	Coastal	Local fisherfolk, boat builders, lumber dealers involved in boat building at: a) Line Path b No. 84 outfall c) No. 78 Village	a) Moderate b) High c) High	a) Moderate b) Moderate c) Moderate	**a) Medium** **b) High** **c) High**
Shoreline Protection: River Dam Protection	Regulating	• There has been significant erosion of mangrove cover from No. 75 Village to Scottsburg. The municipality requested support from NAREI to replant mangroves in the area. However, rip rap sea defense structures have been installed in Scottsburg. Mangroves are not harvested but some persons collect dried mangroves to use as firewood. • Erosion of the sand bank in No. 79 Village has decreased use of the area for recreational purposes.	Mangrove Forests, Coastal	Local communities **ES Linkages:** Fishing, Grazing, Erosion regulation, Pollination	Moderate	Moderate	**Medium**
Cultural: Religious	Cultural	• Religious activities held in the area at Line Path, Scottsburg, Springlands, and Spring Garden by 20-50 persons daily and hundreds on weekends. • Some Christian groups also perform baptisms in these areas.	Coastal	Local Hindu and Christian communities, using shoreline areas for worship Burial site	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**
Food: wild meat	Provisioning	• More than 10 persons are engaged in hunting of iguanas on a weekly basis along the shoreline in Scottsburg. Each week about 50 iguanas are caught and sold forGYD$4,000-5,000 each by 5-7 persons. A few rabbits are also caught for meat.	Mangroves, shoreline	Local people **ES Linkages:** Tourism	Moderate	Moderate	**Medium**
Livestock Farming	Provisioning	• There are fewer than 30 cows grazing along the shoreline in the NDC. According to the bylaws of the TC, there should be no livestock farming in the town.	Mangroves, Sea Dam, Pastures	Local communities, private cattle farmers	Low	High	**Low**
Tourism and Recreation	Cultural	• There are approximately five tour operators who provide trips down the Corentyne River. Sometimes regattas and other events like pageants are held in communities in the river such as Orealla. • Locals use beaches and shoreline areas in the municipality for relaxation and recreation in No. 79 Village, Springlands, and Scottsburg.	Coastal and River	a) Local communities in Town and Region 6 and Suriname involved in tourism in the Corentyne River b) Locals using beaches and shoreline areas for recreation	a) Moderate b) Moderate	a) Low b) Moderate	**a) High** **b) Medium**
Socioeconomic: Informal Housing	Provisioning	• Squatting occurs at Line Path, Dukestown, Scottsburg, and No. 78 & No. 79 villages by approximately 30 households.	Coastal	Local fisherfolk, local people squatting in the municipality	High	Moderate	**High**
Cultivated Crops	Provisioning	• Approximately 35 persons are engaged in cash crop and fruits cultivation most areas of the shore and sea dam at Line Path, Scottsburg, Dukestown, and No. 75 Village. • Irrigation pump located at the koker in No. 74 Village	Sea dam; cultivated areas	a) Local farmers, residents cultivating crops on sea dams b) Local farmers benefiting from irrigation pump	a) Moderate b) Moderate	a) Moderate b) Moderate	**a) Medium** **b) Medium**

APPENDIX D

NDCs Meeting Schedule

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REGION 5 NDCS

Name of NDC	Date and Time (2018)		Date and Time (2019)	
Woodlands/Farm	Wed, Jan 17	9:30 AM	Mon, May 20	9:00 AM
Hamlet/Chance	Wed, Jan 17	1:30 PM	Mon, May 20	11:00 AM
Profit/Rising Sun	Wed, Jan 17	3:00 PM	Mon, May 20	2:00 PM
Mahaicony/Abary	Thur, Jan 18	9:30 AM	Tue, May 21	9:00 AM
Union/Naarstigheid	Thur, Jan 18	1:30 PM	Tue, May 21	2:00 PM
Seafield/Tempie	Fri, Jan 19	9:30 AM	Tue, May 21	11:00 AM
Bath/Woodley Park	Mon, Jan 22	9:30 AM	Wed, May 22	9:00 AM
Woodlands/Bel Air	Mon, Jan 22	1:30 PM	Wed, May 22	11:00 AM
Zeelugt/Rosignol	Tues, Jan 23	9:30 AM	Wed, May 22	2:00 PM

REGION 6 NDCS

Name of NDC (Coastal)	Date and Time (2018)		Date and Time (2019)	
Ordinance/Fort Lands	Wed, Jan 24	1:30 PM	Mon, June 24	8:30 AM
Kintyre/No.37	Thur, Jan 25	9:00 AM	Mon, June 24	11:00 AM
Gibraltar/Fyrish	Thur, Jan 25	1:30 PM	Mon, June 24	2:00 PM
Kilcoy/Hampshire	Fri, Jan 26	9:00 AM	Tues, June 25	8:30 AM
Rose Hall Town Council	Fri, Jan 26	1:30 PM	Tues, June 25	11:00 AM
Port Mourant/John	Mon, Jan 29	9:00 AM	Tues, June 25	3:00 PM
Bloomfield/Whim	Mon, Jan 29	1:30 PM	Wed, June 26	9:00 AM
Lancaster/ Hogstye	Tues, Jan 30	9:00 AM	Wed, June 26	11:00 AM
Black Bush Polder*	Tues, Jan 30	1:30 PM		
Good Hope/No.51	Wed, Jan 31	9:00 AM	Thur, June 27	2:00 PM
Macedonia/Joppa	Wed, Jan 31	1:30 PM	Thur, June 27	11:00 AM
Bushlot/Adventure	Thur, Feb 1	9:00 AM	Wed, June 26	2:00 PM
Maida/Tarlogie	Thur, Feb 1	1:30 PM	Thur, June 27	9:00 AM
No. 52/No. 74	Fri, Feb 2	9:00 AM	Fri, June 28	9:00 AM
Corriverton Town Council	Fri, Feb 2	1:30 PM	Fri, June 28	11:00 AM

* Not included in the validation exercise

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APPENDIX E

Validation Data Summary

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ACRONYMS

CDC	Community Development Councils
GIS	Geographic Information System
NAREI	National Agricultural Research and Extension Institute
NDC	Neighbourhood Democratic Council
TC	Town Council
VC	Village Council

1. INTRODUCTION

As detailed in Section 1.2, after documenting the findings and analysis, the final phase in the process was to validate the compiled data and verify that the associated detailed mapping was accurate. An ecosystem services validation exercise commenced in May 2019 and concluded in July 2019. As described in Section 2.4, in addition to validating previously recorded information, the validation exercise allows for the collection of any new data relating to ecosystem services functions and values since the previous engagements, while also providing the opportunity to collect updated socioeconomic data at the community level.

The information presented in this Validation Data Summary appendix is limited to the feedback obtained from stakeholders during the validation stage whereby the socioeconomic and biodiversity experts presented the findings of the ecosystem services study and the coastal sensitivity maps on which the results of the ecosystem services study were displayed. These were presented to 62 of the original 64 Neighbourhood Democratic Councils (NDCs), Town Councils (TCs), Village Councils (VCs), and Community Development Councils (CDCs) in the coastal area of Regions 1, 2, 3, 4, 5, and 6.

The responses received during the validation exercise are detailed below, presented by region and stakeholder group. Feedback regarding additional or changed ecosystem services data is reflected under the “Ecosystem Services Survey” heading. Issues not directly related to ecosystem services functions or values, but related generally to socioeconomic status, are also noted under “Other data collected” headings for the purpose of documentation. References within the data to changes over time (e.g., increase in population, decrease in fishing) refer to the time which has lapsed since the 2017/2018 original data were collected and the 2019 validation exercise. In some cases, there are specific notes regarding changes that will be made within the Liza Project Geographic Information System (GIS) database. These are captured within the responses in order to maintain accuracy in the reporting and subsequent mapping efforts. The findings outlined in this appendix are provided in detail within the Detailed Findings Sections of the report.

Some minor changes and updates were recommended as indicated by individual focus groups. These minor updates relate mainly to adjustments in the quantitative data for some ecosystem services presented, as well as location of some activities. In a few instances, additional uses/services in some areas were recommended to be included. The spatial adjustments of locations and inclusion of new uses have been updated in the Liza GIS Database.

Additional socioeconomic data at the NDC, CDC, VC, and TC level were also collected, including updated population figures.

The NDCs, CDCs, VCs, and TCs generally expressed gratitude for the information shared and the opportunity to participate in the original screening and scoping process, and subsequent validation exercise. At their request, finalized maps of their area depicting the ecosystems services within their area as well as the summarized analysis was provided to each of the participating NDCs, CDCs, VCs, TCs, and Regional Councils in December 2019.

The NDCs, CDCs, VCs, and TCs generally expressed gratitude for the information shared and the opportunity to participate in the original screening and scoping process, and subsequent validation exercise. At their request, finalized maps of their area depicting the ecosystems services within their area as well as the summarized analysis was provided to each of the participating NDCs, CDCs, VCs, and TCs and Regional Councils in December 2019.

1.1 Region 5

This section presents the feedback from the ecosystem services validation exercise within Region 5. Engagements with the following NDCs within Region 5 were conducted during the period 20 May to 22 May 2019:

- Woodlands/Farm
- Hamlet/Chance
- Mahaicon/Abary
- Profit/Rising Sun
- Seafield/Tempie
- Union/Naarstigheid
- Bath/Woodley Park
- Woodlands/Bel Air
- Zeelugt/Rosignol

1.1.1 Woodlands/Farm NDC

Ecosystem Services Survey

- There is significant hunting along the NDC shoreline for iguanas, labba, and wild birds for domestic and commercial purposes.
- There is significant fishing within the Bellamy Canal behind the sea dam. More than ten people visit this canal daily during the dry season to catch fish and shrimp.
- A new beach is being built up at Taymouth Manor that has potential for recreation activities. Current access to the area is a challenge, but the NDC is hoping to build the necessary infrastructure.
- The sea defense is under threat, with erosion taking place in some sections, particularly the Fairfield seashore.
- There is beekeeping within the NDC but not at the shoreline. However, the bees might be feeding within the mangroves at the shoreline.
- [Note: The Fish Landing Site that was included under the Unity/Vereegining NDC (Region 4) is actually within this NDC area and should be labeled as such in the GIS database.]

Other Data Collected

- The population is approximately 20,000.

- Small businesses within the NDC are increasing.
- There has been an increase in coconut cultivation recently.

1.1.2 Hamlet/Chance NDC

Ecosystem Services Survey

- There is significant hunting of iguanas on the seashore and along the banks of the Mahaicony River. Songbirds are caught for trade. Birds caught along the shore and river banks include Twa Twa, Grasie, Canary, Red, and Love birds.
- More than ten people catch fish by lines and nets daily in the Mahaicony River for subsistence.
- Few cattle graze within the NDC, but the main stocks are kept at the backlands where there are pastures.

Other Data Collected

- The population is approximately 1,500.

1.1.3 Mahaicony/Abary NDC

Ecosystem Services Survey

- The number of boats fluctuates with the fish season. In summer, the number increases when the catch is plentiful. The sargassum is a constant burden to the fisherfolk, affecting their nets and ability to catch fish. There are numerous wrecks in the area that affect the fisherfolk as their nets become tangled. Drift mud also affects fishing activities.
- People from other regions come to the mangroves and swamps to catch shrimp and crabs during the summer months.
- Songbirds are caught during the summer months when they are plentiful on the shore and river banks.
- There is an increased use of the beach at Good Faith as beaches in other areas are being covered by mud and taken over by mangroves. There is a small beach at Abary that is frequented by a number of people.

Other Data Collected

- The population is approximately 8,000.
- There has been an increase in agriculture, consisting of both crops and livestock.

1.1.4 Profit/Rising Sun NDC

Ecosystem Services Survey

- The fishing boats move according to the migration of the fish to different fishing grounds. Six people set pin seines in low tide on the mud flats.

- There is an increase in birdwatching in the area by tourists, which is promoted by the Georgetown birdwatching groups. Species of note include curri curri, pellew, and duckla. There are thousands of duckla in the area in the afternoons when the tide is low.
- More than 2,000 sheep, goats, and cattle graze in the NDC, but the activity is plagued by thieves.
- The beach is used by many people and expected to be used by more as a bridge and a new road are built to access the beach.

Other Data Collected

- The population is approximately 7,500.
- There is an increase in small-scale agricultural activity, including both livestock and crop farming.

1.1.5 Seafield/Tempie NDC

Ecosystem Services Survey

- The mangroves have reduced at Jacoba and more fishing boats are now in the area as the mud is washing away.
- Erosion has significantly reduced the shoreline within the NDC over the years. The area has old sluices that are in the sea approximately 1 kilometer (.62 mile) from the present shoreline.
- The farmers are fearful of the salt water intruding onto their farms as some people are cutting the mangroves for their own purposes in # 42 and # 37 Villages.
- Grazing has increased at Ross, Seafield, and Tempie.
- Cash crop cultivation is increasing along the sea defense.

Other Data Collected

- The population is approximately 5,000.
- There is an increase in small scale agricultural activity, including both livestock and crop farming.

1.1.6 Union/Naarstigheid NDC

Ecosystem Services Survey

- Fishing has increased within the NDC with more boats at Bushlot.
- More than 30 people are involved in the on-land fishing of tilapia and shrimp for commercial purposes.
- There is an increase in mangroves, especially at Onverwagt. The extensive coverage of mangroves deters the residents of the NDC from making full use of the seashore.
- Recreation activities are facilitated by the Hope Town Community Center. Other locals use Bushlot, Union, Bel Air, and Lovely Lass for recreation purposes.

- There are more animals grazing now in the NDC than in 2018. The animals compete with the cash-crop farmers for space on the sea dam and reserves.
- There are no religious activities at Lovely Lass. [Note: Remove this point from the map.] These activities are conducted at Onverwagt and Bush Lot.
- Many sea birds are hunted for meat and sale in the local markets. Iguanas are hunted mainly during the summer months when they are more plentiful in the area.
- Beekeeping is conducted at Union, Lovely Lass, Onderneeming, Hopetown, and # 29.

Other Data Collected

- The population is approximately 15,000 and is increasing due to new housing areas.

1.1.7 Bath/Woodley Park NDC

Ecosystem Services Survey

- Many people are fishing in the swamps and nearshore during the period when sugar estates are out of season. It is estimated that 10 people conduct this activity regularly, with a peak of 30 to 35 people when crops are out of season. Locals can be seen dragging long seines within the various swamps to catch shrimp.
- In July and August, hundreds of people catch crabs by the thousands in the region, including the NDC. [Note: The priority rating in the GIS database for this activity should be changed to medium.]
- One fisherfolk used pin seine along the mudflats for his daily catch.
- Experiment, Bath, # 11, and # 12 villagers use the façade canal for religious purposes, as the shore is almost inaccessible.
- Grazing is about the same in the NDC from 1 year ago and is plagued by thieves.
- There is significant squatting along the façade canal throughout the NDC. The squatters engage in crop farming.
- Mangroves have been reduced by erosion in some areas in the NDC.

Other Data Collected

- The population is approximately 18,000.
- There has been an increase in economic activities within the NDC, including cash crop cultivation, taxi services, wash bays, and supermarkets.

1.1.8 Woodlands/Bel Air NDC

Ecosystem Services Survey

- There is mangrove growth throughout the NDC shoreline, which has reduced religious and recreational activities along the shoreline. The # 6 beach has been taken over by mangroves and the local people are forced to travel further to find a beach for recreation.
- There is no bee keeping at # 10, as was indicated on the map. [Note: Remove this from the map.] However, there are wild bees and bee hives in the NDC.
- Two fishing boats now dock at # 9 Village.
- There is cash crop cultivation throughout the NDC except in the # 10 Village.
- There is grazing of animals throughout the NDC. The National Agricultural Research and Extension Institute (NAREI) Ranger monitors for grazing within the mangroves.
- Many people catch fish and shrimp in the swamps and drainage canals using nets or long seines.

Other Data Collected

- The population is approximately 1,200.
- There has been a slight increase in agricultural activities.

1.1.9 Zeelugt/Rosignol NDC

Ecosystem Services Survey

- The cremation site at # 2 is no longer used by the people of the NDC.
- There are approximately seven Hindu temples at De Edward, Cotton Tree, # 3, Bennett Dam, Victory Dam, and along the main canal.
- The Berbice River Bridge is used by thousands of people daily and the Berbice River launch transports approximately 1,000 school children and government workers on weekdays between Rosignol and New Amsterdam.
- There are now 90 boats at Rosignol and 75 boats at De Edward. More fishing boats are ordered from Crabwood Creek, where there is better wood available for construction.
- Many cows, goats, sheep, donkeys, and pigs are found grazing the NDC.
- Cage birds are caught along the shore.
- Shrimp is abundant in the swamp and crabs are caught during the season.
- Iguanas are hunted almost daily by approximately 50 people in the NDC.

Other Data Collected

- The population is approximately 2,000.

- There has been an increase in economic activities within the area, especially at Rosignol and De Edward.

1.2 Region 6

This section presents the feedback from the ESS Validation Exercise within Region 6. Engagements with the NDCs and TCs within Region 6 were conducted during the period of 24 to 28 June 2019:

- Ordinance/ Fort Lands
- Kintyre/ No. 37
- Gibraltar/ Fyrish
- Kilcoy/ Hampshire
- Rose Hall Town Council
- Port Mourant/ John
- Bloomfield/ Whim
- Lancaster/ Hogstye
- Bushlot/ Adventure
- Maida/ Tarlogie
- Macedonia/ Joppa
- Good Hope/ No. 51
- No. 52/ No. 74
- Corriverton Town Council

1.2.1 Ordinance/ Fort Lands NDC

Ecosystem Services Survey

- The sawmill located at Sheet Anchor continues to operate and employs between 10 and 50 workers on a part-time basis. Logs are transported to the sawmill using the Canje River.
- The wharves located at the Canje Bridge are used to dock vessels either transporting building supplies or waiting for boat repairs. Approximately four vessels dock at the wharves daily. Boat repairs are also continuing.
- Fishing boats dock at Sheet Anchor, Cumberland, and Seawell; however, the majority of these boats dock at Sheet Anchor because of the wharf.
- The closure of the sugar estates has caused former employees to seek new employment opportunities; and many of them have ended up in the agriculture sector raising livestock. This has increased the number of livestock to more than 2,000 head of cattle grazing at Cumberland, Fort Ordinance, Palmyra, and No. 2, and more than 100 head of cattle, goats, and sheep grazing in Sheet Anchor.
- Similarly, the downturn of the sugar industry has resulted in approximately 50 to 60 people seeking employment in fishing, especially within the swamps along the shoreline areas. Catch is sold within and outside of the NDC.

- Cash crop cultivation is occurring in close proximity to the seawall, including in Seawell. It was prevalent in the past, but slowed in recent years; however, with the downturn of the sugar industry, it appears to be increasing.
- There has been no change in the extent of mangrove coverage in the NDC. Mangroves are a habitat for wild bees, birds, crabs, fish, and shrimp.
- Fish and shrimp are caught daily in the mangroves and canals using cast nets and seines and are sold on the market.
- Locals hunt seabirds such as curi curi, plower, and wisi wisi ducks for meat.
- Crabbing occurs throughout the year and there are two crab meat processing operations located in the NDC.
- Squatting on the seawall at Sheet Anchor and Cumberland has increased by a few households.
- Religious activities are conducted by Hindu communities at Sheet Anchor and on the dams leading to the Canje River. People from the NDC also use dams in Canefield, a neighboring community, for religious purposes.

Other Data Collected

- The population within the NDC area is 8,500 and is relatively stable. A new residential area has opened in Fort Ordinance where approximately 2,500 to 3,000 people reside. Although it has not yet been handed over to the NDC by the Government of Guyana, the NDC has already provided some services to the area.
- Cash crop cultivation in areas close to the seawall in Seawell was prevalent in the past but had declined in recent years. However, cultivation has recommenced in this area by former sugar workers.

1.2.2 Kintyre/ No.37 NDC

Ecosystem Services Survey

- More residents are involved in crabbing and raising livestock due to high levels of unemployment from the closure of the sugar estates.
- The downturn in sugar has also led to an increase in grazing of animals in the NDC.
- Approximately 10 residents are involved in daily hunting of seabirds such as curi curi, plower, and wisi wisi ducks for meat and for sale. More residents participate in hunting during peak seasons (for example, curi curi during the dry season).
- There is a cemetery located in close proximity to the seashore in Bohemia.
- There is brick making in lands adjacent to the shoreline. Soil from the NDC is extracted to burn for the creation of bricks. However, complaints have been lodged to the Regional Health Officer because it is disrupting the nearby cemetery. In addition, concerns were raised that brick making

increases erosion risk due to the extraction of soil and excavation in the direction of the shoreline.

- There has been no change to the extent of mangrove cover in the NDC. Mangroves protect the NDC from the impacts of the sea. In addition, crabs, shrimp, fish, and seabirds are abundant.
- Shrimp and fish are still caught in the communal fish ponds located in the NDC. Residents throughout the Corentyne Coast benefit from the use of these ponds.
- Hindu religious activities are practiced in Borlam daily, particularly on Sundays.
- Drainage pumps located at Borlam are still operational.
- Crab Island and Borlam Beach are used for recreational purposes.
- There is no farming of cash crops and fruits on the sea dam and adjacent areas.

Other Data Collected

- The population within the NDC area is 1,000 and is relatively stable.
- It was reported that mosquitoes are more prevalent when culverts are opened, which the NDC does to allow shrimp to swim from the ocean into shrimp ponds.
- At present, two species of crab are being caught; however, the “sheriga” crabs, which were previously abundant, are now scarce.

1.2.3 Gibraltar/ Fyrish NDC

Ecosystem Services Survey

- The main source of livelihoods in the NDC comes from livestock farming. There is pig farming in the back dam of No. 1 Village and two large poultry farms in the Fyrish back dam.
- There has been no change to the 12 shrimp ponds located along the seashore.
- Many residents of the NDC were employed by the sugar industry and were retrenched when the estates closed. Many people pursued alternative livelihoods such as crabbing, fishing, shrimping, and raising livestock farming.
- Cattle, goats, sheep, and pigs graze on lands adjacent to the mangroves.
- There is a cemetery in Fyrish that is used for burials by all religions.
- Sea birds such as curi curi, plower, and wisi wisi ducks are hunted for meat and sale. The number of residents involved in these activities has increased, also likely due to the downturn in the sugar industry.
- Hindu religious activities are practiced along the shoreline in areas where there is access to the shoreline such as the eastern section of Fyrish and the No. 1 Village.
- The No. 4 Village is not located within the NDC. However, people from the NDC use the dam in the No. 4 Village for Hindu religious activities.

Other Data Collected

- The NDC population is approximately 5,600 and remains stable.
- There are grazing pastures (cattle, goats, sheep, and pigs) in each of the four villages located in the NDC. The NDC is receiving support from the Government of Guyana for the construction of pastures. There is a new pasture in the No. 1 Village.
- The Government of Guyana provided an excavator to clear the channels around the sea dam to facilitate easier refilling and emptying of the shrimp ponds. Currently, the NDC is engaged with the Sea Defence Board to ensure that the sea dams are sufficient to protect lands from the impacts of the sea.
- In the past, there was a breach of the sea dam as a result of shrimping activities (to refill the shrimp ponds in the NDC), resulting in saline intrusion into residential areas, and the destruction of more than 1,000 mango trees in the back dams of Fyrish and Gibraltar.
- There is no landfill in the NDC and consequently residents and businesspeople (as they are required to pay) illegally dump garbage on the access dam. A significant quantity of garbage ends up in the channels. The NDC is allowed to dispose of garbage free of cost at the landfill located in the Rose Hall Municipality. However, businesspeople are required to pay to dispose of their garbage at the Rose Hall landfill and most are unwilling to do so.

1.2.4 Kilcoy/Hampshire NDC

Ecosystem Services Survey

- The number of fishing boats associated with the Albion landing site has increased to 160 boats during off-season and to175 boats during peak season. Approximately 450 to 475 residents are employed in fishing[6].
- More residents than in years past are involved fishing, crabbing, and hunting for subsistence and sale as a result of the downturn in the sugarcane industry. This includes:
    - Fishing with cast and drag nets;
    - Crabbing; and
    - Hunting iguanas and sea birds in the mangroves.
- There are 40 privately owned shrimp ponds in the NDC in close proximity to the sea dam.
- Iguanas and seabirds are caught for meat and sale in the mangroves. These activities are mostly done by young people who have completed secondary school but are unemployed. Young people from within and outside of the NDC are engaged in this activity.

[6] Based on data collected from fisherfolk at the Albion landing site as part of the Participatory Fishing Study (PFS), approximately 50 boats routinely use the Albion landing site. It is unlikely that the landing site has capacity for 175 boats. Based on the PFS findings, boats that previously landed at Albion are docking at the Adventure landing site due to ease of access and clearance of the channel. As a consequence, while more people in the NDC are involved in fishing, they are using alternative landing sites located on the Corentyne Coast.

- The number of people from the NDC who catch crabs on a weekly basis for sale has increased. In addition, crab catching is also considered a recreational activity and the crabs caught are for subsistence use.
- The poultry farm located in Kilcoy and Chesney has five large multi-story chicken pens, which house approximately 100,000 chickens.
- A few residents engage in farming of cash crops and fruits for subsistence and sale on the sea dam and adjacent lands.
- Hindu temples are in close proximity to the seashore at Chesney, Hampshire, and Nigg, and two temples are located in Belvedere. Hindu religious activities are also conducted on the sea dam in No. 4 Village.
- Wild bees are found in hives in the mangroves at Hampshire.
- The extent of mangrove cover in the NDC has increased, extending further offshore. In previous years, there was significant harvesting of mangroves resulting in almost 1 kilometer of erosion inland. However, mangrove harvesting has been reduced.

Other Data Collected

- The population of the NDC is 25,000 and is increasing as new housing accommodations have been built in Kilcoy/Chesney and Block X of Belvedere/Nigg/Hampshire.
- Land has been earmarked by the Government of Guyana in Hampshire North for the establishment of a new industrial site.
- There is cattle rearing in Hampshire but it is not located in proximity to the seashore.
- Region 6 is heavily dependent on GUYSUCO and negative effects of the closure of the estates are being experienced throughout the region.
- In previous years, there was significant harvesting of mangroves resulting in almost 1 kilometer of erosion inland. However, mangrove harvesting has been reduced although a few people still cut mangroves to use in their kitchen gardens.

1.2.5 Rose Hall Town Council

Ecosystem Services Survey

- The beach in Rose Hall and No. 63 remain popular, with comparable users during the Easter holidays in 2019. Rose Hall has increased in popularity; hundreds of people visit it daily—upwards of 500 people on weekends.
- Religious activities by Hindus on the Rose Hall beach has increased and approximately 200 people use the area on a weekly basis, with more on Sundays and Tuesdays. Thousands of people use the area on special days of worship for Hindus.

- There has been no change in the number of people engaged in fishing in the NDC[7].
- The extent of mangrove coverage in the municipality has declined, as trees and cover are harvested for firewood, building materials, and fishing rods.
- Approximately 100 cattle, sheep, and goats are grazed on the shore and nearshore areas.
- Seabirds are caught for subsistence and sale, and include spika, cranes, and wisi wisi ducks. Some residents from the municipality visit fish ponds located in other areas of the Corentyne Coast to catch large birds for sale.
- Farming on the sea dam and on adjacent lands has decreased due to saline intrusion.

Other Data Collected

- There are approximately 15,000 people in the municipality.
- The access road to the Rose Hall beach is in poor condition. The Ministry of Social Cohesion visited the municipality to assess opportunities for improving infrastructure, including construction of an access road and providing electricity. However, this project is on hold.
- Region 6 was very dependent on the sugar industry. Many businesses in the municipality depended on "crop seasons" of the sugar estates. In addition, the closure of the estate in Rose Hall has negatively affected the revenues in the municipality as fewer people purchase from vendors in the markets and vendors are unable to pay their rates to the TC. Similarly, residents from the municipality who lost their jobs are employed in alternative activities such as farming for subsistence use and fishing in canals in the back dams.

1.2.6 Port Mourant/ John NDC

Ecosystem Services Survey

- There are nine boats employing between 33 to 40 people that use the Port Mourant outfall for fishing and shrimping. Fishing is considered a second job for sugar workers during out-of-crop seasons.
- Approximately 20 to 25 residents catch fish and shrimp in the swamp areas and drainage canals on a daily basis, while up to 100 residents catch fish and shrimp in these same areas during out-of-crop seasons.
- There are approximately 100 shrimp and fish ponds owned by 40 people in the Rose Hall to Babu John area. Ponds have been expanded, converted, or restored, and there are different sections for diverse species. In addition, areas formerly used for rice cultivation have been converted to shrimp and fish ponds. The ponds in Babu John have been rehabilitated and are currently in use. All ponds in the NDC are privately owned.
- The poultry farm at Johns has five large multi-story pens with approximately 25,000 chickens.

[7] Note: Based on findings of the PFS, the number of vessels operating at the Rose Hall landing site has declined over the last six months due to the difficulty accessing the channel and personal challenges encountered by the fisherfolk.

- Sea- and shore birds are hunted for subsistence and for sale. Although a few people routinely catch these birds, there are peak numbers of people involved on a seasonal basis.
- There has been no change in mangrove cover in the NDC but there is no monitoring. Some people collect dried mangrove roots for use in their kitchen gardens and as firewood.
- Religious activities are held at Port Mourant. In addition, the main cremation site at Babu John is dedicated to the late President Cheddi Jagan. There is also a cemetery at Babu John.

Other Data Collected

- There are approximately 16,000 people in the NDC. The population may be increasing as several people from New Amsterdam, Mara, Canje, and Black Bush Polder have relocated to the NDC.
- The closure of the sugar estates in Region 6 has significantly affected the quality of life in the NDC. Former sugar workers have been struggling to find alternative livelihoods such as fishing and subsistence farming. The overall reduction in disposable income in the NDC has adversely affected businesses and vendors in the Port Mourant market. In addition, sports like cricket have been severely affected following the closure of the estates.

1.2.7 Bloomfield/ Whim NDC

Ecosystem Services Survey

- The outfalls at Letter Kenny and Whim are used as landing sites for fishing boats; however, they are infrequently used because the channels are heavily silted making passage difficult.
- Approximately 28 fishing boats are owned by people from the NDC who use landing sites at Adventure and Complex 66. In addition, more than 100 people in the NDC are employed as fisherfolk on boats at different landing sites throughout the Corentyne Coast.
- Approximately 15 people catch crab on a regular basis for sale.
- Approximately 15 people fish along the shoreline using pin seines and cast nets.
- There are approximately 30 shrimp ponds owned by 10 to 15 people from the NDC.
- As a result of the downturn in the sugar industry, grazing of cows, goats, and sheep along the sea dams and shoreline has increased.
- Cultivation of cash crops and fruits in close proximity to the sea dams at Letter Kenny and Whim occurs during the wet seasons when freshwater is easily available.
- Hindu religious activities are held between Bloomfield to Letter Kenny. People from within and outside of the NDC come to these areas for worship.
- There are three Hindu temples located in close proximity to the shoreline at Letter Kenny and Whim.
- There are cemeteries at Letter Kenny and Whim which are used by all religions.

- There is a nursery school located in close proximity to the seashore in Letter Kenny.
- A Guyana Water Inc. water pump is located in Letter Kenny and provides water to Whim, Bloomfield, Letter Kenny, and Auchlyne.

Other Data Collected

- The NDC population is approximately 4,000 and it is expected to increase because of new housing accommodations in Bloomfield.
- The owners of the fish and shrimp ponds destroy the mangroves to allow for emptying and refilling of their ponds. Some residents collect dried mangroves for use in their kitchen gardens and as firewood.
- The activities in the NDC are the same as a year ago, but participation in fishing, raising livestock, and cultivating crops has increased as a result of the downturn in the sugar industry.

1.2.8 Lancaster/ Hogstye NDC

Ecosystem Services Survey

- There are 12 boats that use the Hogstye/Adventure outfall for fishing. The number of large fishing boats landing at the Hogstye/Adventure outfall has increased, as there is easy access to the landing and alternative landing sites (e.g., Complex 66) are overcrowded. None of the boats at the outfall are owned by people from the NDC; however, NDC residents, mostly from Lancaster, work on the fishing boats that land at various sites along the Corentyne Coast.
- People throughout the NDC utilize pin seines and cast nets for fishing along the shoreline.
- There is one shrimp pond and one tilapia pond in Lancaster occupying 198 acres of land close to the seashore. Two people own these ponds.
- Iguanas are hunted daily for subsistence and sale by unemployed young people in the NDC. There is limited hunting of birds in the NDC.
- The beaches at Alness and Manchester are utilized for recreation, relaxation, and religious purposes. These activities have increased due to improved access.
- Grazing of cows, goats, sheep, and horses occurs throughout the shoreline of the NDC.
- Pig farming and grazing in Manchester has stopped; however, a new developer has requested permission from the NDC to construct pig pens along the shoreline.
- Natural regrowth of mangroves is continuing in the NDC.
- Cultivation of cash crops and fruits along the shoreline has increased, with more crops being planted during the wet seasons. In Lancaster, there have been land conflicts between farmers and owners of the fish and shrimp ponds. In addition, there are complaints from some residents of the NDC that spraying of pesticides on the crops adversely impacts their lives.

Other Data Collected

- The NDC's population is approximately 2,500 people and is relatively stable.
- There is squatting in Manchester, Ulverston, Liverpool, and Lancaster.

1.2.9 Bushlot/ Adventure NDC

Ecosystem Services Survey

- There are approximately 6 fishing boats that dock at the Bushlot/Kildonan outfall and 12 boats at the Adventure outfall.
- As a result of the downturn in the sugar industry, the number of residents who fish along the shoreline using pin seines and cast nets has increased.
- Shorebirds are hunted mostly in Bushlot for subsistence and sale. A few residents also hunt iguanas. This is mostly done by young people who have completed secondary school and are unemployed.
- Although a few residents regularly catch crabs for sale during off season, more residents are involved during crab season.
- There are three shrimp ponds in the NDC—two are in Bushlot Farm and are privately owned by two people, and one is in Bushlot and communal.
- There is no squatting along the seashore. There is only one structure in Kildonan and this is used by the sluice attendant.
- Approximately 100 people use the Bushlot beach on a weekly basis for recreation purposes, although several hundred people use the beach on special holidays like Easter.
- The use of the Bushlot beach for Hindu religious activities has also increased and people from other areas as far east as Hampshire use the beach for religious purposes.
- Cultivation of cash crops and fruits has increased along the sea dam from Bushlot to Adventure and is attributed to higher levels of unemployment resulting from the closure of the sugar estates. There is no farming on private lands.
- Mangrove cover at Kildonan has increased. People from the NDC use dried mangroves in their kitchen gardens and sometimes as firewood.

Other Data Collected

- The NDC population is estimated to be over 6,000, with 3,400 of voting age.

1.2.10 Maida/ Tarlogie NDC

Ecosystem Services Survey

- The mangrove seedlings planted in the NAREI restoration plot in Wellington Park have died, with sawdust washing up onshore being the likely cause. However, the mangroves in other areas in the NDC, such as Kilmarnock, have grown.
- More than 1,000 cows and sheep graze along the shoreline throughout the NDC. The owners of these animals reside in Wellington Park, Philippi, and Kilmarnock.
- Hindu religious activities are held in areas where there is access to the sea such as Wellington Park, Kilmarnock, Maida, and Tarlogie.
- Hunting of iguanas and seabirds for subsistence and sale in the mangroves has increased, with approximately 20 to 25 people participating daily.
- Crabbing for subsistence and recreation remains important in the NDC.
- Approximately 14 fishing boats land at Tarlogie, Maida, Kilmarnock, and Wellington Park depending on the ease of traversing the channels to access the sites. Approximately 60 people are employed in these boats.
- The number of residents who fish along the shoreline using pin seines and cast nets has increased.
- More people are planting cash crops and fruits along the sea dam in Maida. Cultivation on the sea dam and adjacent lands is also continuing in Tarlogie and Wellington Park.
- Additional privately owned shrimp ponds have been created on Wellington Park, Maida, and Kilmarnock, with approximately 125 buckets harvested from these ponds monthly. Approximately 8 to 10 people own these ponds.
- There are canals and swamp basins in Tarlogie open for communal fishing and shrimping.

Other Data Collected

- The NDC's population is approximately 3,500 people and is relatively stable.
- Rice cultivation is on the decline, as the farmers have encountered several challenges.
- Decline in mangrove cover resulted in saltwater intrusion in Wellington Park which affected cash crop farming.

1.2.11 Macedonia/ Joppa NDC

Ecosystem Services Survey

- There is extensive mangrove cover in the NDC and the mangrove stand has been increasing.
- More than 8,000 cows, goats, and sheep graze in Bengal, Joppa, Brighton, Eversham, Kiltaira, and No. 35 Village. The least amount of grazing occurs in Eversham. In addition, in between the rice crops, some animals are taken to the rice fields to graze.

- Fishing boats that use the outfall in No. 43 Village have declined, as larger boats use the landing at Complex 66. However, there are facilities for boat construction and maintenance and seine mending at the No. 43 outfall.
- There are approximately five boats that use the Eversham Outfall.
- There are five privately owned shrimp ponds on the sea dams of Bengal, Kiltyre, and No. 36 Village.
- Approximately 100 residents catch shrimp, tilapia, and hassar in the mangroves, canals, and shorelines using pin seines and cast nets daily for subsistence. If there is excess catch, it is sold within the NDC.
- Crabbing is important in the NDC, with residents from Canje visiting the NDC during crab season.
- Turtles are sometimes caught in the mangroves for subsistence.
- Cultivation of cash crops and fruits has continued on the government reserves in Brighton Canal, Kiltyre, and Eversham. However, there are challenges with saltwater intrusion and high water levels. Cultivation of cash crops and fruits increases during the wet seasons which fresh water is available.
- Hindu religious activities occur at the shoreline in No. 43 Village.

Other Data Collected

- The NDC population is 3,535 and remains relatively stable.
- The government has constructed sea defense dams from Wellington Park to Eversham in 2018 and 2019. Previously, there was erosion of the mangroves and breach of the sea defense that resulted in flooding of the shoreline area and public road of the No. 43 Village.
- The closure of the sugar estates has affected livelihoods in the NDC and former sugar workers are seeking alternative employment in the agriculture and fishing sectors.

1.2.12 Good Hope/ No. 51 NDC

Ecosystem Services Survey

- Wild bees are present in the mangroves in No. 45, No. 47, No. 48, No. 50, and No. 51. Honey is harvested from these hives for subsistence use. However, the numbers of bees are increasing and there have been complaints of bees swarming residences.
- Approximately 30 to 40 people from within and outside of the NDC catch crabs in the mangrove forests in the NDC for sale.
- Hunting of iguanas has increased significantly in the mangroves throughout the NDC. People from the Corentyne Coast, including New Amsterdam, visit the NDC to catch iguanas for sale.

- Hunting of shorebirds has increased and is done daily at No. 45, No. 48, No. 50, and No. 51 Villages. In addition, cage birds are caught for sale and training in the NDC at No. 45, No. 48, No. 50, and No. 51 Villages.
- One resident of No. 49 Village grazes goats on the sea dam and in the mangroves, while other residents graze cows, goats, and sheep at No. 45, No. 47, No. 48, No. 50, and No. 51 Villages.
- A few boats still use the landing site at No. 51 Village. No. 43 is outside of the NDC district.
- People fish along the shoreline using pin seines and cast nets daily throughout the NDC.
- There is brick burning by four to eight people on the sea dams of No. 51 Village.
- Cultivation of cash crops and fruits on the sea dam and adjacent lands in No. 47 Village has stopped due to significant saltwater intrusion where the dam was eroded and there were breaches in the mangroves. Farming is continuing on the sea dams on No. 50 and No. 51 Villages.
- There are four large shrimp ponds in the No. 49 Village, which are all privately owned.
- In the No. 51 Village, there is a swamp area where people catch fish and shrimp for subsistence use. This area is also used by residents from the No. 52 village, located outside of the NDC.
- Mangrove coverage throughout the NDC is increasing and the TC is actively trying to stop the mangrove harvesting.
- Religious activities are held in No. 49 and No. 51 Villages with the most people on Fridays and Sundays. There is easy access to the shoreline at No. 49 Village.

Other Data Collected

- There were 2,354 people and 735 households in the NDC in 2013. This is relatively stable.
- Following the breach of the sea defense at No. 47 Village, the government constructed a sand foundation for the sea dam. There was no future work and the sand dam has already experienced significant erosion. There were no sea defense works from No. 48 to No. 51 Villages.

1.2.13 No. 52/ No. 74 Villages NDC

Ecosystem Services Survey

- Approximately 4,000 people in the NDC are directly or indirectly employed in the fishing sector.
- The number of fishing boats using the landing at Complex 66 has increased to approximately 400. Fishing boats from Regions 4, 5 and along the Corentyne Coast use this landing site.
- There are approximately 100 boats at the No. 65 outfall.
- Approximately ten meters from the No. 65 outfall, construction of a fish processing plant has commenced, which is expected to employ 500 people. The owner of this processing plant has also purchased 45 new fishing boats.

- At No. 63 village, there are approximately 20 small boats that use pin seines to fish along the shoreline. In total, there are approximately 60 to 75 small boats in the NDC that practice pin seine fishing along the shoreline for sale.
- The number of people involved in hand seine and cast net fishing along the shoreline has increased.
- There is significant to complete erosion of mangroves in No. 52 – No. 63, No. 67, No. 69, No. 70, No. 73, and No. 74 Villages. There is no cutting of mangroves and it is likely that these are natural deaths due to the age of the stand.
- Due to the erosion of mangroves, crabbing has significantly declined and crabs are only caught during crab season.
- Hunting of iguanas in the mangroves has continued, while only a few people hunt birds (as they are not prevalent in the area).
- Grazing of animals along the shoreline has decreased significantly because of mangrove forest erosion. Grazing has shifted largely to the back dam areas, but cattle farmers face challenges with rustlers in the back dams.
- More people are involved in cattle rearing than before, but there is less livestock overall in the NDC.
- Cash-crop cultivation along the shoreline has decreased due loss of lands as a result of mangrove erosion.
- Boat building occurs on both sides of the dam at Complex 66. Surinamese fisherfolk order fishing boats at the boat-building sites at Complex 66 due to the quality of wood used in Guyana and the skills of the boat builders. A boat construction facility has also been opened adjacent to the new fish process plant at No. 65 Village.
- Religious activities are held throughout the NDC where there is easy access to the shoreline including No. 63, No. 69, No. 70, No. 71, and No. 73 Villages.

Other Data Collected

- The population of the NDC is approximately 20,000 and it is relatively stable.
- The closure of the sugar estates in Region 6 has had significant adverse impacts on livelihoods and well-being of people in the NDC. In particular, there has been a significant increase in the number of people involved in fishing and livestock farming in the NDC since the closure of the estates. It is estimated that over 1,000 people are involved in the fishing sector.

1.2.14 Corriverton Town Council

Ecosystem Services Survey

- A wind turbine with a capacity of 275 KVA was installed on the riverbank, but is not yet operational. The company is awaiting permission from the Government of Guyana before it can proceed.

- The wharf located at Line Path is used by farmers and loggers to transport their commodities from Orealla and Siparuta to Corriverton.
- Passengers use the "backtrack route" at No. 78 Village to access a ferry service to Suriname. When in operation, the ferry lands at Moleson Creek, which is not located in the municipality.
- There are approximately 40 boats at No. 79 Village that fish in the Corentyne River and catch various species of fish and shrimp.
- Approximately 10 to 50 people are engaged in daily use of seines for catching mullet and shrimp.
- Catching sardines is seasonal, with more than 100 people engaged during peak season using seines.
- Speed boat construction is done at the No. 78 Village.
- Hindu religious activities occur at Line Path, Scottsburg, Spring Garden, and Springlands. Some Christian groups also perform baptisms in these areas.
- There has been significant erosion of mangrove cover from No. 75 Village to Scottsburg. The municipality requested support from NAREI to replant mangroves in the area. Rip rap sea defense structures have been installed in Scottsburg.
- Mangroves are not harvested but some people collect dried mangroves to use as firewood.
- Erosion of the sand bank in No. 79 Village has decreased use of the area for recreational purposes.
- The area on the No. 78 Village shoreline, which was earmarked for developmental works by the municipality, is now being used by the Sea Defence Division to store materials and equipment.
- More than 10 people are engaged in the hunting of iguanas on a weekly basis along the shoreline in Scottsburg.
- There are fewer than 30 cows grazing along the shoreline in the NDC. According to the bylaws of the TC, there should be no livestock farming in the town.
- There are approximately five tour operators who provide trips down the Corentyne River. Sometimes regattas and other events like pageants are held in communities in the river, such as Orealla.
- Approximately 30 households squat along the sea dam in Line Path, Dukestown, and No. 78 and No. 79 Villages.
- Approximately 35 people are engaged in cultivation of cash crops and fruits along the shore and sea dams of Line Path, Scottsburg, Dukestown, and No. 75 Village.

Other Data Collected

- The NDC population is approximately 17,000 to 18,000 people in the municipality.

- The closure of the Skeldon Sugar Estate has resulted in increased fishing, crop cultivation, livestock farming, and hire car services operating on the municipality.
- The municipality has received a request to construct a Hindu temple on the No. 79 village seashore.
- There is significant dumping of garbage along the seashore of the municipality and there are certain areas where depressions in the ground cause garbage to accumulate.

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ATTACHMENT A: REGISTRATION SHEETS

Attachment A1: Region 5

Name	Designation	Contact Information
Woodlands/ Farm NDC		
Wainright Henry	Businessman/Chairman	On file
Shawndell Bristol	Overseer	On file
Roxanne Abrams	Vice Chairperson	On file
Hamlet/ Chance NDC		
Marlon McRae	Chairman	On file
Gloria Vaux	Councillor	On file
Lewis Bourne	CEI worker	On file
Cheryl Mingo		On file
Coritta Richmond		On file
Stacey Abel		
Carolyn Nedd		On file
Shundell Robertson	Overseer	On file
Marcie Richmond	Vice Chairwoman	On file
Maxine Halley	Farmer	On file
Mahaicony/ Abary NDC		
Gafeth Williams		On file
Marsha Pereira Tappin	Housewife	On file
Vibert Sealey	Pensioner	On file
Deonarine Dindayal	Pensioner	On file
Wilbert Inniss	Farming	On file
Mohini Singh	Shop Keeper	On file
Charles Gibbons	Pensioner	On file
Andrea Moriah	Overseer	On file
Tamica John	Sanitary/ E.H.A	On file
Profit/ Rising Sun NDC		
Debris David		On file
Cassandra Pellord		On file
Shanneta Bisnauth	Overseer	On file
Andrea Noble	Asst. Overseer	On file
Toiwana Reynolds	Environmental Health Asst.	On file
Gloria Fraser	Asst. Chairperson	On file
Marwa Belgrave	Housewife	On file

Name	Designation	Contact Information
David Ross	Farmer	On file
Eon V. Warde		On file
Joseph Rooplall	Farmer	On file
Seafield/ Tempie NDC		
Desirey Mentore	Dentex	On file
Oneca Sam	Overseer	On file
Delon Crawford	Councillor	On file
Bradley Downer	Environmental Health Asst.	On file
Carol Inniss	Councillor	On file
Michelle McPherson	C.E.T.L	On file
Leticia Kissoonchand	E.H.A	On file
Union/ Naarstigheid NDC		
Rameshwar Samaroo	Nurse	On file
Vinceroy Jordan	Engineer	On file
Trevor Gravl	Businessman	On file
Suvaeh Ramlochan	Business/ Farmer	On file
Seonaid Richmond Welch	Pastor	On file
Myrtle Christian	Overseer	On file
Lolita Chesney	Nurse	On file
Bath/ Woodley Park NDC		
Annesia Ramchand	Asst. Overseer	On file
Dinesh Gossai	Student/ Councillor	On file
Krishna Sewlall	Farmer	On file
Adrian Singh	Field Supervisor (Blairmont Estate GUYSUCO)	On file
Sudesh Persaud	Self Employed	On file
W. Isahack	Driver	On file
Candacia Jacobs	Crop Extension Officer	On file
Kamini Amantram	Clerk	On file
Mohanlall Chandlall	Councillor	On file
Woodlands/ Bel Air NDC		
M. Heeralall	Overseer	On file
Letitia Blackman	E.H.A	On file
Joycelyn Braithwaite	Vice Chairperson	On file
Shanti Seenarine	Councillor	On file
Fiona Reynolds	Chairperson	On file
Surujdai Ramdin	Councillor	On file
Shermon B. Vyphuis	Team Leader	On file

Name	Designation	Contact Information
Zeelugt/ Rosignol NDC		
Olanda O Donoghue	E.H.A	On file
Sheniza Noble	E.H.A	On file
Kamine Anthonio	Assistant Overseer	On file
Joseph Jageshwar	Councillor	On file
Samuel Gagnandan	Councillor	On file
Choutar Dewan	Pensioner	On file
Eshwarnath Singh	Councillor	On file
Agnes Karamchand	Councillor	On file
Iqbal Alli	Councillor	On file
Andrea Cummings	E.H.O	On file
Shellon Peters	Councillor	On file

Attachment A2: Region 6

Name	Designation	Contact Information
Ordinance/ Fort Lands NDC		
Haimwattie Clifford	Nursing Assistant	On file
Karmanand Ramash	Pastor	On file
Tessie Ramnauth	Overseer (ag)	On file
Subhaschan Beer	Shop Keeper	
Kintyre/ No.37 NDC		
V. Totaram	Security	On file
Benawattie Gulcharran	Charwoman	On file
Basant Persaud	Vice Chairman	On file
Chandroutie Paul	Housewife	On file
Vijay Persaud	Typist/ Clerk	On file
Gibraltar/ Fyrish NDC		
Joshua P. Sewdat	Overseer	On file
Kilcoy/ Hampshire NDC		
Pittamdai Tamradwagh	Housewife	On file
L. Harcharran	Housewife	On file
R. Ramson		On file
U. Gowkarran		On file

Name	Designation	Contact Information
P. Kisten	Pensioner	On file
Arjuna Veerasamy	Cane Harvestor	On file
Ashook Balcharran	Truck Driver	On file
Chrismadat Noel	Overseer	On file
D. Kasinath	Pump Operator	On file
Shamal Sugrim	Sales Manager	On file
Rose Hall Town Council		
Chatergoon Ramnauth		On file
Natasha Griffith		On file
Vedwat Ramnarain	Councillor	On file
Sandra Chisholm	Councillor	On file
S. Ramdhail	M/Treasurer	On file
Winston Hope	Councillor	On file
Sharon Mc Allistor	ag Sgt	On file
Quacey Cort	Councillor	On file
Gaitree Sheonarain	Councillor	On file
Shelly Clarke	Clerk of Market (ag)	On file
Port Mourant/John NDC		
Ramdat Isar	Farmer	On file
Maipaul Persaud	C. Leader	On file
Satie Hussain	Councillor	On file
Narainsamy	Chairman	On file
Reshma Roopram	Rates Collector	On file
Budwatty Ramnarine	Overseer	On file
Anmal K. Mohan	Councillor	On file
O. Mc Daipall	Councillor	On file
Bloomfield/Whim NDC		
DonnieTony		On file
KC Harilall		On file
J. Baijnath		On file
C. Pooran		On file
S. Ishmael		On file
Khemraj Permaul		On file
Lalchand Rupchand	Overseer	On file

Name	Designation	Contact Information
K. Tejram	Revenue Collector	On file
Kamalda Singh	Councillor	On file
H. LaPelimar		On file
Omadevi Ramnarine	Office Assistant	On file
Lancaster/ Hogstye NDC		
Leroy Smith	Small Business Owner	On file
Intikak Ali	Businessman	On file
Chandani Drejodhan	Assistant Overseer	On file
Lorna Hope	Chairwoman	On file
Bonita Leitch	Team Leader	On file
Arnold Clinton	Farmer	On file
Kim Rambarose	Housewife	On file
Bridget Chichester	Supervisor	On file
Bushlot/ Adventure NDC		
Collin E. Moore	Chairman	On file
Gillian Bennett	Overseer	On file
Preya Mohanlal	Rates Collector	On file
Maida/ Tarlogie NDC		
Tenisha Williams	Asst. Overseer	On file
Davyani Karim Basil	Overseer	On file
Bebe Khedaroo	Councillor	On file
Annie Pestano	Councillor	On file
Macedonia/ Joppa NDC		
Aticha Persaud	Overseer	On file
Valsha Lomash	Councillor	On file
Lennox Haynes	Councillor	On file
Patricia Lewis	Councillor	On file
Vera France	Councillor	On file
Good Hope/ No.51 NDC		
Swarsate Devi Sharif	Housewife- Chairperson	On file
Coleen North	Housewife- Councillor	On file
Sharron Davis	Housewife- Councillor	On file
Kamaldeo	Labourer	On file
Letika E. Cornelius	Student	On file

Name	Designation	Contact Information
G. Samuels	Overseer	On file
Lelo Murrid		On file
No.52/ No.74 NDC		
Jaichand Ramraj	No. 64 Village	On file
V. Ramsaywack	No.52 Village	On file
Alvin Singh	Student	On file
Teneisha Smartt	Student	On file
Lakhram Singh	Councillor	On file
Jailall Tahal	Councillor	On file
Roslyn Hawker	Asst. Overseer	On file
Ravindra Dass	Overseer	On file
Anil Ramgahan	Chairman	On file
Shanaaz Ram	Councillor	On file
H. Ghansham	Councillor	On file
Jason Gravesande	Vice Chairman	On file
Nella Jaundoo	Charwoman	On file
S. Narine		On file
P. Bholanath	Councillor	On file
Denzil Lewis	PHI	On file
Shakuntalla Bhoj	Social Worker	On file
Corriverton Town Council		
Winston Roberts	Mayor	On file
Imran Amin	D/Mayor	On file
Mahendra Sukhram	Town Clerk	On file
D. Singh	Councillor	On file

ATTACHMENT B: IMAGES

Attachment B1: Region 5

Woodlands-Farm NDC





Hamlet-Chance NDC





Mahaicony-Abary NDC





Profit-Rising Sun NDC





Seafield-Tempie NDC





Union-Naarstigheid NDC





Bath-Woodley Park NDC





Woodlands-Bel Air NDC





Zeelugt-Rosignol NDC





Attachment B2: Region 6

Ordinance-Fort Lands NDC




Kintyre-No.37 NDC




Gibraltar-Fyrish NDC




Kilcoy-Hampshire NDC




Rose Hall Town Council




Port Mourant-John NDC




Bloomfield-Whim NDC




Lancaster-Hogstye NDC




Bushlot-Adventure NDC




Maida-Tarlogie NDC




Macedonia-Joppa NDC




Good Hope-No.51 NDC




No.52-No.74 NDC




Corriverton Town Council




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APPENDIX W

Payara EIA Comments and Responses

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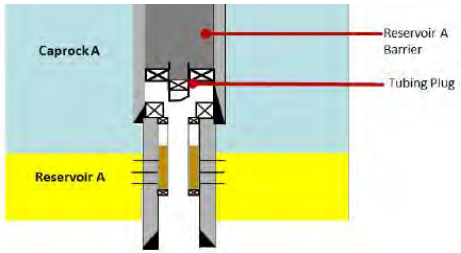
	Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
EIA Section/Topic	**EPA Comments**	**Response to Comment**	**Section in Which Addressed**
Payara Development Project Volume 1, Part 1 - EIA			
General Comments			
	General statement: The document mentions the evaluation of alternatives for antifouling chemical dosing, however, timelines nor types of alternatives for consideration were not mentioned. This should be addressed.	Flow assurance chemicals are evaluated and selected based on a competitive technical and commercial evaluation bid process that includes various independent oilfield chemical supplier participants. Technical evaluations on oilfield chemical supplier proposed chemicals can include various tests and lab analyses to assess and evaluate chemical characteristics and performance against project specified functional requirements, chemical performance specifications, and Company/Country specific criteria. Selection of flow assurance chemicals and associated oilfield chemical suppliers will be based on Company specified technical and commercial evaluation specific to the project. Specialty chemicals such as asphaltene inhibitor will also undergo additional Company evaluation by utilizing Company's proprietary research and lab testing capabilities to validate supplier proposed inhibitor chemicals against technical criteria. Types of flow assurance chemicals specified for the Payara Project (such as but not limited to asphaltene inhibitor, scale inhibitor, xylene, methanol, etc.) are categories of industry standard chemicals that have been typically utilized within ExxonMobil and the oil and gas industry. As of January 2020, flow assurance chemicals for the Payara Project have not been selected, but chemical suppliers in competition for the Payara Oilfield chemicals goods and services contract have previously provided similar chemicals for other oil and gas ventures. For example, the Liza Phase 1 Project has selected a similar chemical supplier that provide flow assurance chemicals such as asphaltene inhibitor, scale inhibitor, xylene, and methanol volumes. Bulk chemicals such as methanol and xylene are industry standard chemicals utilized across oil and gas ventures. Due to the competitive nature of the bidding process, specialty chemicals such as the asphaltene inhibitor and scale inhibitor chemicals proposed by chemical suppliers specific to the Payara bid may not be an industry standard chemical, as each supplier uses their proprietary capabilities to develop and propose optimized chemicals that are best suited for the Payara bid criteria. Although these chemicals are optimized, general chemical compositions and associated chemical information (e.g., safety data sheets) are still provided to Company for proper design, chemical management, chemical handling purposes as well as environmental standards.	2.12.1
	Detailed technical process overview of the entire process including start-up to be inserted in the document.	Please see the embedded Payara Process Overview (Rev 0) pdf that addresses the following processes; • Oil Processing System Overview • Gas Processing Overview including: • Flash Gas Compression • Main Gas Compression • Gas Treatment System • Injection Gas Compression The final Payara EIA will be updated with similar text and supporting figures. The FPSO start-up sequence is as follows; • Gas Turbine Generators (GTGs) on Marine Gas Oil (MGO), • Utilities, • Oil systems, • Main Gas Compression (MGC), • GTGs on fuel, • Flash Gas Compression (FGC), • Injection Gas Compressor (IGC), • Seawater treatment injection systems, • Produced water treatment.	2.7.3.2 2.8 6.1.3.2
Specific Comments			
2.7.3.2	Gas Processing: This section to include detailed technical description/overview and schematics of the Gas Processing system .i.e.: • Gas compression and injection system • Gas treatment system	Please see detailed response above (row 9) and the associated embedded Payara Process Overview (Rev 0) pdf.	2.7.3.2
2.7.4.3	Flaring System: This section to include the following information: • Flare Profile for Payara Operations, including start-up and non-routine flaring • Optimizations for early flare out and a gas flaring minimisation plan • Well Ramp Up and FPSO commissioning activities schedule to achieve flare out.	• Please see EIA, Volume II, Appendix F - Air Quality Modeling Report for specific information pertaining to flare specifications and emissions. • Please see EIA Volume I, Chapter 6.1 for specific information on flare minimization. • Details on start-up and FPSO commissioning activities will be developed during the Project Detailed Design phase, which will have as an objective the minimization of flaring.	---
3.3.3	Emergency Response Model: This section of the document gives examples of the different tiers of emergency (tier 1, 11, 111); it further explains how an oil spill can escalate from one tier to the next. The document lacks information on how other emergencies (explosions, fires etc.) are being categorized and placed under the different tiers.	As described in the OSRP, the Tier level for oil spill incident severity is a globally recognized classification methodology based on the extent of resources applied for the response. The tier level is a subset of ExxonMobil's overall tiered incident severity classification (Severity Levels 1, 2, & 3) which considers a broader range of potential consequences, including: • Health / Injury • Public Impact • Environmental (including the oil spill tier levels) • Process Safety / Emergency Response Operations • Security • Financial • External Exposure The actual extent of the emergency response is driven by the objectives to protect people, environment, assets and reputation, using a no regrets approach to the deployment of resources in responding, that being to over respond with resources (people, equipment, … etc.) and then to effectively manage the response as more details become available.	---

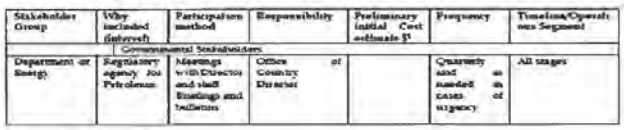
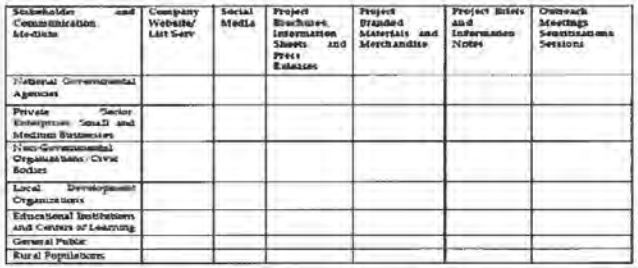
	Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
EIA Section/Topic	**EPA Comments**	**Response to Comment**	**Section in Which Addressed**
Page 346	Table indicates that produced water containing oil and grease requires treatment. Besides the embedded controls, there is no indication of what particular technology or treatment process will be used to meet discharge criteria. What specific deoiling technology will be utilized?	Please see detailed response below (row 17) and the associated embedded Payara Process Overview (Rev 0) pdf.	2.7.3.2
Page 341	Defining Intensity levels: Qualitative definitions are provided as- localized area, moderately sized etc. Quantitative ranges can be provided instead and if possible, a spatial representation of the ranges.	Intensity is rated differently for different resources because, as described in Section 4.6.1.1, the same impact could be experienced differently by different receptors. The inherent differences in the way impacts are experienced by different receptors require some flexibility in the way intensity is rated across the various receptors. Qualitative spatial descriptions are used most frequently in the intensity ratings for physical resources (e.g., water quality, sediment quality) because the actual areas over which relevant thresholds would be exceeded (i.e., at most a few hundred meters) are insignificant at the seascape level, and any quantitatively defined areas (e.g., 500m, 1000m, 5000m) that could have been used to define the bounds of the intensity scale would have been arbitrary. To cover the various types of impacts that could be relevant for a given resource, the intensity levels were therefore defined qualitatively where appropriate, to afford the ability to represent an impact on the resource that was not constrained to a specific quantitative bounds.	---
7.3.2.2	Coastal Birds: Under the Coastal Bird Survey data collected 2017-2019 in AOS, the reporting under the non-tropical seasonal regimes should consider Guyana's seasonal conditions. Or explain the reasons of such labeling.	Non-tropical seasonal regimes, specifically the North America seasonal regime (winter, spring, summer, and fall), were used for the coastal bird surveys because the presence/absence of migratory species in Guyana during spring and fall is the primary driver for the seasonal changes in coastal bird species composition and abundance due to Guyana's location within a major migratory corridor. The Guyana rainy and dry seasons affect the ability to detect birds, local bird activity, habitat use, etc. but not to the degree that migration affects these metrics. Nevertheless, the tropical seasonal regimes in Guyana largely mirror the North America seasons, with the winter, spring, summer, and fall seasons coinciding with the January/February wet season, April dry season, June/July wet season, and September/early October dry season.	---
Waste Water Management	a) The procedure used for testing of produced water is not clear. b) What logs does EEPGL have monitoring the produced water? c) What standards are followed when dealing with produced water? d) What are the overboard discharge specifications highlighted in 2.7.8.1. e) The difference between stripping water and produced water should be clearly defined within the EIA. f) Table 2.12-1: What will happen with the water based drill cutting? The manner in which water based drill cuttings will be treated should be highlighted within the document. g) For section 2.12-7 where are the documents which speak about the treatment?	For items a) - d) please see the embedded Payara Process Overview (Rev 0) pdf that addresses the following processes; • Produced Water Treatment and Testing • Produced Water Monitoring and Recordkeeping • Produced Water Treatment Standards • Overboard Discharge Standard The final Payara EIA will be updated with similar text and supporting figures. **e) Stripping Water** Each cargo oil tank is fitted with a stripping eductor. Cargo tank stripping up to the 100 mm level can be achieved via crude oil pumps; should further stripping be required, the stripping eductors will be used. The source of slop water is from hazardous and non-hazardous drains from topsides that are collected in the slop tanks. The water from the slop tanks used to drive the stripping eductors and strip the cargo tanks below 100mm to prepare the cargo tank for entry is defined as 'Stripping Water'. The oily water mixture from the bottom of the tank is routed back to the slop tanks. Note that the slop system is capable of treating the slop water (heat-assisted 2-stage gravitational separation) such that the overboard discharge will not contain more than 15 ppm oil. **Produced Water** Produced Water will be discharged after being treated by the topsides. Off-spec produced water from topsides will be directed to a dedicated produced water tank. Treated produced water will be discharge overboard via an Oil Content Monitor (OCM) if the oil content is less than 42 ppm or will be returned to the topsides IGF unit for further treatment. In the event of unavailability of the produced water tank, the produced water will be transferred to slop tanks. If the produced water is routed to the slop tanks, any overboard water discharge from the slop tanks will not exceed 15 PPM oil content.	2.7.3.2 2.7.3.3 2.7.8.1
		f) WBDF Management Water Based Drilling Fluids (WBDF) will be used to drill the initial open hole sections where WBDF returns and drilling cuttings are discharged at the seabed. This is consistent with the industry practices used globally to drill the top 28" hole sections of development and exploration wells. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. Drilling fluids are selected to ensure they are suitable for deepwater operations and the temperatures and pressures that will be encountered to ensure the safety and integrity of the drilling operations including well control and borehole stability. The WBDF contain the commonly used products: saltwater, polymers and stabilizers - which are not harmful to marine life and the environment. They include the following products: • Sodium chloride brine – this is salt water made from table salt; it is largely the same salt as seawater, but a little more concentrated • Xanthan gum - this is a polysaccharide with many industrial uses, including as a common food additive. It is an effective thickening agent and stabilizer to prevent ingredients from separating. It can be produced from simple sugars using a fermentation process, and derives its name from the species of bacteria used, Xanthomonas campestris. Xanthan gum can be found as an ingredient in many foods: ketchup, yoghurt, salad dressing, among others. It is not harmful to humans or the marine environment. • Caustic soda – in a small concentration to stabilize the fluid to a pH of 7.5 – 9.0; • Bactericide – a very small concentration (5 gal/1000 bbl), similar to caustic soda; helps as a stabilizer for xanthan gum • Barite – a natural occurring mineral (barium sulfate, an inert solid) This WBDF is the standard formulation also used for drilling the top holes in the Gulf of Mexico. All these products disperse quickly in the seawater and degrade readily with the exception of barite - an inert mineral used to increase the density of the fluids critical for safety. Additional testing of WBDF containing barite have been routinely performed across the industry. Toxicity testing of WBDF easily pass such tests. **g)** Additional text will be added as noted above to the Final Payara EIA.	2.5.3

	Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
EIA Section/Topic	**EPA Comments**	**Response to Comment**	**Section in Which Addressed**
Solid Waste Management	h) Why is there no contingency plan for hazardous waste? EEPGL will be generating a significant amount of hazardous waste. i) What are the plans for the disposal of garbage? Will the garbage be transported to shore or elsewhere? j) Does EEPGL have sufficient infrastructure to facility the amount of waste they are generating.	EEPGL has built in contingency through the use of conservative estimates of both hazardous and non-hazardous waste types and quantities within the Payara EIA, as reflected in the comprehensive integrated Waste Management Plan (WMP) provided in Volume III of the Payara EIA. EEPGL continues to implement those embedded controls and mitigation measures to reduce the generation of wastes at the source. This appendix contains separate sections on the strategy for handling hazardous and nonhazardous waste (Section 5), available disposal and treatment methods (Section 6), and a plan for record keeping and reporting (Section 8). In terms of "contingencies", the various management methods that may be used by EEPGL are described in Section 6. EEPGL's continued program operations are contingent on the availability of sufficient infrastructure to manage its hazardous waste, and to that end EEPGL maintains flexibility in terms of which specific hazardous waste management infrastructure can be used. Each contracted 3rd party vessel supporting EEPGL's Drilling, Installation and Production Operations has a Garbage Management Plan and per MARPOL maintains, a Garbage Record Book that outlines how such wastes will be managed. Consistent with EEPGL's WMP, such non-hazardous wastes, garbage (e.g., trash, rubbish, refuse, paper, cardboard, kitchen wastes) are either reused, recycled or disposed of in a landfill. Food wastes can be incinerated on board a vessel, macerated and discharged per MARPOL or disposed onshore in accordance with such plans and Guyana laws and regulations. Wastes are tracked, records are kept and monthly and annual waste reports prepared and submitted documenting how those wastes were managed. EEPGL has recognized and continues to recognize the nearer and longer-term need for additional 3rd party waste facilities and service providers in Guyana. To address this, EEPGL has performed multiple waste capacity assessments that identified and supported the growth of existing 3rd party waste storage, treatment and disposal facilities to date. Further, most recently in 2019, EEPGL issued an Invitation to Tender and is currently evaluating commercial bids to enable the award of additional contracts for the continued expansion of waste storage, treatment, recycling and disposal facilities and services to meet the needs of EEPGL and the Payara Development Project. Section 8 of the EIA discusses the mitigation measures that were already in the process of being implemented at the time the EIA was written to address potential infrastructure capacity constraints. Based on the progress with these measures, EEPGL has concluded that sufficient waste management infrastructure will be in place to manage the wastes from the Project.	---
Section 8 (Socio-economic)	How many Guyanese will be hired? There was no mention of diversification in the social and economic section.	Additional information will be added to the Project Description section of the EIA to indicate the targeted proportion of Guyanese workers that will be hired for the Payara Project. EEPGL is committed to supporting the economic and social development of the communities where it operates. In July 2017, EEPGL established the Centre for Local Business Development to assist small- and medium-sized Guyanese businesses building their capacity and improving their competitiveness for the broader economy. In addition, EEPGL has been working closely with the Council for Technical and Vocational Education Training for over the past year and half to identify training areas where development will not only fit into the emerging industry, but will also offer sustainable skills to young Guyanese. Following visits to Guyana's regional institutions and in depth discussions to review the existing TVET Programmes, EEPGL and the regional institutions have aligned in the selection of craft skill areas to develop diverse vocational programs, which will further develop competencies . Those craft skills are expected to produce an enhanced technical workforce with the ability to span different economic sectors.	2.3
Payara Development Project Volume III, Environmental and Socioeconomic Management Plan			
General Comments			
3.1.2 (Management Measures), pg.26-47	Within this section the different potential impacts from the project are highlighted in table form. The different tables highlight water quality measures, air quality measures, etc., however the table lacks information on who/whom from within the different involved facilities will be responsible for the management of the measures	Key roles and responsibilities as it relates to implementation of the management measures outlined in the ESMP are outlined in Table 2-4 of the ESMP. This organizational structure and the associated organizational roles and responsibilities will be further defined in future revisions of this document, as needed, once the Project achieves a Final Investment Decision (which occurs after the Project receives regulatory approvals). In some cases these roles correspond to individuals, in others they correspond to teams. As indicated in Table 2-4, ER&S staff implement are responsible for the implementation of individual management measures, and responsibility for implementation of the ESMP as a whole resides with the Environment and Regulatory Manager. The Lead Country Manager has ultimate responsibility for ensuring compliance with all regulatory requirements, including the measures in the ESMP.	---
Table 3.2 Water Quality Measures, pg.30	States that if the oil content of produced waste water is observed to exceed the accepted limits, it will be routed to an appropriate storage tank on the FPSO until treatment system is restored. Please clarify whether the rerouting if necessary will be automatic or manual.	Please see detailed response below (row 17) and the associated embedded Payara Process Overview (Rev 0) pdf.	---
Cultural Heritage Monitoring Programme, Figure 3.3	Chance Find Reporting Form, pg 49: The reporting form should include a picture of the chance find / artifact.	The EIA will be modified to reflect that an image or photo of the chance find, or a replica thereof, will be included in the completed Chance Find Reporting Form.	ESMP (3.2.2.6)
Additional Comments Provided to EEPGL on February 10, 2020			
	Natural Disasters - Request from EPA to document where in the Payara EIA there is a discussion of the risk of earthquakes or hurricanes to impact offshore operations.	Section 5.2.1 of the Payara EIA includes a discussion of the assessment of potential for geological/seismic impacts.	---

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	Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
EIA Section/Topic	**EAB Comments**	**Response to Comment**	**Section in Which Addressed**
Executive Summary Section	The Executive Summary whilst well performed can be improved with the addition of a small amount of detail on the Oil Spill Response Plan (OSRP) and the frequency of the oil spill response drills.	EEPGL conducted the following joint exercises with Guyana regulators; **1) Aug. 2019** simulating a hose line break with regulators and key service providers (e.g. OSRL), Stabroek Co-Venturers (Hess & CNOOC), with the ExxonMobil Americas Regional Response Team mobilized to support the exercise. **2) Jan. 2020** with the EPA, Coast Guard, CDC and MARAD providing training in operation of oil spill trajectory and fate model as well as training in oil spill response strategies with a focus on oil dispersants. The next exercise has not been planned yet by EEPGL.	---
Chapter 2: Project Description			
Project Description	This section of the document lacks detailed information on the potential employment figures of the project. Whilst a definitive amount might be difficult to determine, more information can and should be provided, especially information on the social and demographic characteristics of the potential beneficiaries.	Additional information will be added to this section about the types of jobs and types of potential beneficiaries, although predictive discussions on social and demographic characteristics of those individuals may not be appropriate.	2.3 8.2.3.1
	The identification and description of alternatives is an area of the document that requires further attention as no detail was provided. Sound alternatives are an important part of the validation of the EIA process and must be fully and comprehensively considered. Alternatives that must be considered should include location, project layout, technology, scheduling and project scale.	Several Alternative options were discussed in detail in Section 2.17 including; • Location alternatives, • Development concept alternatives, • Technology and process alternatives, • No-go alternative.	---
Chapter 3: Administrative Framework			
National and Legal Frameworks Section	The National and Legal Frameworks including International Conventions and protocols were fully considered in the project with the exception of the inclusion of the Sustainable Development Goals (SDGs).The Government of Guyana is fully committed to SDGs and it is embedded in the overarching framework of the Green State Development Strategy.	A discussion on Guyana's Sustainable Development Goals will be added to this section.	3.3.1
Chapter 4: Methodology			
Environmental Assessment (EA) and Social Impact Assessment Methods	The EIA utilized appropriate EA methods for the environmental assessments; however, the methods used to collect socio-economic data and assess socio-economic impact were not provided or clearly identifiable. The lack of the presentation of the socio-economic methods employed affected the ability of the EAB to verify the dependability of the conclusions drawn from the social impact assessment. There was also a lack of detailed household characteristics and the livelihoods labor distribution in the household especially in relation to gender labor roles. In some cases, even the demographic information of the indigenous villagers is not gender disaggregated nor information provided on the number of children. These social characteristics have implications for the impacts of the project on the socio-economic fabrics of the communities and should have been included. The EIA should have used an ethnographic methodology.	The socioeconomic assessment methodology is described in Chapter 4. The Consultants utilized all available open source information, including census data obtained by the Government of Guyana. However, there is no available open source disaggregated data by gender or ethnicity at the HH level. The Consultants did utilize ecosystem services studies to collect village-level demographic data related to employment and livelihoods and population statistics in 62 coastal NDCs from Region 1 to Region 6. Data from these efforts are provided throughout Chapter 8. The Consultants will append the final EIA with the final ESS Reports. If the EAB or EPA knows of additional open source disaggregated data available at the household level, the Consultant team can also include these data within the EIA. That said, the Consultants feel that the socioeconomic information collected for the EIA is fit-for-purpose relative to the nature of potential socioeconomic impacts associated with the Project.	4.5.3.2 8.9.2 Appendix V
	Another deficit of the social impact analysis is the lack of the establishment of clear cause and effect relationships. Specifically, for the economic impact assessment, the economic impacts presented were vague. It was also not possible to identify the tools that were used to assess the economic impacts. Rate of return on the investment as well as Social Rate of Return on the Investment (SROI}are tools that could have been employed for the economic and social impact analysis.	Social Rate of Return on Investment and other predictive economic modelling were not within the scope of the approved Terms of Reference, and are not typical for an EIA; while these tools can provide useful information, they are typically utilized for strategic community investments or other efforts targeted at informing policy development or community development. As noted for direct and indirect economic impacts, it is typically sufficient to indicate that the Project will result in a certain type of positive impact, without characterizing the exact degree of positive change likely to occur (since there are too many factors outside of the normal course of one Project under consideration - e.g. government role in revenue and spending; contractual and business terms; other macroeconomic factors).	---

	Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
EIA Section/Topic	**EAB Comments**	**Response to Comment**	**Section in Which Addressed**
Chapter 6: Physical Resources			
Air Quality: Impacts	The total emissions by Payara would be 3.1tonnes C02 per year during 2023-2025 and 1.46 million tonnes of C02 per year between 2026 and 2044. As a reference, Guyana in 2016 had 2 million tonnes of C02 for all their activities (transport, energy, mining, agriculture, etc.). The emission in the EIA are only for extraction of oil, which will be allocated to Guyana inventory. The consortium assigned a moderate impact due to Guyana being sink of carbon (58 million C02 per year), so this would mean Guyana would be a sink of 56 million C02 per year which is reducing our sink capacity by only 3%. However, if assessed against the current Guyana emissions, this is about the increase in Guyana emission of C02 by 159% first two years and 73% in the next 18 years. This increase cannot be considered a small amount and should not be considered as moderate effect. The EAB also recommends that the regulator EPA should have a very strict monitoring protocols on those emissions, as this will influence considerably Guyana's inventory. The monitoring of these emissions requires a clear comprehension of its source(s) and detail analysis of the figures.	To clarify, EEPGL estimates that within the FPSO commissioning and start-up period (currently planned for 2023-2025), the maximum GHG emissions for any one year will be 3.07 million tonnes (i.e., the estimated emissions for the other years in this period are lower); within the post-start-up operating period (currently planned for 2026-2044), the maximum GHG emissions for any one year will be 1.36 million tonnes. In any case, the Consultants acknowledge that the GHG emissions for the Project represent a significant percentage increase relative to Guyana's published GHG emissions as reported in its Second National Communication on Climate Change in 2012. If the basis for the impact significance rating was solely a function of the percentage increase in baseline reported national emissions, the Consultants would concur that a higher significance rating would be appropriate. However, in light of the fact that the baseline value is for emissions from sources within the political boundaries of Guyana and incremental impacts on climate from the Project are more appropriately measured against at the global level (i.e., as an incremental increase in total global emissions), the Consultants assigned the significance rating primarily by considering the Project's GHG intensity factor (compared to the industry average). Additionally, as noted by the commenter, the Consultants considered the fact that Guyana is a sink of carbon (58 million tonnes of C02 per year), of which the Project's emissions would represent a 2.5% decrease. With this basis for assigning an impact significance rating, the Consultants felt that a Moderate rating was appropriate. With respect to monitoring, EEPGL understands that the EPA's authority will include monitoring of the Project's emissions and EEPGL will complete the required recordkeeping and reporting of its emissions to ensure that the EPA has the necessary information to fulfill this role.	---
	Requested breakdown of GHG in table 6.1-19 Tonnes CO_2e/year | 2020-2022 | 2023-2025 | 2026-2044 FPSO Venting Methane (without burning)? FPSO Flaring (temporary, non-routine, ...) FPSO Other Tanker Loading Area Sources Drill Ships TOTAL | 249,000 | 3,176,000 | 1,459,000	A breakdown of GHG emissions by source and by year for the Project can be found in Tables 7a and 7b of the Air Quality Modeling Report Technical Appendix (Appendix F to the Payara EIA, provided in Volume II). In addition, EEPGL provides the table below as requested. Annual Emissions (ktonnes) Pollutant | Source Category | 2020 - 2022 | 2023 - 2025 | 2026 - 2044 GHGs | FPSO Other | 0 | 898 | 893 GHGs | FPSO Tanks (Venting) | 0 | 1 | 1 GHGs | FPSO Flaring (temporary, non-routine) | 0 | 1884 | 352 GHGs | Tanker Loading | 0 | 9 | 7 GHGs | Area Sources | 163 | 192 | 101 GHGs | Drill Ships | 86 | 86 | 0 GHGs | Total | 250 | 3070 | 1355	6.1.4
	Other questions and concerns regarding the GHG emissions are as follows: • What happens during decommissioning? How is the well going to be sealed? What is the life expectancy of the sealing? How will the company ensure there is no leakage of natural gas?	The objective of permanent plugging and abandonment (P&A) is to achieve permanent barriers with a zero leak rate. Permanent P&A is achieved by restoring suitable caprock through placement of P&A barriers. Barriers will be verified in a manner appropriate to the specific barrier which may include: tagging, positive or negative pressure testing, diagnostic logging, and/or review of the process that installed the barrier. Wells will be permanently P&A'd by installing suitable mechanical barriers that extend across the wellbore (rock-to-rock) to prevent escape of hydrocarbons to the environment. P&A barriers will be installed in the wellbore, and these will be of adequate length to contain reservoir fluids and deep enough to resist being bypassed by reservoir pressure. The number of barriers required will depend on the distribution of hydrocarbon-bearing permeable zones within the wellbore. Example showing caprock in relation to a reservoir:  	2.11
	• The water separated from the oil will be treated and returned to the sea, what is the performance standards of the treatment plant? What is the chemical composition of this water?	Please see detailed response in the EPA tab (row 17) and the associated embedded Payara Process Overview (Rev 0) pdf.	2.7.8.1

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	• During operations it can be expected that there would be some leakage from the wellbore and pipe prior to arriving to the FPSO. Are those leakage accounted for, and if they are, where?	There is no expected leakage from the wellbore and pipe prior to or after the FPSO arrival. All critical sealing equipment in the wellbores are pressure-tested during well construction, and subsea equipment is pressure-tested at the time of installation to ensure no leakage (loss of containment) for the expected well conditions and well life. Further well integrity preventative maintenance (PM) programs are in place that monitor and periodically test the integrity of these barriers.	---
	• Who will pay for spill remediation works and associated environmental fines? Spills of oil can affect significantly the environment and even the fishing industry and other marine related livelihoods that would be entitled to compensation for damages and losses. Is there any insurance for these possibilities? Is the insurance part of production cost? Exxon should have responsibility for spills and their associated costs.	The EIA states that EEPGL will determine financial liability in the event of a spill. The Consultants are operating under the premise that the mitigation measures and recommendations in the EIA, ESMP, and Oil Spill Response Plan will, in conjunction with the conditions in an Environmental Permit issued by the EPA, comprise regulatory obligations that EEPGL will have to satisfy when undertaking the Project (throughout its lifetime). From the perspective of the Consultants, these management measures, combined with the legal framework that would apply to EEPGL in the event of an oil spill, are sufficient to assuage concerns regarding EEPGL's commitments to satisfy appropriate financial obligations related to a spill response.	---
Stakeholder Engagement			
Chapter 8: Socioeconomic Resources	The EIA acknowledges the role of stakeholder participation in the successful implementation of the project and as a mitigation action for both environmental and social impacts. However, it was unclear what tools were used in the stakeholder engagement. The EAB therefore recommends that the copies of questionnaires, focus group questions or focus group question guide, key informant questions or interview guides, etc. be provided in the Annexes.	The Consultants will provide in the final EIA the templates used for the engagements for ecosystem services studies, participatory fishing studies, social infrastructure studies, and one-on-one meetings that informed the EIA.	4.5.1 SEP
	Also, it would be useful for the consortium to provide any ethno-social tools or considerations such as Free Prior and Informed Consent (FPIC) used in the consultations with indigenous groups. The information presented to stakeholders such as handouts or brochures, notes need to be provided to adequately assess the effectiveness of the consultations.	The Consultants will provide in the EIA examples of the non-technical summary information, briefing materials, brochures, and other information that was shared with Indigenous groups. All data collected in those engagements has already been included as part of Chapter 8, Appendix V, and the Stakeholder Engagement Plan.	4.5.1 SEP
	The stakeholder engagement sections of the document could have benefited from clear analysis of the stakeholders of the project, their associated social group(s), their roles in the project (and the stages or segments of the project activities) and ranking them. This was particularly lacking for non-governmental stakeholders.Potential Project Affected Persons (PAPs) or groups/groups in opposition to the project needed to be clearly identified; and clear actions and plans established to engage them meaningfully. There was no clear stakeholder engagement plan presented which should also include a communications plan and the responsible persons or persons for the implementation of the stakeholder engagement plan.	The Stakeholder Engagement Plan, which is part of Volume III of the regulatory submittal, provides the information requested in the comment.	---
	The EAB therefore suggests the development of a stakeholder engagement plan with an associated communications plan and a budget of the costs. Possible templates are presented below:	The Stakeholder Engagement Plan, which is part of Volume III of the regulatory submittal, provides the information requested in the comment (with the exception of budgetary information, which is not typically included in a plan of this nature). Stakeholder Engagement Plan  Communication Plan 	---

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EIA Section/Topic	**EAB Comments**	**Response to Comment**	**Section in Which Addressed**
Impact Predictions			
Chapter 9: Unplanned Events	Impact prediction techniques were well performed for species and natural ecosystems as it relates to oil spills and other unplanned events. However, clarity is needed on the basis for the use of surface oil thickness threshold of 1.og/m2 for the modelling of spills.	The tools utilized in the oil spill modeling analyses are gridded numerical models. They are designed to predict the flow of very small quantities of oil through the environment over time. Therefore, it is necessary to identify a thickness threshold that will be utilized as the lower limit of concern. The 1g/m2 threshold that was utilized corresponds to an average oil thickness of 0.001 mm over that grid cell, as referenced below: Threshold Type | Average Concentration Threshold | Rationale | Visual Appearance | References Oil on Sea Surface | 1 g/m² = 1 µm (0.001 mm) on average over the grid cell | A conservative ecological threshold for consideration of sublethal effects* on birds, marine mammals, and sea turtles from floating oil. | Fresh oil at this thickness corresponds to a slick being a dark brown or metallic sheen. | French McCay 2016 * Sublethal effects do not produce mortality in exposed individuals. As noted, the 1g/m2 thickness corresponds to oil sheens in the environment.	---
Chapter 8: Socioeconomic Resources - Social and Economic Impacts (Magnitude)	Regarding the magnitude of impacts, the biological and the social impacts were well documented. However, clarification of the tools used for the social and economic impacts will allow a better judgment of the impacts.	As part of the impact assessment process, subject-matter expert(s) from the Consultants designate the magnitude of each potential impact based on methodology that is specific to the type of resource/receptor being impacted. Section 4 of the EIA describes the methodology for rating impacts (including socioeconomic impacts), and each resource-specific subsection within Section 8 provides further details on how resource-specific magnitude and sensitivity were rated for each socioeconomic resource.	---
Chapter 8: Socioeconomic Resources - Social and Economic Impacts	The EIA also suffered from an inadequate identification and explanation of the social groups that will be affected positively and negatively by the social impacts. For example, the EIA identifies increase in governmental social spending as a positive economic and social impact of the project but fails to identify the groups that will benefit from this increase in social spending. Similarly, in identifying the job creation impacts of the project, it does not identify the social groups that will benefit from the newjobs created. Another example is the possibility of the impacts of the project on fishermen in the Berbice area. Household characteristics information and demographic information does not allow for a thorough analysis of the impact on the household and their resiliency or ability to absorb the shocks of the project activities. The social distribution of the impact's effects (both positive and negative) is one of the scientific and technical relevance of the EIA.	Further specificity can be added in the Project Description regarding type of jobs and direct spend, and generally the types of groups who will benefit. However, it should be reiterated that direct jobs generated by the Project will be limited; therefore, the Consultants concluded that assessing potential impacts at a household level is not warranted. While additional governmental social spending can be expected, that is at the discretion of the Government of Guyana.	2.3 8.2.3.1
Monitoring of Management Plans			
	Finally, regarding the monitoring of the management plans, a framework is presented but a clear comprehensive plan is not discernible. For species and ecosystems, the EIA did, mostly, address when and where sampling would be done, and tests carried out and some information on how results would be evaluated. However, the EAB was unable to locate information that addresses the specific frequency of monitoring for some animals such as the marine turtles, marine mammals, riverine mammals, and the financial and human resources needed for the successful implementation of the management plan.	Table 3-9 in the ESMP describes the frequency at which the individual proposed monitoring measures would be carried out. Some elements relate to EEPGL's activities rather than to seasonal environmental trends, and can therefore be accomplished at any time of year (e.g., facility audits, emissions reporting, etc.). Other monitoring required by the ESMP would occur with sufficient frequency (e.g., continuously, daily, quarterly) to detect seasonal variations. The Consultant team considers the detail provided in this table to be sufficient for the purposes of the regulatory submittal. It is also noted that EEPGL has undertaken multiple years of biological resource studies and intends to work with the EPA to conduct appropriate studies to evaluate potential impacts over time.	---

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WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Planning and Effective Management of the Resources and Use of Marine Area		
Chapter 7: Biological Resources		
Guyana's marine environment has been described as an Ecologically and Biologically Significant Area - the Amazonian-Orinoco Influence Zone1.At the same time, the reliance on its resources are growing, not only from traditional sectors such as fishing, but from rapidly growing new extractive sectors such as oil and gas.	The Consultants acknowledge the comment.	---
Maintaining healthy and productive oceans is a priority for Guyana, and given the current lack of data and knowledge, there is a strong need for better understanding the marine environment in order to effectively manage and preserve it. As done in previous submissions to the EPA relating to the oil and gas sector, we would like to advocate for better understanding of resources (particularly biological resources), how the space is used from a biological standpoint (for instance, identification of feeding, breeding, migratory grounds); and strategic/integrated planning for the use and conservation of marine resources.	The EIA includes, either directly or by reference, several baseline biological studies covering numerous biological resources. In most cases, the impact assessments for specific biological resources were supported by data from multiple years of study. The Consultants reviewed this information and determined that when considered in aggregate, the current body of biological knowledge as reflected in the EIA is sufficient to support an assessment of the Project's potential impacts on biological resources, development of appropriate embedded controls and mitigation measures, and a responsible and defensible decision on whether and under what conditions to permit the Project.	---
The area still remains highly understudied and poorly understood, even as a larger third phase of EEPGL activities, which will bring the total number of development wells to 95, are set to be implemented. First oil from the Liza 1 project will also be extracted in December 2019 and will move full pace ahead, all in the absence of any real baseline data. Lack of such data on species and populations affects the accurate determination of impacts in the marine and coastal areas. For example, should baseline data determine that critical habitats exist in the area (this is likely given that the areas offshore Guyana have been described as ecologically and biologically significant), then international best practices would necessitate that the developer implements additional safeguards - such as biodiversity offsets and appropriately designed, long-term biodiversity monitoring and evaluation programmes.	The Consultants take issue with the statement that the Payara Development Project EIA was carried out "in the absence of any real baseline data". Eight of the ten biological resource-specific impact assessments included in the EIA reference recent field studies conducted in the Direct and/or Indirect AOI. The impact assessments for the two other biological resources for which field studies were not carried out (Protected Areas and Special Status Species, and Ecological Balance and Ecosystems) are heavily supported by information from online sources that are widely accepted in the conservation community (e.g., the IUCN) and/or the scientific literature. With respect to critical habitat, Critical Habitat Assessment (CHA) is a unique element of EIAs conducted under the IFC Performance Standards, and is not generally included in EIAs that are not subject to the IFC Performance Standards (such as the Payara Project). Compliance with the IFC Performance Standards was not part of the Terms and Scope issued by the EPA for the Payara EIA, so it would be inappropriate to require a CHA for the Project. The inappropriateness of a CHA in the context of the Payara Development Project notwithstanding, the impact assessments for several biological resources (including marine birds, marine mammals, and marine fish) include several attributes that would typically be considered in a CHA (such as listing status, congregatory behavior, and migratory life histories) as factors when determining sensitivity to potential Project impacts.	---
The sector is expanding greatly at a fast rate, as other developers are actively pursuing exploration and are discovering more hydrocarbon resources - evidenced by the two recent finds made only 6 weeks apart, by Tullow in the Orinduik Block. However national processes, capacities and knowledge of the ocean is less developed. This increases the urgency of better knowing, planning for and managing the EEZ. We would like to recommend that the developer (also in partnership with other operators in the sector) conduct detailed assessments in order to gather new data and make more informed decisions about impacts of its development and facilitates/funds ongoing research in the marine/coastal ecosystems by universities and independent stakeholders. Data generated from assessments and studies should be freely available to the public, unlike what prevails at this point in time.	As described in the response to the comment above, the impact assessments for most biological receptors in the Payara Development Project EIA are well supported by a combination of extensive field study and desktop-based research from reliable sources. In the Consultants' view, the current body of biological knowledge as reflected in the EIA is sufficient to support a robust assessment of the Project's potential impacts on biological resources, development of appropriate embedded controls and mitigation measures, and a responsible and defensible decision on whether and under what conditions to permit the Project. All of the reports detailing the findings of these studies (including the appendices with data tables) have been made available to the EPA, and are available to the public in pdf form on the EPA's website. Neither the EIA nor the ESMP for the Project envision stand-alone, open-ended research programs because such programs are not required to assess the accuracy and effectiveness of the EIA or ESMP, respectively. Nevertheless, EEPGL regards environmental monitoring as a critical component of their performance assurance program and as indicated in Section 3.7 of the Environmental and Social Management Plan for the Project, the results of the proposed monitoring program will be externally reported. Volume III of the regulatory submittal contains the ESMP, and Section 3 of the ESMP describes the proposed monitoring program for the Project.	---
At the same time the ability of regulators to verify the accuracy of information presented by the developer from its monitoring of environmental impacts and the implementation of safeguards remains constrained by a lack of technical (and other) capacity. Programmes should be established to continually train and build capacity of EPA staff and staff of other agencies that are involved in the regulation of the sector. Investments should also be made to retain human/technical resources. [Part 4] below includes additional recommendations.	The Consultant team that prepared the Payara EIA recognizes the institutional challenges in Guyana. Although these challenges do not directly affect the content of the EIA document, the Consultant team has met directly with the EPA to deliver a series of technical workshops with EPA staff focused on elaborating the technical approaches and findings of the EIA. Further, the Consultant team has also sought to build local capacity by inviting government agency (e.g., Fisheries Department, Protected Areas Commission) personnel to take part in fieldwork that was used to support the Payara EIA.	---

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WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Onshore Land-Use Planning		
As discovered quantities of offshore hydrocarbon resources continue to grow, there will be a corresponding increase in the demand for land and other onshore resources in the city and surrounding areas that directly or indirectly result from the project. Land/urban planning; and, implementing and enforcing high standards of practice will need to be strengthened - including addressing challenges experienced over the years relating to financing, equipment and human resources short falls, lack of cooperation among and decision-making by responsible agencies;and low levels of transparency and accountability. EPA, Georgetown Mayor and City Council, Local Government bodies, GLSC, Central Housing and Planning Authority, Civil Defence Commission, Ministry of Public Infrastructure, Department of Energy Civil Society and other relevant stakeholders should come together and plan for the effective use of onshore spaces and resources. This planning must take into account zoning for commercial activities; nature (such as the storage and transport of hazardous materials) and size/scope of activities, proximity to and potential to degrade/contaminate and persist water, soil and other resources; and health and well-being of residents and the environment in the long and short term. Oil companies are expected to be active in Guyana for at least 20 years and thus the plan must take this time frame and even beyond into account. Evidence for the urgency of this type of activity was highlighted when residents advocated against the construction of a chemical storage facility, which would have been within the vicinity of residential communities on the East Bank Demerara, by Nalco Champion Guyana. Hundreds of thousands of kilograms of toxic oil-field chemicals would have otherwise been stored/mixed at the site.	EEPGL remains committed to engaging government agencies and key stakeholders to provide information on project activities, to increase understanding of the permitting process and so that decisions are based on relevant facts; this facilitates project activities, including supplier development and workforce capacity, being developed in Guyana in an environmentally and socially acceptable manner. EEPGL has a three-pronged approach to local content development. This includes workforce development, supplier development and strategic investments. Through the Centre for Local Business Development, EEPGL is working with local businesses to strengthen local competitiveness, including meeting Guyanese and international standards. Other programs being developed with banking institutions include banking packages to reduce the financial burden on local businesses. EEPGL, in collaboration with the Council for Technical and Vocational Education and Training, is supporting training in safety so students enter the workforce with greater hazard awareness and tools to identify and minimize risks. In addition, this collaboration includes supporting upskilling of the workforce through curriculum development, instructor training and provision of relevant equipment for identified programs that will support growth in the broader economy – including the construction sector.	---
The expansion of port facilities in estuarine and coastal environments in and around the Berbice and Demerara rivers to service the offshore oil production will result from this and other oil and gas projects. Such expansion can increase the vulnerability of the city and communities to effects of flooding, storm surges and erosion as loss of critical coastal defense species such as mangrove forests will result. Much of Guyana's shoreline is already highly vulnerable due to depleted mangrove forests and weakened man-made coastal defenses, and as such planning for onshore development must happen quickly, be effective, benefit from robust stakeholder consultations. Onshore development will also result in increased traffic and congestion from the transport of equipment, chemicals and other industrial supplies to serve drill ships offshore and the industry in general. Such considerations must also be integrated into urban development and management plans.	With respect to the potential for coastal impacts (e.g., mangroves, sea defense) from industrial development, EEPGL is not proposing any onshore/coastal development as part of the Project. Any such developments would be conducted by third parties, and mitigation of any such potential impacts would therefore be addressed through the regulatory permitting process undertaken by such parties. With respect to potential traffic congestion to which EEPGL could contribute, in recognition of the potential for multiple oil & gas developments to result in a combined impact to onshore traffic congestion, the Consultants included as part of the cumulative impact assessment a "cumulative" traffic impact assessment. This assessment measured traffic congestion levels at 50 intersections around Georgetown and modeled the changes in congestion levels that would be expected to result from the combined activities of the Project, the two prior development projects (Liza Phase 1 and Liza Phase 2), two future development projects, and continued exploration drilling through 2021. The modeling demonstrated that anticipated EEPGL-related vehicle trip-counts through 2025 are not expected to meaningfully change congestion ratings at any of the 50 intersections studied. In any case, with respect to ongoing management of potential traffic concerns, EEPGL has already adopted a Road Safety Management Procedure for its vehicle operations in Guyana; among other aspects, this procedure includes provisions for logistics/journey management planning to reduce potential conflicts with local road traffic. To this end, EEPGL will continue to monitor traffic conditions into the future, and will adjust its vehicle movements as needed in keeping with this procedure.	---
A strategic environmental assessment which links both onshore and offshore considerations would also likely greatly benefit the process of managing the sector and the impacts it generates. In addition, all developmental projects onshore directly or indirectly linked to the industry must be strongly regulated in keeping with best practices to address secondary impacts	The Consultants acknowledge the comment, noting that such a Strategic Environmental Assessment falls outside of the scope of the Payara EIA. That said, as discussed in responses to other comments, the cumulative impact assessment for the Project considered other projects that were reasonably foreseeable by the Consultants. This suite of other projects included other activities by other oil & gas operators (noting that at the time the EIA was written, no exploration activities from other oil & gas operators beyond 4Q2019 - a year earlier than the first proposed Payara drilling - had been publicly announced, and none of the operators had announced definitive plans for development projects).	---

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Guyana has committed to transitioning to renewable energy in order to meet the demands of its households and the private sector; and established several targets in its nationally determined Contributions to the UNFCCC in order to limit carbon emissions. This goal is timely and relevant particularly in the context of the recent IPCC report in which leading climate scientists have warned that there is only 12 years remaining for global warming to be kept to a maximum of 1.5 degrees Celsius. Beyond this, the risk will be worsened for severe droughts, floods, extreme heat and poverty.	EEPGL acknowledges the comment regarding Guyana's published goals for carbon reduction. With respect to GHG mitigation for the Project, Section 6.1.3.2 of the EIA contains tables listing the embedded controls and mitigation measures that will be incorporated to reduce emissions of GHGs and other atmospheric emissions.	---
The EIA has again focused narrowly C02 /GHGs generated from the company's operation and has determined that there will be little or no impact to climate and air quality. A closer look shows that EEPGLs project alone will almost double Guyana's current annual total GHG emissions, and apart from reporting on emissions annually, not much else is planned. Exxon Mobil, the primary partner in EEPGL, has publicly declared its commitment to fighting climate change and making meaningful progress on climate actions. Given the current climate crisis, it is relevant that a plan be developed as part of this EIA to show how they will make meaningful contributions in Guyana. Some options include adopting use of renewable energy and supporting Guyana's transition to renewable energy, sustainable forest and land management, mangrove rehabilitation and restoration, etc.	Since 2015, EEPGL has committed more than $12.5 million (US) in community investments in Guyana. Focus areas include STEM education, youth, women, community empowerment and environmental sustainability. EEPGL's contributions to the Iwokrama science program, for example, fund research into resilient forests. In addition, government revenues generated by EEPGL offshore operations will positively impact the strategies developed by the government of Guyana to encourage sustainable economic development (e.g. the Green State Development Strategy and Low-Carbon Development Strategy). Finally, EEPGL is working with the government to evaluate building a pipeline to shore to provide clean burning natural gas to support power generation in the country. Currently Guyana generates most of its power using heavy fuel oil. The Payara EIA submission provides context regarding Guyana's net emissions and shows that Guyana will remain a net carbon sink even if multiple FPSOs are active offshore Guyana. To minimize carbon emissions, ExxonMobil evaluates energy efficiency design options and GHG reduction opportunities. EEPGL's FPSO projects have been designed to incorporate a number of controls and mitigation measures that will reduce GHG emissions, including avoidance of routine flaring, minimization of non-routine flaring, use of more energy efficient turbines to power the FPSOs, and the use of waste heat recovery units on the FPSO turbines. These measures, among others, reduce greenhouse gas emissions on our FPSOs by approximately 80 percent compared to a baseline design that does not include these measures.	---
In the big picture view: what are the impacts of the eventual burning of 6 billion plus barrels of oil? Many more billions of barrels are likely to be discovered by EEPGL and other companies. In this regard, how does Guyana reconcile its vision of being the greenest country on earth with its status of being a big oil producer and contributor to the ongoing global change?	With respect to GHG mitigations for the Project, Section 6.1.3.2 of the EIA contains tables listing the embedded controls and mitigation measures that will be incorporated to reduce emissions of GHGs and other atmospheric emissions. These measures represent good international industry practice to reduce emissions from a Project of this nature. Beyond the Project incorporating these practices, decisions regarding the balance between the social/economic benefits of a fossil-fuel project in Guyana and the incremental emissions resulting from such a project are appropriately addressed by the Government of Guyana at a policy level and are therefore not within the scope of the EIA.	---
We believe that offsetting some of this impact is critical as Guyana is at the forefront of green development. At a national level, some key actions driven by government should include: renewable energy transition well before 2040; maintenance of intact landscapes, establishment of additional protected areas, and integrated land-use planning to maintain biodiversity ecological integrity and function; protection of freshwater; robust forest management, stronger regulation of the mining sector and better land-use planning should move quickly ahead. The establishment of marine protected areas and sustainable fishing zones to ensure maintenance of fish stocks and marine biodiversity and general ocean health; and ensuring wider ocean governance is strong, must also be considered as part of the suite of actions. It is the also the role of private sector actors and developers in the oil and gas sector to support green development.	The Consultants acknowledge the comment, noting that the suggestions relate to national policy issues that are beyond the scope of the Payara EIA. The Consultants also note that offsets are typically applied as a last resort to address residual negative impacts that cannot be managed to acceptable levels in any other way. The EIA has demonstrated that the project design and application of management controls (primarily embedded controls) would ensure that residual impacts on climate from normal operations would be no higher than Moderate. With respect to the role of developers such as EEPGL in these areas, Section 6.1 of the EIA addresses potential Project impacts on climate and describes the embedded controls and mitigation measures put in place by EEPGL to ensure that the carbon intensity of the Project is limited in accordance with good international industry practice. Offsets	---

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WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Capacity Building for Monitoring and Regulating the Sector		
EEPGL suggests a vast number of best practices and standards for reducing impacts to the environment and people. The EPA, DoEnergy, GGMC, MNR etc. does not have the required capacity, either singly or collectively, to manage this new sector. Capacity development in some areas is ongoing and this is a positive indication, but much more investment in this is needed. The pace at which the oil and gas industry is expanding in Guyana has outmatched the pace at which regulatory institutions are benefiting from strengthening of their capacities - in terms of personnel, having specialist staff in all relevant levels of expertise, technical knowledge and financial resources. It is critical for agencies to be able to access and secure necessary resources to help them exercise their authority and enable them to respond to the demands of industry expansion. Sufficient budget and technical expertise must be a priority if effective national oversight is to be achieved for the sector. Further, political leaders must ensure that the regulatory agencies are empowered, including maintaining autonomy, to be able to ensure stringent safety regulations are maintained.	The Consultants acknowledge the comment and note that this is a recommendation to the Government as to what political leaders must ensure. EEPGL's strategic community investments complement our business and are aligned with Guyana's economic and social goals. Initiatives are focused on assisting the development of local capabilities and improving the broader socioeconomic environment. As an example, EEPGL has been engaged with the Guyana' Environmental Protection Agency on development of a program to support environmental monitoring. The scope of the capacity building program is being finalized, but could potentially address training opportunities for EPA staff, the provision of systems/tools to support administration of environmental monitoring, and the provision of a third party consultant for technical support.	---
At the same time, we recommend that regulatory agencies be supported with independent technical monitoring (as their capacity is being built) to ensure adherence to mitigation actions and embedded controls proposed in the EIA. We strongly recommend that an international, independent, competent firm be hired to conduct annual monitoring, during the project and more-so during the production phase onward, to ensure that activities are being implemented in the best possible ways, utilizing most updated technologies and the best available standards and practices. The goal of independent monitoring would be to drive continuous improvement in policies and practices since the reliance on a prescriptive regulation with inspection model would not be effective. EEPGL should then be required to adapt based on monitoring recommendations and accommodate upgraded technology and practices during the lifetime of the project. In this process of regulating the sector, a coordinated approach among agencies would be necessary for proper management. Experiences from trying to build such an approach for other sectors indicate that communication, leadership, resource sharing and strong political commitment and the platforms necessary to support this, are needed. These agencies would likely include: EPA, Department of Energy, Department of Environment and GRA.	The Consultants acknowledge the comment and note that these are recommendations to the Government and regulatory authorities.	---

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WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Management of Wastes; Wastewater Management		
The EIA has noted the lack of long-term capacity of waste disposal facilities to deal with non-hazardous wastes; and that the existing capacity will be exhausted by 2019-2020. Given that this project will be operating in Guyana for more than 20 years, this situation must be improved quickly. It is likely that new sites or expansion of current sites will be undertaken. In this process, we recommend practicing planning in line with Renewable Energy Transition and Climate Change Commitments (mentioned above) - where human health and the environment are given first priority. The current challenges experienced by residents of communities located within the zone of impact of the Haggs Bosch Landfill site, for example, should not be allowed to recur.	Since the completion of the draft Payara EIA, the construction of a second cell at the Haags Bosch Landfill has been proceeding as planned and approved. Continued upgrades and improvements at the Haags Bosch Landfill have also been undertaken. The current and near-term local non-hazardous solid waste management needs for the Payara Development Project can be met by existing landfills. Subsequent decisions of whether further expansion of existing or new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the Ministry of Communities and the Environmental Protection Agency and participation of the public and other stakeholders. Further, in the summer of 2019, EEPGL released a Request for Information (RFI) to the Guyana market to find qualified suppliers to perform waste management services. After evaluation of the responses, EEPGL invited qualified suppliers to a bid process, the results of which are still under review. This will build additional capacity for EEPGL to process hazardous and nonhazardous wastes. EEPGL plans to complete the evaluation and award the contract for additional waste management capacity in 1Q2020, and the capacity deriving from the associated actions will meet the needs of EEPGL and the Payara Development Project. In addition, EEPGL continues to plan and execute a series of waste management capacity building workshops with the EPA and MoC, with the first of such planned for 2Q2020.	---
The management of hazardous wastes requires immediate attention, as there are no facilities to treat and dispose of such wastes. EEPGL projects that thousands of tons will be generated during the lifetime of this project. Any treatment of hazardous wastes should be done in keeping with best available standards and technology. In the EIA, it is simply not sufficient to not have a concrete, environmentally sound plan of disposing of hazardous waste - only storage and disposal at sites not identified - at this stage of the developer's operation. Thus, the EPA must ensure that the developer has a well-documented plan. The management of some types of wastes generated will lie with sub-contractors. In the absence of adequate national standards to guide their operations, sub-contractors should operate in accordance with generally established standards for the industry or standards of EEPGL. We also recommend that EEPGL hold responsibility for negative impacts resulting from sub-contractors and regularly monitor sub-contractors' operations as it relates to the handling, disposal, transport etc. of wastes generated from EEPGL activities.	Payara EIA Vol. III Appendix 1 contains EEPGL's Integrated Waste Management Plan. Each contracted vessel is required under MARPOL to comply with international standards and practices as reflected in their Garbage Management Plan, Garbage Record Book and Oil Record Book. Environmental training of crews is performed to ensure they are familiar with such plans as well as the permit conditions and obligations applicable to each marine survey, exploration well drilled ,or development project undertaken by EEPGL. This training includes waste management, waste recordkeeping and reporting. EEPGL provides to the EPA monthly drilling waste reports, end of well waste summary reports as well as an annual waste inventory report that documents wastes generated, stored, treated and disposed during that calendar year by the development projects and - beginning on December 20, 2019 - production operations.	---
Incineration on-shore is also mentioned as a waste disposal method in the EIA, but there is no information on number of functioning incinerators, capacity of incinerators to deal with waste volumes, location of incinerators (are they within the vicinity of residential areas or will their operation affect residents). This needs further clarity in the EIA.	The shorebase facilities where contracted onshore support activities (not limited to but including waste incineration) would occur are neither owned nor operated by EEPGL, but are operated under their own environmental authorizations. The EIA considers impacts associated with EEPGL's use of these facilities (vehicular traffic to and from the shorebases, for example), but the EIA's scope does not include assessments of impacts associated with the shorebases' presence or activities that are carried out by shorebase or tenant staff at the shorebases under separate environmental permits. With respect to capacity of incineration infrastructure to accommodate the Project's needs, this is addressed in detail in Chapter 8 of the EIA - as it relates to the Project's potential to result in limitations on such infrastructure capacity.	---

Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Chapter 7: Biological Resources; Chapter 9: Unplanned Events		
Safeguarding the environment, not only Guyana's but of all territories within the project's area of influence including those of South America and the wider Caribbean, is of greatest importance given the sensitivity/vulnerability of marine, estuarine and coastal areas, and the severe long-term impacts that will result should there be a major oil spill. The oil spill modelling results presented in the EIA indicates that there is a very high risk of oil swiftly reaching Guyana's coastal regions should a large spill occur - a 20% chance of oil reaching Guyana's coastline in as little as 5 days. The impacts would be far reaching: protected areas, mangroves, marshes, coastal wildlife including special status species, indigenous and other communities, and families depending on the ocean's resources for their livelihoods, marine/cargo transportation and commercial fishery sector. If feeding, nesting, breeding, spawning or calving areas are affected the severity and long-term effects of a spill even more catastrophic. It is important to note that in the EIA impacts to the marine ecosystem are underestimated since they were made in the absence of spatial and temporal data on biodiversity, critical habitats, etc. of the marine area (see Planning and effective management of the resources and use of marine area, above).	The Consultant team agrees that in the event of oil from a Tier III spill event reaching the Guyana coast, the consequences for biodiversity could be severe. The sensitivity of the ecosystem to such an event is the primary reason that several of the environmental resources received a Moderate risk rating for unplanned events, even though the likelihood of such an event is exceedingly low. However, the Consultants wish to clarify that even if a Tier II spill event - which is itself a very remote possibility - were to occur, the chances of oil reaching most of the Guyana coast are very small (the 5 to 20 percent likelihood of oil reaching the Guyana coast reflects an unmitigated scenario, and mitigated spill modeling predicts no shoreline impacts in Guyana). The Consultants would also reiterate that the assessments of impacts (including potential impacts from unplanned events such as oil spills) on biological receptors in the Payara Development Project EIA are well supported by a combination of extensive field study and desktop-based research from reliable sources. In the Consultants' view, the current body of biological knowledge as reflected in the EIA is sufficient to support a robust assessment of the project's likely impacts, including potential impacts from oil spills.	---
These modelling results referred to above also determined that an unmitigated oil spill would reach Venezuela, Aruba, Bonaire, Curao. Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, St. Lucia etc. Such an event would have an extreme impact on the community's livelihoods, national economies and biodiversity of these regions and exacerbate economic, climate and social vulnerabilities. We suggest that on-going monitoring (linked to Capacity building for monitoring and regulating the sector, above) for adherence to environmental safeguards be conducted as it is a critical element for ensuring that activities occur with the least impact to the environment.	As described in the Oil Spill Response Plan submitted with the EIA, a Net Environmental Benefit Analysis (NEBA) would be conducted in the event of a large oil spill. The purpose of NEBA is to identify the combination of key response strategies that would be appropriate, given the specific situation, fate, and trajectory of the oil spill and weather conditions, and to identify and select the option or combination of options that minimizes overall harm to environmental and socioeconomic resources. Stand-alone, open-ended research programs are not required to support the NEBA process, but as indicated in Section 6.1 of the Oil Spill Response Plan, a wildlife monitoring program would be initiated in the event of a large spill to assess the effects of the spill on wildlife.	---
The models in the EIA for the worst-case scenario is a 30-day loss of well control event. What if the loss of well-control event lasts beyond the 30 days? In the Oil Spill Response Plan, several local organisations were identified including the Guyana Marine Conservation Society, Conservation International and Karanambu Trust. However, upon inquiry organisations were not able to identify what role they would play in the event of an oil spill. How did the developer involve these stakeholders? What are their roles? These should be clear stated for the public.	As described in Section 2.4.2 of the Oil Spill Response Plan (OSRP), the responsibilities of the Government's maritime sector in an oil spill response scenario would be consistent with the roles established in the country's draft Guyana National Oil Spill Contingency Plan. The Civil Defence Commission would assume overall responsibility on behalf of the government as the lead agency for oil spill response operations. The Lands and Surveys Department of the Ministry of Agriculture would have jurisdiction over response activities in river waters. The Transport and Harbors Department of the Ministry of Public Works, Communications, and Regional Development would be responsible for port areas and territorial waters. However, the Guyana Coast Guard enforces all maritime regulations and is a key operational organization in any marine incident, investigating reports of pollution in navigable waters on behalf of the relevant ministry and department. In addition, the Guyana Defense Force and the Fire Service would also assume some operational responsibility for pollution response. Although NGOs' roles in a spill scenario would depend somewhat on the location, size, and severity of a spill, the OSRP envisions the Karanambu Trust as assisting with rehabilitation of otters should otters be affected by a spill, and the Guyana Marine Conservation Society as assisting with marine turtle-oriented response activities.	---

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WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Chapter 9: Unplanned Events		
Further, the Civil Defence Commission is an important partner for EEPGL in oil spill response. What is the state of readiness of the CDC? This should be rated clearly in the EIA with measures clearly elaborated to improve the CDC's state of readiness. Decentralisation of capacity to respond to oil spill is critical given the geography of Guyana's coastline. To what extent is capacity being built, refreshed and retained in order to respond to emergencies? What are the measures to be implemented? Feedback indicates that spill response training so far has not meaningfully prepared local stakeholders to respond. The EIA should also describe what measures the developer is taking to have an early warning system.	While EEPGL certainly recognizes that the Civil Defence Commission is a key partner for oil spill response, it is not EEPGL's position to comment on their overall state of readiness. The CDC's participation in training, demonstrations, and exercises is building skills and experience in key areas of emergency incident management. CDC Volunteer Emergency Response Team (VERT) members have also been involved in similar activities. Where practical, relevant Guyanese authorities and stakeholders have been and will continue to be actively involved in these annual oil spill response exercises. In addition, regional oil spill capacity building has been on-going. This training and, most recently, regional deployment of oil spill response equipment has progressively developed the response capability of government authorities, agencies and volunteer responders. As part of the continued commitment to capacity building, EEPGL will be working with the relevant agencies to transition from demonstration of the equipment to staging open ended exercises where local responders will be expected to identify response strategies and equipment required, and to deploy the equipment consistent with their strategy under the guidance of experienced responders. The long-term objective is to enable every regional response team to be able to respond confidently, independently of experienced coaches. The National Oil Spill Contingency Plan and the resourcing of decentralized oil spill response capability (equipment and personnel) is a matter for the National Oil Spill Committee in conjunction with the agencies identified in the plan with assigned responsibilities to determine. As a competent operator, EEPGL is providing resources to respond to any Tier 1 events, and with appropriate local and international support (as detailed in the EEPGL Oil Spill Response Plan) to be able to respond to all events, including the Tier 3 worst case scenario of loss-of-well-control event).	---
	In respect of any unlikely oil spill event from EEPGL facilities, EEPGL have an established notification matrix (detailed in the OSRP) that provides immediate notification of key agencies, and in particular is aligned with the notification directly to the MARAD Georgetown Lighthouse as required in the National Oil Spill Contingency Plan. Once this notification is made, all other relevant agencies and response organizations can me mobilized, which is effectively the Early Warning System. This represents approximately 9 days advance notice to prepare for any possible response activities required along the Guyana coastline (for any spill from an EEPGL facility). These early notification obligations exist for any person who releases oil to water – including a ship or oil and gas facility operator.	---
We would also like to recommend the establishment of a special fund dedicated to increasing preparedness (including education, research), cleaning-up, rehabilitating, restoring, compensating, etc. those affected by a spill, should it occur. To support this, a robust framework for compensation should be developed separately with wide stakeholder involvement. We recommend that, in keeping with the 'polluter pays' principle, oil and gas developers should finance the fund - the people of Guyana should not pay for damage resulting from developer's negligence. Based on the current agreements in place regarding developer's operation in Guyana, a clear position should be communicated to the public on who currently bears the legal and financial implications should an oil spill occur. This is important as it has implications for the social and economic well-being of Guyanese well into the future.	The EIA states that EEPGL will determine financial liability in the event of a spill. As noted in Section 9.1.9, in the unlikely event of an oil spill, EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. In addition, EEPGL and its co-venture partners have entered into agreements with insurance companies which require verification that adequate financial resources are in place to satisfy environmental obligations, including those in the unlikely event of a spill.	---

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WWF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Socio-Economic Impacts		
Chapter 8: Socioeconomic Resources		
Economic impacts have been rated as POSITIVE within the EIA, but this seems to be narrowly based on the fact that Guyana will get some quantity of revenue. The EIA further mentions that it is the Government's responsibility to responsibly use and invest its share of money. There are several negative impacts, which can directly or indirectly result from EEPGL projects and the sector, more broadly: inflation - increases in the cost of housing, food and services, for instance; and widening of the gap between rich and poor, which undermines poverty reduction goals. Loss of livelihood and access to natural resources to support livelihoods are acknowledged as risks of the project, but it is not clear how these will be meaningfully addressed.	A quantitative assessment of economic impacts is not included within the scope of the Terms of Reference issued for the Payara EIA. A qualitative evaluation of potential impacts on social infrastructure, including those related to increases in cost of living, is included in Chapter 8. An analysis of the Project's contribution to poverty reduction goals is outside the scope of an EIA. With the exception of the loss of access by a small tuna fishing fleet to a limited area over 200km offshore, loss of livelihood and access to natural resources would only occur as a result of unplanned events and would therefore be covered under the Claims and Livelihood Remediation Process discussed in Section 9.1.9 - something that cannot feasibly be developed in advance of an unknown, unplanned event.	---
How are such considerations being meaningfully addressed through the project's social safeguards? Are there hard measures in place given that first oil is to be produced from December 2019? Who are the other parties with responsibility and what actions are being taken? In addition, strong measures should be put in place to ensure that maximum benefits go to the people of Guyana including: local content plan that is not dictated by the developer; mechanisms to address the loss and disruption of livelihoods (which are noted in the EIA); and ensuring that the people of Guyana do not bear the legal and financial burdens associated with an oil spill. Also, there is need to ensure that measures are in place to have positive influence and ensure sustainability of other important sectors such as fisheries, agriculture, tourism and other land-based sectors. These measures should include budgeting of revenues to support to sustainable growth of the sectors and creating policies to more deliberately ensure the oil and gas sector does not have negative effects on other sectors and their ability to function effectively.	The Consultants acknowledge the comments, noting that they are directed at policy-makers and are not within the scope of the EIA.	---
Cummulative Impacts - Chapter 10: Cumulative Impacts		
Cumulative impacts, not only from EEPGL project activities, but form other oil and gas projects both on and offshore should be evaluated bearing in mind earlier comments on impact rating lack of data, socio-economic impacts etc. The assessment should be done at the seascape-coastal level rather than being site specific.	The cumulative impact assessment for the Project considered other projects that were reasonably foreseeable by the Consultants. This suite of other projects included other activities by other oil & gas operators; however, the other oil & gas operators in Guyana are still at a relatively early stage of their exploration efforts. At the time the EIA was written, no exploration activities from other oil & gas operators beyond 4Q2019 (a year earlier than the first proposed Payara drilling) had been publicly announced, and none of the operators had announced definitive plans for development projects. The Consultants therefore did not make assumptions about the potential success of these operators' exploration activities, and did not reflect in the EIA a prolonged exploration program or any associated development projects that could be contemplated if discoveries are made.	---
Depletion Policy		
We would like to recommend the development of a depletion policy as it could impact national investments, planning for the management of the industry, energy policies and transition to renewable energy, development of other economic sectors and economic diversification, etc.	This comment address policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana.	---

Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
Comments	**Response to Comment**	**Section in Which Addressed**
General Remarks		
1. Use of dispersants - It is of the highest importance of EXXON exploring other solutions to deal with oil spills /other than using dispersants/, which in many cases have proven to be even more toxic to living organisms than the oil.	As described in the Oil Spill Response Plan (OSRP), in the event of an oil spill EEPGL would conduct a Net Environmental Benefit Analysis (NEBA) to support decisions as to the combination of response measures to implement in a given response scenario. The purpose of the NEBA analysis would be to ensure that any response measure implemented would be beneficial compared to the "no response" scenario. Use of dispersants is an important strategy for EEPGL to have available in the event of a spill, but would not be used unless the NEBA analysis demonstrates the benefit of such use.	---
2. Economic Valuations -Work conducted on the social and economic valuation of fishing communities is not sufficiently robust.	Data collected through engagements with members of the fishing industry are included in Chapter 8. In particular, the Consultant team is conducting a Participatory Fishing Study which collects social and economic baseline data on the artisanal and subsistence fishing industry. This work is ongoing and additional information will be published as additional study is completed.	---
3. Bird surveys in Region 01 - Absence of baseline data for birds in Region 01. Bird surveys and a full biodiversity survey of the areas inside and outside of the Shell beach protected area should be conducted.	The Shell Beach Protected Area (SBPA) is unlike other portions of Guyana's coast in that it is the only large coastal area in the country that has been the subject of a formal, relatively recent biodiversity study (the 2011 Proposed Shell Beach Delineation Process Report). Although the Consultant team agrees that the information in this report could have been updated with more recent field data for the EIA, the report contains valuable information on the biodiversity of the SBPA, and these data - together with more recent survey data from other sites with similar habitats (coastal beach, intertidal mud flats, mangroves, etc.) - were deemed sufficient information by the Consultants to credibly assess potential Project-related impacts on resources in the SBPA.	---

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CIF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
General Remarks		
Abide by high standards. Given EEPGL developments are the first of their kind in Guyana, they will set the benchmark for future oil and gas exploration and development projects in the country. It is therefore paramount that the project abides by high industry standards of accountability and good governance.	ExxonMobil (EEPGL's parent organization) and its affiliates (including EEPGL) are committed to conducting business in a manner that is compatible with the environmental and socioeconomic needs of the communities in which it operates, and that protects the safety, security, and health of its employees, those involved with its operations, its customers, and the public. These commitments are documented in its Safety, Security, Health, Environmental (SSHE), and Product Safety policies. These policies are of the highest industry standards that are put into practice globally by ExxonMobil through a disciplined management framework called the Operations Integrity Management System (OIMS). Effective and consistent application of these policies will constitute the primary safeguards against occupational hazards for Project workers, and all Project workers and contractors will receive training on implementation of these principles and will be required to adhere to them in the daily execution of their duties.	---
Adopt the precautionary principle. The high level of complexity in the technical aspects of this kind of project's operations, inherent high variability and complexity of oceanic systems (and more broadly, water as a medium) and the relative paucity of knowledge of Guyana's marine ecosystems, create conditions in which there could be far-reaching unknown impacts. This warrants application of the Precautionary Principle encompassed in Section 4(a) of the Environmental Protection Act, (2006). Considering this principle, we recommend the use of independent, third-party monitoring on a periodic basis to verify management plans and data, as well as 'structuring independent research programs to enhance the information available for improved decision-making.	EEPGL agrees that monitoring is vital to performance assurance. The ESMP does not envision stand-alone, open-ended research programs because such programs are not required to assess the accuracy and effectiveness of the EIA or ESMP, respectively; however, as indicated in Section 3.7 of the Environmental and Social Management Plan for the Project, the results of the proposed monitoring program will be externally reported. Volume III of the regulatory submittal contains the ESMP, and Section 3 of this plan describes the proposed monitoring program for the Project. Tables 3-1 through 3-9 contain over 25 resource-specific monitoring measures, and additional monitoring measures are included in the Waste Management, Stakeholder Engagement, Preliminary Decommissioning Plan, and Oil Spill Response Plan, which are included in Volume III of the regulatory submittal. These measures are intended to monitor the effectiveness of the proposed management measures and inform the EPA and EEPGL of any potential impacts not identified in the EIA, should they arise.	---
Undertake a cumulative EIA encompassing all three current development projects. We echo recommendations that EEPGL produce a cumulative EIA covering all three currently proposed or permitted projects, in addition to the stand-alone EIAs for each project. This should also be done for the at least two additional planned development projects in the Stabroek Block. This is essential since the cumulative effects of the EEPGL and non-EEPGL projects (for example, three other oil and gas operators are planning or executing I exploration programs in blocks adjacent to the Stabroek Block) could exacerbate potential negative impacts to the environmental and social conditions of Guyana. Similarly, increased development along the banks of the Demerara River for increased shore-based activities will result in significant impacts to mangrove and mud flat ecosystems.	The cumulative impact analysis conducted as part of the Payara EIA meets the requirements for cumulative impact analysis established in Part IV Section 17 of the Environmental Protection Act. It considers future offshore oil and gas development projects in the Stabroek Block (including the three development projects approved or proposed to date as well as to future developments referred to as FPSO #'s 4 and 5), future exploration projects in the Stabroek and adjacent blocks, and landside development activities including development of a fiber optic network, and a natural gas processing plant and gas fired power plant (referred to as the FOC Project and the Gas to Shore Project, respectively). Other oil and gas operators' activities were also considered although these operators do not have any publicly-announced activities that overlap temporally with those of the Project.	---
Aim at achieving net gain for biodiversity and communities. Given the important precedent this project will set, we recommend that it adopts a net gain goal for biodiversity and communities. This is especially given the current uncertainties around Guyana's marine biodiversity and ecosystems, and the potential future additional oil and gas development which might increase the effects of indirect and cumulative impacts. We believe that this should be done regardless of whether the project would cause significant residual impacts from any planned activities. The project could achieve net gains by identifying additional opportunities to enhance habitat, conserve biodiversi ty, support communities' livelihoods and well-being, and contribute to research and knowledge about the country's marine and coastal resources.	The Consultants acknowledge the comment, noting that net gain for biodiversity receptors is neither a requirement of the Environmental Protection Act nor a condition of the Terms of Reference for the Payara Development Project EIA; accordingly, it is not an appropriate standard to apply to the EIA. That said, the Consultants note that EEPGL has conducted extensive research regarding Guyana's biological resources, in programs that have spanned multiple years and contributed significantly to scientific knowledge for the country.	---

Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
CIF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Adopt continuous and meaningful engagement with communities and Indigenous Peoples. As per IFC Performance Standards, there should be robust stakeholder engagement during the life of the project. For each of those engagements the Project should ensure deliberative spaces and appropriate communication tools that are inclusive and tailored to the different audiences and enable effective participation of vulnerable and underrepresented stakeholders. We note the expressions of interest to present the findings of the ESIA in a user-friendly format during the 2017/2018 stakeholder meetings hosted by the EPA at the time of preparation of the Environmental Impact Assessment Guidelines for Offshore Hydrocarbon Exploration and Production. We are however, of the view that this was not adequately carried out and may result in many stakeholders being unable to sufficiently comprehend the information contained in the EIA documents to constructively comment on it. This lack of follow through can no doubt negatively affected the credibility of the management processes undertaken by the company and impressions of the proposed development.	Engagement of the Consultant team and EEPGL with communities, including Indigenous Communities, is described in the Stakeholder Engagement Plan. However, the Consultants will include in the EIA additional reference to the fact that engagement of Indigenous Communities has always included an Indigenous leader representative from the National Toshoas Council (NTC) to ensure all the engagements are fair and impartial and the concerns of the Indigenous Communities are raised and addressed. The participation of the NTC is beneficial since communities are generally more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, have more confidence in the process and participate freely in the discussions. The SEP documents the multiple years of engagement that have taken place by EEPGL and its consultants. In reference to the comment regarding user-friendly material, in response to comments received in other EEPGL Project consultations about the complexity of the materials, the Consultants developed for the Payara EIA a highly visual Non-Technical Summary as well as other materials to help in messaging the Project risks and benefits. This NTS will be appended to the SEP.	SEP
Execute on-going monitoring programs for vulnerable species to inform a Critical Habitat Assessment (CHA). We recommend the project, following a Precautionary Principle (referenced above), execute an on-going monitoring program for vulnerable species identified through the field studies, even if residual impacts affecting them are considered negligible. Special emphasis should also be placed on a comprehensive baseline assessment of herpetofauna along the coast, as these are usually the first indicators of ecosystem health. The results of all these additional studies should help eventually inform a Critical Habitat Assessment (CHA) to determine if critical habitats are likely be impacted and to what degree.	With respect to critical habitat, Critical Habitat Assessment (CHA) is a unique element of EIAs conducted under the IFC Performance Standards, and is not generally included in EIAs that are not subject to the IFC Performance Standards (such as the Payara Project). Compliance with the IFC Performance Standards was not part of the Terms and Scope issued by the EPA for the Payara EIA, so it would be inappropriate to require a CHA for the Project. The inappropriateness of a CHA in the context of the Payara Development Project notwithstanding, the impact assessments for several biological resources (including marine birds, marine mammals, and marine fish) include several attributes that would typically be considered in a CHA (such as listing status, congregatory behavior, and migratory life histories) as factors when determining sensitivity to potential Project impacts.	---
Support mechanisms for strengthening data collection to improve knowledge and management of Guyana's marine natural resources and ecosystems. The development of the sector offshore in ecosystems that are poorly understood also present unique challenges especially when combined with the pace of this development. The environmental data collection that is being undertaken in the marine environment by EIA consultants for the various oil and gas developments is exceedingly valuable because of the paucity of research in Guyana's Exclusive Economic Zone (EEZ). It is therefore of great importance that measures be put in place to manage this data and result in progressively improved knowledge of the space within which these projects are being developed, especially given that the research is almost entirely new. One possible means of doing this is the establishment of a data management system to which the EIA consultants conform and use to collate and submit their data. This would allow for future research to build on prior set of work and support further research activities and identification of gaps. The Project should consider sharing the information collected from baseline and monitoring assessments more broadly in ways and formats that are useful for wider use by the EPA, the conservation community, academia and the general public. Additionally, EEPGL has a great opportunity to support research efforts and initiatives that can contribute to increasing knowledge and understanding of the marine ecosystems and natural resources of Guyana.	The Consultants agree that much of the information that has been generated through ongoing studies, including those that informed the Payara EIA, is new and of significant value to the Government of Guyana, academic institutions, NGOs, and other stakeholders with an interest in conserving Guyana's natural heritage. All of the reports detailing the findings of the studies that informed the Payara EIA (including the appendices with data tables) have been made available to the EPA, and are available to the public in pdf form on the EPA's website.	---

Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
CIF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
Chapter 4: Methodology for the EIA		
Criteria for rating impacts should consider stakeholder's impact acceptability. Best practice recognizes that the process for determining impact significance and acceptability should effectively integrate value judgments and preferences of affected stakeholders and the general public.	As described in Section 4.5 of the EIA, a robust stakeholder engagement process was undertaken to inform the EIA and stakeholder concerns were documented in the EIA. Public perceptions and tolerance for anticipated Project-related impacts were incorporated into the significance ratings for selected receptors where appropriate, and factored most strongly in the intensity component of the magnitude ratings for socioeconomic receptors such as Community Health and Wellbeing (for which public anxiety was itself a potential impact considered), Marine Use and Transportation, and Social Infrastructure and Services.	---
Impacts determined as having negligible significance should include a robust justification. For impacts determined to have negligible significance, the EIA should explicitly state the reasons behind this classification. For instance, it would be essential to also assess the level of uncertainty associated with the predictions. We also recommend that the significance of the projected impacts be assessed based on a matrix intersecting the likelihood of each impact occurring and the magnitude of the impact likely should it occur.	The impact assessment methodology assesses impact significance for planned activities based on magnitude and sensitivity rather than magnitude and likelihood. Likelihood is incorporated only for unplanned event risk ratings (and refers to likelihood of the event occurring, as opposed to likelihood of impact). The Consultants note that the methodology used is more conservative than the methodology suggested in the comment because the methodology is based on a worst-case assumption that all impacts associated with planned activities are certain to occur. The justification for ratings of negligible significance can be found in Section 4 of the EIA, which describes in detail how magnitude and sensitivity are assessed and how they are combined to arrive at a final significance rating in the EIA, and in the resource-specific impact discussions in Sections 6, 7, and 8 - which provide further explanation of the how the rating system was applied to each receptor and impact.	---
Impact reversibility should be addressed within the Impact Significance Rating Matrix. Interpretations of Sections 4(a) and 11(5) of the Environmental Protection Act (2006) and the EPA's Environmental Impact Assessment Guidelines for Mining (2000), suggest that evaluation of reversibility of impacts is a non-negotiable component of an EIA. Therefore, it should be consistently addressed in the EIA within the Impact Significance Rating Matrix and integrated within the evaluation of the magnitude of the impact.	The Consultants acknowledge that reversibility is explicitly included in the EPA's guidelines (and that the concept of irreversible damage is addressed in the EP Act). Rather than adding reversibility as a distinct characteristic in the magnitude determination matrix (Figure 4.6-2 in Chapter 4 of the EIA), the concept of reversibility was integrated into the "duration" characteristic. In other words, the rating chosen for "duration" reflects the combination of the length of time the impact-causing activity would occur and the length of time the impact would be expected to sustain after the impact-causing activity ceased. The EIA also summarizes the degree of irreversibility inherent in the individual ratings in Sections 3.5 and 12.4.	---
Most valuable environmental and social resources/receptors for relevant stakeholders (even if impacts are determined as negligible in this project) should be considered for the cumulative impact assessment. Although negligible impacts from this project might not significantly affect a resource/receptor, when considered in combination with impacts from other ongoing and planned projects and sources of external pressure, it might become significant. We understand that the cumulative impact assessment was conducted in accordance with the IFC best practice standards; however, we recommend that the cumulative impact assessment consider the most valuable environmental and social resources/receptors determined by relevant stakeholders, independent of the significance determined by each individual EIA.	As noted in the comment, an international best practice approach was utilized for the cumulative impact assessment. Consistent with this approach, those resources that were determined to have a negligible impact from the Project were excluded from further consideration. It is noted, however, that the resources excluded from the EIA would only be measurably impacted by the Project in the event of an oil spill.	---
Description of Existing Conditions, Appendices K - T		
Baseline Assessment - Chapter 7: Biological Resources		
Regularly conduct species surveys throughout the term of the Project. The purpose of the biological species surveys (a 2-year long process) was to assess species abundance and status against the International Union for the Conservation of Nature (IUCN) Red list of Threatened Species. Overall, the methodology is robust, and we commend the approach of increasing survey coverage in under- surveyed portions and the survey team for their robust assessment. Further, we are pleased to see that the team plans to continuously survey for the remainder of year 2, however, we recommend monitoring throughout the entire lifetime of the Project.	The ESMP (Volume III of the regulatory submittal) contains numerous monitoring measures focused on physical environmental indicators. Assuming the Project is permitted, the Consultants have concluded that implementation of these measures should provide the EPA with sufficient data to determine if the Project is performing acceptably with respect to managing impacts on habitat for IUCN listed species. In addition to the habitat-related monitoring measures, the ESMP includes a requirement to report detections of marine mammals and marine turtles made from Project vessels (including the FPSO) over the operational lifetime of the Project (see Table 3.9). Marine mammals and turtles constitute account for several of the most commonly-observed IUCN-listed species in the Project AOI and this measure will effectively convert the MMO/PSO study program that has been ongoing since 2015 into a long term monitoring program.	---

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Development of a Biodiversity Action/Management Plan (BAP/BMP) to protect threatened species. Considering the high biodiversity value of the coasts of Guyana, as well as the potential uncertainties about project impacts, a stand-alone BAP/BMP Is important to communicate clearly to stakeholders the company's selected mitigation strategy, and its working philosophy and ability to operate responsibly in areas of known conservation value. EEPGL could also opt to incorporate biodiversity-related mitigation and management measures into more general Environmental Management Plans or Action Plans, but the risk in this case, is that commitments might appear less evident or buried among many others, and possibly be less focused. Five species of international conservation concern were documented during the survey: White-bellied Piculet ("Vulnerable"), Rufous Crab Hawk (Buteogallusaequinoctialis) ("Near Threatened"), Bicolored Conebill (Conirostrum bicolor) ("Near Threatened"), Semipalmated Sandpiper ("Near Threatened"), and Red Knot ("Near Threatened"). In addition, 10 Important Bird Habitats were identified due to high bird abundance and species richness.We reiterate strong encouragement to develop Biodiversity Action Plans (BAPs) to ensure the protection of these species and their respective habitats.	The planned activities of the Project are not anticipated to impact any IUCN red-list bird species. Embedded controls that are incorporated into the Project design minimize or avoid potential impacts to Red List species. Only unplanned events, specifically an oil spill, could potentially impact these species and implementation of the Project-specific OSRP would minimize or avoid impacts to these species in the unlikely event of an oil spill.	---
Expand the scope of IUCN assessment to include all observable species. We commend the EIA's identification of IUCN Red List species in Guyana and overlap with respect to coastal bird species; however, clarity is needed for observed marine bird, marine mammal, fishes, flora, fauna, and turtle species and whether they are on the IUCN Red List of Threatened Species.	Section 7.1 describes how many IUCN-listed species listed in Table have been documented by field studies cited in the EIA, but the Consultants agree that this information could be presented in a clearer fashion. The section will be edited accordingly.	7.1.2.2
The marine mammal observation data presented should be strengthened. We believe this data lacks structured attempts to catalogue these species and relies largely on opportunistic sightings from marine vessels over a period of 10 years. This method is limited as it is neither systematic nor structured and assumes that vessel captains can correctly identify species.	The Consultants agree that there has been an element of opportunism to the MMO data collected to date; however, as indicated above, the ESMP includes a requirement to report detections of marine mammals and marine turtles made from Project vessels (including the FPSO) over the operational lifetime of the Project (see Table 3.9). The FPSO will remain stationary for the entire monitoring period, which will effectively create a permanent, full-time monitoring point within the Project AOI. This will introduce a level of rigor and reproducibility into the MMO data that had not existed previously. It is also noted that vessel captains are not responsible for identifying marine species; all protected species observations are made by trained protected species observers who are required to pass a proficiency exam to function in this capacity.	
The turtle telemetry data presented should be strengthened. This data was collected from few turtles and over only one nesting season. This data is therefore not sufficiently indicative of the migratory routes all nesting species utilize. More robust data is needed to formulate a clearer picture.	The Consultant team considers the turtle telemetry data presented in the EIA to be sufficient for the purposes of rating the anticipated impacts on the Payara Development Project on marine turtles. It is noted that a second year of turtle telemetry work is currently underway and a report on the results of this work will be provided to the EPA at the conclusion of the study.	---
Adopt recommendations that the sampling area be widened to appropriately assess baseline conditions of areas potentially impacted by indirect or cumulative impacts. While the sampling sites were deemed to be representative of the immediate Payara project development area, they do not discuss the area that could potentially be impacted from an indirect or cumulative perspective, and therefore, do not reflect the conditions in the entirety of the project's AOI.	The Consultants note that biological resource data have been collected from across the Stabroek Block (and between the Stabroek Block and the shoreline), specifically for marine fish, marine birds, and marine mammals. Further, coastal bird data have been collected across the Guyana coast. With respect to future monitoring, the monitoring program described in the ESMP focuses on the Direct AOI because the Direct AOI (specifically the immediate vicinity of the FPSO and drill centers) is where the most significant Project-related environmental impacts are expected to occur. To the extent that low-level impacts could occur farther away from the Direct AOI, the EIA predicts that their significance would be too low to warrant a seascape-level monitoring program. However some marine receptors that are vulnerable to potential impacts outside of the immediate vicinity of the FPSO and wells (such as vessel collisions with marine mammals and sea turtles, for example) will be monitored wherever Project vessels are operating.	---

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Present information on sampling dates and locations in a clearer manner to better convey their seasonal and temporal variations. It was previously recommended that "additional sampling periods be carried out to better capture temporal variations in baseline conditions." While additional sampling has been proposed for various studies it is still not clear whether capturing seasonal or temporal variation has been factored in the studies associated with this EIA. We suggest presenting this information in a clearer way, by including an additional column to better denote the studies done to date, and when they were done, including aspects such as the season during which they were performed. This will allow for better and easier assessment of the robustness of sampling conducted and gaps can be clearly assessed.	The biological field studies were conducted with seasonal variations in mind. Not all taxonomic groups (deep marine benthos for example) are likely to be affected by seasonal changes, but efforts were made to collect data in the wet and dry seasons for the major taxonomic groups that are likely to be affected by seasonal changes. In addition, sampling events have been conducted over multiple years for most taxonomic groups. Information on when and where the field studies for each of the major taxonomic groups is included in the relevant reports in Volume II of the regulatory submittal.	---
Recommended Additional Studies		
Continue subsea noise pollution monitoring. We acknowledge that monitorization efforts now also include a subsea noise pollution study component to gauge and track potential impacts of sound arising from Liza and Payara project-related activities, as this was one of CI's recommendation from an earlier EIA review. Furthermore, we are pleased to learn that the deeper water at Payara lowers the sound levels, and therefore presents less danger to marine populations.	Although the EIA included a marine noise modeling analysis, it does not include a recommendation to monitor marine noise. The EIA does recommend that operational activities are conducted in accordance with international best practice regarding mitigation of noise impacts on marine mammals, including soft starts for pile driving and adherence to the JNCC Guidelines during seismic activities, which the Consultants consider adequate to manage noise impacts on marine mammals.	---
Establish baselines for the Shell Beach Protected Area (SBPA). Given the potential for significant impacts to the SBPA from unplanned events such as oil spills, we recommend that baselines be establish for the protected area, especially for the elements that would be the most affected by such events. The SBPA should also be included as part of the continuous biodiversity monitoring over the life of the project.	The SBPA is unlike other portions of Guyana's coast in that it is the only large coastal area in the country that has been the subject of a formal, relatively recent biodiversity study (the 2011 Proposed Shell Beach Delineation Process Report). Although the Consultant team agrees that the information in this report could have been updated with more recent field data for the EIA, the report contains valuable information on the biodiversity of the SBPA, and these data, together with more recent survey data from other sites with similar habitats (coast beach, intertidal mud flats, mangroves, etc.), were deemed sufficient by the Consultants to credibly assess potential Project-related effects on the SBPA.	---
Project Generated Impacts		
We recognize that the EIA references the World Bank's Environmental, Health and Safety Guidelines (EHS Guidelines) for the evaluation and selection of resource efficiency and pollution prevention and control techniques for the Project. However, we recommend the following:	No response required (header for subsequent comments)	---
It is important to also consider the risks and potential impacts on priority ecosystem services that may be exacerbated by climate change, as per IFC PS4. For instance, socio-economic impacts on fisheries and fishing communities due to climate change which might also be exacerbated by the Project's exclusion zones.	Compliance with the IFC PS was not part of the Terms and Scope for the Payara Development Project EIA, so it PS4 is technically not applicable to the EIA. The fact that the IFC PS are not applicable to the EIA notwithstanding, the Consultants recognize the importance of impacts on climate and ecosystem services to Guyanese society, and have assessed them separately in Sections 6.1 and 8.9 of the EIA, respectively. With specific regard to potential loss of fishing ground access from exclusion zones, the assessment of these impacts in Chapter 8 explains that the only fisherfolk that will potentially be affected by exclusion zones would be a relatively small commercial tuna fishery, and even in this case the loss of fishing ground access is minimal relative to the size of the EEZ.	---
Vessel offshore anchoring might disturb seabed habitats; this is an additional project interaction with environmental resources/receptors that should also be considered.	It is noted that only the FPSO will be moored; no other Project vessels will be anchored, moored, or otherwise attached to the seafloor at any time. The potential physical impacts associated with the FPSO's mooring spread are assessed in Section 6.3 and the biological impacts of the mooring spread are assessed in several locations in Section 7 including Section 7.5 (marine mammals), Section 7.8 (marine fish), and Section 7.9 (marine benthos).	---

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We welcome the commitment of the developer to not flare gas, except in cases of emergency, and to monitoring greenhouse gas (GHG) emissions of the project. This would be critical to support Guyana's low carbon, green economic development ambitions. The Project should however consider going beyond monitoring to offsetting its GHG emissions through investments in management of natural forests in protected areas and other effective means.	As indicated by the comment, EEPGL has committed to environmental performance monitoring and reporting management systems that are in line with international good practice methods with respect to GHG management. In addition, as noted in Section 6.1.3.2, EEPGL has committed to a number of embedded controls and mitigation measures that will aid in reducing GHG emissions from the Project. Embedded controls and mitigation measures that will reduce emissions include re-injecting produced gas that is not utilized as fuel gas on the FPSO to avoid venting or routine production flaring, waste heat recovery, high efficiency gas turbines, VOC recovery on the oil storage tanks, and efficient operation of combustion equipment, among others.	---
The proposed disposal of solid waste detailed in the EIA must take into consideration the already insufficient capacity of current landfills in Georgetown; these may not have enough capacity for the additional waste the project will generate. Special emphasis should be placed on the efficient and effective disposal of the project's hazardous waste, taking into consideration that Guyana does not currently have a functioning commercial incinerator.	The Payara EIA did take into consideration the types and quantities of solid and hazardous waste to be generated by the Project. Since the completion of the draft Payara EIA, the construction of a second cell at the Haags Bosch Landfill has been proceeding as planned and approved. Continued upgrades and improvements at the Haags Bosch Landfill have also been undertaken. The current and near-term local non-hazardous solid waste management needs for the Payara Development Project can be met with the use of exist landfills. Subsequent decisions of whether further expansion of existing or new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the Ministry of Communities and the Environmental Protection Agency and participation of the public and other stakeholders. EEPGL has issued an invitation to tender to increase local 3rd party waste management facilities, services and technologies in Guyana for the continued management of hazardous and non-hazardous wastes. An award of this contract is expected in 1Q2020, with the expected development and implementation of such additional waste facilities and capabilities throughout 2020 and beyond. In addition, EEPGL continues to plan and execute waste management capacity building workshops with the EPA and MoC, with the first of such planned for 2Q2020.	---
Development of the decommissioning plan should be informed by a socio-economic analysis to better understand the cost and benefits, especially with respect to fisheries and fishing communities, of the different decommissioning alternatives.	Near the time of decommissioning, EEPGL will develop an initial decommissioning plan, in consultation with the appropriate Guyanese regulators. EEPGL will perform comparative assessments of facilities components where there may be multiple decommissioning options. The comparative assessment is designed to evaluate five (5) criteria including safety, environmental, technical, impact to other users of the sea, and economics - and to select the best option for the final decommissioning plan. Consultation with stakeholders would also be conducted by EEPGL during decommissioning planning. A revised Plan will be submitted to the appropriate Guyanese regulators in advance of commencing field work.	---
Chapter 9: Unplanned Events; Chapter 10: Cumulative Impacts		
Impacts from unplanned events (i.e. oil spill): We consider that the rating of impacts on marine species, coastal habitats as well as communities and indigenous peoples from a potential oil spill or natural geological event should be conservative and follow a precautionary principle. We recommend evaluating these potential impacts from the perspective of the possible magnitude, alongside the likelihood of their occurrence. The likelihood of these event might be low but the magnitude and irreversibility of the impacts which would result should they occur could be very significant, as it could take decades or more for all these receptors/resources to fully recover.	Consistent with the typical approach taken for assessment of unplanned events, a risk assessment approach was taken in order to incorporate the aspect of likelihood (i.e., to distinguish from assessment of an event which is planned or practically certain to occur). The Consultants agree that there are a number of resources for which the consequence/severity of an oil spill would be high, and many of the resources have therefore been assigned the highest consequence/severity rating in the methodology. That said, the likelihood of an oil spill of sufficient magnitude to produce this type of consequence is very low and it is therefore appropriate to assign a likelihood rating of Unlikely. It is acknowledged that this produces a combined risk rating that is Moderate (rather than Major), and this is consistent with typical risk assessment methodology - which does not automatically assume a very rare event will happen. It is further noted that the measures proposed by EEPGL represent good international industry practice, and different/additional measures would not be proposed even if the risk rating were to be raised to Major.	---
An economic assessment and valuation of all resources which can potentially be impacted by an unplanned event should be conducted to ensure an accurate economic baseline exists should an unplanned event occur.	A baseline economic evaluation of resources that could be affected by a hypothetical spill scenario is neither practical (because the scope of such an event is impossible to predict and therefore the scope of an assessment cannot be defined) nor typical for an EIA.	---

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The Precautionary Principle should also be applied when assessing potential cumulative impacts, given the additional exploration projects projected by EEPGL and other companies. The project should actively manage, where feasible, the spatial and temporal overlap of their additional projects' activities.	The precautionary principle dictates a conservative approach to impact assessment where appropriate to ensure that impacts of novel activities are well understood and accurately predicted. The cumulative impact assessment in the EIA incorporates conservatism where particular aspects of EEPGL's future activities are not certain, including assuming that all future exploration drilling activities would take place in the Stabroek Block (thereby maximizing the potential for overlap of impacts from different exploration campaigns on water quality or the seabed), and assuming conservatively high numbers of vehicles in the level of service projections for the vehicular traffic assessment (thereby maximizing the projected demand on the existing road network). It is noted that the cumulative impact assessment (Chapter 10) makes specific recommendations relative to management of EEPGL's multiple development project and exploration operations - with the express purpose of reducing the additive potential for impacts associated with an increased activity level.	---
Ensuring costs of expected activities and social benefits, unplanned events and/or unanticipated post-decommissioning environmental and social risks are covered: Measures such as performance bonds, insurance agreements, escrow accounts, etc., should be considered to ensure costs of managing environmental and social risks from expected on-going events, unplanned events and/or unanticipated post-decommissioning risks will be adequately covered, as well as all promised social benefits are delivered.	This comment addresses policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana.	---
Stakeholder Engagement: Chapter 8: Socioeconomic Resources		
Adopt permanent, meaningful and inclusive stakeholder engagement. EEPGL has been engaging with different stakeholders in a variety of ways during the development of the various projects within the Stabroek Block. We recommend moving forward that for each of those engagements the Project demonstrates engagement through deliberative spaces and simple communication tools that are inclusive and tailored to the different audiences, as well as enable effective participation of vulnerable and underrepresented stakeholders.	EEPGL's and its consultants' engagement with communities, including Indigenous Communities, is described in the Stakeholder Engagement Plan (SEP). The SEP details the multiple years of engagement that have taken place by EEPGL and its consultants. In response to comments received in other EEPGL Project consultations about the complexity of the materials, the Consultants developed a highly-visual Non-Technical Summary as well as other materials to help in messaging the Project risks and benefits. This information will be appended to the SEP.	4.5.1 SEP
Adopt ongoing reporting to potentially affected communities. We also recommend that the project ensures ongoing reporting to potentially affected communities and transparency about consultation reports. These should capture stakeholder concerns and comments during all consultation activities and show how they were addressed or otherwise treated.	Continuous engagement with affected communities is described in the SEP, as well as a summary of concerns and comments received during engagements. Furthermore, all ongoing engagements and resulting actions are tracked by EEPGL through an automated, stakeholder engagement database.	---

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Chapter 9: Unplanned Events		
Ensure Informed Consultation and Participation (ICP) and Free, Prior and Informed Consent (FPIC). The Project should ensure the ICP of the indigenous peoples about the potential risks, impacts and proposed mitigation actions pertaining to the possibility of an oil spill. This can be effectively achieved through guidance and relationships with partners, such as indigenous NGOs, who have great experience and expertise in effective engagement with these communities. According to IFC PS1, an oil spill stemming from offshore drilling would constitute "(ii) impacts from unplanned but predictable developments caused by the project that may occur later or at a different location." While the offshore drilling is not being developed on indigenous peoples' lands per se, its adverse impacts (an accidental spill) could significantly impact the lands and resources traditionally owned or under the customary use of indigenous peoples. Therefore, ICP is required, and the case for FPIC as the preferred course of action is a strong one, because of the following: a) The potential unplanned event (oil spill) could impact the Indigenous Peoples' related natural resources (particularly the marine resource, given that they are fishing communities) b) FPIC would allow the project to develop more robust required emergency preparedness plans, mitigation plans, and compensation schemes. c) The indigenous communities in question may fall into the particularly vulnerable status, thereby requiring extra measures per IFC PS1 d) The benefit would outweigh the cost over the long-term.	Compliance with the IFC PS was not part of the Terms and Scope for the Payara Development Project EIA, so PS1 is technically not applicable to the Project or the EIA. Likewise, FPIC and ICP are not required by either the Environmental Protection Act or the Terms and Scope for this Project. The fact that neither the IFC PS, FPIC, nor ICP are applicable to the EIA notwithstanding, EEPGL recognizes the importance of effective communication and engagement with Guyanese society (and especially potentially vulnerable communities) to obtaining and maintaining a "social license" to construct and operate the Project. The Consultants likewise recognize the importance of communication and engagement to the execution of a robust and defensible EIA. With these needs in mind and as described in the SEP, EEPGL has engaged in a multi-year engagement process with communities across the coast (including indigenous communities) and these engagements informed both the scope and findings of the EIA.	---
Environmental and Socioeconomic Management Plan		
We echo the consultant's recommendation that EEPGL incorporate all imbedded controls and adopt the recommended mitigation measures in the EIA Chapter 13.	EEPGL has adopted and implemented the embedded controls and management and mitigation measures reflected in the final Liza Phase 1 EIA and Liza Phase 2 EIA, and would do the same with the final Payara EIA.	---
Lessons from the Environmental and Social Management Plan (ESMP) implementation should inform policies and decision-making. Considering the oil and gas sector within Guyana is in its infancy, we reiterate the recommendation that the ESMP and its implementation be used as an organizational learning process in which the lessons experienced are fed back into policy, institutions and subsequent project designs, thus building the country's capacity to better manage such large-scale projects in the future. We recommend having clarity on the institution and mechanisms responsible for implementing this.	This comment addresses recommended actions and policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana.	---
The socioeconomic management plan should include important emphasis on local capacity for delivering sector related services. The Project should ensure assistance to build capacity of local businesses (to an accredited level acceptable to EEGPL) to cater to the needs of the sector, e.g. Solid Waste Management (incineration services, solid waste disposal, treatment of hazardous chemicals, etc.), Oil Spill Wildlife Response (training at the University, schools of Veterinary Medicine and the Guyana Wildlife Conservation and Management Commission how to care for, clean and rehabilitate oiled wildlife).	Capacity building and local content is covered in EEPGL's Local Content Plan, which is provided under separate cover to the Government. The Centre for Local Business Development also builds capacity for local businesses including, but not limited to mentoring for ISO 9001 certification. The Consultants can provide additional information on both within Chapters 2 and 8. The ESMP includes related measures including employing Guyanese citizens having the appropriate qualifications and experience where reasonably practicable, partnering with select local institutions and agencies to support workforce development programs, proactively messaging Project-related employment opportunities, and procuring Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive.	---

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Decommissioning of equipment should ensure coral reef inoculation. It is expected that upon decommissioning the risers, flowlines, umbilicals, subsea equipment, FPSO mooring lines, and anchor piles will be disconnected and abandoned in place on the seafloor and we recommend that the strategy encourage coral reef inoculation on substrate metals or ensure that all EEPGL equipment will not pose danger to wildlife. While it is likely that natural ecosystem succession will occur, abandoning equipment on the seafloor would potentially reduce the aesthetic quality of the area and can create safety hazards, such as injuring wildlife (e.g. sharp metal edges. ingesting inedible materials, poisonous materials, and entanglement).	EEPGL has committed in Section 1.1 of the Preliminary Decommissioning Plan that "abandoned facilities will be left in a condition that avoids harm to the environment." The final Decommissioning Plan will elaborate on this commitment and provide more information on the specific methods to be used to prepare equipment to be abandoned on the seafloor. Given the length of time that the SURF will be in use, it is likely that encrusting benthic species will have colonized the equipment before decommissioning begins. This could make coral inoculation difficult to accomplish without disturbing the existing biological community; however, an assessment will be made at that time to identify the least disruptive/most beneficial method of abandoning the SURF in place.	---
Monitoring should be carried out on three levels and ensure adaptive management. In addition to the consultant's recommended adaptive management strategy in EIA Chapter 4 to retire existing mitigation measures that no longer demonstrate value, we would like to clarify a few best practice principles for biodiversity monitorization. These are: i. In field monitoring of relevant biodiversity values; ii. Monitoring of implementation and effectiveness of mitigation measures and management controls; and iii. Monitoring of status of non-project related ongoing threats to biodiversity values in the project's vicinity and the extent to which the project might exacerbate them.	As indicated in several responses above, the monitoring program described in Volume III of the regulatory submittal (the ESMP) is focused on the Direct AOI because the Direct AOI (specifically the immediate vicinity of the AOI and drill centers) is where the most significant Project-related environmental impacts are expected to occur. In the Consultants' view, when taken in aggregate, the monitoring measures proposed in the ESMP are adequate to validate the findings of the EIA and support effective oversight by the EPA for several reasons. These reasons include inclusion of direct sampling and testing of physical parameters that can be compared to quantitative performance criteria that are widely used in the oil and gas industry and relevant to Guyana's environmental treaty obligations (e.g., residual oil on cuttings, oily content and temperature of discharged water, etc.), as well as a long term focus on protected marine species (marine mammals and turtles) that can be considered indicators of general marine ecosystem health. The ESMP will be revised periodically to ensure that the various measures described in the plan remain aligned with Project needs and reflect current technologies, thereby integrating an adaptive element into the monitoring program	---
Finally, the Project should ensure adaptive management practices to adjust methodologies and practices to the ways ecosystems and biodiversity are being managed and monitored. Additionally, the following suggestions could ensure a robust and impactful monitoring programme: i. Increased training for ANY vessels (not just EEPGL associated vessels) moving to and from the FPSO and drilling ships to identify marine mammals and adjust course/speed accordingly to prevent collisions. ii. Better preventative protocols in place to avoid an influx of invasive alien species from untreated ballast water. iii. Continuous monitoring of water quality surrounding FPSO by independent labs to determine temperatures, pollutants levels, algal blooms etc. 1v. The inclusion of measures to enable community participation, especially Indigenous People and communities, in the project's research and monitoring would be of great value to effective monitoring, amongst other things.	As described in several locations in Volume III of the regulatory submittal, the ESMP will be revised periodically to ensure that the various measures described in the ESMP remain aligned with Project needs and reflect current technologies. The "evergreen" nature of the ESMP reflects an adaptive management approach to management of Project-related impacts.	---

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CIF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
a. Robust stakeholder engagement and training program		
i. Conduct regular oil spill response drills.It is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises involving appropriate Guyanese authorities and stakeholders in these activities in order to help delineate clear lines of action, roles, and responsibilities for the different stakeholders. EEPGL should also document the availability of appropriate response equipment on board the FSPO and demonstrate that offsite equipment could be mobilized for a timely response. Recognizing the important role potential affected communities, local government agencies, and other relevant parties could play in supporting implementation of the response plan during an emergency, it is fundamental that the project gives significant priority to the training and preparation of all entities to ensure coherent and effective emergency response when needed.	The description and details of EEPGL's oil spill response drills, exercises and training can be found in the Payara EIA, Vol. III Oil Spill Response Plan Sections 2, 8 and 9 including Tables 10, 11 and 12, which include the individual exercise type, description, purpose and frequency. The specific list of oil spill response equipment on the FPSO is found in Table 7 of the OSRP. This is further supported by the additional oil spill response materials and equipment found in Table 6 that are maintained on board the Project Support Vessels and Fast Supply Vessels (PSV and FSV). Deployment of mechanical recovery equipment from the FPSO poses a significant safety risk given the prevailing metocean conditions, particularly as this activity would not be routine. Consequently, EEPGL are using the FPSO as an infield storage location for dispersant, to enable rapid transfer to the many service vessels which are equipped with dispersant application devices to quickly treat any spill (rather than having them need to return to the shorebase to reload additional dispersant. Should mechanical recovery oil spill response equipment be considered appropriate, and the metocean conditions safe, then the mechanical recovery equipment could be loaded onto the next departing service vessel leaving the shorebase terminal for field deployment. The oil spill exercise program described in the OSRP and implemented by EEPGL leverages a number of other key activities conducted as part of the broader oil spill response capacity building initiatives EEPGL has been undertaking for more than three years and will continue to perform in the future. There is an annual oil spill response drill, which in 2019 was the focus of our major triannual exercise of the ExxonMobil Americas Regional Response Team.	---
	This exercise had multiple participants from Guyanese authorities and stakeholders, including: • Civil Defence Commission (CDC), • Environmental Protection Agency, • Department of Energy, • Coast Guard, • Guyana Defense Force, • Maritime Administration Department, • Guyana Energy Agency, • Ministry of the President, • Centre for Local Business Development, • CDC Volunteer Emergency Response Team (VERT), • Guyana Geology & Mines Commission. Where practical, relevant Guyanese authorities and stakeholders have been and will continue to be actively involved in these annual oil spill response exercises. It is not practical to deploy the response equipment during every drill given the resources required. However, as part of the ongoing drill and exercise program, as well as with regular maintenance, tests are done on an on-going basis. This training and, most recently, regional deployment of oil spill response equipment has progressively developed the response capability of government authorities, agencies and volunteer responders. As part of the continued commitment to capacity building, EEPGL will be working with the relevant agencies to transition from demonstration of the equipment to staging open-ended exercises where local responders will be expected to identify response strategies and equipment required, and to deploy the equipment consistent with their strategy under the guidance of experienced responders. The long-term objective is to enable every regional response team to be able to respond confidently, independently of experienced coaches. While it is not practical, safe or cost effective to physically deploy oil spill response equipment during every drill, as part of the ongoing oil spill response drill and exercise program, as well as during regular maintenance and testing of such equipment to verify its functionality, EEPGL will trigger the deployment of some equipment to be able to show, educate and demonstrate to the Guyanese authorities and stakeholders on the effectiveness of EEPGL's processes in place to respond and mobilize all such equipment in the unlikely event of a spill or release.	---

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CIF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
ii. Partner with local academic institutions and/or non-governmental organizations (NGOs) to build capacity on oil spill response. We suggest that the Project partners with academic and training institutions, such as the University of Guyana, and/or NGOs to sustain training for implementation of response plans in case of an oil spill.	EEPGL acknowledges that there is potential for partnering with the academic and training institutions within Guyana; the maximum benefit in any partnership with these institutions would be in a broader understanding of the oil and gas industry, and development of the technical skills necessary to support sustainable development within Guyana. For oil spill response support, there are several Guyana-based commercial entities already developing the skills and building the network of trained personnel to support a significant oil spill response effort. By working with these entities, the industry will foster job development locally, which in turn will draw on the academic and training institutes to build a competent workforce. By working with established businesses, this will also ensure there are ongoing response resources that will directly be able to support the National Oil Spill Contingency Plan response capability. Additional, EEPGL as part of ExxonMobil globally, will continue to maintain strong relationships and agreements with recognized international oil spill response service providers (e.g. Oil Spill Response Limited, Boots and Coots, and others) to ensure immediate access to these resources, in the very unlikely event of a significant spill. Consequently, at this stage, EEPGL does not anticipate that it will be pursuing a formal partnership with the University of Guyana or other training institutions specifically focused on such training for implementation of response plans in case of an oil spill, as UG and other NGOs can engage directly with these existing commercial entities. These local suppliers can provide regional training, education, exercises, and demonstrations as well as provide logistical support and oil spill response equipment maintenance and inspections.	---
iii. Comply with best practice for the use of dispersants. In the event of an oil spill, it is critical that the use of dispersants comply with best practices and standards, given that they might create cumulative effects. Dispersants do not reduce the amount of oil entering the environment but push the effects of the spill underwater. While dispersants make the oil spill less visible, dispersants and dispersed oil under the ocean surface are hazardous for marine life. EEGPL should strive to employ the most biodiversity friendly dispersants should the need arise	The National Academy of Science published The Use of Dispersants in Marine Oil Spill Response in 2019. This document is available for download at https://www.nap.edu/download/25161. The report represents the best currently available scientific understanding of oil dispersant use and benefits from the learnings gained during the 2010 Gulf of Mexico deepwater blowout, where significant quantities of oil dispersants were utilized. It is understood and utilized as a guide for the use of oil dispersants by EEPGL. The report is highly recommended for utilization by government regulatory agencies, oil spill responders, and NGOs. The reviewer noted that oil dispersants move oil from the surface and make it less visible. This is not an accurate assessment of oil dispersant's function. Spilled oil at the surface of the water will cause harm to birds, marine mammals, planktonic organisms at the water/atmosphere interface, and fish eggs and larvae near the water surface. Surface oil treated with dispersants will break the slick into small droplets (<100 um) where waves, winds, and currents will mix those droplets into the upper 10m of the water column. The concentration of the dispersed oil quickly dilutes to low ppm's in hours and low ppb's in <24 hours. Once the surface oil has been treated, the small droplets in the water column are subjected to degradation processes including biodegradation and photo-degradation. Biodegradation occurs when the small droplets are utilized as a food source by oil degrading bacteria that are ubiquitous in the marine environment. This biodegradation produces CO2 and H2O. Lab-based studies indicate that oil-dispersant mixtures, when released into the environment, are generally biodegraded and /or photodegraded on the order hours to days. The use of oil dispersants on surface slicks therefore removes oil that would be persistent for days to weeks to the water column, where the low concentrations produce less physical and toxic effects and the oil and dispersant is degraded in hours to days. All modern oil dispersants are designed for low toxicity and higher efficacy to increase the window of opportunity for their utilization. The oil and dispersant mixture is no more toxic than the oil alone.	---

Payara EIA Comments Received January 2, 2020; Responses to Comments Submitted January 27, 2020		
CIF and GMCS Comments	**Response to Comment**	**Section in Which Addressed**
b. Transboundary considerations and ability to respond		
i. Support development of frameworks that clearly organize roles, priorities and devote resources for responding to an unplanned event. There needs to be a clear plan with respect to who is responsible for cleanup activities, who funds initial response, who funds recovery from culminative effects, who is responsible for loss of country revenue (sea/sand/sun product).	EEPGL recognizes the overall initiative the Government of Guyana has taken with the development of the draft National Oil Spill Contingency Plan (1 November 2019), which has been developed under the direction of the Minister of State (with Responsibility for Disaster Risk Management) by the CDC. Within the National Oil Spill Contingency Plan (NOSCP), EEPGL would be considered the Responsible Party in the unlikely event of a spill from one of its offshore facilities, with obligations to provide notification to MARAD (as the National Focal Point – Marine) upon identification of an oil spill event. The EEPGL OSRP works in conjunction with the NOSCP, addressing how, as the Responsible Party, EEPGL would respond. Initially, EEPGL would appoint an Incident Commander to lead the Incident Management Team (IMT), utilizing the internationally recognized Incident Command Systems processes. An appropriately resourced IMT would be established in Georgetown, including relevant agencies. EEPGL would remain as the Incident Commander (either as overall, or as part of Unified Command with the Competent National Authority) unless the Competent National Authority considered it necessary to assume the Incident Commander role. Per the Payara EIA Vol. 1, Section 9.1.9, in the unlikely event of an oil spill, EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. In addition, EEPGL and its co-venture partners have entered into agreements with insurance companies which require verification that adequate financial resources are in place to satisfy environmental obligations, including those in the unlikely event of a spill.	---
ii. Establish an environmental bond for unplanned events. The very limited mechanisms in place for the regulatory agencies to deal with an oil spill, along with weak legal frameworks that exist within the region, suggest that impacted countries would be in a highly disadvantageous position, and highly dependent on the developer, to respond to a transboundary oil spill event. We reiterate the recommendation for the establishment of an environmental bond or the triggering of an immediate imposition of an early payment (within the fee structure of the environmental permit) that can be immediately used by the Government of Guyana to work with its neighboring countries and other affected parties in the event of an oil spill. We note that this matter becomes increasingly important as the number of wells increases.	The Payara EIA Vol. 1, Section 9.1.9 outlines the Claims and Livelihood Remediation Processes, which includes in the unlikely event of an oil spill causing losses to stakeholders that EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. Further, EEPGL and its Co-V's carry insurance coverage that meet or exceed global industry practice to enhance their financial resources to respond in the event of a spill, and will comply with Guyana's regulatory requirements related to demonstration of financial responsibility.	---
iii. We recommend the inclusion of a terrorist response scenario or plan for both offshore and shore-based sites. There are references to several emergency response plans triggered by events such as bomb threats or civil disturbances, however given Guyana's limited capacity to respond to a mass casualty event (medical, terrestrial security forces, mortuary services, emergency Coast Guard deployment, etc.), there needs to be a clear emergency plan, which can be efficiently implemented.	ExxonMobil Global Security has conducted formal risk assessments on all operations in Guyana, which included the threat from terrorism. Emergency response plans for security incidents have been implemented. Additionally, shorebase and offshore assets fully comply with the International Ship and Port Facility Security (ISPS) Code.	---

Payara EIA Comments Received February 14, 2020; Responses to Comments Submitted February 21, 2020			
Topic	**EPA Comments**	**Response to Comment**	**Section in Which Addressed**
Flare Profile and Flare Minimization Plan	Via Preliminary Comments on the EIA, the EPA had requested the following information which was not provided and thus must be included in the Amended EIA: • Flare Profile for Payara Operations, including start-up and non-routine flaring. • Optimizations for early flare out and a gas flaring minimisation plan. • Well Ramp Up and FPSO commissioning activities schedule to achieve flare out.	Startup flaring for the Project includes temporary flaring for a period of approximately 90 days. During commissioning and start-up planning, EEPGL will work to minimize the duration of startup flaring. EEPGL will incorporate lessons learned from Liza Phase 1 and Liza Phase 2 startups in the Payara commissioning and start-up planning. Approximately 12 months prior to startup, EEPGL will conduct a workshop with EPA and other appropriate regulators, and seek to align on the flare out timeline with the EPA. Based on this workshop, EEPGL will provide an additional submittal that documents the agreed flare out targets that were reached through a collaborative partnership.	**6.1.3.2**
Produced Gas Profile	Additionally, the following information must be included in the Payara EIA: 1. Produced gas profile for each well. This should include the amount of gas produced in each Well over the lifetime of the projects, as well as the amount of gas reinjected based on the gas production rate of each well.	Data on the produced gas profile for each well can be discussed in a separate workshop with EPA.	---
	2. The Gas-Oil Ratio (GoR).	The Gas-Oil Ratio (GoR) can be discussed in a separate workshop with EPA.	---
	3. When gas breakthrough is expected, what are the impacts/consequences of the gas breakthrough, and what mitigation measures will be implemented to deal with gas breakthrough	The following information on gas breakthrough has been added to the EIA in Section 2.7.3.2: Gas breakthrough is predicted to begin in 2026 (approximately 2 years after field start-up). If unmanaged, gas breakthrough can impact effective reservoir sweep. Moreover, excessive gas production beyond facility handling limit results in deferred oil production. The water-alternating-gas (WAG) injection scheme employed for the Payara development allows for managing gas breakthrough and drives optimal utilization of injected gas. WAG offers flexibility to redistribute available gas to reservoirs that will benefit the most from gas injection, with the spreading of gas providing mitigation against gas cycling through a reservoir. Further mitigation of gas breakthrough is enabled by implementation of multi-zone completions that offer selective choking of segments of completions where gas is continuously produced. Overall, the reservoir management strategy assumes no gas flaring during steady-state production operations, and gas is primarily utilized for improving recovery.	**2.7.3.2**
Injection of Sea Water vs. Injection of Produced Water	Comparative assessment on the use of sea water versus produced water during re-injection must be provided. This assessment must include the following details: technological, environmental and safety considerations justifying selection.	Injection of produced water was evaluated, and the full details of that evaluation can be now be found in Chapter 2 of the EIA (Section 2.17.3.5). After several years, once produced water is generated, there are two primary options for its disposition. It can either be treated and discharged overboard, or it can be combined with sea water and injected. Overboard discharge of treated produced water was selected for the Payara Project, based on the Best Available Technology analysis, which is described in Section 2.17.3.5. Note that the environmental impact for overboard discharge of treated produced water was assessed as negligible (see Table 6.4-10). Modeling conducted for the EIA indicated a 98.6% reduction in oil and grease and other residual production chemicals.	**2.17.3.5**
		A new section on the water systems has been added to the EIA (Section 2.7.3.3) as follows: In order to increase oil recovery, water is injected into oil reservoirs to refill the voidage created by the removal of oil and natural gas, and to help direct oil to the producing wells. The water to be injected to assist with oil recovery can consist of produced water recovered from producing wells, and/or sea water. Produced water is water that is produced as a byproduct during the extraction of oil and natural gas. Oil and gas reservoirs nearly always have water as well as hydrocarbons, sometimes in a zone that lies under the hydrocarbons, and sometimes in the same zone with the oil and gas. Produced water is not forecast to be produced until the wells have been producing for several years. Therefore, the FPSO must be designed for injection of sea water to assist with oil recovery so that voidage can be managed starting closely after commencement of production from the reservoir(s).	**2.7.3.3**
	The use of sea water for re-injection present several challenges, such as scaling, corrosion of tubular and formation damage. In this regard, details must be provided on proposed treatment methods prior to use.	Section 2.7.3.5 contains further details on the sea water treatment and water injection system. The produced water treatment system is discussed further in section 2.7.3.4.	**2.7.3.4** and **2.7.3.5**

Topic	EPA Comments	Response to Comment	Section in Which Addressed
Capping Stack Deployment	A justification must be provided for the 9-day deployment period of the capping stack outlined in the EIA. Justifications must include all technical and logistical considerations.	At the time the EIA was submitted, the response time associated with the Boots & Coots GRIP capping stack deployment was based off preliminary and conservative logistics assumptions. After establishing the subscription to the Boots & Coots GRIP system, and in conjunction with the ongoing capping stack study, the response time model has been refined to reflect current logistics strategies and it is now estimated that the capping stack deployment is possible within 5 days.	**OSRP**
	Further, during discussions on the Oil Spill Response Component during environmental session at the Field Development Plan meeting in Houston, Texas, it was mentioned that another model which speaks to 6-day deployment period for the capping stack was mentioned. In this regard the Company is required to provide reasons for not including this model in the EIA.	The EIA and OSRP text will be modified to reflect this timeline. The oil spill response modeling will not be amended, since the intent of the modeling is to ensure robust oil spill response planning. EEPGL will complete revised oil spill modeling representative of the Stabroek block, and will revise the OSRP again by August 31, 2020. The revised OSRP and oil spill modeling will align with the future agreed (with Government) outcome of the capping stack study as per the Liza Phase 2 License condition.	**EIS (Exec Summary)** **EIS (3.3.5)** **9.24.4** **OSRP**
Decommissioning	The conceptual decommissioning plan provide in the EIA study must be amended to include the following details: 1. Regulatory framework guiding the decommissioning programme. 2. Overview of installations that will be decommissioned. 3. Proposing decommissioning options/methods and environmental considerations. 4. Proposed methods for disposal and removal of waste. 5. Proposed monitoring programmes post decommissioning. 6. Projected schedule.	A revised Preliminary End of Operations Decommissioning Plan has been included in the EIA (Volume III)	**Volume III - Preliminary End of Operations Decommissioning Plan**
Seismology Study and Hydraulic Fracturing	The EIA must include a seismology study which discusses the potential for earthquakes and tremors due to hydraulic fracturing from drilling operations.	There will not be any hydraulic fracturing activities. The Payara development isn't relying or planning on fracking for enhanced well productivity and there is no plan to inject above fracture pressures. The reservoir management strategy focuses on pressure maintenance and avoids depletion extremes. Section 5.2.1 of the EIA includes an assessment of the potential for geological/seismic impacts. The EIA concluded that the Project is considered to have a negligible potential to result in seismic risk, including risk of tsunamis reaching Guyana.	**5.2.1**
De-Sanding Facilities	The EIA to include the following details on de-sanding facilities: process overview, impacts and mitigation measures.	The EIA (Section 2.7.3.1) has been modified to include details on de-sanding facilities, including a process overview, impacts, and mitigation measures.	**2.7.3.1**

Payara EIA Comments Received February 28, 2020; Responses to Comments Submitted March 5, 2020			
Topic	**EPA Comments**	**Response to Comment**	**Section in Which Addressed**
Availability of site-specific and deep water baseline information, and use of such information in the EIA	The project will be located in a deepwater area, but much of the information presented focuses more on nearshore and coastal areas. It is recognized that this could be because data and information in those areas are more readily available compared to the deeper waters of the project area. To this end, it is recommended that more site-specific detail is included or being clear about when data are not available and making appropriate extrapolations or providing information from analogous areas that have been better studied. It may also be appropriate to identify important data gaps if no relevant information is available (e.g., consistently disclose where there is relatively little information for a given resource or category of resources).	The statement that "much of the information presented focuses more on nearshore and coastal areas" under-represents the large amount of data that have been collected offshore Guyana and included in the Payara EIA. Although the EIA contains a large amount of nearshore- and coastal-oriented information, the information on existing conditions in the deepwater marine environment presented in the EIA reflects an extensive program of site-specific studies over several years, including: four separate offshore air quality surveys, four environmental baseline surveys (which included water quality, sediment quality, and benthic biological sampling), nine separate marine bird surveys, over 30 marine mammal surveys (using both visual and acoustic survey methods), and two deepwater marine fish surveys. All of these surveys were conducted in deepwater environments within the Stabroek Block or adjoining deepwater environs. The results of these studies are presented in detail in the EIA and in Volume II of the regulatory submittal.	**No Edits**
Sources of Information	In general, there seemed to be an inconsistent use of references to primary literature to support conclusions or assertions. If this is related to a paucity of information, it is recommended that this made clear. A lot of information was presented in this document, yet it was not always clear where that information was coming from. It is felt that the proponent could better support findings using relevant research and referencing within the document.	The sources of the information presented in Chapters 6, 7, and 8 of the EIA are fully cited in Chapter 15. These chapters account for well over 300 individually referenced sources, and the detail with which the sources in Chapters 6, 7, and 8 have been documented provides a complete record of the information that has been included for each receptor in the EIA. It is acknowledged that the amount and sources of the baseline information included in the EIA varies across the different receptors, and that the data from the site-specific studies are combined with information from the scientific literature, government reports, and other available data sources in different ways and to varying degrees across different receptor discussions in the EIA; however, these differences are driven less by the availability of data and more by a deliberate effort to achieve a balance between inclusiveness and overwhelming the public with extraneous baseline data. It is emphasized that the EIA is not intended to provided an academic treatise on each receptor. Rather, the EIA is intended to succinctly provide the necessary information for the public to understand the Project's impacts without being overly voluminous or too technically challenging. While the EIA was designed to strike this balance appropriately, in recognition of the volume and variety of information included in these chapters, brief summaries of the types of baseline information that appears in each chapter have been added to the beginnings of Chapters 6, 7, and 8. In addition, in recognition of the desire for additional literature references, a number of selected references have been added where appropriate to further support the conclusions of the EIA.	**Chapters 6, 7, and 8**
Rating Methodology	The last two sentences in section 7.5.3.4 seem inconsistent without a "because" statement. The sentences read "Impacts would occur within the Direct AOI (PDA) and would be Continuous and Long-term. Accordingly, the magnitude of impact is Negligible (Table 7.5-15)." However, it is not obvious how something "continuous" and "long-term" could be considered negligible. The content preceding these sentences does not provide clarity.	The rating methodology used in the EIA involves a number of variables, and the multi-variable nature of the rating system is a direct result of the EPA's prior request (during review of the Liza Phase 2 EIA) to enhance the level of detail leading up to the EIA ratings. The key to understanding how something that is continuous and long-term could be considered negligible is to refer to the magnitude rating matrix depicted in Figure 4.6-2 in Section 4.6.2 of the EIA. As illustrated in this matrix, any impact that is assigned a Negligible intensity rating receives an overall magnitude rating of Negligible, regardless of how the duration or frequency factors are rated for that impact. As clearly indicated in the section referenced by the comment, the intensity of potential impacts on marine mammals from exposure to permitted discharges is considered Negligible (for the reasons described in the text); therefore, the overall magnitude of the impact is also rated as Negligible.	**No Edits**
Rating Methodology	The last paragraph in section 7.9.3.4 makes statements that seem inconsistent with the final conclusions in the paragraph without more explicit explanations. For example, mortality is "anticipated to be high," organisms "may be left with injuries" and population structure "may temporarily change." Despite these comments, the intensity of impact is labeled as "low," which seems to be a disconnect. Further, it is stated that "this impact will only occur within a small percentage of the Subsea PDA", yet there is no "because" statement to go with this assertion. It could be interpreted by the reader that this is the reason the impacts are considered to be "low", yet this is unclear.	The intensity rating for impacts related to injury or disturbance of marine benthos due to FPSO and SURF installation is driven primarily by the extremely small percentage of seabed habitat that would be directly affected within the PDA and Stabroek Block (approximately 1% and 0.003%, respectively). Although there will very likely be some level of benthos injury and mortality in the installation footprint, the proportion of the larger benthic ecosystem that would be affected would be sufficiently small to render the impact insignificant at an ecosystem scale. The specific passage of Section 7.9.3.4 identified in the comment has been edited to explain this rationale more clearly.	**7.9.3.4**
Ecosystem Services	The discussion on ecosystem services focuses on coastal and nearshore with nothing from deep sea, as even the "fishing" category appears to focus more on areas around the coast. What about deep sea ecosystem services?	Additional language and references have been added in Sections 7.10.2 and 7.10.3 on deep marine ecosystem services and the Project's potential impacts on them.	**7.10.2, 7.10.3, 8.9**
Noise and Light Impacts	Further discussions on the potential impact of noise and light on marine benthos can be provided.	It is noted that many of the marine benthic organisms known to occur in the PDA through the EBS surveys do not have complex eyes and ears, and are therefore physiologically limited in their ability to detect (and therefore be impacted by) acoustic or light impacts. Although it is believed that the existing assessment in the EIA is adequate to address the potential impacts on marine benthos, additional detail has been added to Section 7.9.3 to support the conclusions of the EIA.	**7.9.3.4**

Topic	EPA Comments	Response to Comment	Section in Which Addressed
Impacts on Fish	Improve discussions on the potential impacts to fish due to seafloor disturbance.	Although it is believed that the existing assessment in the EIA is adequate to address the potential impacts on marine fish from seafloor disturbance, additional detail has been added to Section 7.8.3 to support the conclusions of the EIA.	**7.8.3.5**
Impacts on Hard Seafloor Features	Provide analysis of hard seafloor features since the geological discussions are more focused on soft sediments. If this information is not documented for the project area, we suggest considering seafloor surveys and avoidance protocols for live bottom, archaeological resources, or other sensitive sea floor areas.	Section 7.8.2 describes the types of organisms that occur on the HSFs identified in the PDA, and Section 7.8.3 describes the types of impacts that these organisms would likely experience as result of installation of the wells and SURF components. Section 6.3.3.2 provides an estimate of the number of HSFs that could be impacted by sediment deposition outside the SURF footprint as a result of installing the wells. In light of the relatively small number of HSFs that are expected to be impacted within the sediment deposition zone (approximately 53 HSFs, or 0.005 percent of the more than 1.1 million HSFs that are estimated to exist within the study area), the EIA has concluded that avoidance protocols to protect HSFs are not necessary. With respect to archaeological resources, Volume III of the regulatory submittal contains the chance find procedure that would be implemented in the event that archaeological resources are found during the course of constructing or operating the Project.	**No Edits**

APPENDIX X

Payara EIA Comments and Responses—Updated June 2020

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Stakeholder Comments on the Environmental Impact Assessment for the Payara Development Project

Stakeholder	Comment
WWF Guianas and the Guyana Marine Conservation Society	**1. Planning and effective management of the resources and use of marine area.** Guyana's marine environment has been described as an Ecologically and Biologically Significant Area – the Amazonian-Orinoco Influence Zone1. At the same time, the reliance on its resources are growing, not only from traditional sectors such as fishing, but from rapidly growing new extractive sectors such as oil and gas. **Response:** The Consultants acknowledge the comment. Maintaining healthy and productive oceans is a priority for Guyana2, and given the current lack of data and knowledge, there is a strong need for better understanding the marine environment in order to effectively manage and preserve it. As done in previous submissions to the EPA relating to the oil and gas sector, we would like to advocate for better understanding of resources (particularly biological resources), how the space is used from a biological standpoint (for instance, identification of feeding, breeding, migratory grounds); and strategic/integrated planning for the use and conservation of marine resources. **Response:** The EIA includes, either directly or by reference, several baseline biological studies covering numerous biological resources. In most cases, the impact assessments for specific biological resources were supported by data from multiple years of study. The Consultants reviewed this information and determined that when considered in aggregate, the current body of biological knowledge as reflected in the EIA is sufficient to support an assessment of the Project's potential impacts on biological resources, development of appropriate embedded controls and mitigation measures, and a responsible and defensible decision on whether and under what conditions to permit the Project. The area still remains highly understudied and poorly understood, even as a larger third phase of EEPGL activities, which will bring the total number of development wells to 95, are set to be implemented. First oil from the Liza 1 project will also be extracted in December 2019 and will move full pace ahead, all in the absence of any real baseline data. Lack of such data on species and populations affects the accurate determination of impacts in the marine and coastal areas. For example, should baseline data determine that critical habitats exist in the area (this is likely given that the areas offshore Guyana have been described as ecologically and biologically significant), then international best practices would necessitate that the developer implements additional safeguards – such as biodiversity offsets and appropriately designed, long-term biodiversity monitoring and evaluation programmes3. **Response:** The Consultants take issue with the statement that the Payara Development Project EIA was carried out "in the absence of any real baseline data." Eight of the ten biological resource-specific impact assessments included in the EIA reference recent field studies conducted in the Direct and/or Indirect AOI. The impact assessments for the two other biological resources for which field studies were not carried out (Protected Areas and Special Status Species, and Ecological Balance and Ecosystems) are heavily supported by information from online sources that are widely accepted in the conservation community (e.g., the IUCN) and/or the scientific literature. With respect to critical habitat, Critical Habitat Assessment (CHA) is a unique element of EIAs conducted under the IFC Performance Standards, and is not generally included in EIAs that are not subject to the IFC Performance Standards (such as the Payara Project). Compliance with the IFC Performance Standards was not part of the Terms and Scope issued by the EPA for the Payara EIA, so it would be inappropriate to require a CHA for the Project. The inappropriateness of a CHA in the context of the Payara Development Project notwithstanding, the impact assessments for several biological resources (including marine birds, marine mammals, and marine fish) include several attributes that would typically be considered in a CHA (such as listing status, congregatory behavior, and migratory life histories) as factors when determining sensitivity to potential Project impacts. The sector is expanding greatly at a fast rate, as other developers are actively pursuing exploration and are discovering more hydrocarbon resources - evidenced by the two recent finds made only 6 weeks apart, by Tullow in the Orinduik Block. However national processes, capacities and knowledge of the ocean is less developed. This increases the urgency of better knowing, planning for and managing the EEZ. We would like to recommend that the developer (also in partnership with other operators in the sector) conduct detailed assessments in order to gather new data and make more informed decisions about impacts of its development and facilitates/funds ongoing research in the marine/coastal ecosystems by universities and independent stakeholders. Data generated from assessments and studies should be freely available to the public, unlike what prevails at this point in time. **Response:** As described in the response to the comment above, the impact assessments for most biological receptors in the Payara Development Project EIA are well supported by a combination of extensive field study and desktop-based research from reliable sources. In the Consultants' view, the current body of biological

Stakeholder	Comment
	knowledge as reflected in the EIA is sufficient to support a robust assessment of the Project's potential impacts on biological resources, development of appropriate embedded controls and mitigation measures, and a responsible and defensible decision on whether and under what conditions to permit the Project. All of the reports detailing the findings of these studies (including the appendices with data tables) have been made available to the EPA, and are available to the public in pdf form on the EPA's website. Neither the EIA nor the ESMP for the Project envision stand-alone, open-ended research programs because such programs are not required to assess the accuracy and effectiveness of the EIA or ESMP, respectively. Nevertheless, EEPGL regards environmental monitoring as a critical component of their performance assurance program and as indicated in Section 3.7 of the Environmental and Social Management Plan for the Project, the results of the proposed monitoring program will be externally reported. Volume III of the regulatory submittal contains the ESMP, and Section 3 of the ESMP describes the proposed monitoring program for the Project. At the same time the ability of regulators to verify the accuracy of information presented by the developer from its monitoring of environmental impacts and the implementation of safeguards remains constrained by a lack of technical (and other) capacity. Programmes should be established to continually train and build capacity of EPA staff and staff of other agencies that are involved in the regulation of the sector. Investments should also be made to retain human/technical resources. Part 4 below includes additional recommendations. **Response:** The Consultant team that prepared the Payara EIA recognizes the institutional challenges in Guyana. Although these challenges do not directly affect the content of the EIA document, the Consultant team has met directly with the EPA to deliver a series of technical workshops with EPA staff focused on elaborating the technical approaches and findings of the EIA. Further, the Consultant team has also sought to build local capacity by inviting government agency (e.g., Fisheries Department, Protected Areas Commission) personnel to take part in fieldwork that was used to support the Payara EIA. Coastal sensitivity maps have been produced under this project – have they been ground truthed and verified as accurate? **Response:** The coastal sensitivity mapping completed to date has consisted of initial desktop-based research, followed by field verification in specific areas (Regions 1–6 in Guyana, and Trinidad and Tobago). In the case of coastal sensitivity maps prepared for Guyana, the information provided on the maps derives from field verification for ecosystem services, shoreline classification/sensitivity, mangrove sensitivity, important coastal bird habitats, and important fish habitats. Additionally, ecosystem services were subjected to an additional verification exercise in 2019. 1 https://www.cbd.int/marine/ebsa/booklet-02-wcar-en.pdf 2 As expressed in the Green State Development Strategy – Vision 2040 3 IFC Performance Standards on Environmental and Social Sustainability, 2012 **2. Onshore land-use planning** As discovered quantities of offshore hydrocarbon resources continue to grow, there will be a corresponding increase in the demand for land and other onshore resources in the city and surrounding areas that directly or indirectly result from the project. Land/urban planning; and, implementing and enforcing high standards of practice will need to be strengthened - including addressing challenges experienced over the years relating to financing, equipment and human resources short falls, lack of cooperation among and decision-making by responsible agencies; and low levels of transparency and accountability. EPA, Georgetown Mayor and City Council, Local Government bodies, GLSC, Central Housing and Planning Authority, Civil Defence Commission, Ministry of Public Infrastructure, Department of Energy Civil Society and other relevant stakeholders should come together and plan for the effective use of onshore spaces and resources. This planning must take into account zoning for commercial activities; nature (such as the storage and transport of hazardous materials) and size/scope of activities, proximity to and potential to degrade/contaminate and persist water, soil and other resources; and health and well-being of residents and the environment in the long and short term. Oil companies are expected to be active in Guyana for at least 20 years and thus the plan must take this time frame and even beyond into account. Evidence for the urgency of this type of activity was highlighted when residents advocated against the construction of a chemical storage facility, which would have been within the vicinity of residential communities on the East Bank Demerara, by Nalco Champion Guyana. Hundreds of thousands of kilograms of toxic oil-field chemicals would have otherwise been stored/mixed at the site.

Stakeholder	Comment
	Response: EEPGL remains committed to engaging government agencies and key stakeholders to provide information on project activities, to increase understanding of the permitting process and so that decisions are based on relevant facts; this facilitates project activities, including supplier development and workforce capacity, being developed in Guyana in an environmentally and socially acceptable manner. EEPGL has a three-pronged approach to local content development. This includes workforce development, supplier development, and strategic investments. Through the Centre for Local Business Development, EEPGL is working with local businesses to strengthen local competitiveness, including meeting Guyanese and international standards. Other programs being developed with banking institutions include banking packages to reduce the financial burden on local businesses. EEPGL, in collaboration with the Council for Technical and Vocational Education and Training, is supporting training in safety so students enter the workforce with greater hazard awareness and tools to identify and minimize risks. In addition, this collaboration includes supporting upskilling of the workforce through curriculum development, instructor training and provision of relevant equipment for identified programs that will support growth in the broader economy – including the construction sector. The expansion of port facilities in estuarine and coastal environments in and around the Berbice and Demerara rivers to service the offshore oil production will result from this and other oil and gas projects. Such expansion can increase the vulnerability of the city and communities to effects of flooding, storm surges and erosion as loss of critical coastal defence species such as mangrove forests will result. Much of Guyana's shore line is already highly vulnerable due to depleted mangrove forests and weakened man-made coastal defences, and as such planning for onshore development must happen quickly, be effective, benefit from robust stakeholder consultations. Onshore development will also result in increased traffic and congestion from the transport of equipment, chemicals and other industrial supplies to serve drill ships offshore and the industry in general. Such considerations must also be integrated into urban development and management plans. **Response:** With respect to the potential for coastal impacts (e.g., mangroves, sea defense) from industrial development, EEPGL is not proposing any onshore/coastal development as part of the Project. Any such developments would be conducted by third parties, and mitigation of any such potential impacts would therefore be addressed through the regulatory permitting process undertaken by such parties. With respect to potential traffic congestion to which EEPGL could contribute, in recognition of the potential for multiple oil & gas developments to result in a combined impact to onshore traffic congestion, the Consultants included as part of the cumulative impact assessment a "cumulative" traffic impact assessment. This assessment measured traffic congestion levels at 50 intersections around Georgetown and modeled the changes in congestion levels that would be expected to result from the combined activities of the Project, the two prior development projects (Liza Phase 1 and Liza Phase 2), two future development projects, and continued exploration drilling through 2021. The modeling demonstrated that anticipated EEPGL-related vehicle trip-counts through 2025 are not expected to meaningfully change congestion ratings at any of the 50 intersections studied. In any case, with respect to ongoing management of potential traffic concerns, EEPGL has already adopted a Road Safety Management Procedure for its vehicle operations in Guyana; among other aspects, this procedure includes provisions for logistics/journey management planning to reduce potential conflicts with local road traffic. To this end, EEPGL will continue to monitor traffic conditions into the future, and will adjust its vehicle movements as needed in keeping with this procedure. A strategic environmental assessment which links both onshore and offshore considerations would also likely greatly benefit the process of managing the sector and the impacts it generates. In addition, all developmental projects onshore directly or indirectly linked to the industry must be strongly regulated in keeping with best practices to address secondary impacts. **Response:** The Consultants acknowledge the comment, noting that such a Strategic Environmental Assessment falls outside of the scope of the Payara EIA. That said, as discussed in responses to other comments, the cumulative impact assessment for the Project considered other projects that were reasonably foreseeable by the Consultants. This suite of other projects included other activities by other oil & gas operators (noting that at the time the EIA was written, no exploration activities from other oil & gas operators beyond 4Q2019 - a year earlier than the first proposed Payara drilling - had been publicly announced, and none of the operators had announced definitive plans for development projects). **3. Renewable energy transition and climate change commitments** Guyana has committed to transitioning to renewable energy in order to meet the demands of its households and the private sector; and established several targets in its Nationally determined Contributions to the UNFCCC in order to limit carbon emissions. This goal is timely and relevant particularly in the context of the recent IPCC report in which leading climate scientists have warned that there is only 12 years remaining for global warming to be kept to a maximum of 1.5 degrees Celsius. Beyond this, the risk will be worsened for severe droughts, floods, extreme heat and poverty.

Stakeholder	Comment
	Response: EEPGL acknowledges the comment regarding Guyana's published goals for carbon reduction. With respect to GHG mitigation for the Project, Section 6.1.3.2 of the EIA contains tables listing the embedded controls and mitigation measures that will be incorporated to reduce emissions of GHGs and other atmospheric emissions. The EIA has again focused narrowly CO2 /GHGs generated from the company's operation and has determined that there will be little or no impact to climate and air quality. A closer look shows that EEPGLs project alone will almost double Guyana's current annual total GHG emissions, and apart from reporting on emissions annually not much else is planned. Exxon Mobil, the primary partner in EEPGL, has publicly declared its commitment to fighting climate change and making meaningful progress on climate actions. Given the current climate crisis, it is relevant that a plan be developed as part of this EIA to show how they will make meaningful contributions in Guyana. Some options include: adopting use of renewable energy and supporting Guyana's transition to renewable energy, sustainable forest and land management, mangrove rehabilitation and restoration, etc. **Response:** Since 2015, EEPGL has committed more than $12.5 million (US) in community investments in Guyana. Focus areas include STEM education, youth, women, community empowerment, and environmental sustainability. EEPGL's contributions to the Iwokrama science program, for example, fund research into resilient forests. In addition, government revenues generated by EEPGL offshore operations will positively impact the strategies developed by the government of Guyana to encourage sustainable economic development (e.g., the Green State Development Strategy and Low-Carbon Development Strategy). Finally, EEPGL is working with the government to evaluate building a pipeline to shore to provide clean burning natural gas to support power generation in the country. Currently, Guyana generates most of its power using heavy fuel oil. The Payara EIA submission provides context regarding Guyana's net emissions and shows that Guyana will remain a net carbon sink even if multiple FPSOs are active offshore Guyana. To minimize carbon emissions, ExxonMobil evaluates energy efficiency design options and GHG reduction opportunities. EEPGL's FPSO projects have been designed to incorporate a number of controls and mitigation measures that will reduce GHG emissions, including avoidance of routine flaring, minimization of non-routine flaring, use of more energy efficient turbines to power the FPSOs, and the use of waste heat recovery units on the FPSO turbines. These measures, among others, reduce greenhouse gas emissions on our FPSOs by approximately 80 percent compared to a baseline design that does not include these measures. In the big picture view: what are the impacts of the eventual burning of 6 billion plus barrels of oil? Many more billions of barrels are likely to be discovered by EEPGL and other companies. In this regard, how does Guyana reconcile its vision of being the greenest country on earth with its status of being a big oil producer and contributor to the ongoing global change? **Response:** With respect to GHG mitigations for the Project, Section 6.1.3.2 of the EIA contains tables listing the embedded controls and mitigation measures that will be incorporated to reduce emissions of GHGs and other atmospheric emissions. These measures represent good international industry practice to reduce emissions from a Project of this nature. Beyond the Project incorporating these practices, decisions regarding the balance between the social/economic benefits of a fossil-fuel project in Guyana and the incremental emissions resulting from such a project are appropriately addressed by the Government of Guyana at a policy level and are therefore not within the scope of the EIA. We believe that offsetting some of this impact is critical as Guyana is at the forefront of green development. At a national level some key actions driven by government should include: renewable energy transition well before 2040; maintenance of intact landscapes, establishment of additional protected areas, and integrated land-use planning to maintain biodiversity ecological integrity and function; protection of freshwater; robust forest management, stronger regulation of the mining sector and better land-use planning should move quickly ahead. The establishment of marine protected areas and sustainable fishing zones to ensure maintenance of fish stocks and marine biodiversity and general ocean health; and ensuring wider ocean governance is strong, must also be considered as part of the suite of actions. It is the also the role of private sector actors and developers in the oil and gas sector to support green development. **Response:** The Consultants acknowledge the comment, noting that the suggestions relate to national policy issues that are beyond the scope of the Payara EIA. The Consultants also note that offsets are typically applied as a last resort to address residual negative impacts that cannot be managed to acceptable levels in any other way. The EIA has demonstrated that the project design and application of management controls (primarily embedded controls) would ensure that residual impacts on climate from normal operations would be no higher than Moderate. With respect to the role of developers such as EEPGL in these areas, Section 6.1 of the EIA addresses potential Project impacts on climate and describes the embedded controls and mitigation measures put in place by EEPGL to ensure that the carbon intensity of the Project is limited in accordance with good international industry practice.

Stakeholder	Comment
	4. Capacity building for monitoring and regulating the sector EEPGL suggests a vast number of best practices and standards for reducing impacts to the environment and people. The EPA, DoEnergy, GGMC, MNR etc. does not have the required capacity, either singly or collectively, to manage this new sector. Capacity development in some areas is ongoing and this is a positive indication, but much more investment in this is needed. The pace at which the oil and gas industry is expanding in Guyana has outmatched the pace at which regulatory institutions are benefiting from strengthening of their capacities - in terms of personnel, having specialist staff in all relevant levels of expertise, technical knowledge and financial resources. It is critical for agencies to be able to access and secure necessary resources to help them exercise their authority and enable them to respond to the demands of industry expansion. Sufficient budget and technical expertise must be a priority if effective national oversight is to be achieved for the sector. Further, political leaders must ensure that the regulatory agencies are empowered, including maintaining autonomy, to be able to ensure stringent safety regulations are maintained. **Response:** The Consultants acknowledge the comment and note that this is a recommendation to the Government as to what political leaders must ensure. EEPGL's strategic community investments complement our business and are aligned with Guyana's economic and social goals. Initiatives are focused on assisting the development of local capabilities and improving the broader socioeconomic environment. As an example, EEPGL has been engaged with the Guyana Environmental Protection Agency on development of a program to support environmental monitoring. The scope of the capacity building program is being finalized, but could potentially address training opportunities for EPA staff, the provision of systems/tools to support administration of environmental monitoring, and the provision of a third party consultant for technical support. At the same time, we recommend that regulatory agencies be supported with independent technical monitoring (as their capacity is being built) to ensure adherence to mitigation actions and embedded controls proposed in the EIA. We strongly recommend that an international, independent, competent firm be hired to conduct annual monitoring, during the project and more-so during the production phase onward, to ensure that activities are being implemented in the best possible ways, utilizing most updated technologies and the best available standards and practices. The goal of independent monitoring would be to drive continuous improvement in policies and practices since the reliance on a prescriptive regulation with inspection model would not be effective. EEPGL should then be required to adapt based on monitoring recommendations and accommodate upgraded technology and practices during the lifetime of the project. In this process of regulating the sector, a coordinated approach among agencies would be necessary for proper management. Experiences from trying to build such an approach for other sectors indicate that communication, leadership, resource sharing and strong political commitment and the platforms necessary to support this, are needed. These agencies would likely include: EPA, Department of Energy, Department of Environment and GRA. **Response:** The Consultants acknowledge the comment and note that these are recommendations to the Government and regulatory authorities. **5. Management of Wastes** The EIA has noted the lack of long-term capacity of waste disposal facilities to deal with non-hazardous wastes; and that the existing capacity will be exhausted by 2019-2020. Given that this project will be operating in Guyana for more than 20 years, this situation must be improved quickly. It is likely that new sites or expansion of current sites will be undertaken. In this process we recommend practicing planning in line with point 3 above – where human health and the environment are given first priority. The current challenges experienced by residents of communities located within the zone of impact of the Haggs Bosch Landfill site, for example, should not be allowed to recur. **Response:** Since the completion of the draft Payara EIA, the construction of a second cell at the Haags Bosch Landfill (HBL) has been proceeding. Continued upgrades and improvements at the HBL are ongoing. The EPA continues to monitor and manage the oversight of the HBL. The EPA is working to ensure the design of the second cell includes the installation of a synthetic liner in addition to the clay liner layer and leachate collection system already installed. The current and near-term local non-hazardous solid waste management needs for the Payara Development Project can be met by the completion of the HBL second cell, currently expected in 2021. Subsequent decisions as to further expansion of existing or new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the Ministry of Communities and the Environmental Protection Agency and participation of the public and other stakeholders.

Stakeholder	Comment
	In 2018 and 2019, EEPGL's contribution of non-hazardous solid waste volumes sent to HBL was approximately 6 percent of the total annual volume received by HBL. EEPGL expects that a similar volume of non-hazardous solid waste will continue to be sent to the HBL in 2020. Currently the HBL receives approximately 500 tonnes daily, of which approximately 30 tonnes is attributed to EEPGL / EEPGL Contractor drilling and production operations. Further, in the summer of 2019, EEPGL released a Request for Information (RFI) to the Guyana market to find qualified suppliers to perform waste management and recycling services. After evaluation of the responses, EEPGL invited qualified suppliers to a bid process, the results of which were reviewed and finalized. This will build additional capacity for EEPGL's hazardous, non-hazardous, and exempt hazardous waste to be stored, processed, treated, or recycled. EEPGL has completed the evaluation and plans to award the contract for additional waste management capacity in 3Q2020. The added waste management capacity derived from these efforts will protect human health and the environment as well as meet the needs of EEPGL, the Payara Development Project, and beyond. The management of hazardous wastes requires immediate attention as there are no facilities to treat and dispose of such wastes. EEPGL projects that thousands of tonnes will be generated during the lifetime of this project. Any treatment of hazardous wastes should be done in keeping with best available standards and technology. In the EIA, it is simply not sufficient to not have a concrete, environmentally sound plan of disposing of hazardous waste – only storage and disposal at sites not identified – at this stage of the developer's operation. Thus, the EPA must ensure that the developer has a well-documented plan. The management of some types of wastes generated will lie with sub-contractors. In the absence of adequate national standards to guide their operations, sub-contractors should operate in accordance with generally established standards for the industry or standards of EEPGL. We also recommend that EEPGL hold responsibility for negative impacts resulting from sub-contractors and regularly monitor sub-contractors' operations as it relates to the handling, disposal, transport etc. of wastes generated from EEPGL activities. **Response:** One waste management facility in Georgetown, Guyana, Tiger Rentals Guyana (TRG), is currently permitted to store, process, and treat hazardous waste. TRG's processes for treatment are in keeping with best available standards and technology. As mentioned above, EEPGL is working to award a contract that will enable qualified third-party waste service providers to be able to add additional waste management facility capacity to Guyana. The Payara EIA Vol. III Appendix 1 contains EEPGL's Integrated Waste Management Plan (WMP). Further, each contracted vessel is required under the International Convention for the Prevention of Pollution by Ships, 1973, as modified by the Protocol of 1978 (MARPOL) to comply with international standards and practices as reflected in their development and implementation of a Garbage Management Plan, Garbage Record Book, and Oil Record Book. Environmental training of crews is performed to ensure they are familiar with such plans as well as the permit conditions and obligations applicable to each marine survey, exploration well drilled, or development project undertaken by EEPGL. This training includes waste management, waste recordkeeping, and reporting. EEPGL provides the EPA with monthly drilling waste reports, end of well waste summary reports, as well as an annual waste inventory report that documents wastes generated, stored, treated, and disposed during that calendar year by development projects and Liza Destiny's production operations. The WMP lists EEPGL responsibilities and includes review of contractor and subcontractor developed WMP procedures. EEPGL ensures drill ships, FPSO vessels, installation, supply, and support vessels are overseeing their WMP-specific duties. The WMP calls for EEPGL to conduct audits of its contractors. Additionally, the WMP requires marine vessels and waste service providers to execute numerous specific responsibilities ranging from periodic self-assessments to maintenance and review of waste records, recordkeeping and supporting paperwork. Incineration on-shore is also mentioned as a waste disposal method in the EIA, but there is no information on number of functioning incinerators, capacity of incinerators to deal with waste volumes, location of incinerators (are they within the vicinity of residential areas or will their operation affect residents). This needs further clarity in the EIA. **Response:** The shorebase facilities where contracted onshore support activities (not limited to but including waste incineration) would occur are neither owned nor operated by EEPGL, but are operated under their own environmental authorizations. The EIA considers impacts associated with EEPGL's use of these facilities (vehicular traffic to and from the shorebases, for example), but the EIA's scope does not include assessments of impacts associated with the shorebases' presence or activities that are carried out by shorebase or tenant staff at the shorebases under separate environmental permits. With respect to capacity of incineration infrastructure to accommodate the Project's needs, this is addressed in detail in Chapter 8 of the EIA - as it relates to the Project's potential to result in limitations on such infrastructure capacity.

Stakeholder	Comment
	6. Oil/hydrocarbon spill and managing the impacts Safeguarding the environment, not only Guyana's but of all territories within the project's area of influence including those of South America and the wider Caribbean, is of greatest importance given the sensitivity/vulnerability of marine, estuarine and coastal areas, and the severe long-term impacts that will result should there be a major oil spill. The oil spill modelling results presented in the EIA indicates that there is a very high risk of oil swiftly reaching Guyana's coastal regions should a large spill occur – a 20% chance of oil reaching Guyana's coastline in as little as 5 days. The impacts would be far reaching: protected areas, mangroves, marshes, coastal wildlife including special status species, indigenous and other communities, and families depending on the ocean's resources for their livelihoods, marine/cargo transportation and commercial fishery sector. If feeding, nesting, breeding, spawning or calving areas are affected the severity and long-term effects of a spill even more catastrophic. It is important to note that in the EIA impacts to the marine ecosystem are underestimated since they were made in the absence of spatial and temporal data on biodiversity, critical habitats etc. of the marine area (see point 1 above). **Response:** The Consultant team agrees that in the event of oil from a Tier III spill event reaching the Guyana coast, the consequences for biodiversity could be severe. The sensitivity of the ecosystem to such an event is the primary reason that several of the environmental resources received a Moderate risk rating for unplanned events, even though the likelihood of such an event is exceedingly low. However, the Consultants wish to clarify that even if a Tier II spill event - which is itself a very remote possibility - were to occur, the chances of oil reaching most of the Guyana coast are very small (the 5 to 20 percent likelihood of oil reaching the Guyana coast reflects an unmitigated scenario, and mitigated spill modeling predicts no shoreline impacts in Guyana). The Consultants would also reiterate that the assessments of impacts (including potential impacts from unplanned events such as oil spills) on biological receptors in the Payara Development Project EIA are well supported by a combination of extensive field study and desktop-based research from reliable sources. In the Consultants' view, the current body of biological knowledge as reflected in the EIA is sufficient to support a robust assessment of the project's likely impacts, including potential impacts from oil spills. These modelling results referred to above also determined that an unmitigated oil spill will reach Venezuela, Aruba, Bonaire, Curaçao, Trinidad and Tobago, Grenada, St. Vincent and the Grenadines, St. Lucia etc. Such an event would have an extreme impact on the community's livelihoods, national economies and biodiversity of these regions and exacerbate economic, climate and social vulnerabilities. We suggest that on-going monitoring (linked to point 4 above) for adherence to environmental safeguards be conducted as it is a critical element for ensuring that activities occur with the least impact to the environment. **Response:** As described in the Oil Spill Response Plan submitted with the EIA, a Net Environmental Benefit Analysis (NEBA) would be conducted in the event of a large oil spill. The purpose of NEBA is to identify the combination of key response strategies that would be appropriate, given the specific situation, fate, and trajectory of the oil spill and weather conditions, and to identify and select the option or combination of options that minimizes overall harm to environmental and socioeconomic resources. Stand-alone, open-ended research programs are not required to support the NEBA process, but as indicated in Section 6.1 of the Oil Spill Response Plan, a wildlife monitoring program would be initiated in the event of a large spill to assess the effects of the spill on wildlife. We would also like to recommend the establishment of a special fund dedicated to increasing preparedness (including education, research), cleaning-up, rehabilitating, restoring, compensating, etc. those affected by a spill, should it occur. To support this, a robust framework for compensation should be developed separately with wide stakeholder involvement. We recommend that, in keeping with the 'polluter pays' principle, oil and gas developers should finance the fund – the people of Guyana should not pay for damage resulting from developer's negligence. Based on the current agreements in place regarding developer's operation in Guyana, a clear position should be communicated to the public on who currently bears the legal and financial implications should an oil spill occur. This is important as it has implications for the social and economic well-being of Guyanese well into the future. **Response:** The EIA states that EEPGL will determine financial liability in the event of a spill. As noted in Section 9.1.9, in the unlikely event of an oil spill, EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. In addition, EEPGL and its co-venture partners have entered into agreements with insurance companies which require verification that adequate financial resources are in place to satisfy environmental obligations, including those in the unlikely event of a spill. The models in the EIA for the worst-case scenario is a 30-day loss of well control event. What if the loss of well-control event lasts beyond the 30 days?

Stakeholder	Comment
	In the Oil Spill Response Plan, several local organisations were identified including the Guyana Marine Conservation Society, Conservation International and Karanambu Trust. However, upon inquiry organisations were not able to identify what role they would play in the event of an oil spill. How did the developer involve these stakeholders? What are their roles? These should be clear stated for the public. **Response:** As described in Section 2.4.2 of the Oil Spill Response Plan (OSRP), the responsibilities of the Government's maritime sector in an oil spill response scenario would be consistent with the roles established in the country's draft Guyana National Oil Spill Contingency Plan. The Civil Defence Commission would assume overall responsibility on behalf of the government as the lead agency for oil spill response operations. The Lands and Surveys Department of the Ministry of Agriculture would have jurisdiction over response activities in river waters. The Transport and Harbors Department of the Ministry of Public Works, Communications, and Regional Development would be responsible for port areas and territorial waters. However, the Guyana Coast Guard enforces all maritime regulations and is a key operational organization in any marine incident, investigating reports of pollution in navigable waters on behalf of the relevant ministry and department. In addition, the Guyana Defense Force and the Fire Service would also assume some operational responsibility for pollution response. Although NGOs' roles in a spill scenario would depend somewhat on the location, size, and severity of a spill, the OSRP envisions the Karanambu Trust as assisting with rehabilitation of otters should otters be affected by a spill, and the Guyana Marine Conservation Society as assisting with marine turtle-oriented response activities. Further, the Civil Defence Commission is an important partner for EEPGL in oil spill response. What is the state of readiness of the CDC? This should be rated clearly in the EIA with measures clearly elaborated to improve the CDC's state of readiness. Decentralisation of capacity to respond to oil spill is critical given the geography of Guyana's coastline. To what extent is capacity being built, refreshed and retained in order to respond to emergencies? What are the measures to be implemented? Feedback indicates that spill response training so far has not meaningfully prepared local stakeholders to respond. The EIA should also describe what measures the developer is taking to have an early warning system. **Response:** While EEPGL certainly recognizes that the Civil Defence Commission is a key partner for oil spill response, it is not EEPGL's position to comment on their overall state of readiness. The CDC's participation in training, demonstrations, and exercises is building skills and experience in key areas of emergency incident management. CDC Volunteer Emergency Response Team (VERT) members have also been involved in similar activities. Where practical, relevant Guyanese authorities and stakeholders have been and will continue to be actively involved in these annual oil spill response exercises. In addition, regional oil spill capacity building has been on-going. This training and, most recently, regional deployment of oil spill response equipment has progressively developed the response capability of government authorities, agencies, and volunteer responders. As part of the continued commitment to capacity building, EEPGL will be working with the relevant agencies to transition from demonstration of the equipment to staging open ended exercises where local responders will be expected to identify response strategies and equipment required, and to deploy the equipment consistent with their strategy under the guidance of experienced responders. The long-term objective is to enable every regional response team to be able to respond confidently, independently of experienced coaches. The National Oil Spill Contingency Plan and the resourcing of decentralized oil spill response capability (equipment and personnel) is a matter for the National Oil Spill Committee in conjunction with the agencies identified in the plan with assigned responsibilities to determine. As a competent operator, EEPGL is providing resources to respond to any Tier 1 events, and with appropriate local and international support (as detailed in the EEPGL Oil Spill Response Plan) to be able to respond to all events, including the Tier 3 worst case scenario of loss-of-well-control event). In respect of any unlikely oil spill event from EEPGL facilities, EEPGL have an established notification matrix (detailed in the OSRP) that provides immediate notification of key agencies, and in particular is aligned with the notification directly to the MARAD Georgetown Lighthouse as required in the National Oil Spill Contingency Plan. Once this notification is made, all other relevant agencies and response organizations can me mobilized, which is effectively the Early Warning System. This represents approximately 9 days advance notice to prepare for any possible response activities required along the Guyana coastline (for any spill from an EEPGL facility). These early notification obligations exist for any person who releases oil to water – including a ship or oil and gas facility operator. **7. Socio Economic Impacts.** Economic impacts have been rated as POSITIVE within the EIA, but this seems to be narrowly based on the fact that Guyana will get some quantity of revenue. The EIA further mentions that it is the Government's responsibility to responsibly use and invest its share of money. There are several negative impacts which can directly or indirectly result from EEPGL projects and the sector, more broadly: inflation - increases in the cost of housing, food and services, for instance; and widening of the gap between rich and poor, which undermines poverty reduction goals. Loss of livelihood and access to natural resources to support livelihoods are acknowledged as risks of the project, but it is not clear how these will be meaningfully addressed.

Stakeholder	Comment
	Response: A quantitative assessment of economic impacts is not included within the scope of the Terms of Reference issued for the Payara EIA. A qualitative evaluation of potential impacts on social infrastructure, including those related to increases in cost of living, is included in Chapter 8. An analysis of the Project's contribution to poverty reduction goals is outside the scope of an EIA. With the exception of the loss of access by a small tuna fishing fleet to a limited area over 200 km offshore, loss of livelihood and access to natural resources would only occur as a result of unplanned events and would therefore be covered under the Claims and Livelihood Remediation Process discussed in Section 9.1.9 - something that cannot feasibly be developed in advance of an unknown, unplanned event. How are such considerations being meaningfully addressed through the project's social safeguards? Are there hard measures in place given that first oil is to be produced from December 2019? Who are the other parties with responsibility and what actions are being taken? In addition, strong measures should be put in place to ensure that maximum benefits go to the people of Guyana including: local content plan that is not dictated by the developer; mechanisms to address the loss and disruption of livelihoods (which are noted in the EIA); and ensuring that the people of Guyana do not bear the legal and financial burdens associated with an oil spill. Also, there is need to ensure that measures are in place to have positive influence and ensure sustainability of other important sectors such as fisheries, agriculture, tourism and other land-based sectors. These measures should include budgeting of revenues to support to sustainable growth of the sectors and creating policies to more deliberately ensure the oil and gas sector does not have negative effects on other sectors and their ability to function effectively. **Response:** The Consultants acknowledge the comments, noting that they are directed at policy-makers and are not within the scope of the EIA. **8. Cumulative impacts** Cumulative impacts, not only from EEPGL project activities, but form other oil and gas projects both on and offshore should be evaluated bearing in mind earlier comments on impact ratings, lack of data, socio-economic impacts etc. The assessment should be done at the seascape-coastal level rather than being site specific. **Response:** The cumulative impact assessment for the Project considered other projects that were reasonably foreseeable by the Consultants. This suite of other projects included other activities by other oil & gas operators; however, the other oil & gas operators in Guyana are still at a relatively early stage of their exploration efforts. At the time the EIA was written, no exploration activities from other oil & gas operators beyond 4Q2019 (a year earlier than the first proposed Payara drilling) had been publicly announced, and none of the operators had announced definitive plans for development projects. The Consultants therefore did not make assumptions about the potential success of these operators' exploration activities, and did not reflect in the EIA a prolonged exploration program or any associated development projects that could be contemplated if discoveries are made. **9. Depletion Policy** We would like to recommend the development of a depletion policy as it could impact national investments, planning for the management of the industry, energy policies and transition to renewable energy, development of other economic sectors and economic diversification etc. **Response:** This comment addresses policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana.
Conservation International Foundation (Guyana) and Guyana Marine Conservation Society)	General Remarks a) Abide by high standards. Given EEPGL developments are the first of their kind in Guyana, they will set the benchmark for future oil and gas exploration and development projects in the country. It is therefore paramount that the project abides by high industry standards of accountability and good governance. **Response:** ExxonMobil (EEPGL's parent organization) and its affiliates (including EEPGL) are committed to conducting business in a manner that is compatible with the environmental and socioeconomic needs of the communities in which they operate, and that protects the safety, security, and health of their employees, those involved with their operations, their customers, and the public. These commitments are documented in their Safety, Security, Health, Environmental (SSHE), and Product Safety policies. These policies are of the highest industry standards that are put into practice globally by ExxonMobil through a disciplined management framework called the Operations Integrity Management System (OIMS). Effective and consistent application of these policies will constitute the primary safeguards against occupational hazards for Project workers, and all Project workers and contractors will receive training on implementation of these principles and will be required to adhere to them in the daily execution of their duties.

Stakeholder	Comment
	b) Adopt the precautionary principle. The high level of complexity in the technical aspects of this kind of project's operations, inherent high variability and complexity of oceanic systems (and more broadly, water as a medium) and the relative paucity of knowledge of Guyana's marine ecosystems, create conditions in which there could be far-reaching unknown impacts. This warrants application of the Precautionary Principle encompassed in Section 4(a) of the Environmental Protection Act, (2006). Considering this principle, we recommend the use of independent, third-party monitoring on a periodic basis to verify management plans and data, as well as structuring independent research programs to enhance the information available for improved decision-making. **Response:** EEPGL agrees that monitoring is vital to performance assurance. The ESMP does not envision stand-alone, open-ended research programs because such programs are not required to assess the accuracy and effectiveness of the EIA or ESMP, respectively; however, as indicated in Section 3.7 of the Environmental and Social Management Plan for the Project, the results of the proposed monitoring program will be externally reported. Volume III of the regulatory submittal contains the ESMP, and Section 3 of this plan describes the proposed monitoring program for the Project. Tables 3-1 through 3-9 contain over 25 resource-specific monitoring measures, and additional monitoring measures are included in the Waste Management Plan, Stakeholder Engagement Plan, Preliminary Decommissioning Plan, and Oil Spill Response Plan, which are included in Volume III of the regulatory submittal. These measures are intended to monitor the effectiveness of the proposed management measures and inform the EPA and EEPGL of any potential impacts not identified in the EIA, should they arise. c) Undertake a cumulative EIA encompassing all three current development projects. We echo recommendations that EEPGL produce a cumulative EIA covering all three currently proposed or permitted projects, in addition to the stand-alone EIAs for each project. This should also be done for the at least two additional planned development projects in the Stabroek Block. This is essential since the cumulative effects of the EEPGL and non-EEPGL projects (for example, three other oil and gas operators are planning or executing exploration programs in blocks adjacent to the Stabroek Block) could exacerbate potential negative impacts to the environmental and social conditions of Guyana. Similarly, increased development along the banks of the Demerara River for increased shore-based activities will result in significant impacts to mangrove and mud flat ecosystems. **Response:** The cumulative impact analysis conducted as part of the Payara EIA meets the requirements for cumulative impact analysis established in Part IV Section 17 of the Environmental Protection Act. It considers future offshore oil and gas development projects in the Stabroek Block (including the three development projects approved or proposed to date as well as two future developments referred to as FPSO #'s 4 and 5), future exploration projects in the Stabroek and adjacent blocks, and landside development activities including development of a fiber optic network, and a natural gas processing plant and gas fired power plant (referred to as the FOC Project and the Gas to Shore Project, respectively). Other oil and gas operators' activities were also considered, although these operators do not have any publicly announced activities that overlap temporally with those of the Project. d) Aim at achieving net gain for biodiversity and communities. Given the important precedent this project will set, we recommend that it adopts a net gain goal for biodiversity and communities. This is especially given the current uncertainties around Guyana's marine biodiversity and ecosystems, and the potential future additional oil and gas development which might increase the effects of indirect and cumulative impacts. We believe that this should be done regardless of whether the project would cause significant residual impacts from any planned activities. The project could achieve net gains by identifying additional opportunities to enhance habitat, conserve biodiversity, support communities' livelihoods and well-being, and contribute to research and knowledge about the country's marine and coastal resources. **Response:** The Consultants acknowledge the comment, noting that net gain for biodiversity receptors is neither a requirement of the Environmental Protection Act nor a condition of the Terms of Reference for the Payara Development Project EIA; accordingly, it is not an appropriate standard to apply to the EIA. That said, the Consultants note that EEPGL has conducted extensive research regarding Guyana's biological resources, in programs that have spanned multiple years and contributed significantly to scientific knowledge for the country. e) Adopt continuous and meaningful engagement with communities and Indigenous Peoples. As per IFC Performance Standards, there should be robust stakeholder engagement during the life of the project. For each of those engagements the Project should ensure deliberative spaces and appropriate communication tools that are inclusive and tailored to the different audiences and enable effective participation of vulnerable and underrepresented stakeholders. We note the expressions of interest to present the findings of the ESIA in a user-friendly format during the 2017/2018 stakeholder meetings hosted by the EPA at the time of preparation of the Environmental Impact Assessment Guidelines for Offshore Hydrocarbon Exploration and Production. We are however of the view that this was not adequately carried out and may result in many stakeholders being unable to sufficiently comprehend the information contained in the EIA documents to constructively comment on it. This lack of follow through can no doubt negatively affected the credibility of the management processes undertaken by the company and impressions of the proposed development. **Response:** Engagement of the Consultant team and EEPGL with communities, including Indigenous Communities, is described in the Stakeholder Engagement Plan. However, the Consultants have included in Chapter 4 of the EIA additional reference to the fact that engagement of Indigenous Communities has always included an

Stakeholder	Comment
	Indigenous leader representative from the National Toshaos Council (NTC) to ensure all the engagements are fair and impartial and the concerns of the Indigenous Communities are raised and addressed. The participation of the NTC is beneficial since communities are generally more comfortable during the engagements as a result of the presence of the representative of the NTC and, as such, have more confidence in the process and participate freely in the discussions. The SEP documents the multiple years of engagement that have taken place by EEPGL and its consultants. In reference to the comment regarding user-friendly material, in response to comments received in other EEPGL Project consultations about the complexity of the materials, the Consultants developed for the Payara EIA a highly visual Non-Technical Summary as well as other materials to help in messaging the Project risks and benefits. This NTS has been appended to the SEP as Attachment D. f) Execute on-going monitoring programs for vulnerable species to inform a Critical Habitat Assessment (CHA). We recommend the project, following a Precautionary Principle (referenced in point 3b above), execute an on-going monitoring program for vulnerable species identified through the field studies, even if residual impacts affecting them are considered negligible. Special emphasis should also be placed on a comprehensive baseline assessment of herpetofauna along the coast, as these are usually the first indicators of ecosystem health. The results of all these additional studies should help eventually inform a Critical Habitat Assessment (CHA) to determine if critical habitats are likely be impacted and to what degree. **Response:** With respect to critical habitat, Critical Habitat Assessment (CHA) is a unique element of EIAs conducted under the IFC Performance Standards, and is not generally included in EIAs that are not subject to the IFC Performance Standards (such as the Payara Project). Compliance with the IFC Performance Standards was not part of the Terms and Scope issued by the EPA for the Payara EIA, so it would be inappropriate to require a CHA for the Project. The inappropriateness of a CHA in the context of the Payara Development Project notwithstanding, the impact assessments for several biological resources (including marine birds, marine mammals, and marine fish) include several attributes that would typically be considered in a CHA (such as listing status, congregatory behavior, and migratory life histories) as factors when determining sensitivity to potential Project impacts. g) Support mechanisms for strengthening data collection to improve knowledge and management of Guyana's marine natural resources and ecosystems. The development of the sector offshore in ecosystems that are poorly understood also present unique challenges especially when combined with the pace of this development. The environmental data collection that is being undertaken in the marine environment by EIA consultants for the various oil and gas developments is exceedingly valuable because of the paucity of research in Guyana's Exclusive Economic Zone (EEZ). It is therefore of great importance that measures be put in place to manage this data and result in progressively improved knowledge of the space within which these projects are being developed, especially given that the research is almost entirely new. One possible means of doing this is the establishment of a data management system to which the EIA consultants conform and use to collate and submit their data. This would allow for future research to build on prior set of work and support further research activities and identification of gaps. The Project should consider sharing the information collected from baseline and monitoring assessments more broadly in ways and formats that are useful for wider use by the EPA, the conservation community, academia and the general public. Additionally, EEPGL has a great opportunity to support research efforts and initiatives that can contribute to increasing knowledge and understanding of the marine ecosystems and natural resources of Guyana. **Response:** The Consultants agree that much of the information that has been generated through ongoing studies, including those that informed the Payara EIA, is new and of significant value to the Government of Guyana, academic institutions, NGOs, and other stakeholders with an interest in conserving Guyana's natural heritage. All of the reports detailing the findings of the studies that informed the Payara EIA (including the appendices with data tables) have been made available to the EPA, and are available to the public in pdf form on the EPA's website. **Methodology for the Environmental Impact Assessment, Chapter 4** a. Criteria for rating impacts should consider stakeholder's impact acceptability. Best practice recognizes that the process for determining impact significance and acceptability should effectively integrate value judgments and preferences of affected stakeholders and the general public. **Response:** As described in Section 4.5 of the EIA, a robust stakeholder engagement process was undertaken to inform the EIA and stakeholder concerns were documented in the EIA. Public perceptions and tolerance for anticipated Project-related impacts were incorporated into the significance ratings for selected receptors where appropriate, and factored most strongly in the intensity component of the magnitude ratings for socioeconomic receptors such as Community Health and Wellbeing (for which public anxiety was itself a potential impact considered), Marine Use and Transportation, and Social Infrastructure and Services.

Stakeholder	Comment
	b. Impacts determined as having negligible significance should include a robust justification. For impacts determined to have negligible significance, the EIA should explicitly state the reasons behind this classification. For instance, it would be essential to also assess the level of uncertainty associated with the predictions. We also recommend that the significance of the projected impacts be assessed based on a matrix intersecting the likelihood of each impact occurring and the magnitude of the impact likely should it occur. **Response:** The impact assessment methodology assesses impact significance for planned activities based on magnitude and sensitivity rather than magnitude and likelihood. Likelihood is incorporated only for unplanned event risk ratings (and refers to likelihood of the event occurring, as opposed to likelihood of impact). The Consultants note that the methodology used is more conservative than the methodology suggested in the comment because the methodology is based on a worst-case assumption that all impacts associated with planned activities are certain to occur. The justification for ratings of negligible significance can be found in Section 4 of the EIA—which describes in detail how magnitude and sensitivity are assessed and how they are combined to arrive at a final significance rating in the EIA, and in the resource-specific impact discussions in Sections 6, 7, and 8 - which provide further explanation of the how the rating system was applied to each receptor and impact. c. Impact reversibility should be addressed within the Impact Significance Rating Matrix. Interpretations of Sections 4(a) and 11(5) of the Environmental Protection Act (2006) and the EPA's Environmental Impact Assessment Guidelines for Mining (2000), suggest that evaluation of reversibility of impacts is a non-negotiable component of an EIA. Therefore, it should be consistently addressed in the EIA within the Impact Significance Rating Matrix and integrated within the evaluation of the magnitude of the impact. **Response:** The Consultants acknowledge that reversibility is explicitly included in the EPA's guidelines (and that the concept of irreversible damage is addressed in the EP Act). Rather than adding reversibility as a distinct characteristic in the magnitude determination matrix (Figure 4.6-2 in Chapter 4 of the EIA), the concept of reversibility was integrated into the "duration" characteristic. In other words, the rating chosen for "duration" reflects the combination of the length of time the impact-causing activity would occur and the length of time the impact would be expected to sustain after the impact-causing activity ceased. The EIA also summarizes the degree of irreversibility inherent in the individual ratings in Sections 3.5 and 12.4. d. Most valuable environmental and social resources/receptors for relevant stakeholders (even if impacts are determined as negligible in this project) should be considered for the cumulative impact assessment. Although negligible impacts from this project might not significantly affect a resource/receptor, when considered in combination with impacts from other ongoing and planned projects and sources of external pressure, it might become significant. We understand that the cumulative impact assessment was conducted in accordance with the IFC best practice standards, however, we recommend that the cumulative impact assessment consider the most valuable environmental and social resources/receptors determined by relevant stakeholders, independent of the significance determined by each individual EIA. **Response:** As noted in the comment, an international best practice approach was utilized for the cumulative impact assessment. Consistent with this approach, those resources that were determined to have a negligible impact from the Project were excluded from further consideration. It is noted, however, that the resources excluded from the cumulative impact assessment would only be measurably impacted by the Project in the event of an oil spill. **Description of Existing Conditions, Appendices K – T** **a. Baseline assessment** i. Regularly conduct species surveys throughout the term of the Project. The purpose of the biological species surveys (a 2-year long process) was to assess species abundance and status against the International Union for the Conservation of Nature (IUCN) Red list of Threatened Species. Overall, the methodology is robust, and we commend the approach of increasing survey coverage in under-surveyed portions and the survey team for their robust assessment. Further, we are pleased to see that the team plans to continuously survey for the remainder of year 2, however, we recommend monitoring throughout the entire lifetime of the Project. **Response:** The ESMP (Volume III of the regulatory submittal) contains numerous monitoring measures focused on physical environmental indicators. Assuming the Project is permitted, the Consultants have concluded that implementation of these measures should provide the EPA with sufficient data to determine if the Project is performing acceptably with respect to managing impacts on habitat for IUCN-listed species. In addition to the habitat-related monitoring measures, the ESMP includes a requirement to report detections of marine mammals and marine turtles made from Project vessels (including the FPSO) over the operational lifetime of the Project (see Table 3-9). Marine mammals and turtles account for several of the most commonly-observed IUCN-listed species in the Project AOI and this measure will effectively convert the MMO/PSO study program that has been ongoing since 2015 into a long-term monitoring program.

Stakeholder	Comment
	ii. Development of a Biodiversity Action/Management Plan (BAP/BMP) to protect threatened species. Considering the high biodiversity value of the coasts of Guyana, as well as the potential uncertainties about project impacts, a stand-alone BAP/BMP Is important to communicate clearly to stakeholders the company's selected mitigation strategy, and its working philosophy and ability to operate responsibly in areas of known conservation value. EEPGL could also opt to incorporate biodiversity-related mitigation and management measures into more general Environmental Management Plans or Action Plans, but the risk in this case, is that commitments might appear less evident or buried among many others, and possibly be less focused. Five species of international conservation concern were documented during the survey: White-bellied Piculet ("Vulnerable"), Rufous Crab Hawk (Buteogallusaequinoctialis) ("Near Threatened"), Bicolored Conebill (Conirostrum bicolor) ("Near Threatened"), Semipalmated Sandpiper ("Near Threatened"), and Red Knot ("Near Threatened"). In addition, 10 Important Bird Habitats were identified due to high bird abundance and species richness. We reiterate strong encouragement to develop Biodiversity Action Plans (BAPs) to ensure the protection of these species and their respective habitats. **Response:** The planned activities of the Project are not anticipated to impact any IUCN Red List bird species. Embedded controls are incorporated into the Project design to minimize or avoid potential impacts to Red List species. Only unplanned events, specifically an oil spill, could potentially impact these species and implementation of the OSRP would minimize or avoid impacts to these species in the unlikely event of an oil spill. iii. Expand the scope of IUCN assessment to include all observable species. We commend the EIA's identification of IUCN Red List species in Guyana and overlap with respect to coastal bird species, however, clarity is needed for observed marine bird, marine mammal, fishes, flora, fauna, and turtle species and whether they are on the IUCN Red List of Threatened Species. **Response:** Section 7.1 describes how many IUCN-listed species listed in Table 7.1-4 have been documented by field studies cited in the EIA, but the Consultants agree that this information could be presented in a clearer fashion. Section 7.1.2.2 has been edited accordingly. iv. The marine mammal observation data presented should be strengthened. We believe this data lacks structured attempts to catalogue these species and relies largely on opportunistic sightings from marine vessels over a period of 10 years. This method is limited as it is neither systematic nor structured and assumes that vessel captains can correctly identify species. **Response:** The Consultants agree that there has been an element of opportunism to the MMO data collected to date; however, as indicated above, the ESMP includes a requirement to report detections of marine mammals and marine turtles made from Project vessels (including the FPSO) over the operational lifetime of the Project (see Table 3-9). The FPSO will remain stationary for the entire monitoring period, which will effectively create a permanent, full-time monitoring point within the Project AOI. This will introduce a level of rigor and reproducibility into the MMO data that had not existed previously. It is also noted that vessel captains are not responsible for identifying marine species; all protected species observations are made by trained protected species observers who are required to pass a proficiency exam to function in this capacity. v. The turtle telemetry data presented should be strengthened. This data was collected from few turtles and over only one nesting season. This data is therefore not sufficiently indicative of the migratory routes all nesting species utilize. More robust data is needed to formulate a clearer picture. **Response:** The Consultant team considers the turtle telemetry data presented in the EIA to be sufficient for the purposes of rating the anticipated impacts of the Payara Development Project on marine turtles. It is noted that a second year of turtle telemetry work is currently underway and a report on the results of this work will be provided to the EPA at the conclusion of the study. vi. Adopt recommendations that the sampling area be widened to appropriately assess baseline conditions of areas potentially impacted by indirect or cumulative impacts. While the sampling sites were deemed to be representative of the immediate Payara project development area, they do not discuss the area that could potentially be impacted from an indirect or cumulative perspective, and therefore, do not reflect the conditions in the entirety of the project's AOI. **Response:** The Consultants note that biological resource data have been collected from across the Stabroek Block (and between the Stabroek Block and the shoreline), specifically for marine fish, marine birds, and marine mammals. Further, coastal bird data have been collected across the Guyana coast. With respect to future monitoring, the monitoring program described in the ESMP focuses on the Direct AOI because the Direct AOI (specifically the immediate vicinity of the FPSO and drill centers) is where the most significant Project-related environmental impacts are expected to occur. To the extent that low-level impacts could occur farther away from the Direct AOI, the EIA predicts that their significance would be too low to warrant a seascape-level monitoring program. However, some marine receptors that are vulnerable to potential impacts outside of the immediate vicinity of the FPSO and wells (such as vessel collisions with marine mammals and sea turtles, for example) will be monitored wherever Project vessels are operating.

Stakeholder	Comment
	vii. Present information on sampling dates and locations in a clearer manner to better convey their seasonal and temporal variations. It was previously recommended that "additional sampling periods be carried out to better capture temporal variations in baseline conditions." While additional sampling has been proposed for various studies it is still not clear whether capturing seasonal or temporal variation has been factored in the studies associated with this EIA. We suggest presenting this information in a clearer way, by including an additional column to better denote the studies done to date, and when they were done, including aspects such as the season during which they were performed. This will allow for better and easier assessment of the robustness of sampling conducted and gaps can be clearly assessed. **Response:** The biological field studies were conducted with seasonal variations in mind. Not all taxonomic groups (deep marine benthos for example) are likely to be affected by seasonal changes, but efforts were made to collect data in the wet and dry seasons for the major taxonomic groups that are likely to be affected by seasonal changes. In addition, sampling events have been conducted over multiple years for most taxonomic groups. Information on when and where the field studies for each of the major taxonomic groups were conducted is included in the relevant reports in Volume II of the regulatory submittal. **b. Additional studies** i. Continue subsea noise pollution monitoring. We acknowledge that monitorization efforts now also include a subsea noise pollution study component to gauge and track potential impacts of sound arising from Liza and Payara project-related activities, as this was one of CI's recommendation from an earlier EIA review. Furthermore, we are pleased to learn that the deeper water at Payara lowers the sound levels, and therefore presents less danger to marine populations. **Response:** Although the EIA included a marine noise modeling analysis, it does not include a recommendation to monitor marine noise. The EIA does recommend that operational activities are conducted in accordance with international best practice regarding mitigation of noise impacts on marine mammals, including soft starts for pile driving and adherence to the JNCC Guidelines during seismic activities, which the Consultants consider adequate to manage noise impacts on marine mammals. ii. Establish baselines for the Shell Beach Protected Area (SBPA). Given the potential for significant impacts to the SBPA from unplanned events such as oil spills, we recommend that baselines be establish for the protected area, especially for the elements that would be the most affected by such events. The SBPA should also be included as part of the continuous biodiversity monitoring over the life of the project. **Response:** The SBPA is unlike other portions of Guyana's coast in that it is the only large coastal area in the country that has been the subject of a formal, relatively recent biodiversity study (the 2011 Proposed Shell Beach Delineation Process Report). Although the Consultant team agrees that the information in this report could have been updated with more recent field data for the EIA, the report contains valuable information on the biodiversity of the SBPA, and these data, together with more recent survey data from other sites with similar habitats (coast beach, intertidal mud flats, mangroves, etc.), were deemed sufficient by the Consultants to credibly assess potential Project-related effects on the SBPA. **Project Generated Impacts** We recognize that the EIA references the World Bank's Environmental, Health and Safety Guidelines (EHS Guidelines) for the evaluation and selection of resource efficiency and pollution prevention and control techniques for the Project. However, we recommend the following: i. It is important to also consider the risks and potential impacts on priority ecosystem services that may be exacerbated by climate change, as per IFC PS4. For instance, socio-economic impacts on fisheries and fishing communities due to climate change which might also be exacerbated by the Project's exclusion zones. **Response:** Compliance with the IFC PS was not part of the Terms and Scope for the Payara Development Project EIA, so it PS4 is technically not applicable to the EIA. The fact that the IFC PS are not applicable to the EIA notwithstanding, the Consultants recognize the importance of impacts on climate and ecosystem services to Guyanese society, and have assessed them separately in Sections 6.1 and 8.9 of the EIA, respectively. With specific regard to potential loss of fishing ground access from exclusion zones, the assessment of these impacts in Chapter 8 explains that the only fisherfolk that will potentially be affected by exclusion zones would be a relatively small commercial tuna fishery, and even in this case the loss of fishing ground access is minimal relative to the size of the EEZ. ii. Vessel offshore anchoring might disturb seabed habitats; this is an additional project interaction with environmental resources/receptors that should also be considered.

Stakeholder	Comment
	Response: It is noted that only the FPSO will be moored; no other Project vessels will be anchored, moored, or otherwise attached to the seafloor at any time. The potential physical impacts associated with the FPSO's mooring spread are assessed in Section 6.3 and the biological impacts of the mooring spread are assessed in several locations in Section 7, including Section 7.5 (marine mammals), Section 7.8 (marine fish), and Section 7.9 (marine benthos). iii. We welcome the commitment of the developer to not flare gas, except in cases of emergency, and to monitoring greenhouse gas (GHG) emissions of the project. This would be critical to support Guyana's low-carbon, green economic development ambitions. The Project should however consider going beyond monitoring to offsetting its GHG emissions through investments in management of natural forests in protected areas and other effective means. **Response:** As indicated by the comment, EEPGL has committed to environmental performance monitoring and reporting management systems that are in line with international good practice methods with respect to GHG management. In addition, as noted in Section 6.1.3.2, EEPGL has committed to a number of embedded controls and mitigation measures that will aid in reducing GHG emissions from the Project. Embedded controls and mitigation measures that will reduce emissions include re-injecting produced gas that is not utilized as fuel gas on the FPSO to avoid venting or routine production flaring, waste heat recovery, high efficiency gas turbines, VOC recovery on the oil storage tanks, and efficient operation of combustion equipment, among others. iv. The proposed disposal of solid waste detailed in the EIA must take into consideration the already insufficient capacity of current landfills in Georgetown; these may not have enough capacity for the additional waste the project will generate. Special emphasis should be placed on the efficient and effective disposal of the project's hazardous waste, taking into consideration that Guyana does not currently have a functioning commercial incinerator. **Response:** Since the completion of the draft Payara EIA, the construction of a second cell at the Haags Bosch Landfill (HBL) has been proceeding. Continued upgrades and improvements at the HBL have also been completed. The EPA continues to monitor and manage the oversight of the HBL. The EPA is working to ensure the design of the second cell includes the installation of a synthetic liner in addition to the clay liner layer and leachate collection system already installed. The current and near-term local non-hazardous solid waste management needs for the Payara Development Project can be met by the completion of the HBL second cell, currently expected in 2021. Subsequent decisions of whether further expansion of existing or new municipal waste landfills will be undertaken by the Government of Guyana with the input and support of the Ministry of Communities and the Environmental Protection Agency and participation of the public and other stakeholders. In 2018 and 2019, EEPGL's contribution of non-hazardous solid waste volumes sent to HBL was approximately 6 percent of the total annual volume received by HBL. EEPGL expects that a similar volume of non-hazardous solid waste will continue to be sent to the HBL in 2020. Currently the HBL receives approximately 500 tonnes daily, of which approximately 30 tonnes is attributed to EEPGL / EEPGL Contractor drilling and production operations. Further, in the summer of 2019, EEPGL released a Request for Information (RFI) to the Guyana market to find qualified suppliers to perform waste management and recycling services. After evaluation of the responses, EEPGL invited qualified suppliers to a bid process, the results of which were reviewed and finalized. This will build additional capacity for EEPGL's hazardous, non-hazardous, and exempt hazardous waste to be stored, processed, treated, or recycled. EEPGL has completed the evaluation and plans to award the contract for additional waste management capacity in 3Q2020. The added waste management capacity derived from these efforts will protect human health and the environment as well as meet the needs of EEPGL, the Payara Development Project, and beyond. v. Development of the decommissioning plan should be informed by a socio-economic analysis to better understand the cost and benefits, especially with respect to fisheries and fishing communities, of the different decommissioning alternatives. **Response:** Near the time of decommissioning, EEPGL will develop an initial decommissioning plan, in consultation with the appropriate Guyanese regulators. EEPGL will perform comparative assessments of facility components where there may be multiple decommissioning options. The comparative assessment is designed to evaluate five (5) criteria including safety, environmental, technical, impact to other users of the sea, and economics - and to select the best option for the final decommissioning plan. Consultation with stakeholders would also be conducted by EEPGL during decommissioning planning. A revised Plan will be submitted to the appropriate Guyanese regulators in advance of commencing field work. vi. Impacts from unplanned events (i.e. oil spill): We consider that the rating of impacts on marine species, coastal habitats as well as communities and indigenous peoples from a potential oil spill or natural geological event should be conservative and follow a precautionary principle. We recommend evaluating these potential impacts from the perspective of the possible magnitude, alongside the likelihood of their occurrence. The likelihood of these event might be low but the magnitude and irreversibility of the impacts which would result should they occur could be very significant, as it could take decades or more for all these receptors/resources to fully recover.

Stakeholder	Comment
	Response: Consistent with the typical approach taken for assessment of unplanned events, a risk assessment approach was taken in order to incorporate the aspect of likelihood (i.e., to distinguish from assessment of an event which is planned or practically certain to occur). The Consultants agree that there are a number of resources for which the consequence/severity of an oil spill would be high, and many of the resources have therefore been assigned the highest consequence/severity rating in the methodology. That said, the likelihood of an oil spill of sufficient magnitude to produce this type of consequence is very low and it is therefore appropriate to assign a likelihood rating of Unlikely. It is acknowledged that this produces a combined risk rating that is Moderate (rather than Major), and this is consistent with typical risk assessment methodology - which does not automatically assume a very rare event will happen. It is further noted that the measures proposed by EEPGL represent good international industry practice, and different/additional measures would not be proposed even if the risk rating were to be raised to Major. vii. An economic assessment and valuation of all resources which can potentially be impacted by an unplanned event should be conducted to ensure an accurate economic baseline exists should an unplanned event occur. **Response:** A baseline economic evaluation of resources that could be affected by a hypothetical spill scenario is neither practical (because the scope of such an event is impossible to predict and therefore the scope of an assessment cannot be defined) nor typical for an EIA. viii. The Precautionary Principle should also be applied when assessing potential cumulative impacts, given the additional exploration projects projected by EEPGL and other companies. The project should actively manage, where feasible, the spatial and temporal overlap of their additional projects' activities. **Response:** The precautionary principle dictates a conservative approach to impact assessment where appropriate to ensure that impacts of novel activities are well understood and accurately predicted. The cumulative impact assessment in the EIA incorporates conservatism where particular aspects of EEPGL's future activities are not certain, including assuming that all future exploration drilling activities would take place in the Stabroek Block (thereby maximizing the potential for overlap of impacts from different exploration campaigns on water quality or the seabed), and assuming conservatively high numbers of vehicles in the level of service projections for the vehicular traffic assessment (thereby maximizing the projected demand on the existing road network). It is noted that the cumulative impact assessment (Chapter 10) makes specific recommendations relative to management of EEPGL's multiple development project and exploration operations - with the express purpose of reducing the additive potential for impacts associated with an increased activity level. ix. Ensuring costs of expected activities and social benefits, unplanned events and/or unanticipated post-decommissioning environmental and social risks are covered: Measures such as performance bonds, insurance agreements, escrow accounts, etc., should be considered to ensure costs of managing environmental and social risks from expected on-going events, unplanned events and/or unanticipated post-decommissioning risks will be adequately covered, as well as all promised social benefits are delivered. **Response:** This comment addresses policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana. **Stakeholder Engagement** i. Adopt permanent, meaningful and inclusive stakeholder engagement. EEPGL has been engaging with different stakeholders in a variety of ways during the development of the various projects within the Stabroek Block. We recommend moving forward that for each of those engagements the Project demonstrates engagement through deliberative spaces and simple communication tools that are inclusive and tailored to the different audiences, as well as enable effective participation of vulnerable and underrepresented stakeholders. **Response:** EEPGL's and its consultants' engagement with communities, including Indigenous Communities, is described in the Stakeholder Engagement Plan (SEP). The SEP details the multiple years of engagement that have taken place by EEPGL and its consultants. In response to comments received in other EEPGL Project consultations about the complexity of the materials, the Consultants developed a highly visual Non-Technical Summary as well as other materials to help in messaging the Project risks and benefits. This information has been appended to the SEP as Appendix D. ii. Adopt ongoing reporting to potentially affected communities. We also recommend that the project ensures ongoing reporting to potentially affected communities and transparency about consultation reports. These should capture stakeholder concerns and comments during all consultation activities and show how they were addressed or otherwise treated.

Stakeholder	Comment
	Response: Continuous engagement with affected communities is described in the SEP, as well as a summary of concerns and comments received during engagements. Furthermore, all ongoing engagements and resulting actions are tracked by EEPGL through an automated, stakeholder engagement database. iii. Ensure Informed Consultation and Participation (ICP) and Free, Prior and Informed Consent (FPIC). The Project should ensure the ICP of the indigenous peoples about the potential risks, impacts and proposed mitigation actions pertaining to the possibility of an oil spill. This can be effectively achieved through guidance and relationships with partners, such as indigenous NGOs, who have great experience and expertise in effective engagement with these communities. According to IFC PS1, an oil spill stemming from offshore drilling would constitute "(ii) impacts from unplanned but predictable developments caused by the project that may occur later or at a different location." While the offshore drilling is not being developed on indigenous peoples' lands per se, its adverse impacts (an accidental spill) could significantly impact the lands and resources traditionally owned or under the customary use of indigenous peoples. Therefore, ICP is required, and the case for FPIC as the preferred course of action is a strong one, because of the following: a) The potential unplanned event (oil spill) could impact the Indigenous Peoples' related natural resources (particularly the marine resource, given that they are fishing communities) b) FPIC would allow the project to develop more robust required emergency preparedness plans, mitigation plans, and compensation schemes. c) The indigenous communities in question may fall into the particularly vulnerable status, thereby requiring extra measures per IFC PS1 d) The benefit would outweigh the cost over the long-term **Response:** Compliance with the IFC PS was not part of the Terms and Scope for the Payara Development Project EIA, so PS1 is technically not applicable to the Project or the EIA. Likewise, FPIC and ICP are not required by either the Environmental Protection Act or the Terms and Scope for this Project. The fact that neither the IFC PS, FPIC, nor ICP are applicable to the EIA notwithstanding, EEPGL recognizes the importance of effective communication and engagement with Guyanese society (and especially potentially vulnerable communities) to obtaining and maintaining a "social license" to construct and operate the Project. The Consultants likewise recognize the importance of communication and engagement to the execution of a robust and defensible EIA. With these needs in mind and as described in the SEP, EEPGL has engaged in a multi-year engagement process with communities across the coast (including indigenous communities) and these engagements informed both the scope and findings of the EIA. **Environmental and Socioeconomic Plan** a) We echo the consultant's recommendation that EEPGL incorporate all imbedded controls and adopt the recommended mitigation measures in the EIA Chapter 13. **Response:** EEPGL has adopted and implemented the embedded controls and management and mitigation measures reflected in the final Liza Phase 1 EIA and Liza Phase 2 EIA, and would do the same with the final Payara EIA. b) Lessons from the Environmental and Social Management Plan (ESMP) implementation should inform policies and decision-making. Considering the oil and gas sector within Guyana is in its infancy, we reiterate the recommendation that the ESMP and its implementation be used as an organizational learning process in which the lessons experienced are fed back into policy, institutions and subsequent project designs, thus building the country's capacity to better manage such large-scale projects in the future. We recommend having clarity on the institution and mechanisms responsible for implementing this. **Response:** This comment addresses recommended actions and policy concerns that are beyond the scope of the EIA and would more appropriately be directed to the Government of Guyana. c) The socioeconomic management plan should include important emphasis on local capacity for delivering sector related services. The Project should ensure assistance to build capacity of local businesses (to an accredited level acceptable to EEGPL) to cater to the needs of the sector, e.g. Solid Waste Management (incineration services, solid waste disposal, treatment of hazardous chemicals, etc.), Oil Spill Wildlife Response (training at the University, schools of Veterinary Medicine and the Guyana Wildlife Conservation and Management Commission how to care for, clean and rehabilitate oiled wildlife). **Response:** Capacity building and local content is covered in EEPGL's Local Content Plan, which is provided under separate cover to the Government. The Centre for Local Business Development also builds capacity for local businesses including, but not limited to mentoring for ISO 9001 certification. Additional information regarding local content and capacity building has been added to Chapters 2 and 8 of the EIA. The ESMP includes related measures including employing Guyanese citizens having the appropriate qualifications and experience where reasonably practicable, partnering with select local institutions and agencies to support workforce

Stakeholder	Comment
	development programs, proactively messaging Project-related employment opportunities, and procuring Project goods and services locally when available on a timely basis and when they meet minimum standards and are commercially competitive. d) Decommissioning of equipment should ensure coral reef inoculation. It is expected that upon decommissioning the risers, flowlines, umbilicals, subsea equipment, FPSO mooring lines, and anchor piles will be disconnected and abandoned in place on the seafloor and we recommend that the strategy encourage coral reef inoculation on substrate metals or ensure that all EEPGL equipment will not pose danger to wildlife. While it is likely that natural ecosystem succession will occur, abandoning equipment on the seafloor would potentially reduce the aesthetic quality of the area and can create safety hazards, such as injuring wildlife (e.g. sharp metal edges. ingesting inedible materials, poisonous materials, and entanglement). **Response:** EEPGL has committed in Section 1.1 of the Preliminary Decommissioning Plan that "abandoned facilities will be left in a condition that avoids harm to the environment." The final Decommissioning Plan will elaborate on this commitment and provide more information on the specific methods to be used to prepare equipment to be abandoned on the seafloor. Given the length of time that the SURF will be in use, it is likely that encrusting benthic species will have colonized the equipment before decommissioning begins. This could make coral inoculation difficult to accomplish without disturbing the existing biological community; however, an assessment will be made at that time to identify the least disruptive/most beneficial method of abandoning the SURF in place. e) Monitoring should be carried out on three levels and ensure adaptive management. In addition to the consultant's recommended adaptive management strategy in EIA Chapter 4 to retire existing mitigation measures that no longer demonstrate value, we would like to clarify a few best practice principles for biodiversity monitorization. These are i. In field monitoring of relevant biodiversity values; ii. Monitoring of implementation and effectiveness of mitigation measures and management controls; and iii. Monitoring of status of non-project related ongoing threats to biodiversity values in the project's vicinity and the extent to which the project might exacerbate them. **Response:** As indicated in several responses above, the monitoring program described in Volume III of the regulatory submittal (the ESMP) is focused on the Direct AOI because the Direct AOI (specifically the immediate vicinity of the AOI and drill centers) is where the most significant Project-related environmental impacts are expected to occur. In the Consultants' view, when taken in aggregate, the monitoring measures proposed in the ESMP are adequate to validate the findings of the EIA and support effective oversight by the EPA for several reasons. These reasons include inclusion of direct sampling and testing of physical parameters that can be compared to quantitative performance criteria that are widely used in the oil and gas industry and relevant to Guyana's environmental treaty obligations (e.g., residual oil on cuttings, oil content and temperature of discharged water, etc.), as well as a long-term focus on protected marine species (marine mammals and turtles) that can be considered indicators of general marine ecosystem health. The ESMP will be revised periodically to ensure that the various measures described in the plan remain aligned with Project needs and reflect current technologies, thereby integrating an adaptive element into the monitoring program Finally, the Project should ensure adaptive management practices to adjust methodologies and practices to the ways ecosystems and biodiversity are being managed and monitored. Additionally, the following suggestions could ensure a robust and impactful monitoring programme: i. Increased training for ANY vessels (not just EEPGL associated vessels) moving to and from the FPSO and drilling ships to identify marine mammals and adjust course/speed accordingly to prevent collisions. ii. Better preventative protocols in place to avoid an influx of invasive alien species from untreated ballast water. iii. Continuous monitoring of water quality surrounding FPSO by independent labs to determine temperatures, pollutants levels, algal blooms etc. iv. The inclusion of measures to enable community participation, especially Indigenous People and communities, in the project's research and monitoring would be of great value to effective monitoring, amongst other things. **Response:** As described in several locations in Volume III of the regulatory submittal, the ESMP will be revised periodically to ensure that the various measures described in the ESMP remain aligned with Project needs and reflect current technologies. The "evergreen" nature of the ESMP reflects an adaptive management approach to management of Project-related impacts.

Stakeholder	Comment
	Oil Spill Response Plan (OSRP), Volume III – Section 9 **a. Robust stakeholder engagement and training program** i. Conduct regular oil spill response drills. It is critical that EEPGL commit to regular oil spill response drills, simulations, and exercises involving appropriate Guyanese authorities and stakeholders in these activities in order to help delineate clear lines of action, roles and responsibilities for the different stakeholders. EEPGL should also document the availability of appropriate response equipment on board the FPSO and demonstrate that offsite equipment could be mobilized for a timely response. Recognizing the important role potential affected communities, local government agencies and other relevant parties could play in supporting implementation of the response plan during an emergency, it is fundamental that the project gives significant priority to the training and preparation of all entities to ensure coherent and effective emergency response when needed. **Response:** The description and details of EEPGL's oil spill response drills, exercises and training can be found in the Payara EIA, Vol. III Oil Spill Response Plan Sections 2, 8 and 9 including Tables 10, 11 and 12, which include the individual exercise type, description, purpose, and frequency. The specific list of oil spill response equipment on the FPSO is found in Table 7 of the OSRP. This is further supported by the additional oil spill response materials and equipment found in Table 6 that are maintained on board the Project Support Vessels and Fast Supply Vessels (PSV and FSV). Deployment of mechanical recovery equipment from the FPSO poses a significant safety risk given the prevailing metocean conditions, particularly as this activity would not be routine. Consequently, EEPGL are using the FPSO as an infield storage location for dispersant, to enable rapid transfer to the many service vessels which are equipped with dispersant application devices to quickly treat any spill (rather than having them need to return to the shorebase to reload additional dispersant. Should mechanical recovery oil spill response equipment be considered appropriate, and the metocean conditions safe, then the mechanical recovery equipment could be loaded onto the next departing service vessel leaving the shorebase terminal for field deployment. The oil spill exercise program described in the OSRP and implemented by EEPGL leverages a number of other key activities conducted as part of the broader oil spill response capacity building initiatives EEPGL has been undertaking for more than three years and will continue to perform in the future. There is an annual oil spill response drill, which in 2019 was the focus of our major triannual exercise of the ExxonMobil Americas Regional Response Team. This exercise had multiple participants from Guyanese authorities and stakeholders, including: • Civil Defence Commission (CDC), • Environmental Protection Agency, • Department of Energy, • Coast Guard, • Guyana Defense Force, • Maritime Administration Department, • Guyana Energy Agency, • Ministry of the President, • Centre for Local Business Development, • CDC Volunteer Emergency Response Team (VERT), • Guyana Geology & Mines Commission. Where practical, relevant Guyanese authorities and stakeholders have been and will continue to be actively involved in these annual oil spill response exercises. It is not practical to deploy the response equipment during every drill given the resources required. However, as part of the ongoing drill and exercise program, as well as with regular maintenance, tests are done on an on-going basis. This training and, most recently, regional deployment of oil spill response equipment has progressively developed the response capability of government authorities, agencies, and volunteer responders. As part of the continued commitment to capacity building, EEPGL will be working with the relevant agencies to transition from demonstration of the equipment to staging open-ended exercises where local responders will be expected to identify response strategies and equipment required, and to deploy the equipment consistent with their strategy under the guidance of experienced responders. The long-term objective is to enable every regional response team to be able to respond confidently, independently of experienced coaches. While it is not practical, safe or cost effective to physically deploy oil spill response equipment during every drill, as part of the

Stakeholder	Comment
	ongoing oil spill response drill and exercise program, as well as during regular maintenance and testing of such equipment to verify its functionality, EEPGL will trigger the deployment of some equipment to be able to show, educate and demonstrate to the Guyanese authorities and stakeholders on the effectiveness of EEPGL's processes in place to respond and mobilize all such equipment in the unlikely event of a spill or release. ii. Partner with local academic institutions and/or non-governmental organizations (NGOs) to build capacity on oil spill response. We suggest that the Project partners with academic and training institutions, such as the University of Guyana, and/or NGOs to sustain training for implementation of response plans in case of an oil spill. **Response:** EEPGL acknowledges that there is potential for partnering with the academic and training institutions within Guyana; the maximum benefit in any partnership with these institutions would be in a broader understanding of the oil and gas industry, and development of the technical skills necessary to support sustainable development within Guyana. For oil spill response support, there are several Guyana-based commercial entities already developing the skills and building the network of trained personnel to support a significant oil spill response effort. By working with these entities, the industry will foster job development locally, which in turn will draw on the academic and training institutes to build a competent workforce. By working with established businesses, this will also ensure there are ongoing response resources that will directly be able to support the National Oil Spill Contingency Plan response capability. Additional, EEPGL, as part of ExxonMobil globally, will continue to maintain strong relationships and agreements with recognized international oil spill response service providers (e.g. Oil Spill Response Limited, Boots and Coots, and others) to ensure immediate access to these resources, in the very unlikely event of a significant spill. Consequently, at this stage, EEPGL does not anticipate that it will be pursuing a formal partnership with the University of Guyana or other training institutions specifically focused on such training for implementation of response plans in case of an oil spill, as UG and other NGOs can engage directly with these existing commercial entities. These local suppliers can provide regional training, education, exercises, and demonstrations as well as provide logistical support and oil spill response equipment maintenance and inspections. iii. Comply with best practice for the use of dispersants. In the event of an oil spill, it is critical that the use of dispersants comply with best practices and standards, given that they might create cumulative effects. Dispersants do not reduce the amount of oil entering the environment but push the effects of the spill underwater. While dispersants make the oil spill less visible, dispersants and dispersed oil under the ocean surface are hazardous for marine life. EEGPL should strive to employ the most biodiversity friendly dispersants should the need arise. **Response:** The National Academy of Science published The Use of Dispersants in Marine Oil Spill Response in 2019. This document is available for download at https://www.nap.edu/download/25161. The report represents the best currently available scientific understanding of oil dispersant use and benefits from the learnings gained during the 2010 Gulf of Mexico deepwater blowout, where significant quantities of oil dispersants were utilized. It is understood and utilized as a guide for the use of oil dispersants by EEPGL. The report is highly recommended for utilization by government regulatory agencies, oil spill responders, and NGOs. The reviewer noted that oil dispersants move oil from the surface and make it less visible. This is not an accurate assessment of oil dispersant's function. Spilled oil at the surface of the water will cause harm to birds, marine mammals, planktonic organisms at the water/atmosphere interface, and fish eggs and larvae near the water surface. Surface oil treated with dispersants will break the slick into small droplets (<100 um) where waves, winds, and currents will mix those droplets into the upper 10m of the water column. The concentration of the dispersed oil quickly dilutes to low parts per million (ppm) in hours and low parts per billion in <24 hours. Once the surface oil has been treated, the small droplets in the water column are subjected to degradation processes including biodegradation and photo-degradation. Biodegradation occurs when the small droplets are utilized as a food source by oil degrading bacteria that are ubiquitous in the marine environment. This biodegradation produces CO_2 and H_2O. Lab-based studies indicate that oil-dispersant mixtures, when released into the environment, are generally biodegraded and /or photodegraded on the order of hours to days. The use of oil dispersants on surface slicks therefore removes oil that would be persistent for days to weeks to the water column, where the low concentrations produce less physical and toxic effects and the oil and dispersant is degraded in hours to days. All modern oil dispersants are designed for low toxicity and higher efficacy to increase the window of opportunity for their utilization. The oil and dispersant mixture is no more toxic than the oil alone.

Stakeholder	Comment
	b. Transboundary considerations and ability to respond i. Support development of frameworks that clearly organizes roles, priorities and devote resources for responding to an unplanned event. There needs to be a clear plan with respect to who is responsible for cleanup activities, who funds initial response, who funds recovery from culminative effects, who is responsible for loss of country revenue (sea/sand/sun product). **Response:** EEPGL recognizes the overall initiative the Government of Guyana has taken with the development of the draft National Oil Spill Contingency Plan (1 November 2019), which has been developed under the direction of the Minister of State (with Responsibility for Disaster Risk Management) by the CDC. Within the National Oil Spill Contingency Plan (NOSCP), EEPGL would be considered the Responsible Party in the unlikely event of a spill from one of its offshore facilities, with obligations to provide notification to MARAD (as the National Focal Point – Marine) upon identification of an oil spill event. The EEPGL OSRP works in conjunction with the NOSCP, addressing how, as the Responsible Party, EEPGL would respond. Initially, EEPGL would appoint an Incident Commander to lead the Incident Management Team (IMT), utilizing the internationally recognized Incident Command Systems processes. An appropriately resourced IMT would be established in Georgetown, including relevant agencies. EEPGL would remain as the Incident Commander (either as overall, or as part of Unified Command with the Competent National Authority) unless the Competent National Authority considered it necessary to assume the Incident Commander role. Per the Payara EIA Vol. 1, Section 9.1.9, in the unlikely event of an oil spill, EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. In addition, EEPGL and its co-venture partners have entered into agreements with insurance companies which require verification that adequate financial resources are in place to satisfy environmental obligations, including those in the unlikely event of a spill. ii. Establish an environmental bond for unplanned events. The very limited mechanisms in place for the regulatory agencies to deal with an oil spill, along with weak legal frameworks that exist within the region, suggest that impacted countries would be in a highly disadvantageous position, and highly dependent on the developer, to respond to a transboundary oil spill event. We reiterate the recommendation for the establishment of an environmental bond or the triggering of an immediate imposition of an early payment (within the fee structure of the environmental permit) that can be immediately used by the Government of Guyana to work with its neighboring countries and other affected parties in the event of an oil spill. We note that this matter becomes increasingly important as the number of wells increases. **Response:** The Payara EIA Vol. 1, Section 9.1.9 outlines the Claims and Livelihood Remediation Processes, which includes in the unlikely event of an oil spill causing losses to stakeholders that EEPGL will establish a claims process and, depending on the magnitude of the spill, a livelihood remediation program. Further, EEPGL and its co-venture partners carry insurance coverage that meet or exceed global industry practice to enhance their financial resources to respond in the event of a spill, and will comply with Guyana's regulatory requirements related to demonstration of financial responsibility. iii. We recommend the inclusion of a terrorist response scenario or plan for both offshore and shore-based sites. There are references to several emergency response plans triggered by events such as bomb threats or civil disturbances, however given Guyana's limited capacity to respond to a mass casualty event (medical, terrestrial security forces, mortuary services, emergency Coast Guard deployment, etc.), there needs to be a clear emergency plan which can be efficiently implemented. **Response:** ExxonMobil Global Security has conducted formal risk assessments on all operations in Guyana, which included the threat from terrorism. Emergency response plans for security incidents have been prepared. Additionally, shorebase and offshore assets fully comply with the International Ship and Port Facility Security (ISPS) Code.
Joe Ryan	1. Use of dispersants - It is of the highest importance of EXXON exploring other solutions to deal with oil spills /other than using dispersants/, which in many cases have proven to be even more toxic to living organisms than the oil. **Response:** As described in the Oil Spill Response Plan (OSRP), in the event of an oil spill EEPGL would conduct a Net Environmental Benefit Analysis (NEBA) to support decisions as to the combination of response measures to implement in a given response scenario. The purpose of the NEBA analysis would be to ensure that any response measure implemented would be beneficial compared to the "no response" scenario. Use of dispersants is an important strategy for EEPGL to have available in the event of a spill, but would not be used unless the NEBA analysis demonstrates the benefit of such use. 2. Economic Valuations – Work conducted on the social and economic valuation of fishing communities is not sufficiently robust.

Stakeholder	Comment
	Response: Data collected through engagements with members of the fishing industry are included in Chapter 8. In particular, the Consultant team is conducting a Participatory Fishing Study which collects social and economic baseline data on the artisanal and subsistence fishing industry. This work is ongoing and additional information will be published as additional study activities are completed. 3. Bird surveys in Region 01 – Absence of baseline data for birds in Region 01. Bird surveys and a full biodiversity survey of the areas inside and outside of the Shell beach protected area should be conducted. **Response:** The Shell Beach Protected Area (SBPA) is unlike other portions of Guyana's coast in that it is the only large coastal area in the country that has been the subject of a formal, relatively recent biodiversity study (the 2011 Proposed Shell Beach Delineation Process Report). Although the Consultant team agrees that the information in this report could have been updated with more recent field data for the EIA, the report contains valuable information on the biodiversity of the SBPA, and these data - together with more recent survey data from other sites with similar habitats (coastal beach, intertidal mud flats, mangroves, etc.) - were deemed sufficient information by the Consultants to credibly assess potential Project-related impacts on resources in the SBPA.
Environmental Assessment Board	**Executive Summary Section** The Executive Summary whilst well performed can be improved with the addition of a small amount of detail on the Oil Spill Response Plan (OSRP) and the frequency of the oil spill response drills. **Response:** EEPGL conducted the following joint exercises with Guyana regulators: (1) Aug. 2019 simulating a hose line break with regulators and key service providers (e.g. OSRL) and the Stabroek co-venture partners (Hess & CNOOC), with the ExxonMobil Americas Regional Response Team mobilized to support the exercise; and (2) Jan. 2020 with the EPA, Coast Guard, CDC and MARAD—providing training in operation of oil spill trajectory and fate model as well as training in oil spill response strategies, with a focus on oil dispersants. The next exercise has not been planned yet by EEPGL. **Project Description Section** This section of the document lacks detailed information on the potential employment figures of the project. Whilst a definitive amount might be difficult to determine, more information can and should be provided, especially information on the social and demographic characteristics of the potential beneficiaries. **Response:** Additional information has been added to Section 2.3 and 8.2.3.1 about the types of jobs and types of potential beneficiaries, although predictive discussions on social and demographic characteristics of those individuals may not be appropriate. The identification and description of alternatives is an area of the document that requires further attention as no detail was provided. Sound alternatives are an important part of the validation of the EIA process and must be fully and comprehensively considered. Alternatives that must be considered should include location, project layout, technology, scheduling and project scale. **Response:** Several Alternative options were discussed in detail in Section 2.17 including; • Location alternatives, • Development concept alternatives, • Technology and process alternatives, • No-go alternative. **National and Legal Frameworks Section** The National and Legal Frameworks including International Conventions and protocols were fully considered in the project with the exception of the inclusion of the Sustainable Development Goals (SDGs). The Government of Guyana is fully committed to SDGs and it is embedded in the overarching framework of the Green State Development Strategy. **Response:** A discussion on Guyana's Sustainable Development Goals has been added to Section 3.3.1.

Stakeholder	Comment
	Environmental Assessment (EA) and Social Impact Assessment Methods The EIA utilised appropriate EA methods for the environmental assessments, however the methods used to collect socio-economic data and assess socio-economic impact were not provided or clearly identifiable. The lack of the presentation of the socio-economic methods employed affected the ability of the EAB to verify the dependability of the conclusions drawn from the social impact assessment. There was also a lack of detailed household characteristics and the livelihoods labour distribution in the household especially in relation to gender labour roles. In some cases, even the demographic information of the indigenous villagers is not gender disaggregated nor information provided on the number of children. These social characteristics have implications for the impacts of the project on the socio-economic fabrics of the communities and should have been included. The EIA should have used an ethnographic methodology. **Response:** The socioeconomic assessment methodology is described in Chapter 4. The Consultants utilized all available open source information, including census data obtained by the Government of Guyana. However, there is no available open source disaggregated data by gender or ethnicity at the household level. The Consultants did utilize ecosystem services studies to collect village-level demographic data related to employment and livelihoods and population statistics in 62 coastal NDCs from Region 1 to Region 6. Data from these efforts are provided throughout Chapter 8. The Consultants have appended the EIA with the final ESS Reports (Appendix V) and updated the discussion in the EIA accordingly (Section 8.9.2). If the EAB or EPA knows of additional open source disaggregated data available at the household level, the Consultant team can also include these data within the EIA. That said, the Consultants feel that the socioeconomic information collected for the EIA is fit-for-purpose relative to the nature of potential socioeconomic impacts associated with the Project. Another deficit of the social impact analysis is the lack of the establishment of clear cause and effect relationships. Specifically, for the economic impact assessment, the economic impacts presented were vague. It was also not possible to identify the tools that were used to assess the economic impacts. Rate of return on the investment as well as Social Rate of Return on the Investment (SROI) are tools that could have been employed for the economic and social impact analysis. **Response:** Social Rate of Return on Investment and other predictive economic modelling were not within the scope of the approved Terms of Reference, and are not typical for an EIA; while these tools can provide useful information, they are typically utilized for strategic community investments or other efforts targeted at informing policy development or community development. As noted for direct and indirect economic impacts, it is typically sufficient to indicate that the Project will result in a certain type of positive impact, without characterizing the exact degree of positive change likely to occur (since there are too many factors outside of the normal course of one Project under consideration - e.g., government role in revenue and spending; contractual and business terms; other macroeconomic factors). **Impact Predictions** Impact prediction techniques were well performed for species and natural ecosystems as it relates to oil spills and other unplanned events. However, clarity is needed on the basis for the use of surface oil thickness threshold of 1.0g/m2 for the modelling of spills. **Response:** The tools utilized in the oil spill modeling analyses are gridded numerical models. They are designed to predict the flow of very small quantities of oil through the environment over time. Therefore, it is necessary to identify a thickness threshold that will be utilized as the lower limit of concern. The 1g/m² threshold that was utilized corresponds to an average oil thickness of 0.001 mm over that grid cell, as referenced below: | Threshold Type | Average Concentration Threshold | Rationale | Visual Appearance | References | |---|---|---|---|---| | **Oil on Sea Surface** | 1 g/m² ≈ 1 µm (0.001 mm) on average over the grid cell | A conservative ecological threshold for consideration of sublethal effects* on birds, marine mammals, and sea turtles from floating oil. | Fresh oil at this thickness corresponds to a slick being a dark brown or metallic sheen. | French McCay 2016 | * Sublethal effects do not produce mortality in exposed individuals. As noted, the 1g/m² thickness corresponds to oil sheens in the environment. Regarding the magnitude of impacts, the biological and the social impacts were well documented. However, clarification of the tools used for the social and economic impacts will allow a better judgment of the impacts.

Stakeholder	Comment
	Response: As part of the impact assessment process, subject-matter expert(s) from the Consultants designate the magnitude of each potential impact based on methodology that is specific to the type of resource/receptor being impacted. Section 4 of the EIA describes the methodology for rating impacts (including socioeconomic impacts), and each resource-specific subsection within Section 8 provides further details on how resource-specific magnitude and sensitivity were rated for each socioeconomic resource. The EIA also suffered from an inadequate identification and explanation of the social groups that will be affected positively and negatively by the social impacts. For example, the EIA identifies increase in governmental social spending as a positive economic and social impact of the project but fails to identify the groups that will benefit from this increase in social spending. Similarly, in identifying the job creation impacts of the project, it does not identify the social groups that will benefit from the new jobs created. Another example is the possibility of the impacts of the project on fishermen in the Berbice area. Household characteristics information and demographic information does not allow for a thorough analysis of the impact on the household and their resiliency or ability to absorb the shocks of the project activities. The social distribution of the impact's effects (both positive and negative) is one of the scientific and technical relevance of the EIA. **Response:** Further specificity has been added in the Project Description (Section 2.3) regarding type of jobs and direct spend, and generally the types of groups who will benefit. However, it should be reiterated that direct jobs generated by the Project will be limited; therefore, the Consultants concluded that assessing potential impacts at a household level is not warranted. While additional governmental social spending can be expected, that is at the discretion of the Government of Guyana. **Air Quality Section** For the air quality section of the EIA. The EAB noted the following: The total emissions by Payara would be 3.1 tonnes CO2 per year during 2023-2025 and 1.46 million tonnes of CO2 per year between 2026 and 2044. As a reference, Guyana in 2016 had 2 million tonnes of CO2 for all their activities (transport, energy, mining, agriculture, etc.). The emission in the EIA are only for extraction of oil, which will be allocated to Guyana inventory. The consortium assigned a moderate impact due to Guyana being sink of carbon (58 million CO2 per year), so this would mean Guyana would be a sink of 56 million CO2 per year which is reducing our sink capacity by only 3%. However, if assessed against the current Guyana emissions, this is about the increase in Guyana emission of CO2 by 159% first two years and 73% in the next 18 years. This increase cannot be considered a small amount and should not be considered as moderate effect. The EAB also recommends that the regulator EPA should have a very strict monitoring protocols on those emissions, as this will influence considerably Guyana's inventory. The monitoring of these emissions requires a clear comprehension of its source(s) and detail analysis of the figures. **Response:** To clarify, EEPGL estimates that within the FPSO commissioning and start-up period (currently planned for 2023-2025), the maximum GHG emissions for any one year will be 3.07 million tonnes (i.e., the estimated emissions for the other years in this period are lower); within the post-start-up operating period (currently planned for 2026-2044), the maximum GHG emissions for any one year will be 1.36 million tonnes. In any case, the Consultants acknowledge that the GHG emissions for the Project represent a significant percentage increase relative to Guyana's published GHG emissions as reported in its Second National Communication on Climate Change in 2012. If the basis for the impact significance rating was solely a function of the percentage increase in baseline reported national emissions, the Consultants would concur that a higher significance rating would be appropriate. However, in light of the fact that the baseline value is for emissions from sources within the political boundaries of Guyana and incremental impacts on climate from the Project are more appropriately measured at the global level (i.e., as an incremental increase in total global emissions), the Consultants assigned the significance rating primarily by considering the Project's GHG intensity factor (compared to the industry average). Additionally, as noted by the commenter, the Consultants considered the fact that Guyana is a sink of carbon (58 million tonnes of Co_2 per year), of which the Project's emissions would represent a 2.5% decrease. With this basis for assigning an impact significance rating, the Consultants felt that a Moderate rating was appropriate. With respect to monitoring, EEPGL understands that the EPA's authority will include monitoring of the Project's emissions and EEPGL will complete the required recordkeeping and reporting of its emissions to ensure that the EPA has the necessary information to fulfill this role.

Stakeholder	Comment
	The EAB therefore recommends that a breakdown of the numbers for the GHG be done in the following format as an example for Table 6.1-19:

Requested breakdown of GHG in table 6.1-19

Tonnes CO_2e/year	2020-2022	2023-2025	2026-2044
FPSO Venting Methane (without burning)?			
FPSO Flaring (temporary, non-routine, ...)			
FPSO Other			
Tanker Loading			
Area Sources			
Drill Ships			
TOTAL	249,000	3,176,000	1,459,000

Response: A breakdown of GHG emissions by source and by year for the Project can be found in Tables 7a and 7b of the Air Quality Modeling Report Technical Appendix (Appendix F to the Payara EIA, provided in Volume II). In addition, EEPGL provides the table below as requested.

		Annual Emissions (ktonnes)		
Pollutant	Source Category	2020 - 2022	2023 - 2025	2026 - 2044
GHGs	FPSO Other	0	898	893
	FPSO Tanks (Venting)	0	1	1
	FPSO Flaring (temporary, non-routine)	0	1884	352
	Tanker Loading	0	9	7
	Area Sources	163	192	101
	Drill Ships	86	86	0
	Total	250	3070	1355

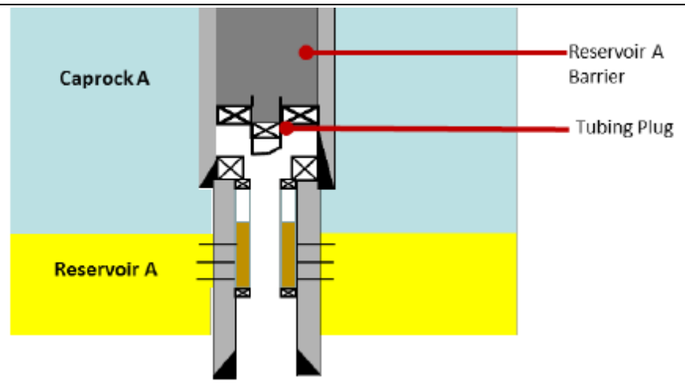
Other questions and concerns regarding the GHG emissions are as follows:

- What happens during decommissioning? How is the well going to be sealed? What is the life expectancy of the sealing? How will the company ensure there is no leakage of natural gas?

  Response: The objective of permanent plugging and abandonment (P&A) is to achieve permanent barriers with a zero leak rate. Permanent P&A is achieved by restoring suitable caprock through placement of P&A barriers. Barriers will be verified in a manner appropriate to the specific barrier, and these may include: tagging, positive or negative pressure testing, diagnostic logging, and/or review of the process that installed the barrier.

  Wells will be permanently P&A'd by installing suitable mechanical barriers that extend across the wellbore (rock-to-rock) to prevent escape of hydrocarbons to the environment. P&A barriers will be installed in the wellbore, and these will be of adequate length to contain reservoir fluids and deep enough to resist being bypassed by reservoir pressure. The number of barriers required will depend on the distribution of hydrocarbon-bearing permeable zones within the wellbore. Section 2.11 has been updated to reflect additional information related to this topic.

  The following diagram is an example showing caprock in relation to a reservoir:

Stakeholder	Comment
	 • The water separated from the oil will be treated and returned to the sea, what is the performance standards of the treatment plant? What is the chemical composition of this water? **Response:** Produced Water will be discharged after being treated by the topsides. Off-spec produced water from topsides will be directed to a dedicated produced water tank. Treated produced water will be discharge overboard via an Oil Content Monitor if the oil content is less than 42 ppm or will be returned to the topsides induced gas flotation unit for further treatment. In the event of unavailability of the produced water tank, the produced water will be transferred to slop tanks. If the produced water is routed to the slop tanks, any overboard water discharge from the slop tanks will not exceed 15 ppm oil content. Additional information has been added to Section 2.7.3.3 further describing the produced water treatment system that will be utilized. • During operations it can be expected that there would be some leakage from the wellbore and pipe prior to arriving to the FPSO. Are those leakage accounted for, and if they are, where? **Response:** There is no expected leakage from the wellbore and pipe prior to or after the FPSO arrival. All critical sealing equipment in the wellbores are pressure-tested during well construction, and subsea equipment is pressure-tested at the time of installation to ensure no leakage (loss of containment) for the expected well conditions and well life. Further well integrity preventative maintenance (PM) programs are in place that monitor and periodically test the integrity of these barriers. • Who will pay for spill remediation works and associated environmental fines? Spills of oil can affect significantly the environment and even the fishing industry and other marine related livelihoods that would be entitled to compensation for damages and losses. Is there any insurance for these possibilities? Is the insurance part of production cost? Exxon should have responsibility for spills and their associated costs. **Response:** The EIA states that EEPGL will determine financial liability in the event of a spill. The Consultants are operating under the premise that the mitigation measures and recommendations in the EIA, ESMP, and OSRP will, in conjunction with the conditions in an Environmental Permit issued by the EPA, comprise regulatory obligations that EEPGL will have to satisfy when undertaking the Project (throughout its lifetime). From the perspective of the Consultants, these management measures, combined with the legal framework that would apply to EEPGL in the event of an oil spill, are sufficient to assuage concerns regarding EEPGL's commitments to satisfy appropriate financial obligations related to a spill response. **Stakeholder Participation** The EIA acknowledges the role of stakeholder participation in the successful implementation of the project and as a mitigation action for both environmental and social impacts. However, it was unclear what tools were use in the stakeholder engagement. The EAB therefore recommends that the copies of questionnaires, focus group questions or focus group question guide, key informant questions or interview guides, etc. be provided in the Annexes.

Stakeholder	Comment
	Response: The Consultants have added to the SEP (Attachment E) examples of the templates used for the engagements for ecosystem services studies, participatory fishing studies, social infrastructure studies, and one-on-one meetings that informed the EIA. Also, it would be useful for the consortium to provide any ethno-social tools or considerations such as Free Prior and Informed Consent (FPIC) used in the consultations with indigenous groups. The information presented to stakeholders such as handouts or brochures, notes need to be provided to adequately assess the effectiveness of the consultations. **Response:** The Consultants have added to the SEP (Attachment C) examples of the non-technical summary information, briefing materials, brochures, and other information that were shared with Indigenous groups. All data collected in those engagements has already been included as part of Chapter 8, Appendix V, and the Stakeholder Engagement Plan. The stakeholder engagement sections of the document could have benefited from clear analysis of the stakeholders of the project, their associated social group(s), their roles in the project (and the stages or segments of the project activities) and ranking them. This was particularly lacking for non-governmental stakeholders. Potential Project Affected Persons (PAPs) or groups/groups in opposition to the project needed to be clearly identified; and clear actions and plans established to engage them meaningfully. There was no clear stakeholder engagement plan presented which should also include a communications plan and the responsible persons or persons for the implementation of the stakeholder engagement plan. **Response:** The Stakeholder Engagement Plan, which is part of Volume III of the regulatory submittal, provides the information requested in the comment. The EAB therefore suggests the development of a stakeholder engagement plan with an associated communications plan and a budget of the costs. Possible templates are presented below: **Stakeholder Engagement Plan** **Communication Plan** **Response:** The Stakeholder Engagement Plan, which is part of Volume III of the regulatory submittal, provides the information requested in the comment (with the exception of budgetary information, which is not typically included in a plan of this nature).

Stakeholder Engagement Plan

Stakeholder Group	Why included (interest)	Participation method	Responsibility	Preliminary initial Cost estimate $[1]	Frequency	Timeline/Operations Segment
Governmental Stakeholders						
Department of Energy	Regulatory agency for Petroleum	Meetings with Director and staff Briefings and bulletins	Office of Country Director		Quarterly and as needed in cases of urgency	All stages

Communication Plan

Stakeholder and Communication Medium	Company Website/ List Serv	Social Media	Project Brochures, Information Sheets and Press Releases	Project Branded Materials and Merchandise	Project Briefs and Information Notes	Outreach Meetings Sensitizations Sessions
National Governmental Agencies						
Private Sector, Enterprises, Small and Medium Businesses						
Non-Governmental Organizations/Civic Bodies						
Local Development Organizations						
Educational Institutions and Centers of Learning						
General Public						
Rural Populations						

Stakeholder	Comment
	Monitoring of Management Plans Finally, regarding the monitoring of the management plans, a framework is presented but a clear comprehensive plan is not discernible. For species and ecosystems, the EIA did, mostly, address when and where sampling would be done, and tests carried out and some information on how results would be evaluated. However, the EAB was unable to locate information that addresses the specific frequency of monitoring for some animals such as the marine turtles, marine mammals, riverine mammals, and the financial and human resources needed for the successful implementation of the management plan. **Response:** Table 3-9 in the ESMP describes the frequency at which the individual proposed monitoring measures would be carried out. Some elements relate to EEPGL's activities rather than to seasonal environmental trends, and can therefore be accomplished at any time of year (e.g., facility audits, emissions reporting, etc.). Other monitoring required by the ESMP would occur with sufficient frequency (e.g., continuously, daily, quarterly) to detect seasonal variations. The Consultant team considers the detail provided in this table to be sufficient for the purposes of the regulatory submittal. It is also noted that EEPGL has undertaken multiple years of biological resource studies and intends to work with the EPA to conduct appropriate studies to evaluate potential impacts over time.
U.S. Bureau of Ocean Energy Management (BOEM)	1. The project will be located in a deepwater area, but much of the information presented focuses more on nearshore and coastal areas. It is recognized that this could be because data and information in those areas are more readily available compared to the deeper waters of the project area. To this end, it is recommended that more site-specific detail is included or being clear about when data are not available and making appropriate extrapolations or providing information from analogous areas that have been better studied. It may also be appropriate to identify important data gaps if no relevant information is available (e.g., consistently disclose where there is relatively little information for a given resource or category of resources). **Response:** The statement that "much of the information presented focuses more on nearshore and coastal areas" under-represents the large amount of data that has been collected offshore Guyana and included in the Payara EIA. Although the EIA contains a large amount of nearshore- and coastal-oriented information, the information on existing conditions in the deepwater marine environment presented in the EIA reflects an extensive program of site-specific studies over several years, including: four separate offshore air quality surveys, four environmental baseline surveys (which included water quality, sediment quality, and benthic biological sampling), nine separate marine bird surveys, over 30 marine mammal surveys (using both visual and acoustic survey methods), and two deepwater marine fish surveys. All of these surveys were conducted in deepwater environments within the Stabroek Block or adjoining deepwater environs. The results of these studies are presented in detail in the EIA and in Volume II of the regulatory submittal. 2. In general, there seemed to be an inconsistent use of references to primary literature to support conclusions or assertions. If this is related to a paucity of information, it is recommended that this made clear. A lot of information was present in this document, yet it was not always clear where that information was coming from. It is felt that the proponent could better support findings using relevant research and referencing within the document. **Response:** The sources of the information presented in Chapters 6, 7, and 8 of the EIA are fully cited in Chapter 15. These chapters account for well over 300 individually referenced sources, and the detail with which the sources in Chapters 6, 7, and 8 have been documented provides a complete record of the information that has been included for each receptor in the EIA. It is acknowledged that the amount and sources of the baseline information included in the EIA varies across the different receptors, and that the data from the site-specific studies are combined with information from the scientific literature, government reports, and other available data sources in different ways and to varying degrees across different receptor discussions in the EIA; however, these differences are driven less by the availability of data and more by a deliberate effort to achieve a balance between inclusiveness and overwhelming the public with extraneous baseline data. It is emphasized that the EIA is not intended to provide an academic treatise on each receptor. Rather, the EIA is intended to succinctly provide the necessary information for the public to understand the Project's impacts without being overly voluminous or too technically challenging. While the EIA was designed to strike this balance appropriately, in recognition of the volume and variety of information included in these chapters, brief summaries of the types of baseline information that appears in each chapter have been added to the beginnings of Chapters 6, 7, and 8. In addition, in recognition of the desire for additional literature references, a number of selected references have been added where appropriate to further support the conclusions of the EIA. 3. It was noted that statements were made regarding important topics/conclusions/findings/etc., but there were not necessarily strong explanations to support those statements. In this regard, it is recommended that more “because” statements throughout to better connect the dots for the reader as to why impact conclusions are what they are. For example:

Stakeholder	Comment
	• The last two sentences in section 7.5.3.4 seem inconsistent without a "because" statement. The sentences read "Impacts would occur within the Direct AOI (PDA) and would be Continuous and Long-term. Accordingly, the magnitude of impact is Negligible (Table 7.5-15)." However, it is not obvious how something "continuous" and "long-term" could be considered negligible. The content preceding these sentences does not provide clarity. **Response:** The rating methodology used in the EIA involves a number of variables, and the multi-variable nature of the rating system is a direct result of the EPA's prior request (during review of the Liza Phase 2 EIA) to enhance the level of detail leading up to the EIA ratings. The key to understanding how something that is continuous and long-term could be considered negligible is to refer to the magnitude rating matrix depicted in Figure 4.6-2 in Section 4.6.2 of the EIA. As illustrated in this matrix, any impact that is assigned a Negligible intensity rating receives an overall magnitude rating of Negligible, regardless of how the duration or frequency factors are rated for that impact. As clearly indicated in the section referenced by the comment, the intensity of potential impacts on marine mammals from exposure to permitted discharges is considered Negligible (for the reasons described in the text); therefore, the overall magnitude of the impact is also rated as Negligible. • The last paragraph in section 7.9.3.4 makes statements that seem inconsistent with the final conclusions in the paragraph without more explicit explanations. For example, mortality is "anticipated to be high," organisms "may be left with injuries," and population structure "may temporarily change." Despite these comments, the intensity of impact is labeled as "low," which seems to be a disconnect. Further, it is stated that "this impact will only occur within a small percentage of the Subsea PDA," yet there is no "because" statement to go with this assertion. It could be interpreted by the reader that this is the reason the impacts are considered to be "low," yet it is unclear. **Response:** The intensity rating for impacts related to injury or disturbance of marine benthos due to FPSO and SURF installation is driven primarily by the extremely small percentage of seabed habitat that would be directly affected within the PDA and Stabroek Block (approximately 1% and 0.003%, respectively). Although there will very likely be some level of benthos injury and mortality in the installation footprint, the proportion of the larger benthic ecosystem that would be affected would be sufficiently small to render the impact insignificant at an ecosystem scale. The specific passage of Section 7.9.3.4 identified in the comment has been edited to explain this rationale more clearly. 4. The discussion on ecosystem services focuses on coastal and nearshore with nothing from deep sea, as even the "fishing" category appears to focus more on areas around the coast. What about deep sea ecosystem services? **Response:** Additional language and references have been added in Sections 7.10.2 and 7.10.3 on deep marine ecosystem services and the Project's potential impacts on them. 5. Further discussions on the on the potential impact of noise and light on marine benthos can be provided. **Response:** It is noted that many of the marine benthic organisms known to occur in the PDA through the EBS surveys do not have complex eyes and ears, and are therefore physiologically limited in their ability to detect (and therefore be impacted by) acoustic or light impacts. Although it is believed that the existing assessment in the EIA is adequate to address the potential impacts on marine benthos, additional detail has been added to Section 7.9.3.4 to support the conclusions of the EIA. 6. Improve discussions on the potential impacts to fish due to seafloor disturbance. **Response:** Although it is believed that the existing assessment in the EIA is adequate to address the potential impacts on marine fish from seafloor disturbance, additional detail has been added to Section 7.8.3.5 to support the conclusions of the EIA. 7. Provide analysis of hard seafloor features since the geological discussions are more focused on soft sediments. If this information is not documented for the project area, we suggest considering seafloor surveys and avoidance protocols for live bottom, archeological resources, or other sensitive sea floor areas. **Response:** Section 7.8.2 describes the types of organisms that occur on the hard seafloor features (HSFs) identified in the PDA, and Section 7.8.3 describes the types of impacts that these organisms would likely experience as result of installation of the wells and SURF components. Section 6.3.3.2 provides an estimate of the number of HSFs that could be impacted by sediment deposition outside the SURF footprint as a result of installing the wells. In light of the relatively small number of HSFs that are expected to be impacted within the sediment deposition zone (approximately 53 HSFs, or 0.005 percent of the more than 1.1 million HSFs that are estimated to exist within the study area), the EIA has concluded that avoidance protocols to protect HSFs are not necessary. With respect to archaeological resources, Volume III of the

Stakeholder	Comment
	regulatory submittal contains the chance find procedure that would be implemented in the event that archaeological resources are found during the course of constructing or operating the Project.
Environmental Protection Agency	**<u>Initial Comments – January, 2020</u>** **Payara Development Project Volume 1, Part I – Environmental Impact Assessment** **General Comment** **1.** The document mentions the evaluation of alternatives for antifouling chemical dosing, however, timelines nor types of alternatives for consideration were not mentioned. This should be addressed. **Response:** Flow assurance chemicals are evaluated and selected based on a competitive technical and commercial evaluation bid process that includes various independent oilfield chemical supplier participants. Technical evaluations on oilfield chemical supplier proposed chemicals can include various tests and lab analyses to assess and evaluate chemical characteristics and performance against project specified functional requirements, chemical performance specifications, and Company/Country specific criteria. Selection of flow assurance chemicals and associated oilfield chemical suppliers will be based on Company specified technical and commercial evaluation specific to the project. Specialty chemicals such as asphaltene inhibitor will also undergo additional Company evaluation by utilizing Company's proprietary research and lab testing capabilities to validate supplier proposed inhibitor chemicals against technical criteria. Types of flow assurance chemicals specified for the Payara Project (such as but not limited to asphaltene inhibitor, scale inhibitor, xylene, methanol, etc.) are categories of industry standard chemicals that have been typically utilized within ExxonMobil and the oil and gas industry. As of June 2020, flow assurance chemicals for the Payara Project have not been selected, but chemical suppliers in competition for the Payara Oilfield chemicals goods and services contract have previously provided similar chemicals for other oil and gas ventures. For example, the Liza Phase 1 Project has selected a similar chemical supplier that provides flow assurance chemicals such as asphaltene inhibitor, scale inhibitor, xylene, and methanol volumes. Bulk chemicals such as methanol and xylene are industry standard chemicals utilized across oil and gas ventures. Due to the competitive nature of the bidding process, specialty chemicals such as the asphaltene inhibitor and scale inhibitor chemicals proposed by chemical suppliers specific to the Payara bid may not be an industry standard chemical, as each supplier uses their proprietary capabilities to develop and propose optimized chemicals that are best suited for the Payara bid criteria. Although these chemicals are optimized, general chemical compositions and associated chemical information (e.g., safety data sheets) are still provided to Company for proper design, chemical management, and chemical handling purposes, as well as environmental standards. Section 2.12.1 of the EIA has been updated to include additional information relevant to this topic. **2.** Detailed technical process overview of the entire process including start-up to be inserted in the document. **Response:** The FPSO start-up sequence is as follows: • Gas Turbine Generators (GTGs) on Marine Gas Oil (MGO), • Utilities, • Oil systems, • Main Gas Compression (MGC), • GTGs on fuel, • Flash Gas Compression (FGC), • Injection Gas Compressor (IGC), • Seawater treatment injection systems, • Produced water treatment. Chapter 2 of the Payara EIA has been updated with text and supporting figures regarding the following processes; • Oil Processing System Overview • Gas Processing Overview including: ○ Flash Gas Compression

Stakeholder	Comment
	○ Main Gas Compression ○ Gas Treatment System ○ Injection Gas Compression **Specific Comments** 1. **2.7.3.2. Gas Processing:** This section to include detailed technical description/overview and schematics of the Gas Processing system .i.e.: • Gas compression and injection system • Gas treatment system **Response:** Please see response to above comment. 2. **Section 2.7.4.3. Flaring System:** This section to include the following information: • Flare Profile over the lifetime of the Payara Operations, including start-up and non-routine flaring • Optimizations for early flare out and a gas flaring minimisation plan • Well Ramp Up and FPSO commissioning activities schedule to achieve flare out. • Lessons learnt from the start-up of the Liza Phase 1 Development Project and proposed corrective actions **Response:** • Please see EIA, Volume II, Appendix F - Air Quality Modeling Report for specific information pertaining to flare specifications and emissions. • Please see EIA Volume I, Chapter 6.1 for specific information on flare minimization. • Details on start-up and FPSO commissioning activities will be developed during the Project Detailed Design phase, which will have as an objective the minimization of flaring. • Section 2.7.4.3 of the EIA has been updated to discuss lessons learned regarding the start-up challenges experienced with the Liza 1 FPSO, and the measures being undertaken based on these lessons learned. 3. **Section 3.3.3 Emergency Response Model:** This section of the document gives examples of the different tiers of emergency (tier 1, 11, 111); it further explains how an oil spill can escalate from one tier to the next. The document lacks information on how other emergencies (explosions, fires etc.) are being categorized and placed under the different tiers. **Response:** As described in the OSRP, the Tier level for oil spill incident severity is a globally recognized classification methodology based on the extent of resources applied for the response. The tier level is a subset of ExxonMobil's overall tiered incident severity classification (Severity Levels 1, 2, & 3) which considers a broader range of potential consequences, including: • Health / Injury • Public Impact • Environmental (including the oil spill tier levels) • Process Safety / Emergency Response Operations • Security • Financial • External Exposure

Stakeholder	Comment
	The actual extent of the emergency response is driven by the objectives to protect people, environment, assets and reputation, using a no regrets approach to the deployment of resources in responding, that being to over respond with resources (people, equipment, … etc.) and then to effectively manage the response as more details become available. 4. **Page 346:-** Table indicates that produced water containing oil and grease requires treatment. Besides the embedded controls, there is no indication of what particular technology or treatment process will be used to meet discharge criteria. What specific deoiling technology will be utilized? A detailed technical description of the process (with accompanying schematics) must be provided. **Response:** Additional information regarding produced water treatment, including discharge criteria, de-oiling technology, and a description and schematics of the process, has been added to Section 2.7.3.3. 5. **Pg 341: Defining Intensity levels:** Qualitative definitions are provided as- localized area, moderately sized etc. Quantitative ranges can be provided instead and if possible, a spatial representation of the ranges. **Response:** Intensity is rated differently for different resources because, as described in Section 4.6.1.1, the same impact could be experienced differently by different receptors. The inherent differences in the way impacts are experienced by different receptors require some flexibility in the way intensity is rated across the various receptors. Qualitative spatial descriptions are used most frequently in the intensity ratings for physical resources (e.g., water quality, sediment quality) because the actual areas over which relevant thresholds would be exceeded (i.e., at most a few hundred meters) are insignificant at the seascape level, and any quantitatively defined areas (e.g., 500m, 1000m, 5000m) that could have been used to define the bounds of the intensity scale would have been arbitrary. To cover the various types of impacts that could be relevant for a given resource, the intensity levels were therefore defined qualitatively where appropriate, to afford the ability to represent an impact on the resource that was not constrained to a specific quantitative bounds. 6. **7.3.2.2 Coastal Birds**: Under the Coastal Bird Survey data collected 2017-2019 in AOS, the reporting under the non-tropical seasonal regimes should consider Guyana's seasonal conditions. Or explain the reasons of such labeling. **Response:** Non-tropical seasonal regimes, specifically the North America seasonal regime (winter, spring, summer, and fall), were used for the coastal bird surveys because the presence/absence of migratory species in Guyana during spring and fall is the primary driver for the seasonal changes in coastal bird species composition and abundance due to Guyana's location within a major migratory corridor. The Guyana rainy and dry seasons affect the ability to detect birds, local bird activity, habitat use, etc. but not to the degree that migration affects these metrics. Nevertheless, the tropical seasonal regimes in Guyana largely mirror the North America seasons, with the winter, spring, summer, and fall seasons coinciding with the January/February wet season, April dry season, June/July wet season, and September/early October dry season. 7. **Waste Water Management and Solid Waste Management** a) The procedure used for testing of produced water before discharge is not clear. b) What logs does EEPGL have monitoring the produced water? c) What standards are followed when dealing with produced water? d) What are the overboard discharge specifications highlighted in 2.7.8.1. **Response:** For items a) - d), additional text and schematics have been added to Section 2.7.3.4 regarding the following processes; • Produced Water Treatment and Testing • Produced Water Monitoring and Recordkeeping • Produced Water Treatment Standards • Overboard Discharge Standard Additional detail regarding the produced water treatment system, including the process for testing produced water before discharge, has also been added to Section 2.17.3.5.

Stakeholder	Comment
	e) The difference between stripping water, slop water, wash water, production water and produced water should be clearly defined within the EIA, as well as their discharge criteria and applicable International Standards. **Response:** The discharge streams associated with FPSO operations are discussed below. This information has been added to Section 2.7.3 of the EIA, along with the discharge criteria for each stream. **Produced Water** Produced water is a general term used to describe the water that comes from the reservoir (i.e., along with recovered hydrocarbons). Produced Water will be discharged after being treated by the topsides. Off-spec produced water from topsides will be directed to a dedicated produced water tank. Treated produced water will be discharge overboard via an Oil Content Monitor if the oil content is less than 42 ppm or will be returned to the topsides induced gas flotation unit for further treatment. In the event of unavailability of the produced water tank, the produced water will be transferred to slop tanks. If the produced water is routed to the slop tanks, any overboard water discharge from the slop tanks will not exceed 15 ppm oil content. **Slop Water** Slop water (also referred to as "slop tank water") is made up of process wastewater streams and surface runoff from all areas and oily drains on the FPSO main deck that is routed to the slop tank through gravity drains. The slop system is capable of treating the slop water (heat-assisted 2-stage gravitational separation) such that the overboard discharge will not contain more than 15 ppm oil. **Stripping Water** Each cargo oil tank is fitted with a stripping eductor. Cargo tank stripping up to the 100 mm level can be achieved via crude oil pumps; should further stripping be required, the stripping eductors will be used. The water from the slop tanks used to drive the stripping eductors and strip the cargo tanks below 100 millimeters to prepare the cargo tank for entry is defined as "Stripping Water." The source of slop water is from hazardous and non-hazardous drains from topsides that are collected in the slop tanks. The oily water mixture from the bottom of the tank is routed back to the slop tanks. The resulting oily water mixture from the bottom of the tank is routed back to the slop tanks for treatment and discharge in accordance with slop water discharge specification (less than 15 ppm oil content). **Wash Water** Wash water is a term that is used specifically to describe fresh water that is used for desalting the crude. Wash water is filtered seawater that has been demineralized via reverse osmosis membranes. The aqueous streams resulting from the crude desalting process are combined with produced water and discharged overboard after being treated to the discharge specification of less than 42 mg/L. **Bilge Water** Bilge water is made up of water that may accumulate in the low point areas of the Machinery Spaces within the vessel due to condensation, washing, firefighting, etc., and collected in bilge wells and subsequently routed to the bilge holding tank. From there, bilge water is sent to the bilge water separator unit for oil/water separation, with separated water (meeting the specification of less than 15 ppm oil content) discharged overboard and separated oil sent to the oily bilge tank. Oil and sludge from the oily bilge tank is pumped to a supply vessel for onshore disposal. **Sewage (Grey and Black Water)** The sewage treatment system comprises separate sanitary drain collection networks provided for grey and black water streams and sewage treatment facilities including a grey water treatment tank, chlorination/de-chlorination dosing facilities and a sewage treatment plant (STP). Black water discharges from all sources are sent to the STP aeration tank for treatment. Black water treatment then continues inside the STP progressively, starting from the STP's aeration tank, then into its settling tank, and finally into its contact tank. The contact tank's contents will be sterilized by ultraviolet as the primary method, with an option to chlorinate using the STP's dosing pumps as a secondary method. Treated black water will be discharged overboard via the STP overboard discharge points located on the port and starboard sides of the FPSO (with a total residual chlorine concentration as low as practical, but not less than 1 ppm). Grey water discharges from all sources, (except for food waste from the galley macerator) are combined and dosed with chlorine automatically via the chlorine dosing system just before entering the grey water treatment tank. Chlorination will then continue inside the tank. At a predetermined tank level, the duty grey water pump will automatically start and pump the tank contents overboard. In an upset condition, all sewage overflows from the affected sewage collection points (STP, Grey Water Treatment Tank, and/or Grease Trap/Separator) will be sent to the oily bilge tank for collection and discharge to a supply vessel for onshore disposal. The FPSO will not have a unique discharge stream referred to as "production water."

Stakeholder	Comment
	f) Table 2.12-1: What will happen with the water based drill cutting? The manner in which water based drill cuttings will be treated should be highlighted within the document. A detailed technical description (with accompanying schematic) of the process must be provided. **Response:** **WBDF Management** Water Based Drilling Fluids (WBDF) will be used to drill the initial open hole sections where WBDF returns and drilling cuttings are discharged at the seabed. This is consistent with the industry practices used globally to drill the top 28" hole sections of development and exploration wells. WBDF contains no hydrocarbons; accordingly, no treatment of WBDF-based cuttings is required. Drilling fluids are selected to ensure they are suitable for deepwater operations and the temperatures and pressures that will be encountered to ensure the safety and integrity of the drilling operations including well control and borehole stability. Section 2.5.3 of the EIA presents this information and has been updated to include a schematic depicting the discharge of WBDF returns and cuttings at the seabed. The WBDF contain the commonly used products: saltwater, polymers and stabilizers - which are not harmful to marine life and the environment. They include the following products: • Sodium chloride brine – this is salt water made from table salt; it is largely the same salt as seawater, but a little more concentrated • Xanthan gum - this is a polysaccharide with many industrial uses, including as a common food additive. It is an effective thickening agent and stabilizer to prevent ingredients from separating. It can be produced from simple sugars using a fermentation process, and derives its name from the species of bacteria used, *Xanthomonas campestris*. Xanthan gum can be found as an ingredient in many foods: ketchup, yoghurt, salad dressing, among others. It is not harmful to humans or the marine environment. • Caustic soda – in a small concentration to stabilize the fluid to a pH of 7.5 – 9.0; • Bactericide – a very small concentration (5 gal/1000 bbl), similar to caustic soda; helps as a stabilizer for xanthan gum • Barite – a natural occurring mineral (barium sulfate, an inert solid) This WBDF is the standard formulation also used for drilling the top holes in the Gulf of Mexico. All these products disperse quickly in the seawater and degrade readily with the exception of barite - an inert mineral used to increase the density of the fluids critical for safety. Additional testing of WBDF containing barite has been routinely performed across the industry. Toxicity testing of WBDF easily passes such tests. g) For section 2.12-7 where are the documents which speak about the treatment? A detailed technical description (with accompanying flow diagram) of each treatment process must be provided. **Response:** Regarding the streams in Table 2.12-7 indicated as requiring treatment, additional text has been added to the Payara EIA as follows: • Section 2.7.3.4 has been added to the EIA to describe the produced water treatment system, including a process flow diagram. • Section 2.7.3.6 has been added to the EIA to describe the slop system treatment system, including a process flow diagram. • Section 2.7.3.7 has been added to the EIA to describe the bilge water treatment system, including a process flow diagram. • Section 2.7.3.8 has been added to the EIA to describe the sewage treatment system, including a process flow diagram. h) Why is there no contingency plan for hazardous waste? EEPGL will be generating a significant amount of hazardous waste. i) What are the plans for the disposal of garbage? Will the garbage be transported to shore or elsewhere? j) Does EEPGL have sufficient infrastructure to facility the amount of waste they are generating. **Response:** EEPGL has built in contingency through the use of conservative estimates of both hazardous and non-hazardous waste types and quantities within the Payara EIA, as reflected in the comprehensive integrated Waste Management Plan (WMP) provided in Volume III of the Payara EIA. EEPGL continues to implement those embedded controls and mitigation measures to reduce the generation of wastes at the source. The WMP contains separate sections on the strategy for handling hazardous and nonhazardous waste (Section 5), available disposal and treatment methods (Section 6), and a plan for record keeping and reporting (Section 8). In terms of ""contingencies"", the various management methods that may be used by EEPGL are described in Section 6. EEPGL's continued program operations are contingent

Stakeholder	Comment
	on the availability of sufficient infrastructure to manage its hazardous waste, and to that end EEPGL maintains flexibility in terms of which specific hazardous waste management infrastructure can be used. Each contracted 3rd party vessel supporting EEPGL's Drilling, Installation and Production Operations has a Garbage Management Plan and per MARPOL maintains, a Garbage Record Book that outlines how such wastes will be managed. Consistent with EEPGL's WMP, such non-hazardous wastes, garbage (e.g., trash, rubbish, refuse, paper, cardboard, kitchen wastes) are either reused, recycled or disposed of in a landfill. Food wastes can be incinerated on board a vessel, macerated and discharged per MARPOL or disposed onshore in accordance with such plans and Guyana laws and regulations. Wastes are tracked, records are kept, and monthly and annual waste reports prepared and submitted documenting how those wastes were managed. EEPGL has recognized and continues to recognize the nearer and longer-term need for additional 3rd party waste facilities and service providers in Guyana. To address this, EEPGL has performed multiple waste capacity assessments that identified and supported the growth of existing 3rd party waste storage, treatment and disposal facilities to date. Further, in the summer of 2019, EEPGL released a Request for Information (RFI) to the Guyana market to find qualified suppliers to perform waste management and recycling services. After evaluation of the responses, EEPGL invited qualified suppliers to a bid process, the results of which were reviewed and finalized. This will build additional capacity for EEPGL's hazardous, non-hazardous, and exempt hazardous waste to be stored, processed, treated, or recycled. EEPGL has completed the evaluation and plans to award the contract for additional waste management capacity in 3Q2020. The added waste management capacity derived from these efforts will protect human health and the environment as well as meet the needs of EEPGL, the Payara Development Project, and beyond. Section 8 of the EIA discusses the mitigation measures that were already in the process of being implemented at the time the EIA was written to address potential infrastructure capacity constraints. Based on the progress with these measures, EEPGL has concluded that sufficient waste management infrastructure will be in place to manage the wastes from the Project. **8. Socio-economic Section** How many Guyanese will be hired? There was no mention of diversification in the social and economic section. **Response:** Additional information has been added to Section 2.3 of the EIA to indicate the targeted proportion of Guyanese workers that will be hired for the Payara Project. EEPGL is committed to supporting the economic and social development of the communities where it operates. In July 2017, EEPGL established the Centre for Local Business Development to assist small- and medium-sized Guyanese businesses building their capacity and improving their competitiveness for the broader economy. In addition, EEPGL has been working closely with the Council for Technical and Vocational Education Training for over the past year and half to identify training areas where development will not only fit into the emerging industry, but will also offer sustainable skills to young Guyanese. Following visits to Guyana's regional institutions and in depth discussions to review the existing TVET Programmes, EEPGL and the regional institutions have aligned in the selection of craft skill areas to develop diverse vocational programs, which will further develop competencies. Those craft skills are expected to produce an enhanced technical workforce with the ability to span different economic sectors. **Payara Development Project Volume III - Environmental and Socioeconomic Management Plan** **General Comments** a) **Section 3.1.2 Management Measures, pgs 26-47:** within this section the different potential impacts from the project are highlighted in table form. The different tables highlight water quality measures, air quality measures, etc., however the table lacks information on who/whom from within the different involved facilities will be responsible for the management of the measures. **Response:** Key roles and responsibilities as it relates to implementation of the management measures outlined in the ESMP are outlined in Table 2-4 of the ESMP. This organizational structure and the associated organizational roles and responsibilities will be further defined in future revisions of this document, as needed, once the Project achieves a Final Investment Decision (which occurs after the Project receives regulatory approvals). In some cases, these roles correspond to individuals, in others they correspond to teams. As indicated in Table 2-4, ER&S staff implement are responsible for the implementation of individual management measures, and responsibility for implementation of the ESMP as a whole resides with the Environment and Regulatory Manager. The Lead Country Manager has ultimate responsibility for ensuring compliance with all regulatory requirements, including the measures in the ESMP.

Stakeholder	Comment
	b) **Table 3.2 Water Quality Measures, pg 30:** states that if the oil content of produced waste water is observed to exceed the accepted limits, it will be routed to an appropriate storage tank on the FPSO until treatment system is restored. Please clarify whether the rerouting if necessary will be automatic or manual. **Response:** Sections 2.7.3.3 and 2.17.3.5 have been updated to include additional information on the re-routing of produced water which does not achieve discharge criteria prior to overboard discharge. As described therein, re-routing will be automatic. c) **Cultural Heritage Monitoring Programme, figure 3.3** Chance Find Reporting Form, pg 49: The reporting form should include a picture of the chance find / artifact. **Response:** Figure 3-3 of the ESMP has been modified to reflect that an image or photo of the chance find, or a replica thereof, will be included in the completed Chance Find Reporting Form. **<u>Comments from Field Development Plan Meeting in Houston Texas, February, 2020</u>** **a.Flare profile and flare minimization plan** Via preliminary comments on the EIA, the EPA had requested the following information which was not provided and thus must be included in the amended EIA: 1. Flare profile for Payara Operations, including start-up and non-routine flaring 2. Optimizations for early flare out and a gas flaring minimisation plan 3. Well Ramp Up and FPSO commissioning activities schedule to achieve flare out. **Response:** Startup flaring for the Project includes temporary flaring for a period of approximately 90 days. During commissioning and start-up planning, EEPGL will work to minimize the duration of startup flaring. EEPGL will incorporate lessons learned from Liza Phase 1 and Liza Phase 2 startups in the Payara commissioning and start-up planning. Approximately 12 months prior to startup, EEPGL will conduct a workshop with EPA and other appropriate regulators, and seek to align on the flare out timeline with the EPA. Based on this workshop, EEPGL will provide an additional submittal that documents the agreed flare out targets that were reached through a collaborative partnership. Section 6.1.3.2 of the EIA has been updated to include this information. Additionally, the following information must be included in the Payara EIA: 1. Produced gas profile for each well. This should include the amount of gas produced in each Well over the lifetime of the projects, as well as the amount of gas reinjected based on the gas production rate of each well. **Response:** Data on the produced gas profile for each well can be discussed in a separate workshop with EPA. 2. The Gas-Oil Ratio (GoR) **Response:** The Gas-Oil Ratio (GoR) can be discussed in a separate workshop with EPA. 3. When gas breakthrough is expected, what are the impacts/consequences of the gas breakthrough, and what mitigation measures will be implemented to deal with gas breakthrough? **Response:** The following information on gas breakthrough has been added to the EIA in Section 2.7.3.2: Gas breakthrough is predicted to begin in 2026 (approximately 2 years after field start-up). If unmanaged, gas breakthrough can impact effective reservoir sweep. Moreover, excessive gas production beyond facility handling limit results in deferred oil production. The water-alternating-gas (WAG) injection scheme employed for the Payara development allows for managing gas breakthrough and drives optimal utilization of injected gas. WAG offers flexibility to redistribute available gas to reservoirs that will benefit the most from gas injection, with the spreading of gas providing mitigation against gas cycling through a reservoir. Further mitigation of gas breakthrough is enabled by implementation of multi-zone completions that offer selective choking of segments of completions where gas is continuously produced. Overall, the reservoir management strategy assumes no gas flaring during steady-state production operations, and gas is primarily utilized for improving recovery.

Stakeholder	Comment
	b.Injection of Sea Water versus Injection of Produced Water Comparative assessment on the use of sea water versus produced water during re-injection must be provided. Considering the use of both produced water and sea water, the assessment must include the following details: technological, environmental and safety considerations justifying selection, all chemical reaction equations associated with the formation of precipitates, scale mitigation strategies, fouling of wells and its associated impacts, flow assurance additives and its associated impacts. **Response:** Injection of produced water was evaluated, and the full details of that evaluation can be now be found in Chapter 2 of the EIA (Section 2.17.3.5). After several years, once produced water is generated, there are two primary options for its disposition. It can either be treated and discharged overboard, or it can be combined with sea water and injected. Overboard discharge of treated produced water was selected for the Payara Project, based on the Best Available Technology analysis, which is described in Section 2.17.3.5. Note that the environmental impact for overboard discharge of treated produced water was assessed as negligible (see Table 6.4-10). Modeling conducted for the EIA indicated a 98.6% reduction in oil and grease and other residual production chemicals. Additional information on produced water treatment and seawater injection systems has been added to the EIA (Section 2.7.3.4 and 2.7.3.5). In order to increase oil recovery, water is injected into oil reservoirs to refill the voidage created by the removal of oil and natural gas, and to help direct oil to the producing wells. The water to be injected to assist with oil recovery can consist of produced water recovered from producing wells, and/or sea water. Produced water is water that is produced as a byproduct during the extraction of oil and natural gas. Oil and gas reservoirs nearly always have water as well as hydrocarbons, sometimes in a zone that lies under the hydrocarbons, and sometimes in the same zone with the oil and gas. Produced water is not forecast to be produced until the wells have been producing for several years. Therefore, the FPSO must be designed for injection of sea water to assist with oil recovery so that voidage can be managed starting closely after commencement of production from the reservoir(s). Additional information has been added to Section 2.17.3.5 providing the chemical reaction equations associated with the formation of precipitates, the associated potential effects on injectivity, and scale mitigation strategies—including flow assurance additives. The use of sea water for re-injection present several challenges, such as scaling, corrosion of tubular and formation damage. In this regard, details must be provided on proposed treatment methods prior to use. **Response:** Section 2.7.3.4 contains further details on the sea water treatment and water injection system. **c.Capping Stack Deployment** A justification must be provided for the 9-day deployment period of the capping stack outlined in the EIA. Justification must include all technical and logistical considerations. **Response:** At the time the EIA was submitted, the response time associated with the Boots & Coots GRIP capping stack deployment was based off preliminary and conservative logistics assumptions. After establishing the subscription to the Boots & Coots GRIP system, and in conjunction with the ongoing capping stack study, the response time model has been refined to reflect current logistics strategies and it is now estimated that the capping stack deployment is possible within 5 days. The OSRP has been updated to reflect the revised capping stack deployment basis. Further, during discussions on the Oil Spill Response Component during the environmental session at the Field Development Plan meeting in Houston, Texas, it was mentioned that another model which speaks to a 6-day deployment period for the capping stack was mentioned. In this regard, the Company is required to provide reasons for not including this model in the EIA. **Response:** The EIS (Executive Summary and Section 3.3.5), EIA (Section 9.24.4), and OSRP have been modified to reflect a 5-day capping stack deployment timeline. Additionally, oil spill response modeling has been revised to reflect this deployment timeframe. **d.Decommissioning** The conceptual decommissioning plan provide in the EIA study must be amended to include the following details:

Stakeholder	Comment
	1. Regulatory framework guiding the decommissioning programme. 2. Overview of installations that will be decommissioned 3. Proposed decommissioning options/methods and environmental considerations 4. Proposed methods for disposal and removal of waste 5. Proposed monitoring programmes post decommissioning 6. Projected schedule **Response:** A revised Preliminary End of Operations Decommissioning Plan has been included in the EIA (Volume III). **e.Seismology Study and Hydraulic Fracturing** The EIA must include a seismology study which discusses the potential for earthquakes and tremors due to hydraulic fracturing from drilling operations. **Response:** There will not be any hydraulic fracturing activities. The Payara development is not relying or planning on fracking for enhanced well productivity and there is no plan to inject above fracture pressures. The reservoir management strategy focuses on pressure maintenance and avoids depletion extremes. Section 5.2.1 of the EIA includes an assessment of the potential for geological/seismic impacts. The EIA concluded that the Project is considered to have a negligible potential to result in seismic risk, including risk of tsunamis reaching Guyana. **f.De-sanding Facilities** The EIA to include the following details on de-sanding facilities: a detailed technical description of the process (with accompanying schematics), an estimation of the quantities to be processed per year, impacts of the process and measures to mitigate those impacts, and final disposal of all waste from the process (including disposal parameter) **Response:** The EIA (Section 2.7.3.1) has been updated to include additional details on de-sanding facilities, including a process overview, a process schematic, information regarding treatment and disposition of accumulated sand (temporary storage for eventual onshore disposal), and estimated quantities of sand that will be generated for disposal. **<u>Additional Comments – June, 2020</u>** 1. Cradle to Grave Analysis of Waste Streams: For each waste stream, the analysis should include but not be limited to the following: • Point(s) of generation along with composition, concentration and quantity generated. • Treatment methods/technologies (for both onshore and offshore treatment). Should include a detailed technical description of each treatment process accompanied by flow diagram(s)). Aslo, the composition, concentration and quantity of the waste before and after treatment should be reported. • If the waste stream is discharged offshore, show the composition, concentration, quantity and frequency of the discharge. • If the waste stream is disposed of onshore, show the composition, concentration, quantity, frequency of disposal and disposal location. • A mass/material balance of all waste streams from the point of origin to the point of final disposal or discharge. • All applicable standards and best practices that are currently being adhered to, in regards to waste generation, treatment and disposal (both onshore and offshore). **Response:** The Waste Management Plan (WMP), included in Volume III of the regulatory submittal for the Payara Development Project, includes information regarding the types of wastes that will be generated by the Project and the management methods that will be considered for these wastes. In particular, Appendix A (Section A.3) includes tabular summaries of Project waste streams, their estimated quantities, and treatment methods. Please note that a similar request for this information from the EPA dated June 2, 2020, was received by EEPGL and is being managed separately. EEPGL provided an initial response on June 30, 2020, and received further comments from the EPA on July 7, 2020, that a substantially revised submission addressing outstanding items

Stakeholder	Comment
	would be need by July 24, 2020. EEPGL is actively addressing the required submission as requested. EEPGL continues to work proactively with the EPA and Ministry of Communities on the planning and execution of a continued series of waste management capacity building workshops with the first of such planned for 3Q2020 when it is expected the health, safety, and security of all involved can be assured once the current COVID-19 pandemic has subsided. 2. The potential for hydraulic oil spills during installation must be discussed. Information must include but not limited to: impacts, mitigation measures, potential sources of spills, estimated quantities of hydraulic fluid that maybe released, etc. **Response:** Additional information has been added to Section 9.1.1 describing a hydrocarbon spill scenario involving a release of hydraulic oil, the potential sources of such a release, and the management and mitigation measures employed to prevent or respond to such a release. 3. Produced Water Dispersion Modelling: To assist in understanding the potential impacts of the routine discharge of produced water, produced water dispersion modelling should be conducted. The dispersion modelling study should be done using minimum and maximum flow rates, taking into consideration the various seasons of the year. This approach will assist in identifying the environmental values and sensitive that will be at risk of exposure on a seasonal basis. **Response:** The potential impacts from discharge of produced water on physical resources (Table 6.4-8) and biological resources (Table 7.4-6, Table 7.5-4, Table 7.7-3, and Table 7.8-3) and the cumulative impacts from discharge of produced water from multiple FPSOs (Section 10.6.2) are discussed individually in the EIA. These impacts are based on detailed water quality modeling (Appendix J), which includes dispersion modeling for individual discharges (produced water; Appendix J Section 3.4.2) and modeling to assess potential for overlap of concurrent produced water discharges from multiple FPSOs (Appendix J Section 4). Produced water modeling considered the maximum flow rates for produced water discharge, extreme (5 and 95 percent exceedance) and typical (50 percent exceedance) currents, and typical (50 percent exceedance) ambient temperatures to consider a range of dispersion characteristics. 4. Cooling water dispersion modelling study: To access the change in temperature and the residual chlorine concentration in the cooling water stream, cooling water dispersion modelling should be undertaken. The dispersion modelling study should be done using minimum and maximum flow rates, taking into consideration the various seasons of the year. This approach will assist in identifying the environmental values and sensitive that will be at risk of exposure on a seasonal basis. **Response:** The potential impacts from routine discharge of cooling water (elevated temperatures and residual chlorine) on physical resources (Table 6.4-8) and biological resources (Table 7.4-6, Table 7.5-4, Table 7.7-3, and Table 7.8-3) and the cumulative impacts from discharge of cooling water from multiple FPSOs (Section 10.6.2) are discussed individually in the EIA. These impacts are based on detailed water quality modeling (Appendix J), which includes dispersion modeling for individual discharges (cooling water; Appendix J Section 3.4.1) and modeling to assess potential for overlap of concurrent cooling water discharges from multiple FPSOs (Appendix J Section 4). Cooling water modeling considered the maximum flow rates for the cooling water stream, extreme (5 and 95 percent exceedance) and typical (50 percent exceedance) currents, and extreme (1 and 99 percent exceedance) ambient temperatures to consider a range of dispersion characteristics. 5. Waste water dispersion modelling study: As the waste water may contain constituents exceeding levels of the ambient marine waters, a waste water dispersion modelling study should be done. The study should identify the near field mixing and dilution zone during static weak, medium and strong current strengths. The dispersion modelling study should take into consideration the various seasons of the year. This approach will assist in identifying the environmental values and sensitive that will be at risk of exposure on a seasonal basis. **Response**: The impacts from routine waste discharges such as Sulfate Removal and Potable Water Processing Brines on physical resources (Table 6.4-8) and biological resources (Table 7.4-6, Table 7.5-4, Table 7.7-3, and Table 7.8-3) and the cumulative impacts from discharge of these streams from multiple FPSOs (Section 10.6.2) are discussed individually in the EIA. These impacts are based on detailed water quality modeling (Appendix J), which includes dispersion modeling for individual discharges (Sulfate Removal and Potable Water Processing Brines; Appendix J Section 3.4.3) and modeling to assess potential for overlap of concurrent discharges from multiple FPSOs (Appendix J Section 4). Sulfate Removal and Potable Water Processing Brines modeling considered the maximum flow rates for the waste stream, extreme (5 and 95 percent exceedance) and typical (50 percent exceedance) currents, and typical (50 percent exceedance) ambient temperatures to consider a range of dispersion characteristics. Other aqueous discharges (Appendix J Table 3-1) were considered *de minimis* compared to the streams modeled in detail (Appendix J Table 3-2) and are expected to have discharge plumes much smaller than the ones modeled. Additionally, an upset case of emergency release of untreated black water (Appendix J Section 3.4.6) was also modeled and the risks from this scenario are discussed in the relevant resource-specific sections in Chapter 9 of the EIA.

Stakeholder	Comment
	6. Climate change: The potential project risks and mitigation measures associated with climate change should be discussed more in depth. Climate change models simulating the effects of the emission of greenhouse gases into the future, based on current understanding of atmospheric physics and chemistry, should be presented. To provide context, a comparative analysis should be conducted. The analysis should compare the quantity of greenhouse gases emitted by the FPSO vs the quantity of greenhouse gases emitted: in Guyana, in the Caribbean, and globally, respectively. **Response:** Potential climate impacts are a global concern and stem from cumulative worldwide GHG emissions. The Global Circulation Models (GCMs) used to predict climate impacts from global emissions are built around emissions on a global scale, and thus are not capable of modeling impacts from the GHG emissions contributions from a single project such as the Payara Project. Statistical downscaling methods can be used to establish a statistical relationship between global climate and local climate using observed data, and can be used to estimate future local climate changes based on the results of GCMs. However, the reverse approach of predicting the impact of local GHG emissions on global (or local) climate change is not feasible due to the multiple factors—beyond that of a single project—that drive global climate change predictions. The Task Force on Climate-related Financial Disclosure (TCFD) cites a global GHG baseline emission level of 55.3 gigatonnes/year for 2018. The ranges of global GHG emissions modeled by the Intergovernmental Panel on Climate Change (IPCC) to determine the target global GHG emissions necessary to reach the commonly discussed target scenarios of 1.5°C and 2°C above pre-industrial levels by the end of the century are 25 and 41 gigatonnes/year CO_2e, respectively for the year 2030[1]. The Payara Project will emit on the order of 1,355 kilotonnes (i.e., approximately 0.001355 gigatonnes) CO_2e per year (at peak production). This amounts to approximately 0.002% of the 2018 baseline emission level and 0.005 to 0.003 percent of the global GHG emissions modeled for the 1.5°C and 2°C scenarios, respectively. In other words, the global GHG emission input values used to model impacts to global climate are tens of thousands of times higher than the peak steady-state Project emissions. With respect to a comparative analysis, Guyana's most recent (2015) submittal to the UNFCCC under the Paris Agreement (the "Revised Intended Nationally Determined Contribution") states that the most recent GHG inventory for Guyana is for the year 2004, and comprised aggregate emissions of 4,617 kilotonnes CO_2e (excluding removals). Referring to the Second National Communication (which is cited in the Revised Intended Nationally Determined Contribution for this value), the correct value appears to be 4,671 kilotonnes CO_2e. A separate estimate developed from the World Resources Institute's Climate Analysis Indicators Tool (CAIT), estimates that Guyana emitted 37,420 kilotonnes CO_2e in 2016. Accordingly, depending on the value selected as the most representative GHG emission level for Guyana, the Payara Project estimated GHGs emissions at peak production (1,355 kilotonnes per year) represent between a 3.6 percent (against the WRI's estimate for 2016) and 29 percent (against Guyana's stated emissions for 2004) increase in national GHG emissions. From a regional perspective, the Inter-American Development Bank, in its 2013 publication *The Climate and Development Challenge for Latin America and the Caribbean*, projected regional emissions of 6,730,000 kilotonnes per year CO_2e by 2050 for a "business as usual" scenario and 1,450,000 kilotonnes per year for a "GHG target" scenario (which is based on a target of 2 tonnes per capita, which converts to roughly 1.45 gigatonnes CO_2e). Considering these regional estimates, the Payara Project estimated GHG emissions at peak production (1,355 kilotonnes per year) represent between 0.02 and 0.09 percent of the projected regional 2050 emissions. From a global perspective, the Payara Project estimated GHG emissions at peak production represent 0.002 percent of the baseline 2018 global GHG emission estimated by the TCFD and between 0.003 and 0.005 percent of the targeted global emissions corresponding to the 1.5°C and 2°C scenarios of 25,000,000 and 41,000,000 kilotonnes CO_2e, respectively—as stated in the United Nations Environment Programme Emissions Gap Report for 2019. Table 1 below summarizes the comparison of Project GHG emissions to the other emission levels discussed above.

[1] United Nations Environment Programme. Emissions Gap Report 2019. Table 3.1 on page 50 of PDF. https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf

Stakeholder	Comment
	Table 1. Comparison of Project Emissions to Guyana, and Latin America and Caribbean Region and Global Emissions

	GHG Emissions *(million tonnes CO_2e/year)*	Percent Represented by Payara Project Annual Emissions at Peak Production
Payara Project Steady State Emissions (Peak Production Year)	1.36	---
Most recent NDC estimate of Guyana's GHG Emissions (2004)[2]	4.67	29.0%
Most recent WRI estimate of Guyana's GHG Emissions (2016)[3]	37.4	3.6%
Latin America and Caribbean[4] "BAU" Projection[5] by 2050[6]	6,730	0.02%
Latin America and Caribbean GHG Target[7] by 2050[8]	1,450	0.09%
Global Emissions in 2018[9]	55,300	0.002%
Global Emissions (1.5 °C and 2 °C scenarios; by 2030)[10]	25,000 to 41,000	0.005% to 0.003%

Section 6.1.3.4 has been updated to include the additional information presented above.

7. Quality Assurance/Quality Control (QA/QC) Procedures: The process or set of processes used to measure and assure the quality of a product and ensuring products and services meet expectations, has not been discussed in the EIA. The EIA should discuss in detail EEPGL's internal QA/QC procedures and control programs, and what measures are implemented to ensure that all subcontractors adhere to the QA/QC program.

Response: Section 2.18 has been added to the EIA, describing the Quality Process that will be employed for the Project.

[2] Government of Guyana. Guyana – Second National Communication to the UNFCCC. March 2012. https://unfccc.int/resource/docs/natc/guync2.pdf
[3] World Resources Institute Climate Analysis Indicators Tool (WRI CAIT 2.0, 2016). https://www.climatewatchdata.org/
[4] Latin America and Caribbean includes the following countries: Argentina, Bahamas, Bolivia, Brazil, Cuba, Chile, Colombia, Ecuador, Guatemala, Guyana, Honduras, Mexico, Nicaragua, Panama, Peru, Suriname, Venezuela.
[5] BAU Indicates "Business as Usual" projection in 2050 (i.e., trajectory if certain mitigations and controls are not enacted).
[6] Inter-American Development Bank, *The Climate and Development Challenge for Latin America and the Caribbean*, 2013.
[7] The Latin America and Caribbean GHG target is 2 tonnes per capita, which converts to roughly 1.45 gigatonnes CO_2e.
[8] Inter-American Development Bank, *The Climate and Development Challenge for Latin America and the Caribbean*, 2013.
[9] United Nations Environment Programme. Emissions Gap Report 2019. Text in Section 2.2 on page 29 of PDF. https://wedocs.unep.org/bitstream/handle/20.500.11822/30797/EGR2019.pdf
[10] Task Force on Climate-related Financial Disclosures; https://www.fsb-tcfd.org/

Stakeholder	Comment
Environmental Protection Agency	**<u>Comments received by EEPGL on June 18, 2020</u>** **Payara Environmental Impact Assessment** 1. Various comments addressing concerns over potential effects of the project on the Amazonian-Orinoco Influence Zone. **Response:** EEPGL recognizes that the entire Guyana Exclusive Economic Zone falls within the Amazonian-Orinoco Influence Zone Ecologically or Biologically Significant Area (EBSA), and that a loss-of-well-control event from anywhere within the Stabroek Block would therefore impact this area. As noted in the comment, there are no prohibitions for oil and gas exploration and production activities in the area. In any case, EEPGL has put extensive measures in place to prevent a loss-of-control event from occurring in the first place, and has modelled multiple worst-case loss-of-well-control oil spill scenarios to help plan response measures in the highly unlikely event such an event were to occur. To emphasize the importance EEPGL places on avoiding spill, EEPGL highlights the following points from Chapter 9 (Assessment and Mitigation of Potential Impacts from Unplanned Events) of the Payara EIA: • A total of 15 different oil spill scenarios were considered, including two Tier III level events (these are events where the spill is of a sufficient magnitude to warrant response management in a coordinated manner with regional and internationally sourced resources). These two modeled Tier III events included: o Most Credible Worst Case Discharge – an offshore release of oil from a loss-of-well-control event that (assuming no response measures are implemented) results in a 30-day duration of release at a rate of 20,000 barrels of oil per day (BOPD); and o Maximum Worst Case Discharge – an offshore release of oil from a loss-of-well control event that (assuming no response measures are implemented) results in a 30-day duration of release at an initial rate of 202,192 BOPD. These Worst Case Discharge scenarios represent the maximum theoretical release rate for a loss-of-well-control scenario, and are used to understand the maximum scope of a response that would be necessary in the event that such a release occurred. These scenarios are extremely unlikely to occur. While these scenarios were modeled in the absence of response measures, the reality is that a robust response would certainly occur. On the basis a loss-of-well-control release has been stopped within a period of 5 days (the feasibility of which has been confirmed by EEPGL), and with the application of spill response measures as reflected in EEPGL's Oil Spill Response Plan, modeling results indicate a significant reduction in the amount of oil that would be released to the environment, and a correspondingly significant reduction in the ocean area that would be affected by a spill. Modeling indicates that even a worst case Worst Case Discharge event would not result in a shoreline impact in Guyana. With respect to the potential for impacts outside of Guyana waters, EEPGL will work with representatives of the respective countries that could be potentially impacted by the spill, and provide funding where appropriate, by: • Coordinating operations and communications between different command posts; • Creating a transboundary workgroup to manage waste from a product release, including identifying waste-handling locations in the impacted regions and managing commercial and legal issues (wastes collected in countries outside of Guyana will be handled according to the regulations required specific to that location); • Identifying places of refuge in the impacted region where response vessels could go for repairs and assistance; • Determining how EEPGL and the impacted regional stakeholders can work together to allow equipment and personnel to assist in a spill response outside the region while still retaining a core level of response readiness within the jurisdictions; • Determining financial liability and establishing claims and/or livelihood remediation processes during a response to a transboundary event; and • Working with local communities within the impacted areas to raise awareness of oil spill planning and preparations. 2. Various comments addressing concerns over a lack of baseline data collection. **Response:** EEPGL respectfully disagrees that adequate baseline information has not been collected to support an evaluation of the natural resources that may be affected by the Payara Project. Over a multi-year period, EEPGL has funded the most extensive campaign of onshore and offshore environmental and socioeconomic baseline data

<table>
<tr><th>Stakeholder</th><th>Comment</th></tr>
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collection ever conducted in Guyana. The following is an overview of the key environmental and socioeconomic studies conducted from 2014 to present to expand the scientific knowledge base regarding natural resources in Guyana.
<table>
<tr><th>Year</th><th>Scope</th></tr>
<tr><td>2014</td><td>Liza area - Environmental Baseline Study (EBS) collecting samples for sediment, water quality and benthos; marine mammal observations.</td></tr>
<tr><td>2016</td><td>Liza area – EBS collecting samples for sediment, water quality, and environmental DNA; geophysical survey; metocean survey; marine mammal observations; offshore air quality monitoring.</td></tr>
<tr><td>2017</td><td>Liza area – EBS collecting samples for water sediment, water quality, benthos, and environmental DNA; geophysical survey; metocean survey; marine bird survey; marine mammal observations; coastal sensitivity mapping; ROV survey.</td></tr>
<tr><td>2018</td><td>Canje Block – EBS collecting samples for water quality, sediment quality, and environmental DNA.</td></tr>
<tr><td>2018</td><td>Liza Phase 2 – EBS collecting samples for sediment, water quality, and environmental DNA; metocean survey; marine mammal observations; marine fish study; marine birds surveys; coastal bird surveys, marine turtle tagging and telemetry study; offshore air quality study; onshore traffic study; marine vessel traffic survey; coastal sensitivity mapping; ecosystem services assessment.</td></tr>
<tr><td>2018</td><td>Payara – EBS collecting samples for sediment, water quality, and environmental DNA; metocean survey; marine mammal observations; marine fish study; plankton sampling; participatory fish study; marine bird surveys; riverine mammals surveys; marine turtle tagging and telemetry study; coastal bird surveys; offshore air quality study; onshore air quality study; onshore traffic assessment; social infrastructure study; ecosystem services assessment validation.</td></tr>
<tr><td>2019</td><td>Hammerhead – EBS collecting samples for sediment, water quality, and environmental DNA.</td></tr>
<tr><td>2019</td><td>Southeast Stabroek Block – EBS collecting samples for sediment, water quality, and environmental DNA.</td></tr>
<tr><td>2019</td><td>Kaieteur Block – EBS collecting samples for sediment, water quality, and environmental DNA.</td></tr>
</table>
3. Various comments concerning the potential adverse effects of ballast water.

Response: EEPGL acknowledges, as stated in Section 7.10 of the EIA, there is a potential for introduction of exotic species from ballast exchanges by export tankers visiting Guyana waters during production operations. In keeping with standard global maritime norms, EEPGL's planned ballast water management program will be consistent with international best practice, including provisions in the International Convention for the Control and Management of Ships' Ballast Water (IMO 2004). Ballast water for export tankers will be exchanged (prior to arrival in Guyanese waters) with water from deep international waters. This practice is generally thought to reduce the likelihood of introducing invasive species to new near-coastal habitats because oceanic organisms are considered unlikely to colonize near-coastal habitats (Ruiz et al. 2005). This rationale is based on an assumption that coastal waters (where most ports are located and where ballast water is taken on) are sufficiently different from the open ocean in terms of salinity and physical habitat conditions such that most organisms from the coast will not be able to survive and colonize the open ocean, and vice versa. The environmental conditions at the offshore point where near-coastal ballast water is exchanged for oceanic water will likely be somewhat similar to the conditions in the Stabroek Block. This means that at least some organisms entrained in deeper oceanic waters and then discharged into the Stabroek Block will likely survive the event; however, this also means that these organisms will likely include many of the same open-ocean species that occur naturally in the Stabroek Block.

4. Comment on Project physical footprint area.

Response: With respect to the physical subsea disturbance footprint of the Payara Project, the following is clarified:

The EIA identifies an area referred to as the Project Development Area, within which Project activities will be conducted. A polygon drawn around the extents of the subsea infrastructure encompasses an area on the order of 7,800 hectares (i.e., the areas depicted in Figure 2.1-1). It is important to note, however, that the bulk of the seafloor within this polygon will not experience physical disturbance, as the various components of subsea infrastructure are separated by 100's or 1,000's of meters.

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	• Adding up the seabed footprint of each of the Project components that will be in contact with the seafloor, yields a total physical disturbance area of approximately 53 hectares. Incorporating a 50 percent contingency factor yields a value of approximately 80 hectares that could potentially be disturbed by installation of various infrastructure components. It is noted that this area will be subject to essentially one-time disturbance by the installation activities. The remaining approximately 99% of the subsea Project Development Area will not involve physical disturbance of the seafloor. 5. Various comments addressing estimates of Greenhouse Gas ("GHG") emissions from end-use of products that may in part have been derived from petroleum produced from the Project. **Response**: ExxonMobil supports the goals of the Paris Agreement, an agreement among national governments to reduce carbon emissions from their economies. Nationally Determined Contributions (NDCs) submitted by Paris Agreement signatories represent each country's plans to reduce its emissions. Consistent with third party reports, ExxonMobil's Outlook for Energy, which projects future energy supply and demand, expects the world to meet, in aggregate with the NDCs of the 2030 Paris Agreement pledges. ExxonMobil plays a critical role in providing the energy that supports economic growth and improves the quality of life for people around the world. Energy demand is projected to increase as the global population rises to 9.2 billion by 2040 from 7.5 billion today, and because of growing prosperity and an expanding middle class. Over the coming decades, meeting this increase in energy demand will require significant investment in new supplies of oil and natural gas, even considering the Paris Agreement's 2°C goal. The International Energy Agency (IEA), in its Sustainable Development Scenario ("SDS", a 2°C scenario), estimated that more than $13 trillion of investment will be needed for oil and natural gas supply for 2019-2040. At the same time, there is need to pursue further emission-reduction efforts and technologies in support of the goals of the Paris Agreement. As described in more detail in Section 6.1.3.2 of the EIA, numerous embedded emissions controls and mitigations will be incorporated into the project to support these objectives. GHG emissions that result from the consumption or use of the Company's products ("end use GHG emissions") are not within its direct control. End use GHG emissions are a function of demand for energy products and are the result of choices consumers make regarding when and how to use energy, including ExxonMobil's products. An estimate of end-use GHG emissions from the project is not within the scope of the EIA, which complies with the Environmental Protection Act and applicable regulations. This is consistent with guidance for the oil and gas industry which recognizes that reporting end-use (sometimes referred to as "Scope 3") GHG emissions may not be possible under circumstances such as the current project. The guidance, published by the International Petroleum Industry Environmental Conservation Association ("IPIECA") states, "[I]n certain cases, the eventual end use of sold intermediate products may be unknown, and companies may be unable to reasonably estimate the downstream emissions associated with processing, end uses or waste of the intermediate product. In such cases, companies can disclose and justify the exclusion of downstream emissions in any account." See IPIECA, Estimating petroleum industry value chain (Scope 3) greenhouse gas emissions - Overview of methodologies, https://www.ipieca.org/resources/good-practice/estimating-petroleum-industry-value-chain-scope-3-greenhouse-gas-emissions-overview-of-methodologies (accessed July 21, 2020). EEPGL notes that the United Kingdom has similar statutes and regulations to the Environmental Protection Act, and does not require reporting of end-use GHG emissions from crude oil production projects. Like in Guyana, regulations in the United Kingdom require Environmental Impact Assessments and Environmental Statements for petroleum production projects to include descriptions of the direct and indirect significant effects of the relevant project on human health, biodiversity and land, soil, water, air and climate. See United Kingdom Offshore Petroleum Production and Pipelines (Environmental Impact Assessment and Other Miscellaneous Provisions) (Amendment) Regulations 2017. Those regulations are not interpreted to require reporting of estimated end-use GHG emissions. Furthermore, the UK's Offshore Petroleum Regulator for Environment and Decommissioning uses similar language in its guidance for producing EIAs, but does not require reporting of end-use GHG emissions. 6. Appendix 2 to comments: "Assessment of the No Action Alternative Fails to Inform Decision-Makers and Stakeholders of Substantial Economic Risks [of] EEPGL's Proposed Activities" prepared by Dr. Chernaik, which concludes that "Under a scenario in which: 1) the world is flooded by new supplies of crude oil; 2)oil demand has peaked and is declining because of the growing global market share of electric vehicles and 3) CO2 emissions are taxed at a level of US$75 per ton on average globally by 2030, then the rose-colored glasses outlook presented in Section 2.17.4 of the EIA for the Payara Development Project is defective." **Response:** The predictions in the referenced report are speculative and contrary to data. It is undisputed that the world's population is growing, especially in developing nations whose need for affordable, reliable energy will only increase. The currently-available alternatives to petroleum products to supply that energy do not deliver the scale of energy that will be required. Thus, the need for petroleum products will not be eliminated in the foreseeable future. In fact, the IEA's most aggressive forecast for the

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	implementation of emission reduction policies, the SDS, estimates the world will still need 67 million barrels of oil per day in 2040. See IEA World Energy Outlook 2019, page 132. The EIA presents non-speculative scientific evidence concerning the potential effects of the project and balances the economic, social, and environmental costs of the project. Furthermore, in determining whether to grant the Environmental Authorization for the project, it is important to consider that a failure to produce the crude oil from this project will not result in a decline in global market demand (the driving force behind the use of energy products) nor a net reduction of worldwide consumption of petroleum products. Instead, other producers worldwide will supply the crude oil that the market demands. 7. Multiple comments generally advocating for a rejection of petroleum production activities in Guyana due to perceived contribution of the energy industry to global climate change, or asserting that Guyana's published objectives for GHG mitigation are inconsistent with permitting of petroleum production activities. **Response:** ExxonMobil is committed to providing the energy and vital products society needs to support economic development while minimizing environmental impacts and the risks of climate change. As noted in previous responses to stakeholder comments, Section 6.1.3.2 of the EIA contains tables listing the embedded controls and mitigation measures that will be incorporated to manage emissions of GHGs and other atmospheric emissions. Decisions regarding the overall benefits of an energy project are appropriately addressed by the Government of Guyana and are therefore not within the scope of the EIA. 8. Appendix 1, p. 5. Applying the median GSCC from the 2018 study demonstrates that, for the years 2024-2030 inclusive, indirect CO_2 emissions of EEPGL's development activities would exact a global social cost of **US$248 billion** (US$417/tCO_2 x 85 million tCO_2/year x 7 years). **Response:** It is not clear why this particular 2018 study was selected as a means to revise the Social Cost of Carbon (SCC) estimates used in the prior section. Other recent credible studies do not agree with the value in the cited study. For example, see: https://www.pnas.org/content/114/7/1518 9. Appendix 1, p. 6. If this estimate is accurate, then the indirect CO_2 emissions of EEPGL's overall development activities would exact a global social cost of **US$717 billion** (US$417/tCO_2 x 4 billion barrels x 0.43 metric tons CO_2/barrel). **Response:** If the project does not go forward, then the oil and gas needed to satisfy market demand will be produced elsewhere. A cancellation of the project would therefore not result in a substantial net reduction in global emissions. Applying the SCC to the indirect and direct emissions from the project, without recognizing the offsetting activity of other producers on global emissions would lead to an inaccurate estimate of global social cost. 10. p. 12. As set out in the Scientists' Warning, IPCC reports, IUCN research and other scientific evidence referred to in this submission there is now full scientific certainty that the earth is on the brink of the double catastrophe of climate change and biodiversity collapse. **Response:** It is not clear where the IPCC has made the statement claimed here.

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