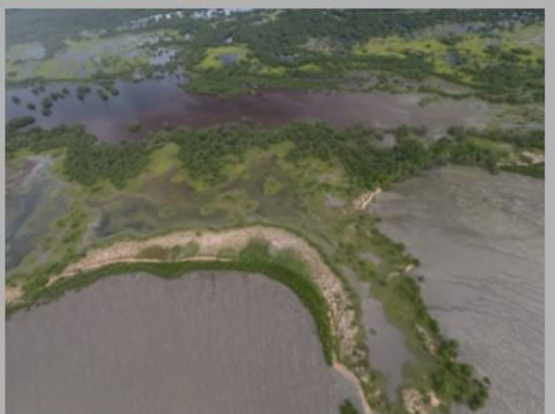
FINAL DRAFT ENVIRONMENTAL & SOCIAL IMPACT ASSESSMENT FOR THE NEARSHORE EXPLORATION DRILLING PROJECT 2019, SURINAME



Prepared by:

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Environmental & Social Impact Assessment For Staatsolie Maatschappij Suriname N.V. Nearshore Exploration Drilling Project 2019, Suriname

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STANDARD INFORMATION SHEET

Project Name	ESIA Nearshore Exploration Drilling Project 2019
Development Location	Nearshore Blocks A to D, Suriname
Type of Project	Exploration Drilling Project
Undertaker	Staatsolie Maatschappij Suriname N.V.
Licensee/Owner	Staatsolie Maatschappij Suriname N.V.
Short description	The Project involves the drilling of a maximum of 10 exploration wells within Nearshore Blocks A to D
Significant Environmental Aspects identified	Yes
Statement prepared by	Environmental Sciences Limited (ESL)

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GLOSSARY

GLOSSARY	
TERM	**MEANING**
Abiotic	Non-living chemical and physical factors in the environment which affect ecosystems
Air Pollution	The introduction into the atmosphere of chemicals, particulates or biological materials that cause discomfort, disease, or death to humans, damage other living organisms such as food crops, or damage the natural environment or built environment
Airborne Magnetic Survey	A common type of geophysical survey carried out using a magnetometer aboard or towed behind an aircraft.
Ammoniacal Nitrogen	Substances containing ammonia, or those that are similar to it, are called ammoniacal
Anthropogenic	Caused or produced by humans
Apiculture	The raising and care of bees for commercial or agricultural purposes
Appraisal Well	An appraisal well is used to assess characteristics (such as flow rate) of a proven hydrocarbon accumulation
Aquaculture	The farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic plants
Aquifer	A body of permeable rock that can contain or transmit groundwater
Autotrophs	An autotroph or producer, is an organism that produces complex organic compounds (such as carbohydrates, fats, and proteins) from simple substances present in its surroundings, generally using energy from light (photosynthesis) or inorganic chemical reactions (chemosynthesis)
Avifauna	Refers collectively to birds
Ballast water	Ballast water is water carried in ships' ballast tanks to improve stability, balance and trim.
Barite	A mineral consisting of barium sulphate and is the most common weighting agent used in drilling today.
Baseline	Ambient, or preceding the Project or development of any kind
Baseline	The ambient conditions of the environment, prior to the execution of a Project. It is a reference point against which potential changes to the study area can be measured, in order to determine the potential effects of the Project after it has been implemented

GLOSSARY	
TERM	**MEANING**
Bathymetry	The measurement of depth of water in oceans, seas, or lakes
Benchmark	A standard or point of reference against which things may be compared or assessed
Benthic	Anything associated with or occurring on the bottom of a body of water
Benthic Fauna	Benthic fauna refers to various organisms found on (epifauna) and in (infauna) the seabed
Benthos	The animals and plants that live on or in the bottom of the body of water
Bentonite	Bentonite is an absorbent aluminium phyllosilicate, essentially impure clay consisting mostly of montmorillonite
BEST Analysis (PRIMER)	A PRIMER tool which utilises the linking of multivariate biotic patterns to suites of environmental variables to determine correlation between biotic and abiotic factors (includes permutation tests)
Bilge Water	Water that collects and stagnates in the bilge of a ship
Bioaccumulation	Refers to the accumulation of substances, such as pesticides, or other organic chemicals in an organism. Bioaccumulation occurs when an organism absorbs a toxic substance at a rate greater than that at which the substance is lost
Bio-concentration	The process by which a chemical concentration in an aquatic organism exceeds that in water as a result of exposure to a waterborne chemical
Biodiversity	Biodiversity is the degree of variation of life. This can refer to genetic variation, species variation, or ecosystem variation within an area, biome, or planet
Biological	Pertaining to biology or to life and living things
Biological Oxygen Demand (BOD)	The amount of dissolved oxygen needed by aerobic biological organisms in a body of water to break down organic material present in a given water sample at certain temperature over a specific time period
Bio-magnification	The increasing concentration of a substance, such as a toxic chemical, in the tissues of organisms at successively higher levels in a food chain. As a result of bio-magnification, organisms at the top of the food chain generally suffer greater harm from a persistent toxin or pollutant than those at lower levels

GLOSSARY	
TERM	**MEANING**
Bioremediation	The use of a biological process (via plants or microorganisms) to clean up a polluted environmental area (such as an oil spill)
Biotic	A living or once living component of an ecosystem
Black water	Wastewater from toilets, which likely contains pathogens. Blackwater can contain faeces, urine, water and toilet paper from flush toilets
Blowout	The uncontrolled escape of oil, gas, or water from a well due to the release of pressure from a reservoir or the failure of containment systems
Blowout Preventer (BOP)	A device consisting of valves and hydraulic jaws used to stop an uncontrolled escape of gas or oil during the drilling process
Brackish	Water that has more salinity than fresh water, but not as much as seawater, that is between 0.5 and 30 parts per thousand.
Bray-Curtis Similarity Coefficient	A statistic used to quantify the compositional dissimilarity between two different sites, based on counts at each site
Bubble Curtain	A system that produces bubbles in a deliberate arrangement in water. Perforated pipe is laid along the sea or riverbed and air pumped through continuously. The upwelling of tiny bubbles acts as a barrier to fine sediments and sound waves. The curtain traps suspended sediment on the turbid side of the curtain it also stops the propagation of waves or the spreading of particles and other contaminants (Bray 2008)
Cartagena Convention	The Convention for the Protection and Development of the Marine Environment in the Wider Caribbean Region (WCR) or Cartagena Convention is a regional legal agreement for the protection of the Caribbean Sea
Category B Path 3	An activity requiring the conduct of a full Environmental and Social Impact Assessment (ESIA) (NIMOS EA Guidelines 2009 and Guidance Note 2017)
Celerity	In general, celerity refers to speed or swiftness of movement
Chemical Oxygen Demand (COD)	An indirect measurement of the amount of pollution (that cannot be oxidised biologically) in a sample of water
Chenier	A former beach that, through the activities of nature, have become isolated from the sea. The local name is 'rits'

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TERM	**MEANING**
CITES APPENDIX I	Appendix 1 of the CITES convention that speaks about taxon threatened with extinction and therefore trade is permitted only in exceptional circumstances)
CITES APPENDIX II	Appendix 2 of the CITES convention speaks about species are not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilisation incompatible with their survival
CITES Appendix III	Appendix 3 of the CITES convention speaks about Specimens: species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling their trade. Changes to this appendix is different from I and II as each party can make unilateral changes to it
Clinker	The stony residue from burnt coal or from a furnace
Cluster Analysis (PRIMER)	Also known as clustering, this is a PRIMER statistical tool which groups a set of objects in such a way that objects in the same group (called cluster) are more similar (in some sense or another) to each other than to those in other groups (clusters)
CMS Nomeco	CMS Nomeco Inc was founded in 2001 and is filed as a Foreign For-Profit Corporation in the State of Texas and is no longer active. The Company's line of business includes performing geophysical, geological, and other exploration services for oil and gas
Coloniser	A country which send settlers to (a place) and establish political control over it
Concession Block	It refers to an area subjected to a concession which is usually called a block with its own rights and obligations. The concession is a form of contract in the oil and gas industry between a State and a company to explore and develop these resources
Consequence	The effect, result, or outcome of something occurring earlier.
Contour Gradient Analysis	A graphical representation of the values detected for a given parameter (water, sediment, benthic species abundance) across the study area, where values are discretised into classes and a colour scale is applied to determine gradient (where deeper colours, indicate higher values)
Controls	The actions undertaken to ensure that risk is reduced
Correlated	To have a mutual relationship or connection, in which one thing affects or depends on another
Cretaceous Period	Of, relating to, or denoting the last period of the Mesozoic era, between the Jurassic and Tertiary periods, from about 146 million to 65 million years ago

GLOSSARY	
TERM	**MEANING**
De-ballasting	The process of taking out ballast water from the ballast tanks to make them empty
Decibel	The decibel (dB) is a logarithmic unit that indicates the ratio of a physical quantity (usually power or intensity) relative to a specified or implied reference level
Deflocculant	A thinning agent used to reduce viscosity or prevent flocculation
Demersal	Dwelling at or near the bottom of the body of a water
Dendrogram	A tree diagram, esp. one showing taxonomic relationships
Diatom	Diatoms are a major group of algae, and are among the most common types of phytoplankton. Most diatoms are unicellular, although they can exist as colonies in the shape of filaments or ribbons, fans, zigzags, or stars
Dissolution	Reduction to a liquid form
Dissolved Oxygen (DO)	Also referred to as oxygen saturation, this is a relative measure of the amount of oxygen that is dissolved or carried in a given medium (measured in milligrams per litre (ppm) or mg/l)
Domain Land	Land that cannot be sold because it legally belongs to the citizenry. It is managed by a public entity—such as a state, region, province or municipality—directly or by institutes or state companies
Draftsman's Plot	Also called Pair's Plot, this is a method for looking at the interrelations between variables in multivariate data; it is typically an array of scatterplots for columns of numeric data, where each plot is meant to indicate if there is any correlation between any 2 parameters
Drill Cuttings	Drill cuttings are the broken bits of solid material removed from a borehole drilled by rotary, percussion, or auger methods
Drilling Mud	Drilling mud is normally a mixture of clay and chemicals, which is pumped down the well bore during drilling operations
Ecosystem	A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit
Ecosystem services	Ecosystem services are the many and varied benefits that humans freely gain from the natural environment and from properly-functioning ecosystems
Ekman spiral	The Ekman spiral is a structure of currents or winds near a horizontal boundary in which the flow direction rotates

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	as one moves away from the boundary. It derives its name from the Swedish Oceanographer Vagn Walfrid Ekman
El Niño Southern Oscillation	A band of anomalously warm ocean water temperatures that occasionally develops off the western coast of South America and can cause climatic changes across the Pacific Ocean. The 'Southern Oscillation' refers to variations in the temperature of the surface of the tropical eastern Pacific Ocean (warming and cooling known as El Niño and La Niña, respectively) and in air surface pressure in the tropical western Pacific. The two variations are coupled: the warm oceanic phase, El Niño, accompanies high air surface pressure in the western Pacific, while the cold phase, La Niña, accompanies low air surface pressure in the western Pacific
Emission	A substance discharged into the air, especially by an internal combustion engine
Endangered Species	An endangered species is a species of organisms facing a very high risk of extinction
Endemic	A species whose natural occurrence is confined to a certain region and whose distribution is relatively limited
Environment	The surroundings or conditions in which a person, animal, or plant lives or operates
Environmental & Social Management Plan	A compilation of the measures which must be taken to mitigate the significant negative potential impacts and enhance the positive potential impacts of the Project, as well as a description of the studies required to be conducted to assess the effectiveness of the mitigation measures proposed.
Environmental and Social Impact Assessment	An environmental and social impact assessment (ESIA) is an assessment of the possible impacts that a proposed project may have on the environment, consisting of the environmental, social and economic aspects
Environmental Impact Assessment (EIA)	A decision-making tool used to assess the potential impacts of a Project on the various aspects of the physical, biological, cultural and socio-economic environments, and to recommend measures to eliminate or reduce these impacts
Environmental Law	Environmental law is a collective term describing international treaties (conventions), statutes, regulations, and common law or national legislation (where applicable) that operates to regulate the interaction of humanity and the natural environment, toward the purpose of reducing the impacts of human activity

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Estuarine Zone	See “Estuary” below
Estuary	A partially enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea. Estuaries form a transition zone between river environments and maritime environments
Exclusion zone	An exclusion envelope set up for the safety of all and to allow a high risk activity to proceed,
Exclusive Economic Zone	The coastal water and sea bed around a country's shores extending up to 200 nm, to which it claims exclusive rights for fishing, oil exploration, etc (also called maritime boundary)
Exploration drilling	An activity in which wells are drilled to determine if hydrocarbons can be extracted from a particular field or reservoir
Exploratory Well	An exploratory well is drilled in an attempt to conclusively determine the presence or absence of oil or gas.
Fauna	Refers to a typical collection of animals found in a specific time or place
Flora	Refers collectively to the plant species which are found within a vegetated area
GDP	A monetary measure of the market value of all final goods and services produced in a period (quarterly or yearly) of time
GDP per capita	Per capita GDP is a measure of the total output of a country that takes the gross domestic product (GDP) and divides it by the number of people in that country. The per capita GDP is especially useful when comparing one country to another, because it shows the relative performance of the countries
GDP Purchasing Power Parity	Countries use different currencies, and so the GDP of a country typically has to be measured in a manner which makes it comparable to that of other countries. One way to make values comparable is by applying purchasing power parity (PPP). The purchasing power of a currency refers to the quantity of the currency needed to purchase a given unit of a good, or common basket of goods and services. Purchasing power is determined by the relative cost of living and inflation rates in different countries. Purchasing power parity means equalising the purchasing power of two currencies by taking into account these cost of living and inflation differences.

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Geology	The science which deals with the physical structure and substance of the earth, their history, and the processes which act on them
Grey water	Wastewater from household use other than toilets. Greywater results from washing food, clothing, dishes, as well as from showering or bathing
Guirlande	A form of overwash bar which is not straight in form (translates as 'garland')
Halocline	A distinct layer in a large body of fluid caused by a strong, vertical salinity gradient within a body of water
Hazardous substance	Dangerous goods are solids, liquids, or gases that can harm people, other living organisms, property, or the environment. They are often subject to chemical regulations
Heterotrophs	An organism that cannot produce its own food, relying instead on the intake of nutrition from other sources of organic carbon, mainly plant or animal matter. In the food chain, heterotrophs are secondary and tertiary consumers
Holocene	Relating to or denoting the present epoch, which is the second epoch in the Quaternary period and followed the Pleistocene
Hydrocarbon	A compound of hydrogen and carbon, such as any of those which are the chief components of petroleum and natural gas
Hydrological	Pertaining to the movement, distribution, and quality of water on Earth
Hydrostatic Pressure	The pressure exerted by a fluid at equilibrium at a given point within the fluid, due to the force of gravity. Hydrostatic pressure increases in proportion to depth measured from the surface because of the increasing weight of fluid exerting downward force from above
Hz	The hertz is the derived unit of frequency in the International System of Units and is defined as one cycle per second.
Impact	The effect of an activity, in this case, on the environment in which the Project is taking place
Indicator species	Refers to any biological species that defines a trait or characteristic of the environment. In other words, an organism that occurs only in areas with specific environmental conditions because of their narrow ecological tolerance. The presence or absence of these species on a site is a good indicator of environmental conditions

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Intertropical Convergence Zone (ITCZ)	A low pressure area that lies between the subtropical pressure maxima in the Northern and Southern Hemispheres) and tropical waves
Iron (Fe)	Iron is a chemical element with the symbol Fe and atomic number 26. It is a metal in the first transition series. It is the most common element forming the planet Earth as a whole, forming much of Earth's outer and inner core
Isobath	An imaginary line or a line on a map or chart that connects all points having the same depth below a water surface (as of an ocean, sea, or lake)
Jack-up rig	An offshore drilling rig the legs of which are lowered to the seabed from the operating platform
K-selection	A form of selection that occurs in an environment at or near carrying capacity, favouring a reproductive strategy in which few offspring are produced
LC50	The concentration of the chemical that kills 50% of the test animals in a given time (usually several hours)
Likelihood	The probability of an event happening
Low-Water Mark	The level reached by seawater at low tide or by other stretches of water at their lowest level
Meteorological Information	Refers to information of or pertaining to atmospheric phenomena, especially weather and weather conditions
micropascal (dB re 1 µPa)	A unit of measuring pressure
Mining Activities	Refer to mines that are currently engaged in mineral and metal extraction operations
Mitigate	To implement measures to eliminate or reduce the negative potential impacts of a Project on the environment
Multi-Dimensional Scaling (MDS)	A set of related statistical techniques often used in information visualization for exploring similarities or dissimilarities in data (see Cluster Analysis). Visually illustrated in a plot for graphical presentation
Multilateral Environmental Agreement	It is a legally binding agreement between three or more states relating to the environment
Multiple Use Management Areas (MUMAs)	Protected area, designed to provide for the sustained production of water, timber, wildlife, pasture, and outdoor recreation, with the conservation of nature primarily oriented to the support of economic activities (although specific zones may also be designed within these areas to achieve specific conservation objectives)
Multivariate	Involving two or more variable quantities

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National Hurricane Centre (NHC)	The division of the United States' National Weather Service responsible for tracking and predicting weather systems within the tropics between the Prime Meridian and the 140th meridian west poleward to the 30th parallel north in the northeast Pacific Ocean and the 31st parallel north in the northern Atlantic Ocean.
National Oceanic and Atmospheric Administration (NOAA)	An American scientific agency within the United States Department of Commerce that focuses on the conditions of the oceans and the atmosphere. NOAA warns of dangerous weather, charts seas, guides the use and protection of ocean and coastal resources and conducts research to provide understanding and improve stewardship of the environment
Natural resources	Materials or substances occurring in nature which can be exploited for economic gain
Nature Reserve	A nature reserve is a protected area of importance for wildlife, flora, fauna or features of geological or other special interest, which is reserved and managed for conservation and to provide special opportunities for study or research
Nearctic region	Belonging or pertaining to a geographical division comprising temperate Greenland and arctic North America, sometimes including high mountainous regions of the northern Temperate Zone
Nearshore	A legally defined area north of Suriname's coastline, assigned to Staatsolie for the purpose of hydrocarbon exploration
Oceanography	The branch of science that deals with the physical and biological properties and phenomena of the sea
Ozone-depleting Substances	These are gases which damage the ozone layer in the upper atmosphere
Palaeocene	Of, relating to, or denoting a geologic epoch that lasted from about 66 to 56 million years ago
Pannen	Lagoon (dutch)
Parastatal	An organisation can be considered parastatal if it has some political authority and indirectly serves the State or Government of the country under whose laws it operates
Pecten	Any of a number of comb-like structures occurring in animal bodies, in particular
Pelagic	Relating to or living in or on oceanic waters. The pelagic zone of the ocean begins at the low tide mark and includes the entire oceanic water column
Permanent Threshold Shift (PTS)	Recommended by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS 2016)

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Temporary Threshold Shifts (TTS)	Recommended by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS 2016)
pH	A measure of the activity of the (solvated) hydrogen ion, p[H], which measures the hydrogen ion concentration
Phosphorus (P)	Phosphorus (P) is an essential element classified as a macronutrient due to the relatively large amounts of P required by plants. Phosphorus (P) is one of the three nutrients generally added to soils in fertilisers. One of the main roles of P in living organisms is in the transfer of energy (Busman *et. al* 2009)
Photosynthesis	A process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities (energy transformation)
Pielou's Evenness Index	The number derived from the Shannon diversity index and is the maximum possible value of (if every species was equally likely), equal to: J' is constrained between 0 and 1
Pluralistc	Relates to a system in which two or more states, groups, principles, sources of authority, etc., coexist. In the context
Pollutant	Refers to any substance that is introduced into the environment that has undesired effects, or adversely affects the usefulness of a resource
Pollution	The presence in or introduction into the environment of a substance which has harmful or poisonous effects
Potable Water	Potable water or drinking water is water safe enough to be consumed by humans or used with low risk of immediate or long term harm
Precautionary Principle	States that if there are threats of serious irreversible environmental damage associated with the proposed development, lack of full scientific certainty will not be used as a reason for postponing measures to prevent environmental degradation
Primary Productivity	The rate at which energy is converted by photosynthetic and chemosynthetic autotrophs to organic substances
PRIMER	A collection of specialist routines for analysing species or sample abundance (biomass). It is primarily used in the scientific community for ecological and environmental studies
Project cycle	The manner in which a typical Project is implemented. All projects can be mapped to the following simple life cycle structure: starting the project, organizing and preparing, carrying out the work, and closing the project. This is known as a four-phase life cycle and the phases are usually referred to as: initiation, planning, execution, and

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	closure. Feedback is also important to the project life cycle
Project Scoping	Scoping is conducted to identify the issues that are likely to be of most importance during the ESIA and eliminate those that are of little concern. Typically, this process concludes with the establishment of the TOR for the preparation of the ESIA. In this way, scoping ensures that ESIA studies are focused on the significant effects, by maximising time and financial resources within the Project Cycle
Protected Areas	Refer to locations which receive protection because of their recognised natural, ecological and/or cultural values
Purchasing Power Parity	A theory which states that exchange rates between currencies are in equilibrium when their purchasing power is the same in each of the two countries
Ratified	To sign or give formal consent to (a treaty, contract, or agreement), making it officially valid
Receptor	Sensitive component of the ecosystem that reacts to or is influenced by environmental stressors
Red List categories (IUCN)	List of species status categories in the IUCN Red List. Extinct (EX), Extinct in the Wild (EW), Critically endangered (CR), Endangered (EN), Vulnerable (VU), Near threatened (NT), Least Concern (LC), Data deficient (DD), Not evaluated (NE)
Residential area	An area in which the land use is predominantly housing
Ripe fish	Female fish with enlarged, fully mature eggs ready to be fertilised, also referred to as `running ripe', or ready to spawn as evidenced by a slight pressure on the abdomen causing eggs or milt to be shed
Risk	Risk is the product of the consequence and the probability (likelihood) of occurrence of the unpleasant /undesired event
Root mean square (rms)	The square root of the arithmetic mean of the squares of a set of values
Salinity	A measure of the dissolved salt content (such as sodium chloride, magnesium and calcium sulfates, and bicarbonates) of a body of water
Seismic survey (2D & 3D)	The seismic survey is one form of geophysical survey that aims at measuring the earth’s (geo-) properties by means of physical (-physics) principles such as magnetic, electric, gravitational, thermal, and elastic theories. It is typically used to determine the hydrocarbon potential of a field or reservoir. 2D (two-dimensional) surveys are typically less detailed and focused than 3D (three-dimensional) surveys

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TERM	**MEANING**
Semi-Diurnal	Occurring twice a day
Sensitivity	A species may be sensitive if it is locally and internationally threatened or protected; or if they may be affected by particular activities e.g. drilling
Severity	The degree to which something is strict or extreme
Shannon-Weiner Index	A widely used species diversity index for examining overall community characteristics comparing two or more distinct habitats. The S-W index is a measure of the likelihood that the next individual will be the same species as the previous sample. It combines two quantifiable measures (1) Species richness (the number of species in the community) and (2) species evenness (how even are the numbers of individuals of each species)
Shareholder	A holder of shares in a company. A sole shareholder has possession of all shares i.e. full ownership
Significance	The degree of importance ascribed, in this case, to an impact
Significant Wave Height	The mean wave height (trough to crest) of the highest third of the waves (H1/3)
Socio-economic	Relating to or concerned with the interaction of social and economic factors
Sound source	Any activity or device that emits sound
Spit	A spit is an extended stretch of beach material that projects out to sea and is joined to the mainland at one end. Spits are formed where the prevailing wind blows at an angle to the coastline, resulting in longshore drift (Sen Nag 2017)
SPLpeak	Maximum sound pressure level
SPLrms	A way to average values that are part of complex waves
Staatsolie	Short for Staatsolie Maatschappij Suriname, N.V., the State Oil Company of Suriname
Stakeholder	Entities (individuals or organisations) with an interest or concern related to the execution of a Project
Standard (value)	A point of reference against which things may be compared or assessed (also called Guideline, limit or Benchmark)
Standard Deviation	This statistic (represented by the symbol sigma, σ) shows how much variation or "dispersion" exists from the average (mean, or expected value). A low standard deviation indicates that the data points tend to be very close to the mean; high standard deviation indicates that the data points are spread out over a large range of values

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Stochastic	Having a random probability distribution or pattern that may be analysed statistically but may not be predicted precisely
Stressor	An environmental condition or influence that stresses (i.e. causes stress for) an organism; or any event or situation that precipitates a change. It may also be physical, chemical, or biological entities that can induce adverse effects on ecosystems or human health
Sub-lethal Effects	Not quite lethal; insufficient to cause death
Super-saturation	A state of a solution that contains more of the dissolved material than could be dissolved by the solvent under normal circumstances. It can also refer to a vapor of a compound that has a higher (partial) pressure than the vapor pressure of that compound
Surface agitation	The movement of water on the surface of the waterbody
Sustainable Development	Sustainable development refers to a mode of human development in which resource use aims to meet human needs while ensuring the sustainability of natural systems and the environment, so that these needs can be met not only in the present, but also for generations to come
Synthetic Oil Based Mud (SOBM)	Non-aqueous, water-internal (invert) emulsion muds in which the external phase is a synthetic fluid rather than an oil
Taxa	This is the plural of “taxon” (see below)
Taxon	This is in reference to a single species, and may refer to the species named at the family, genus or specific level
Terms of Reference (TOR)	The requirements for the conduct of an ESIA, based on the scoping of the Project
Territorial Waters	The part of the ocean adjacent to the coast of a state that is considered to be part of the territory of that state and subject to its sovereignty
Thermocline	An abrupt temperature gradient in a body of water
Thermocline	The thermocline is a rapid change in the temperature of seawater with depth, as opposed to the relatively steady (but gradually decreasing) temperatures of the surface (mixed layer) and deeper, colder water. The surface layer tends to be of a higher but stable temperature owing to the effect of insolation, wind and warm air, whilst the deeper, colder waters are steady in temperature owing to the absence of these factors. The thermocline is therefore the transition zone between the 2 (NOAA 2012). The thermocline is a typical feature of deeper marine waters,

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	given than deep ocean waters are not well mixed (Bergman 2011; NOAA 2012)
Thermohaline Currents	Refers to a part of the large-scale ocean circulation that is driven by global density gradients created by surface heat and freshwater fluxes
Tidal prism	The tidal prism is the volume of water exchanged between a lagoon or estuary and the open sea in the course of a complete tidal cycle (American Meteorological Society; n.d.).
Topographical Map	In modern mapping, a topographic map is a type of map characterised by large-scale detail and quantitative representation of relief, usually using contour lines
Topography	The arrangement of the natural and artificial physical features of an area
Total Petroleum Hydrocarbons (TPH)	A term used to describe a broad family of several hundred chemical compounds that originally come from crude oil. TPH is really a mixture of chemicals. They are called hydrocarbons because almost all of them are made entirely from hydrogen and carbon
Total Phosphorus	Total Phosphorus is the sum of reactive, condensed and organic phosphorous
Trace Contaminants	These are elements, complexes and compounds that are naturally occurring or man-made pollutants found in water at very low levels that must be removed for health or regulatory reasons
USEPA	An independent agency of the United States federal government for environmental protection
USGS	A scientific agency of the United States government that studies the landscape of the United States, its natural resources, and the natural hazards that threaten it
Water Pollution	Is the contamination of water bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). It occurs when pollutants are directly or indirectly discharged into water bodies without adequate treatment to remove harmful compounds
Water-Based Mud	A drilling fluid (mud) in which water or saltwater is the major liquid phase as well as the wetting (external) phase
Wave Action	Wave action refers to the behaviour of ocean waves
WGS 84	The standard U.S. Department of Defense definition of a global reference system for geospatial information and is the reference system for the Global Positioning System (GPS)
WGS 84_UTM Zone 21	A projected coordinate reference system (CRS) suitable for use in between 60°W and 54°W, southern hemisphere between 80°S and equator, onshore and offshore

GLOSSARY	
TERM	**MEANING**
Wilcoxon Ranking Test	It is a non-parametric statistical hypothesis test used when comparing two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ (i.e. it is a paired difference test)
Xtide	A harmonic tide clock and tide predictor
Zooplankton	Small floating or weakly swimming organisms that drift with water currents and, with phytoplankton, make up the planktonic food supply upon which almost all oceanic organisms are ultimately dependent

ACRONYMS

ACRONYMS	Meaning
°C	Degrees Celsius
µg/m³	Microgram per Cubic Meter
µmol/g	Micromole per Gram
µPa	Micropascal
1 µPa	Micropascal
2D	Two Dimensional
3D	Three Dimensional
ACT	Amazon Cooperation Treaty
ADCP	Acoustic Doppler Current Profiler
Af	Tropical rainforest climate
AHSTV	Anchor handling and support tug vessel
Al	Aluminium
AMAP	Arctic Monitoring and Assessment Programme
API	American Petroleum Institute
ARPEL	Associacíon Regional de Empresas de Petróleo y Gas Natural en Latinoamérica y el Caribe (Regional Association of Oil and Natural Gas Companies in Latin America and the Caribbean)
As	Arsenic
ASRC	Arctic Slope Regional Corporation
ATM	Ministry of Labour, Technological Development and Environment of Suriname
Aw	Tropical Wet or Savannah Climate
Ba	Barium
BAP	Biodiversity Action Plan
$BaSO_4$	Barite
BAT	Best Available Techniques
bbl	Barrels of oil per day
bbls	Barrel
bbls/hr	Barrels per Hour
BDL	Below Detectable Limit
BEST	Bio-Env, Linktree (PRIMER tool)
BHA	Bottom Hole Assemble
BOD	Biological Oxygen Demand
BOEM	Bureau of Ocean and Energy Management
BOP	Blow Out Preventer
BSEE	Bureau of Safety and Environmental Enforcement
BTEX	Benzene, Toluene, Ethylbenzene, and Xylenes
BV	Hoekstra Binnenvaart Transport
Cd	Cadmium

ACRONYMS	Meaning
CEP	Caribbean Environment Programme
CEVIHAS	Central Fish Supply Port of Suriname (Centrale Visaanvoer Haven Suriname)
CI	Conservation International
CISQG	Canadian Interim Marine Sediment Quality Guidelines
CITES	Convention on International Trade in Endangered Species
CMNR	Coppename-Monding Nature Reserve
CNFC	China National Fisheries Corporation
CNFM	Chief of National Forestry Management
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COD	Chemical Oxygen Demand
Cr	Chromium
Cr^{6+}	Hexavalent Chromium
CRP	Community Relations Plan
CSA	Continental Shelf and Associates Limited
CTD	Conductivity-Temperature-Depth
Cu	Copper
CZCS	Coastal Zone Colour Scanner
dB	Decibel
dBA	Decibels using an A weighting filter
DO	Dissolved Oxygen
DOI	Department of the Interior
DP	Drill Pipe
DPM	Diesel particulate matter
DREAM	Dose-related Risk and Effect Assessment Model
DST	Drill Stem Testing
E	East
EA	Environmental Assessment
EBA	Endemic Bird Area
EC	Equatorial Current
ECC	Equatorial Counter Current
EEZ	Exclusive Economic Zone
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMA	Environmental Management Authority
EMP	Environmental Management Plan
EMS	Emergency Medical Services
ENE	East North East
EOM	Extractable Organic Matter

ACRONYMS	Meaning
EPS	Extra-cellular Polymeric Substances
ERL	Environmental Resources Limited
ERP	Emergency Response Plan
ESA	Environmentally Sensitive Areas
ESE	East South East
ESIA	Environmental and Social Impact Assessment
ESL	Environmental Sciences Limited
ESMP	Environmental & Social Management Plan
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FCC	Federal Communications Commission
Fe	Iron
ft	Feet
g/l	Gram per Litre
g/m^3	Gram per Cubic Metre
GC	Guiana Current
GDP	Gross Domestic Product
GFI	General Field Instructions
GHFS	Green Heritage Fund Suriname
GIIP	Good International Industry Practice
GMD	Geological Mining Service of Suriname
GNR	Galibi Nature Reserve
GOM	Gulf of Mexico
GORTT	Government of the Republic of Trinidad and Tobago
GPS	Global Positioning System
Grondwet	The Constitution of the Republic of Suriname
H_2S	Hydrogen Sulphide
ha	Hectare
Hg	Mercury
HGMD	Head of The Geologic Mining Department
HI	Ministry of Trade and Industry of Suriname
HSE	Health, Safety and Environment
HSEMS	Health, Safety and Environmental Management Systems
HYCOM	Hybrid Coordinate Ocean Model
Hz	Hertz
IADC	International Association of Drilling Contactors
IBA	Important Birding Area
IBRD	International Bank for Reconstruction and Development
IDA	International Development Association

ACRONYMS	Meaning
IFAW	International Fund for Animal Welfare
IFC	International Finance Corporation
ILO	International Labour Organisation
IMCA	The International Marine Contractors Association
IMO	International Maritime Organisation
ISPS	International Ship and Port Facility Security
ITCZ	Inter-Tropical Convergence Zone
ITOPF	International Tank Owners Pollution Federation
IUCN	International Union for Conservation of Nature
IUU	Illegal, Unreported and Unregulated fishing
JNCC	Joint Nature Conservation Committee
kg	Kilogram
kg/m^3	Kilogram per cubic metre
km	Kilometre
km^2	Square Kilometre
kohms-cm	Kohms-centimeter
kW	Kilowatt
$l/sec/km^2$	Litres per Second per Square Kilometre
LBB	Suriname Forest Service
LC	Least Concern (IUCN Category)
L_{eq}	Equivalent Sound Pressure Level
LOT	Leak-off test
LVV	Ministry of Agriculture, Animal Husbandry and Fisheries of Suriname
m	Metre
m/s	Metre per Second
m^2	Metre Squared
m^3	Cubic Metre
m^3/s	Cubic metre per second
MARPOL	International Convention for the Prevention of Pollution from Ships
MAS	Maritime Authority of Suriname
MD-BRT	Measured Depth Below Rotary Table
MDS	Multi-Dimensional Scaling
MEEA	The Ministry of Energy and Energy Affairs
MERP	Medical Emergency Response Procedure
METS	Movement for Ecotourism in Suriname
mg/kg	Milligrams per Kilogram
mg/l	Milligrams per Litre
MICOM	Miami Isopycnic-Coordinate Ocean Model
ml	Millilitre
mm	Millimetre

ACRONYMS	Meaning
MMbbl	One million barrels
MMO	Marine Mammal Observer
MMSTB	Million Stock Tank Barrels
MODU	Mobile Offshore Drilling Unit
MPL	Maximum Permissible Limit
mS/cm	Milli-Siemens per Centimetre
MSD	Marine Sanitation Device
MSL	Mean Sea Level
MUMA	Multiple Use Management Area
N/D	Nipple Down
NAAQS	National Ambient Air Quality Standards
NASA	National Aeronautics and Space Administration
NB	Nature Conservation Division
NBAP	National Biodiversity Action Plan
NBC	North Brazil Current
NBS	National Biodiversity Strategy
NCB	Nature Conservation Department
NCCR	National Coordination Centre for Disaster Management
NCD	Nature Conservation Division
NCDC	National Climate Data Centre
NCEP	National Centre for Environmental Prediction
NDCC	National Data Climate Centre
NE	North East
NECC	North Equatorial Counter Current
NEDECO	Netherlands Development Company
NGO	Non-governmental organisation
NH	Ministry of Natural Resources
NH_3	Ammonia
NH_3-N	Ammoniacal Nitrogen
Ni	Nickel
NIMOS	National Institute for Environment and Development in Suriname
nm	Nautical mile
NMFS	The US National Marine Fisheries Service
nmi	Nautical mile
NMR	National Council of the Environment
NO	Nitrous Oxide
NO_2	Nitrite
NO_3	Nitrate
NOAA	National Oceanic and Atmospheric Administration
NOU	National Ozone Unit

ACRONYMS	Meaning
NO_x	Oxides of Nitrogen
NP	Nature Park
NR	Nature Reserve
NTL	Notice to Lessees and Operators
NTU	Nephelometric Turbidity Unit
NW	North West
O&G	Oil and Grease
OAS	Organisation of American States
OCS	Outer Continental Shelf
ODPM	The Office of Disaster Preparedness and Management
OGP	International Association of Oil and Gas Producers
OPRC	Oil Pollution Preparedness, Response & Co-operation
OOC	Offshore Operators Committee
OSCAR	Oil Spill Contingency and Response
OSRP	Oil Spill Response Plan
OSH Agency	The Occupational Safety and Health Authority of Trinidad and Tobago
OSPAR	Convention for the Protection of the Marine Environment of the North-East Atlantic
OSRL	Oil Spill Response Limited
P	Phosphorus
P&A	Plug & Abandon
P/U	Pick up
PAHs	Polycyclic Aromatic Hydrocarbons
Pb	Lead
pers. comm	Personal Communication
PO_4-P	Phosphate
POC	Paradise Oil Company N.V., subsidiary of Staatsolie
POOH	Pull out of Hole
ppb	Parts per Billion
PPE	Personal Protective Equipment
ppm	Parts per Million
PPP	Purchasing Power Parity
ppt	Parts per Thousand
PRIMER	Plymouth Routines in Multivariate Ecological Research
PSC	Public Service Commission
PSD	Particle Size Distribution
psi	Pounds per Square Inch
psu	Practical Salinity Unit
PSV	Platform Supply Vessel

ACRONYMS	Meaning
PTS	Permanent Threshold Shift
QA/QC	Quality Assurance/ Quality Control
R&W	Rust en Werk (suburb in district Commewijne)
R/D	Rig Down
RIH	Run in Hole
rms	Root mean square
ROC	Retained Oil on Cuttings
ROGB	Ministry of Spatial Planning, Lands and Forestry Management
SAIL	Suriname American Industries Limited
SCBA	Self-Contained Breathing Apparatus
SCE	Solids Control Equipment
SDS	Safety Data Sheet
SEP	Sample Execution Plan
SE	South East
SeaWiFS	Sea-viewing Wide Field-of-view Sensor
SEC	Southern Equatorial Current
SHATA	Suriname Hospitality and Tourism Association
SIDS	Small Island Developing States
SINTEF	Stiftelsen for Industriell og Teknisk Forskning: Fundação para a Pesquisa Científica e Industrial (The Foundation for Industrial and Technical Research: Foundation for Scientific and Industrial Research)
SK	Suriname Coast or Surinaamse Kust
SMS	Surinamese Shipping Company
SO_2	Sulphur Dioxide
SOBM	Synthetic Oil Based Muds
SOP	Standard Operating Procedure
SOPEP	Shipboard Oil Pollution Emergency Plan
SPL	Sound Pressure Level
SPL_{peak}	Sound Pressure Level Peak
SPL_{rms}	Sound Pressure Level root mean squared
SPM	Suspended Particulate Matter
SPP	Suspended Sediment Phase
SS	Social Solutions
SSA	De Surinam Seafood Association
Staatsolie	Staatsolie Maatschappij Suriname N.V
STINASU	Foundation for Nature Conservation in Suriname
SW	South West
SWI	Shannon-Weiner Index
TCT	Ministry of Communication and Tourism of Suriname
TD	Total Depth

ACRONYMS	Meaning
TEDs	Turtle Exclusion Devices
TEWG	Turtle Expert Working Group
TMP	Traffic Management Plan
TOC	Total Organic Carbon
TOC	Top of Casing
TOG	Total Oil and Grease
TOR	Terms of Reference
Total P	Total Phosphorus
TPH	Total Petroleum Hydrocarbons
TSPM	Total Suspended Particulate Matter
TSS	Total Suspended Solids
TTAPR	Trinidad and Tobago Air Pollution Rules 2014
TTMS	Trinidad and Tobago Meteorological Service
TTS	Temporary Threshold Shift
TTWPR	Trinidad & Tobago Water Pollution Rules 2001 (as amended)
TVD	True Vertical Depth
TWA	Time Weighted Average
UN	United Nations
UNCBD	United Nations Convention on Biological Diversity
UNCLOS	United Nations Convention on the Law of the Sea
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USCG	United States Coast Guard
USD	United States Dollar
USEPA	United States Environmental Protection Agency
USEPA GOM	United States Environmental Protection Agency Gulf of Mexico
UTM	Universal Transverse Mercator
VEC	Valued Ecosystem Component
VESTOR	Organisation of Suriname Tour Operators (Vereniging van Surinaamse Touroperators)
VOCs	Volatile Organic Compounds
WBM	Water Based Mud
WGS 84	World Geodetic System 84
WGS 84 UTM Zone 21	World Geodetic System 84 Universal Transverse Mercator coordinate system Zone 21

ACRONYMS	Meaning
WHSRN	Western Hemisphere Shorebird Reserve Network
WICE	World Institute for Conservation and Environment
WMP	Waste Management Plan
WTU	Waste Treatment Unit
WWF	World Wildlife Fund
YCP	Young Coastal Plain
Zn	Zinc

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EXECUTIVE SUMMARY

Introduction

Staatsolie Maatschappij Suriname N.V. (Staatsolie) is the State oil company of the Republic of Suriname and owns the sole rights for the development of the oil industry from the ‘Nearshore’ area of Suriname. The ‘Nearshore’ area consists of Blocks A, B, C and D which stretches across Suriname’s coastline and cover an area of approximately 11,133 km^2 within water depths of 0 – 30 m and extends 28-45 km offshore from the coastline. The Company is proposing to embark on a 10-well drilling project, hereafter referenced as the Nearshore Exploration Drilling Project 2019, within Blocks A, B and C. The project is expected to commence in the second quarter of 2019 for a 9-month period.

The National Institute for Environment and Development in Suriname’s (NIMOS), the local environmental regulatory body, has determined that this is a Category B Path 3 activity, (as per NIMOS’ 2009 EA Guidelines) requiring the conduct of a full Environmental and Social Impact Assessment (ESIA). Staatsolie is committed to ensuring that all health, safety and environmental matters take precedence over operational matters and are and continue to be proactive in the protection of the environment. The Company therefore engaged Environmental Sciences Limited (ESL) for environmental services and the proposed Project was subjected to environmental scoping (inclusive of public consultation), the result of which was the preparation of a Final Scoping Report (Terms of Reference or TOR) to guide this ESIA Project.

The structure of the ESIA is arranged in 8 main Chapters, whereby Chapter 1 introduces the Project and provides background information. Chapter 2 discussed the regulatory framework for environmental management based on the scope of activities of the Project. Chapters 3 and 4 provide technical details of the proposed Project and discusses optional considerations for execution respectively. Chapter 5 describes the physical, biological and socio-economic baseline data. Most critical portions of the ESIA include Chapters 6 and 7, which identifies and characterises the potential impacts of the Project and recommends mitigation, management and monitoring strategies. Finally, a list of document sources used in the compilation of this ESIA are provided in Chapter 8.

Project Description

The rationale of the Project is to explore hydrocarbons within the Nearshore area and moreover attempt to identify and quantify the potential reserves that currently exist within the Blocks to establish the presence of hydrocarbon reserves which can be developed commercially. Staatsolie has already identified 5 focus areas within Blocks A-C, where drilling will be targeted based on 2D and 3D seismic surveys. Within these focus areas, 15 preliminary potential drilling locations have been identified of which the Company intends to drill 10. These locations, however have not been confirmed and there may be adjustments closer to the Project commencement within the focus areas, based on further geological evaluations of seismic data. The drilling of these wells are expected to provide information on stratigraphy, reservoir distribution, size and possibly productivity. The target will be the Paleocene (2,000 - 3,000 ft) and Cretaceous (4,000 – 8,500 ft) sections. In cases where oil is found, the wells will be plugged and abandoned (no well testing or production are planned for this phase and no pumping of oil or flaring will occur). The follow-up programs will be defined based on the results of the Nearshore Exploration Drilling Project 2019.

The proposed Project will involve 3 major phases; pre drilling, drilling and post drilling. Pre drilling involves the mobilisation and transportation of the rig to the well locations; positioning of the rig and mobilisation; and transportation of personnel, materials and equipment to the drilling site. Following the drilling activities, post drilling will involve well abandonment (plugging on completion of the drilling phase); demobilisation/decommissioning and transport of the rig, materials, equipment and personnel back to origin.

Three anchor handling and support tug vessels (AHSTVs) will tow a mat-type Jack-up drilling rig to the 1st well-site location (in Block C) after clearing customs (at the mouth of the Suriname River). Maritime notices will be placed in advance, informing fishermen and other stakeholders of the rig move (~2 days), so that priority can be given to the slow moving/towed rig. When the rig arrives at the well location, the AHSTVs and the rig will anchor for stability at the final well-site coordinate. The rig will be winched in accordance with the Rig Contractor's instructions to within accepted surface tolerance. The coordinates will be verified and de-ballasting/ballasting of the mat and jacking of the legs will occur.

Once the rig is positioned and fully stabilised, the 3 AHSTVs will leave and the chase vessel will be stationed at the rig to maintain the 500 m exclusion zone[1] around the rig. Three platform supply vessels (PSVs) and a crew vessel will transport materials and crew from 3 optional shorebases/ports (Vabi, Kuldipsingh and/or Integra Marine at Smalkalden) on the eastern side of Suriname to the rig for commencement of the drilling process. A similar process will occur at the subsequent drilling locations (within Blocks B and C) during the pre drilling phase, as described above. However, the PSVs will originate from Nieuw Nickerie and the crew vessel from Boskamp for the wells that are expected to be drilled within Block A (western side of Suriname). Daily vessel movement of at least one vessel (as they will be on rotation) will occur for the duration of the drilling phase to replenish supplies.

The drilling phase of the Project will involve the drilling and well evaluation at the proposed exploration well-sites that will be performed in accordance with local regulations and internationally acceptable (IADC and API) standards. Drilling will commence through the installation of a 20/30" conductor pipe via piling at each well-site to an approximate depth of 425 ft and will serve to anchor

[1] *Maritime notices will be published prior to the rig positioning advising of the exclusion zone.*

the blow out prevention (BOP) system. This process is estimated to be about 10 hours long. Three subsequent hole sections (16”, 12 ¼” and 8 ½”) will be drilled, installed with casing and subsequently cemented. Seven of the 10 wells will be shallow (2,400-4,000 ft) and the other 3 will be deeper (5,700-8,900 ft). The final drilling program and section depths will be confirmed upon receipt of actual well locations and prognosed lithology.

The drilling muds is a mixture of clay and chemicals that are pumped down the well-bore during drilling operations to reduce friction in the well-bore and transport dill cuttings out of the well-bore and cool the drill bit. Only water based muds (WBM) will be utilised for this Project and an estimated volume of 1,290 bbls and 2,205 bbls for the shallow and deep wells, respectively, will be required. The major components of WBM are clay and bentonite, which are chemically inert and non-toxic. The type and quantities of additives mixed with the drilling mud is a function of conditions unique to each specific well and the particular stage of drilling. Safety Data Sheets (SDS) for all drilling fluid additives are available and will be on-site during the drilling operation.

Drill cuttings generated during the drilling process are normally brought to the surface and are typically washed to remove excess drilling mud and tested (sheen test) before discharge overboard. The discharged cuttings consist of small rock particles (gravel size). Some of the drilling muds will be recycled in the subsequent wells and be discharged overboard at the end of drilling the last well.

Fuel (diesel) used for generators and engines will be stored on-site in approved tanks on the rig and replenished when necessary. During replenishment, the diesel will be transported from the port to the rig in approved covered containers via support vessels. These containers will be separated and secured to minimise spills (through accidents).

Potable water will also be transported from the shorebase(s) to the drilling rig via supply vessels in addition to water provided by the desalination unit on the rig. An estimated 65–80 bbls of potable water will be required per well. All other water demand will be satisfied by extraction of sea water, therefore minimal demand for water from the public water supply will result.

Domestic solid waste generated from the site will normally consist of small quantities of cans, bottles and sacks. Garbage from the well-site will include food waste, packaging material and other non-hazardous solid wastes, estimated at not more than 1.5 – 1.7 kg/person/day in general (American Society of Civil Engineers 2010). For domestic waste items, a portable waste bin will be provided which will be emptied at an approved waste disposal site in Suriname.

Waste oil and other hazardous waste would be collected and transferred to onshore facilities for proper re-use, recycling, treatment or disposal at a Staatsolie approved treatment facility. Grey and black wastewater streams will be generated on-board the drilling rig over the duration of the exploration drilling Project, estimating 1.5 m^3/person/day grey water and 0.008 m^3/person/day sewage (ESL 2013). The rig will be equipped with a certified Omnipure^{TM} 12MC Unit to process all the generated sewage prior to discharge overboard according to MARPOL (73/78) requirements (disposal of treated waste is 5.6 km from the nearest land).

In the offshore environment, there will be some minor combustion emissions associated with the vessels (surveying/sampling vessels and support vessels). These are expected to be quickly dispersed based on the short Project timeline (9 months, however drilling will be 2-3 weeks at a time for 24-hour operations), in the offshore environment with high wind dispersion.

Noise emissions during drilling activities will originate from piling operations (10 hours per well), equipment and machinery, vessels and generators. The general noise levels are expected to range 70-85 dBA during normal drilling operations (i.e. non piling activities).

The drilling rig will be well-lit for on-board safety and maintain exterior lighting to ensure visibility to other vessels operating in the area as well as due to 24-hour operations.

It is expected that approximately 70 employees (aboard the rig) will be required for this Project. Most of the staffing required for the construction will be skilled craftsmen. Local content inclusion will be a major objective for this Project and will be maximised once the required skill set is available. However, both local and expatriate staff will be utilised for the Project. Recruitment, housing and detailed transportation arrangements will be determined later on by the Company prior to the start of the Project.

Analysis of Alternatives

An alternative is defined as any course of action, means or method by which the proposed Project objectives may be attained. This Chapter demonstrates that all feasible alternatives for the proposed Nearshore Exploration Drilling Project 2019 have been considered and methodically assessed based on environmental, social, economic and technical criteria. This ensures that the final decision results in the best method of achieving Project objectives with minimal impacts to people and the environment. In most cases, alternatives are constrained by their practicality, cost and/or potential to cause adverse environmental impacts. The assessment of alternatives also includes the “no action” option, which is the continuation of existing activities without the implementation of the proposed Project.

Four drilling rig alternatives were discussed, whereby the Jack-up mat-type rig was the most feasible due to technical suitability with respect to the shallow water depth, type of seafloor conditions and financial benefits as well.

Two types of drilling muds were assessed, WBM and synthetic oil based mud (SOBM). The first was the most feasible for all criteria assessed. The WBM were assessed to have lower environmental impacts due to reduced toxicity over SOBM. It was also more economical and technically feasible as SOBM is more suitable for deep wells as complexity of formation changes, which is not the case for this Project. Two drill cuttings disposal methods were also evaluated and based on the composition of the WBM, the preference was treatment and overboard discharge as a result of low environmental impacts, which did not warrant additional costs for more intensive treatment onshore.

Two sewage treatment alternatives were discussed: the use of a marine macerator or a marine sanitation device (MSD). The latter was considered more feasible due to the lower environmental impacts that may potentially arise.

A total of 6 ports/shorebases were discussed for this Project, whereby 4 from the eastern and 2 from the western areas/parts of Suriname were evaluated based on when the drilling will occur in Blocks B and C (eastern) versus Block A (western). Nieuwe Haven port/shorebase was considered as the main receiving port for materials and equipment for further transport to Staatsolie's facility at Nieuwe Haven for disbursement to Blocks B and C from the other 3 eastern ports (Vabi, Kuldipsingh or Integra Marine at Smalkalden). Of the 4 ports/shorebases located along the Suriname River, Nieuwe Haven was the closest to the Blocks and to Staatsolie's facilities and therefore most economical and environmentally viable. In terms of technical consideration, the Kuldipsingh port/shorebase has the largest harbour size and could be more suitable based on ability to handle the increase in business from greater demand in logistics for supply of materials and personnel to the offshore Block with respect to vessel movement. On the western side, Staatsolie considered the Nieuw Nickerie and Boskamp ports/shorebases, however limited information is available for the latter and this port is only considered for crew transport. Based on the foregoing, Nieuw Nickerie is the preferred port/shorebase on the western side to service drilling operations within Block A, due to proximity and subsequent financial savings.

Given the current economic climate to develop oil and gas in Suriname, the "no-action" alternative was not considered a viable option as hydrocarbon exploration and production in Suriname is essential for stimulation of local economy through supplying worldwide demands for hydrocarbons.

Description of the Environment

The extent and nature of the studies conducted to describe the environment were prescribed in the Final Scoping Report (Appendix A.1), with review and approval by NIMOS. The baseline study area (see Figure 5-1 of the main report) includes areas which may be potentially affected by this Project and comprises the immediate Project footprint and a wider study area. The immediate Project footprint consists of the environment within a 500 m radius of the Jack-up rig (for a maximum of 10 preliminary drilling locations), marine transit corridors for the rig and supply vessels, and the ports/shorebases and associated road networks to be used for this Project. The wider study area for the Project includes the rest of Blocks A, B, C and D, and the surrounding coastal

Nearshore and marine offshore waters of the north coast of Suriname, as well as a terrestrial (coastal) zone within 2 km of the coastline of Suriname.

The assessment covered the physical, biological and social aspects of the onshore and offshore environments and the detailed analysis is presented in Chapter 5. A wide range of data were collected from existing reports, (local, where available and international) and other sources and supplemented by targeted field studies including a comprehensive Block-wide assessment of water, sediment and macrobenthic quality from sampling conducted in June-August 2017 (long wet season) and September-November 2017 (long dry season). Other primary physical datasets which were used for analyses include meteorological data for the period July – December 2017, from a meteorological station located at Weg naar Zee; oceanographic (currents, waves and tides) data for the period October – December 2017 obtained from an ADCP deployed in the Nearshore area; and ambient surface noise readings taken at several stations along the shoreline (onshore) from Albina to Nieuw Nickerie in July 2017. ESL also conducted an aerial flyover in July 2017, with site reconnaissance at several locations along the shoreline in February 2018.

Where possible, the targeted field studies were compared with previously collected data (within a 5-year period, as stipulated by NIMOS) to give contextual meaning to the results. These previously collected data provide a useful benchmark against which the data collected for the Staatsolie Nearshore Exploration Drilling Project 2019 ESIA can be assessed.

The Physical Environment

The Project area (Blocks A to D) is located in front of the coastline of the Young Coastal Plain (YCP) and is located on the Continental Shelf. The Coastal Plain forms the marginal part of the large Guiana Basin in which subsidence and sea level movements have greatly influenced sedimentation. Seismic and well data obtained by Staatsolie in recent years have indicated oil fields and oil and gas shows; Bassias 2016 and CGG 2014 also indicate the presence of oil seeps within Nearshore Blocks A to D.

With respect to hydrodynamic conditions, the Suriname coast is classified as a low to medium energy coast (Augustinus 1978). It is dynamic and subjected to an active geomorphological development, which is determined by a system of cyclic accretion and erosion. These processes drive the occurrence of the main physiographic features of the coastline, including: shoreface-attached mudflats/mudbanks; overwash bars; guirlande ridges; and stretches of straight and indented coastlines, the latter being indented to various degrees.

Surface freshwater resources include rivers, swamps and lagoons; changes in the rainfall pattern are directly observed in the hydrological regime of the swamps and rivers, of which there are 7 main ones (from west to east): Corantijn; Nickerie; Coppename; Saramacca; Suriname; Commewijne; and Marowijne. The tidal estuaries and areas of confluence which may be directly affected by Project activities are those of the Suriname, Coppename and Corantijn Rivers, of which the latter is the largest by discharge volume.

Suriname's weather is dictated mainly by the ITCZ and associated NE and SE trade winds; differences in the monthly rainfall totals result in 4 seasons (Scherpenzeel 1977). These include:

- Long rainy: end of April to mid-August;
- Long dry: mid-August to early December;
- Short rainy: early December to early February; and
- Short dry: early February to the end of April.

Highest average monthly rainfall occurs during the months May, June and July (long rainy season); the driest months in Suriname are September, October and November (long dry season). The highest wind speeds occur during the period February-April; at Lichtschip (located within Block C) and along exposed coastlines, the monthly mean ranges between 2.5 and 4.5 m/s. Meteorological data obtained at Weg naar Zee for the long wet season (July 2017) and long dry season (August – November 2017) showed that the majority of wind speeds were ≤ 4 m/s, with marginally higher wind speeds during the short wet season (December 2017; 6 – 7 m/s). Calm winds (hourly speeds less than 0.5 m/s), are very frequent across most of Suriname, occurring over 50% of the time, with the highest frequency during June-July (Scherpenzeel 1977), hence the lowest wind speeds occur in May-August, ranging between 0.7 and 1.1 m/s.

The wind directions in Suriname correlate to the position of the ITCZ, whereby the directions NE and ENE usually have the highest frequencies. This was corroborated by the Meteorological data obtained at Weg naar Zee; for the long wet season, the predominant wind direction was from the NNE. For the long dry season, winds from the ENE and NE dominated, and for the short wet season, winds from the NE predominated, with components from the E and ESE.

The bathymetry of the Nearshore Blocks A to D is gently undulating, with water depths of 0 – 30 m; the slope of the seafloor is gently sloping from shore to offshore. The tide along the Surinamese coast is classified as semi-diurnal, with 2 high tide events and 2 low tide events during a 24-hour period. The tidal range varies between 1.00 m at neap tide and 2.80 m at spring tide, so that the average is calculated as 1.9 m. At the shoreline, the resultant component of the tidal currents and the Guiana Current is in a NW direction during the complete tidal cycle.

The highest waves along the Suriname coast occur from December to March (short wet and short dry seasons; 1.6 m); the lowest significant wave height (and so, the calmest period) usually occurs during September (long dry season; 0.75 m).

The wind stress to the Atlantic Ocean is the most important driving force for currents in the upper strata of the ocean. The main current, the wind-driven Guiana Current flows from east to west along the coastline, with a NW trajectory, parallel and close to the Guiana Coast in relatively shallow fore-shore. The maximum velocity is 1.5 to 2.0 m/s at up-current locations off French Guiana and decreases in a westerly direction. In eastern Suriname, the Guiana Current varies between 1.1 m/s and 0.75 m/s, respectively, during the rough season (April/ May) and calm season (September – October), decreasing to 0.5 m/s and 0.3 m/s for western Suriname locations. Another key aspect of regional oceanography related to currents involves the NBC retroflection, which leads to a weaker Guiana current along the coast, when in operation during June to December.

Current data collected for the period October to December 2017 (long dry season and short wet season), from an ADCP indicated that, in the Nearshore area, measured currents oscillate according to the movement of flood and ebb tides at this location, with a resultant current flowing to the W. The data also revealed that the highest observed velocities were less than 0.7 m/s.

Sediment grain size results for the long wet and dry seasons indicated that clay was the dominant sediment type at 90% of the stations sampled, and the results did not vary significantly when comparisons were made between 2013 and 2017 data for Block C.

The sediment total metals chromium, lead, zinc and aluminium displayed highest values within Blocks C and D (both seasons). A similar finding was made for the water total metals, aluminium, iron, lead, chromium, nickel, copper, as well as phenols, total phosphorus, ammoniacal nitrogen and nitrite. It is likely that the sediments and overlying water sampled in 2017 contained total metals from oil and gas seepages which are known to occur along the coast of Suriname (Bassias 2016 and CGG 2014).

The sediment total metals chromium, lead and zinc exceeded their relevant USEPA Benchmarks (52.30 mg/kg; 30.20 mg/kg; and 124.00 mg/kg); values detected during the long wet season were higher than those detected in the long dry season, and, along with mercury and aluminium, values of these 3 parameters were higher than the values recorded in the short wet season of 2013 within Block C. For water, nitrite, and phenols were higher in 2017 as compared to 2013, but nitrate, total phosphorus, TSS, TPH, hexavalent chromium, and the total metals, copper, lead, iron and aluminium were lower than the values recorded in 2013.

When taking both water and sediment quality results into account, it can be concluded that, over time, prevailing (natural) environmental conditions within the Nearshore environment played a significant role in influencing the quality of marine water and sediment, including the changes which may have occurred within the western portion of Block C between 2013 and 2017. These natural environmental conditions include runoff from the Coppename and Suriname Rivers and naturally occurring oil and gas seepages, both of which would be affected by regional oceanographic conditions along the Guiana coast.

The 2017 *in-situ* pH was found to be neutral to slightly alkaline and conformed to the expected levels in the marine environment. Temperature and salinity data did not indicate the presence of thermoclines and haloclines, respectively, indicating a well-mixed water column during both seasons. Levels of these 2 parameters also conformed to expected conditions within the marine environment, with the influence of local and regional rivers on salinity obvious.

An examination of the DO and chlorophyll-a datasets for 2017 revealed that it was likely that all 245 stations sampled in 2017 fell within the Brown water zone at the time of sampling, in which the water is highly turbid and light penetration is low (less than 0.1 m; Lowe-McConnell 1962 and Froidefond *et al*. 2002).

Monitoring of ambient surface noise along the shoreline revealed quiet ambient conditions at the time of sampling during July 2017). A comparison of underwater noise assessments conducted in September 2010 and June – December 2014 revealed that, generally, the baseline level recorded in June - December 2014 (115 – 125 dB re 1µPa) was higher than that recorded in September 2010 (90 – 100 dB re 1µPa).

The Ecological Environment

Analysis of benthic macrofaunal samples retrieved across 245 stations during both seasons revealed a total of 35,549 specimens from 164 taxa in the long wet season and 37,163 specimens from 160 taxa in the long dry season. Arthropods, annelids and molluscs dominated the species composition for both seasons. Analysis in PRIMER utilising dendrograms and MDS plots showed that the similarity in faunal distributions varied, with some stations being identical in taxonomic distribution at the family level. MDS analyses also indicated that sediment grain size may have influenced the species composition at Block B, but that species composition (in any Block) may not have been influenced by water depth. When biotic and abiotic (water and sediment) data were subjected to multivariate analyses using PRIMER's BEST (Bio-Env) tool, the abiotic factors (water and sediment) which formed the highest correlation with the biotic data (species composition) was variable between blocks. Blocks A, B and C recorded the highest correlation with total phosphorus in water and Block D recorded the highest correlation with lead in water. These data generally indicated that biotic composition was influenced in different ways by the abiotic factors at the time of sampling.

Regarding other benthic fauna and habitats, a review of available literature revealed that neither seagrass beds, macroalgal beds, nor reef assemblages are known to occur within Blocks A to D; a coastal ecological study conducted in 2010 revealed the presence of an isolated soft coral taxa within Block C.

Results of the long wet and long dry plankton analyses indicated that the planktonic community within Nearshore Blocks A to D was both diverse and dense at the time of sampling. There was an overall increase in taxonomic diversity and decrease in planktonic density from the long wet season to the long dry season.

Analysis in PRIMER utilising dendrograms and MDS plots showed that there was low similarity in faunal distributions among the stations sampled, with abiotic factors such as water quality indicating no significant effects on biotic data.

Numerous secondary data sources indicate that the offshore waters of Suriname are taxonomically diverse regarding cetaceans; 12 whale taxa, 17 dolphin taxa and the West Indian manatee (a sirenian) may be found in the waters of Suriname, in general. Based on available literature and recent marine mammal surveys in the waters of Suriname (de Boer 2015), the following was noted: (i) Bryde's whale may be is present in Suriname's deeper waters (outside of the Blocks) during May – September; (ii) Sperm, Pygmy and Dwarf sperm whales may be encountered in deeper waters during June – August; (iii) numerous dolphin taxa, including the most common to Suriname's riverine estuaries (Guiana dolphin), may occur within the Nearshore area and further offshore during the period June to November; and (iv) Humpback whales may be encountered during January to May. It is likely that these taxa may be encountered within Suriname's waters during the proposed drilling period (April – December 2019). These taxa also display varying levels of vulnerability, based on their respective IUCN Red List of Threatened Species classifications.

The 5 species of marine turtle which are known to nest along Suriname's coast are internationally and locally protected species. These taxa typically nest during the overall period of January – August, with peak nesting from April to June. Published data sources indicated that 32,000 Leatherbacks nested along the east coast beaches at Galibi and Matapica in 2009, and WWF Guianas tagging studies indicate the presence of these taxa in the offshore and Nearshore waters. Thus, the occurrence of these taxa also coincides with the proposed drilling period.

Of the 539 fish taxa known to occur in Suriname's waters, many of these are commercially important, including sciaenids, some taxa of which move inshore to estuaries (Corantijn, Coppename and Suriname Rivers) during June to August, and this coincides with the proposed drilling period. Also commercially important are the decapod taxa belonging to the family Penaeidae (shrimp), which account for a large proportion of income earned from fisheries exports.

Migratory shorebirds can be found in peak numbers in Suriname during the southbound (July–November) and northbound (February–May) migration periods; the proposed drilling period of April – December 2019 coincides with the peak southbound migration, and with the latter part of the northbound migration. Breeding occurs throughout the year, although most birds breed during the long wet season (late April to mid-August and as late as September), with peak breeding during May – June. Based on this, breeding (colony and non-colony forming birds) will occur for the duration of the drilling period (April – December 2019).

The terrestrial area to the south of Blocks A to D is habitat-diverse and species-rich. Ecosystems which are critical in the support of biodiversity include: mudflats, mangroves and lagoons. More specifically, marine waters, soft mudflats, firm clay flats, young coastal mangrove, older stands of Black mangrove and brackish water lagoons and swamps provide habitat for over 729 avifaunal species. Of these 209 are either partly or entirely dependent on the Suriname coastal area for survival. The coast of Suriname contains the most important feeding, breeding and nesting sites for resident coastal birds, and is internationally important for North and South American migrant species. A total of 118 species utilise this coastal area for nesting, 70 of which are waterfowl species. The coastal area is critical (internationally important) for 7 waterfowl species, and there are very high nesting colony densities for herons and ibises along the Saramacca coast, based on unpublished data from Spanns for 2009 (3,000 – 6,000 nests) and 2011 (2,750 – 3,500 nests).

Finally, the following protected areas overlap with Nearshore Blocks A to D: 4 MUMAs (Bigi Pan, North Coronie, North Saramacca and North Commewijne – Marowijne) and 4 NRs (Peruvia, Coppename Monding, Wia-Wia and Galibi). Most of these are very important feeding and breeding areas for birds (Bigi Pan MUMA and CMNR are WHSRN sites, and the latter is also a Ramsar site, while the former is proposed); while Galibi is so designated for the protection of turtles nesting areas.

Socio-Cultural and Economic Environment

The resource users who can be found within terrestrial, Nearshore and marine environments which comprise the baseline study area include: local residents; local (national) users; tourists (regional/international); tour operators and guides, NGO and CBO groups; farmers; fisherfolk; agricultural and fish processing and distribution/export companies; oil & gas companies; mining companies; service sector companies; marine transport users and Government (federal and local).

The fishing industry is an important economic sector in Suriname. The gross value of the fisheries' output was estimated at 87.1 million USD in 2014. The Nearshore Blocks A to D has the potential to affect both artisanal and industrial fisheries. An analysis of the fathom zones within which the various types of fishing are allowed, revealed that SK, SKL and SKB fishers (who fish within allowed areas between the shore and the 10 fathom line), Seabob trawlers (who operate between the 10 – 18 fathom lines), and sport fishers, may be adversely affected by drilling activities within the Block. Industrial fishers (who operate beyond the 15 fathom line) may not be disrupted by drilling activities, except perhaps in the topmost portion of Block B, where the 15 fathom line intersects its northern boundary. There is the potential for all fishers to be affected if marine traffic is halted to accommodate movement of the rig and equipment.

Several shipwrecks are located within Blocks A to D (based on data provided by MAS). International and regional freight traffic occurs along established navigation routes which traverse the Nearshore area. To enable large ships to enter and leave Suriname, 4 navigation channels are located along the coast at the entrance of the main rivers. there is a “ship to ship” location, where bulk freight (e.g. gravel) is loaded from smaller boats onto larger ships. The ship to ship location is in close proximity to the navigation channel for the Suriname River.

Stakeholder participation in the ESIA process involved consultations on the draft scoping report (inclusive of interviews and an initial public consultation meeting in June 2017), as well as stakeholder interviews held during November 2017 – January 2018).

Some of the concerns raised included: waste management strategies for drilling muds and cuttings; the need for direct consultation with fishers, including on matters relating to compensation where losses to fishers may arise as a result of Project execution; the potential environmental impacts of hydrocarbon spills, noise from drilling and the disposal of drilling muds and cuttings after drilling. Many of the stakeholders also expressed a desire to be included in further consultations, so as to have an opportunity to provide feedback on matters such as the development of the Oil Spill Response Plan for this Project.

Impacts & Risk Assessment

The impacts of the Staatsolie Exploration Nearshore Drilling Project 2019 were assessed using the valued ecosystem approach, through a 4-stage process which entailed the following:

- An identification of change resulting from the stressors (planned initiating events of the various phases of the Project, i.e. pre drilling, drilling and post drilling) on the receiving environmental (i.e. physical, biological and socio-economic) of the defined study area. Inherent mitigation was considered as incorporated into the design of the Project;
- Understanding the nature of the likely change in terms of exposure (spatial, temporal, frequency) of the environmental features to the stressors;
- Evaluation of the vulnerability of the environmental features as a basis for assessing the nature of the impact and its significance (medium, high or critical) or not significant (negligible or low) as defined by an ESL-based impact classification table; and
- Identification of impact reduction measures to manage any impacts to as low as reasonably practicable (ALARP) that were found to be significant.

Where the relevant Project details were available, the quantitative assessment was supported by numerical calculations, which took the maximum of 10 wells into account. For the qualitative assessment, spatial extent included the location of all 15 preliminary drilling locations as well as the focus areas.

The approach also took into account impacts during upset conditions (such as from potential hydrocarbon spills). Numerical modelling was executed by TETRA TECH to simulate oil and diesel spills for the long and short seasons from 5 modeling sites within the Project area.

A total of 13 stressors were identified from the 3 Project Phases and 3 of these were considered to have significant impacts (moderate to high), 8 of them were considered to have low impacts and 2 had negligible impacts on the receiving environment. The stressors with high to low impacts were discussed further in this Chapter. These included:

- **Positioning of the Jack-up rig:** potential impacts from rig mat placement (0.012 km^2) and sliding of the rig legs into position may result in scarring of the seabed, crushing of marine benthos (soft-bottom macrobenthos and benthic fish and shellfish), affect marine water quality and affect marine mammals, sea turtles and pelagic fish from under water noise. Overall, the impact during the pre drilling phase on the physical nature of the seabed, water quality, sound quality (below water), benthic fish and shellfish and offshore soft-bottom dwelling and feeding macrofauna is considered to be short to medium term and over a small area, thereby contributing to a **low** impact;
- **Anchoring:** a total impact area of 5.34 x 10^{-3} km^2 gives similar impacts (**low**) as positioning of the Jack-up rig, occurring at all 3 Project phases;
- **Vessel movement:** a total of 724 return trips daily for supply/crew vessels (and a single return trip during the pre and post drilling phases for the anchor handling tugs) could create impacts through physical movement, noise and gas emission. The most significant potential impact of vessel movement from all phases is expected on marine mammals (whales and dolphins) and sea turtles, evaluated to be **negative**, **direct** and **moderate** (for all phases) and **indirect** for fisheries and resource users (fishers) during the drilling phase. The impact on marine ports and traffic was evaluated as **negative**, **direct** and **low** during the drilling phase;
- **Conductor pipe, drilling and casing placement:** underwater noise impacts from piling activities on marine mammals, sea turtles, benthic fish and shellfish (crustacea) and pelagic fish has been classified as **negative**, **direct** and **moderate**. Impacts to fisheries and resource users (fishers) was classified as **negative**, **indirect** and **low**. Placement of the conductor pipe (4.56 m^2) can also crush benthic fish and shellfish, and benthic soft-bottom macrofauna on the seabed contributing to a **negative**, **direct** and **low** impact. The impact of above-water noise from piling on resources users (fishers), marine and coastal avifauna has been classified as **negative**, **direct, indirect** and **low;**
- **Discharge of WBMs and cuttings:** drill cuttings and drilling mud volumes of 1,210 bbls and 2,086 bbls respectively were considered for this Project. Modeling results show the maximum deposition thicknesses were 24 mm and 17 mm for the short and long seasons, respectively (and below the 50 mm threshold), which corresponds with areas of 223 m and 209 m of thickness >1 mm. The impacts from the discharge of drilling muds and cuttings to benthic fish and shellfish, soft-bottom macrofauna, marine sediment, marine mammals, sea turtles, pelagic fish and plankton, fisheries and resource users was **negative, direct, cumulative** and **low;**
- **Improper solid waste disposal:** improperly disposed solid waste on the biological (benthic fish and shellfish, soft-bottom macrobenthos, marine mammals, sea turtles, pelagic fish, coastal and marine avifauna) and socio-economic (resource users (fishers and other vessel operators)

fisheries and marine ports and traffic) receptors as well as water quality has been evaluated as **negative**, **direct** and **indirect**, **cumulative** and **low** for all phases of the project;

- **Discharge of sanitary and organic waste:** The impacts of treated sanitary and organic waste discharge is considered **negative**, **direct**, **direct** and **low** for the drilling phase and **indirect** for pre drilling and post drilling (as well as marine sediment quality for all phases);
- **Vehicular movement:** the impact of vehicular movement (and the ports/shorebases) on road infrastructure and traffic and noise on human health is considered **negative**, **direct** and **low** for all phases of the Project;
- **Operational discharge:** the potential impacts during drilling and post drilling on marine mammals; sea turtles, pelagic and benthic fish and marine and coastal avifauna, pelagic fish, marine resource users (fishers) human health and marine water are considered to be **negative**, **direct, cumulative and low;**
- **Hydrocarbon and chemical spills:** the impact was regarded as being **negative**, **direct** and **indirect** of a **low to high** significance in drilling and post drilling phases; and **negative**, **direct** and **low** in the pre drilling phase; and
- **Gas emissions:** overall, the impact of gas emissions from all Project activities on air quality has been classified as **negative**, **cumulative**, **direct** and **low** for all phases.

Cumulative impacts were also evaluated as those that have the potential to cause accumulation of environmental effects within a particular location and timeframe, within the Project as well as in conjunction with other Projects. For this Project, the stressor which could potentially have the highest negative impact on water column biota such as marine mammals, sea turtles, benthic and pelagic fish, and marine and coastal avifauna, and noise (from vessels and drilling) as wells as fisheries (barring mitigation), is hydrocarbon and chemical spills (**negative**, **indirect** and **high** for the drilling phase).

Mitigation, Monitoring & Management Plan

Staatsolie has proposed strategies to mitigate, monitor and manage the potential impacts on the receiving environments from its drilling activities at the well-sites within the Project area. The procedures will be consistent with national regulations, internationally accepted industry standards and guidelines recommended by the World Bank for offshore oil and gas exploration. This Project will be the subject to a Health, Safety and Environment (HSE) Plan developed specifically for this Project, prior to Project start-up.

Mitigation measures outlined in this Section were recommended via a receptor-based approach on the following:

- **Seabed physical nature:** the additional mitigation to further reduce the impact of anchoring will include using vessels equipped with dynamic positioning (DP), where possible;
- **Water quality:**
    - **Sanitary and organic waste discharge:** this will be managed by Staatsolie's Project-specific Waste Management Plan (WMP). *Additional mitigation* will include monitoring the effluent stream. Staatsolie will have on-board representative to enforce;
    - **Improper solid waste disposal**: this will be managed as per Staatsolie's WMP. *Additional mitigation* will include on-board representative Staatsolie to ensure compliance with waste management (collection, storage and disposal) strategies;
    - **Operational discharge:** all hydrocarbon-contaminated runoff (deck drainage) on the rig will be routed to an oil/water separator and monitored prior to discharge in compliance with MARPOL 73/78 and USEPA GOM Effluent Limits 2007. *Additional mitigation will include* having a designated Staatsolie representative on-board for ensuring compliance is executed by the Drilling Contractor. Operational discharge will not be released into the marine environment in the event of non-compliance;
    - **Hydrocarbon and chemical spills:** this will be managed by Staatsolie's Project-specific Emergency Response Plan or ERP (which will be developed prior to Project execution) and Oil Spill Response Plan (OSRP); secondary containment for fuel storage and utilising a Blow Out Preventer (BOP) stack during drilling. *Additional mitigation* will include an in-country oil spill response and support team. Staatsolie shall also employ an experienced drilling contractor. Staatsolie will only bunker during calm seas and will develop a Project-specific Traffic Management Plan (TMP);
    - **Drilling muds & cuttings discharge:** Staatsolie will utilise WBM over synthetic based mud (SOBM) for this Project and drill cuttings will be treated in accordance with the USEPA GOM Effluent Limits 2007 before discharge. Also rig preparation will occur for using WBMs. The *additional mitigation* will be to monitor (prior to discharge) and onshore treatment for exceedance;
- **Air quality:** *additional mitigation* of regular maintenance for internal combustion engines (rig, vessel and vehicle) in accordance with manufacturer's specifications to reduce emissions and reduced vessel transit time;
- **Benthic habitats and fauna:** these measures include a WMP and management of drill cuttings in accordance with the USEPA GOM Effluent Limits 2007;
- **Marine mammals, sea turtles, pelagic fish and marine and coastal avifauna:** mitigation as outlined above for waste streams in water. *Additional mitigation* will include reducing underwater sound by drilling instead of piling the conductor pipe in place; enclosing the ramming pile with acoustically isolated material; installation of air bubble curtains around the pile; MMOs should also be used;

- **Fisheries and fishers:** these measures include a TMP, mariner's notices, enforcement of an exclusion zone and having established vessel routes. *Additional mitigation* will include a Community Relations Plan (CRP);
- **Protected areas, sensitive ecosystems, terrestrial fauna, recreation and tourism and resource users:** this will be the same as water quality section above;
- **Emergency resources, marine ports and traffic and other resource users:** these will be addressed by the TMP;
- **Archeological resources:** 5 km buffer around shipwrecks and liaise with the key stakeholders (governmental) in establishing a plan to manage any impacts from potential hydrocarbon spill; and
- **Human health:** these are the same as outlined in the section above for water quality, air quality and marine mammals (for noise).

Staatsolie will undertake the following monitoring:

- **Post drilling environmental monitoring:** sampling of water, sediment and benthic organisms to evaluate change in the environment. This will be compared to the results of the baseline assessment conducted in 2017.
- **Environmental monitoring during the drilling process:** sampling of effluents entering the water column and seabed sediments will be collected and quantitatively analysed to ensure compliance with applicable local and international standards.

Staatsolie will also undertake the following management actions:

- Environmental and Social Management Plan (ESMP);
- Oil Spill Response Plan;
- Emergency Response Plan;
- Waste Management Plan;
- Traffic Management Plan;
- Community Relations Plan.

1 INTRODUCTION

1.1 Background

Staatsolie Maatschappij Suriname N.V. (Staatsolie) is the State oil company of the Republic of Suriname, a sovereign state on the north-eastern Atlantic coast of South America, with ties to the Kingdom of the Netherlands (Figure 1-1 below). It was established on December 13th, 1980, towards the goal of development of the oil industry of Suriname via the execution of petroleum policy on behalf of the Government of Suriname, who is the sole shareholder.

Staatsolie's commercial activities involve exploration, drilling, production, refining, marketing, sale and transport of crude and refined petroleum products. At the institutional level, Staatsolie is involved in the assessment of hydrocarbon potential, promotion, contracting and monitoring activities of International oil companies on behalf of the State.

Staatsolie operates the onshore oil fields of Tambaredjo, Calcutta, and Tambaredjo North-West, targeting Saramacca crude. Crude production is estimated at 17,000 barrels of oil per day, and Staatsolie's refinery has a processing capacity of 15,000 barrels of oil per day. Refinery products include: premium diesel and gasoline, Staatsolie diesel, fuel oil, bitumen and sulphuric acid. Its main markets are Suriname and the Caribbean.

Staatsolie also owns the sole rights for the development of the oil industry from the 'Nearshore' area of Suriname, which is a legally defined area north of Suriname's coastline, assigned to Staatsolie for the purpose of hydrocarbon exploration. To this end, the Nearshore Exploration Drilling Project 2019 has been proposed for the period April 1st – December 31st, 2019. The Nearshore area currently consists of 4 contiguous Blocks, Blocks A, B, C and D, which stretch across Suriname's coastline and cover an area of approximately 11,133 km^2 (see Figure 1-2 below), which extends 28-45 km offshore from the coastline. The water depths in the study area ranges from 0 – 30 m.

Staatsolie is planning an exploration drilling program of a maximum of 10 well locations across Blocks A to C within the Nearshore area; a potential well location has not yet been identified within Block D. Based on previous 2D and 3D seismic surveys, 5 focus areas were identified within the Blocks, within which the potential wells could be drilled (see Figure 1-2 below).

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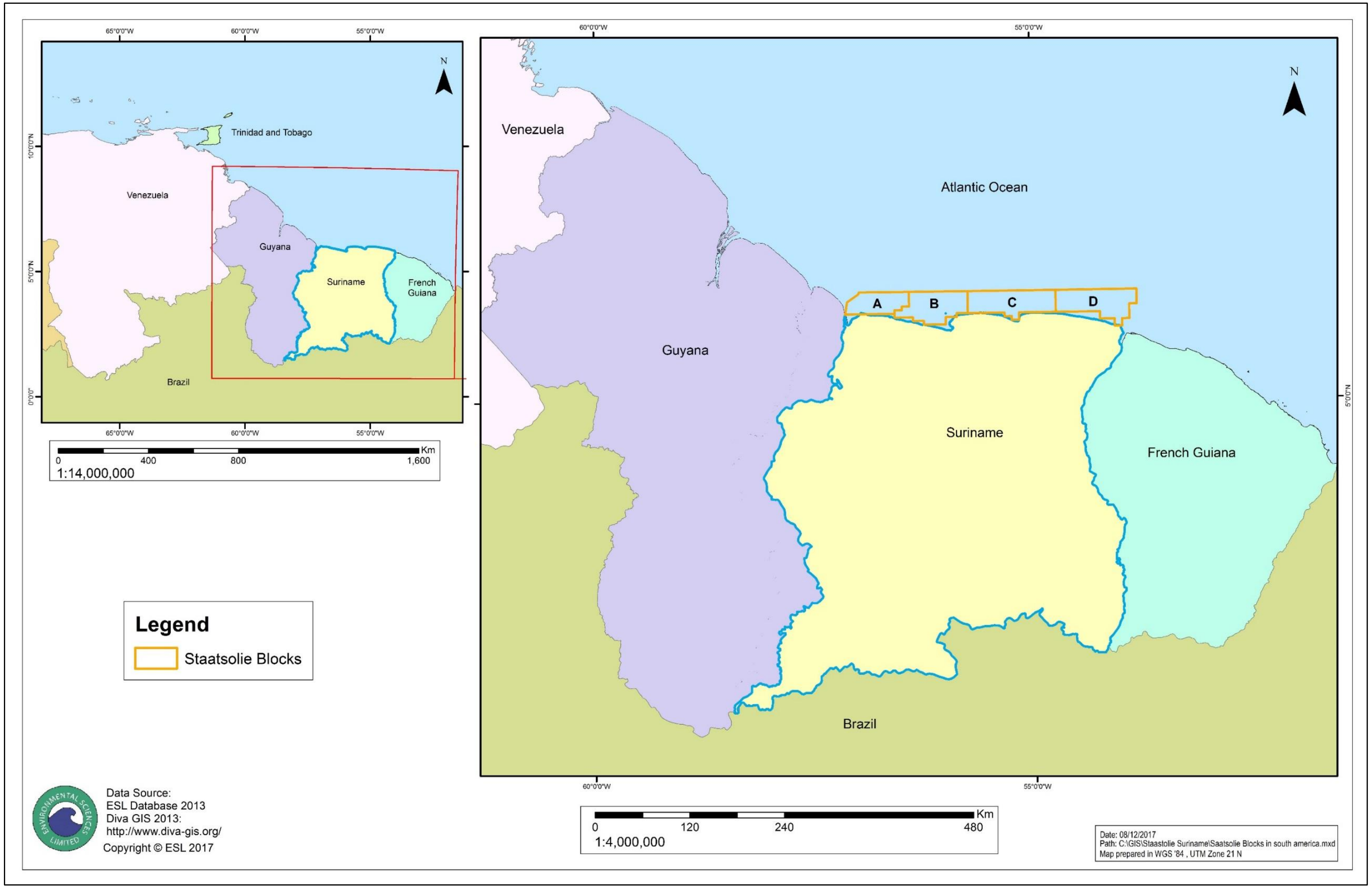


Figure 1-1: Regional Map showing the location of Suriname

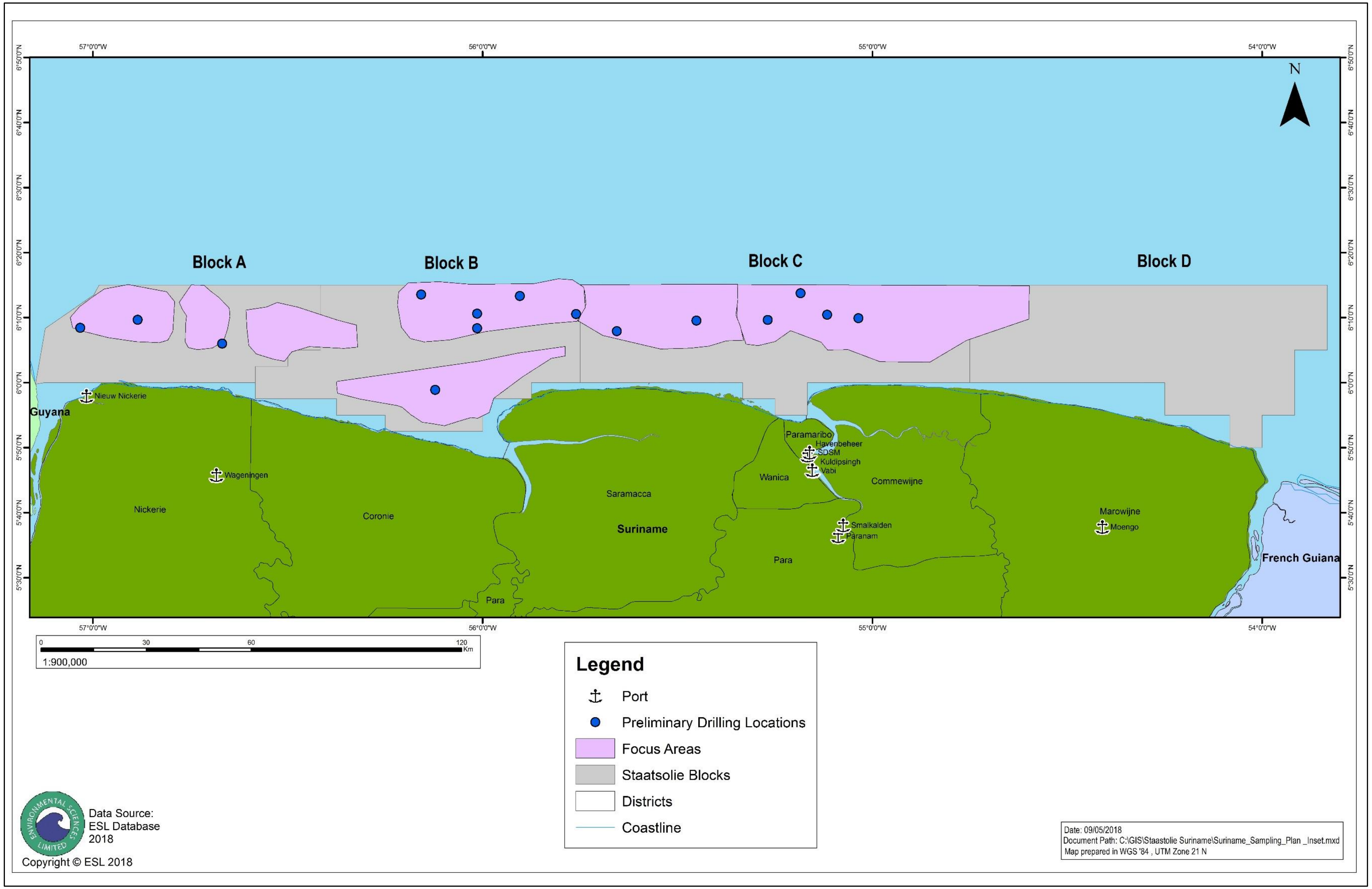


Figure 1-2: Staatsolie Concession Blocks A, B, C & D, earmarked for Nearshore Exploration Drilling (April – December 2019)

1.2 Application Process

In April 2014, preparations for the proposed exploration drilling program began with the selection of a viable Environmental Contractor to conduct the Environmental & Social Impact Assessment (ESIA) for this program. At that time, Blocks A to D were divided into 7 Blocks, Blocks 1 – 7, and the ESIA was required for Blocks 1 – 3 and 5 – 7, Block 4 having been the subject of a previous ESIA (with approvals granted) for exploration drilling (ESL 2013b). Unfavourable economic conditions caused the delay in this process until May 2017, at which time, ESL was selected as the ESIA Contractor.

Staatsolie is committed to conducting its business activities in such a way, as to prevent adverse impacts on the safety and health of its employees, contractors, neighbours and the environments that may be affected by its operations. To determine the effects of the activities of this exploration program, Staatsolie has adopted the National Institute for Environment and Development in Suriname's (NIMOS) Environmental Assessment (EA) Guidelines, Volume 1: Generic (2nd Ed.; August 2009) and the Guidance Note NIMOS Environmental Assessment Process (August 2017). As such, NIMOS was engaged in respect of this Program and determined that it is a Category B Path 3 activity, requiring the conduct of a full Environmental and Social Impact Assessment (ESIA).

In line with NIMOS' EA Process (based on the 2009 and 2017 documents mentioned above), the proposed exploration drilling Program was subjected to environmental scoping (inclusive of public consultation), the result of which was the preparation of the Draft Scoping Report (Terms of Reference or TOR) to guide this Project. This Draft Scoping Report was subject to review by NIMOS and all comments received were incorporated into the Final Scoping Report (see Appendix A.1 and Section 1.3 below for additional details on scoping).

1.3 Scope & Objective of the ESIA

The objective of this ESIA study is to predict the potential impacts, both negative and positive, associated with the proposed exploration drilling program and to prepare an Environmental and Social Management & Monitoring Plan (ESMP) for implementation of the findings. The schematic diagram below (Figure 1-3) presents an overview of the process:

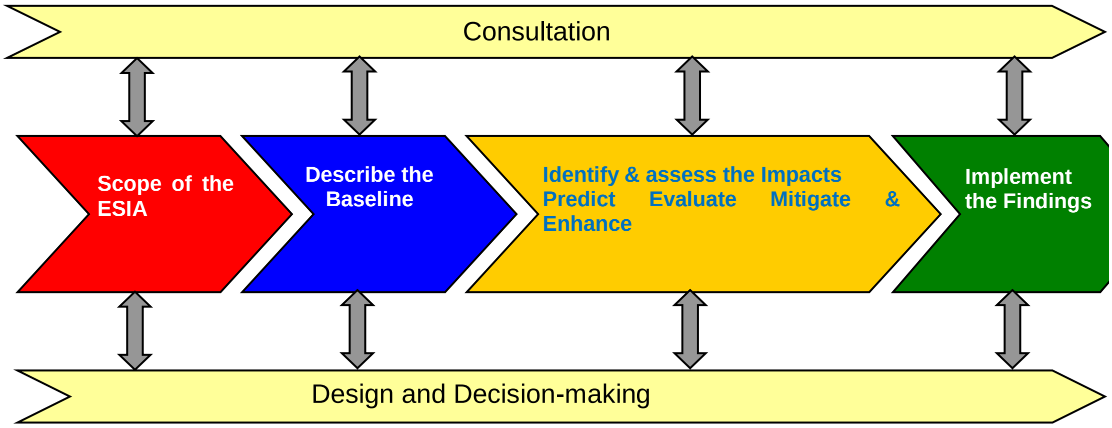


Figure 1-3: Overview of the EIA Process

An ESIA is a critical decision-making tool which is essentially a risk management process entailing 4 steps:

1. Scoping of the Project to identify the issues that are likely to be of most importance during the ESIA and eliminate those that are of little concern. Typically, this process concludes with the establishment of the TOR for the preparation of the ESIA. In this way, scoping ensures that ESIA studies are focused on the significant effects, by maximising time and financial resources within the Project Cycle;
2. Characterise the existing environment and identify which environmental or socio-economic resources may be impacted by activities associated with the proposed Project;
3. Assess the likelihood, consequence severity, and significance of these identified potential impacts, and identify and describe actions or controls to eliminate or reduce the likelihood or consequence of these potential impacts; and
4. Develop plans and procedures to manage the risks of likely as well as unplanned events (accidents and upsets).

Integral to the ESIA process is the incorporation of stakeholder perception and expectations, including the public with respect to a particular activity. Stakeholder consultations must be undertaken to ensure adequate knowledge of the project and receiving environment, and the general public must be consulted to obtain their views on, and acceptance of, the proposed project.

For the purposes of Staatsolie's exploration drilling Program, collection of environmental and social background data is an integral part of the project planning process. The ESIA process will allow the identification of potential physical-chemical, biological and socio-cultural impacts, and development of appropriate measures to eliminate or minimise the impacts. Data collected for the ESIA will facilitate development of an effective ESMP to ensure implementation of all identified mitigation and control measures.

Staatsolie is committed to Health, Safety and Environment (HSE), and Community related matters and continues to look at areas where their performance can be improved upon, as illustrated in Staatsolie's Core Value 1 (HSEC focused) within Staatsolie's Vision 2020 (see Appendix A.2). This has been achieved through the following:

- Staatsolie believes that to achieve a better understanding of the full life cycle of the activities being proposed, it is important to consider all environmental and socio-economic aspects and effects (positive and negative), of these project activities. This enables proper, risk-based, management, monitoring and review/ auditing in line with existing Staatsolie procedures (General Field Instructions - GFI's) and Project-specific procedures.

- Implementation of the Project in line with the relevant legal and regulatory requirements and taking into account the integration of sustainable development principles as outlined in Suriname's Development Plan 2012 – 2016. Thus, this Project will positively contribute towards the coordinated, balance and integrated actions required to achieve Suriname's sustainable development goals (as outlined in Suriname's National Report in preparation of the Third International Conference on Small Island Developing States or SIDS) (Government of Suriname 2013)

1.4 Structure of the Document

The remainder of this document is laid out as follows:

Chapter 2: Discusses the relevant policy, legislative and regulatory framework for environmental management, with specific emphasis on environmental permitting (managed by NIMOS) and the scope of the Project covered by this ESIA;

Chapter 3: Gives a description of the proposed Project development scheme;

Chapter 4: Considers alternatives for achieving the objectives of the proposed development;

Chapter 5: Describes the physical, biological and socio-economic baseline data;

Chapter 6: Details the impact assessment methodology and characterises the impacts identified;

Chapter 7: Presents the recommendations for an environmental management and monitoring plan; and

Chapter 8: Provides the List of References & Bibliography for this ESIA report.

2 LEGAL AND INSTITUTIONAL FRAMEWORK

2.1 Introduction

This Chapter describes the relevant environmental legislative and regulatory framework of Suriname that is applicable to the proposed Staatsolie Nearshore Exploration Drilling Project 2019 within the Blocks A, B, C & D. All pertinent national regulations and guidelines governing environmental quality are presented below. Additionally, all relevant international accords, treaties, agreements and guidelines, as well as Staatsolie's HSE and Community Relations Policies, principles and guidelines have been identified and discussed henceforth.

2.1.1 Staatsolie's Health, Safety and Environment Policy

The following is Staatsolie's Health, Safety and Environmental (HSE) Policy and its commitment to health and safety for its employees, contractors, community and environment, which is guided by 3 main principles and the implementation of an HSE Management System.

MAATSCHAPPIJ SURINAME N.V.

STATE OIL COMPANY SURINAME N.V.

HSEQ Policy

Staatsolie demonstrates a firm commitment to Health, Safety, Environment & Quality (HSEQ) by effectively using an integrated management system, through which we continuously:

- Comply with relevant laws and legislation, and Staatsolie's requirements, while taking the needs of our stakeholders into account;
- Identify risks, determine mitigating measures, and apply these measures to our work in order to prevent incidents and damage to the environment;
- Hold all employees and contractors accountable to follow Staatsolie's HSEQ requirements, in order to achieve excellent performance with zero harm;
- Continually improve our management system by enhancing processes, services, and our product quality through the setting of explicit performance objectives;
- Involve all employees and contractors in the decision-making processes of our HSEQ management system.

February 2018
Rudolf Elias
Managing Director

2.1.2 Staatsolie's Community Relations Policy

The following is Staatsolie's Community Relations Policy which is developed to ensure that the communities' interests and expectations with regard to socio-environmental aspects are adequately considered when business activities are undertaken by the company.

MAATSCHAPPIJ SURINAME N.V.
STATE OIL COMPANY SURINAME N.V.

COMMUNITY RELATIONS POLICY

Staatsolie performs its business activities in such a way that communities' interests and expectations with regard to socio-environmental aspects are properly considered.

Staatsolie is committed to this policy by taking into consideration the following key elements:

1. Establish and encourage relationships of trust with the communities and their representatives, based on continuous dialogue.
2. Conduct business activities in accordance with applicable local laws, regulations and international treaties, ratified by the Government of the Republic of Suriname, with special emphasis on Human Rights and cultural values of a multi-ethnic community.
3. Conduct socio-environmental baselines studies and develop and implement an effective socio-environmental management system to minimize socio–environmental impacts.
4. Maximize positive impacts through initiatives and social alliances aiming at mutual benefits, value creation, and sustainable local development.
5. Ensure community participation and engagement with impacted communities and other stakeholders, during the full lifecycle of projects.
6. Communicate and disseminate the contents of this Community Relations Policy to our various stakeholders, including contractors and suppliers.
7. Communicate and report periodically, publicly the results of community relations management.

To ensure the effectiveness, the Community Relations Policy will be reviewed bi-annually.

December 13, 2011

M.C.H. Waaldijk
Managing Director

2.2 National Council of the Environment (NMR)

The NMR, which has been installed by Presidential Order on June 9th 1997, has the mandate to support the Government of the Republic of Suriname by means of advises concerning the preparation of environmental policy at the national level and exercise of control in the implementation thereof. According to this Order, the NMR will be assisted in the implementation by NIMOS. The regulations for the NMR states that it will consist of 10 members who are appointed by the President of the Republic of Suriname for two years.

Besides the 5 experts who are nominated by the government, representatives from the trade and industry, labour unions, Indigenous- and Maroon communities and consumer organizations are seated in the NMR.

2.3 National Institute for Environment and Development in Suriname (NIMOS)

NIMOS is the environmental authority of the Republic of Suriname and the executive agency of The National Council for the Environment (NMR). It is not the permitting agency of Suriname, but the main management, policy and advisory body and acts as a research institute. It was originally established in 1998 by Presidential Decree as an entity subordinate to the President's office, and reports its activities to the Cabinet of the President. NIMOS administers the environmental permitting process in Suriname, within the constraints of the legal and regulatory framework currently in force.

The mission of NIMOS is to initiate the development of a national legal and institutional framework for environmental policy and management in the interest of sustainable development. NIMOS has developed the Environmental Assessment (EA) Guidelines (Volumes I, II, III, IV and V; see Section 2.3.3 below) which will have a strong legal basis after promulgation of environmental law. In addition, where and when it is appropriate, NIMOS uses international guidelines such as those issued by the World Bank.

The key roles and responsibilities of NIMOS are:

- Development of an EA system of procedures and guidelines;
- Supervision of the EA process;
- Execution of environmental audits under the EA process;
- Development and monitoring of environmental standards and norms;
- Enforcement of environmental laws (in the absence of national environmental standards, comparable international environmental standards may be adopted);

- Coordination of Government agencies with regard to environmental legislation and regulations;
- Drafting of environmental legislation and regulations; and
- Review of environmental conventions.

2.3.1 Cabinet of the President

The Cabinet of the President was established in 1996 to provide support to the President for constitutional tasks as administrative and policy apparatus to effectively and efficiently achieve the objectives of Government policy. Given that NIMOS is tasked with the environmental permitting process in Suriname, other entities under the purview of the Cabinet of the President may be involved in the approval process.

Core tasks of The Cabinet of the President includes:

- The preparation and adoption of all Statutory Regulations, State and Governance Decrees that are endorsed by the President;
- Caring for the State and Administrative Relations of the President with the National Assembly and with the other People's Representative Bodies;
- The provision of administrative and policy support to the President in the exercise of:
  - his executive powers, with the exclusion of any other body;
  - his responsibilities for State Bodies, which he directs;
- The care for the optimal support of the President as Commander-in-Chief of the armed forces and in the maintenance of national security;
- The optimal support of the President in leading foreign policy and international relations as well as in promoting the international legal order;
- The care for the establishment of a coherent Government policy and for the supervision of its implementation;
- The care for communication with and for the information to the population for the Government;
- Ensuring optimal mobilisation and participation of the people in development policy and policy making; and
- All other duties assigned by the President to his Cabinet by Presidential Decree.

Additionally, environmental tasks were added to responsibilities of the Cabinet of the President by resolution, which includes:

- Coordination of the preparation of environmental policy and monitoring of the implementation;
- Promotion of the implementation of environmental treaties;
- Promotion and realisation of environmental legislation;

- Promotion of the use of environmentally sound technologies;
- Identification, preparation and implementation of environmental training and education programs for environmental institutes and organisations;
- Inspection of companies on the use of environmentally harmful materials and technologies; and
- Involvement of the public to combat environmental pollution.

Although this agency has no direct role in the EA process, as its technical working arm, NIMOS, is obligated to report to the Cabinet of the President.

2.3.2 Draft Environmental Act, 2002

The Draft Environmental Act, 2002, established NIMOS as the Environmental Authority. The Act is a framework law that was prepared as a result of the Rio Declaration (1992) in order to introduce international legal requirements into Suriname's environmental legislation scheme. This draft Act also established a Supervisory Board, an Environmental Fund and an Inter-Ministerial Advisory Committee. It also states the need for an EIA for all new economic activities that might have an adverse impact on the environment and which includes tools for pollution control. Furthermore, it also requires permits for waste management and contingency plans for potential accidents that may cause environmental pollution. An important step in the Draft Environmental Act, 2002, is the use of public participation as a tool in the decision-making process related to the environment.

2.3.3 NIMOS Environmental Assessment Guidelines (2009)

NIMOS has issued 5 volumes of EA Guidelines (2009), which are as follows:

- EA Guidelines Volume I: Generic;
- EA Guidelines Volume II: Mining;
- EA Guidelines Volume III: Forestry;
- EA Guidelines Volume IV: Social Impact Assessment; and
- EA Guidelines Volume V: Power Generation and Transmission Projects.

These guidelines provide a clear and comprehensive understanding of the decision-making process by NIMOS in the context of the relevant sectors (mining, forestry, social environment and power generation and transmission). Each of the guidelines comprise of the following phases:

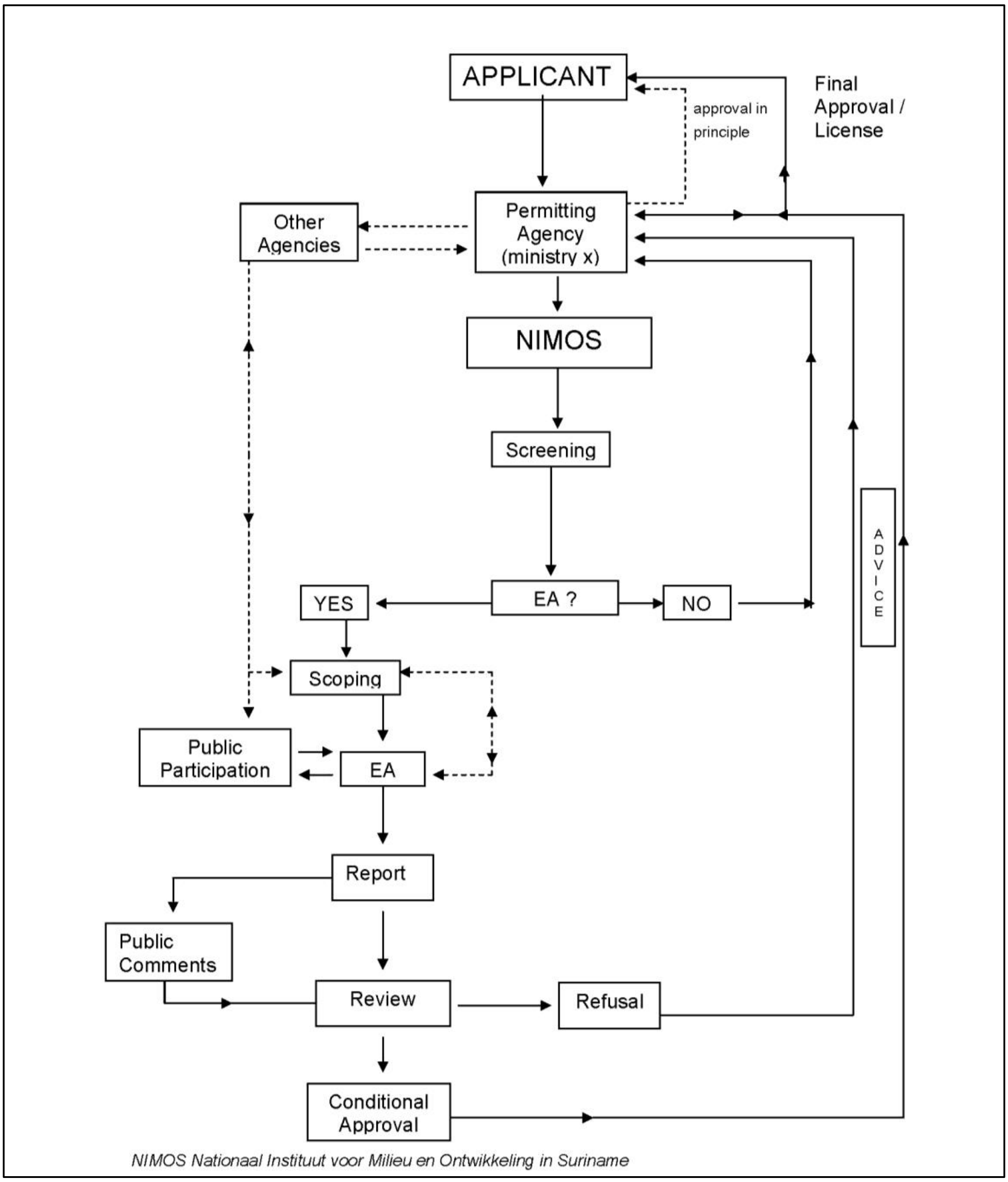
- Screening;
- Scoping;
- Assessment;

- Review;
- Decision and Monitoring; and
- Public Consultation and Participation[2] (NIMOS 2009).

It should be noted that NIMOS issued Guidance Notes with respect to their EA process in August 2017; this does not replace the actual EA Guidelines used in Suriname.

Figure 2-1 outlines the steps involved in the EA process. Each of these steps is described in the relevant sub-sections below.

[2] NIMOS 2009 Guidance Notes supersedes the August 2017 version in this respect, since public participation and consultation was identified as key by NIMOS in the Final Scoping Report (Appendix A.1).



(Source: NIMOS 2009)

Figure 2-1: NIMOS Environmental Assessment (EA) Procedure

2.3.3.1 Screening Phase

The level of environmental clearance required for a proposed development is determined through a screening process that is communicated to the Applicant, which, in this case, is Staatsolie. The Applicant must submit an application for a permit to the permitting agency (the Ministry of Natural Resources, NH). If the initial conditions of the permitting agency are met, the Applicant's project proposal will be approved.

The permitting agency, however, will send information on the Project to NIMOS for advice. This is to determine whether an EA is needed or not. The Applicant is required to submit the application along with details of the Project (e.g. Project description, site plan, possible impacts and alternatives to the Project). The application will then be assessed using the screening guidelines of NIMOS.

The screening process will determine the category of the Project, which is the deciding factor on whether an EA is needed. There are 3 categories:

- Category "A": EA is mandatory.
  - This includes projects likely to have adverse impacts that may be extensive, irreversible and diverse. The extent and scale of the environmental impacts can only be determined after thorough environmental assessment. Mitigation measures can only be formulated after the results of the assessment are known.
- Category "B": EA will be required or some other environmental document.
  - This category includes projects whose impact depends on the sensitivity of the location, scale and predictability. Projects must undergo a checklist after which the decision can be taken on whether or not an EA or lesser form is required. The necessary environmental information is obtained from the Project proponent. Category B consist of the following 3 paths:
    - Path 3 – An EIA is required
    - Path 2 – Another environmental document is needed (EMP/Social Impact Assessment/Waste Management Plans/Environmental Impact Statement/Ecological Impact Study, etc)
    - Path 1 – No EIA is required, but some environmental information is required before a decision can be taken

- Category "C": No EA is required, but the proponent will have to keep with the minimal guidelines.

  This category includes projects having no impacts or are well known, predictable, mitigable and minuscule in scale.

If an EA is not required, NIMOS will issue the permit within 14 days. However, if an EA is needed, the Applicant will publish or announce a notification of intent in the media (7 or 60 days in case of appeal by the applicant). This will inform the public of the proposed Project.

NIMOS has determined, according to the EA Guidelines (2009) that this Nearshore Exploration Drilling Project 2019 is Category B path 3 (see Appendix B.1).

2.3.3.2 Scoping Phase

Scoping enables the preparation of the appropriate Terms of Reference (TOR), for the EA study, encapsulated within the Scoping Report for a given Project. If the EA is required, the Applicant has to publish a notification of intent to the public of the proposed Project. Thereafter, the Applicant will be required to submit a TOR for the EA to be conducted for the proposed Project. In this case, ESL developed the Final Scoping Report/TOR (see Appendix A.1) together with a project specific Sample Execution Plan (SEP) which were subsequently approved by Staatsolie and NIMOS.

This Project is currently under the assessment phase of the EA Process, and this ESIA report has been prepared in accordance with the NIMOS approved Final Scoping Report/TOR.

2.3.3.3 Assessment Phase

NIMOS is the responsible authority and will ensure that the applicant considers the full range of environmental and social, as well as the significance of the positive and negative impacts. Upon completion, the applicant is required to submit to NIMOS the EIS (Environmental Impact Statement (EIS), inclusive of an executive summary.

2.3.3.4 Reviewing Phase

The responsibility of the reviewing phase also lies with NIMOS. The EIS is assessed through a number of criteria using a review checklist for technical quality, accuracy and completeness. According to the EIS Regulation for EIS review (Regulation 9.3), NIMOS must appoint a working group, chaired by a representative of NIMOS, which includes a representative of the Ministry of Natural Resources and other relevant Governmental bodies or institutes, to assist in the review of the EIS. The working group must take into account any written comments received from members of the public pursuant to Regulation 8.3 and any reviews expressed orally by members of the public during any public hearing held. An independent consultant may be appointed by NIMOS if expert advice is necessary.

If the EIS is considered to be deficient in any aspect, it will be returned to the Applicant, who will have to update the EIS and resubmit it. If the EIS is adequate, NIMOS will prepare an EIS review report and acceptance letter to submit to the permitting agency. The permitting agency will then send a copy to the Applicant.

2.3.3.5 Decision and Monitoring Phase

This stage of the EA system enables NIMOS and the permitting agency to make a decision on the outcome of the EA process as well as a post-decision evaluation of the proposed Project. Apart from the information on the quality, accuracy and completeness of the EA study, it is suggested that the EA review team also report on the justification of the approval (or denial) of the Project. The binding advice from NIMOS is based on the Review Report and compiled into a letter for the decision-maker or the permitting agency (EA Guidelines Vol. I: Generic, August 2009).

Within 14 business days after the Review Committee has recommended approval, the permitting agency and NIMOS are responsible for issuing a permit for the proposed Project.

2.3.3.6 Public Consultation and Participation

This final stage of the EA system ensures that NIMOS and the Applicant obtain timely and meaningful input from the public with respect to concerns, issues and suggestions. This is done via the adoption of procedures to capture full public consultation/participation throughout the EA process. As such, a variety of communication and public participation mechanisms is usually employed for public hearings. In addition, small community-based meetings may be held to ascertain the groups' views. Of note, the major positive and negative impacts, as well as proposed mitigation measures are usually communicated to the public.

2.3.4 Environmental Impact Assessment Standard

Impact significance evaluations are based on various criteria that distinguish the impacts associated with this specific Project. Procedures for the scientific evaluation of impact significance have been developed over decades of study (Duinker and Beanlands 1986). There are no international standards for impact assessment significance criteria; however, all international guidelines require consideration of the following factors in evaluating significance: 1) magnitude of the adverse environmental effect; 2) geographic extent of the adverse environmental effect; and 3) ecological context of the adverse impact.

2.4 Other Regulatory Authorities & Relevant Legislature

The Constitution of the Republic of Suriname (Grondwet) is the highest national law providing for rules regarding the sovereignty, principles for freedom, equity and democracy. The Constitution and a few national acts have some provisions of relevance to the preservation of the environment and management of natural resources.

One of the social objectives of the State stipulates the creation and promotion of conditions for the protection of the environment and preservation of the ecological balance (Article 6g). Another important provision is in Article 41, which stipulates that natural riches and resources are property of the nation and shall be used to promote economic, social and cultural development. The nation shall have the inalienable right to take complete possession of the natural resources in order to apply them to the needs of the economic, social and cultural development of Suriname.

The responsibility for environmental (and social) issues is widely spread between a number of agencies and departments in various ministries. The following sub-sections briefly describe the other local authorities or Government ministries that are responsible for ensuring the environmental quality, socio-economic stability, and health and safety during and after the Project. Relevant legislature applicable to the activities of this Project is also briefly described hereunder.

2.4.1 Ministry of Natural Resources (NH)

The key responsibilities of the Ministry of NH are:

- The national policy with regard to energy and natural resources, with the exception of the forest policy;
- The inventory, exploration, optimal exploitation and management of minerals, water and energy; and
- Monitoring the compliance of the rules and regulations with regard to water management, minerals, the generation, transport and distribution of energy.

In relation to this Project, the Ministry of NH is responsible for the enforcement of the laws described in the subsequent sub-sections.

2.4.2 Geological Mining Service (GMD)

The GMD falls under the Ministry of NH. The role of the GMD is to supervise exploration of mineral reserves and to provide research support for the issuing of mining rights. The following sections present the relevant legislations that are applicable to the Nearshore Exploration Drilling Project 2019.

2.4.2.1 Petroleumwet 1990 S.B. 1991 no. 7, z.l.g. bij SB. 2001 no.58 (Petroleum Law 1990 S.B. 1991 no. 7, as amended by S.B. 2001 no. 58)

The Petroleum Law 1990 governs petroleum operations in Suriname. The Law contains rules, regulations, and investment incentives for the execution of petroleum operations in Suriname.
According to the Petroleum Law 1990, State enterprises with petroleum concession rights are authorized to enter into petroleum agreements with other established petroleum companies for the prospecting, exploration, and exploitation of petroleum subject to approval by the Government. The Articles highlighted below are applicable to this Project:

- Article 6 e states “Petroleum activities should be carried out in such a way, that negative impacts on the environment and natural resources are prevented”;
- Article 7, sub 1, states “For the performance of petroleum activities, due account should be given to the prevailing legal regulations, to build, establish, maintain and use all facilities that are necessary or advantageous for the proper performance of the petroleum activities”;
- Article 7, sub 2, states “Upon termination of the petroleum activities on state land, the land should return to its original condition insofar as reasonably possible”;
- Article 23 sub 1 states that “In the context of a petroleum agreement, a development plan shall be formulated for any petroleum field that will be developed”;
- Article 23 sub 2 states “The development plan shall be submitted to the State Company who are granted the rights referred to in Article 2, before a start is made with the implementation of this plan”; and
- Article 28, sub c, states “Further rules regarding conservation of petroleum, prevention of spilling and protection of the fisheries, shipping and other activities shall be laid down by means of a State Order.” However, this State Order still does not exist.

2.4.2.2 Decreet Mijnbouw S.B. 1986 no. 28, z.l.g. bij S.B. 1997 no. 44 (Mining Decree S.B. 1986 no. 28 as amended by S.B. 1997 No. 44)

This Decree governs the reconnaissance, exploration and exploitation of all mineral resources. Article 2 states that *“all raw material in and above the ground, including the territorial sea are property of the State”*.

It is further stated in Article 3 stipulates that *“all safety measures should be undertaken”.* Furthermore, with regards to the environment, it is stated that the discharge of gases, fluids and substances should meet safety standards and Article 4, sub 1 states that *“during the mining operation all mining activities should be carried out ... applying the most modern international techniques ...professionally making use of advanced* *technology and appropriate materials taking into account current requirements regarding safety and health... including requirements to protect the ecosystems."*

Article 16, sub 1 states that *"After closure of the mining concession the holder of the right will, to the satisfaction of the Minister (of Natural Resources), take all necessary measures in the interest of public safety, the conservation of the deposit, the rehabilitation of the land concerned and the protection of the environment".*

2.4.2.3 Besluit Mijnbouw – installaties S.B. 1989 No.38 (State Decision on Mining Installations S.B. 1989 No.38)

The Government Decree on Mining Installations makes provisions for mining installations placed on or above the sea area. This Governmental decision made on May 11th, 1989, deals with offshore mining operations and includes petroleum exploration and development. There are 15 chapters in this Decree, and each chapter governs specific elements of offshore mining operations:

1. Installation of the platform;
2. Installation methods and furnishing of the platform;
3. Protection of the environment;
4. Removal of the platform;
5. Traffic and transportation;
6. Safety and security; and
7. Scientific research.

By this Decree, it is also prohibited to throw overboard or drain substances into the sea in concentrations that are hazardous for humans, animals and the environment. The Decree also states that the sea environment of neighbouring coastal states must not be polluted and that mining activities must be carried out in such a way that ecosystems are not destroyed. It also calls for the removal of a mining installation that is not being used, and that scientific research must also be carried out in such a way that the environment is not being polluted.

2.4.2.4 Het Decreet van 11 mei 1981, houdende machtiging tot verlening aan de Staatsolie Maatschappij Suriname N.V. van een vergunning voor het doen van onderzoek naar en van een concessie voor de ontginning van koolwaterstofvoorkomens Decreet E-8B, S.B. 1981 No. 59 (Decree of 11 May 1981 regarding the authorization of Staatsolie to do research and exploitation of hydrocarbons Decree E-8B S.B. 1981 no. 59)

Decree E-8B makes provisions for research and exploitation of hydrocarbons by Staatsolie Maatschappij NV. In accordance with Article 4, hydrocarbons extracted by Staatsolie become property of Staatsolie, who has been granted authorization to enter into agreements with third parties for petroleum operations. The contractor (third party) has reporting obligations and the State has access for inspection. The contractor is obligated to take all good oilfield practices into consideration with regards to safety. Additionally,

Article 9 of the decree states that *"all operations shall be carried out according… most modern international techniques and methods in general… accustomed to in the oil industry and in accordance with "good oilfield practice"; the company is responsible for a safe discharge of water and waste oil".*

Article 13: states that "*right holders and third parties are obliged to permit in and on the land, within the concession area, the search and extraction of hydrocarbons by the concession holder if they are notified on time and previously assured compensation*".

The Petroleum Law, however has repealed and replaced E-8; see article 29 – 1b of the Petroleum Law:

"Decree of 3 December 1980 giving Staatsolie Maatschappij Suriname N.V. license to explore and concession for development of hydrocarbon resources, and the establishment of related regulations (Decree E-8, S.B. 1980 No. 128, as modified by S.B. 1981 No. 37 and by S.B. 1985 No. 66)."

Subsequently, on 11 July 1993, Resolution No. 3051/93 granted Staastolie the exclusive rights to explore for, develop and produce petroleum in the sea area of Suriname with an extent of 70,080 km inclusive of Blocks A, B, C & D among other. It should be noted that an extension to this Resolution No. 3051/93 has been requested for the said concession area.

2.4.3 Ministry of Spatial Planning, Land and Forest Management (ROGB)

As per the State decree of 6 September 2005 no. 94 for the newly established Ministry of ROGB, the services and tasks thereof are:

- a proper spatial planning, in consultation with the Ministry of Regional Development, the Ministry of Public Works, the Ministry of Planning and Development Cooperation and the Ministry of Natural Resources;
- topography, cartography, geodesy, soil research and soil mapping;
- the land use, where necessary in an interdepartmental connection;
- an informed land issue, in cooperation with the appropriate ministries, where necessary in an interdepatriate manner;
- the land register and the public registers at the mortgage office;
- the monitoring of the legitimate and efficient use of allocated land and, where necessary, in an interdepartmental connection;

- checking compliance with rules and regulations with regard to geodesy;
- the inventory, exploration, optimal exploitation and management of the resource, flora and fauna;
- responsible nature conservation and nature protection;
- verification of compliance with rules and regulations concerning the production of wood and wood products, flora and fauna

The following Sections presents the relevant legislation of the Ministry of ROGB that may be applicable to the Nearshore Exploration Drilling Project 2019.

2.4.3.1 Natuurbeschermingswet 1954, G.B. 1954 no. 26 z.l.g. bij S.B. 1992 no. 80 (Nature Conservation Act 1954, G.B. 1954 no. 26 as amended by S.B. 1992 no. 80)

The Nature Conservation Act of 1954 is the legislative cornerstone for conservation in Suriname and is composed of 14 sections (Articles). This Act recognizes that establishing protected areas is important to scientific knowledge, recreation, and education, as well as for ethical and economic reasons. Section 2 of the Act states that *"in order to be declared as a nature reserve, the area shall be such that it requires protection from public authorities for reasons of natural beauty or because there is a presence of fauna, flora, or geological objects of particular scientific or cultural importance."* The President of Suriname can designate Nature Reserves for the protection and maintenance of its natural resources (Article 1). Furthermore, the Act states that it is prohibited to, intentionally or due to negligence, damage the condition of the soil, the natural beauty, the fauna, and the flora or to perform acts that may impair the value of the reserve as such. It is also prohibited to hunt and to fish and persons are also not allowed to possess dogs, firearms, and any hunting or catching device, without the required license thereto (Article 5).

Suriname has established 13 protected areas, which encompass a wide range of ecosystems, from tropical forests to coastal formations, making Suriname's nature conservation system one of the most representative in South America. In general, management of these nature reserves is entrusted to the Chief of National Forestry Management (CNFM), who is counseled by the Nature Conservation Division (NB) of the Suriname Forest Service (Section 3 of the Act). The Chief has the authority to close completely or in part a nature reserve under Section 4 of the Act. Section 4 also prohibits fishing, hunting, and other activities without permission from the Chief. Sections 6 and 7 provide for certain exemptions from the prohibition to undertake activities. A special permission for scientific or educational purpose may be granted by the Chief under Section 6, whereas Section 7 grants powers to the Chief to approve certain commercial activities in parts of reserves that are not closed under Section 4, in particular fisheries, grazing, and keeping of livestock.

It should be noted that the Government Decree on nature protection, Coppename Monding en Brinkheuvel (G.B. 1966 no. 59) of the Nature Protection Act, Article 1 states that:

"To protect and preserve the natural resources present in Suriname, the following areas belonging to the Lands are designated as nature reserves, namely:

a. The area located on the Atlantic Ocean bounded to the north:
by the low-water line along the coast; to the east:
by a North-South line at a distance of 3500C from the mouth of the Oranjekreek….. through the right bank of the Zuidrivier."

This is pertinent to the proposed Project, given that the southern part of the Project area intersects with the Coppename Monding (CMNR), Peruvia, Wia Wia and Galibi Nature Reserves.

2.4.3.1.1 Nature Conservation Division (NCD)

The Nature Conservation Division (NCD) of the Forest Service (LBB) falls under the purview of the Ministry of ROGB and is formally in charge of the nature reserves and has been mandated to ensure that the MUMAs are used in accordance with management plans. A major challenge is the management of the system of protected areas and each protected area. Management plans for most of the nature reserves and all the MUMAs have been drafted, as well as for Brownsberg Nature Park (BNP). There are presently 16 nature reserves, one nature park and 4 MUMA areas. Protection and management of these areas are pertinent as the Peruvia, Coppename Monding, Wia Wia and Galibi Nature Reserves as well as all 4 MUMAs, occur within the project study area.

2.4.3.2 The Game Act (GB 1954, No.25), as amended by GB 1971, No.61, SB 1980, No. 99, SB 1980, No.116, SB 1986, No. 2 and SB 1994, No. 54) and Game Resolution (GB 1970, No.104 as amended by GB 1973, No. 173, SB 2002, No. 116, SB 2009, no. 16) and annual Ministerial Decrees)

The Game Act gives full protection to all mammals, birds and sea turtles, except to those species mentioned in the Game Resolution of 2002 and indicated as (a) game species, (b) predominantly harmful species, or (3) pets ('cage birds').

Article 1-1 states: "*Protected animal species" means all types of mammals, birds and sea turtles and other animal species to be designated by State Decree, which belong to a species living in Suriname, with the exception of:*

a. the species of mammals, birds and sea turtles and other animal species designated as "hunting game" pursuant to Article 6 of this Act;
b. the types of mammals, birds and other animal species designated as "caged animal species" by State Decree pursuant to Article 6 of this Act;
c. the types of mammals and birds and other animal species designated "predominantly noxious animal species" designated by the State Decree pursuant to Article 6 of this Act as at all times or temporarily harmful to the forestry, horticulture or oysterbuilding or for hunting or fishing.

Additionally, Article 2 states that *“It is prohibited to capture, kill, attempt to capture, attempt to kill, to possess, to have dead, or live for sale or to have at hand, to offer, to sell, to buy, to trade, to give, to deliver, to transport, to import, or to carry out.”*

Due to the complexity of the various ecosystems that the proposed Project may overlap and intersect with at different times during the project duration, the Game Act has been considered in this assessment.

2.4.3.3 Decreet uitgifte Domeingrond S.B 1982 no. 11, z.l.g bij S.B. 2003 no. 7 (Decree on the Issuance of Domain Land S.B 1982 no. 11 as amended by S.B. 2003 no. 7)

The Decree on the issuance of Domain Land 1982, also called the Land Reform Decree of 1982, includes provisions for the protection of certain natural areas. In accordance with the general provisions (Article 1) of this Act, the Minister responsible for land policy is authorized to have the disposal over domain land. Currently, the Ministry of ROGB has control over the land.

In the past decade, several areas defined as “Multiple Use Management Areas” (MUMAs) have been placed under the purview of the Ministry responsible for land. The Planning Act of 1973 contains the provisions to do so but due to the fact that the required planning institutions are not established, the L-2 Decree functioned as the parent Act for the establishment of these MUMAs by placing them under the purview of the Ministry of NH, now the responsibility of the Ministry of ROGB. This was enacted by Ministerial Order.

A MUMA is designated to maintain biological productivity, ensure the health of globally significant wildlife and protect resources for sustainable livelihoods. Although MUMAs are intended to be multiple-use areas, the conservation of biodiversity and maintenance of ecosystem services is the ultimate management objective. MUMAs may be commercially utilised within sustainable limits with permits required for both research and resource extraction. There are no general guidelines in the MUMA decisions about the minimum management requirements or how the area should be managed efficiently. This gap still exists in the draft law (Lawyers 2014).

2.4.3.4 Ministeriële beschikking van 30 december 1987, om Bigi Pan te bestemmen als bijzonder beheersgebied) S.B. 2002 no. 94 (Ministerial Order from 30 December 1987, to Designate Bigi Pan as a Multiple-Use Management Area S.B. 2002 no. 94)

The Bigi Pan MUMA is designated between the Coppename River and the canal of Burnside. This area is so assigned due to the numerous ecological functions of the area such as:

- a breeding and feeding area for specified fish;
- a spawning and nursery ground for the marine fauna;
- an important feeding ground for migratory shorebirds;

Also, the nearshore ecosystems and the range of biodiversity it offers provides for ecotourist activities. Additionally, these ecosystems add value to the near shore small-scale and offshore industrial fisheries.

Article 2 states that *“this area needs to be protected because of reclamation of this area and pollution of the water by pesticides”*.

It should be noted however, that lands issued before the MUMA’s came into effect, is not included in the MUMA.

The Nature Conservation Division of the Ministry of ROGB is responsible for the enforcement of the Ministerial Orders with respect to all MUMA. This special management area is pertinent to this project as the nearshore Block A lies in close proximity to the Bigi Pan MUMA.

2.4.3.5 Ministeriële beschikking om Noord Coronie te bestemmen als Multiple-Use Management Area S.B. 2002 no. 87 (Ministerial ordination to design Noord-Coronie as a Multiple-Use Management Area S.B. 2002 no. 88)

The North Coronie MUMA is a highly productive estuarine zone of Suriname, and consists of several coastal wetland ecosystems including mudflats, mangrove forest, open lagoons and brackish grass swamps. The area is a designated MUMA as it acts an important breeding and feeding area for scarlet ibises, egrets and herons. Tt also serves as an important feeding ground for migratory shorebirds from the North during winter. Likewise, the biodiversity offers a range of ecotouristic activities. In addition, the Coronie mangrove forests functions as a protective medium against coastal erosion, whilst enhancing sedimentation and stimulates coastal accretion. The MUMA also acts as spawning and nursery grounds for the marine fauna and these ecosystems add value to the nearshore small-scale and offshore industrial fisheries.

This order is applicable since the North Coronie MUMA intersects with the southern boundary of the nearshore Block B of this Project.

2.4.3.6 Ministeriële beschikking om Noord Saramacca te bestemmen als Multiple-Use Management Area S.B. 2002 no. 88 (Ministerial ordination to design North Saramacca as a Multiple-Use Management Area S.B. 2002 no. 88)

The objective of this Ministerial Order is to establish the North Saramacca MUMA. Article 2 of the Ministerial Order states that this area needs to be protected because of the increasing threats such as disturbance of the water flow due to reclamation for oil production, agriculture (rice and animal husbandry), and pollution of the water by pesticides, organic waste and oil. Staatsolie's Nearshore Exploration Drilling Project 2019 is expected to occur in the near-shore area north of the Suriname coastline inclusive of the MUMAs north of Nickerie, Coronie, Commewijne and Marowijne districts.

The Nature Conservation Division of the Ministry of ROGB is responsible for the enforcement of this Ministerial Order. Given that lands issued before the implementation of the Ministerial Order are not included in the order, presents a challenge for the management of the MUMA, as they are disjointed and not a continuous area. The current management structure for protected areas is actually based on a system where the central government is responsible for taking decisions. To date, no formal institutional mechanisms are established to regulate the involvement of stakeholders in the management of these areas.

2.4.3.7 Ministeriële beschikking om Noord Commewijne/Marowijne te bestemmen als Multiple-Use Management Area ARS. 2002 no. 94 (Ministerial ordination to design North Commewijne/Marowijne as a Multiple-Use Management Area ARS. 2002 no. 94)

The North Commewijne/Marowijne MUMA is the Coastal belt located between the Suriname and Marowijne river, in the north of the Commewijne and the Cottica rivers. The Ministerial order has designated this MUMA due to:

- the mangrove forest that protects the coast and river estuaries against erosion;
- A breeding and feeding area for specified fish which have their larva stage in the brackish coastal waters;
- protection of sea turtles
- important feeding ground for migratory shore birds;

- a range of ecotouristic activities;
- the potentials for aquaculture, apiculture, animal husbandry and agriculture

Protection of this area is essential because disturbance of the freshwater flow may affect the optimal function of mangrove; increased pollution of the rivers (and brackish creeks) by oil, industrial effluence, pesticides, organic waste and (potential) mercury that threatens the breeding and production function. Additionally, is the disadvantage of pesticides and mercury for fish, shrimps, poultry and wild meat for the local consumption and export. The North Commewijne/Marowijne MUMA is applicable to this project it lies in close proximity to the nearshore Block D of the proposed Project.

2.4.3.8 Ministeriële beschikking Richtlijnen Gronduitgifte Estuariene Beheersgebied 2005 S.B. 2005 no. 16 (Ministerial ordination Guidelines for Land Issuance in the Estuarine Management Areas 2005 S.B. 2005 no. 16)

In February 2005, the Minister of Natural Resources (since 2005, the Minister of ROGB) issued this Ministerial Order to provide guidelines for the issuance and use of domain land within the estuarine zone. The considerations for setting the guidelines are to maintain the natural functions of the estuarine zones, such as coastal and shore protection function, hydrological function, and biological function, i.e. spawning and nursery area for fish, shrimp and birds.

This Ministerial Order provides specific requirements for the use of domain land in the estuarine management areas. Article 4 states for the issuance of domain land in the estuarine management area:

- a strip of 500 m on both sides of the rivers and a stroke of 200 m on both sides of creeks is reserved for protection forest or conversion forest;
- it is prohibited to withdraw water from the estuarine swamps; and
- the discharge of wastewater containing chemicals, including pesticides, is prohibited.

2.4.4 Ministry of Transport, Communication & Tourism (TCT)

This Ministry has the responsibility for the water and air transport and management of all ports. Given that the all personnel, materials and supplies will be transported by vessels from 3 potential shorebases, all necessary procedures in relation to transportation routes and marine traffic activities will be adhered to by Staatsolie as discussed in Section 2.4.4.1 to Section 2.4.4.4 below.

2.4.4.1 Maritime Authority Act, 2002

This legislation establishes the Maritime Authority Suriname (MAS) as a corporation under Article 3 in the framework of privatization of public services. The Corporation shall be responsible for safe and efficient maritime traffic to and from Suriname in accordance with international conventions ratified by Suriname, and the supervision and control of maritime navigation in accordance with laws of Suriname. The Corporation shall further render services to sea-going vessels and oversee compliance with regulatory requirements of the shipping industry. Additionally, MAS is responsible for the certification of port facilities by the International Ship and Port Facility Security (ISPS) standards.

In relation to this Project, MAS is responsible for the enforcement of the law described in the subsequent sub-section.

2.4.4.2 Maritime Authority Suriname (MAS)

The Maritime Authority Suriname, which was established under the Maritime Authority Regulation (Maritime Authority Act) in 2002, among other things responsible for the registration of fishing vessels under the flag of Suriname. The Maritime Authority is established as a legal person under Article 3 in connection with the privatization of public services. The MAS is responsible for safe and efficient maritime traffic to and from Suriname in accordance with international conventions ratified by Suriname were, supervision and control of maritime navigation in accordance with the laws of Suriname.

2.4.4.3 Decreet Havenwezen, S.B. 1981 No. 86 (Harbours Decree S.B. 1981 No. 86)

This Decree provides provisions for harbours. In accordance with Article 17 of this Act, it is prohibited to throw ballast, waste and condemned goods overboard into public waters (sea and rivers). It is also prohibited to pump oil, oil contained ballast and bilge water.

The implementing agencies for the Harbours Decree 1981 (S.B. 1981 No. 86) are as follows:

- The Shipping Services of Suriname;
- The Maritime Authority of Suriname;
- The District Commissioner, who is assisted by the Prosecutor's Office;
- The Police; and
- The Ministry of Trade and Industry.

2.4.4.4 Port Authority (Paramaribo)

NV Havenbeheer Suriname is the Port Authority of Suriname located in Paramaribo. This medium natural river port functions as the first port of entry into Suriname and provides a number of facilities that will be applicable to this Project. This includes loading and unloading, lifts and cranes, port services such as navigation equipment and electrical repair, as well as supplies (water, diesel oil, fuel oil etc.).

2.4.5 Ministry of Agriculture, Animal Husbandry and Fisheries (LVV)

The key responsibilities of this Ministry are to:

- Formulate policy regarding agriculture, animal husbandry, fisheries and apiculture;
- Monitor the appropriate use of issued land and water for the agricultural sector;
- Regulate aquaculture and farming industries; and
- Control the implementation of laws and regulations regarding fisheries, agriculture, animal husbandry, and apiculture for food supply and export.

Of recent, the Ministry of LVV has developed a Fisheries Management Plan 2014-2018 for better management of the fisheries of Suriname with the identification of priority areas. Section 2.5.3 below provides greater detail of this plan. During the Staatsolie Nearshore Exploration Drilling Project 2019, the Fisheries Division of the Ministry of LVV will make public announcements and directly contact stakeholders such as the fishermen to inform them about Project activities.

2.4.5.1 Zeevisserijwet 1980, S.B. 1980 no. 144 z.l.g. bij S.B. 2001 no. 120 (Sea Fisheries Act 1980, S.B. 1980 no. 144 as amended by S.B. 2001 no. 120)

The Sea Fisheries Act forms the legal basis for the protection of the sea (with the possibility for fishing quotas). It is also enforced by the Underdirectorate of Fisheries of the Ministry of LVV.

It also amends the 1961 Law on the Protection of Stocks of Fish and repeals the 1971 Fishing Vessels Decree. The Sea Fisheries Act is composed of 39 Articles and defines the 3 categories of fishing vessels for purposes of registration, licenses for sea fishery, certificate of seaworthiness, and other requirements (Suriname fishing vessel, foreign fishing vessel, and alien fishing vessel).

According to Article 14 of the Act, a license is required for catching fish. The Minister may set general conditions under which the license will be given, among which are the type of dragnet to be used, the open season, fishing areas and minimum and maximum size of catching fish etc. Given that fishing occurs in the nearshore area which is contiguous with the proposed project area, the potential impact of an adverse event from the exploration activities on fishermen (liscensed vs. unliscensed) will be pertinent with respect to compensation, if nescessary.

2.4.5.2 Ministry of Regional Development (RO)

The Ministry of Regional Development is responsible for:

- Regional Administration;
- Integrated Government actions, aimed at regional development and enhancement of the living environment of the districts and reconstruction of the interior;
- Cooperation between districts for mutual benefits;
- All secondary and tertiary civil technical works in Suriname, except Paramaribo (The Ministry of Public Works is responsible for secondary and tertiary works in Paramaribo); and
- Waste collection in all districts except for Paramaribo (The Ministry of Public Works is responsible for town planning, waste management and surface water control in Paramaribo).

This Ministry is responsible for the proper disposal of wastes generated within Suriname, except in the capital Paramaribo. In this Project, this Ministry is responsible for ensuring that the various wastes streams brought onshore will be appropriately treated and disposed of as necessary.

2.4.5.3 Ministry of Justice and Police

The Ministry of Justice and Police's prime responsibilities are:

- Maintenance of public order and peace, prevention of violations thereof, and the protection of persons and goods; and
- Investigation of crime and enforcement of regulations.

In relation to this Project, the Ministry of Justice and Police is responsible for the enforcement of the laws described in the subsequent sub-sections.

2.4.6 Ministry of Defense

The key responsibilities of the Ministry of Defense are:

- Defending the sovereignty and independence of the State;
- Upon request and in accordance with the laws, provide assistance to prevent accidents and disasters and combat effects; and

- Monitoring and protection of all activities in the territorial waters, economic zone and continental shelf, in accordance with international law.

The Ministry's role during this Project relates to monitoring and protection of sea vessels and Project activities. In relation to this Project, the Ministry of Defense is responsible for the enforcement of the law described in the subsequent sub-section.

2.4.6.1 Wet Maritieme zones S.B. 2017 no. 41 (Maritime Zones Act S.B. 2017 no. 41).

This law defines the territorial sea of Suriname at 12 nautical miles from the nearest point on the line of the low-water mark along the shore and establishes, the Exclusive Economic Zone (EEZ; 200 nautical miles) for which Suriname claims sovereign rights concerning the exploration, exploitation, conservation, and management of living and non-living resources. Provisions are also made for the granting and revocation of licenses for activities in the EEZ. The Act gives a detailed description of the measures of enforcement that could be used and also prescribes offences and penalties. This Law may be implemented by Government Decree "*if matters dealt within this Law require amending for the sake of its proper execution*" (Article 17).

Additionally, Article 17 of LAW of April 2017, states that a permission from the State Decree is specially required for the deliberate disposal and storage of wastes and other matter within the EEZ be it from vessels, aircraft, platforms or other man-made structures. It also states that a permit is required to carry out operations in the continental shelf which infringe on the sovereign rights.

2.4.6.2 National Coordination Centre for Disaster Management (NCCR)

The National Coordination Centre for Disaster Management (NCCR) of Suriname is responsible for policy development, coordination and management, prevention of crises and disasters as well as management of such events where necessary. The services of NCCR may be required should an unplanned event occurrence during the execution of the proposed Project.

2.5 National Environmental Plans and Strategies

The following sections describe those national plans, strategies or policies that have been implemented within Suriname to safeguard the environment.

2.5.1 National Biodiversity Strategy (NBS)

Suriname's NBS establishes the national vision and strategic directions to conserve and sustain rich biodiversity and biological resources. Moreover, the NBS sets out its goals for sustainable management of the nation's natural resources and supports the equitable sharing of biodiversity related to services and benefits. The NBS provides a framework for the development of a National Biodiversity Action Plan (NBAP), which will identify the activities, tasks, outcomes, milestones and the implementation of a strategic programme. The use and management of biodiversity remains a critical element in the maintenance and development of traditional societies and an emerging modern economy in Suriname (Ministry of Labor, Technological Development and Environment (ATM); National Biodiversity Strategy 2006).

The vision and revised goals for biodiversity conservation in Suriname as per the Aichi Targets include:

- Maintaining biodiversity at the local, regional and national levels.
- Implementation of the research and monitoring programs
- Sustainable use of biological resources
- Improving the management capacity and
- Public awareness, education and strengthening communities.

These 5 Aichi targets were identified in an effort to aid in the attainment of the overall objectives (see Figure 2-2 below) of the NBS.

2.5.2 National Biodiversity Action Plan (NBAP) 2013

The National Biodiversity Action Plan (NBAP) 2013, was formulated as per Suriname's National Environmental Policy under the jurisdiction of the then Ministry of ATM. As an elaboration of the NBS, the NBAP 2013 identifies 8 objectives consistent with article 6 of the United Nations Convention on Biological Diversity for the protection of biodiversity.

These objectives are as follows:

- Conservation of biodiversity;
- Sustainable use of biodiversity;
- Regulated access to genetic material and associated knowledge, with fair and equitable sharing of benefits;

- Knowledge acquisition through research and monitoring;
- Capacity building;
- Raising awareness and empowerment through education and communication;
- Cooperation at local and international level; and
- Sustainable financing.

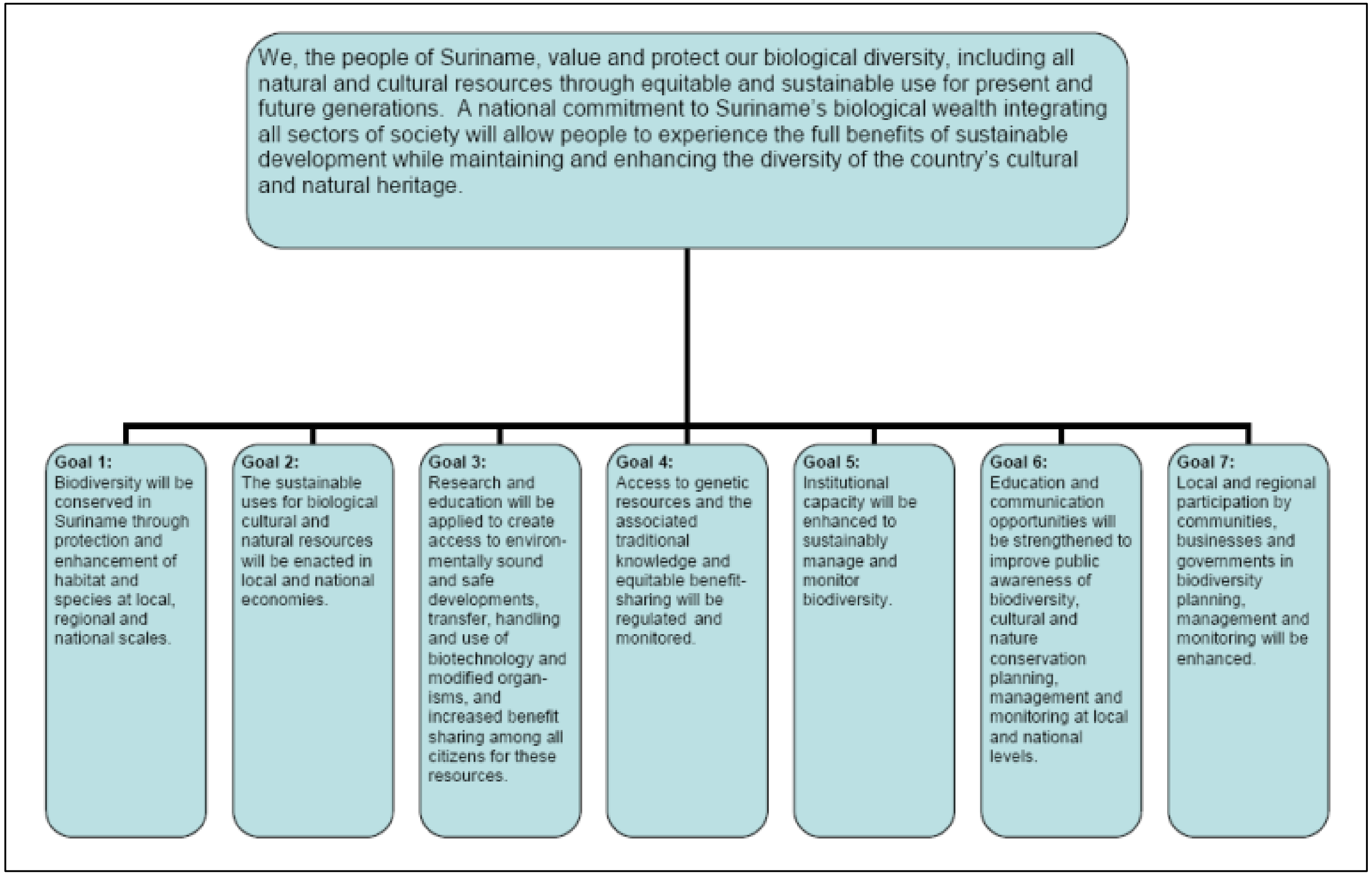
2.5.3 Fisheries Management Plan (2014 – 2018)

This plan was developed in major consultation with the fishing industry in an effort to manage and protect the fisheries of Suriname. Many of the policies outlined in the plan are based on the experience of the actual fishermen. The application of the precautionary principle was employed due to limited information about the state of fish stocks in Surinamese waters. Where it is established that certain fish stocks are under excessive pressure this plan ensures that measures are employed to reduce this pressure. The plan also devotes attention to the effects of fishing on nature by reducing the amount of unwanted catches. This will be achieved by limiting the number of licenses, technical measures regarding fishing methods; and zoning of the fishery.

According to the Ministry of LVV and the agricultural policy, the following are the objectives with respect to fisheries:

- ensuring food security for the entire Surinamese population;
- ensuring food safety in the fishing industry;
- promoting and developing sustainable fisheries;
- the development of the fisheries sector to food producer and supplier for the Caribbean;
- increasing the contribution of fisheries to the national economy;
- creating spatial conditions for the sustainable development of aquaculture;
- managing the risks and constraints in the implementation of the fisheries.

The Fisheries Management Plan 2014 – 2018 was formulated by developing each of the aforementioned objectives. Section 4.5 of the plan explains that fishing zones and protected areas are established with respect to the type of fishing that can be done in the nearshore coastal and deeper waters off the coast of Suriname. During the execution of the project activities, a safety exclusion zone will be established around each drill site. As such, the Fisheries Management Plan is pertinent in the event of a potential oil spill and impacts to fishermen.



(*Source: Ministry of Labor, Technological Development and Environment, National Biodiversity Strategy, March 2006)*

Figure 2-2: Vision and Goals of Biodiversity Conservation for Suriname

An evaluation of the legal and institutional framework for protection of the coastal and marine area revealed that the legislation is fragmented and under the jurisdiction various ministries. The law has been found to be outdated and insufficient to adequately protect the coastal and marine areas. This was also found to be exacerbated by the lack of enforcement of the law due to insufficient financial resources, manpower and inefficient use of existing human resources.

Additionally, the Cartagena Convention seeks to protect the marine environment by requiring parties to take the necessary measures to prevent, control and reduction of pollution by ships by dumping from land, seabed exploration or exploitation and by atmospheric discharges. Suriname is not a party to this treaty. According to del Prado 2017, in order to achieve the Aichi Targets identified therein, by modernisation of current legislation, amending existing legislation and / or adopting new legislation, as well as institutional strengthening and effective implementation of defined policies.

2.6 International Instruments & Commitments

Suriname is party to a number of multilateral environmental agreements which are relevant to this Project (Appendix A.1), and which are described in the relevant sub-sections below:

- International Convention relating to Intervention on High Seas in cases of Oil Pollution Casualties (INTERVENTION, 1969);
- International Convention for the Prevention of Pollution from Ships 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL 1973/1978);
- The United Nations Convention on the Law of the Sea (UNCLOS);
- The United Nations Framework Convention on Climate Change (UNFCCC);
- The United Nations Convention on Biological Diversity (UNCBD);
- Convention on Nature Protection and Wildlife Preservation in the Western Hemisphere;
- The Convention on Wetlands of International Importance (The Ramsar Convention);
- The Vienna Convention for the Protection of the Ozone Layer;
- Montreal Protocol on Substances that Deplete the Ozone Layer;
- International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC), 1990; and
- International Association of Drilling Contractors Guidelines

Suriname is also preparing to accede to the Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region (Cartagena Convention) and its Protocols (oil spills, specially protected areas and wildlife and land-based sources of pollution). Suriname is also an official team member of the Caribbean Environment Programme (CEP).

It should be noted that during the review of this document, some of the legislation outlined in the Final Scoping Report (Appendix A.1) were not applicable to Staatsolie's proposed project and hence omitted from this report. Appendix B.2 presents a summary of these omitted legislative and regulatory considerations.

2.6.1.1 International Convention relating to Intervention on High Seas in cases of Oil Pollution Casualties (INTERVENTION, 1969)

In 1969, Suriname entered the International Convention relating to Intervention on the High Seas in cases of Oil Pollution's Casualities. It was ratified on November 14th, 1976. The Maritime Authority Suriname (MAS) is the focal point of the Convention. The objectives of this Convention are:

- To enable the country to take action on the high seas in cases of a maritime casualty resulting in danger of oil pollution of sea and coastlines; and
- To establish that such action would not affect the principle of freedom of the high seas.

Article *I.* (1) states that "Parties to the present Convention may take such measures on the high seas as may be necessary to prevent, mitigate or eliminate grave and imminent danger to their coastline or related interests from pollution or threat of pollution of the sea by oil, following upon a maritime casualty or acts related to such a casualty, which may reasonably be expected to result in major harmful consequences".

This is Convention is pertinent to the drilling project as crude oil, diesel and other chemicals associated with the project can accidentally enter the high seas during the project duration.

2.6.1.2 International Convention for the Prevention of Pollution from Ships, 1973, as modified by the Protocol of 1978 relating thereto and by the Protocol of 1997 (MARPOL)

The International Convention for the Prevention of Pollution from Ships, 1973, as modified by its Protocol in 1978 (MARPOL 1973/1978) limits and prohibits certain types of vessel-source pollution. Suriname ratified this Convention in February 1989. The Maritime Authority Suriname (MAS) is the national focal point.

MARPOL (73/78) is made up of 6 annexes:

- Annex I Regulations for the prevention of pollution by oil;
- Annex II: Regulations for the control of pollution by noxious liquid substances in bulk;
- Annex III: Prevention of pollution by harmful substances carried by sea in packaged form;

- Annex IV: Prevention of pollution by sewage from ships;
- Annex V: Prevention of pollution by garbage from ships; and
- Annex VI: Prevention of air pollution from ships.

Table 2-1 below provides a summary of the discharge standards for different types of pollution that are applicable to the Project.

Table 2-1: Summary of MARPOL 73/78 Provisions Relevant to Oil and Gas Development* and Other Relevant Discharge Standards

Environmental Aspect	Sub-Category	Provisions of MARPOL 73/78	Where/When discharge permitted	Annex
Accidental oil discharge (Annex I)	Oily waste from cargo tanks of oil tankers	Shipboard oil pollution emergency plan (SOPEP) is required.	• More than 50 nautical miles from the nearest land • Tanker is proceeding en route • Instantaneous rate of discharge <30 liters per nautical mile • Total quantity discharge does not exceed 1/15,000 or 1/30,000 of the total cargo (depending on the age of the vessel) • Oil discharge monitoring and control system and slop tank arrangement to be operating	I
	Machinery space bilges for vessels ≥400 gross tons (Note: also applies "*as far as practicable and reasonable*" to ships < 400 gross tons)		• Proceeding en route • Oil content less than 15 ppm • Oil discharge monitoring and control system and oil filtering equipment to be operating	

Environmental Aspect	Sub-Category	Provisions of MARPOL 73/78	Where/When discharge permitted	Annex
Sewage discharge (Annex IV)	Comminuted and disinfected sewage using an approved system	Discharge of sewage is permitted only if the ship has approved sewage treatment facilities that are capacity rated, the chemical test results of the facilities are documented and compliant with (MARPOL 73/78), whilst residual chlorine is <2 mg/l (TTWRP, 2001), and the effluent will not produce visible floating solids nor cause discoloration of the surrounding water (USEPA GOM Effluent Limits 2007)	>3 nautical miles from nearest land	IV
	Untreated sewage		>12 nautical miles from nearest land	
	Untreated sewage stored in holding tank		>12 nautical miles from nearest land; and discharged at a moderate rate; and ship proceeding en route at a speed of at least 4 knots	
Garbage	Plastics, including synthetic ropes, synthetic fishing nets, plastic garbage bags and incinerator ashes from plastic products	Disposal of garbage from ships and fixed or floating platforms is prohibited. Ships must carry a garbage management plan and shall be provided with a Garbage Record Book.	Prohibited	V

Environmental Aspect	Sub-Category	Provisions of MARPOL 73/78	Where/When discharge permitted	Annex
	Dunnage, lining and packing materials which will float		>25 nm from nearest land.	
	Food wastes that has been ground or comminuted to particles <25 mm		>12 nm from nearest land.	
	Garbage that has been ground or comminuted to particles <25 mm		>3 nm from nearest land	
Air Pollutant Emissions	Ozone-depleting substances	Sets limits on sulphur oxide and nitrogen oxide emissions from ship exhausts and prohibits deliberate emissions of ozone-depleting substances including halons and chlorofluorocarbons (CFCs). Sets limits on emissions of nitrogen	Prohibited	VI
	Nitrogen oxides		Operation of diesel engines >130 kW prohibited unless engine is certified to meet prescribed emission standards Total weighted emission of NO_2: (i) 17.0g/kWh when n is less than 130 rpm (ii) 45.0*n(-0.2) g/kWh when n is 130 or more but less than 2000 rpm	

Environmental Aspect	Sub-Category	Provisions of MARPOL 73/78	Where/When discharge permitted	Annex
		oxides from diesel engines. Prohibits the incineration of certain products on-board such as contaminated packaging materials and polychlorinated biphenyls.	(iii) 9.8 g/kWh when n is 2000 rpm or more	
	Sulphur oxides		Total emission of SO_x from ships should be reduced to 6.0 g SOx/kWh or less (total weight of sulphur dioxide emission) Sulphur content of fuel not to exceed 4.5%	
Drainage water		Ship must be proceeding en route, not within a "*special area*" Vessel must be equipped with an oil-filtering system, automatic cut off, and an oil-retention system.	Oil must not exceed 15 ppm (without dilution)	I
Bulked Chemicals		Prohibits the discharge of noxious liquid substances, pollution hazard substances, and associated tank washings. Vessels required to undergo periodic inspections to ensure		II

Environmental Aspect	Sub-Category	Provisions of MARPOL 73/78	Where/When discharge permitted	Annex
		compliance. All vessels must carry a Procedures and Arrangements Manual and Cargo Record Book.		

**Suriname has ratified MARPOL (73/78) Annexes I, II, III, IV and V.*

2.6.1.3 United Nations Convention on the Law of the Sea (UNCLOS)

The UNCLOS was signed in December 1992. Under UNCLOS, Suriname can claim sovereign rights in a 200 nm EEZ. This allows for exploration, exploitation, conservation and management of all natural resources in the seabed, its subsoil and overlaying waters. UNCLOS allows other states to navigate and fly over the EEZ, as well as to lay submarine cables and pipelines. The inner limit of the EEZ starts at the outer boundary of the Territorial Sea, which is defined as 12 nm from the baseline or low waterline along the coast. The intended exploration activities will occur within Suriname's territorial waters.

The UNCLOS was later ratified by Suriname on July 9th, 1998. In accordance with Article 4 of the Agreement relating to the implementation of Part XI of the Convention, Suriname, by ratifying the Convention, expressed its consent to be bound by that Agreement. Suriname made no declaration upon ratification. The Maritime Authority Suriname (MAS) is the national focal point of this Convention. According to del Prado 2017, further regulations on the use of the maritime area beyond the high seas are needed for the conservation and sustainable use of marine biodiversity.

2.6.1.4 United Nations Framework Convention on Climate Change (UNFCCC)

The UNFCCC, which was signed in 1992, has an ultimate objective of stabilizing greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic (human-induced) interference with the climate system. Suriname ratified the UNFCCC in October 1997 and the Kyoto Protocol in July 2006. The country has also initiated a project on sea-level rise, with the assistance of the Dutch Government. Mr. Winston Lackin is the national focal point (NFP) of the Convention.

This is pertinent to the project based on the requirements if Article 4 and 10. Article 4 (f) state that "*Take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, and employ appropriate methods, for example impact assessments, formulated and determined nationally, with a view to minimizing adverse effects on the economy, on public health and on the quality of the environment, of projects or measures undertaken by them to mitigate or adapt to climate change."* It is within this context that the UNFCCC is applicable to the Nearshore Exploration Drilling Project 2019.

2.6.1.5 United Nations Convention on Biological Diversity (UNCBD)

Suriname signed the United Nations Convention on Biological Diversity (UNCBD) in June 1992 and ratified it on January 12th, 1996. Parts of the UNCBD are covered by provisions in the Nature Preservation Law (under the Forest Service), the Game Law and the Law on Forest Management (both under the Ministry of Natural Resources, Forest Service), the Fish Protection Law and the Sea Fisheries Law (both under the Ministry of Agriculture, Animal Husbandry and Fisheries, Fishery Service). The NFP is Mr. Winston Lackin.

2.6.1.6 The Convention on Nature Protection & Wildlife Preservation in the Western Hemisphere (Western Hemisphere Convention)

The objectives of this Convention are to preserve all species and genera of native fauna and flora from extinction, and to preserve areas of extraordinary beauty, striking geological formations or aesthetic, historic or scientific value. Summaries of the provisions are as follows:

- Parties to establish national parks, national reserves, nature monuments and strict wilderness reserves (Article 2);
- National parks to provide recreational and educational facilities to the public (Article 3);
- Strict wilderness areas to be maintained inviolate (Article 4);
- Cooperation to be maintained between Governments in the field of research (Article 6);
- Listed species to enjoy special protection (Article 8); and
- Controls to be imposed on trade in protected fauna and flora and any part thereof (Article 9).

The Convention has been signed by 22 member countries of the Organization of American States (OAS) and ratified by 19 member countries, Suriname being one of these countries. Suriname has been a member since July 1985. The national focal point is the Ministry of ROGB. Of recent, the Coppename River Estuary Nature Reserve has been established under this convention. Even though no drilling activities are planned within this Nature Reserve, its relative location to the project area with respect to potential impacts from adverse events which may arise from project related activities makes it pertinent to this study.

2.6.1.7 Western Hemisphere Shorebird Reserve Network

The Western Hemisphere Shorebird Reserve Network (WHSRN) is a conservation strategy launched in 1986 with the designation of the first site, in the United States. The Network aligns with the simple strategy that we must protect key habitats throughout the Americas in order to sustain healthy populations of shorebirds. To date, WHSRN site partners are conserving 38 million acres (15 million hectares) of shorebird habitat in 16 countries, one of which is the Republic of Suriname.

This Conservation strategy is developed to signed to:

- Build a strong system of international sites used by shorebirds throughout their migratory ranges.
- Develop science and management tools that expand the scope and pace of habitat conservation at each site within the Network.
- Establish recognition for regional, international, and hemispheric sites and landscapes, raising new public awareness and generating conservation funding opportunities.
- Serve as an international resource, convener, and strategist for issues related to shorebird and habitat conservation.

On March 4, 1989, the Coppenamemonding Nature Reserve, the Wia-Wia Nature Reserve and the Bigi Pan MUMA received the status of “Hemispheric Reserves”; within the Western Hemisphere Shorebird Reserve Network (WHSRN). The areas mentioned were subsequently twinned with two nature reserves in the Bay of Fundy, Canada: the Minas Basin at Nova Scotia and the Shepody Bay at New Brunswick. The flyway populations of Ne-arctic (Charadriidae and Scolopacidae) shorebirds that visit Suriname during northern winters use these Canadian protected areas as a staging area.

2.6.1.8 The Convention on Wetlands of International Importance (The Ramsar Convention)

The Convention on Wetlands is an inter-Governmental treaty that provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. In order to qualify as a Ramsar site, an area must have "*international significance in terms of ecology, botany, zoology, limnology or hydrology*.”

The Convention on Wetlands came into force for Suriname on November 22nd, 1985. The Ministry of ROGB is the national focal point of the Convention. Suriname presently has one site designated as a Wetland of International Importance – the Coppename Monding wetland. This wetland was subsequently listed by legislature as a protected area (CMNR). The wetland complex, which has a surface area of 120 km^2 (12,000 ha), is located on the coastline of District 8 (Saramacca) and is representative of natural or near-natural wetlands which intersects with the southern boundaries of Blocks B and C of the proposed Project.

It should be noted, that although the Ramsar Convention is not a regulatory regime and has no punitive sanctions for violations of or defaulting upon treaty commitments, nevertheless, its terms do constitute a solemn treaty and are binding in international law in that sense. The whole edifice is based upon an expectation of common and equitably shared transparent accountability. Therefore, the Ramsar Secretariat must be informed of any planned oil and gas prospecting activities at the designated Ramsar site. After this, a Ramsar Advisory Mission will be set up to respond to proposed activities by making site visits, organizing consultations, giving short-term and long-term recommendations, as well as suggestions for sources of further external support.

Failure to live up to this expectation could lead to political and diplomatic discomfort in high-profile international fora, or the media, and would prevent any Party concerned from maximizing a robust and coherent system of checks and balances and mutual support frameworks. Moreover, failure to meet the treaty's commitments may also impact upon success in other ways, for example, in efforts to secure international funding for wetland conservation.

Given the occurrence of the Coppename Monding wetland is within close proximity of the project area, Staatsolie will ensure that the necessary precautions are taken to ensure absolutely no disturbance to the area. Also, it should also be note that none of the planned activities intersect with the wetland and hence permission is not require for this drilling project.

2.6.1.9 Treaty for Amazonian Cooperation

Suriname is a signatory to the Amazon Cooperation Treaty (ACT) together with Bolivia, Brazil, Colombia, Ecuador, Guyana, Peru, and Venezuela. Signed in July 1978, this treaty established the Commission on the Amazonian Environment to address conservation in border areas. In 1995, the Permanent Secretariat for the ACT was created to reinforce the Treaty from an organizational point of view, which was later amended in 1998. The Ministry of Foreign Affairs is the national focal point of this Treaty. Guyana is the only country under this treaty whose border is related to this Project. Considering the potential of an oil spill during drilling activities, impacts to the Guyana coastline is possible and thus this Treaty was considered.

2.6.1.10 The Vienna Convention for the Protection of the Ozone Layer

Suriname entered this treaty on October 14th, 1997. The National Ozone Unit (NOU) is the national focal point of the Convention. The objectives of this convention are:

- To protect human health and the environment against adverse effects resulting or likely to result from human activities, which modify or are likely to modify the ozone layer;
- To adopt agreed measures to control human activities found to have adverse effects on the ozone layer;
- To co-operate in scientific research and systematic observations; and
- To exchange information in the legal, scientific and technical fields (UNEP December 2004).

During the execution of the proposed Project, emissions from engine combustion and fugitive gases may occur from supply vessels, diesel generators, rig operations etc. In this respect, the Vienna Convention is applicable to the proposed Project.

2.6.1.11 The Montreal Protocol on Substances that Deplete the Ozone Layer

Suriname ratified the Montreal Protocol on Substances that deplete the Ozone Layer on October 14th, 1997 and the National Ozone Unit (NOU) is the national focal point. This treaty supplements the Vienna Convention for the protection of the Ozone Layer. Under this Protocol, it is Suriname's responsibility to protect human health and the environment from adverse effects of ozone depletion. The Montreal Protocol is therefore designed to regulate the production and consumption of ozone-depleting substances.

As mentioned in the previous section, the proposed Project will entail operations and activities that may generate sulphur oxides, nitrogen oxides as well as ozone depleting substances that have an impact on the ozone layer. Hence, preventative maintenance with respect to all equipment will auger well for optimal performance, whilst ensuring a small carbon footprint for the Project.

2.6.1.12 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC, 1990)

The 1990 International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) of the International Maritime Organization (IMO) is one of the more recent global agreements that Suriname is presently involved in adopting. Suriname recently begun the ratification process of this convention and will attempt to accelerate its approval and implementation, such that proposed measures will be effective in the mitigation of any potential spill from this Project.

This Convention is pertinent to the Nearshore Exploration Drilling Project as oil spills are possible during drilling. As such the following Resolutions are relevant:

Resolution 5 states that each party shall have " *a system which includes a minimum level of pre-positioned oil spill combating equipment, and programmes for its use" and "prompt and effective action should be taken initially at the national level to organize and co-ordinate prevention, mitigation and clean-up activities"*.

Additionally, Resolution 7 states that there must have the availability of oil spill combating equipment as well as of trained oil spill response personnel.

2.6.2 Internationally Recognized Laws, Regulations & Guidelines for ESIAs

At present, there are no national environmental standards in Suriname. Therefore, the internationally recognized laws, regulations and guidelines described hereunder will be applied during the EIA process.

2.6.2.1 United States Environmental Protection Agency (USEPA) - National Ambient Air Quality Standards (NAAQS)

The EPA is an agency of the U.S. Federal Government charged with protecting human health and the environment, by drafting and enforcing regulations based on laws passed by U.S. Congress. The agency conducts environmental assessment, research, and education. It has the primary responsibility for setting and enforcing national standards under a variety of environmental laws, in consultation with state, tribal, and local governments.
The NAAQS were used for comparison to environmental air quality data collected during the baseline assessment for the ESIA (see Chapter 5 of this Report). These standards, established by the USEPA under authority of the Clean Air Act, apply to outdoor air throughout the country and are separated into:

- Primary Standards, designated to protect human health with adequate margin of safety, including sensitive populations such as children, the elderly, and individuals suffering from respiratory diseases; and
- Secondary Standards, designated to protect public welfare from any known or anticipated adverse effects of a pollutant.

The NAAQS are set for 6 principal pollutants, which are called ‘*criteria pollutants*’. In lieu of national air emission standards, the NAAQS limits will be used for this Project.

2.6.2.2 Trinidad and Tobago's Environmental Management Act, 2000 & Subsidiary Legislation

Trinidad and Tobago's Environmental Management Act, 2000 (EM Act, 2000) provides for a coordinated approach to environmental management. Under this act, the Environmental Management Authority (EMA) was legally established as the governing body responsible for enforcing environmental laws and regulations under Section 6, Chapter 35:05. The EMA has published 5 pieces of subsidiary legislation (Rules) aimed at environmental protection in neighbouring Trinidad Tobago. The following EMA Rules were considered during the assessment for this ESIA.

1. Water Pollution Rules, 2001, as amended by the Water Pollution Rules (Amendment), 2006 - The Rules give details in the First and Second Schedules, where the First Schedule represents a list of water pollutants and the Second Schedule gives the maximum permissible levels of water pollutants from effluent point sources to the receiving environment

2. Air Pollution Rules, 2014 - The Air Pollution Rules, 2014, prescribe maximum permissible levels of substances emitted that are deemed to be air pollutants. These air pollutants are named in the First and Second Schedules of the Air Pollution Rules, 2014. Maximum permissible levels for ambient air pollutants form non-point sources are listed in the First Schedule, while maximum permissible levels for air pollutants from stack releases are listed in the Second Schedule

In the absence of national water quality effluent standards, the Trinidad & Tobago Water Pollution Rules, 2001 (TTWPR) will be used for this project to minimise any associated impacts from the discharge of effluent into the marine environment.

Air quality parameters from the Air Pollution Rules, 2014, will be used in the absence of applicable parameters from the NAAQS. Table 2-2 compares the air quality standards between the Air Pollution Rules, 2014 and the NAAQS.

Table 2-2: Comparison of Air Quality Parameters

Substance	Trinidad and Tobago Air Pollution Rules 2014; µg/m³	U.S. EPA National Ambient Air Quality Standard (NAAQS)
Carbon Monoxide (CO)	30,000 (1-hr average)	35 ppm (1-hr average)
Nitrogen Dioxide (NO_2)	200 (1-hr average)	100 ppb (1-hr average)
Sulphur Dioxide (SO_2)	500 (10-min average)	75 ppb (1-hr average)
Particulate Matter (PM_{10})	75 µg/m³ (24-hr average)	150 µg/m³ (24-hr average)

2.6.2.3 World Bank International Finance Corporation (IFC) – Environmental, Health and Safety (EHS) Guidelines for Offshore Oil and Gas Development (June 2015)

The World Bank is an international institution which provides financial and technical assistance to developing countries around the world. It is made up of 2 unique development institutions owned by over 100 member countries, which are the International Bank for Reconstruction and Development (IBRD) and the International Development Association (IDA), with affiliations in the International Finance Corporation (IFC). The IFC is a global investor and advisor and is committed to promoting sustainable projects in developing member countries that are economically beneficial, financially and commercially sound, and environmentally and socially sustainable.

The World Bank/IFC EHS for Offshore Oil and Gas Development will be used during the ESIA’s mitigation and management processes. It is a technical reference document with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards.

The EHS Guidelines for Offshore Oil and Gas Development include information relevant to seismic exploration, exploratory and production drilling, development and production activities, offshore pipeline operations, offshore transportation, tanker loading and unloading, ancillary and support operations, and decommissioning. It also addresses potential onshore impacts that may result from offshore oil and gas activities.

2.7 International Effluent and Emissions Guidelines

At present, there are no national effluent or emission standards for offshore oil and gas activities in Suriname. Staatsolie will comply with appropriate international standards and guidelines, as well as explicit environment protection principles or criteria as stated in Suriname's legislation. Staatsolie will also act in accordance with the company's Health, Safety and Environmental Management System (HSEMS) to address emission and waste volumes.

As noted previously, Suriname is party to MARPOL (73/78). Table 2-1 above summarises MARPOL (73/78) provisions that are relevant for oil and gas exploration to which Saatsolie will comply.

Prior to the discharge of drilling muds and cuttings, a "no free' oil test will be done to ensure that no residual oils are present on the cuttings. This will comply with the USEPA Effluent Limits 2007 for oil and gas activities in the Gulf of Mexico (GOM) presented in Table 2-3 below. Additionally, other project related effluent such as food waste and vessel effluents will also be guided by the USEPA GOM Effluent Limits 2007.

Table 2-3: Effluent limits for Oil and Gas Activity: USEPA (2007)

Source	Discharge Limitation
	Drilling Fluids and Cuttings
Free oil	No free oil on discharge drilling fluids or cuttings
Toxicity	96hr LC_{50} of suspended particulate phase not to exceed 30,000 ppm
Cadmium in stock barite	Not to exceed 3 mg/kg
Mercury in stock barite	Not to exceed 1 mg/kg
Discharge rate	1,000 bbls/hr maximum
Other Effluents	
Food waste	No floating solids or foam
Bilge water	No free oil
Deck drainage	No free oil
Desalination brine	No free oil

Sanitary waste (black and grey water) will be treated on-board the rig to meet the requirements outlined in the IMO Annex A of Resolution MEPC 2(6) 1976. Additionally, for parameters not covered under this regulation, the limits will comply with the Trinidad and Tobago Water Pollution Rules, 2001 Effluent Limits for the marine offshore area, in lieu of national standards. The presence of floating solids in treated sewage will be managed by the USEPA GOM Effluent Limits 2007. These requirements are summarized in Table 2-4 below.

Table 2-4: Sanitary and Organic Wastes Effluent Standards to be used for the Nearshore Exploration Drilling Project 2019

Sanitary & Organic Waste	IMO Annex A of Resolution MEPC 2(6) 1976	TTWPR 2001, 2nd Schedule (as amended) Marine Offshore (> 5km from HWM)	USEPA 2007 Guidelines for Gulf of Mexico (GOM)
COD (mg/L)	-	250	-
pH	-	6 - 9	-
Ammoniacal nitrogen (mg/L)	-	10	-
Total phosphors (mg/L)	-	5	-
Total residual chlorine (mg/L)	As low as practicable	2*	-
BOD5 (mg/L)	50*	100	-
TSS (mg/L)	100*	200	-
Faecal Coliforms (counts per 100 ml)	250*	400	-
Sewage	-	-	No floating solids

-Not Available
** This standard takes precedence where multiple standards are available*

With regards to air pollutant emissions and other aspects of offshore oil and gas operations, the Project will be consistent with international industry best practice.

2.7.1 International Association of Drilling Contractors

Since 1940, the International Association of Drilling Contractors (IADC) has exclusively represented the worldwide oil and gas drilling industry. IADC's vision is for the drilling industry to be recognized for its vital role in enabling the global economy and its high standards of safety, environmental stewardship and operational efficiency. The Association's primary areas of focus include advocating for sensible regulation, giving voice to our industry and improving safety and environmental protection. In this regard, the IADC committee has formulated numerous policies, standards and guidelines in line with their primary focus. For this Project, operations of the rig will be in alignment with that prescribed by the IADC HSE Guidelines for Mobile Offshore Drilling Rigs such as the MODU Code and MODU HSE Cases which are critical for ensuring minimization of incidents.

2.7.2 USEPA GOM Effluent Limits 2007

The United States Environmental Protection Agency (USEPA) promulgated the Oil and Gas Extraction Effluent Guidelines and Standards (40 CFR Part 435) in 1979, and amended the regulations in 1993, 1996, 2001 and 2016. The regulations address wastewater discharges from field exploration, drilling, production, well treatment and well completion activities. These activities take place on land, in coastal areas and offshore. 40 CFR Part 435 Subpart D is pertinent to this Project as the proposed exploration activities will occur in the Nearshore Blocks A-C of Suriname.

Effluent discharge limits for WBM muds and cuttings and a "no free oil" (static sheen test) will be used during the execution of this exploration project to minimise impacts to the receiving environment and its marine biota. Additionally, concentrations of cadmium and mercury in barite stock as well as well as toxicity will be regulated by this guideline. Limits for other effluents from the rig such as deck drainage, bilge water and sewage will also adhere to the requirements herein. Table 2-3 and Table 2-4 above presents the stipulated effluent limits that will be used during this exploration Project.

2.7.3 International Association of Oil and Gas Producers

The International Association of Oil & Gas Producers (OGP, originally called the E&P Forum until 1999) was founded in 1974 and encompasses most of the world's leading publicly-traded, private and state-owned oil and gas companies, oil and gas associations and major upstream service companies. It is concerned with all aspects of oil and gas exploration and production having international implications, and in particular with safety and health and environmental protection. It represents its members' interests at United Nations (UN) agencies, European Union (EU) and other international bodies.

To help its members achieve continuous improvements in safety, health and environment performance as well as in the engineering and operation, the OGP has prepared numerous guidelines to assist in the development and application of Health, Safety and Environmental Management Systems (HSEMS). OGP Members have participated in the preparation of guidelines, to ensure that their collective experience is applied and that the Guidelines have wide acceptance.

The following documents will be applied during the EIA's mitigation and management processes:

- Environmental Management in Oil and Gas Exploration and Production (OGP reference 2.72/254) – This guideline on environmental management in oil and gas exploration and production are based on the collective experience gained by United Nations Environment Programme (UNEP) and the oil industry. It is designed to help meet the challenge of fully integrating protection of the environment in the regulatory and business processes that control the exploration and production of oil and gas. The guideline serves as a basis for preparing or improving regulations, policies and programmes to minimise the impact on the environment of these activities. The document provides an overview of the environmental issues and the technical and management approaches to achieving high environmental performance in the activities necessary for oil and gas exploration and production in the world. Management systems and practices, technologies and procedures are described that prevent and minimise impact. The continued sharing of best practices and the application of comprehensive management systems by oil companies and their contractors and suppliers are essential.

2.7.4 Bureau of Safety and Environmental Enforcement (BSEE) – United States Department of the Interior (DOI)

The BSEE is an agency of the US of Department of the Interior (DOI). It is responsible for promoting safety, protecting the environment, and conserving resources offshore through vigorous regulatory oversight and enforcement on the 1.7 billion acres of U.S. Outer Continental Shelf (OCS). The offshore program, which manages the mineral resources on the OCS, is divided into 3 regions: Alaska, Gulf of Mexico and the Pacific Ocean.
The Notice to Lessees and Operators (NTL) Of Federal Oil and Gas Leases in the Outer Continental Shelf (OCS), Gulf of Mexico OCS Region (GOMR March 2013), will be used during the EIA's mitigation and monitoring processes. It addresses the problem of Mobile Offshore Drilling Units (MODUs) moving off location and the potential impacts and damages to other facilities, vessels and pipelines. 30 CFR 250.417 Subpart D

outlines the scenarios when notification must be given prior to movement of rig.

2.8 Summary of Legal & Regulatory Requirements Linked to Project Specific Activities

Table 2-5 below provides a summary of relevant regulatory requirements for the Staatsolie Nearshore Exploration Drilling Project 2019 and the links to the specific Project activities.

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Table 2-5: Summary of Staatsolie Nearshore Exploration Drilling Project 2019 Legal and Regulatory Requirements Linked to the Specific Project Activities

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
Ministry NH (including GMD)			
Petroleumwet 1990 S.B. 1991 no. 7, z.l.g. bij SB. 2001 no.58 (Petroleum Act 1990 S.B. 1991 no. 7, as amended by S.B. 2001 no. 58	Carry out petroleum activities in such a way that negative impacts on environment and natural resources are prevented. Requires attention to prevailing legal regulations to build, establish, maintain and use all facilities for proper performance of activities, and proper Project closure. For development, a separate plan should be made and submitted for approval by Staatsolie. Conservation of petroleum, prevention of spills and protection of fisheries, shipping and other activities.	Relevant during pre-project planning stage (including ESIA stakeholder engagement during baseline studies and impact assessment), and during execution of project, decommissioning and post-closure.	This ESIA report and its recommendations and resulting management plans (ESMP, ERP, OSRP). Staatsolie and Contractors' HSE and Risk Management policiesand HSE management systems (HSEMS_. Staatsolie's internal project approval processes. In the absence of a specific State Order for conservation, prevention of spills and protection of fisheries and shipping, Staatsolie will develop an OSRP which is in line with the highest international standards. Communication protocols such as MAS Notifications to Mariners, Daily Project Summaries to all relevant stakeholders, and a communication plan with fishermen, are in place.
Decreet Mijnbouw S.B. 1986 no. 28, z.l.g. bij S.B. 1997 no. 44 (Mining Decree S.B. 1986 no. 28 as amended by S.B. 1997 No. 44)	Discharges of gases, fluids and substances should meet safety standards. Activities should be carried out applying the most modern international techniques, advanced technology and appropriate materials, taking into account current requirements regarding safety and health, including requirements to protect the ecosystem.	During all project activities including storage and transportation of materials, fuel bunkering.	• Adherence to the IFC Worldbank/ HSE Guidelines for the Offshore Oil and Gas Development. • Existing Staatsolie and Contractors' HSE, Risk Management and related Policies and HSE management systems. • Contractual agreements with regards to Rig design Rig certification. Vessels inspections etc. • Use of environmentally friendly materials such as Water Based Drilling Muds (WBM). • Oil Spill Response Plan (OSRP) developed by international expert in line with international best

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
			practice and the national oil spill contingency plan. • ESIA reviewed by NIMOS including by international offshore drilling environmental health and safety expert for NIMOS.
Besluit Mijnbouw – installaties S.B. 1989 No.38 (State Decision on Mining Installations S.B. 1989 No.38)	Installation of offshore platform, installation methods and furnishing thereof.	Related to design, furnishing, transport, installation and movement of platform.	Staatsolie and Contractors' HSE, Risk Management and related Policies and HSE management systems. Contractual agreements. Rig design by expert engineers. Certification of rig by internationally renowned institution.
	Protection of the environment.	This item of the Decree is relevant during all Project activities.	Environmental and Social Management Plan of the project (ESMP).
	Removal of the platform	This item of the Decree is of relevance during rig move and Project closure.	Plugging of wells and safe rig move procedures. Post project monitoring (ESMP).
	Traffic and transportation of the rig, material, supplies and personnel using tug boats, chase/crew and supply vessels	This item of the Decree relates to transportation of rig and barge system, personnel, equipment and materials during the entire Project.	Staatsolie HSE and Community Relations Policies, this ESIA report, ESMP and CRP, MAS Notice to Mariners, engagement with potentially affected stakeholders, Traffic management plan
	Safety and security	Safety and Security are relevant aspects during all project activities.	Risk assessment and recommendations from ESIA report, project and OSRP. Staatsolie and Drilling contractor's (including vessels) HSE management system. Shorebase is ISPS certified. Shipboard oil pollution emergency plan - SOPEP and ISPS. Ongoing engagement with, and support from, local Security Forces.

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
	Scientific research	This aspect of the decree is of relevance considering the ESIA baseline studies, geotechnical and geophysical studies.	Studies are conducted in a safe and environmentally friendly manner. Reports (ESIA, Oil spill modelling, Coastal Environmental Sensitivity Analysis), are shared on company websites, on public sessions and their use by relevant authorities (NIMOS, MAS, NCCR, LBB), is consistently being encouraged by Staatsolie. Geotechnical and geophysical studies contractors have HSE management systems in place, and vessels undergo HSE inspection by Staatsolie prior to execution of activities. Daily reporting from these contractor activities to Staatsolie are in place.
	Prohibited to throw overboard or drain substances into the sea in concentrations hazardous for humans, animals and environment. Sea environment of neighbouring coastal states must not be polluted; activities carried out in such a way that ecosystems are not destroyed. Installations not being used must be removed, and scientific research (exploration) done in such a way that the environment is not being polluted).	This part of the Decree is relevant during all Project activities. Handling of hazardous materials; collection, handling and disposal of sanitary and other waste. Discharge of deck and bilge water. In case of emergencies: oil spill response.	An important annex of the ESMP shall be the waste management plan which will comply to the MARPOL 73/78 and IFC guidelines if necessary.
Het Decreet van 11 mei 1981, houdende machtiging tot verlening aan de Staatsolie Maatschappij Suriname N.V. van een vergunning voor het doen van onderzoek naar en van een concessie voor de ontginning van koolwaterstofvoorkomens Decreet E-8B, S.B. 1981 No. 59 (Decree of 11 May 1981 regarding the authorization of Staatsolie to do research and exploitation of hydrocarbons Decree E-8B S.B. 1981 no. 59) & Resolutie No. 3051/93	Contractor has reporting obligations and the State has access for inspection. Contractor shall take all good oilfield practices into consideration with regards to safety. Operations carried out in accordance with most modern international techniques and methods/ good oilfield practice; the company is responsible for a safe discharge of water and waste oil.	These Decrees are of relevance during all Project activities. However, the Petroleum Law has repealed and replaced E-8; see article 29 – 1b of the Petroleum Law: 'Decree of 11 May 1981 giving Staatsolie Maatschappij Suriname N.V. license to explore and concession for development of hydrocarbon resources, and the establishment of related regulations (Decree E-8B, S.B. 1980 No. 128, as modified by S.B. 1981 No. 37 and by S.B. 1985 No. 66).' Subsequently, Resolutie No. 3051/93 of July 1993 granted Staatsolie exclusive rights for exploitation and exploration of hydrocarbons in the sea area of the Republic of Suriname,	Staatsolie ESIA process (stakeholder engagement and consultation). and the resulting ESMP which will be applied during and after the project activities.

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
		including Blocks A, B, C & D among others.	
Ministry Ruimtelijke Ordening, Grond en Bosbeheer (ROGB)			
Natuurbeschermingswet 1954, G.B. 1954 no. 26 z.l.g. bij S.B. 1992 no. 80 (Nature Conservation Act 1954, G.B. 1954 no. 26 as amended by S.B. 1992 no. 80), Government Decree on nature protection Coppename Monding (1966)	Prohibited to intentionally, or due to negligence, damage the condition of the soil, the natural beauty, the fauna, and the flora or to perform acts that may impair the value of the (nature) reserve as such. It is also prohibited to hunt and to fish (etc).	This Act is of relevance during all project activities, including and especially in case of oil spills. Protected areas pertinent to the Project are: Peruvia, Coppename Monding (CMNR), Wia Wia and Galibi Nature Reserves, Bigi Pan MUMA, North Coronie MUMA, North Saramacca MUMA and North Commewijne/Marowijne MUMA.	• EMMP including ERP and OSRP. Well control procedures. • Command System (ICS).
Game Act as amended by GB 1971, No.61, SB 1980, No. 99, SB 1980, No.116, SB 1986, No. 2 and SB 1994, No. 54) and Game Resolution (GB 1970, No.104 as amended by GB 1973, No. 173, SB 2002, No. 116, SB 2009, no. 16) and annual Ministerial Decrees)	Protection of mammals, birds and sea turtles and other animal species that are not designated as "hunting game", 'caged animal's or 'noxious animal species'	All project activites	
Decreet uitgifte Domeingrond S.B 1982 no. 11, z.l.g bij S.B. 2003 no. 7 (Decree on the issuance of Domain Land S.B 1982 no. 11 as amended by S.B. 2003 no. 7)	Establishment of Multiple Use Management Areas (MUMAs)	The Project is not located inside a MUMA, however the project has considered the potential impact to sensitive coastal areas (Bigi Pan, North Coronie, Saramacca and North Commewijne/Marowijne), in case of oil spills.	This ESIA. Coastal environmental sensitivity assessment - technical report, and oil spill modeling, as input to the OSRP. Ongoing engagement with local authorities.
Ministeriële beschikking van 30 december 1987, om Bigi Pan te bestemmen als bijzonder beheersgebied) S.B. 2002 no. 94 (Ministerial Order from 30 December 1987, to Designate Bigi Pan as a Multiple-Use Management Area S.B. 2002 no. 94) **Ministeriële beschikking om Noord Coronie te bestemmen als Multiple-Use Management Area S.B. 2002 no. 87 (Ministerial ordination to design Noord-**	Protection of the MUMA	During all Project activities, any threats to the North Saramacca MUMA shall be avoided.	Staatsolie and Contractors' HSE policies and supporting procedures including waste management, ESMP, OSRP. Access to the drill locations in the nearshore Blocks will be through pre-established safe routes from the most suitable shorebase(s) to be determined by the rig contractor with MUMAs in mind.

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
Coronie as a Multiple-Use Management Area S.B. 2002 no. 88)			
Ministeriële beschikking om Noord Saramacca te bestemmen als Multiple-Use Management Area S.B. 2002 no. 88 (Ministerial ordination to design North Saramacca as a Multiple-Use Management Area S.B. 2002 no. 88)			
Ministeriële beschikking om Noord Commewijne/Marowijne te bestemmen als Multiple-Use Management Area ARS. 2002 no. 94 (Ministerial ordination to design North Commewijne/Marowijne as a Multiple-Use Management Area ARS. 2002 no. 94)			
Ministeriële beschikking Richtlijnen Gronduitgifte Estuariene Beheersgebied 2005 S.B. 2005 no. 16 (Ministerial ordination Guidelines for Land Issuance in the Estuarine Management Areas 2005 S.B. 2005 no. 16)	Guidelines for use of domain land in the estuarine zones in order to protect coastal and shore protection and hydrological/biological function: maintain a strip of 500 m and 200 m, respectively, on both sides of rivers and creeks respectively for forest protection; it is prohibited to withdraw water from the estuarine swamps, and to discharge any wastewater containing chemicals, including pesticides.	The Project does not use any domain land in the estuarine zones.	Staatsolie and Contractors' HSE policies and supporting procedures including waste management. ESMP, OSRP. Water for the project shall not be acquired from estuarine areas/swamps.
Ministry of Transport, Communication and Tourism (TCT)			
Wet Maritieme zones S.B. 2017 no. 41 (Maritime Zones Act S.B. 2017 no. 41)	The Corporation (MAS) is responsible for safe and efficient maritime traffic to and from Suriname in accordance with international conventions ratified, and the supervision and control on maritime navigation in accordance with the laws of Suriname and shall render services to sea-going vessels.	This Act is relevant during all Project activities that relate to transportation of personnel, materials and equipment over water (Suriname river and sea).	This ESIA report and the ESMP. Contractors' policies and HSE management systems in line with MARPOL.
Decreet Havenwezen, S.B. 1981 No. 86 (Harbours Decree S.B. 1981 No. 86)	It is prohibited to throw ballast, waste and condemned goods overboard into public waters. It is also prohibited to pump oil, oil contained ballast and bilge water.	This Decree relates to all Project activities for the Shorebase (port), the rig system and all vessels.	ESMMP, waste management plans, OSRP.
Ministry of Justice & Police			
	Enforcement of the law. Maintenance of public order and peace, prevention of violations thereof, protection of persons and goods, investigation of crime and enforcement of regulations.	All the responsibilities that fall under the Ministry of Justice and Police are of relevance to all of the Project activities.	Staatsolie and Contractors' HSE, CR, Risk Management, Security Policies and procedures in general. HSE and

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
			Security awareness and induction sessions. Emergency response plan scenarios relate to piracy/robbery. Shorebase and Contractor Security plans are in line with ISPS. The project engages closely with the Security Forces.
Ministry of Defense			
Wet Maritieme zones S.B. 2017 no. 41 (Maritime Zones Act S.B. 2017 no. 41)	Defending sovereignty and independence of the State. Assistance to prevent accidents and disasters and combat effects; monitoring of activities in territorial waters, economic zone and continental shelf in accordance with international law.	All Project activities, especially rig operations, transportation of personnel, materials and equipment over sea. Potential engagement with 3rd-party vessels that breach the safety exclusion zone around the drill location. Emergency response, including oil spill response.	Staatsolie and Contractors' policies and security/emergency procedures and plans. ERP (covering all emergency scenarios identified for the project), and OSRP (in case of oil spills). The Project engages closely with the Security Forces.
National Coordination Centre for Disaster Management (NCCR)	Responsible for policy development, coordination and management, prevention of crises and disasters as well as management of such events where necessary.	The services of NCCR may be required should an unplanned event occurrence during the execution of the proposed Project.	Staatsolie and Contractors' policies and security/emergency procedures and plans. ERP (covering all emergency scenarios identified for the project), and OSRP (in case of oil spills).
National Strategies and Plans			
National Biodiversity Strategy	Biodiversity conservation in Suriname through the promotion of local and regional co-operation and collaboration in implementing the Convention on Biological Diversity and the NBSAP; regional and international collaboration with respect to emergency responses to oil spills, as well as strengthening government institutions, NGOs and private businesses engaged in the preparation of environmental impact assessments (EIAs) and develop SIA (social impact assessment) capacity	All Project activities	HSE and CR policies, ESMP, HSEC awareness and induction.
National Biodiversity Action Plan	Biodiversity conservation in Suriname via the implementation of the strategic plans in a phased approached to realisation of the 8 objective of the NBS. During Phase II of the development of the Action Plan, changes in developments and energy consumption lead to an increased requirement for EIAs / ESIAs for a holistic understating and	All Project activities	HSE and CR policies, ESMP, HSEC awareness and induction.

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
	assessment of the potential impacts to the various components of the environment		
Fisheries Management Plan (2014 2018)	Proper management of the fish stock, reduction of fishing pressure of particular species and prevention of unwanted catches. Fishers are required to be registered and in possession of a license to fish, in designated fishing zones that are determined by fishing techniques.	Rig and vessel movement for the duration of the Project	HSE and CR policies, ESMP, HSEC awareness and induction. Mariners' Notice will be issued to inform fishermen on the project activities and restricted areas A safety exclusion zone will be established around each drill site.
International Instruments and Commitments			
Pollution prevention – High Seas, MARPOL 73/78, UNCLOS; OPRC (*although not yet ratified by Suriname, similar to Cartagena convention, important discussions are taking place at national level)	Have high sea and coastline pollution prevention measures in place. Prevent indiscriminate disposal at sea.	These conventions relate to all project activities that take place in Suriname river and at sea.	Environmental & Social Management and Monitoring Plan (ESMP), Staatsolie waste management GFI's, Contractor vessels/rig's waste management plans, ERP and OSRP.
MARPOL 73/78	Annex I: Accidental oil discharge and drainage water • Shipboard oil pollution emergency plan (SOPEP) is required • Oil content less than 15 ppm	Transportation of rig and movement of vessels during project duration	Environmental & Social Management and Monitoring Plan (ESMP), Staatsolie waste management GFI's, Contractor vessels/rig's waste management plans, ERP and OSRP
	Annex II: Bulk Chemicals Prohibits the discharge of noxious liquid substances, pollution hazard substances, and associated tank washings	All project activities	Staatsolie waste management GFI's, Contractor vessels/rig's waste management plans
	Annex IV: Sewage discharge Comminuted & disinfected sewage using approved system	Sanitary and organic waste collection, storage and treatment	• Treatment using the Omnipure^{TM} 12 MC Unit • No discharge within 5.6 km from the coastline of treated sewage • Residual chlorine of 2 mg/l • No floating solids

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
			Environmental & Social Management and Monitoring Plan (ESMP), Staatsolie waste management GFI's, Contractor vessels/rig's waste management plans
	Annex V: Garbage No disposal of plastics or floating packaging material; food waste and other garbage items comminuted to > 25 mm for disposal at >5.6 km from nearest land	Entire project duration on-board the rig and all support vessels	Staatsolie waste management GFI's, Contractor vessels/rig's waste management plans
	Annex VI: Air Pollutant: Ozone depleting substances are prohibited; sets limits on emissions of nitrogen oxides from diesel engines; prohibits the incineration of certain products on-board vessels	Entire project duration on-board the rig and all support vessels	Certified diesel engines and use of diesel with sulphur content <4.5%
UNCBD and Western Hemisphere Convention	Protection of flora and fauna endangered species through hunting and fishing permits, prevents overexploitation, regulates trade/import/export.	These instruments relate to all project activities considering they take place in areas of fisheries, and Nearshore marine mammals (close to environmentally sensitive areas such as estuarine zones, mudflats and mangrove ecosystems).	Preventive and corrective measures addressing these instruments, are in place by means of the ESMP; Health, Safety, Environment and Community training and awareness sessions (HSEC induction) for all project personnel including contractors and visitors. These sessions shall be provided prior to project startup and at the at one of 6 potential ports/shorebases prior to embarking (crew change).
Wetlands – Ramsar (Coppename Monding protected area CMNR)	Protect wetlands such as CMNR	Project activities take place 0.5 – 11 kilometers from the coast. Project routes are in the nearshore area for movement of personnel and materials to and from the surroundings of the projected exploration well locations.	Preventive measures are in place through the EMMP, ERP, OSRP, and relevant HSE procedures in line with MARPOL (73/78) and other international requirements. Based on oil spill modeling (which formed a part of the ESIA and provided the necessary input to the OSRP), protective barriers will be in place around the drill rig platform. Rig and

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
			vessels will be equipped with the necessary spill kits.
Vienna Convention and Montreal Protocol (protection of the Ozone layer)	Protect the Ozone layer	During all Project activities, protection of the Ozone layer is relevant. However, there are no major Ozone depleting substances identified other than uncontrolled or untreated waste disposal, and open burning (e.g. during fire or major Tier 3 oil spill response).	This ESIA, ESMMP, OSRP.
Other Standards and Guidelines: IFC EHS Guidelines for Offshore Oil and Gas Development	Technical reference document relevant to the exploration drilling activities etc.	Relevant to all project activities, as best practice.	Relevant items from IFC have been incorporated through the ESIA review process, into key documents such as the OSRP.
United States Environmental Protection Agency (USEPA) - National Ambient Air Quality Standards (NAAQS)	Guideline for air quality standards for ambient air quality	Gaseous emissions	
Trinidad & Tobago Air Pollution Rules, 2014		Air quality standards for parameters not covered by NAAQS	
Trinidad & Tobago Water Pollution Rules, 2001, Schedule II (Marine offshore)	Effluent discharge limits for: • COD – 250 mg/l • pH – 6-9 • ammoniacal nitrogen – 10 mg/l • total phosphorus – 5 mg/l • residual chlorine - 2 mg/l	Treated sewage for the duration of the Project	Staatsolie's EMMP, ERP, OSRP, and relevant procedures in line with MARPOL (73/78) and other international requirements
IMO Annex A of Resolution MEPC 2(6) 1976	Effluent discharge limits for: • BOD_5 – 50 mg/l • TSS – 100 mg/l • Faecal coliforms – 250 counts/100 ml		
USEPA 2007 Effluent Limits for Gulf of Mexico (GOM)	Discharge of treated sewage with no floating solids		
International Association of Drilling Contractors	HSE Guidelines for Mobile Offshore Drilling Rigs such as MODU Code and MODU HSE Cases	Rig selection based on the design, construction and other safety measures for mobile drilling unit for the duration of the project	Staatsolie and Contractors' HSE, Risk Management and related Policies and HSE management systems. Contractual agreements. Rig design

Relevant Law or Regulation	Requirement	Related Project Activities	Policy, Procedure or Management Plan through which the requirement is addressed
Bureau of Safety and Environmental Enforcement (BSEE) – United States Department of the Interior (DOI)	Responsible for promoting safety, protecting the environment, and conserving resources offshore of the U.S. Outer Continental Shelf - Gulf of Mexico Region. Notice to Lessees and Operators (NTL) Of Federal Oil and Gas Leases in the Outer Continental Shelf (OCS), Gulf of Mexico OCS Region (GOMR March 2013).	Movement of rig off location and the potential impacts and damages to other facilities, vessels and pipelines	by expert engineers. Certification of rig by internationally renowned institution. Geotechnical and geophysical surveys to inform proposed locations for rig placement.

3 PROJECT DESCRIPTION

This Chapter presents a description of the proposed Project, named the Nearshore Exploration Drilling Project 2019 and is divided into the following components:

- Objective and Rationale: This Section presents the purpose and justification for the Project
- Location and Layout: This Section presents the Project site and associated plans
- Key Elements of the Project: This Section provides geology information and drilling history of the Blocks
- Project Overview: This Section presents all aspects of the proposed Project, inclusive of descriptions of all activities (pre drilling, drilling and post drilling), timeline, inputs, logistics and wastes associated with the Project.

3.1 Objective and Rationale

Staatsolie Maatschappij Suriname (Staatsolie) of Suriname has recently acquired 2D seismic data and are proposing to drill a maximum of 10 wells in the Nearshore Blocks A-D.

The rationale of the Project is to explore hydrocarbons within Blocks A-D; and moreover attempt to identify and quantify the potential reserves that currently exist within the Blocks. The objective of the proposed program is to drill a maximum of 10 wells to establish the presence of hydrocarbon reserves which can be developed commercially.

This section provides specific details of the proposed Nearshore Exploration Drilling Project 2019, which can be used to understand the potential impacts and the risks associated with this Project. The company is committed to ensuring that all health, safety and environmental matters take precedence over operational matters and would use proactive approaches to ensure that the safety of all persons (directly employed, subcontracted, and the community in which they are active), and the protection of the environment are maintained.

Furthermore, the company will adhere to all national regulations, internationally accepted industry standards and World Bank Guidelines for drilling activities that are considered to be feasible as well as cost-effective.

3.2 Project Location and Layout

The Nearshore Blocks A-D are located just north of the coastline of Suriname and is bordered to the east by French Guiana and to the west by British

Guyana. To the north, Blocks A-D are bordered by other open shallow oil and gas Blocks and the total acreage of Blocks A-D is ~11,250.73 km^2.

Overall, Blocks A-D lie within the nearshore marine area with water depths ranging from 0-30 m (98 ft) as seen in Figure 3-1 below.

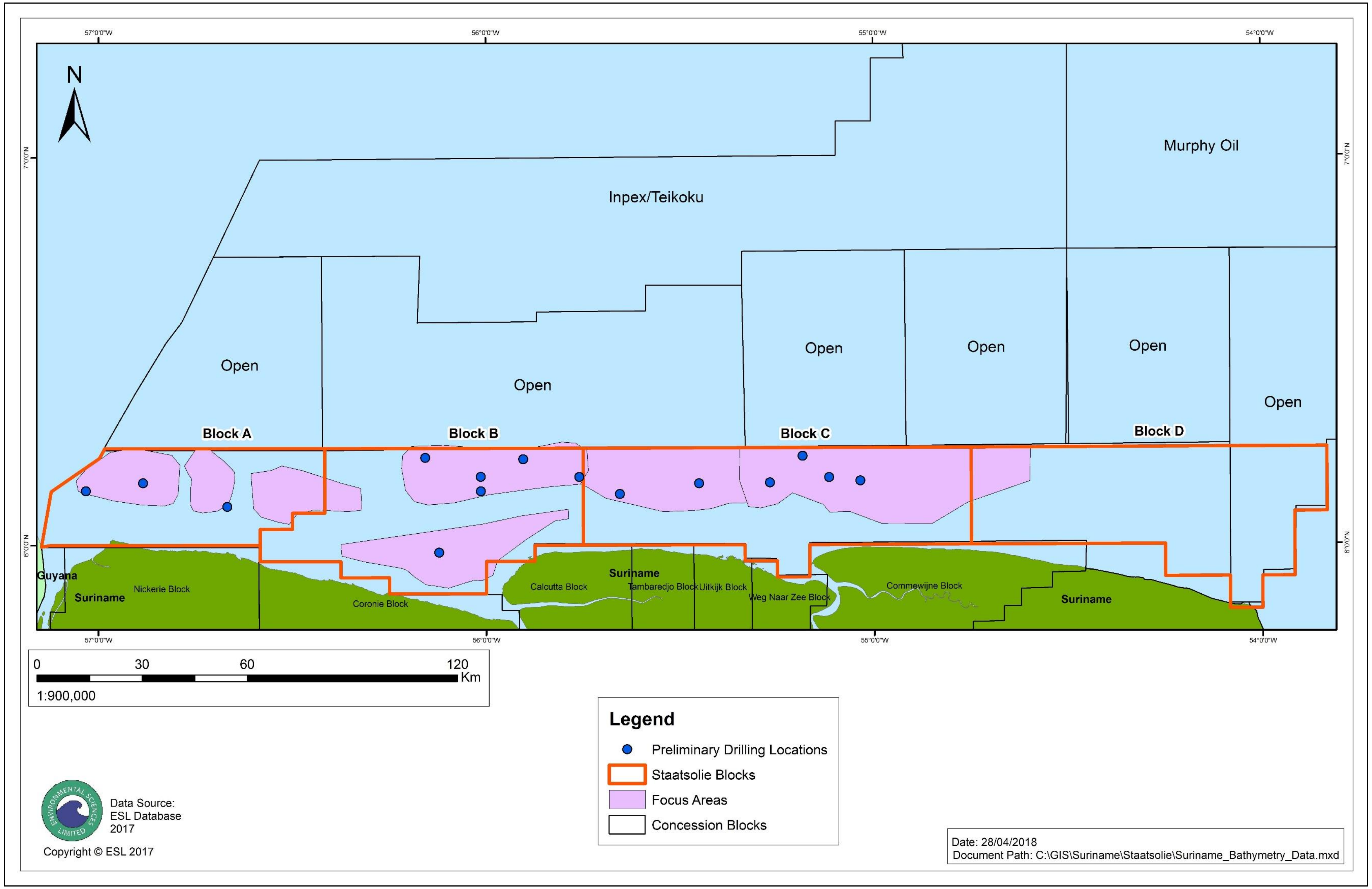

Figure 3-1: Overall Field Layout for Nearshore Blocks A-D and Preliminary Well Locations

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Blocks A-D are delineated by the following coordinates (UTM WGS84 21N) as shown in Table 3-1 below.

Table 3-1: Nearshore Blocks A-D Coordinates

Block	Point	WGS84_UTM Zone 21			
		Latitude (N)	Longitude (W)	Northing	Easting
A	1	6°15'00"	56°25'00"	690876	564528.2
	2	6°05'00"	56°25'00"	672451.3	564548.4
	3	6°05'00"	56°30'00"	672442	555326.9
	4	6°02'30"	56°30'00"	667835.9	555331.2
	5	6°02'30"	56°35'00"	667828.1	546109.2
	6	6°00'00"	56°35'00"	663222.1	546112.7
	7	6°00'00"	57°07'30"	663206.1	486166.3
	8	5°59'46.206"	57°08'50.482"	662783.2	483692.1
	9	6°08'19.767"	57°07'20.009"	678552.1	486476.9
	10	6°13'28.451"	56°59'52.262"	688029.1	500237.8
	11	6°15'00"	56°59'03.15"	690840.3	501746.8
B	1	6°15'00"	55°45'00"	691004.5	638283.2
	2	6°00'00"	55°45'00"	663362.3	638347.6
	3	6°00'00"	55°52'30"	663332.4	624511
	4	5°57'30"	55°52'30"	658725.6	624520.4
	5	5°57'30"	56°00'00"	658698.9	610683.3
	6	5°52'30"	56°00'00"	649485.7	610699.9
	7	5°52'30"	56°15'00"	649442.4	583023.1
	8	5°55'00"	56°15'00"	654048.7	583016.9
	9	5°55'00"	56°22'30"	654031.6	569180.2
	10	5°57'30"	56°22'30"	658637.8	569175
	11	5°57'30"	56°35'00"	658616.1	546116.2
	12	6°02'30"	56°35'00"	667828.1	546109.2
	13	6°02'30"	56°30'00"	667835.9	555331.2
	14	6°05'00"	56°30'00"	672442	555326.9
	15	6°05'00"	56°25'00"	672451.3	564548.4
	16	6°15'00"	56°25'00"	690876.0	564528.2
C	1	6°15'00"	54°45'00"	691372.6	748953.3
	2	6°00'00"	54°45'00"	663716	749069.3
	3	6°00'00"	55°10'00"	663544	702928.1
	4	5°55'00"	55°10'00"	654327.5	702958.7
	5	5°55'00"	55°15'00"	654297.8	693730.4
	6	5°57'30"	55°15'00"	658905.8	693715.8
	7	5°57'30"	55°20'00"	658877.2	684488.6
	8	6°00'00"	55°20'00"	663485.1	684474.7

Block	Point	WGS84_UTM Zone 21			
		Latitude (N)	Longitude (W)	Northing	Easting
	9	6°00'00"	55°45'00"	663362.3	638347.6
	10	6°15'00"	55°45'00"	691004.5	638283.2
D	1	6°15'00"	53°50'00"	691895.4	850465.7
	2	6°05'00"	53°50'00"	673443.9	850575.3
	3	6°05'00"	53°55'00"	673390.5	841340.8
	4	5°55'00"	53°55'00"	654940.5	841444.6
	5	5°55'00"	54°00'00"	654889.9	832208
	6	5°50'00"	54°00'00"	645665.6	832257.5
	7	5°50'00"	54°05'00"	645617.1	823020.1
	8	5°55'00"	54°05'00"	654840.7	822972
	9	5°55'00"	54°15'00"	654746.4	804502.1
	10	6°00'00"	54°15'00"	663968.7	804456.1
	11	6°00'00"	54°45'00"	663716	749069.3
	12	6°15'00"	54°45'00"	691372.6	748953.3

The company intends to drill a maximum of 10 exploration wells, however the locations are still to be confirmed by Staatsolie. Figure 3-1 presents 15 preliminary well locations (with coordinates listed below in Table 3-2) from which the 10 wells can be drilled, however these locations are subject to change based on more refined geological evaluations that are ongoing and the final well locations could be drilled anywhere within the focus areas of Blocks A-C. The drilling of these wells are expected to provide information on stratigraphy, reservoir distribution, size and possibly productivity. The target will be the Paleocene (2,000 - 3,000 ft) and Cretaceous (4,000 – 8,500 ft) sections.

Table 3-2: Coordinates of the Proposed Well Locations

No.	WGS84 UTM 21N	
	Easting - X (m)	Northing -Y (m)
1	536719	674249
2	597188	661233
3	609076	678695
4	512697	680984
5	496400	678717
6	593190	688221
7	700885	688861
8	717369	681838
9	621190	687860
10	637180	682791
11	691594	681266

No.	WGS84 UTM 21N	
	Easting - X (m)	Northing -Y (m)
12	708459	682785
13	609068	682830
14	648757	677954
15	671342	681001

This Project will be approximately 9 months of exploration drilling only. In cases where oil is found, the well will be plugged and abandoned (no well testing or production are planned for this phase, so no pumping of oil or flaring will occur). The follow-up programs will be defined based on the results of the Nearshore Exploration Drilling Project 2019.

3.3 Block A-D History

In the late 1970’s, ELF Petroleum performed a seismic survey in the shallow waters off the coast of Suriname. Gulf acquired additional seismic data in the early 1980’s and drilled 9 wells in this area. Three of these wells, located in the deeper part of the near shore area (I/23-1x, B/34-1x and L/10-1x), penetrated the entire Cretaceous section in which several oil shows were recorded. The other 5 wells were aimed at the Paleocene interval to investigate possible Tambaredjo Oil Field equivalent reservoir settings in the near offshore. Three wells situated in Block C, encountered thin oil horizons in Paleocene reservoir sands, but due to a limited drilling outfit these intervals could not be tested.

In 1986, Austra-Tex Oil Company drilled 5 wells, including 3 appraisal wells, to follow-up the oil discoveries of Gulf in the Paleocene sediments. In one well, a production test was performed which also gave valuable information on the oil properties.

In 1993, Pecten signed a Service and Production Sharing Agreement for a large offshore area north of Tambaredjo. Due to re-organization following the take-over by Shell, further exploration was stopped and the area was relinquished in 1995. However, Shell carried out an analysis of aerial photographs to identify oil slicks and found one overlying the L/7-1 and L/7-3 discovery.

CMS Nomeco performed an evaluation of the near shore area in 1996. They reprocessed and re-interpreted existing seismic lines and identified several structural leads. Infoterra applied side looking radar to identify micro oil seeps and found the highest concentrations in the entire Guiana Basin (including the parts situated in Venezuela, Guyana and French Guiana) within Block C.

In 2001, an Airborne Magnetic Survey was executed in the area and in 2012 a 2D/3D seismic survey was conducted in Block C using OBC technology. A 2D nearshore seismic survey was also done in 2014 within Blocks A, B and C using streamer technology and in 2015, 5 exploration wells were drilled in Block C and 4 of them yielded oil shows. Consequently, Staatsolie now intends to drill up to 10 new exploration/appraisal wells, within Blocks A-C to further evaluate the oil prospects within the nearshore area.

3.4 Process Characterisation

The ESIA has been commissioned as part of the overall planning and approval process required for environmental clearance prior to the onset of the Project. Staatsolie will also use the findings and recommendations of the ESIA in the formulation of environmental management systems for the proposed Project. It is necessary to have an appreciation of the Project’s operational aspects and the potential impacts that may arise at the various stages of the Project cycle (implementation, operations, maintenance and decommissioning), to ensure avoidance of and preparedness to respond in case of unplanned events such as accidents and incidents.

This Chapter provides specific details of the proposed drilling Project which will inform the identification and analysis of the potential impacts that may arise from the related project activities, such as the processes, operations and components that define the “environmental aspects”.

3.5 Project Overview

3.5.1 Project Phasing and Scheduling

The proposed Project will involve the following 3 phases that are defined more in Table 3-3 below with the estimated timelines:

- Pre-Drilling
- Drilling
- Post Drilling

Table 3-3: Expected Dates of Completion of Project Milestones

Phase	Activity	Duration (days)	Total Duration (days)	Total Duration of Phase (days)	Time Period
NIMOS Approval	NIMOS review and approval of the ESIA	60	60	60	May-Aug 2018
	Transportation of the Jack-up	2	2	38.5	April 2019

Phase	Activity	Duration (days)	Total Duration (days)	Total Duration of Phase (days)	Time Period
Pre[3] drilling	rig from the Customs Clearance point (Nearshore) to the first drilling location				
	Movement of the rig to each well-site	2 (per well, for 9 wells)	18		Apr-Dec 2019
	Positioning of the Jack-up Rig for drilling at the well-site	0.25 (per well)	2.5		
	Rig crew and materials transfer	16	16		
Drilling	Placement of the conductor pipe, drilling and casing placement at 7 of 10 well-sites (shallow)	18 (per well)	126	207	Apr-Dec 2019
	Placement of the conductor pipe, drilling and casing placement at 3 of 10 well-sites (deep)	27 (per well)	81		
Post Drilling	Well abandonment at each well, consisting of cement plugs and installation of surface well-head	1 (per well)	10	29.5	Apr-Dec 2019

[3] Site preparation surveys such as geotechnical, geophysical and bathymetry will occur from July-September 2018 and are not included as part of the scope of this ESIA as prior approval from NIMOS is not necessary.

Phase	Activity	Duration (days)	Total Duration (days)	Total Duration of Phase (days)	Time Period
Post Drilling	Rig removal at each well-site	0.25 (per well)	2.5		
	Rig crew and materials transfer	15	15		
	Final demobilisation of the rig from the 10th well-site to the Customs Clearance Point (Nearshore)	2	2		Dec 2019
Total Duration Across All Phases (April 1st – December 31st, 2019)				**275**	

3.5.2 Pre Drilling

This will involve the following at each well location:

- Mobilisation and transportation of the Jack-up rig to the well-sites
- Positioning of the rig and rig up procedures
- Mobilisation and transportation of personnel, materials and equipment to the drilling site.

Three anchor handling and support tug vessels (AHSTVs) will tow the rig to the 1st well-site location after clearing customs. Maritime notices will be placed in advance, informing fishermen and other stakeholders of the rig move, so that priority can be given to the slow moving/towed rig. When the rig arrives at the well location, the AHSTVs and the rig will anchor for stability at the final well-site coordinate[4]. The rig will be winched in accordance with Rig Contractor's instructions to within accepted surface tolerance. The coordinates will be verified and de-ballasting/ballasting of the mat and jacking of the legs will occur.

Once the rig is in position and fully stabilised, the 3 AHSTVs will leave and the chase vessel will be stationed at the rig to maintain the 500 m exclusion

[4] *This is based on results of the geotechnical, geophysical and bathymetry survey at the well-site location for best location of mat placement*

zone[5] around the rig. Three platform supply vessels (PSVs) and a crew vessel will transport materials and crew from 3 optional shorebases/ports (Vabi, Kuldipsingh and/or Integra Marine at Smalkalden) to the rig for commencement of the drilling process.

A similar process will occur at the subsequent drilling locations during the pre drilling phase, as described above. The only difference being the location of the shorebase/port (Nieuw Nickerie) used for the last 2 wells that will be drilled within Block A and crew transfer will also potentially occur from the Boskamp Port.

The company intends to follow the general rig-up procedures outlined below:

- Unload equipment and position at or near the exact location that it will occupy during operations
- Assemble the substructure, pin together, level and make ready for other rig components on the floor
- Equip the Conductor (welding on a drilling nipple to the conductor pipe and attaching a flow line)
- Install stairways and guardrails to allow access to the rig floor
- Set the drawworks in place and secure to the substructure
- Set the engines in place and connect the compound and associated equipment to the drawworks
- Raise the bottom of the mast to the rig floor and pin in place
- Raise the crown section into place on the derrick stand
- Raise the "A-legs" and pin into place
- Pin the monkeyboard in place on the mast and lay out all lines and cables to prevent tangling when the mast is raised
- Conduct a thorough inspection of the mast before raising the mast/derrick
- Start the engines and spool the drilling line onto the drawworks drum
- Raise the mast and pin
- Set the remaining floor equipment into place
- Install a derrick emergency escape device on the mast
- Install handrails, guardrails, stairways, walkways, and ladders where they are needed for safety and access
- Install the power system (this is usually done simultaneously with setting up the rig floor, because power is needed to operate the equipment)
- Connect all power cords, belts, and chains to the machinery from their associated power source
- Simultaneously, set up the fuel lines and tanks
- Start the engines
- Rig up the circulating system

[5] *Maritime notices will be placed prior to the rig positioning advising of the exclusion zone*

- Connect the mud lines and set the electric cords
- Set all remaining drilling and auxiliary equipment into place and install where needed
- Install the V-door and pipe racks and set the pipe and drill collars on the racks
- Perform a complete inspection of the rig before operating

3.5.3 Drilling Operations

The drilling phase of the Project will involve the drilling and well evaluation at the proposed exploration sites using the proposed drilling rig. All rig operations (start-up, drilling and rig-down) will be performed in accordance with local regulations and internationally acceptable (IADC and API) standards.

During the drilling process, Staatsolie will use appropriate control systems to direct the flow of materials and control well pressures to mitigate or eliminate the potential impacts of drill cuttings, mud and other residual fluid effluents on the environment. A "closed-loop" system will be implemented for the management of drilling fluids. In this system, drilling mud, fluid inputs and processes are dependent on the formation encountered.

3.5.3.1 Drilling Rig

A mat-type jack-up drilling rig with similar specifications outlined in Table 3-4 below will be used for this Project. This rig is shown in Figure 3-2.

Table 3-4: Specifications of Preferred Rig

Description	Specifications
Drilling Vessel Description	Mobile Offshore Jack-up Drilling Unit Platform (MODU)
	Constructed by Baker Marine Services; 50 series Design or of equivalent rig construction company and design.
	Columns: 4 x 42" x 160 ft long.
	Jacking System: Baker Electro-Hydraulic rack and pinion
	Mat: 108 ft (length) x 118 ft (width) x 6 ft (depth)
	Normal Towing Draft: 10 ft
Design Operating Conditions	Maximum Water Depth: 110 ft

Description	Specifications
	Minimum Water Depth 17 ft.
	Drilling Depth Capacity 12,000 ft. (with 5” 19.5# drill pipe)
Maximum Operating Environmental Conditions	***Normal Drilling:***
	- Variable Deck Loads 2209 kips
	- Drilling Load 500 kips
	- Wind Speed 70 knots
	- Wave Height 18 ft.
	Hurricane Survival:
	Variable Load 958 kips
	Wind Speed 100 knots
	Wave Height 27 ft.
Rig Storage Capacities	Pipe Racks 1,600 sq. ft.
	Pipe Racks (P/S) 200 Tons
	Weight Material & Cement:
	- Bulk Barite 89,000 lbs
	- Bulk Cement 750 cu ft
	- Sack Storage 500 sacks
	Liquids:
	- Drilling Mud 450 bbls.
	- Drill Water 338 bbls.
	- Diesel Fuel 338 bbls.
	- Potable Water 338 bbls.
Accessory Equipment	Sewage: One (1) OMNI Pure 12 MC sewage treatment

Figure 3-2: Photo of the Typical Jack-up Drilling Rig

3.5.3.2 Drilling Equipment and Related Infrastructure

A list of the drilling equipment and related infrastructure required during the different phases of the drilling Project is provided below in Table 3-5. The company will ensure that all equipment purchased or rented are best suited to the type of work being carried out and are used in accordance with manufacturer's specifications. A detailed inspection would be carried out prior to the start of the operations on all equipment and materials required. Any defective equipment will not be used and will be removed from the operation site.

The drilling rig assembly is a mechanical system consisting of components which function as a physical support for the drilling strings, bits and casing. Other process related functions include fluid chemicals and safety systems (solids control, gas removal and blow-out prevention equipment).

Table 3-5: List of Drilling Equipment and Related Infrastructure

Equipment & Infrastructure	
Hoppers	Drilling Rig
Mixers	Drill Mud Pump
Filtration Unit	Drilling Fluid Tanks
Pressure Gauges	Drill Floor
Diesel Engine driven electric generators – for running hoist	Driller's Instruments
Pumps for pumping mud	Cat Walk
Raw water pumps	Sewage Treatment Unit
Diesel generator – other utilities on rig	Drill Pipe Racks
Sea water maker	Derrick
Potable water pressure set	Fuel transfer pump
Diesel driven fire water pump	Stand Pipe
Blowers (blowing cement into hoppers)	Rotary Hose
Storage bins (cement)	Choke Manifold
Diesel storage	Blow Out Preventor (B.O.P.) Stack
Potable water storage	Divertor
Mud storage tanks	Flow Line
Sump pumps (wash down platform)	Degassers
Drill water pumps	Solids Control Equipment
Separation facilities	Centrifuge
Anchors	Support vessels
Rotary Table	Travelling Block
Top Drive	Annular Preventer
Accumulator	Cranes
Propulsion equipment	Helipad
Garbage grinder	

3.5.3.3 Drilling Programme

Seven of the 10 wells will be shallow, while the other 3 will be deeper wells. The well programme with the representative well-bore schematic (illustration of typical configuration of design of the well) for the shallow (Figure 3-3) and deep (Figure 3-4) wells are provided below:

Option 1: Wells with depth of 2,400-4,000 ft (shallow wells):

- Prepare and install Oil Spill Booms as per OSRP. (Booming approx. covering Rig floor area and deflection booming downstream).
- If necessary, Jack-up Rig to an air gap suitable for drilling operations. Rig up (R/U) for drilling operations, prepare fluids, Pick up (P/U) Conductor/Drill Pipe (DP), etc.
- P/U and run initial casing joints until penetration into seabed is no more. Ensure that conductor is vertical.
- P/U Hammer for 20/30” conductor and begin pile driving operations. Ensure that the conductors are piled vertical on every joint. Pile to refusal approx. ± 425 ft measured depth below rotary table (MD-BRT).
- Cut and secure 20/30” conductor at Texas Deck and nipple up diverter and bell nipple.
- Rig Down (R/D) conductor hammer equipment.
- P/U 16” Clean-out Bottom Hole Assemble (BHA). Spud well and clean out conductor to ± 425 ft measured depth (MD) with seawater. Pull out of Hole (POOH).
- Condition Mud as per program.
- P/U 12 1/4” BHA (same), Run in Hole (RIH) & Test Diverter.
- Drill 12 1/4” hole to ± 1200 ft MD-BRT with 9.1 pounds per gallon (ppg) Water Based Mud (WBM). POOH.
- R/U wire-line equipment. Run wire-line logs as per program.
- R/U and run 9 5/8” surface casing to ± 1190 ft MD-BRT.
- Cement 9 5/8” as per detailed cementing program. Flush annulus to approximately 40 ft below seabed.
- Nipple Down (N/D) diverter. Install riser and 13 5/8” Blow Out Preventer (BOP) stack. Pressure Test BOP stack.
- P/U 8 1/2” BHA and RIH to top of casing (TOC).
- Drill out shoe track & clean out rat-hole. Drill 10ft new formation. Circulate hole clean.
- Pull back into shoe and perform leak-off test (LOT).
- Drill 8 1/2” hole to ± 2400-4000 ft MD-BRT with 9.5ppg WBM.
- POOH and R/U wire-line equipment. Run wire-line logs as per program.
- POOH and R/D logging equipment.
- Prepare for Plug & Abandonment Program.

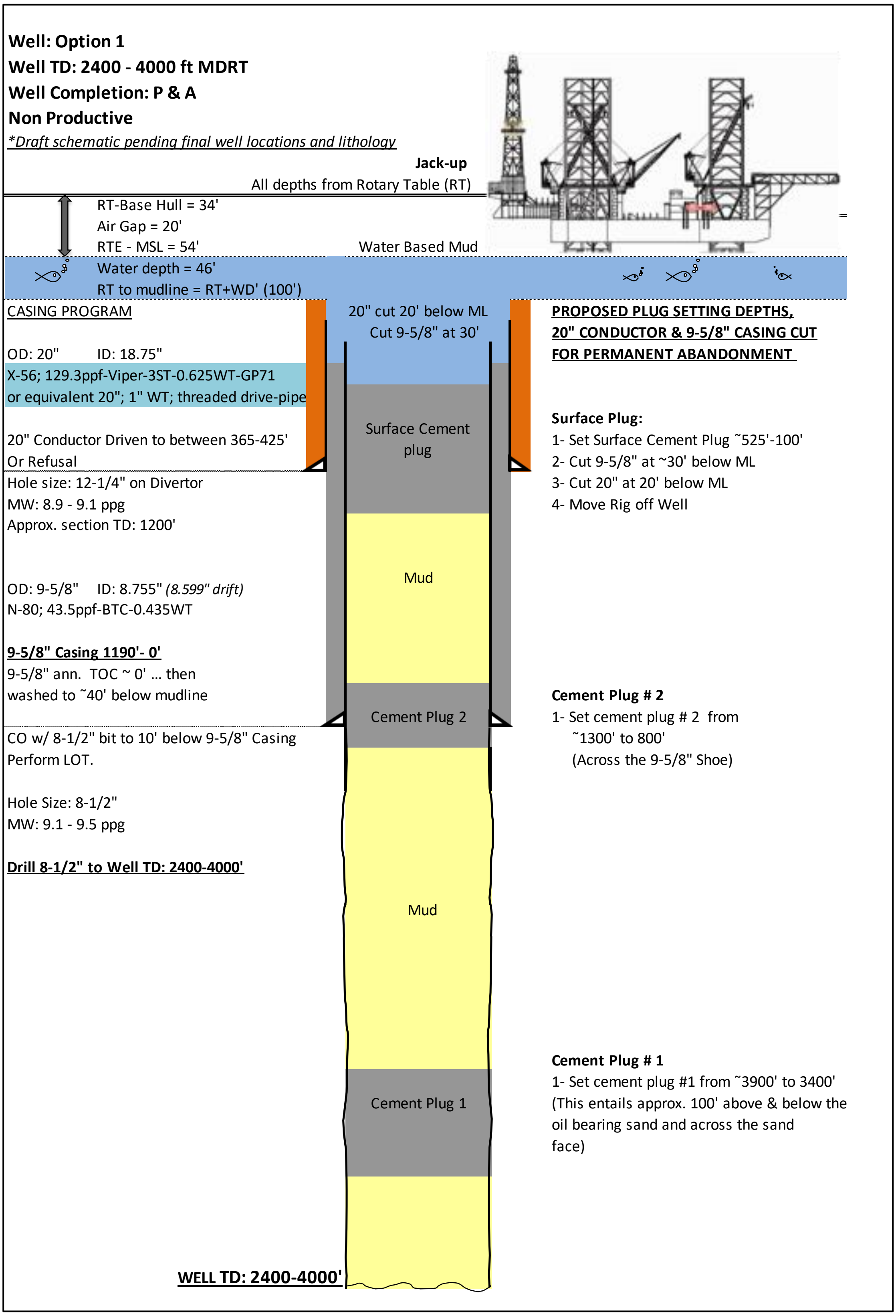

Figure 3-3: Nearshore Well-bore Design – Option 1 (2,400 – 4,000 ft)

Option 2: Wells with depth of 5,700-8,900 ft (deeper wells):

- Prepare and install Oil Spill Booms as per OSRP. (Booming approx. covering Rig floor area and deflection booming downstream).
- If necessary, Jack-up Rig to an air gap suitable for drilling operations. R/U for drilling operations, prepare fluids, P/U Conductor/DP, etc.
- P/U and run initial casing joints until penetration into seabed is no more. Ensure that conductor is vertical.
- P/U Hammer for 20/30" conductor and begin pile driving operations. Ensure that the conductors are piled vertical on every joint. Pile to refusal approx. ± 425 ft MD-BRT.
- Cut and secure 20/30" conductor at Texas Deck and nipple up diverter and bell nipple.
- R/D conductor hammer equipment.
- P/U 16" Drill out BHA. Spud well and clean out conductor to ± 425 ft MD with seawater. POOH.
- Condition Mud as per program.
- P/U 16" BHA (same), RIH & Test Diverter.
- Drill 16" hole to ± 3,000 ft MD-BRT with 9.3ppg WBM. POOH.
- R/U wire-line equipment. Run wire-line logs as per program.
- R/U and run 13 3/8" surface casing to ± 2,990 ft MD-BRT.
- Cement 13 3/8" as per detailed cementing program. Flush annulus to approximately 30 ft below seabed.
- N/D diverter. Install LP riser and 13 5/8" BOP stack. Pressure Test BOP stack.
- P/U 12 1/4" BHA and RIH to TOC.
- Drill out shoe track & clean out rat-hole. Drill 10ft new formation. Circulate hole clean.
- Pull back into shoe and perform LOT test.
- Drill 12 1/4" hole to ± 5,700-8,900 ft MD-BRT with 9.6ppg WBM.
- Contingency
- If any downhole challenges are encountered, control well as necessary & Run wireline logs if possible.
- R/U and run 9 5/8" surface casing to ± 5,990 ft MD-BRT.
- Cement 9 5/8" as per detailed cementing program. Flush annulus to approximately 45 ft below seabed.
- P/U 8 1/2" BHA and RIH to TOC.
- Drill 8 1/2" hole to ± 8,900 ft MD-BRT with 10.5ppg WBM.
- POOH and R/U wire-line equipment. Run wire-line logs as per program.
- POOH and R/D logging equipment.
- Prepare for Plug & Abandonment Program.

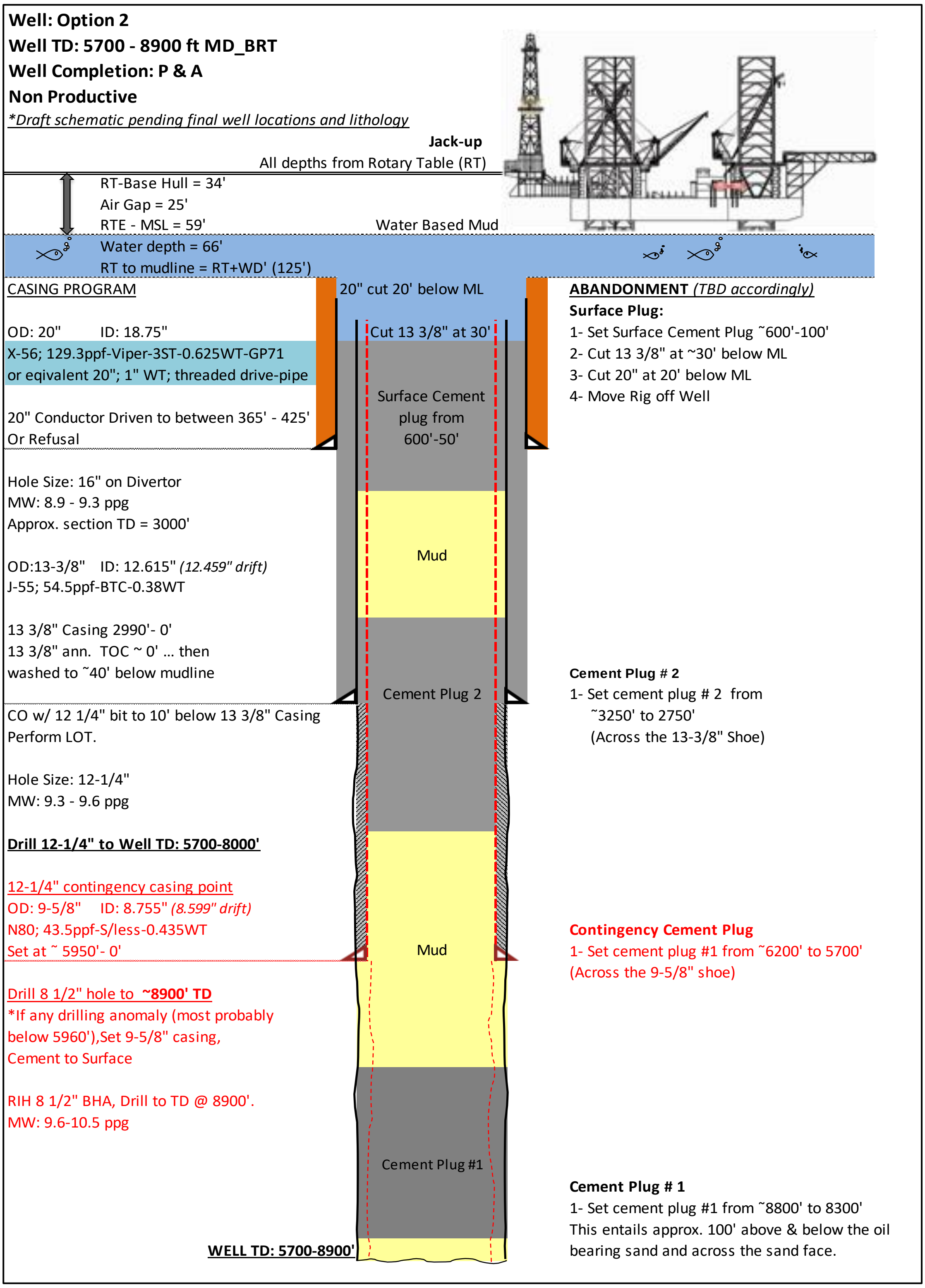

Figure 3-4: Nearshore Well-bore Design – Option 2 (5,700 – 8,900 ft)

It is important to note that the final program and section depths will be confirmed upon receipt of actual well locations and prognosed lithology. Table 3-6 provides specifics of the casing program for drilling exploration wells.

Table 3-6: Casing Program Well Design

Hole Size	Casing Depth ft RKB TVD*	Casing Size	Casing Description	Mud Type and Weight (ppg)
Conductor	425 ft	20/30"	Conductor	N/A
16"	min 2,000ft / max 3,000 ft	13-3/8"	Surface	WBM: 9.1 – 9.3
12 ¼"	min 2,500ft / max 5,700 ft	Open hole / 9 5/8"	Open Hole / Intermediate	WBM: 9.1 – 9.5
8 ½"	open hole – min 6,000 ft / max 8,500 ft	N/Aa	Open hole	WBM: 9.5 – 10.5

**Denotes: Rig Kelly Bushing Total Vertical Depth*

3.5.3.4 Well Testing and Completion

These exploration wells will not be tested or completed, and therefore very limited oil is expected for this project, if any at all. This also means that there will be no flaring for this Project.

3.5.3.5 Design and Normal Operating Capacity of BOPs

Surface casing is usually installed to protect shallow groundwater or aquifers from contamination during the drilling process and is usually incorporated as part of the casing design procedure (based on the pore pressure data). Conductor casing would be driven (through piling) to approximately 130 m (425 ft) and this would serve as the anchor for the BOP system. This process will take approximately 10 hours per well-site.

In case of primary control loss resulting from a sudden increase of formation pressure or lost circulation, it becomes necessary to seal off the well by some other means to prevent an uncontrollable flow, or blowout, of formation fluids as per the established well control procedures. The equipment that performs this secondary control function is the BOP. BOPs are essentially large valves on the surface of the well that are used to seal, control and monitor the well and quickly shut off the well to prevent a blowout from occurring. BOPs are mounted directly to the wellhead in combinations called the BOP stack. Such a stack will normally contain several of the 2 basic BOP types: ram and annular.

Sealing elements, or rams are located in the BOP body on opposite sides of the well-bore (Figure 3-5). Opening and closing is performed with hydraulic cylinders attached to both sides of the BOP body. When open, the rams will leave an unobstructed passage through the well-bore. When closed depending on the type of ram selected they will seal around the drill pipe, seal off the open hole, or in emergencies shear the drill pipe and seal off the hole.

The main feature of the annular preventer (Figure 3-5), is the capability to close and seal on almost any size tools in the borehole drill pipe, tool joints, drill collars, kellys, and casing, within most of its range. It also has the capability to seal off the open hole. The heart of the annular preventer is the sealing element. When the closing mechanism is actuated, hydraulic pressure is applied to the piston, causing it to move upward and force the sealing element to extend into the well-bore around the drill string. Steel segments molded into the element partially close over the rubber to prevent excessive extrusion when sealing under high pressure. The designed operating capacity for the BOP is 5,000 pounds per square inch or psi (see Figure 3-5 below).

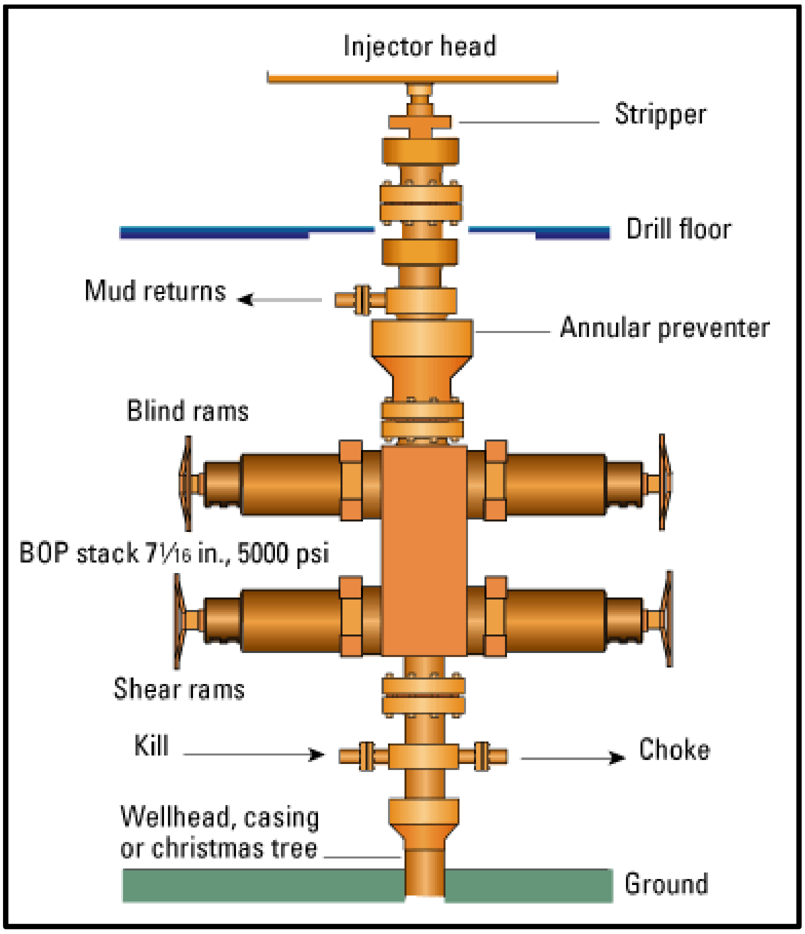

Figure 3-5: Blow-Out Preventer

3.5.4 Post Drilling

3.5.4.1 Well Abandonment

The exploration wells will be plugged and abandoned on completion of the drilling phase for this Project. The guidelines prescribed by NIMOS will be followed and supported by the company's well abandonment procedure to isolate and seal off the well-bore and prevent subsequent environmental degradation. Table 3-7 outlines the general well abandonment procedure. Figure 3-3 and Figure 3-4 illustrate the projected well abandonment procedure to be employed for each well.

Table 3-7: General Well Abandonment Procedure

No.	Steps
1	Hold a pre-job safety meeting with the on-tour crew and service personnel.
2	Rig up 2-7/8" tubing handling equipment.
3	Pick up cementing string which consists of the 2-7/8" mule shoe joint and 23 joints of 2-7/8" drill pipe.
4	Run in hole with cementing string, 2-7/8" X-over to 5" drill pipe to TD.
5	Circulate and condition mud to ensure density is consistent in well-bore in preparation for cementing operations. Reciprocate the string during circulation and record pressure trend throughout.
6	Pick up cement stand and space out to place mule shoe @ 100 ft from bottom of first oil show zone.
7	Rig up and pressure test surface lines from cement unit to 2,000 psi
8	Set First Cement Plug: (*depths to be confirmed as per final wireline log)
a	Displace the cement and spacer with mud from the active system using the cement pump.
b	Close Lo-Torq valve. Disconnect cement hose from cement stand, pull out of hole slowly and rack back cement stand. Slowly pull out to one stand (60') above top of balanced cement plug.
c	Pump down foam ball, circulate clean, monitoring for cement / spacer returns at bottoms up and be prepared to divert to avoid contamination of the system
9	Set Second Cement Plug: (*depths to be confirmed as per final wireline log)
a	Displace the cement and spacer with mud from the active system using the cement pump.
b	Close Lo-Torq valve. Disconnect cement hose from cement stand, pull out of hole slowly and rack back cement stand. Slowly pull out to one stand (60') above top of balanced cement plug

No.	Steps
c	Pump down foam ball, circulate clean, monitoring for cement / spacer returns at bottoms up and be prepared to divert to avoid contamination of the system.
10	Repeat as necessary for oil bearing zones.
11	Set Surface Plug: Place the mule shoe at depth to set a 200ft balanced cement plug across the conductor shoe to approximately 70ft from MudLine.
12	Pull out of hole to surface washing and laying down excess drill pipe.
13	Casing Recovery Operations:
a	Rig down 13-5/8” BOP and well-head. Run in hole with 8-1/4” casing cutter fitted with 13-3/8” Or 9-5/8" cutting arms, RIH and cut casing 25–30ft below the mudline. (Final BHA for weight above and below the cutter to be advised)
b	Rig up casing running equipment and retrieve 13-3/8” OR 9-5/8" casing.
14	20” Casing Recovery Operations: 1. Run in hole with 8-1/4” casing cutter fitted with 20” cutting arms and cut 20” casing 15–20ft below the mudline. (Final BHA for weight above and below the cutter to be advised).
a	Pull out of hole with casing cutter.
b	Latch onto 20’’ and pull out of hole laying down same.
15	Rig Down and Backload ALL excess equipment. Lift Mat and Jack-down legs. Rig Move to New Location

3.5.4.2 Demobilisation of Rig / Decommissioning of Rig

Once the wells have been drilled and the wellheads installed, the well installation is considered complete and the rig is demobilized.
The rigging down process for the rig is the reverse of rigging up as identified in Section 3.5.2, above.

The following is a general outline of this procedure for the Jack-up rig:

- Remove all excess equipment from deck and transport to shore facility;
- Skid rig from drilling position to transport position;
- Secure cranes;
- Jack rig down to floating position and prepare to jet legs / mat (for release from the seabed);

- Jet legs /mat and retract to transport position;
- Secure legs;
- Move rig off location (either to next location or to the Customs clearance location).

3.5.5 Project Logistics, Supply and Support Operations

For this Project, coordinated logistics, support and organisational operations will be required. These include supply vessels and supply route, staffing, materials and utilities.

3.5.5.1 Support Vessel Operation

Support operations for the drilling rig will be from 3 proposed ports/ shorebases specially set-up for this drilling program at VABI, Kuldipsingh or Intergra Marine (at Smalkalden) Port for 8 of the 10 wells and at Nieuw Nickerie Port for the other 2 wells (drilled from Block A), with additional crew transfers from the Boskamp Port.

For the duration of the drilling operations, the rig will be supplied with pipe, drilling fluids and additives, foods, fuel, water (drinking and operations), cement and other consumables. Three supply vessels (PSVs) will be offering these support services to the rig.

On the eastern side of the project area, imported materials for this project will arrive at the Havenbeheer (Nieuwe Haven) Port. These materials will be transported via trucks to the Vabi, Kuldipsingh and/or Integra Marine at Smalkalden Ports where they will be stockpiled and stored at the on-site storage areas. From there the materials will be loaded onto trucks and transported from the nearby port loading area via the PSVs to the rig. These vessels will operate everyday (the vessels will be on rotation, only one will be used at a time) in a 7-day period for the duration of the Project, when drilling is on the eastern side of the Blocks.

On the western side, materials will be stock piled at the Staatsolie's Sarah Maria facility and trucked to the Nieuw Nickerie shorebase/port (203 km away) for shipping to the rig at the 2 Block A well-site locations. The frequency of the PSVs will be the same but will only occur when drilling is within Block A.

The journey time for the PSV would be a min 6 hrs and a max of 12 hrs (one way). For the Crew vessels, it would be 3 hrs min and 5 hours max journey time (one way), from any of the ports/shorebases.

The locations of the shorebases/ports and supply routes are identified in Figure 3-6 below.

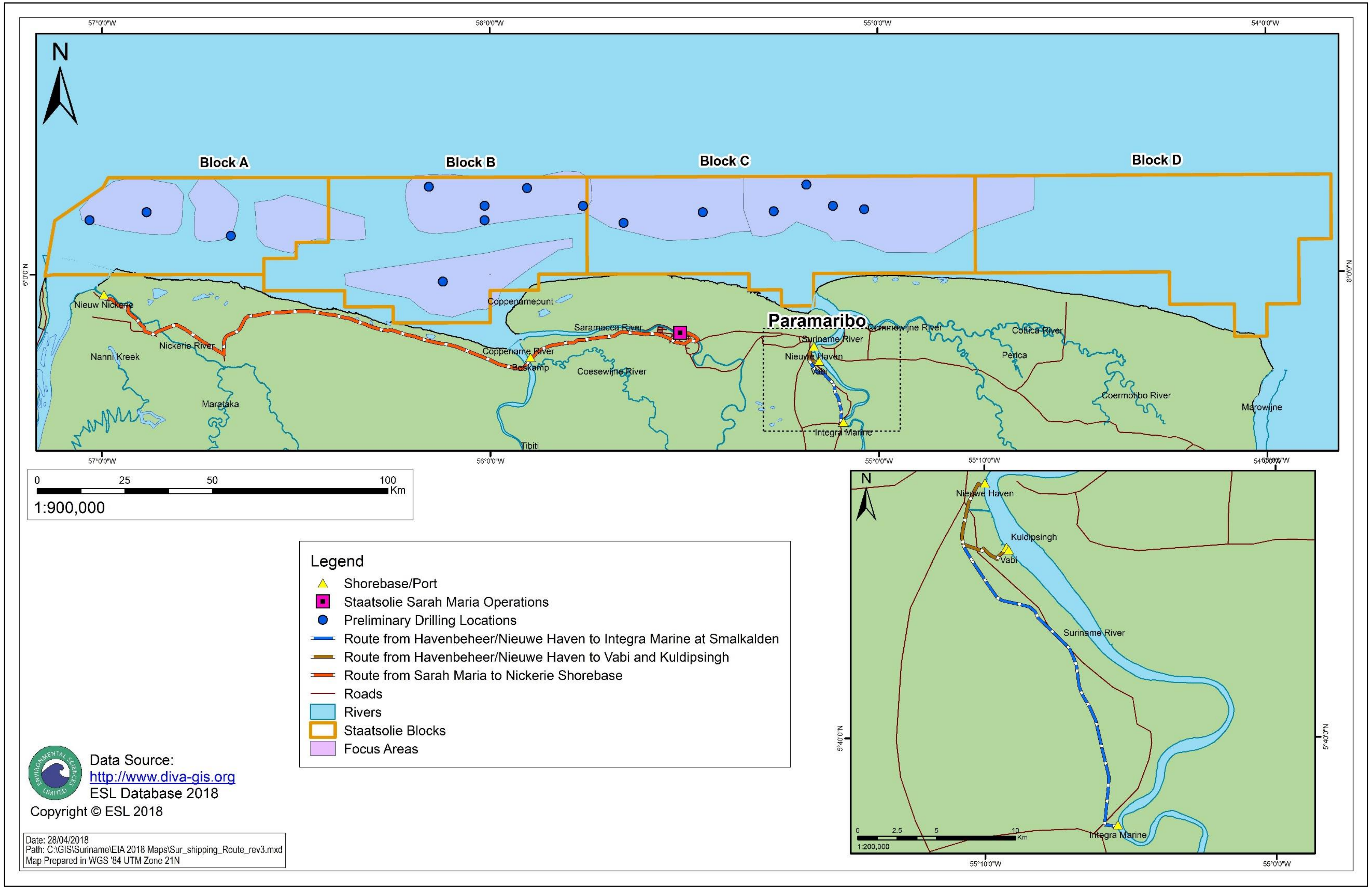

Figure 3-6: Projected Transport/Supply Route

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3.5.5.2 Staffing Requirements

It is expected that approximately 70 employees (aboard the rig) will be required for this Project. Most of the staffing required for the construction will be skilled craftsmen of the following professions:

- Engineers and Supervisors
- Safety Officers
- QA/QC Inspectors
- Fabricators
- Welders
- Riggers
- Divers
- Mechanics
- Heavy Equipment Operators
- Electricians
- Crane Operators
- Machine Operators
- Labourers
- Qualified boat operator/ captain

Local content inclusion will be a major objective for this Project and will be maximised once the required skill set is available. However, both local and expatriate staff will be utilised for the Project. The management staff will be local, but local involvement in the operations will be limited. A few barge and vessel crew will originate from Trinidad via sea travel (during the transportation of the equipment) and the majority will arrive through normal air travel to Suriname. For regular project work, personnel and materials will be transported via river/sea between VABI, Kuldipsingh, Integra Marine (at Smalkalden), Nieuw Nickerie and/or Boskamp Ports and the drilling locations, as identified in Section 3.5.5.1 and Figure 3-6 above. Recruitment, housing and detailed transportation arrangements will be determined later on by the company prior to the start of the Project.

3.5.5.3 Drilling Mud and Cuttings

The use of drilling mud is standard in drilling operations. Drilling mud is normally a mixture of clay and chemicals, which is pumped down the well-bore during drilling operations. This serves to reduce friction in the well-bore between subsurface rock and the drill bit, transport drill cuttings out of the well-bore and cool the drill bit. It is expected that a maximum amount of 1,000 bbls of water based mud (WBM) will be stored at each well-sites. The estimated volume of drilling mud required for drilling of each shallow well is 1,290 bbls and 2,205 bbls for each deep well. Not all the drilling mud will be stored in the drilling rig at the beginning of the Project; rather the volume would be increased as the well is drilled deeper, so that actual storage tanks would not be necessary. The drilling mud system depends on geology and on the drilling program. Some of the drilling fluid from the first well will also be recycled for use in the second and following wells.

Subsurface formations are not homogeneous; there are variations in pore pressure, permeability and temperature at different depths. As a result, the composition of the drilling fluid is a direct function of the removal of liquid phase by both filtration in the well-bore and evaporation from the surface system and the mud weight required to control hydrostatic pressure in the well-bore. The remaining drilling fluid that returns to surface entrained on the cuttings will be conserved from the first drilling event and will be reused in the other wells and any excess will be subsequently discharged overboard after drilling of the last well has been completed.

During the course of drilling the well, the chemical and physical properties of the drilling mud are altered to adjust the mud weight and thereby control the formation's hydrostatic pressure. These properties are altered by adding chemicals and other materials to the drilling mud during the drilling process.

Only water based drilling mud (without oils, acids or caustics) will be used for this Project and will be prepared on-site and stored in tanks. Water based drilling fluids have been demonstrated to have only limited effects on the environment as outlined in the SDS (Appendix C.1).

Drill cuttings generated during the drilling process are normally brought to the surface by the drilling mud (see Figure 3-7). This is passed over the mud shaker system where the drill cuttings are separated from the drilling mud. The drilling mud then goes to the mud tank where it is reused in the well (see Figure 3-7). An example of a Solids Control Equipment (SCE) is shown in Figure 3-8. The drill cuttings are typically washed to remove excess drilling mud and tested (sheen test) before discharge overboard. The discharged cuttings consist of small rock particles (gravel size).

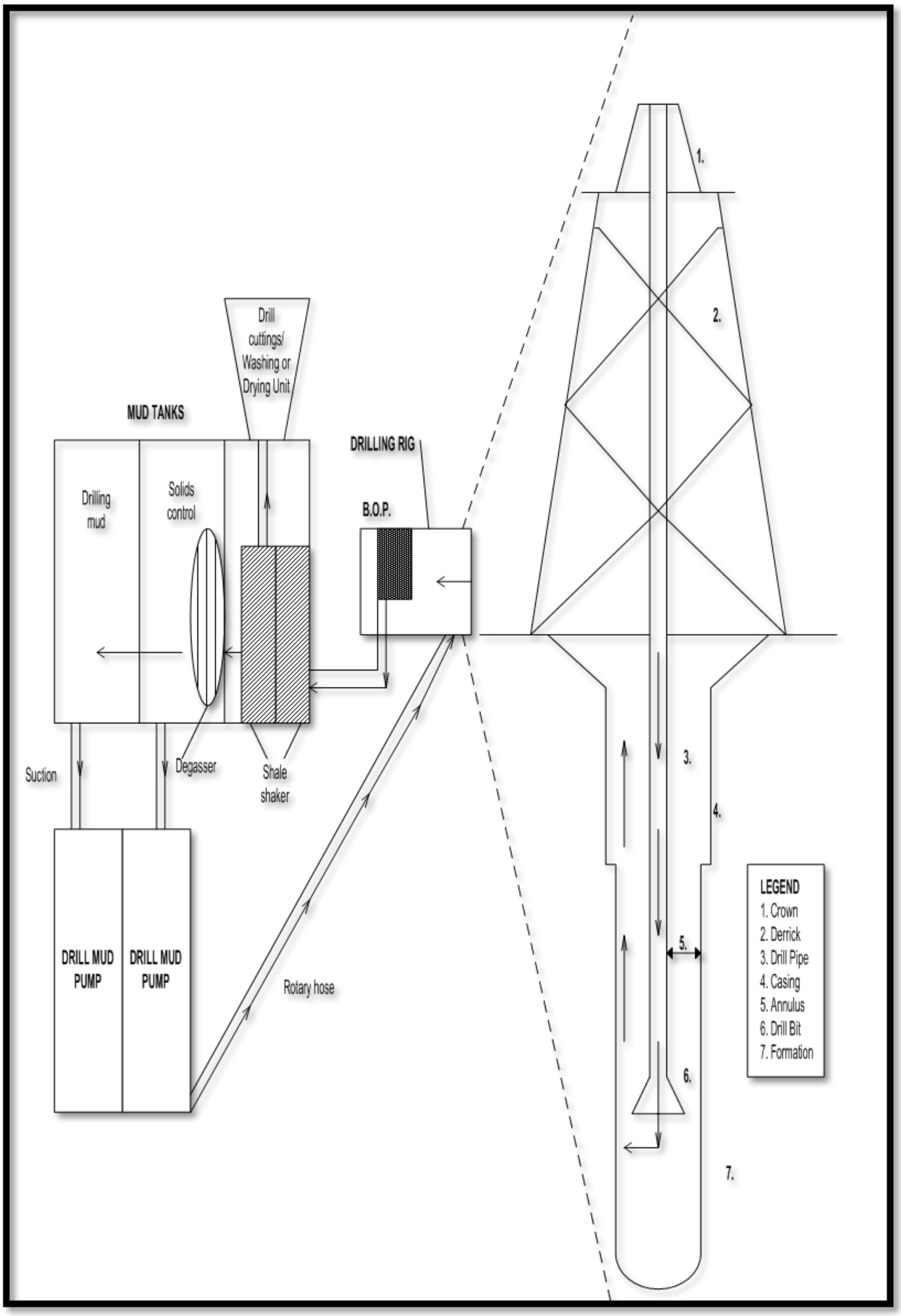

Figure 3-7: Process Flow Diagram for Typical Drilling Operations

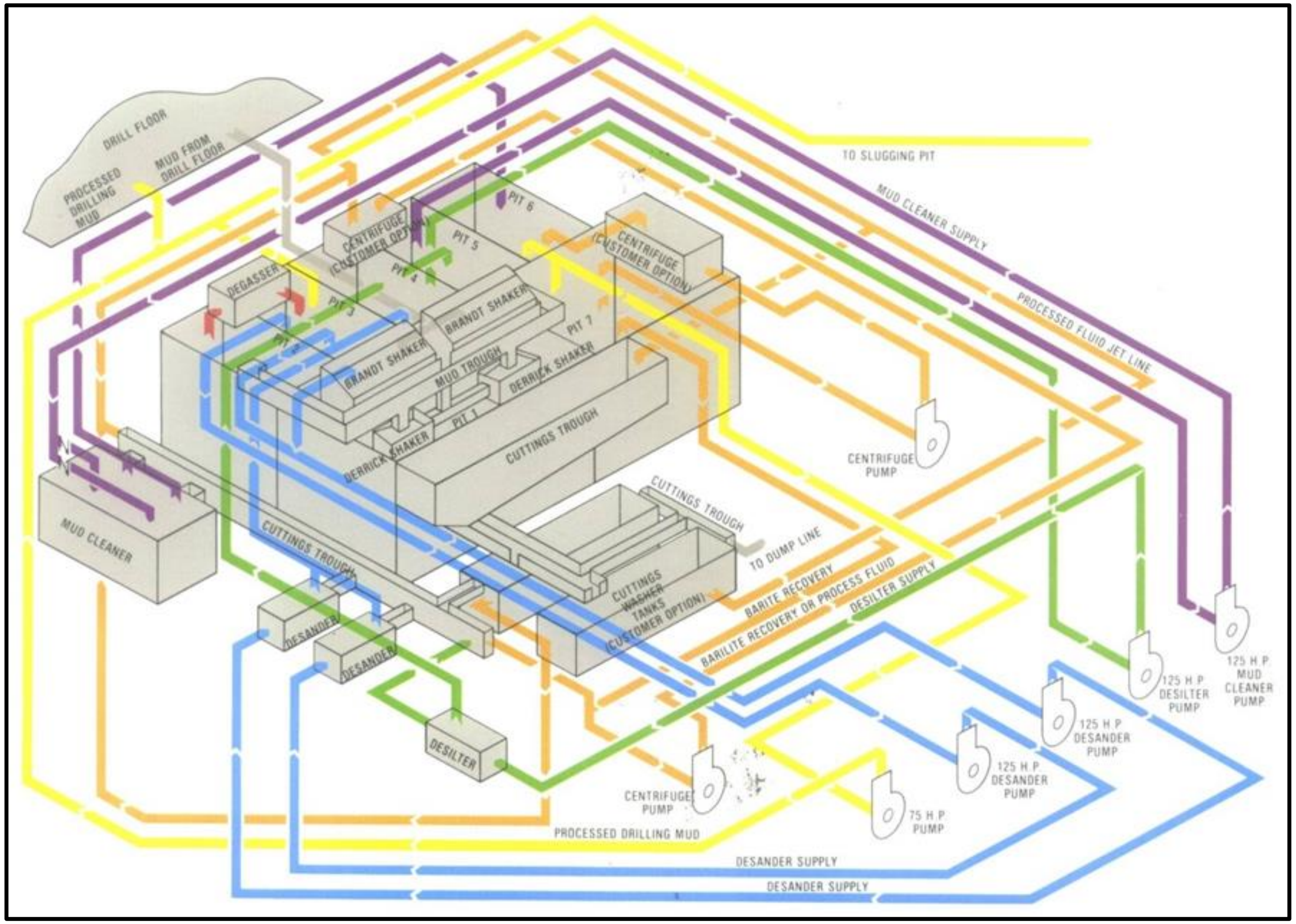

Figure 3-8: Example of Solids Control Equipment

The major components of water based drilling mud are clay and bentonite, which are chemically inert and non-toxic. Bentonite gel has a high swelling capacity in freshwater providing viscosity and colloidal solids for filtration control, which it aids by reducing permeability to the filter cake. The improved texture and quality of the wall cake provides better well-bore stability. Bentonite also aids in cleaning the hole and assists in keeping drill cuttings in suspension so that they will be taken to the surface and removed from the mud. Lignosulfonate is a common drilling mud additive used as a thinner and deflocculant. Lignosulfonate is a complex mixture of small to moderate sized polymeric compounds with sulfonate groups attached to the molecule. Sodium hydroxide is used primarily for pH control of drilling fluids.

The type and quantities of additives mixed with the drilling fluid is a function of conditions unique to each specific well and the particular stage of drilling (Table 3-8). Safety Data Sheets (SDS) for all drilling fluid additives are available and will be on-site during the drilling operation (Appendix C.1).

Table 3-8: Typical Additives for Drilling Operations

Generic Products	Function	Unit Package	Quantity/ Well
Aquagel Bentonite	Viscosifier	50 lbm[6] bag	706 bags
Barabuf	Alkalinity Agent	25 kg bag	46 bags
Drill Thin	Conditioner for Rheology Control	25 lbm bag	33 bags
Excaliber 100 (Calcium carbonate)	Loss Circulation Agent	50 lbm bag	560 bags
Flowzan	Viscosity & Suspension	25 kg bag	74 bags
Pac LV (Polyanionic Cellulose)	Fluid Loss Agent	25 kg bag	129 bags
Soda Ash	Water Treatment	25 kg bag	15 bags

[6] means pound-mass

Generic Products	Function	Unit Package	Quantity/ Well
Sodium Bicarbonate	Cement Contamination Treatment	25 kg bag	4 bags
Barite	Weighting Agent	50 lbm bag	1496 bags
Barite	Weighting Agent	3,300 lbm bag	6 bags

Proper storage of these chemicals is essential to good environmental practice and to ensuring chemical integrity. Barite ($BaSO_4$) is the most common weighting agent used today, and along with other mud related chemicals would be stored in a secured dry location (either in silos on the rig or at the shorebase). Approximately 665 tons of Barite (sourced from Baroid) will be stored at the shorebase facility and replenished when necessary, while 22.3 tons will be kept on the rig. Barite is a weighting material used to increase the density of a liquid drilling fluid system.

Fuel (diesel) used for generators and engines will be stored on-site in approved tanks on the rig and replenished when necessary. During replenishment, the diesel will be transported from the port to the rig in approved covered containers via support vessels. These containers will be separated and secured to minimise spills (through accidents) into the aquatic environments during fuel dispensing and will also have secondary containment to aid in detection and recovery of any spillages. In the event of a fuel spill, it would be immediately reported and cleaned up. Staatsolie will take action to identify the source and take corrective action to prevent further leaks and spills, in accordance with the Company's Oil Spill Response Plan (OSRP) and Emergency Response Plans (ERP). All vessels will have oil/chemical spill equipment to handle a spill in the event one occurs. Note that all spills will be reported immediately to NIMOS. Staatsolie will investigate all incidents through systematic cause analysis methods, and communicate the learnings accordingly, to prevent recurrence or worse.

Drilling mud and oily waste generated will be treated according to the USEPA (2007) standard (see Table 2-3 in Section 2.7 above). Rig preparation for using WBM will also involve the following:

- Efficient deck drainage whereby oil/mud present will be diverted to a separate holding tank or pit;
- Use of a rig vacuum on-board for cleaning up spills and maintaining rig cleanliness;
- Mud saver subs and buckets would be used to reduce mud loss on the rig floor;

- Drill pipe wipers would be encouraged to reduce mud spilled on the drill floor;
- Pressure washing equipment will be used to speed up the clean-up of spills and reduce the amount of surfactant used to clean the rig; and
- Rubber valves, liners and hoses would be checked to ensure compatibility with base oil and replaced if necessary to prevent mud loss or contamination.

Spill control materials and dispersants are kept on-site in approved disposal containers. Containers used for storage in this regard are properly disposed of by crushing or by incineration, which is normally done by a disposal contractor. A waste handler familiar with the collection and disposal of oily waste will be contracted for the application and as part of the company's Waste Management Plan (WMP). This Plan will provide a procedure for the treatment of the drill cuttings and will be made available to NIMOS pending environmental approval and prior to the start of any drilling activities.

3.5.5.4 Water Consumption

The major demand for water during the drilling period is for addition to the drilling mud. Seawater is normally passed through the desalination unit on the rig before mixing with additives to make drilling mud.

Potable water will be transported from the shorebase(s) to the drilling rig via supply vessels in addition to water provided by the desalination unit on the rig. An estimated 65–80 bbls of potable water will be required per well. All other water demand will be satisfied by extraction of sea water, therefore minimal demand for water from the public water supply will result. Table 3-9 gives estimated volumes of liquid required for the Project.

Table 3-9: Total Liquid Material Stored on the Rig (estimated)

No.	Liquid Material	Total Capacity (bbls)
Jack-up Rig		
1	Potable Water	500
2	Drill Water	1,000
3	Diesel fuel	250
4	Drilling Mud	1,000

3.5.5.5 Other Utilities

This exploration drilling Project will not have any demand on other utilities, such as electricity and telecommunications. Electricity will be acquired from standby diesel generators. For the drilling phase however, in the event of an emergency, local medical and security (fire, police and coast guard) assistance will be accessed as outlined in the company's ERP and OSRP.

3.5.6 Waste Management & Emissions

An estimate of the type of wastes generated on this Project is given in Table 3-10. The table also identifies minimization measures and disposal options for each type of waste.

Table 3-10: Types of Waste Generated

WASTE STREAM	SOURCE LOCATION		MINIMIZATION OPTIONS			WASTE MANAGEMENT METHOD	DISPOSAL/ RECYCLE METHODS	COMMENTS
	Rig/ Well-sites	Vessels	Reduce	Reuse	Recycle			
Chemical Sacks	✓		✓			Segregate, bundle and collect in waste skips. Transport to land facility for disposal	Landfill, solidification, incineration (using a Staatsolie approved contractor)	Moderate volume waste stream generated. Consult SDS for handling and disposal of residual chemicals in sacks
Drums (Empty)	✓			✓	✓	Develop drum management plan	Recycle, reuse or landfill, incineration (using a Staatsolie approved contractor)	Very small number of drums will be generated. Decontaminate drums in accordance with relevant international guidelines. Refer to SDS
Food Waste	✓	✓	✓			Treatment using on-board waste treatment unit	Discharge overboard in accordance with MARPOL 73/78	Waste stream will be generated daily
Glass	✓		✓		✓	Collection, sorting and grading	Recycle, landfill	Small volume waste stream generated occasionally.
Medical Wastes	✓	✓	✓			Collect in waste skips prior to disposal	Landfill or incinerate	Small volume waste stream generated occasionally (Approved contractor)

WASTE STREAM	SOURCE LOCATION		MINIMIZATION OPTIONS			WASTE MANAGEMENT METHOD	DISPOSAL/ RECYCLE METHODS	COMMENTS
	Rig/ Well-sites	Vessels	Reduce	Reuse	Recycle			
Metal (scrap)	✓		✓	✓	✓	Segregate if recycled	Recycle or landfill	Small volume waste stream generated occasionally
Oily rags	✓	✓	✓			Collect in drums (covered) prior to disposal	Landfill or incinerate	Small to medium volume waste stream generated with medium frequency. Incinerate in small quantities only
Sanitary Waste	✓	✓	✓			Treatment using on-board waste treatment unit	Discharge overboard in accordance with MARPOL 73/78	Small to medium volume waste stream generated frequently
Paper	✓	✓	✓	✓	✓	Collect in waste skips prior to disposal	Landfill or recycle	Quantity will be too minute to recycle
Plastics	✓	✓	✓	✓	✓	Collect in waste skips prior to disposal	Landfill or recycle	Can be forwarded to external contractor for shipment for recycling

WASTE STREAM	SOURCE LOCATION		MINIMIZATION OPTIONS			WASTE MANAGEMENT METHOD	DISPOSAL/ RECYCLE METHODS	COMMENTS
	Rig/ Well-sites	Vessels	Reduce	Reuse	Recycle			
Operational discharge	✓		✓			Oil-water separation on rig	Treat prior to discharge via Biological Treatment, and other appropriate methods	Generated frequently during drilling operations (10 bbls/day of deck drainage); the company to ensure that appropriate measures are adopted to prevent any contaminants being deposited into the sea
Bilge water		✓		✓		Retaining on an on-board holding tank	Discharge overboard in accordance with MARPOL 73/78	Small to medium volume waste stream generated frequently. Combined discharge from all vessels, approximately 1,000 gallons
Used lube oil	✓	✓	✓			Collect in drums (covered)	Recycled into oil treatment system	Small to medium waste stream, collected from equipment maintenance
Water-Based Contaminated Cuttings	✓		✓			Settling pit system	Discharge- gravity separation and solidification/ treatment	Waste stream generated frequently during drilling. Will be treated properly before discharge. If contaminated, the cuttings will be deposited in a pit and transported to land facility for treatment

WASTE STREAM	SOURCE LOCATION		MINIMIZATION OPTIONS			WASTE MANAGEMENT METHOD	DISPOSAL/ RECYCLE METHODS	COMMENTS
	Rig/ Well-sites	Vessels	Reduce	Reuse	Recycle			
Water-Based Uncontaminat-ed Drill Cuttings	✓		✓			Seabed for marine drilling	Discharge- gravity separation and solidification	Waste stream generated frequently during drilling
Water Based Mud	✓			✓	✓	Reuse and recycle between drilling wells	Discharge the excess water based mud at the last well-site	Single discharge of approximately 600 bbls

3.5.6.1 Non Hazardous Waste

Bins are normally provided at strategic locations on the drilling rig where non-hazardous solid waste would be disposed. These wastes would be transported to a proper land based facility for disposal as described in the company's WMP. General waste will be disposed at a public dump site.

Domestic solid waste generated from the site will normally consist of small quantities of cans, bottles and sacks. Garbage from the well-site will include food waste, packaging material and other non-hazardous solid wastes, estimated at not more than 1.5 – 1.7 kg/person/day in general (American Society of Civil Engineers 2010). For domestic waste items, a portable waste bin will be provided which will be emptied at an approved waste disposal site.

3.5.6.2 Hazardous Waste

Waste oil and other hazardous waste would be collected and transferred to onshore facilities for proper re-use, recycling, treatment or disposal at a Staatsolie approved treatment facility as described in the company's WMP.

Drill cuttings generated during the drilling process are normally brought to the surface by the drilling mud. This is passed over the mud shaker system where the drill cuttings are separated from the drilling mud. The drilling mud then goes to the mud tank where it is reused in the well. The drill cuttings are typically washed to remove excess drilling mud, and then discharged to the sea floor. The drill cuttings and excess drilling mud/fluid will also be tested and monitored by sheen test to comply with the USEPA (2007) effluent limits for gas activities in the US Gulf of Mexico (GOM) as identified in Table 2-3 above.

3.5.6.3 Wastewater (Grey and Black Water)

Grey and black wastewater streams will be generated on-board the drilling rig over the duration of the exploration drilling Project. It is anticipated that there will be a maximum of 70 persons on-board the rig at any given period of time. The projected amounts of these wastes are 1.5 m^3/person/day grey water and 0.008 m^3/person/day sewage (ESL, 2013).

Grey water comprises waste collected from kitchen washing, showering and laundry activities and the discharge of this will be managed by the USEPA (2007) Effluent Limit of no floating solids or foam on food waste discharge.

Black water, on the other hand comprises toilet waste and sewage. The discharge of raw sewage into the sea can create a health hazard, while in coastal areas sewage can also lead to oxygen depletion and an obvious visual pollution. The Jack-up rig will be equipped with a certified Omnipure™ 12MC Unit (see Appendix C.2) to process all the generated sewage prior to discharge overboard according to MARPOL (73/78) requirements (disposal of treated waste is 5.6 km from the nearest land). The Omnipure will also be capacity rated to the maximum number of persons that can be accommodated on the rig in accordance with MARPOL (73/78).

The Omnipure Unit should be able to meet the discharge limits set by the IMO Annex A of Resolution MEPC 2(6) 1976 and supplemented where limited with the TTWPR 2001 (as amended) or the USEPA (2007) effluent limit (see Table 2-4 above).

Monitoring of grey and blackwater steams will occur twice during the drilling phase (at the beginning and at the end). Effluent data from a similar unit to support this is also presented in Appendix C.2.

Additional wastewater streams will be managed by the USEPA (2007) Effluent Limit for oil and gas activities in the Gulf of Mexico as outlined above in Table 2-3 above.

3.5.6.4 Rig Run-off

All hydrocarbon-contaminated runoff would be routed to an oil/water separator, where it will be treated to ensure a concentration below 15 ppm of Total Petroleum Hydrocarbons (TPH), based on MARPOL Annex 1 (73/78) and shall be monitored for TPH at least twice during the drilling phase of the activity per well.

3.5.6.5 Air Emissions

In the offshore environment, there will be some minor combustion emissions associated with the vessels (surveying/sampling vessels and support vessels). These are expected to be quickly dispersed based on the short Project timeline (of 9 months, however drilling will be 2-3 weeks at a time for 24-hr operations), in the offshore environment with high wind dispersion.

The typical air emissions associated with exploration drilling arise from equipment used on-board the drilling rig and vessel movements. These include Carbon Dioxide (CO_2), Carbon Monoxide (CO), oxides of Nitrogen (NO_X), Volatile Organic Compounds (VOCs), Sulphur Dioxide (SO_2) and Hydrogen Sulphide (H_2S). It is not anticipated that these levels generated will exceed the limits for these parameters stipulated in the T&T Air Pollution Rules, 2014 and the USEPA NAAQS, 2015 (see Table 2-2 above).

3.5.6.6 Noise

Noise emissions during drilling activities will originate from piling operations, equipment and machinery, vessels and generators. The Drilling Project is expected to span a period of approximately 9 months during which operations will occur for 24-hrs, whereby the noise levels are expected to range 70-85 dBA.

The drilling operations is not expected to have any significant impact on persons on land since it will take place in the offshore environment where there are minimal impacts to personnel on land.

3.5.6.7 Artificial Light

The drilling rig will be well-lit for on-board safety and maintain exterior lighting to ensure visibility to other vessels operating in the area. It is also important since drilling will be 24-hour operations. This artificial lighting extends to a height of approximately 30 m above mean sea level.

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4 ANALYSIS OF ALTERNATIVES

4.1 Introduction

The purpose of this Chapter is to demonstrate that all feasible alternatives for the proposed Nearshore Exploration Drilling Project 2019 have been considered and methodically assessed. This ensures that the final decision results in the best method of achieving Project objectives with minimal impacts to people and the environment. An alternative is defined as any course of action, means or method by which the proposed Project objectives may be attained. For instance, an alternative could include the use of different materials, drilling rig or disposal methods. However, in most cases, alternatives are constrained by their practicality, cost and/or potential to cause adverse environmental impacts. The assessment of alternatives also includes the “no action” option, which is the continuation of existing activities without the implementation of the proposed Project.

4.2 Decision Analysis

To determine whether the selected alternative is the most feasible and environmentally compatible option, a number of potential alternatives were considered.

These alternatives were classified under the following headings:

- Drilling Unit(s)
- Drilling Mud
    - WBM
    - SOBM
- Cuttings Disposal
- Sewage Treatment
- Port for Mobilisation/Demobilisation
- No-action Alternative

In order to facilitate a proper assessment of each option, the following criteria[7] were used to aid in evaluation:

- Environmental
- Social
- Economic
- Engineering/Technical

Table 4-1 presents the definition of each of the criteria used to evaluate the Project alternatives.

[7] *Modified by ESL*

Table 4-1: Evaluation of Criteria

Criteria	Parameters
Environmental	Negative impacts to natural environment, inclusive of flora, fauna, terrestrial and marine ecosystems, climate, seabed etc.
Social	Negative impacts to public safety, worker health and safety, social unrest, community degradation, impact on livelihoods (employment)
Economic	Negative impacts to Project cost, Project schedule, total Project benefits
Engineering/Technical	Negative impacts to design, constructability, and technical work required

Each of the criteria considered were assessed on a scale of 1 – 5. Based on the severity of the impact, a numeric value was assigned and the total of each option evaluated. Even though a numeric value is assigned for the evaluation criteria, the ranks are qualitative, whereby a lower overall rating indicates greater feasibility. Table 4-2 below indicates the ranking of each numeric value.

Table 4-2: Ranking Assessment

Numeric Value	Rank / Impact
1	Negligible
2	Low
3	Moderate
4	High
5	Extreme

4.3 Project Alternatives

This Section presents the major alternatives considered within the scope of this Project and their respective rating for decision analysis.

4.3.1 Drilling Unit

Marine oil and gas exploration poses a number of different challenges from that on land, the most fundamental of which is the need for an artificial platform for drilling. Platforms can take many forms depending on the characteristics of the well being drilled and the drilling environment. For the purpose of this assessment, 4 alternative drilling units were identified:

- A dynamic positioning drill ship
- A semi-submersible drilling rig
- A Jack-up rig (mat-type)
- Barge type drilling rig

It should be noted that a permanent platform is not considered an alternative at this stage because only exploratory/appraisal drilling is proposed. The main criteria for the selection of a unit for this drilling program is based on technical capability/ suitability for this Project in light of the prevailing conditions within the exploration Block.

A drillship is a maritime vessel that has been fitted with drilling apparatus and is most often used for exploratory offshore drilling of new oil or gas wells in deep water or for scientific drilling and its hull is outfitted with a dynamic positioning system to maintain its position over the well. Modern drill ships have the ability to drill in water depths of more than 2,500 m.

The semi-submersible rig is designed for water depths 90 – 1,000 m. It works by lowering the watertight pontoons, via ballasting, below the water surface and anchoring the unit by dropping mooring lines with attached anchors in preparation for drilling.

Jack-up drilling rigs are self-elevating drilling units that have to be towed to the drill sites by tug boats. They are mobile, stable when elevated, efficient, and associated costs are lower than the drillship and semi-submersible rigs. Jack-up rigs are highly suitable for shallow waters of less than 7 – 140 m, and the rig mat adds more stability.

The barge type drilling rig is smaller, more mobile and less technically demanding than the other units and is more conducive for drilling in shallow water and swampy conditions. However, due to the very shallow sea-conditions in the south of the Block and the soft muddy condition of the seafloor the floating barge type rig would not be stable during drilling and may cause risks of rupture to the drill string during drilling. It is therefore less technically feasible than the Jack-up rig.

Overall, the Nearshore Blocks A-D lies within a shallow marine area with water depths ranging from 0 – 30 m, whereby the shallowest water depths for the proposed wells are ~ 10 m (see Figure 3-1 above).

Given the depth of the blocks, a Barge type drilling rig is most appropriate for drilling in the water depths of Blocks A-D. The costs associated with this unit are lower than the other 3 rigs, and its technical capability is adequate for this proposed drilling Project.

From an environmental perspective, the use of a dynamically positioned drill ship will result in high fuel consumption and consequently an increase in emissions and air pollution. The use of a semi-submersible rig will contribute air emissions and some impacts to benthic fauna from crushing and smothering via large anchors. Likewise the Jack-up drilling rig will result in crushing of benthic fauna and disturbance to the seabed from placement of the rig mat on the seafloor. The barge type drilling rig will also result in disturbance to the seafloor from the bottom of the barge being on the seabed surface, similar to that of the mat-type Jack-up rig option.

Therefore, given the nature of the proposed Project, these alternatives are considered to have similar environmental scores due to the following outlined in Table 4-3 below:

Table 4-3: Drilling Rig Environmental Considerations

Rig Option	Environmental Considerations	
	Air Emissions	Sea Floor Impacts
Drill ship	Highest level of air emissions (major source of environmental impact	No direct seafloor impacts
Semi-submersible	Medium level of air emissions	Some impacts to benthic fauna from crushing and smothering via large anchors
Jack-up rig	Lower level of air emissions	Higher area of benthic crushing and smothering from the rig mat placement
Barge type rig	Lower level of air emissions	Higher area of benthic crushing and smothering from the barge/mat placement

The environmental ranking would be low regardless of the type of rig because air emission levels (from the drill ship) would still be in low concentrations when compared to the national average and the area of benthic impacts from the mat placement (via the Jack-up rig) would be 0.012[8] km^2 and 1.92 x 10^{-4} km^2 for the rig anchors (considering the rig will be using 4 anchors[9] at a time). This gives a total impact area of 0.012 km^2 (or 0.0001 % of Blocks A-D acreage).

The social impacts of the 3 options are considered low since there will be a proposed 500 m safety exclusion zone around the rig regardless of the type.

The use of a dynamic positioning drill ship would greatly increase the Project costs. It is estimated that an additional $100,000 to $250,000 USD per day would be required for the utilisation of these ships compared to a Jack-up drilling rig or barge type drilling rig. This cost, therefore, can only be justified if the exploration wells indicate that there is a large enough petroleum and gas reserve to subsidise this expenditure. Other constraints include the availability of such units and the sailing time from other countries. In part, this is driven by the current high market demand for such ships globally; therefore, the use of these ships could adversely affect the scheduling of the proposed Project.

Table 4-4 below summarises the drilling rig alternatives and based on the evaluation criteria below, the Jack-up rig is considered the most feasible option for this Project.

Table 4-4: Drilling Rig Alternatives

Options	Evaluation Criteria				Total
	Environmental	Social	Economic	Technical	
Dynamic Positioning Drill Unit	2	2	5	3	12
A Semi-submersible Drill Unit	2	2	4	3	11
Jack-up Drilling Rig	2	2	3	1	8
Barge type Drilling Rig	2	2	2	3	9

[8] *The dimension of the rig mat is 108x118 ft =12,744 ft^2 or 0.001184 km^2. The total surface area that would be affected through benthic crushing and smothering is at 10 locations is 0.012 km^2.*
[9] *The area of impact per Flipper Delta Anchors on the rig is determined by dividing the product of the base (1.74 m) and height (2.78 m) by 2. This gives an impact area of 4.8 m^2 per anchor, assuming 4 anchors on the rig at 10 locations, the total surface area is 0.000192 km^2.*

4.3.2 Drilling Mud Alternatives

The drilling of exploration wells can use either water-based mud (WBM) or synthetic oil based mud (SOBM) depending on the depth of the well, type of well, the stability of the well-bore and potential pressure and temperature problems. In comparison, WBM are used in shallow water and stable environments where pressure and temperature are not as high. Blocks A-D occur in shallow water depths ranging from 0 – 30 m. However, the proposed well locations are spread across Blocks A, B & C. The water depths range from 5 – 30 m. The proposed shallow wells will be drilled to depths within the range of approximately 2,400 – 4,000 ft and the deeper wells range from approximately 5,700 – 8,900 m. WBM is thus more technically feasible for this Project. SOBM is generally used for deep wells as complexity of formation changes and are not suitable for use during this Project.

The social impacts of drilling muds would only arise during discharge along with drill cuttings. A proposed 500 m safety exclusion zone will be established around the rig and the drill cuttings will be separated from the muds to pass the sheen test prior to discharge overboard. Therefore, the probability of persons coming in contact with the muds would be very low. In the unlikely event that this does occur, WBM is expected to have a low social impact, due to low toxicity. The toxicity of SOBM is greater than WBM, which increases the risk to human health and environmental impact. In terms of costs, WBM is also more economical than SOBM. This is summarised in Table 4-5 below.

Table 4-5: Drilling Mud Alternatives

Options	Evaluation Criteria				Total
	Environmental	Social	Economic	Technical	
SOBM (Synthetic Oil Based Mud)	4	3	3	4	14
WBM (Water Based Mud)	2	2	2	2	8

4.3.3 Cutting Disposal

During the drilling process the mud that returns to the surface will be passed through special equipment on the drilling rig known as Solids Control Equipment (SCE), shown in Figure 3-7. This typically consists of 5 primary shakers which remove most of the cuttings from the mud circulation system. This system recovers and recycles all mud fluids. The cuttings will be treated and discharged overboard. Drill cuttings dispersion modelling (see Appendix E) calculated a maximum area (for thickness greater than 1 mm) of approximately 209 m (long season) and 223 km^2 (short season) within the

Blocks. The environmental impacts are expected to be low since the cuttings would be treated and assessed with a sheen test to obtain no free oil on discharge and only a small area will be affected by benthic smothering and seabed disturbance in comparison to the size of the Blocks.

Social impacts are expected to be negligible since there will be a proposed 500 m safety exclusion zone around the rig to prevent fishermen from venturing close to the well-site and avoid contact with contaminated drill cuttings and residual fluids.

An alternative to the SCE system is the transportation of the untreated cuttings via cutting boxes to shore and disposal via a waste landfill and/or treatment using a bioremediation system. In this case, there would be an increased risk of contaminated waste impacting the environment - a moderate impact in the event of a spill (given that a spill on land would be easier to contain). A low social impact is expected since there is a greater probability of persons coming into contact with the untreated drill cuttings during the transportation to land.

Moreover, this option is more expensive than using the SCE and logistically has a greater degree of difficulty (i.e. transportation from offshore to a Staatsolie approved treatment site onshore); therefore the preferred option is the use of WBM, treatment of the derived cuttings and discharge over board via the SCE system. This is summarised below (see Table 4-6).

Table 4-6: Drill Cuttings Disposal Alternatives

Options	Evaluation Criteria				Total
	Environmental	Social	Economic	Technical	
Transport to shore for treatment on land	3	2	3	3	11
Treat and discharge overboard	2	1	2	2	7

4.3.4 Sewage Treatment

There are 2 options for sewage treatment namely the use of an Omnipure™ 12MC (sewage treatment unit; see Appendix C.2), which is costly or the use of a marine macerator (JABSCO Macerator Pump; see Appendix C.3) for grinding up solids to approximately 3.18 mm. The use of the Omnipure Unit would result in a lower environmental impact as the sewage would be treated prior to discharge.

The disposal of untreated sewage in the offshore area may have a moderate social impact (see Table 4-7). These impacts may be considered low with the use of the Omnipure Unit as the treatment of sewage prior to disposal will pose limited effects on worker and public health as well as fishers. It should be noted that discharge of sewage will occur according to MARPOL 73/78 discharge standards (i.e. discharge of comminuted and disinfected sewage using an approved system >3 nm from nearest land; and discharge of untreated sewage >12 nm from nearest land), whereby wave action and dissolution would result in the breakdown of sewage. It is expected that any social impacts to fishermen in the marine area from the Omnipure unit may be lower than that of the macerator because processing/treatment occurs in the marine sanitation device (MSD) prior to discharge.

From an environmental perspective, the use of a macerator will have a greater impact on the environment since there is no treatment or disinfection prior to disposal and higher environmental impacts would occur through reduction in water quality and contamination of marine organisms. The use of the Omnipure Unit imparts a lower rating (see Table 4-7). This type of device oxidises and disinfects black and grey water based on electrolytic treatment of the waste.

MSDs with enhanced primary treatment are more costly than macerators; these have been scored in Table 4-7 to reflect increasing economic costs. Additionally, these options have been scored the same regarding technical feasibility as the JABSCO macerator pump and the Omnipure Unit are lightweight, require small footprints and are typically able to function without requiring attention from persons on-board the vessel. After these options were assessed the MSD was considered more feasible due to the lower environmental impacts that may potentially arise. These options are summarised in Table 4-7 below.

Table 4-7: Sewage Treatment Alternatives

Options	Evaluation Criteria				Total
	Environmental	Social	Economic	Technical	
Marine Macerator (JABSCO Macerator Pump)	3	3	2	2	10
On-board MSD (Omnipure Unit)	2	2	3	2	9

4.3.5 Port for Mobilisation/Demobilisation

The transportation routes which will be utilised for this Project will depend on the port facility to and from which the vessels will mobilise. There are 6 options considered by Staatsolie; Nieuwe Haven, VABI Port (Wanica), Kuldipsingh Port, Integra Marine Port at Smalkalden, Boscamp Port and Nieuw Nickerie. Table 4-8 provides further details of the ports, where available.

Of these ports, Staatsolie has identified Nieuwe Haven as the main receiving location for materials on the eastern portion of the country when the drilling is expected to occur in Blocks B and C. This is a medium river port (located along the Suriname River) and is the chief Port of Suriname (Searates 2018). It is a natural harbour with excellent shelter, though harbour entrances are restricted due to tides and overhead limits. At this port, supplies such as provisions, potable water, and fuel (including diesel) are available. This port is the most feasible option due to proximity to the Staatsolie facility at Nieuwe Haven. It is also the closest to Block C; 21 km away.

Three other optional ports are proposed when drilling occurs in Blocks B & C, including VABI, Kuldipsingh and Integra Marine. The port facilities at VABI is small and located along the Suriname River (and is in between the other 2 ports/shorebases). The Kuldipsingh Port which is in close proximity to the VABI Port, on the other hand is a large port, located 4 km away from Nieuwe Haven. The VABI and Kuldipsingh ports are similar to Nieuwe Haven in terms of tidal restriction and available supplies. Limited information is available on the facilities of the Integra Marine port/shorebase. This port is the furthest upstream of the Suriname River and is ~55 km away from Block C.

Staatsolie has also identified the Nieuw Nickerie Port for similar services on the western side, when drilling is expected to occur in Block A. This is a small port (1.5 hectares) located 11.2 km inland of the Nickerie River. It is a natural river habour with fair shelter. Supplies (i.e. provisions, potable water, and fuel are also available. Staatsolie has also considered the port at Boskamp for transport of project personnel to Block A, when drilling is proposed in that block, however there is very limited information about this port.

Staatsolie is in the process of evaluating the ports for final decision on the most feasible option and will take the aspects outlined in Table 4-8 into consideration as well as cost and site inspection for evaluation of the final option.

Table 4-8: Details of Ports

Port Details	Ports					
	Eastern Locations				Western Locations	
	Nieuwe Haven	VABI	Kuldipsingh	Integra Marine (Smalkalden)	Boskamp	Nieuw Nickerie
Anchorage Depth	4.9 m – 6.1 m	Berthing only allowed by means of ropes attached to the jetty mooring piles and the jetty				3.4 – 4.6 m
Cargo Pier Depth	4.9 m – 6.1 m	N/A				1.8 – 3 m
Oil Terminal Depth	4.9 m – 6.1 m	N/A				3.4 – 4.6 m
Dry Dock	N/A	Small	15,800 m^2 and a closed storage area of 1,675 m^2			N/A
Harbour Size	Small	Very Small	Large			Very small
Railway Size	Small	N/A	N/A			N/A
Harbour Type	River Natural	River Natural	River Natural			River Natural
Maximum Size	Over 500 ft. in Length	137 ft. in Length				Up to 500 ft in length
Shelter	Excellent	Excellent	Excellent			Fair

Source: http://www.ports.com (n.d.)

From an environmental perspective, increased travel time from port to the Block will contribute greater air emissions from engine combustion and has been rated as low for Integra Marine Port (at Smalkalden) and negligible for Nieuwe Haven, VABI, Kuldipsingh, Nieuw Nickerie and Boskamp Ports (see Table 4-9). This may result in reduced fuel costs and travel time during mobilisation at Nieuwe Haven in comparison to the other ports along the Suriname River.

The use of either port options will result in an increase in marine traffic along the Suriname River and will require services at the point of berthing. Mobilisation of the rig and movement of the supply vessel (one movement per day over the duration of the Drilling Project) will add to the existing marine traffic in the Suriname River and marine area in the vicinity of the Nearshore Blocks. This may result in negative social impacts with respect to public safety, worker health & safety and increased demand for port services. This was rated as negligible for the Nieuwe Haven, VABI, Kuldipsingh, Nieuw Nickerie and Boskamp Ports which are situated closer to the river estuary as opposed to low for Integra Marine Port which is situated further inland.

In terms of technical criteria, the Nieuwe Haven Port was selected as the preferred port over the VABI or Kuldipsingh Ports based on proximity to Staatsolie's location at Nieuwe Haven to accommodate ease of materials and personnel movement to Blocks B and C. It also has a greater anchorage depth than VABI Port, however Kuldipsingh has the largest harbour size. As a result, Kuldipsingh may still be considered as a viable option in terms of berthing space requirements and vessel traffic within the Suriname River.

Table 4-9: Transportation Route Alternatives

Options	Evaluation Criteria				Total
	Environmental	Social	Economic	Technical	
Nieuwe Haven	1	1	1	1	4
VABI Port	1	1	1	2	5
Kuldipsingh Port	1	1	1	1	4
Integra Marine (Smalkden)	2	2	2	2	8
Boskamp	1	1	1	1	4
Nieuw Nickerie	1	1	1	2	5

4.3.6 "No Action Alternative"

To understand the implications of the "no-action" alternative, consideration has to be given to the state of the prevailing baseline environmental and social-economic conditions in the absence of the implementation of the proposed Project. The implications of the "no action" alternative can be summarized as follows:

- Reduced localised environmental impacts for the physical (sea floor scaring, pocketing and sediment disturbance), chemical (water pollution, sedimentation) and biological (ecological disturbance) environments
- Loss of opportunity to promote positive socio-economic benefits (contribution to macro-economic development, employment, increase in GDP)

Given the current economic climate to develop oil and gas in Suriname, the "no-action" alternative was not considered a viable option as hydrocarbon exploration and production in Suriname is essential if worldwide demand for oil and gas is to be met.

5 DESCRIPTION OF BASELINE ENVIRONMENT

5.1 Introduction

This Chapter presents a detailed description of the study area and provides a clear picture of the existing environmental resources and values within which potential impacts of the proposed Staatsolie Nearshore Exploration Drilling Project 2019 must be considered. The baseline environmental information includes data on physical, ecological and socio-cultural resources as well as their interactions. This is important so that conditions existing before development can be referenced against the subsequent changes.

The objectives of this Chapter are to:

- Describe the environmental conditions which may be influenced by the proposed Project;
- Identify environmental conditions which might influence Project design decisions (e.g. site layout, structural or operational characteristics);
- Identify sensitive issues or areas requiring mitigation or compensation;
- Provide input data to analytical models used for predicting effects; and
- Provide baseline data against which the results of future monitoring programmes can be compared.

Where existing information could not adequately characterise the existing environment, ESL performed field studies to fill in the data gaps and provide more timely or focused information. These studies are outlined in Section 5.2 below and described and discussed in the relevant sub-sections of this Chapter.

Regarding secondary data sources, information was gathered, where possible, from local, verifed sources. Where data were not available, international, verified sources of data were used.

Maps and other graphics are utilised throughout the Chapter to illustrate the various data themes. Graphical representations within the study area are delineated and referenced in relation to the Universal Transverse Mercator (UTM) coordinate system (Zone 21N) within the World Geodetic System 84 (WGS 84) datum.

5.2 Definition of Baseline Study Area

The baseline study area includes areas which may be potentially affected by this Project and comprises the immediate Project footprint and a wider study area (Figure 5-1 below). The immediate Project footprint consists of:

- The environment within a 500 m radius of the Jack-up rig, during transportation to and from Suriname, as well as between well-sites (for

a maximum of 10 wells) within Blocks A, B and C (as no drilling locations have been proposed for Block D);
- Marine transit corridors (exclusive to moving Project-related vessels) between the drilling locations and the shorebases); and
- The ports and shorebases at Havenbeheer/Nieuwe Haven, Vabi and Kuldipsingh in Paramaribo, Integra Marine at Smalkalden, as well as at Boskamp and Nieuw Nickerie, and any major roads used for transportation of equipment and materials during the duration of the Project.

The wider study area for the Project (see Figure 5-1 below) includes the following:

- The rest of Blocks A, B, C and D;
- The surrounding coastal Nearshore and marine offshore waters of the north coast of Suriname, between the Corantijn River, towards the boundary between Guyana and Suriname, to the west, and Marowijne River, towards the boundary between Suriname and French Guiana to the east; and
- The terrestrial (coastal) zone within 2 km of the coastline of Suriname from Corantijn River to Marowijne River (see Figure 5-1 below).

ESL performed various field studies to fill in the data gaps and/or provide more timely or focused information. This included a comprehensive Block-wide assessment of water, sediment and macrobenthic quality from sampling conducted in June-August 2017 (long wet season) and September-November 2017 (long dry season). Baseline water and sediment quality data (including macrobenthos) were also compared to previously conducted studies. These include: baseline sampling within the western half of Block C (formerly Block IV) by ESL in February 2013 (end of short wet season) for the POC ESIA for exploration drilling (ESL 2013b); post drill sampling within the western half of Block C, by ESL in February 2013 for post seismic monitoring related to the POC 2D and 3D seismic program (ESL 2013a); and baseline sampling conducted by CSA International Inc. in May 2014, within offshore Block 52 for Petronas Exploration and Production B.V (CSA 2015a), and which was presented as part of the ESIA submission for Kosmos Energy Suriname's development in offshore Blocks 42 and 45 (CSA 2017).

Other water, sediment and benthic assessment studies have been conducted in the Nearshore area of Suriname in the past. These include datasets collected by ESL in the Nearshore and offshore areas of Suriname in March 2007 (ESL 2007) and September 2010 (ESL 2012), as well as by other parties in April 2010 (Murphy 2010; Teikoku 2010). However, NIMOS has stipulated that the most recent available data (for comparison) must not be older than 5 years, and hence, the results of these previously conducted studies cannot be used in comparison to the baseline data collected for this Nearshore Exploration Drilling Project 2019. Additionally, NIMOS also required that the data be site-specific, and as a result, the data within the 5-year window is not applicable for areas outside of what was previously known as Block IV (and hence the requirement for the project-specific baseline sampling program). A supplementary consideration regarding the site-specific data requirement was that the preliminary drilling locations were not yet known at the time of Staatsolie's application to NIMOS. Instead, focus areas were determined by Staatsolie (within which drilling would be more likely). This drove the planning and design of the Project-specific field surveys mentioned above, where sampling was more rigorous within the confines of the focus areas, as opposed to outside the focus areas, within Blocks A to D.

Seafloor sediment characteristics were also informed by sediment grain size analyses conducted on sediments sampled during the field surveys in June – November 2017. Other primary physical datasets which were used for analyses include meteorological data (for the period July – December 2017) retrieved from ESL's meteorological station located at Weg naar Zee (see Figure 5-1 below); oceanographic (currents, waves and tides) data (for the period October – December 2017) obtained from an ADCP deployed in the Nearshore area, as part of a separate Project between ESL and MAS; and ambient surface noise readings (July 2017) taken at several stations along the shoreline (onshore) from Albina to Nieuw Nickerie (see Figure 5-74 below). Finally, ESL conducted an aerial flyover in July 2017, with site reconnaissance at several locations along the shoreline in February 2018 (see Figure 5-1 below). These data were used for the assessment of coastal environmental sensitivity, and to inform coastal geomorphology.

Other components of the physical environment were assessed through a range of secondary data sources. Bathymetric data was provided by Staatsolie based on previous data collection exercises in the Nearshore area over the period 2014 – 2016. Geology, topography, soil type, and surface and groundwater resources were briefly assessed in this Chapter, based on reports provided by local expert, Mr. Dirk Noordam. Coastal geomorphology, climate and meteorological data were also supplemented with secondary data by Mr. Noordam; and in the case of the latter 2, by the numerical modelling company, Tetra Tech.

Based on previous discussion with NIMOS, it was determined that ambient air quality (offshore), ambient surface noise (offshore) and ambient underwater noise could be described using previous datasets not subject to the 5-year restriction.

Biological components of the coastal Nearshore and marine waters of the north coast marine area (between the westerly Corantijn and easterly Marowijne Rivers were considered in detail. Assessments of marine macrobenthos and plankton were informed by primary data obtained from the June-November 2017 field studies for this Project. Offshore biota, such as marine mammals, sea turtles, fish and shellfish, seagrass beds, macroalgae and coral and reef assemblages were informed by secondary data through Mr. Noordam. The same applied to important onshore biological components, such as mangroves, avifauna, terrestrial mammals, herpetofauna, within an onshore zone 2 km from the coastline, stretching from the river boundaries specified above. The aerial survey conducted in July 2017 also informed the discussion of mangroves, avifauna, ecosystem changes and sensitive habitats across the Suriname shoreline.

The socio-economic and cultural environment was considered within the coastal strip extending from Nieuw Nickerie in the west to Albina in the east (all communities within the coastal plain). The discussion focused on population demographics; economy and employment; identification of resources and resource users; oil & gas activities; emergency resources; fisheries; protected areas; recreation and tourism; archaeological and historical resources; and ports and transportation.

Where applicable, the physical, ecological and socio-cultural data obtained were mapped in relation to the Suriname coastline and Project area, with a view to providing a comprehensive overview of the natural and built resources of the coastal plain. These data, in combination with July 2017 aerial flyover data, were used to conduct environmental sensitivity mapping along the shoreline from Nieuw Nickerie to Albina. These data were ground-truthed at several locations along the shoreline in February 2018. The ultimate goal of the environmental sensitivity mapping exercise was to inform/provide input for the Oil Spill Response Plan (OSRP) to be created and implemented for this Project.

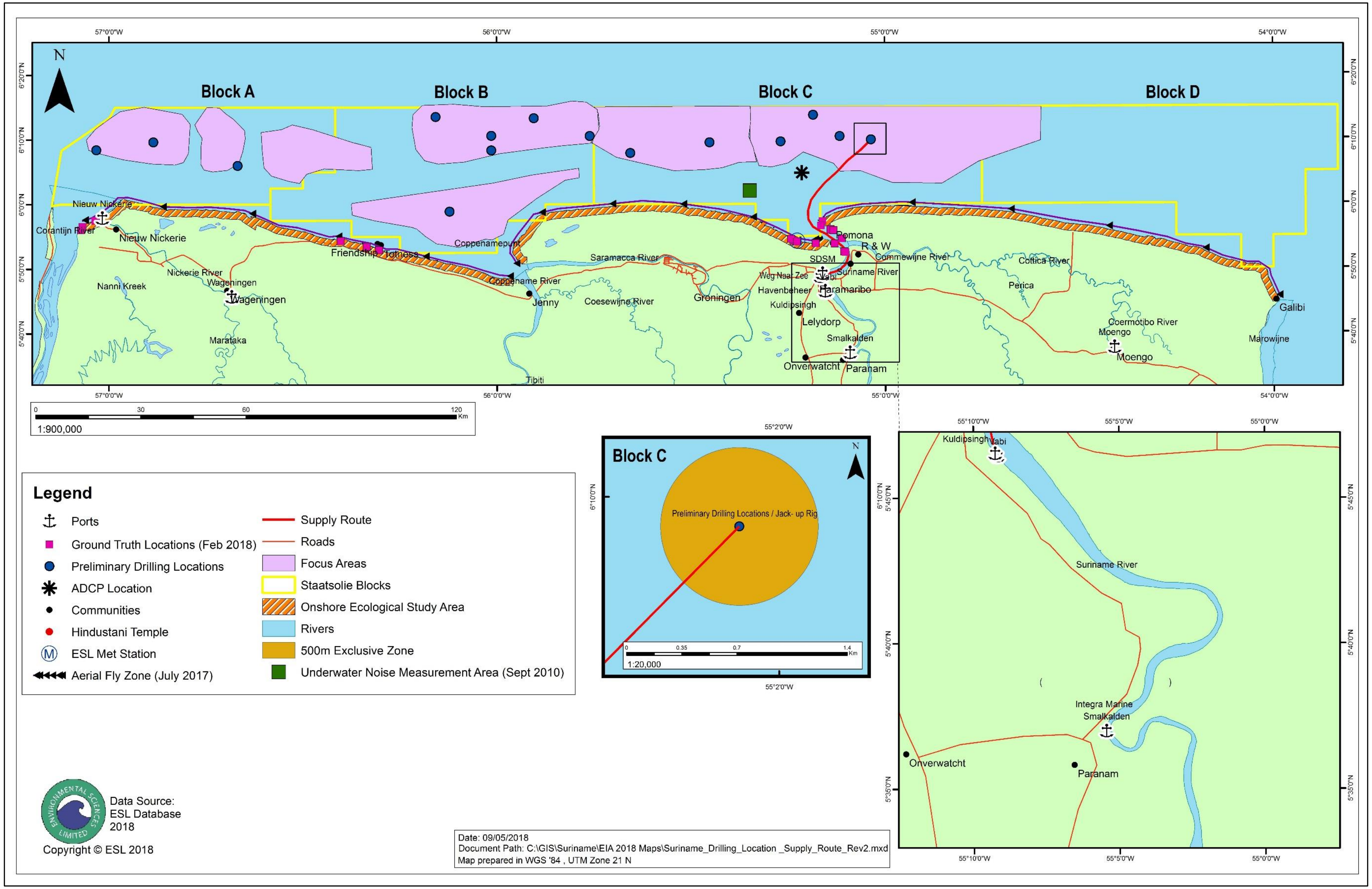

Figure 5-1: Baseline Study Area for the Staatsolie Nearshore Exploration Drilling Project 2019

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5.3 Physical Environment

The Physical Environment comprises the following components each of which will be discussed in detail in the sub-sections below:

- Geology;
- Topography & Soil Type;
- Coastal Geomorphology;
- Hydrology & Drainage;
- Groundwater Resources;
- Climate & Meteorology;
- Bathymetry & Seafloor Surface Characteristics;
- Oceanography;
- Marine Sediment Quality;
- Marine Water Quality;
- Ambient Air Quality (Offshore);
- Ambient Surface Noise (Above Water; Offshore);
- Ambient Surface Noise Quality (Above Water, Onshore); and
- Underwater Noise.

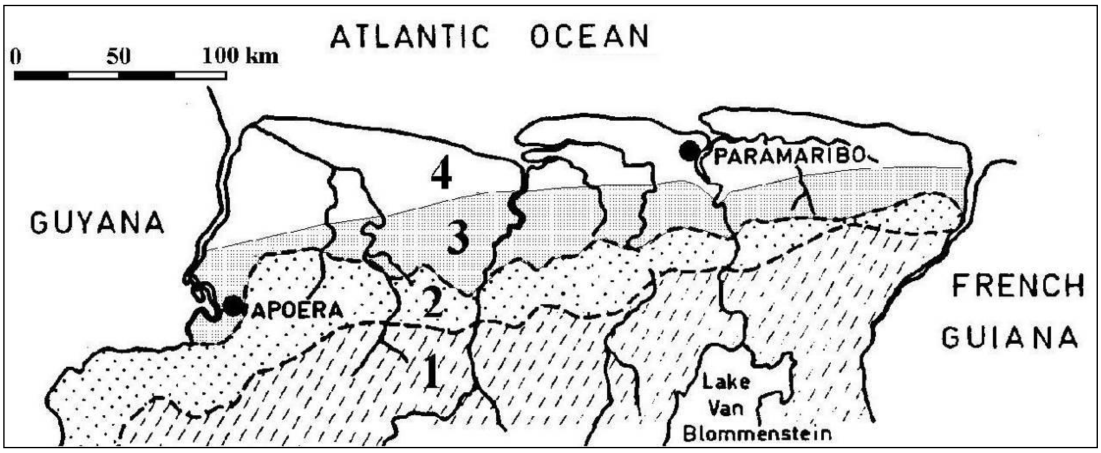
5.3.1 Geology

About three quarters of Suriname is occupied by the Precambrian basement, which consists mainly of igneous and metamorphic rocks of the Guiana Shield. The remainder consists of sediments, which have been deposited since the Late Cretaceous. The oldest outcropping sediments are those of the Late Tertiary Zanderij Formation, which are predominantly of continental origin. North of the Zanderij Formation, the Coastal Plain is found, which can be divided into marine sediments of the Coropina Formation (Pleistocene) and the Coronie and Mara Formations (Holocene).

According to Noordam 2018b (see Appendix D.1), 4 major geographical zones can be distinguished in Suriname based on the geological division (see Figure 5-2):

1. The Precambrian Guyana Shield area, popularly also known as the Interior, the Interior Uplands, or the Hill and Mountain Land;
2. The Zanderij or Savanna Belt (Late Tertiary);
3. The Old Coastal Plain (Pleistocene); and
4. The Young Coastal Plain (Holocene).

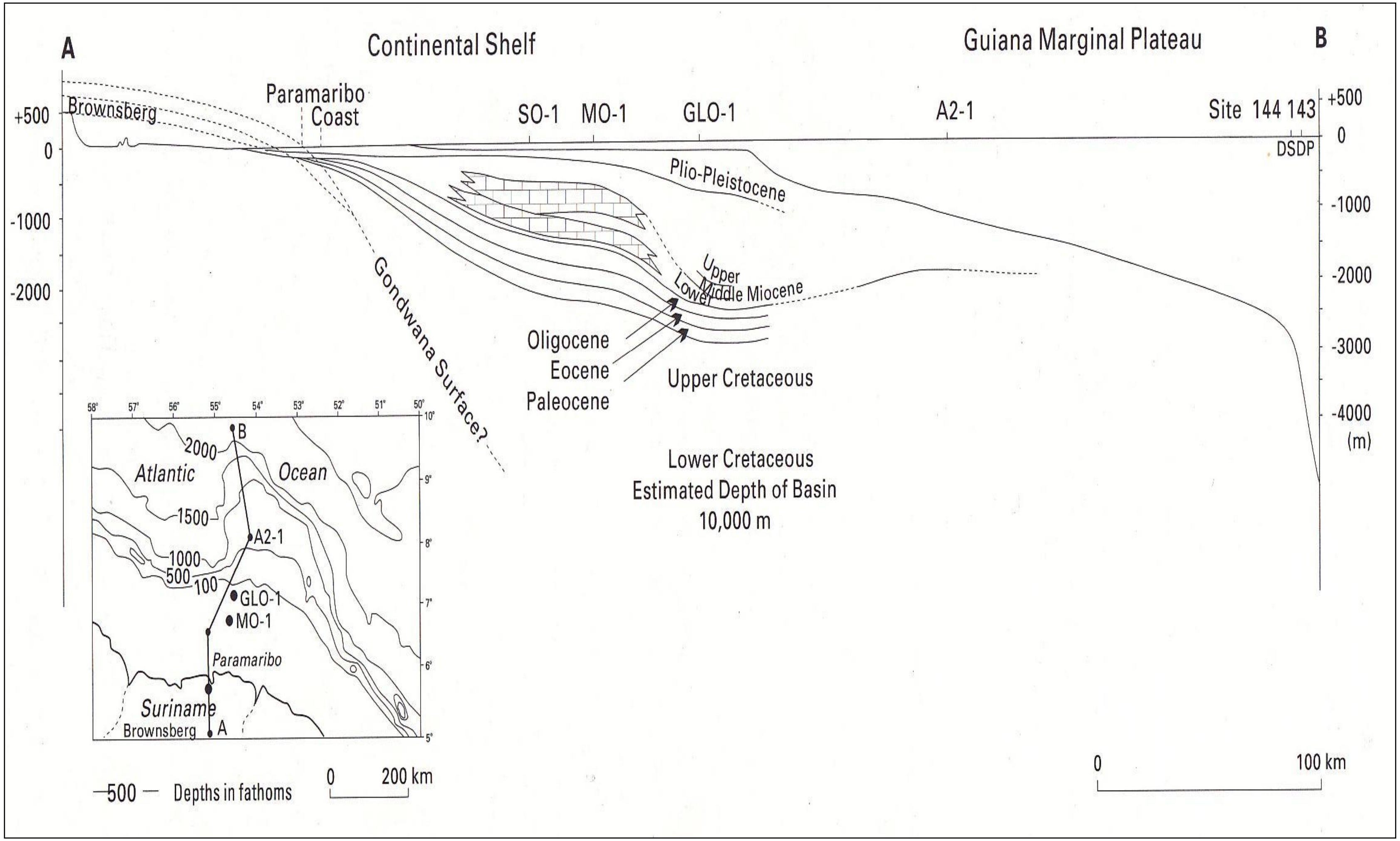
The Project area (Blocks A to D) is located in front of the coastline of the Young Coastal Plain (YCP) and is located on the Continental Shelf. The Coastal Plain (Young and Old, combined; see Figure 5-2 above), together with those of French Guiana and Guyana, forms the marginal part of the large Guiana Basin in which subsidence and sea level movements have greatly influenced sedimentation. This basin originated in the Late Jurassic-Early Cretaceous with the opening of the Atlantic Ocean. After an initial rifting phase, the history of the Guiana Basin has been controlled by the gradual subsidence of a passive or trailing continental margin which underwent little tectonic activity and numerous periods of erosion.



Source: Noordam 1993

Figure 5-2: Outline of the Major Physiographic Regions of Northern Suriname

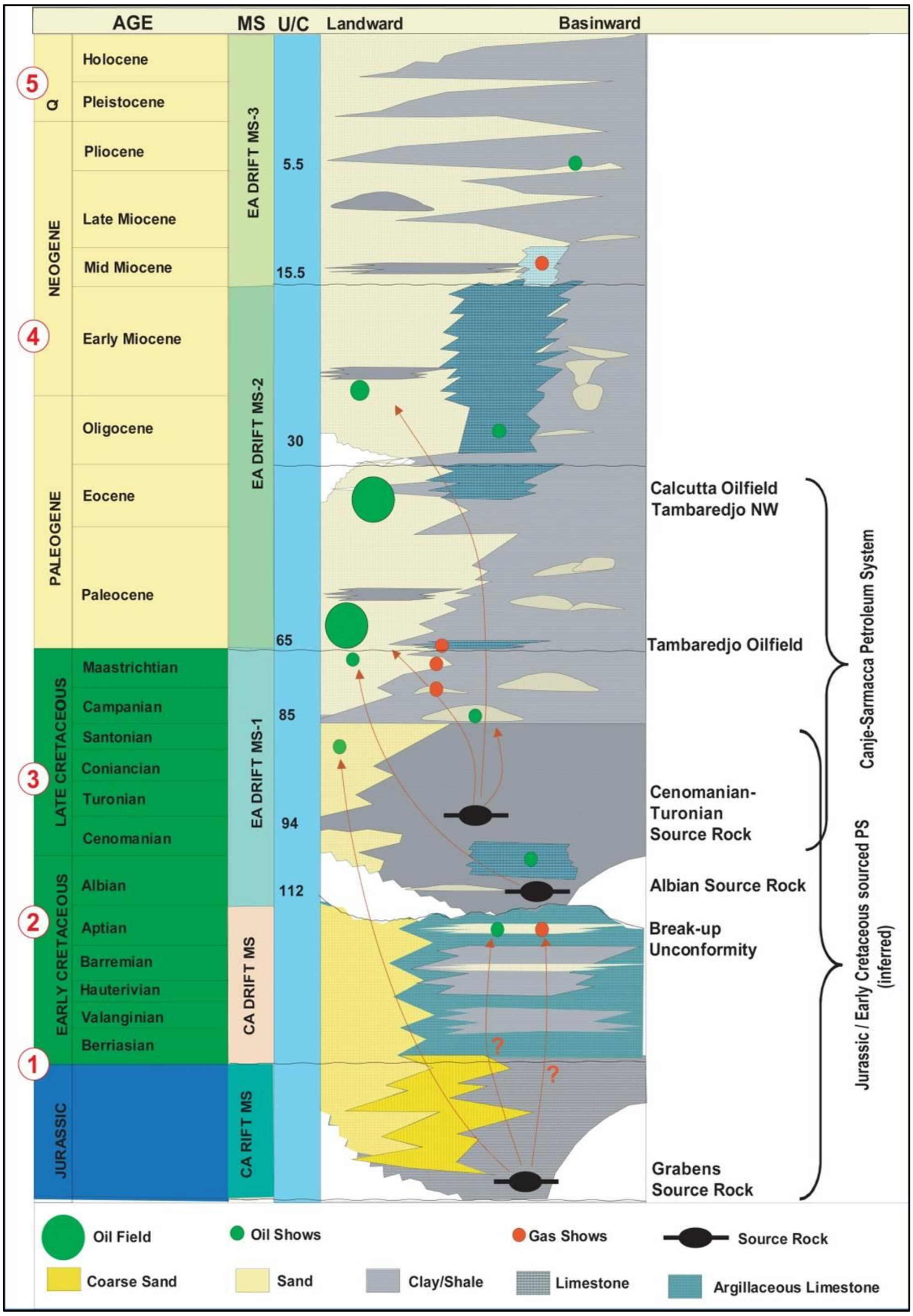
Progressively younger sediments unconformably overlie the gently northward dipping basement rocks. The age of the sediments in the Coastal Plain of Suriname ranges from Late Cretaceous to Holocene. In the offshore area, older sediments of the Early Cretaceous have been encountered. The thickness of the sediment is 5 km at the northern edge of the Continental Shelf to 10 km and more at the Guiana Marginal Plateau to the north of the Shelf. A cross-section showing the sediments is presented in Figure 5-3, based on Krook 1994.



Source: Noordam 2013

Figure 5-3: North-South Section through the Coastal Plain, the Continental Shelf and the Guiana Marginal Plateau

Figure 5-4 below presents the stratigraphic column for the Nearshore area based on seismic and well data obtained by Staatsolie in recent years. The column shows the distribution of coarse sand, sand, clay/shale, limestone and argillaceous limestone which occurs in the Nearshore area (landward and basinward), as well as oil fields and oil and gas shows (Staatsolie 2018a).



Source: Staatsolie 2018a

Figure 5-4: Stratigraphic Column for the Nearshore Area based on Seismic and Well Data obtained by Staatsolie

In the Late Pleistocene, during the last glacial period, regression occurred and the coastline was found 100-150 km north of the current coast along the edge of the shelf (along the top of the Continental Slope; see Figure 5-3 above). Under the prevailing savanna climate of that period, strong erosion occurred and rivers, creeks and gullies dissected the land in the coastal zone. Fringing reefs were formed along the coast of that time, because the water was relatively clear owing to the absence of mud supply from the Amazon River. Fossil coral reefs are still present at the edge of the current shelf (see Section 5.4.1.5 below).

At the end of the Pleistocene, the sea level started to rise and the Continental Shelf was flooded again. The type of sediments changed from predominantly coarse to fine sand into predominantly Amazonian mud. The current sea level was reached about 6,000 years ago and it has remained at about the same level since, although some minor regressions have occurred.

The current coast of Suriname is part of the coastal system which extends from the mouth of the River Amazon in Brazil to the mouth of the River Orinoco in Venezuela. It has been classified as muddy because immense volumes of argillaceous muds (pelite) are being deposited along what is considered the world's longest continuous mud coastline (the Guiana Coast). The source of the pelite, including fine sands, is the Amazon Basin. Much of it (estimates of 36 - 68%) is deposited on the shelf off the Amazon mouth.

It is estimated that approximately 150 x 10^6 tons/year of ‘through transport' takes place in the form of suspended sediment, while an additional 100 x 10^6 tons/year is carried in the mudbanks (Wells and Coleman 1978; Eisma *et al*. 1991). Of all the suspended matter supplied by the Amazon River, a maximum of 1% is deposited along the French Guiana-Suriname-Guyana coast on top of the older Plio-Pleistocene deposits (Eisma *et al.* 1991). Coarser sandy material is currently only supplied by rivers from French Guiana and the Marowijne River. Shells originate from the coastal waters.

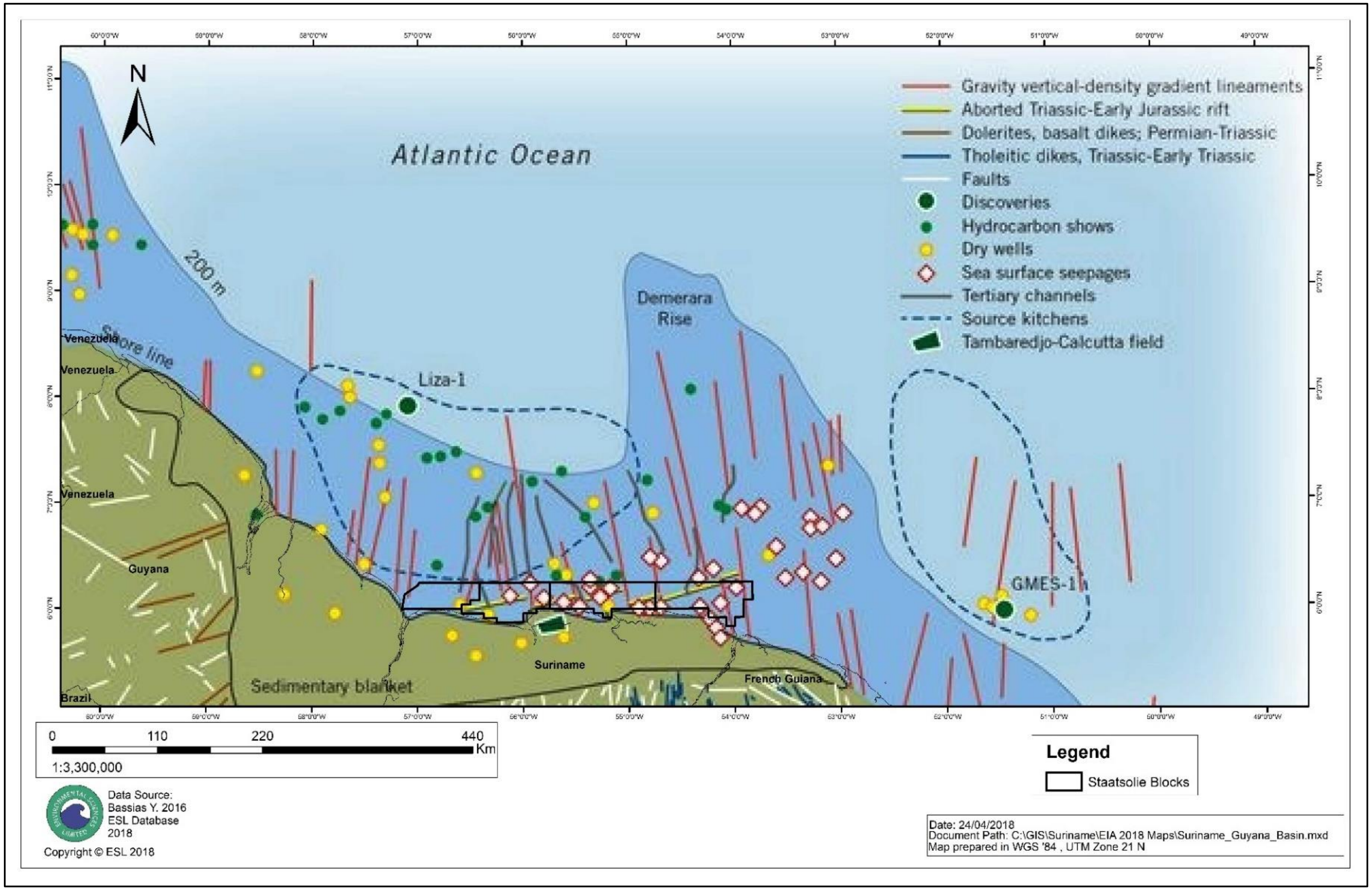
The Project area is situated in the Nearshore section of the Continental Shelf. Along the coast, huge masses of Amazonian mud are present, extending from the coast some 20-30 km outwards. The mud has a thickness of approximately 20 m. To the north of the mud zone, at a depth of 21-30 m, sandy deposits are present at the shelf surface. The bottom configuration and the related sediment in this part of the shelf are considered to be a relic of the Late Pleistocene-Early Holocene transgression (Nota 1958; 1967). A large part was deposited as cheniers along former coastlines that existed during interruptions in the Early Holocene sea level rise.

Oil and gas seeps are natural springs where liquid and gaseous hydrocarbons (hydrogen-carbon compounds) leak out of the sediment surface. Oil and gas seeps are fed by natural underground accumulations of oil and natural gas (USGS 2011). Bassias 2016 states that fault lines lying NNW – SSE within the South American region shown in Figure 5-5 below were reactivated during the

Cretaceous E-W drift creating depositional channels along the same direction. These channels facilitated the southward, shoreward migration of hydrocarbon in the South American – Central Equatorial Margin.

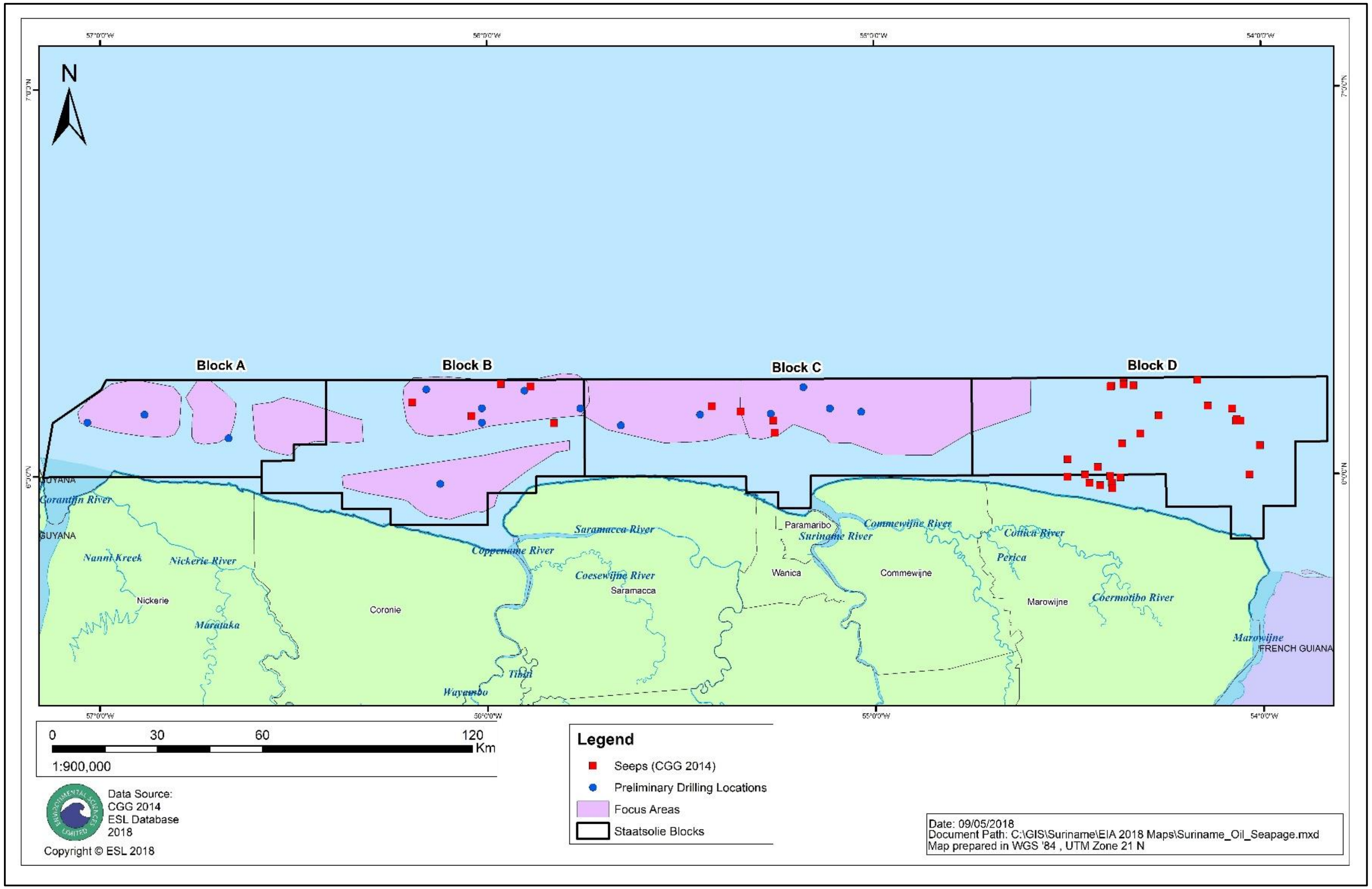
Along the eastern coast of Suriname, sea surface seepages were detected using Landsat, spot optical and radar images. This seepage distribution is consistent with the NNW – SSE faulting direction, direction of the channels formed, and hydrocarbon shows Nearshore Guyana and Suriname (Bassias 2016).

A 2014 study conducted by CGG (UK) Limited revealed the presence of a number of oil seeps within Nearshore Blocks A to D (Figure 5-6 below). The data showed that the majority of seeps are located within Block D, with fewer seep locations in the central portion of Block C, and the northern portion of Block B (CGG 2014).



Source: Bassias 2016

Figure 5-5: Seepage Areas along the Guiana Coast (Bassias 2016)



Source: CGG 2014

Figure 5-6: Oil Seeps occurring within Nearshore Blocks A – D (based on CGG 2014)

5.3.2 Topography & Soil Type

According to the classification by Brinkman and Pons 1968, the land bordering the Nearshore project area is formed on sediments of the Comowine phase, which are not older than 1,000 years. The Nearshore coastal zone is predominantly developed on extensive clay flats, but directly along the coastline, narrow sections with beaches are observed in Marowijne and Commewijne. These beaches are composed of sand and/or shell and only up to 80 m in width (often far less). The most extensive beaches are found directly west of the Marowijne River, near Galibi, and directly east of the Suriname River (Braamspunt). At Braamspunt, the beaches are formed on a number of spits[10] (Figure 5-7 below).

Source: ESL Aerial Flyover, July 2017

Figure 5-7: Spit at Braamspunt

In the coastal section in between Galibi and Braamspunt, beaches usually occur in the form of overwash bars, but extensive sections of clay/mud coast are also found in eastern Commewijne and western Marowijne. Overwash bars are also found in western Coronie and Nickerie, but mostly as the "*guirlande*" (garland) type, forming very low (up 50 cm), narrow (up to 30-35 m wide, usually far less) and thin (up to 50 cm in thickness) sand bodies on top of the clay.

The remaining coastline (east Coronie, Saramacca, Wanica and Paramaribo) have a clay/mud coast. The elevation of the coastal clay flats is estimated at

[10] *A spit is an extended stretch of beach material that projects out to sea and is joined to the mainland at one end. Spits are formed where the prevailing wind blows at an angle to the coastline, resulting in longshore drift (Sen Nag 2017).*

1.5 m above mean sea level (msl), but further inland the land becomes slightly lower due to subsidence as a result of soil ripening. Ridges, if present, are up to 0.50-1.50 m higher. The soil conditions of the clay soils in the area are rather homogeneous, with slight differences in degree of ripening and soil salinity level. Dominating soils can be characterised as "*very poorly drained, saline to brackish, nearly unripe to half ripe (soft) gray clays; usually without a peat layer, or with a thin peat layer up to 20 cm in off coast locations*" (Soil Survey Department 1977, E2 Alliance Inc. 2000). Where coastal land is developed and drained, the clays will be firmer, and have mottles, but are less saline. The degree of increase in ripening will depend upon the period that the land has been subjected to improved drainage. Developed areas along the sea coast are found in Coronie (former plantations), Weg naar Zee (recent development since the 1970s and 1980s) and Matapica (former plantations). In Coronie and Matapica, the clay soils are ripe (firm) with strong mottling. However, the sea has inundated part of these abandoned plantations once more, so that fresh mud has been deposited, while salinity of the soils has increased. In addition, significant parts have been eroded by the sea.

In Coronie, a sea dike (13 km) was constructed in order to protect the land against accelerated coastline erosion. A similar dike is present along the estuary of the Corantijn/Nickerie Rivers (7 km) to protect the inland Nickerie rice polders.

Most developed land at Weg naar Zee has only been used for a short period and the soils have turned into half to nearly ripe clays with moderate mottling. Much of the reclaimed land in this area was eroded during the last decades.

The sandy sediments along the coastline of eastern Suriname are composed of medium sand with or without shell grit and those in western Suriname of fine sand with or without shell grit. Soil development has not yet taken place.

The zone with young mangrove forest is flooded during high tides. The older mangrove forest is only flooded by rainwater as a result of excess rainwater during the rainy season. The mud-mangrove coast is always highly dynamic, and periods of retreat and accretion succeed each other. This is also the case in the study area, which shows sections with accretion alternating with sections with variable degrees of erosion. The coast with significant erosion shows more or less clear "happen" (bites), while the coast without erosion follows a straight line. Additional information on coastal geomorphology is presented in Section 5.3.3 below.

5.3.3 Coastal Geomorphology & Physiography

5.3.3.1 Current Geomorphological Processes along the Coast

With respect to hydrodynamic conditions, the Suriname coast is classified as a low to medium energy coast (Augustinus 1978). It is dynamic and subjected to an active geomorphological development, which is determined by a system of cyclic accretion and erosion. Both are linked to the presence of shoreface-attached mudflats/mudbanks (mudbanks have been defined as the subtidal extension of the intertidal mudflats), which continuously migrate to the west driven by the alongshore Guiana Current and wave action. This migration is the result of deposition of fluid mud at the western side and the simultaneous erosion of the eastern side. The mudbanks are separated by intermediate troughs. In this way, each coastal location is alternately exposed when a trough is passing and protected by a mudbank during the following period.

Based on several investigations and historical information, an average mudbank-trough length of 45 km and a 'periodicity' of approximately 30 years were calculated for Suriname, indicating an average rate of propagation of the mudbank/mudflat systems of 1.5 km/year (Augustinus 1978). Recent investigations indicate that certain mechanisms modify this general pattern. Cyclic changes in wind direction and wind speed (and related to that, the wave climate) are thought to result in changes in mudflat characteristics and changes in the coastal erosion and accretion cycle (Augustinus *et al.* 1989). For instance, the mudbanks show a gradual increase in the length during the last 50 years, while the bank celerity[11] has decreased over this same period (Augustinus 2004a).

Along the Suriname coast, there are large differences in accretion/erosion rates, with, for instance, considerable accretion along the Saramacca coast since the early 1960’s, and ongoing retreat around Coronie, and northwest of Paramaribo (Weg naar Zee area). Generally speaking, accretion occurs at locations sheltered by the mudbanks, whereas coastal retreat occurs in between mudbanks, when the coast is unprotected from waves.

Accretion and erosion are characterised by specific landscapes, which often succeed each other within one accretion-erosion cycle. Three major types of coastal landscapes have been distinguished along the Suriname coast (Augustinus 1978):

a) A mud accretionary coast;
b) A sand accretionary coast; and
c) An erosional coast, which may be either indented or straight.

[11] *In general, celerity refers to speed or swiftness of movement. When used in the context above, this means that the mudbank has slowed its rate of growth, as compared to the last 50 years (based on Augustinus 2004a).*

The movement of mudbanks causes accretion of the coasts where they become attached to the coastline. When a mudflat (Figure 5-8a below) is silted up until around the mean high water mark (MHW), Black mangrove (*Avicennia germinans)* starts to develop. Black mangrove forms an almost uninterrupted belt along the coast (see Section 5.4.6 below). Below MHW, a mudflat is too wet for a healthy mangrove forest to develop.

Beach ridges (Figure 5-8b below) provide an important protection against erosion. When a ridge is eroded, the protection will gradually disappear and erosion will occur (see text below). Extensive sandy beaches are only found in the eastern part of Suriname. Only few of these actually show accretion toward the north and can therefore be indicated as a sand accretionary coast. Most of the beaches here are subjected to beach drift, by which the ridges gradually move towards the west and they do not show accretion. These latter beaches are in fact part of an erosion coast, even though they are sedimentary features.

An erosional coast can be either straight or indented[12]. Erosion occurs mostly in the stretches in-between the mudbanks (in the troughs), where wave action is more intense. Erosional coasts are characterised by uprooted trees that have all fallen in one direction (Figure 5-8c below). Upon severe erosion, tree trunks are still present and large amounts of debris can be seen to the western side of the eroded section. Low cliffs are characteristic of relatively rapid erosion of already firmer (ripened) clay.

When sand or shells are available, a sand accretionary coast may develop. But in most parts of the coast, the quantities of these materials are limited and erosion will occur. As long as sufficient quantities of sand and shells are present, there will be a straight erosional coast, consisting of a beach ("overwash bar") that moves gradually landward while the underlying clay is being eroded (Figure 5-8d below). Overwash bars are composed by relatively thin (on average 50 cm) layers of sand, with or without shell grit, deposited on top of clay. Often, the sand of the overwash bars is thrown into the coastal mangrove forest.

When the overwash bar has become so small that it no longer provides any protection, the erosion will intensify within existing or newly formed erosion channels, which results in an indented coast with bights and capes, locally known as "happen (or bites) coast" (Figure 5-8e below). Small portions of sand may still be present in indented zones with most sand being deposited inside the "bites". The coastal form with such overwash bars is called a "guirlande" (garland) coast (Figure 5-8f below).

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[12] *An indented coastline refers to a coastline which shows a series of hollows, notches, or cuts (*see *Figure 5-8e below). A Straight coastline is typically a stretch of coastline with these hollows, notches and cuts absent (see Figure 5-8b below).*

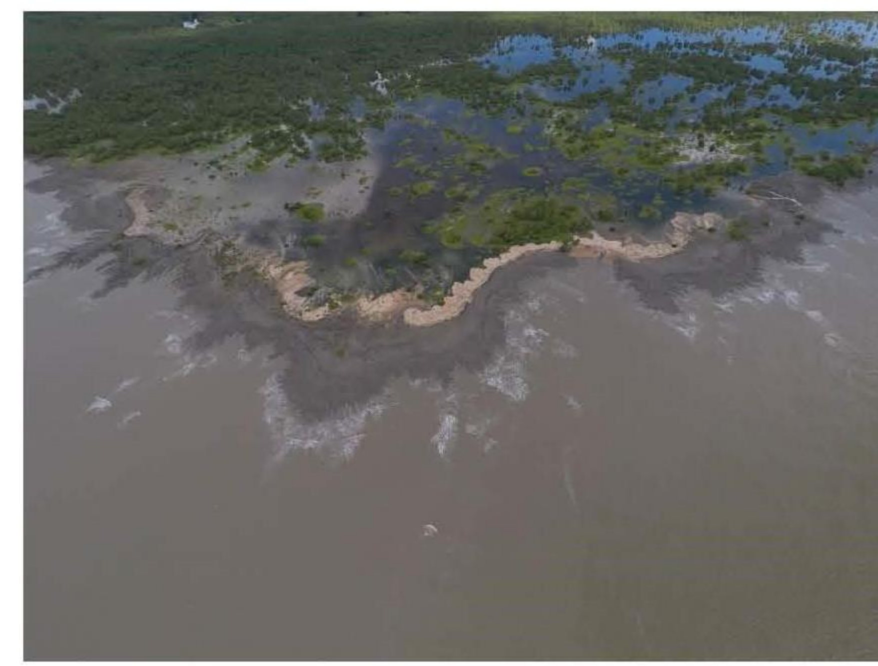
(a) Well-Developed Mudflat in Front of the Saramacca coast

(b) Beach in Commewijne

(c): Erosional Coastline with Uprooted Mangrove Trees in District Coronie (~ 14 km E of Totness)

(d) Overwash Bar with Sand thrown into the Mangrove Forest in District Nickerie (~35 km W of Friendship)

(e) Indented Erosional Coast (Happen Coast) in District Coronie (~7 km E of Totness)



(f) Guirlande Overwash Bar along Happen Coast with Eroded Old Mudflat in District Nickerie (~28 km E of Nieuw Nickerie)

Source: ESL Aerial Flyover, July 2017

Figure 5-8: Geomorphological Features of the Suriname Coastline, based on Aerial Photography (July 13th – 14th, 2017)

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5.3.3.2 The Young Coastal Plain (YCP)

Three main morphological units can be distinguished in the coastal and sea area of the Guiana Basin:

- Onshore:
    - The Coastal Plain
- Offshore:
    - The Continental Shelf or Continental Flat with water depths up to 100 meters
    - The Guiana Marginal Plateau or Demerara Rise where water depths reach 3,000 m or more

The Coastal Plain is discussed hereunder; the offshore aspect is discussed in Section 5.3.10.1 below.

The Coastal Plain has a young (Holocene) and an old (Pleistocene) part, and comprises of Young and Old portions (see Section 5.3.3 and Figure 5-2 above), of which the Young Coastal Plain (YCP) pertains to the baseline study area for this Project. The YCP, which is of Holocene origin, covers the northern part of Suriname, bordering the Atlantic Ocean. It has a width of only a few km in the east, while in the west may extend up to 60 km inland. The YCP covers an area of approx. 12,000 km^2.

The YCP features extensive, flat and low-lying formations of heavy marine clay usually overlain by a layer of peat (locally known as “pegasse”). This landscape has been named the Nickerie landscape. The clay flats have a very low elevation with the major part having elevations around 1 ± 0.5 m (amsl). Due to excess rainfall and very slow drainage, these areas are inundated during the rainy seasons, and also during part of the dry seasons.

The clay flats are locally interspersed by roughly east-west striking ridges (former beaches). The ridges form elongated, narrow bodies, often comprising sand, but locally also admixtures consisting of broken shells (shell grit) and pure shells are also found. The ridges which rise 1-3 m above the surrounding clay flats, may occur singularly, or in bundles, often between 10 – 400 m wide. Ridge bundles are particularly abundant to the west of the main rivers, however, in recent time (Comowine phase: 1,000 yr BP), ridge formation is limited to generally narrow and shallow ridges.

5.3.3.3 Current Physiography of the Coast

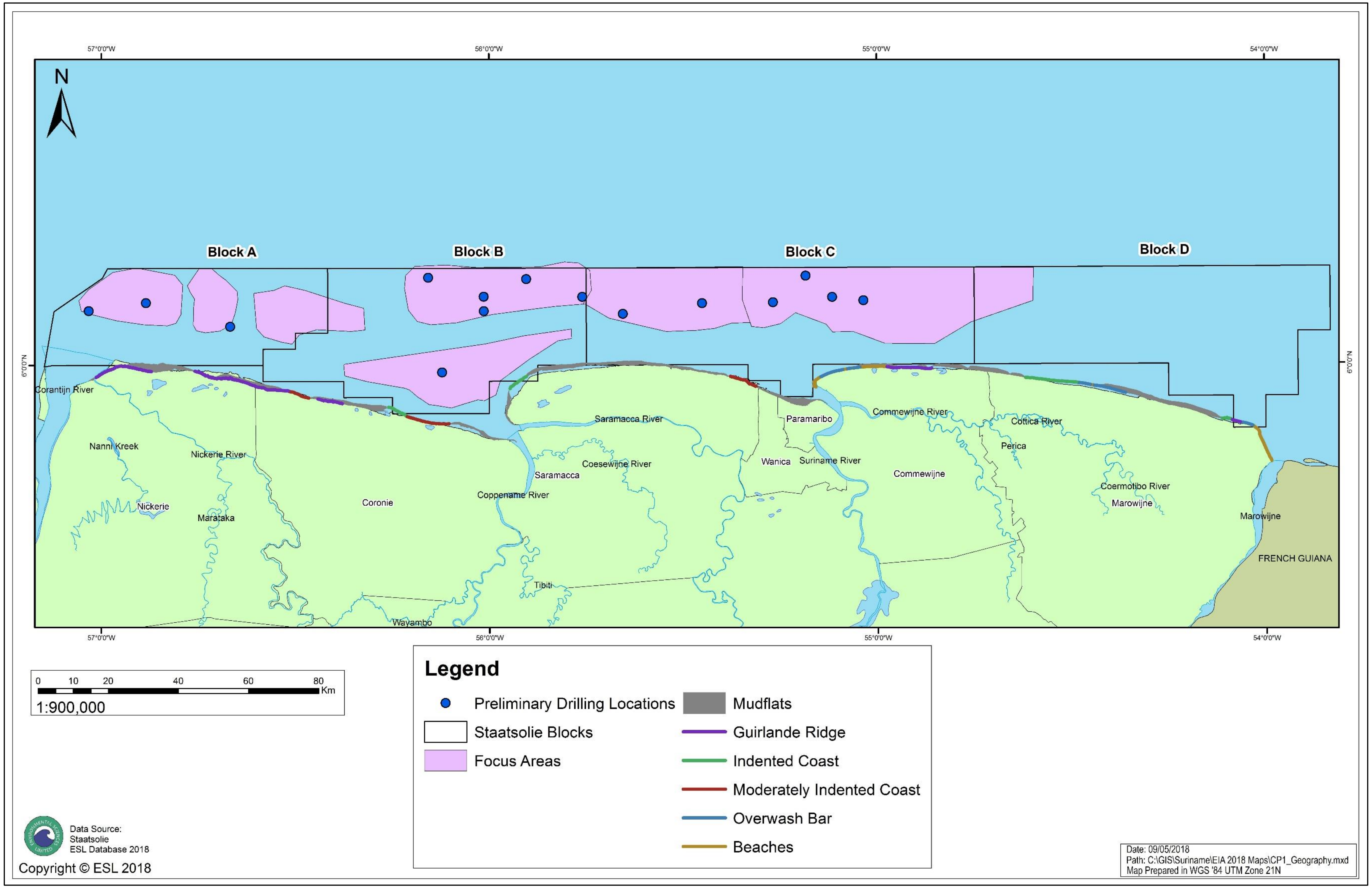
The current coastline is described and illustrated in Figure 5-9 below, based on recent aerial photographs, taken during the coastal flyover on July 13th – 14th, 2017. It should be noted that these photographs showed an area of limited dimensions, owing to the need to fly at a relatively low height in order to decipher coastal features during photographic analysis. Thus, the photographs showed a small section of the coast and often not the full extent of mudflats.

The coast of Suriname is currently characterised by the presence of 10 mud banks with mudflats varying in length between 13 and 58 km (see Figure 5-8a above). The Nickerie and Coronie coastlines are dominated by soft and saline marine clays, but extensive sections with a “guirlande” and straight overwash coastline are found in Nickerie and west Coronie (Figure 5-9 below; see also Figure 5-8d and Figure 5-8f above).

Four mudflats are present along the Nickerie/Coronie coastline, mostly about 20 km in length, but with a shorter one west of the Coppename River (11 km). In between the mudflats the coast shows a ‘happen’ or indented coast (see Figure 5-8e above), with (Nickerie) or without (Coronie) “‘guirlande”’ overwash bars (see Figure 5-8f above). A narrow mudflat is present along the eastern coast of the Corantijn estuary.

The coast of Saramacca, Wanica and Paramaribo is completely built up by clay from mudflats. Mudflats almost completely cover the coastline of these districts, with only 2 short sections of erosional ‘happen’ coast (Figure 5-9 below west of the Suriname River).

The coast of Commewijne and Marowijne has large sections with beaches and overwash bars in the west, centre and east (Figure 5-9 below). In between, clay is found along the coast with 3 mudflats, one shorter one and 2 elongated ones. The mudflats are partly situated in front of beaches. A long stretch with an erosional ‘happen’ coast can be observed along the west Marowijne coast.



Source: Noordam 2018d, based on ESL Aerial Flyover photography; see Appendix D.1)

Figure 5-9: Physiography of the Suriname Coastline, based on Aerial Photography (July 13th – 14th, 2017)

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5.3.4 Hydrology & Drainage

5.3.4.1 Freshwater Resources & Discharge Rates

Surface freshwater resources include rivers, swamps, lagoons and man-made lakes. Changes in the rainfall pattern are directly observed in the hydrological regime of the rivers and swamps. There are 7 main rivers in Suriname. From west to east, they are: Corantijn; Nickerie; Coppename; Saramacca; Suriname; Commewijne; and Marowijne (see Figure 5-1 above).

Most of these rivers have their origin in the centre of the country and flow in a general direction from south to north, though the lower courses of the Commewijne and Saramacca Rivers flow from east to west. Table 5-1 below provides the hydrological characteristics of the main rivers. The largest rivers by discharge volume are the Marowijne and Corantijn Rivers, bordering French Guiana in the east and Guyana in the west, respectively. In contrast, the Saramacca and Commewijne Rivers are the smallest.

Table 5-1: Hydrological Characteristics of the Main Rivers in Suriname

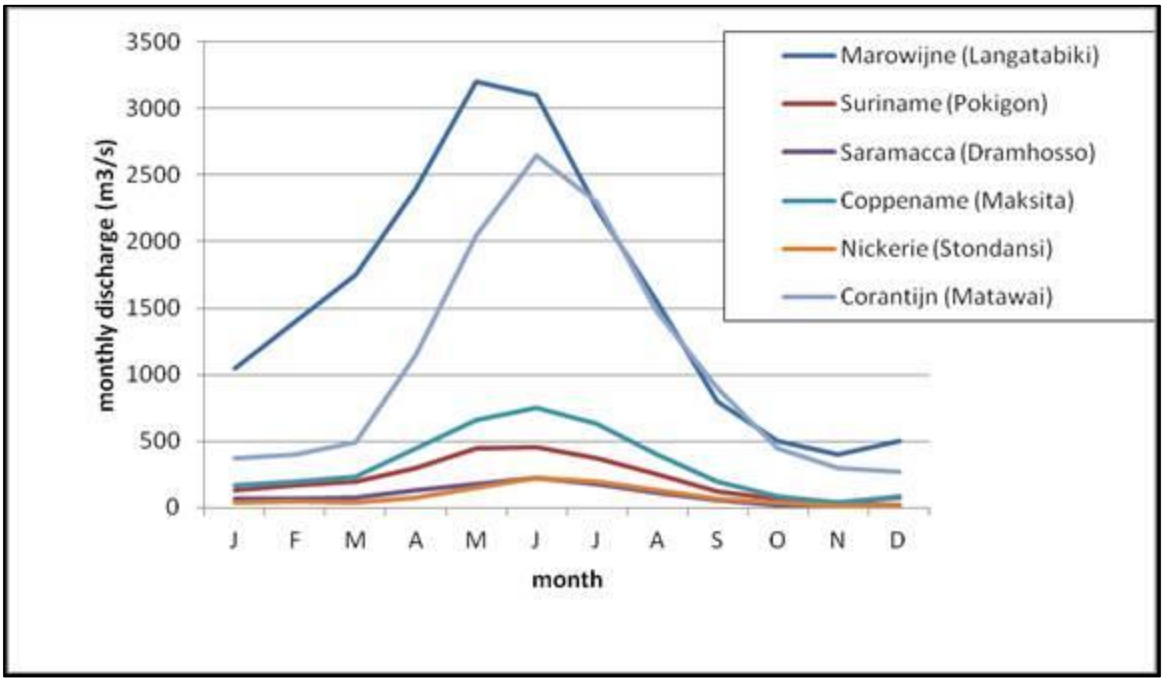
Main River	Basin Area (km^2)	Mean Discharge at Outfall (m^3/s)	Specific Discharge ($l/sec/km^2$)
Marowijne	68,700	1,780	25.9
Commewijne	6,600	120	18.2
Suriname	16,500	426	25.8
Saramacca	9,000	225	25.0
Coppename	21,700	500	23.0
Nickerie	10,100	178	17.6
Corantijn	67,600	1,570	23.2

Source: Amatali and Naipal 1999 in Noordam 2018c; see Appendix D.2

The average mean monthly discharge (m^3/s) of the main rivers over the period 1952-1987[13] is presented in Figure 5-10 below. The data revealed that the Marowijne and Corantijn Rivers had significantly higher discharge than that of the other rivers, and that the Marowijne displayed significantly higher discharge in during the January-June period, over the Corantijn.

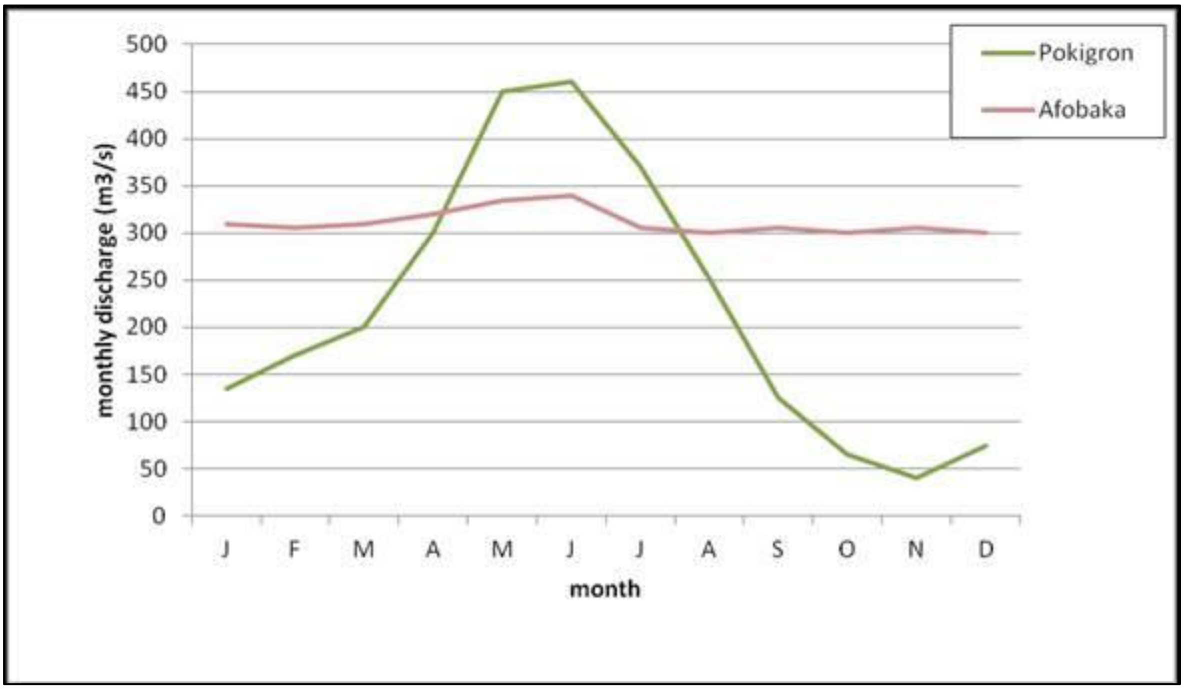
Though the discharge rate varies, the pattern across the year is identical for all rivers. All rivers show peak discharge during May – July and lowest discharge in October and November. The Marowijne River has its peak earlier than the other rivers. The Suriname River is regulated by the dam at Afobaka. Due to this, the discharge downstream of Afobaka is very gradual across the year, with only a minor increase in the May-June period (Figure 5-11 below).

[13] *For most rivers, data are only available for part of this period, and this information refers to stations beyond the tidal limit.*



Source: Amatali and Naipal 1999 in Noordam 2018c; see Appendix D.2

Figure 5-10: Annual Variation in Mean Discharge (m^3/s) of the Main Rivers of Suriname



Source: Amatali and Naipal 1999 in Noordam 2018c; see Appendix D.2

Figure 5-11: Annual Variation Mean Discharge of the Suriname River at Afobaka (downstream of Dam) compared with Pokigron (upstream of Dam)

5.3.4.2 Tidal Influences in Rivers

Given the preliminary drilling locations (see Figure 3-1 in Section 3.2 above) and the prevailing oceanographic conditions along the Guiana Coast (see Section 5.3.8 below), the estuaries and areas of confluence which may be directly affected by Project activities are those of the Suriname, Coppename and Corantijn Rivers (see Figure 5-169 of Section 5.5.7 below). These estuaries are of ecological, economic and socio-cultural importance to Suriname (see Section 5.4 and Section 5.5 below).

These estuaries are tidal; tidal amplitude moves upstream through rivers and creeks, into the YCP and beyond, gradually decreasing with distance further inland from the mouth. The variation of the propagation speed of the tide is fairly large (reaching speeds of up to 25 km/h along the Suriname River). As in all tidal estuaries, tidal prisms[14] occur, the volume of which is dependent upon the tidal range. Tidal characteristics of the main rivers of Suriname are presented in Table 5-2 below.

Table 5-2: Tidal Characteristics of the Main Rivers of Suriname

River	Mean tidal range at outfall (m)	Tidal volume (10^6 m^3)
Corantijn	2.0	300
Coppename	2.0	75
Suriname	1.8	125
Saramacca	nd	50
Nickerie	2.0	10
Commewijne	1.9	40
Marowijne	2.0	200

nd- no data; *Source: Hydraulic Research Division; see Appendix D.2*

The mean tidal range at Paramaribo is 1.85 m. The velocity of the currents can vary rather strongly and depends mainly on the range of the tide, the river discharge and the location. Maximum velocities during flood are somewhat higher than during ebb. Ebb velocities are 10-20% lower than flood velocities, but during the ebb tide, high velocities occur for a longer time. At neap tide, the current velocities are about half of those during the spring tide. The highest current velocities occur in the mouths of the estuaries, up to about 1.8 m/s at spring tide. Farther up-river, the velocities gradually decrease. Average maximum flood flow occurs about 1.5 hours before local high water (Augustinus 1978, NEDECO 1968, Stuip 1982).

[14] *The tidal prism is the volume of water exchanged between a lagoon or estuary and the open sea in the course of a complete tidal cycle (American Meteorological Society; n.d.).*

5.3.5 Groundwater Resources

Suriname consists of 2 hydrologically distinct provinces: an interior Precambrian Shield of crystalline rocks, which comprises 80% of the country; and a Coastal Plain basin, which comprises the remaining 20%. The wider onshore study area is found in the Coastal Plain basin. Here, an abundance of ground water is confined under artesian conditions with water levels close to the ground surface. The aquifers are built up by unconsolidated and consolidated clastic sediments comprising of clay, sandy clay, and coarse-grained angular quartz sand that are more or less kaolinitic (USACE 2001).

Within the coastal area of Suriname, the 3 most important aquifers are the Zanderij (Plio-Pleistocene age), Coesewijne (Miocene age) and A-sand (Oligocene age) freshwater aquifers. The Zanderij aquifer is located nearest the surface, and overlies the Coesewijne aquifer. The A-sand aquifer underlies the Coesewijne aquifer (USACE 2001).

As groundwater typically follows the topography of the surface ground, albeit in a much smoother line, the depths at which the aquifers are found, varies at different locations. Table 5-3 shows the depths the 3 aquifers can be encountered at the western and eastern parts of Suriname.

Table 5-3: Depth and Thickness of Aquifers in Suriname

Aquifer	Western Suriname (Nieuw Nickerie: 0557N05659W)		Eastern Suriname (Paramaribo: 0550N05510W)	
	Depth (m)	Thickness (m)	Depth (m)	Thickness (m)
Zanderij	50	230	30-40	40-50
Coesewijne	230	120	70-110	100
A-sand	340	80	120	50

Source: USACE 2011

Ground water resources of Suriname are used for public supply and to a lesser extent, industry. Ninety-five per cent of the country's total supply of potable water comes from ground water. Of the 63 water supply systems in Suriname, 41 use ground water. In the coastal areas, 40 water treatment plants are supplied by 163 wells (USACE 2001).

5.3.6 Climate & Meteorology

The various aspects that contribute to the climate and meteorology of Suriname is described in the subsequent sub-sections, based on secondary data acquired from published sources within Suriname, and from records held by the Meteorological Service and the Hydraulic Research Division (Noordam 2018c; see Appendix D.2). In the virtual absence of meteorological stations directly along the coastline, stations more inland were encompassed in order to get an overview of climatological conditions in the coastal zone (Figure 5-12 below).

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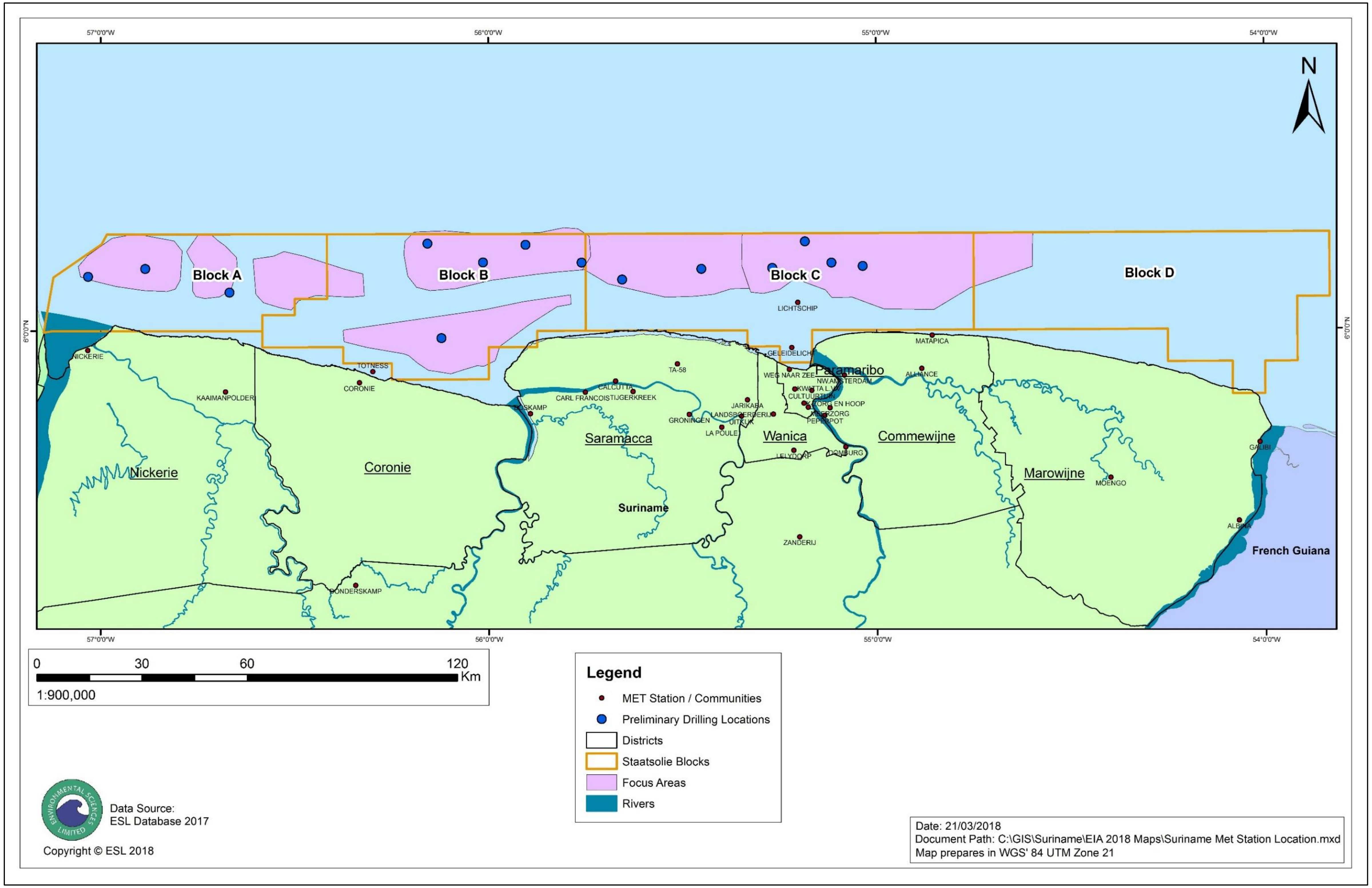

Source: ESL Database 2018, Source: Meteorological Service and Hydraulic Research Division; see Appendix D.2

Figure 5-12: Location of Meteorological Stations used for this Study

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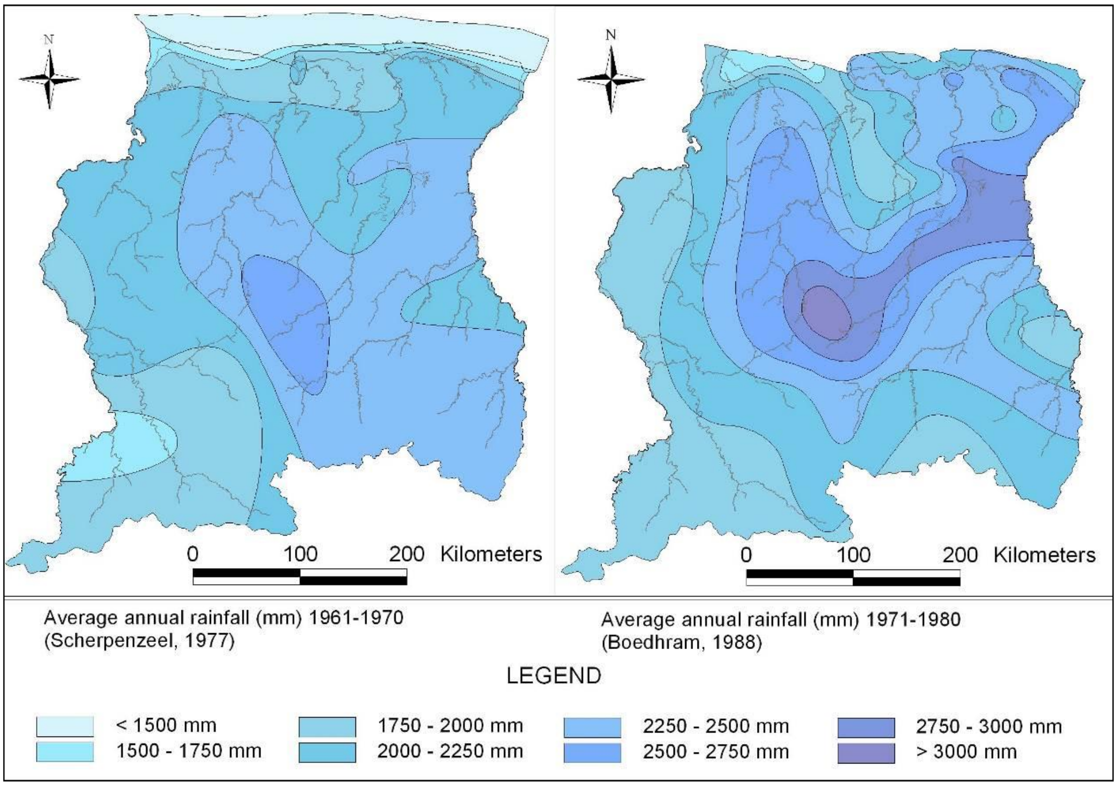
5.3.6.1 Precipitation

5.3.6.1.1 Annual Precipitation

Most of Northern Suriname has a Tropical Rainforest Climate (Af climate in Köppen's classification). Within this climate type, the average rainfall exceeds 60 mm in the driest months. A narrow strip along the coast, which has drier conditions, forms an exception. Here a Tropical Wet and Dry or Savanna Climate (Aw climate in Köppen's classification) is found with less than on average 60 mm in one or more months (Amatali & Naipal 1999).

The driest months in Suriname are September, October and November.The average annual rainfall in the eastern and central part of northern Suriname predominantly ranges between 2,000 and 2,500 mm, but in the narrow coastal strip it ranges from 1,500 and 2,000 mm (Figure 5-13 below). This drier zone extends to the north above the Atlantic Ocean (see Figure 5-13 below, left) and Lichtschip station has only 811 mm of rainfall per year. The western coastal region (west of the Coppename River) is overall drier, with rainfall between 1,500 and 2,000 mm/year, and in some nearcoastal parts even less than 1,500 mm (see Figure 5-13 below).

Meteorological data related to the average annual precipitation over a longer period (1961-2009) at Lichtschip is most representative of the meteorological conditions that may be experienced within the Project area. This is because (i) the Lichtschip meteorological station is located in the marine waters of Block C (about 5 km north of the Suriname's coast; see Figure 5-13 above); and (ii) it is the only offshore location for which meteorological data is available. The average annual precipitation at this station was recorded as 792 mm for this specified period (1961 – 2009), and reflects the reduction in rainfall north of the coast, as stated above.



Source: Scherpenzeel 1977 and Boedhram 1988

Figure 5-13: Average Annual Precipitation over the Periods 1961-1970 and 1971-1980

5.3.6.1.2 Seasonal Precipitation

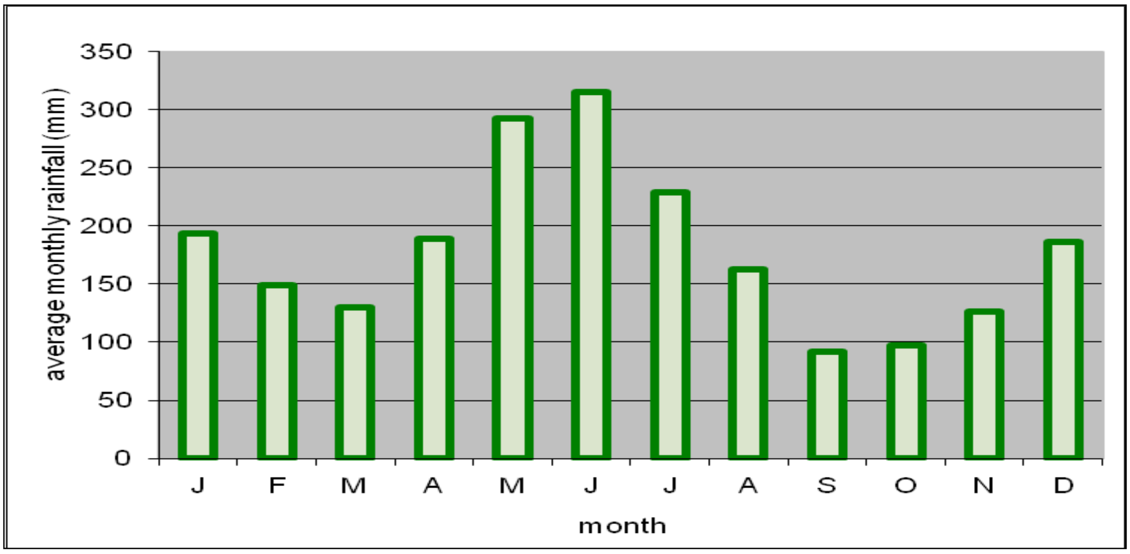
Monthly rainfall totals and, by extension, Suriname's weather as a whole, is dictated mainly by the northeast and southeast trade wind system. This system is called the Inter-Tropical Convergence Zone (ITCZ) which is a belt of low pressure near the Equator where tropospheric air from the Northern and Southern Hemispheres converges. The ITCZ follows the sun in its movement to the north and to the south of the Equator, to about 15° North Latitude and 10° South Latitude, respectively. In so doing, it migrates over Suriname twice per year, bringing heavy rainfall when it is overhead. Differences in the monthly rainfall totals result in 4 seasons (Scherpenzeel 1977; Table 5-4 below):

Table 5-4: Duration and Mean Monthly Rainfall of the Seasons for Suriname

Season	Duration	Mean Monthly Rainfall (mm)
Long rainy	End April - Mid August	About 200 mm; a maximum of about 325 mm in the most humid month
Long dry	Mid-August - Early December	Less than 100 mm
Short rainy	Early December - Early February	About 200 mm
Short dry	Early February - End April	About 100 mm

Source: Scherpenzeel 1977

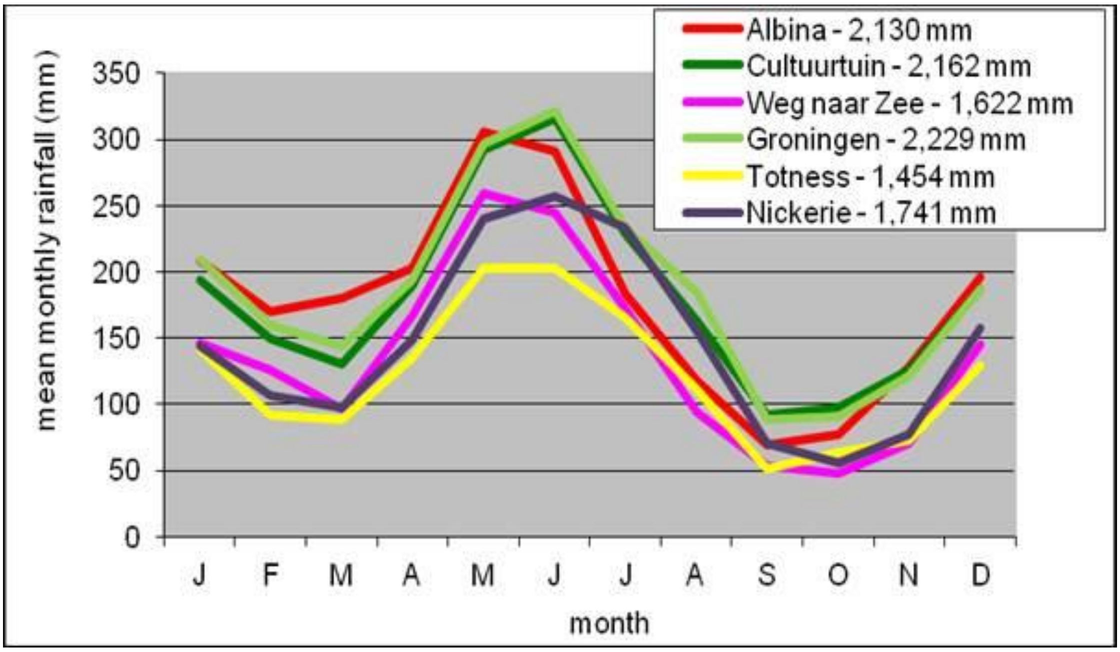
The classification of the seasons (see Table 5-4 above) is developed for Paramaribo, the capital of Suriname, using the recorded rainfall data at station Cultuurtuin (see Figure 5-12 above), but it is applicable to the whole northern part of the country. The average distribution of the annual rainfall throughout the year at Paramaribo is presented in Figure 5-14 below.



Source: Meteorological Service; see Appendix D.2

Figure 5-14: Mean Monthly Rainfall at Paramaribo (Cultuurtuin: 1961-2016; total: 2,162 mm)

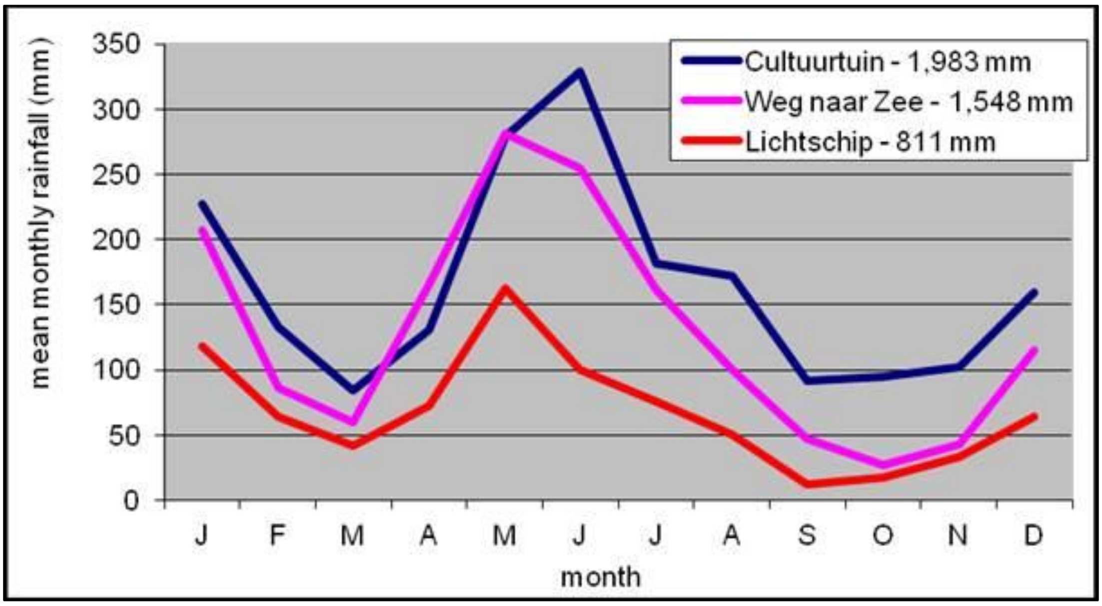
The 4 seasons (see Table 5-4 above) can clearly be identified in Figure 5-15 below, which shows the mean monthly and total annual precipitation for 6 regional meteorological stations (see Annex 1 of Appendix D.2). Highest average monthly rainfall occurs during the months May, June and July, which are in the Long Rainy Season, while minimum values are found during the months September to November, which are in the Long Dry Season. All 5 stations have the same seasonal distribution, but rainfall near the ocean is less in all months with a total of approximately 600 mm less rainfall over the year. Weg naar Zee and Coronie have 2 months (September and October) and Nickerie one month (October) in which the average rainfall is below 60 mm, and these areas thus are therefore classified as having an Aw climate. The other stations are classified as having an Af climate.



Source: Meteorological Service; see Appendix D.2

Figure 5-15: Mean Monthly and Total Annual Precipitation for Regional Stations)

For the Nearshore and offshore areas, meteorological data are limited to observations at Lichtschip station during the period 1961-70. This data is presented in Figure 5-16 below, where it is compared to data from stations at Weg naar Zee and Cultuurtuin, for more or less the same period. Figure 5-16 shows that rainfall at sea is considerably lower than on land, with an annual difference of approximately. 800-1,100 mm. For this period, the difference in average annual rainfall between Cultuurtuin and Weg naar Zee is less obvious than in the 1961-2009 period (see Figure 5-15 above).



Source: Meteorological Service; see Appendix D.2

Figure 5-16: Mean Monthly & Total Annual Precipitation for Selected Stations over the Period 1961-1970 (1964-1970 for Weg naar Zee)

The probability of the maximum intensity of the rainfall at Paramaribo is presented in Table 5-5 below, based on collected rainfall data over the period 1901-1960, expressed in return periods exceeding maximum intensities. The maximum intensities of 22.9 mm in 15 minutes, 34.3 mm in 30 minutes, 39.1 mm in 45 minutes and 42.5 mm in 60 minutes respectively, are on average exceeded once every year. The rainfall intensity decreases when the time interval of the storm increases.

Table 5-5: Return Periods of Exceeding Maximum Rainfall Intensity (Rainfall in mm per Time Interval, t) for Paramaribo (1901-1966)

Return Period	t = 15 min	t = 30 min	t = 45 min	t = 60 min
Once in 50 years	37.9 (2.52)	60.4 (2.01)	69.5 (1.54)	76.3 (1.27)
Once in 10 years	31.7 (2.11)	49.7 (1.66)	57.5 (1.28)	62.7 (1.05)
Once in 1 year	22.9 (1.53)	34.3 (1.14)	39.1 (0.87)	42.5 (0.71)
10 times a year	13.3 (0.88)	17.2 (0.57)	19.0 (0.42)	20.3 (0.34)
25 times a year	9.3 (0.62)	11.8 (0.39)	12.8 (0.28)	13.6 (0.23)

Source: Meteorological Service; see Appendix D.2

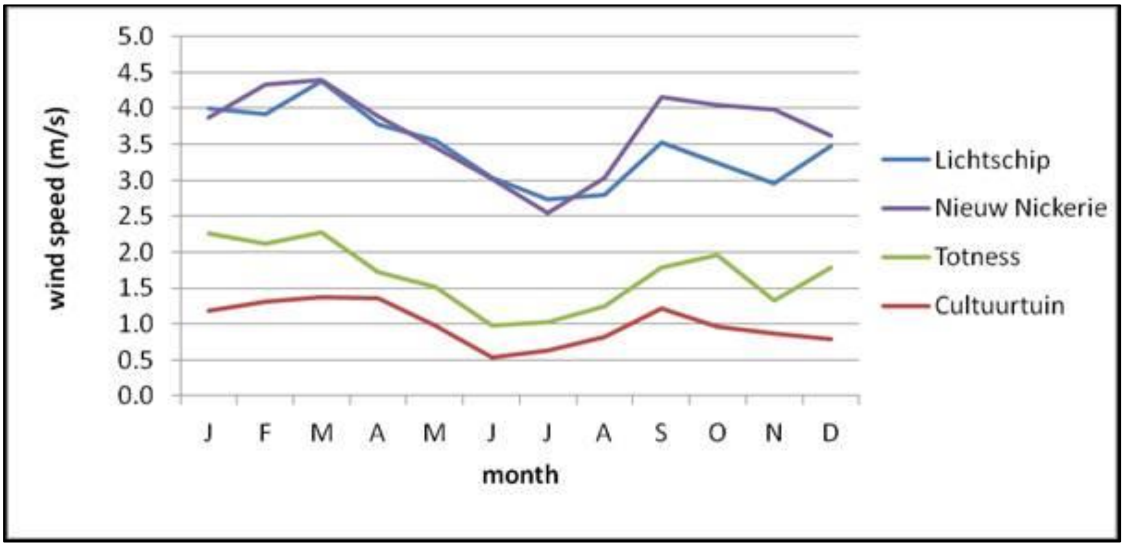
Note: Rainfall intensity values (mm/min) are presented within the brackets.

5.3.6.2 Wind Speed & Direction

5.3.6.2.1 Wind Speed

In Figure 5-17 below, the monthly mean wind speed is presented for 4 stations in the coastal area, including one station at sea (Lichtschip). The others are Nieuw Nickerie, Totness and Cultuurtuin (see Figure 5-12 above), for the period 1961 – 1970. Lowest speeds are recorded for inland stations, with values ranging from 0.7 – 1.5 m/s at Cultuurtuin, which has an annual average of 1.2 m/s.

The highest wind speeds occur during the period February-April, ranging between 1.4 and 1.5 m/s and the second highest speeds occur in September-October, with a value of 1.4 m/s. The lowest wind speeds occur in May-August, ranging between 0.7 and 1.1 m/s, and the second lowest speeds in December-January (1.1 m/s). Wind speed is thus correlated with the seasons (see Table 5-4 above), with higher wind speeds in the dry seasons and lower ones during the rainy seasons.



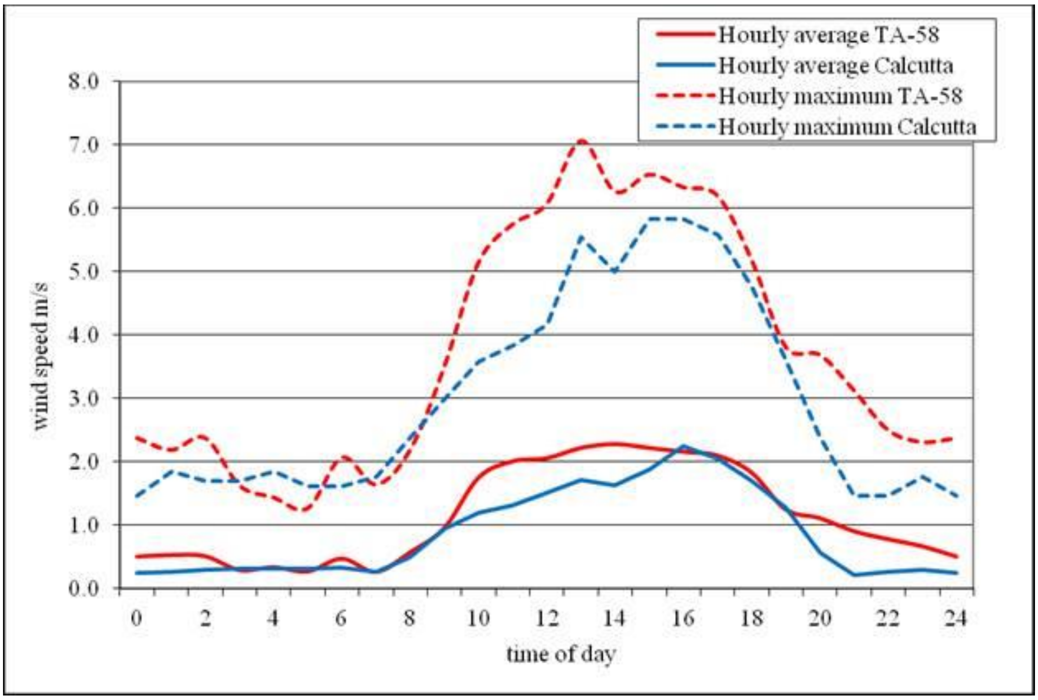
Source: Meteorological Service; see Appendix D.2

Figure 5-17: Mean Monthly Wind Speed for Selected Stations (1961-1971)

Wind speeds at sea (Lichtschip) and along exposed coastlines (Nieuw Nickerie station, located at the airport, directly along the coast) are much higher in comparison to those at Cultuurtuin (see Figure 5-17 above). The monthly means range between 2.5 and 4.5 m/s. The annual pattern of these stations is similar to that of Paramaribo (Cultuurtuin).

Calm winds (hourly speeds less than 0.5 m/s), are very frequent in Paramaribo and most of Suriname, occurring over 50% of the time, and over 60% of the time in the June-July period (Scherpenzeel 1977). The southerly land wind, which is well developed during the period May – December, is typically responsible for calm conditions during the night and early morning. During the day, the wind speed may increase to about 5 m/s, and in some seasons to 5-8 m/s, particularly during the February-April period.

The course of the mean and maximum wind speed over the day is illustrated in Figure 5-18 below, for two stations in the Tambaredjo and Calcutta oil field area of Saramacca district. Unfortunately, data is only available for 2 months in 2006-2007 (TA-58 in December 2006; and Calcutta in June 2007; see Figure 5-12 above). However, the data showed a consistent pattern and were in agreement with the above.



Source: Meteorological Service; see Appendix D.2

Figure 5-18: Average Mean and Maximum Hourly Wind Speed for 2 Stations in the Saramacca Oil Field Area (2006-2007)

5.3.6.2.2 Wind Direction

The wind directions in Suriname correlate to the position of the ITCZ, whereby the directions NE and ENE usually have the highest frequencies. Along the coast, this wind direction is influenced strongly by land- and sea breezes. Wind velocities are relatively high at the sea border and decrease further inland. The strongest winds appear to occur in the short dry season, when temperature gradients are highest.

In Table 5-6 below, the most dominant wind direction during the day and throughout the year at station Cultuurtuin is presented for the period 1931-1960. Based on this data, the dominant wind direction varies between NE and ESE. It appears that, the wind direction is more easterly during the morning period than during the rest of the day when ENE winds dominate. Only during the long dry season (July, August, September, October and November) does the morning wind direction have a southerly component. In the remaining months, the morning wind has a northerly component, or is completely east oriented. This southern component is due to the land wind which is present during the long dry season.

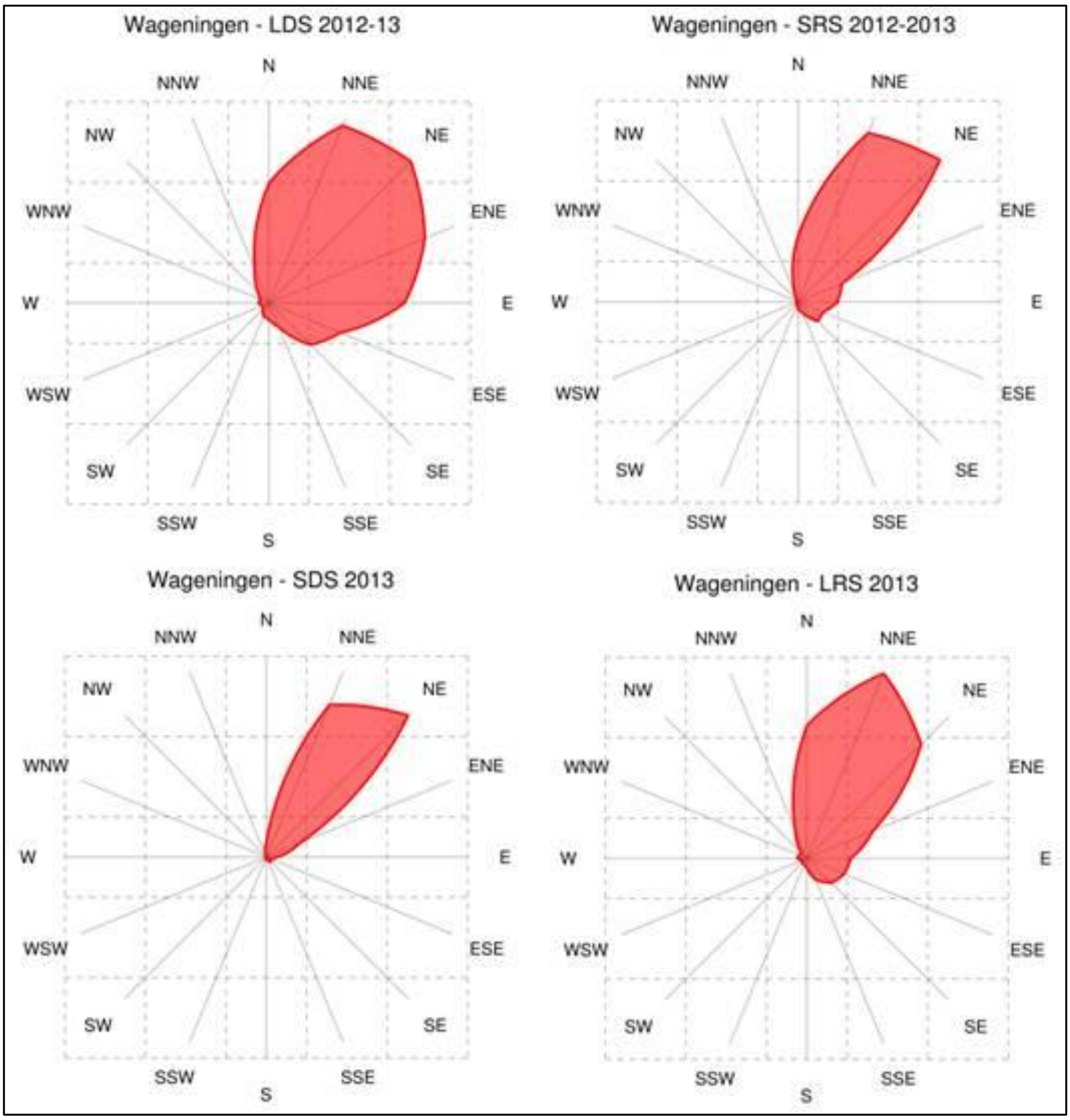
Table 5-6: Dominant Wind Direction throughout the Day at Cultuurtuin (1931-1960)

Time	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
08.00 hr	E	ENE	ENE	ENE	E	E	ESE	ESE	ESE	ESE	ESE	E	E
14.00 hr	ENE	NE	NE	ENE	ENE	ENE	ENE	E	ENE	ENE	ENE	ENE	ENE
18.00 hr	ENE	NE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE	ENE

Source: Meteorological Service; see Appendix D.2

Similar results were obtained during measurements along the coast near station Weg naar Zee (ESL 2013b). For the period October 2010 - February 2011, NNE to ENE winds were recorded during two-thirds of the time. Other relevant wind directions were N and NNE that occurred over 20% of the time.

Figure 5-19 below presents the distribution of wind direction for the main seasons of Suriname. The data was collected in the Kaaiman Polder near Wageningen at approximately 15 km inland (see Figure 5-12 above), by Staatsolie as part of the 2010 – 2015 monitoring programme undertaken for the Wageningen sugarcane to ethanol project (Noordam 2018c; see Appendix D.2). NNE to NE winds dominate for most of the year, with more eastern to south-eastern components occurring in the long dry season and, far less frequently, in the short and long rainy seasons. The data shows good agreement with the above observations.



**LDS-long dry season; SRS-short rainy season; SDS-short dry season; LRS-long rainy season.*
Source: Monitoring Programme for the Staatsolie Wageningen Sugarcane to Ethanol Project (Noordam 2018c; see Appendix D.2)

Figure 5-19: Wind Roses presenting Seasonal Wind Directions for the Staatsolie Field Station in the Kaaiman Polder near Wageningen, for the Period August 2012 – October 2013

ESL deployed a meteorological station at Wen naar Zee which recorded wind speed and direction during the period July to December 2017, the data from which were disaggregated to produce wind roses for the long wet, long dry and short wet seasons (Figure 5-20, Figure 5-21 and Figure 5-22 below).

Figure 5-20 below shows that, for the long wet season (July 2017), the predominant wind direction indicated from the data was NNE, which comprised 11.81% of all hourly wind directions, where the maximum wind speed recorded ranged from 6 – 7 m/s. The highest wind speeds (9 – 10 m/s) were recorded from the NE, but this was for a very small percentage of the measurements (see Figure 5-20 below). Overall, winds from the NE comprised 8.54% of the dataset. The data also indicated that winds were also predominant from the SE, 10.29% of the time over which the measurements were taken, within the range of 0 – 6 m/s. The winds during this period also occurred from the E and ESE, within the ranges 7 – 8 m/s and 6 – 7 m/s, for 6.78% and 7.49% of all hourly wind directions, respectively. Overall, however, it is clear from Figure 5-20 below, that the majority of wind speeds are ≤ 4 m/s.

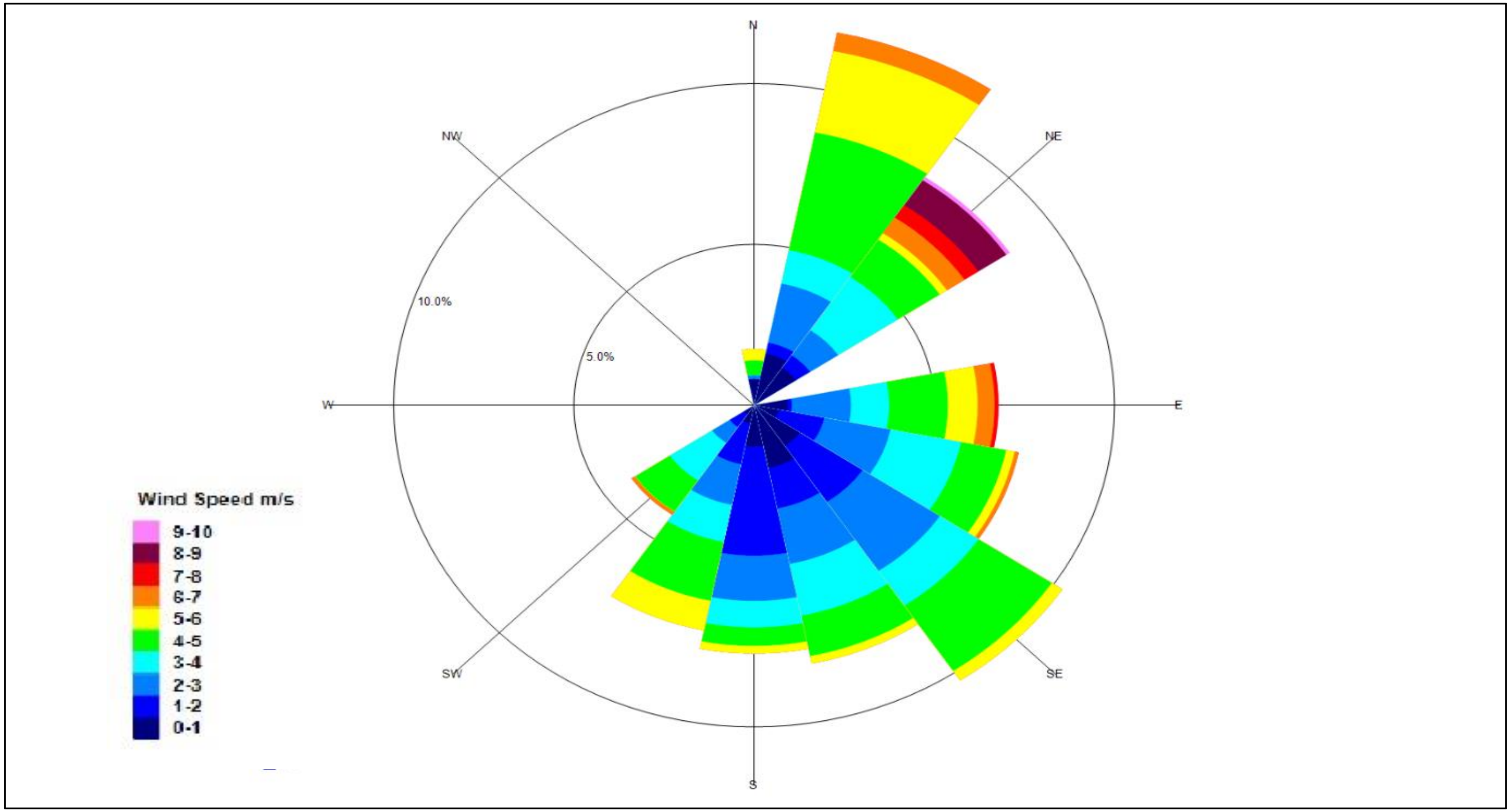
The data for the long wet season as described above corroborate the finding of the highest wind speed frequencies occurring from the northerly components, as stated above. The 2017 data for this period also corroborates the finding of the SE component, as shown by the data from Cultuurtuin for the period 1931-1960. However, this SE component does not occur in the data obtained at at Wageningen in 2012 – 2013 (see bottom right of Figure 5-19 above). Additionally, it was noted above that wind speeds are lowest during the period May – August, ranging between 0.7 – 1.1 m/s, but the ESL data from July 2017 shows higher wind speeds (≤ 4 m/s but as high as 10 m/s for a very small percentage of the time).

Figure 5-21 below shows that, for the long dry season (August – November 2017), winds from the ENE and NE predominated, over a total of 38.93% of the hourly wind directions recorded over the period. From these directions, the wind speeds did not exceed 7 m/s, and most of the data reflected speeds of ≤ 4 m/s. E and SE components were also recorded, 14.62% and 18.42% of the time, respectively. From these directions, wind speeds did not exceed 5 m/s, with the majority of the data reflecting speeds of ≤ 4 m/s. These findings corroborate the directional findings obtained from the ESL wind data obtained during the period October 2010 – February 2011, but the overall percentage of time over which the wind comes from the northerly component in ESL's 2017 data (38.93%) is less than half of that observed from ESL's 2010-2011 data (80%).

The southerly component of the 2017 data (see Figure 5-21 below) corroborates the findings from data retrieved from Cultuurtuin for the long dry season, during the period 1931-1960, and from meteorological data collected in 2012 – 2013 at Kaaiman Polder near Wageningen, approximately 15 km inland (see top left of Figure 5-19 above).

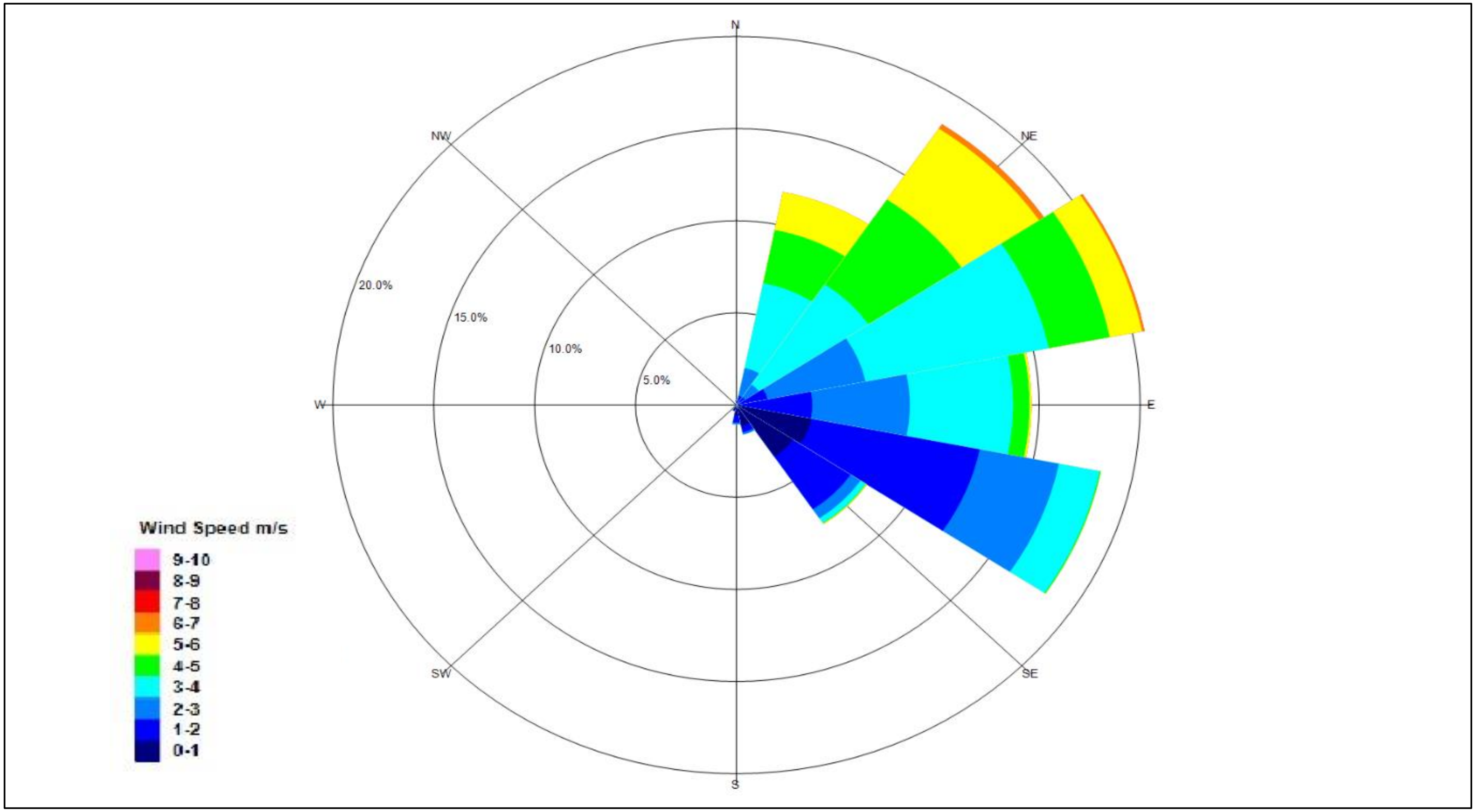
Figure 5-22 below shows that, for the short wet season (December 2017), the wind predominantly blew from the NE (25.67% of the time period), with ENE (17.78%), E (15.27%) and ESE (17.95%) components also evident. The highest winds speeds came from the ENE (6 – 7 m/s), with winds from the E up to 6 m/s and up to 4 m/s from the ESE.

The occurrence of this northerly component corroborates the findings from data retrieved from Cultuurtuin during the period 1931-1960. The 2017 met data for this season also generally agreed with that obtained by ESL in 2010 – 2011, except for the absence of the southerly components in 2010 – 2011 However, the data obtained at Wageningen in 2012 – 2013 did verify the occurrence of these southerly components.



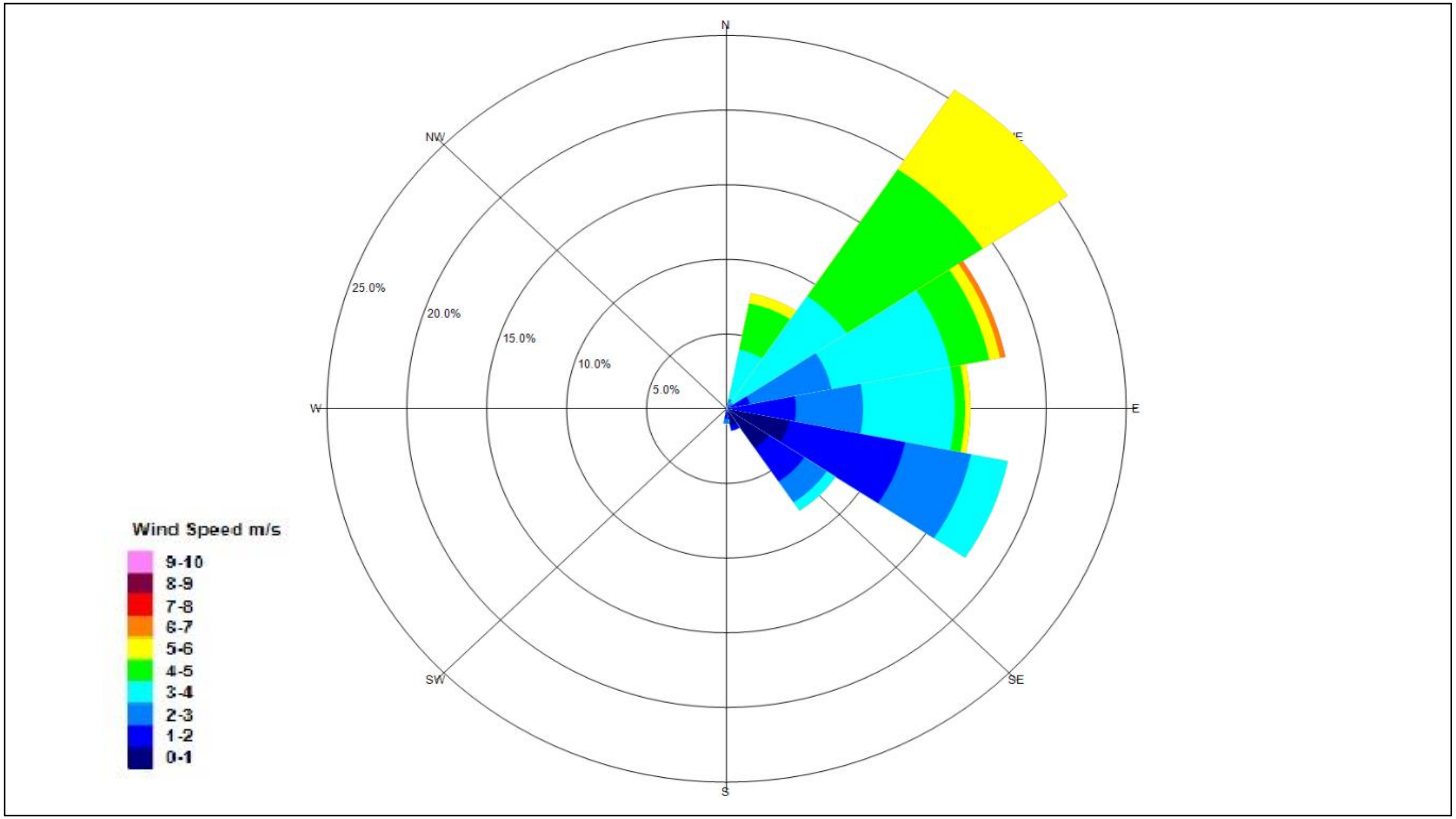
Source: ESL Meteorological Station deployed at Weg naar Zee (July – December 2017)

Figure 5-20: Wind Rose for the Long Wet Season (ESL Met Station; Weg naar Zee; July 2017)



Source: ESL Meteorological Station deployed at Weg naar Zee (July – December 2017)

Figure 5-21: Wind Rose for the Long Dry Season (ESL Met Station; Weg naar Zee; August – November 2017)

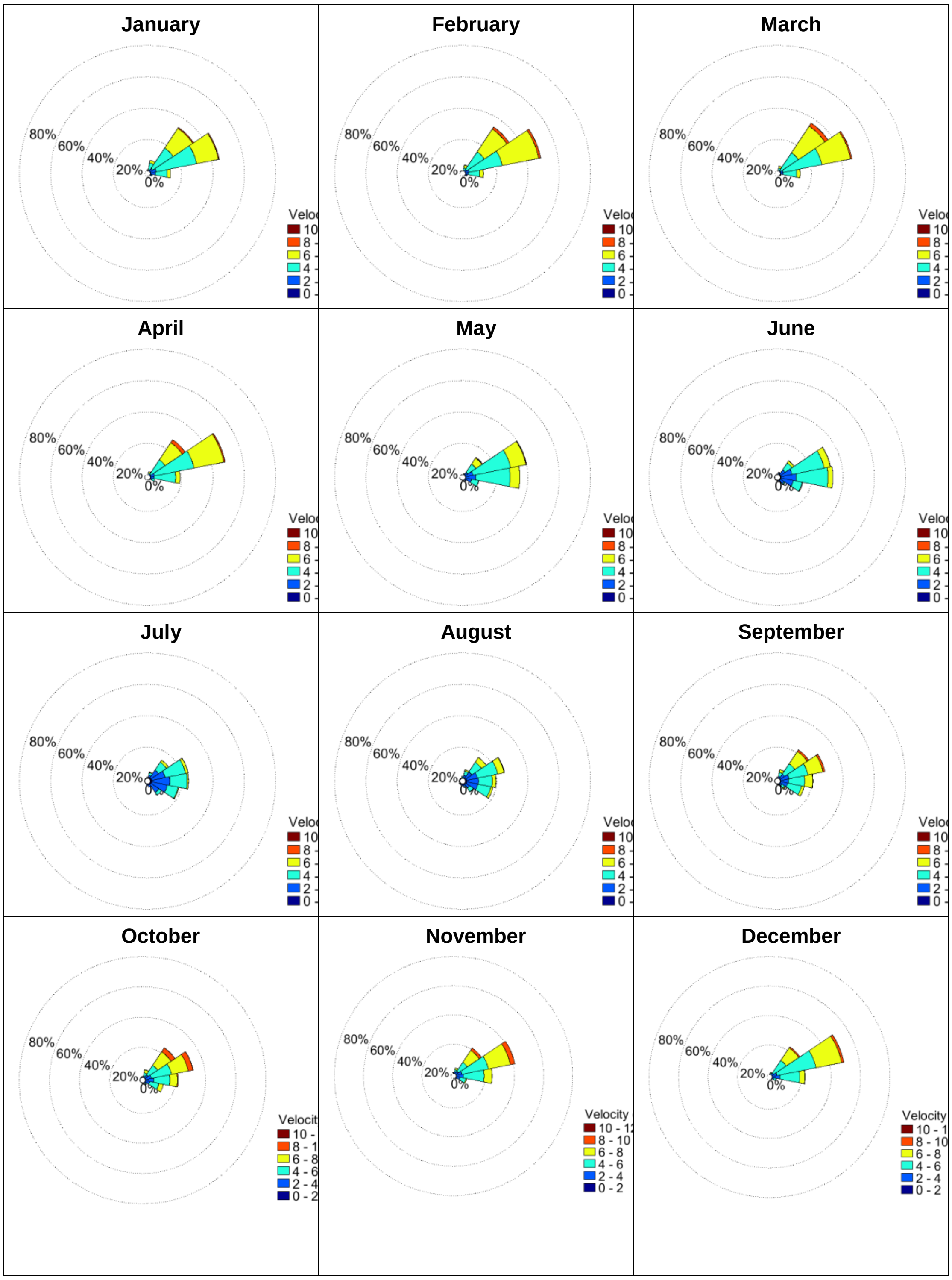


Source: ESL Meteorological Station deployed at Weg naar Zee (July – December 2017)

Figure 5-22: Wind Rose for the Short Wet Season (ESL Met Station; Weg naar Zee; December 2017)

Data related to seasonal wind variability were inputted into the hydrodynamic model used to conduct simulations of potential surface crude oil blowout, diesel fuel spills, and drill cuttings and mud discharges for representative drilling locations within the Project area (Tetra Tech 2018a; see Appendix E). Wind speed and direction data, for the period 2011 to 2017, were obtained from the CFSv2 global reanalysis (Climate Forecast System Reanalysis Version 2; Saha *et. al.* 2014), at 10 m height, for 2 periods. The first is termed the short period, which ranges from early December 2016 to late April 2017 (comprising the short wet and short dry seasons); and the second is termed the long period, from late April to early December 2017 (comprising the long wet and long dry seasons; see Appendix E).

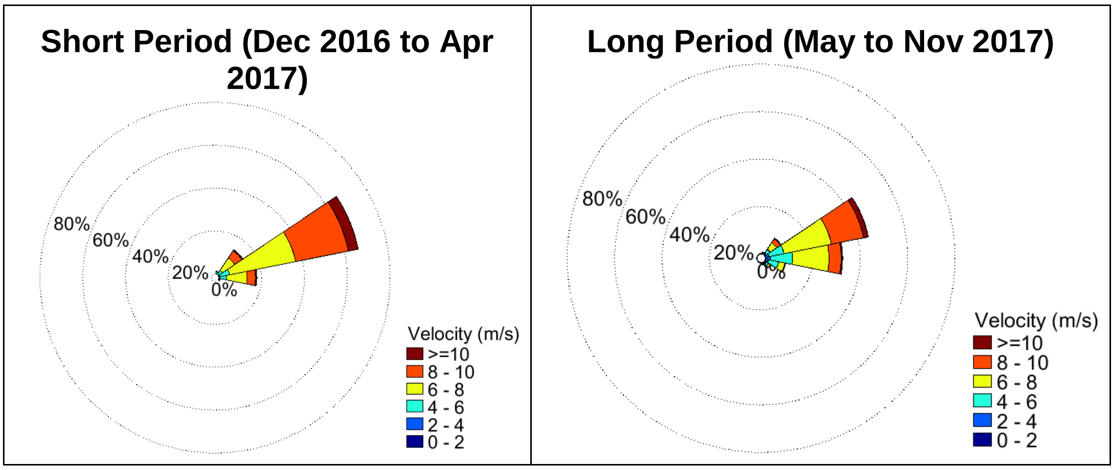
The CFSv2 global reanalysis wind data (2011 – 2017) showed that, from December to April (i.e. the period comprising the short wet and short dry seasons) the wind presents a pattern of stronger winds predominantly from NE and ENE, while in the months between April and November (the period comprising the long wet and long dry seasons) winds are moderate with predominant directions from E and ENE (Figure 5-23 below).



Source: CFSc2 Global Reanalysis Data; see Appendix E

Figure 5-23: Monthly Wind Roses, based on CFSv2 global reanalysis data (2011 – 2017)

Figure 5-24 below presents the wind roses for the short and long modelling periods, where the direction follows the meteorological convention (i.e. the direction from which the wind comes). CFSv2 data revealed that the predominant direction in the short period was from ENE, corresponding to 66.6% of the winds in this period. For the long period, the predominant directions are ENE (44.3%) and E (32.6%). Wind speeds for the predominant wind directions (ENE and E) in the CFSv2 data ranged from 8 – 10 m/s, with only a small percentage exceeding 10 m/s, whereas the wind speeds for the long dry season did not exceed 5 m/s.

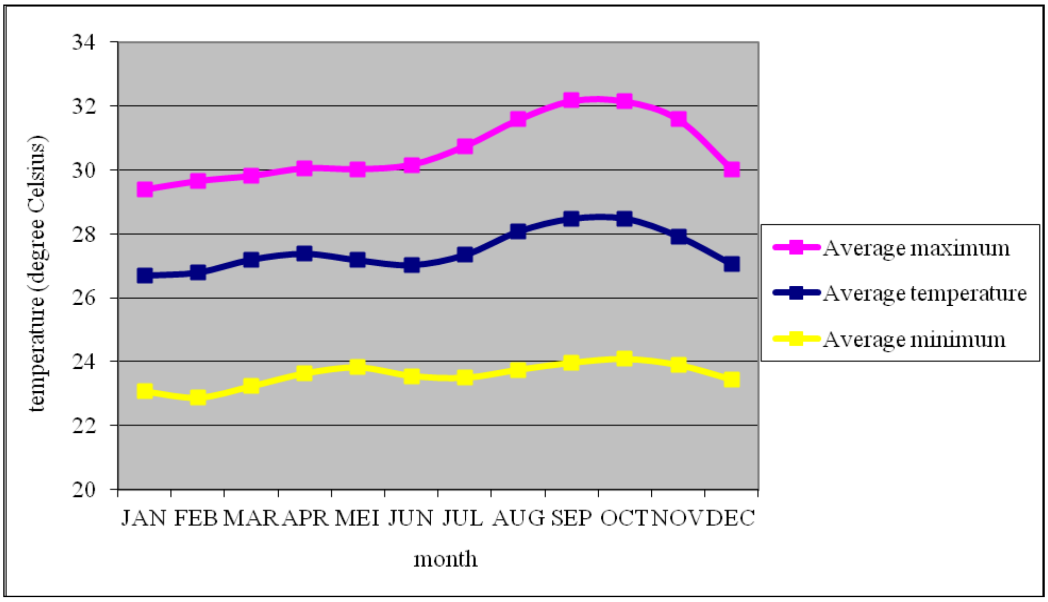


Source: CFSc2 Global Reanalysis Data; see Appendix E

Figure 5-24: Wind Roses of the CFSv2 Wind Vectors in the Modelling Periods, based on CFSv2 global reanalysis data (2011 – 2017)

5.3.6.3 Air Temperature

The long-term (1971 – 2008) monthly averages of the minimum, mean and maximum temperature at station Cultuurtuin (see Figure 5-12 above) is presented in Figure 5-25 below. The average annual temperature at this station over this period is 27.5°C In general, the warmest months are September and October, when the average monthly and average maximum temperatures are the highest. The monthly average temperature during these months is 28.5°C and the monthly average maximum is almost 32.2ºC. The coldest months are January and February, when the average monthly temperature is 26.7 – 26.8°C and the average monthly minimum temperature is as low as 23°C.



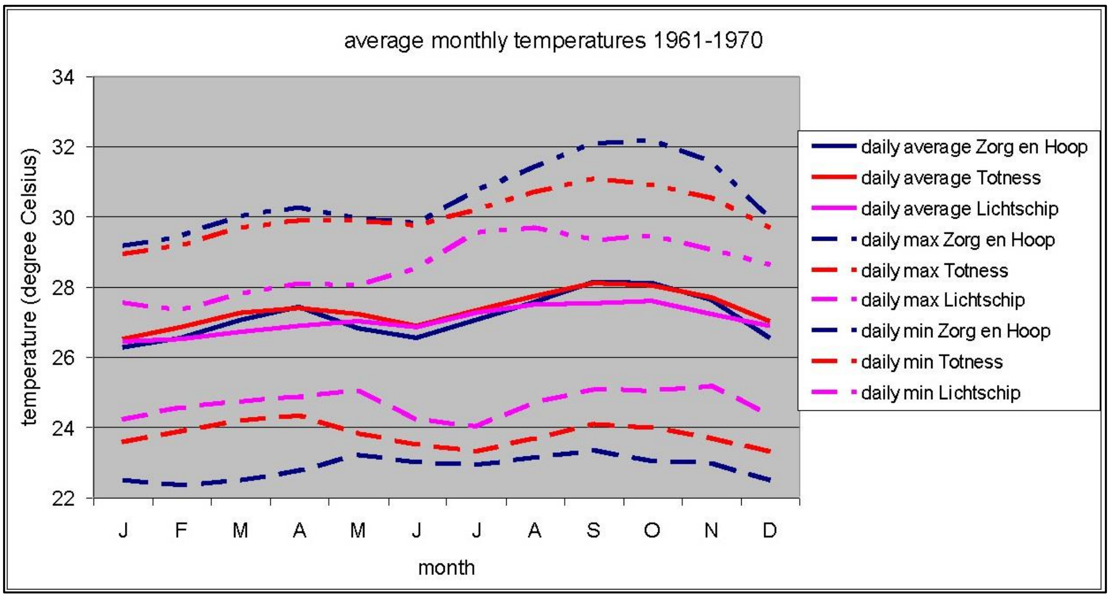
Source: Meteorological Service; see Appendix D.2

Figure 5-25: Average Monthly Temperatures at Cultuurtuin Station (1971-2016)

In Figure 5-26 below, temperatures for 3 stations (at Totness, Lichtschip and Zorg en Hoop; see Figure 5-12 above) are compared to provide insight into the influence of the sea on air temperature. Zorg en Hoop is located inland at approximately 10 km from the coastline; Totness (Coronie) is close to the coastline (2 km); and Lichtschip is located in the Nearshore area, 5 km off the coast.

For reasons of comparability, the period 1961 – 70 was chosen, because no more recent data for Lichtschip are available. The mean annual air temperature at Lichtschip is 27.0ºC, which is only slightly lower than at Zorg en Hoop (27.1ºC) and Totness (27.3ºC).

Mean monthly maximum temperatures at Lichtschip are lower (28.6 versus 30.5ºC) than at Zorg en Hoop, but mean monthly minimum temperatures at Lichtschip are higher (24.6 versus 22.8ºC) than at Zorg en Hoop, due to the presence of the Atlantic Ocean. During the night, the ocean retains heat longer than land and it takes longer to heat up during the daytime. At Zorg en Hoop, the daily temperature range is 7-10ºC and the annual range is about 2ºC. For Lichtschip, variations are smaller, with 3 – 6ºC for the daily range and only 1.2ºC over the year. Data for Totness are in between these two extremes (see Figure 5-26 below). The mean annual air temperature at Paramaribo is 27.3ºC, with a daily range of 7 – 10ºC and with an annual range of about 2ºC.



Source: Meteorological Service; see Appendix D.2

Figure 5-26: Monthly Average Temperatures for Lichtschip compared with Totness and Zorg en Hoop (1961 – 1970)

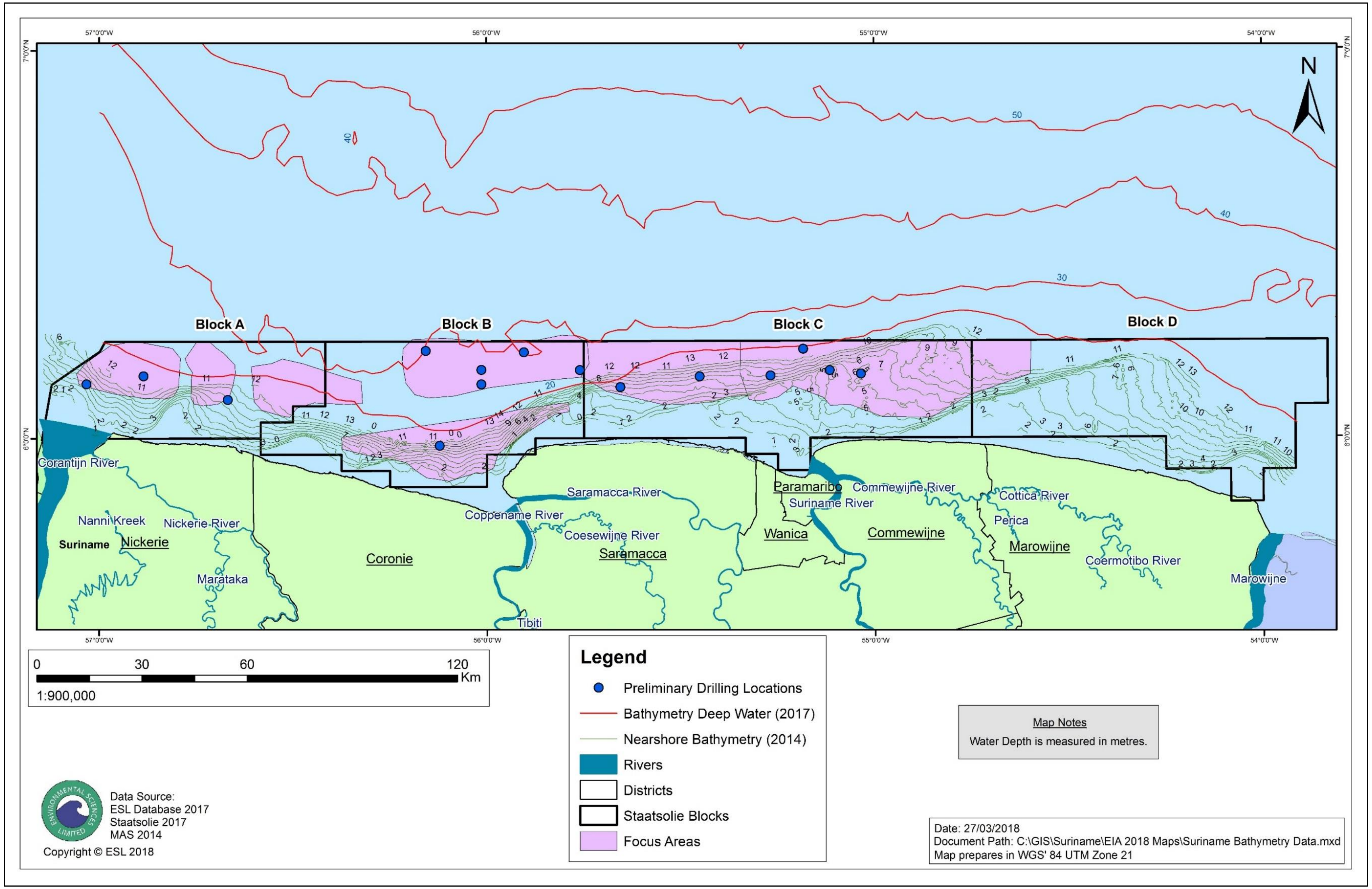
5.3.6.4 Natural Disasters

Suriname is considered to lie outside of the hurricane belt and earthquake zones and thus does not experience either hurricanes or earthquakes. There are also no volcanic eruptions. However, as a country with 386 km of coastline, and low lying coastal plains, Suriname is vulnerable to flooding caused by sea surges, sea level rise and heavy rainfalls, particularly in the coastal cities, where most people reside. Heavy seasonal rainfall in the vast interior can cause sudden rise of river water levels and flooding of the many villages along its embankments. Additionally, floods affecting the coastal zone as well as the interior pose potential significant threats to public health (PAHO 2010). Flooding can also have significant impacts on the natural and built environment of Suriname, inclusive of ecological and economic impacts. In this respect, Suriname, which is considered a Small Island Developing State (SIDS) as a result of its low lying nature, is vulnerable to the impacts of flooding.

5.3.7 Bathymetry

Figure 5-27 below displays isobath or bathymetric contour lines (lines of equal depth) which show the water depth in metres for Suriname's near-coastal and marine waters, based on bathymetry for the Nearshore (Staatsolie 2014) and marine offshore areas (Staatsolie 2017d). Isobaths are provided with depths ranging from 0 – 50 m, with the Nearshore bathymetry being defined by isobaths ranging from 0 – 12 m (see Figure 5-27 below).

Isobaths that are closer together indicate rapid changes in water depth (and so indicate steeper profiles) while those that are further apart indicate water depths that change gradually (indicating less steep profiles). Nearshore Blocks A to D have depths ranging from 0 – 12 m, and show that the Nearshore surface is gently undulating, with less steep profiles, towards the eastern and central Nearshore areas (Blocks C and D). These are separated by steeper profiles (Blocks C and D; see Figure 5-27 below). For the western part of the study area (Blocks A and B, see Figure 5-27 below), the slope is marginally steeper than observed across Blocks C and D, with water increasing from 0 – 13 m depth within 13 km from the shoreline. As for the deeper areas, the slope of the seafloor is gently sloping from shore to offshore from the isobaths for 20 – 50 m (see Figure 5-27 below).



Source: ESL Database 2018; Staatsolie 2014 and Staatsolie 2017d

Figure 5-27: Bathymetry Map for North Suriname

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5.3.8 Oceanography

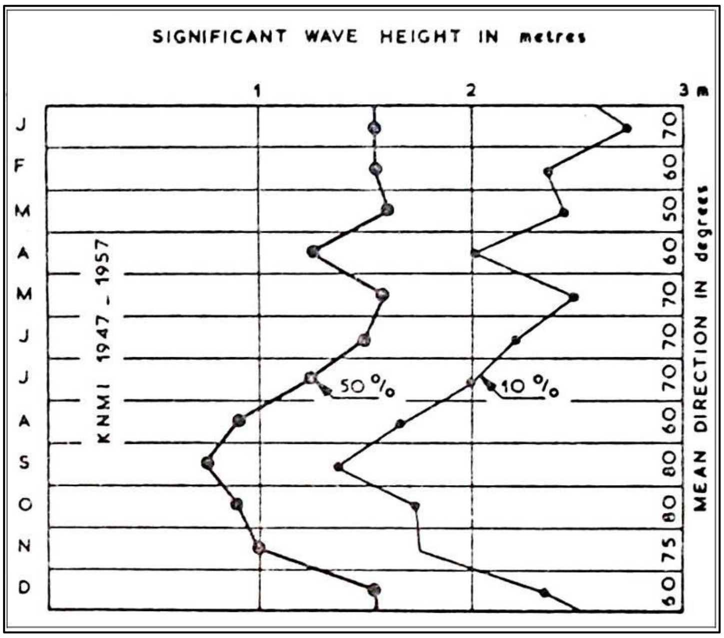
5.3.8.1 Tides

The tide along the Surinamese coast is classified as semi-diurnal, with 2 high tide events and 2 low tide events during a 24-hour period. The 2 estuaries at the mouths of the Suriname/Commewijne and Coppename/Saramacca Rivers are also tidal (see Section 5.3.4.2 above for additional information on tidal influence within these rivers). The main lunar tide component shows the greatest amplitude (86 cm), based on Xtide data for 2011 (Tetra Tech 2018a; see Appendix E). Generally, for Suriname, the tidal range varies between 1.00 m at neap tide and 2.80 m at spring tide, so that the average is calculated as 1.9 m (Amatali and Noordam 2010). The mean tidal range at 3 locations within the coastal zone varies from 1.75 m at Geleidelicht, 1.85 m at Paramaribo and 1.95 m at Boskamp (Figure 5-12 above), and these represent the mean tidal ranges occurring in the Blocks.

Tide phases along the coast (see Appendix E) have small differences (maximum 45 minutes). In and near a river mouth, the tidal motions are influenced by tidal phenomena in the estuary and the discharge of the river (see Section 5.3.4.2 above). At the shoreline, the resultant component of the tidal currents and the Guiana Current is in a NW direction during the complete tidal cycle. This is because the Guiana Current is stronger than the tidal currents (which are generally low). In areas where the coastline is interrupted by a river, the tidal effect dominates. The influence of the Guiana Current varies during the seasonal cycle. Since the tidal cycle is constant during seasons, during calm seasons when the Guiana Current is weaker (when the NBC retroflection is in operation, from June to January; see Section 5.3.8.3 below), the tidal effect is stronger than during the rough season (when the NBC retroflection is not in operation, from January to June).

5.3.8.2 Waves

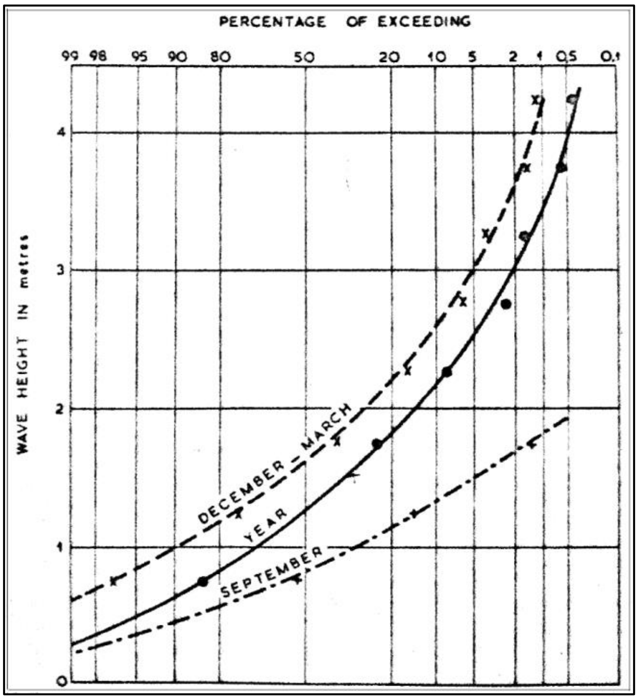
NEDECO 1968 summarises data gathered by the Royal Netherlands Meteorological Institute, which indicate that the highest waves along the Suriname coast occur from December to March (short wet and short dry seasons; see Table 5-4 above and Figure 5-28 below). September (long dry season) was noted as the month with the lowest significant wave height (see Figure 5-28 above), and so is considered the calmest period of the year. Figure 5-28 also shows the 10% and 50% significant wave heights for all the months of the year, as well as the mean direction from which the waves originate (the direction from which the waves come varies between 50 – 80°, which correlates to between NE and ENE (NEDECO 1968). Fishers, the Fishery Department of LVV and MAS have confirmed the findings of the preceding data, and have also indicated a calm period of March/April, and this is corroborated by Figure 5-28 above (see Appendix E).



Source: NEDECO 1968

Figure 5-28: Significant Wave Height throughout the Year

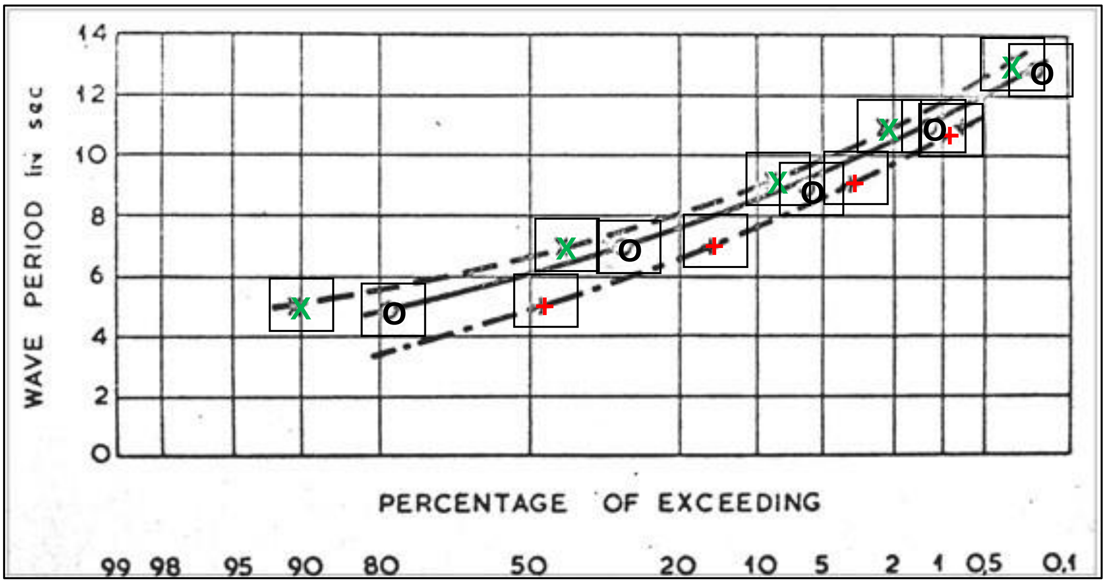
The average wave height over the period December to March (rough period) is about 1.6 m, while a height of 2.5 m is exceeded during 10% of the time (Figure 5-29 below). The month September (calm period) has an average height of 0.75 m. A height of 1.35 m is exceeded only during 10% of the time during this period.



Source: NEDECO 1968

Figure 5-29: Probability of Wave Height

During the months December to March (rough period), the average wave period is slightly less than 7 s, with variations between 5 and 13 s. During September (calm period), periods are about 2 s shorter (see Figure 5-30 below).



Note: + = September; x = December-March; o = Year *Source: NEDECO 1968*

Figure 5-30: Probability of the Wave Period (NEDECO 1968)

5.3.8.3 Currents

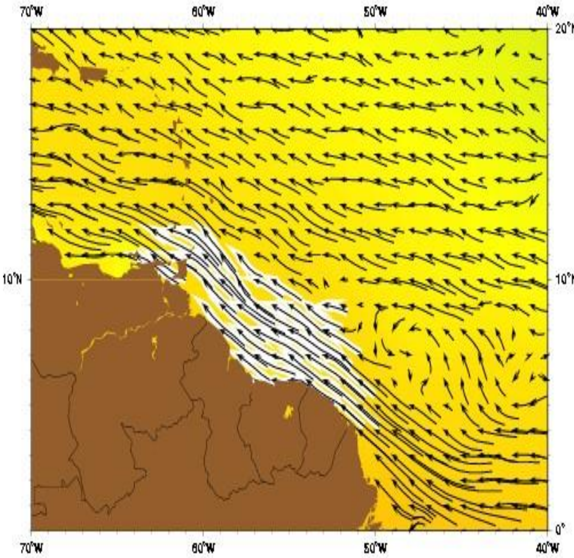
The wind stress to the Atlantic Ocean is the most important driving force for currents in the upper strata of the ocean. The exchange of heat and of water across the air-sea boundary is next in importance, inducing thermohaline currents. Both components are not independent of each other. The trade wind system in the Atlantic induces the South and North Equatorial Currents (SEC and NEC, respectively). The SEC carries South-central Atlantic water along the Brazilian and Guiana Coast and mixes with water coming from the NEC into the Caribbean Sea.

The wind-driven Guiana Current represents an extension of the SEC, and flows in a NW direction, parallel and close to the Guiana Coast in relatively shallow fore-shore. The current pattern has some significant deviations from the average NW-going current. The Equatorial Counter Current (ECC) is flowing southeast-ward during spring and summer, which results from balancing the westward flow of water due to the Equatorial Current (EC). The current velocity is less than the Guiana Current and occurs more offshore. Besides, the prevailing trade winds blowing from southeast directions also produce waves that result in a steady long-shore current flowing northwestwardly in the shallow water along the shore.

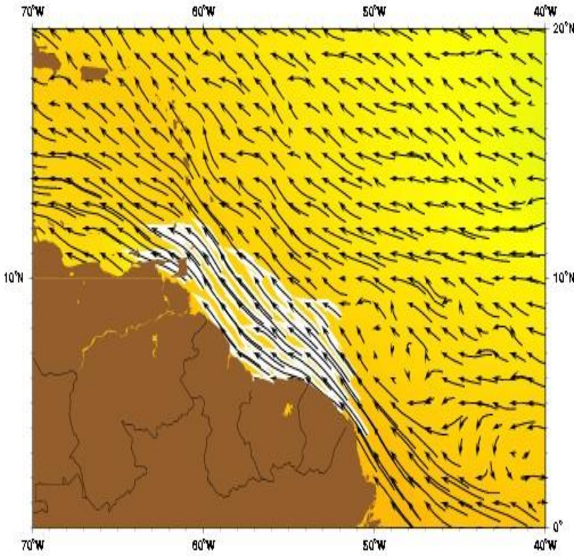
As indicated above, the Guiana Current flows in NW direction, parallel and close to the coast. The discharge of the Guiana Current is estimated at 5 to 10 x 106 m^3/s over a width of 250 km off French Guiana up to 500 km off Suriname. The maximum velocity is 1.5 to 2.0 m/s at up-current locations off French Guiana and decreases in a westerly direction, with Boisvert 1967 quoting speeds as high as 2.16 m/s, although the majority of observations in another study (Febres-Ortega and Herrera 1976) ranged from 0.41 – 1.23 m/s. In eastern Suriname, the Guiana Current varies between 1.1 and 0.75 m/s, respectively, during the rough season (April/ May) and calm season (September – October), decreasing to 0.5 m/s and 0.3 m/s for western Suriname locations. The main current leaves the coast at a point west of French Guiana.

Another important feature of regional oceanography related to currents involves the NBC retroflection. As indicated above, the predominant offshore flow is driven by the Guiana Current (see Figure 5-31 below). As the North Brazil Current (NBC) flows north along the NE coast of South America, it reaches French Guiana, where part of it separates from the coast and joins the North Equatorial Counter Current (NECC); this is called NBC retroflection. The remaining NBC current flows NW to form the Guiana Current (Condie 1991). According to Csanady 1990, the NBC retroflects in the boreal summer and fall (July to December), beginning in May and strengthening in June, and often lasting into the following January. During the rest of the year, January to June, it continues along the coast and becomes the Guiana Current.

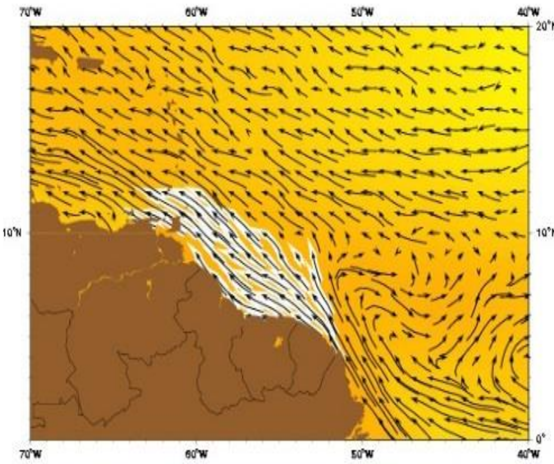
Although in the spring (March to May; when the NBC retroflection is not in operation), the Guiana Current can extend as far as 300 nautical miles offshore (Febres-Ortega and Herrera 1976); Gade 1961 found that the highest velocities in the current occur along the edge of the continental shelf (see further below). In general, the maximum speed occurred in April-May, while the minimum occurred in September due to the migration of the ITCZ and the accompanying variations in the Trade Winds (Febres-Ortega and Herrera 1976).



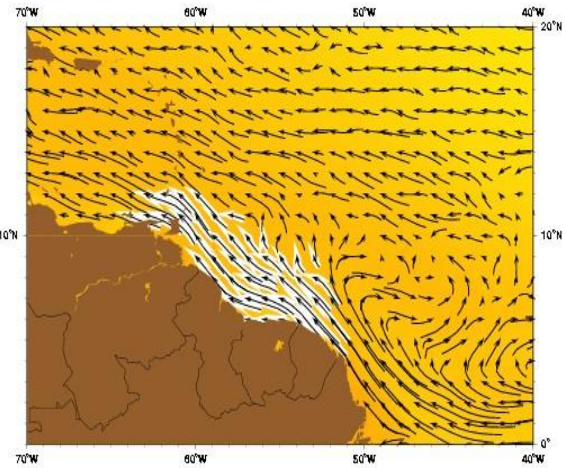
(a) Boreal Winter (Jan-Feb-Mar)



(b) Boreal Spring (Apr-May-June)



(**c) Boreal Summer (July-Sep-Aug)**



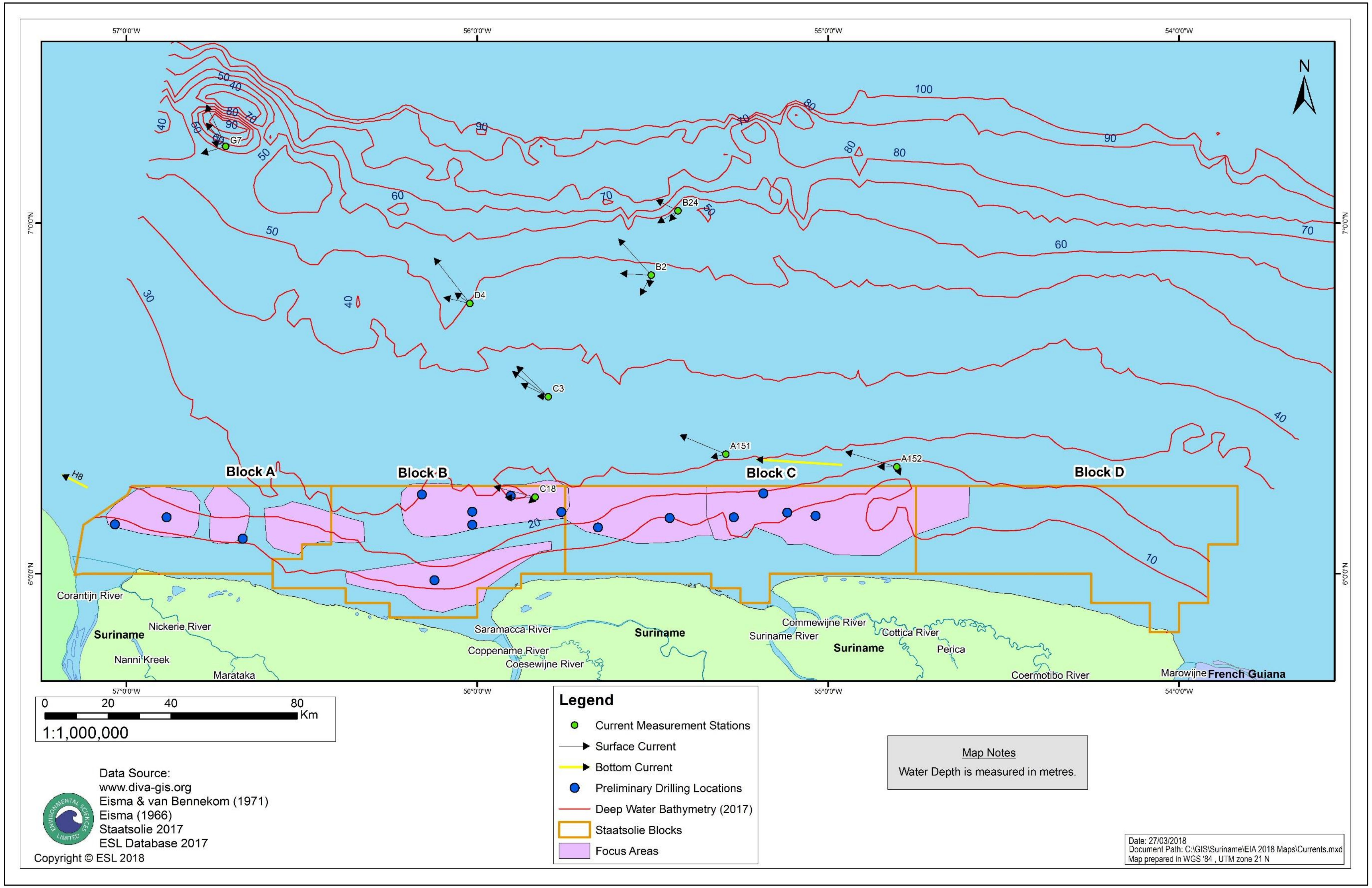
(d) Boreal Fall (Oct-Nov-Dec)

Source: Gyory et al. 2013; see Appendix E

Figure 5-31: Large Scale Seasonal Current Pattern off the NE coast of South America, based on MGSVA Seasonal Plots from Gyory *et al*. 2013

Due to the Ekman spiral type current caused by the rotation of the earth, the surface waters move slightly from the Guiana Coast causing an upwelling from the deep sea in landward direction near the seabed. Here, the trade winds blowing from the SE theoretically give a surface current in the NE direction. The water on the continental shelf should be replaced by the bottom waters that flow up the continental slope. Measurements have indicated that the angle between the velocity vector at the surface and the bottom tends to become larger with increasing depth. The resultant current velocities in the surface layer are 0.20 to 0.90 m/s and slightly directed offshore. In deeper layers, the current is flowing landward, at a velocity of about 0.10 to 0.60 m/s. This circulation pattern holds qualitatively for the area off French Guiana, adjacent Brazil, Suriname and Guyana (Augustinus 1978, NEDECO 1968, Stuip 1982).

Results of velocity measurements by Eisma & van Bennekom in 1971 confirm that the flow direction is different at different depths (Figure 5-32 below). From measurements by Eisma & van Bennekom 1971 and Eisma 1966 at Location C18, found within Block B at a depth of approximately 30 m (see Figure 5-32 below), it can be concluded that the flow direction at the surface mainly varyies between W and NW, whereby the flow is mainly seaward directed.



Source: ESL Database 2018 and Eisma 1966; see Appendix D.2

Figure 5-32: Resultant Currents at Various Depths (Eisma 1966)

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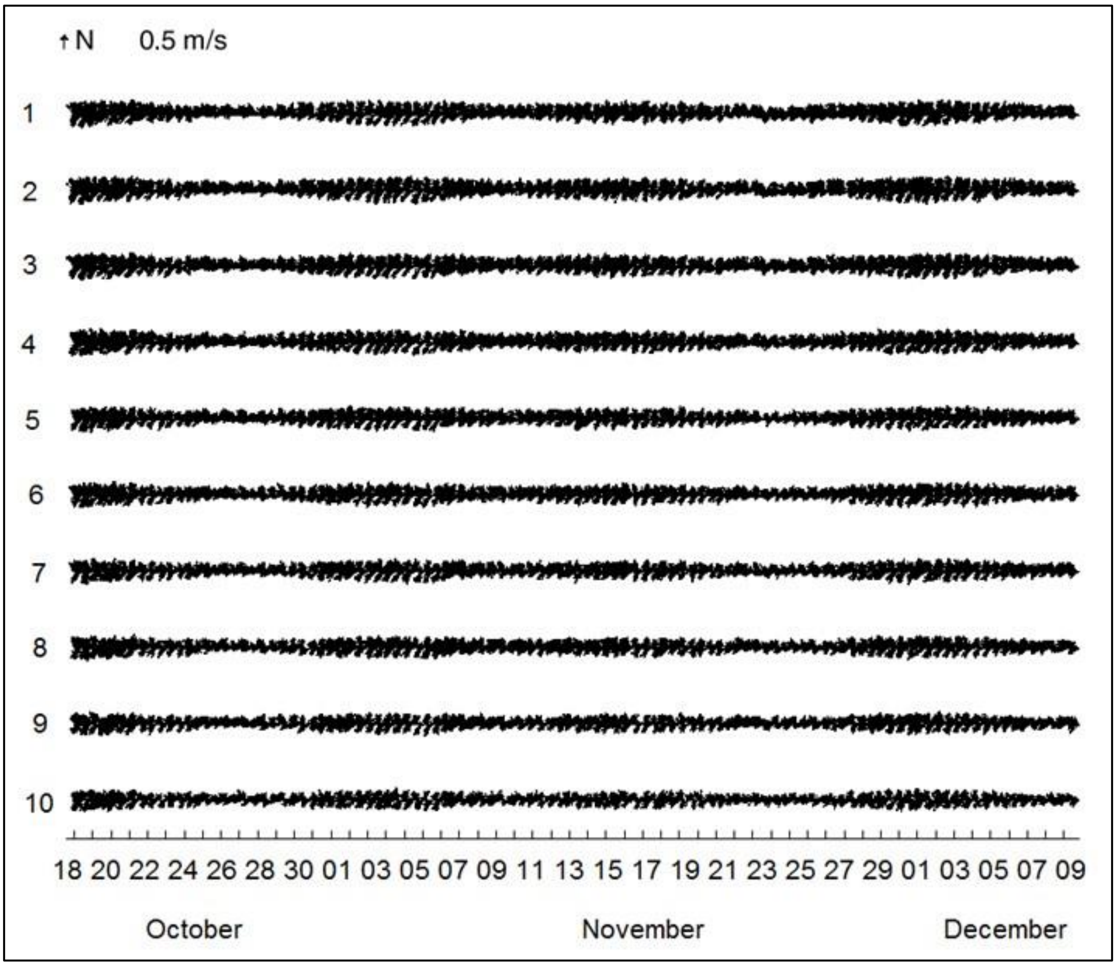
Current data were collected for the period October to December 2017 (long dry season and short wet season), from an ADCP deployed (at a water depth of 7.13 m), by ESL (see Figure 5-1 above). The measured currents oscillate according to the movement of flood and ebb tides at this location, with a resultant current flowing to the W.

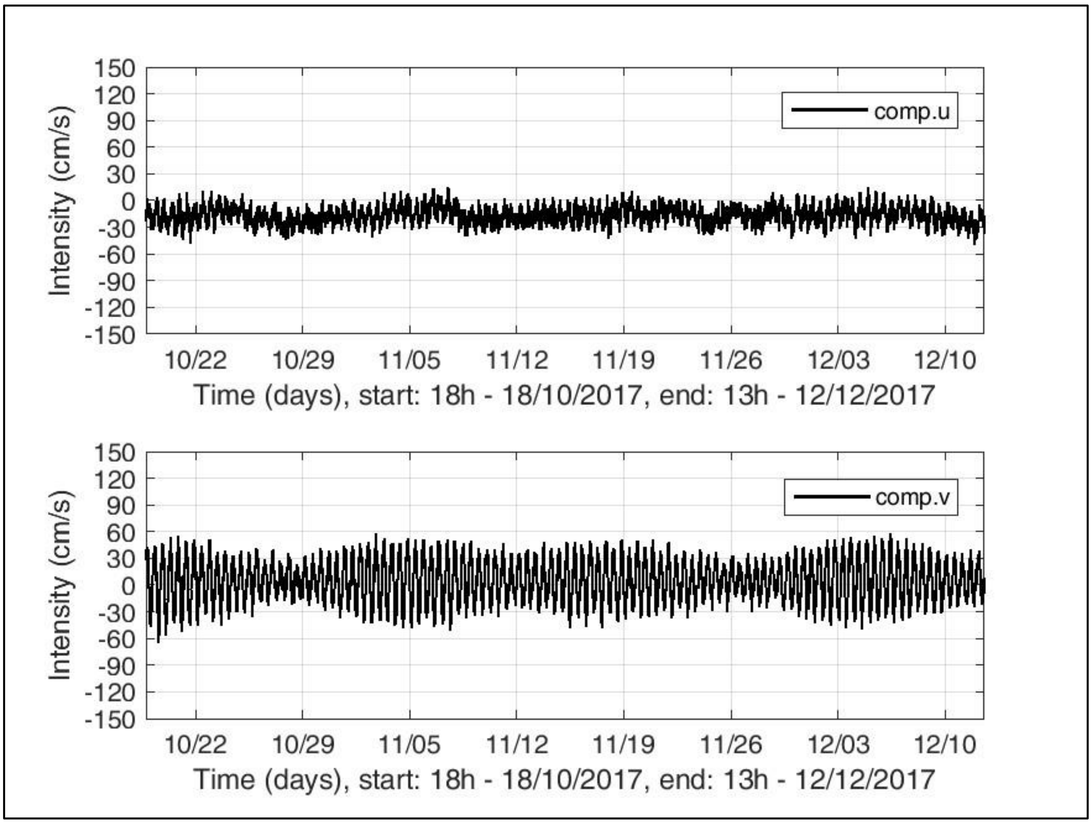
The data showed that there were no significant differences observed among the vertical layers, as shown in Figure 5-33 below, which presents the stick plots with direction and intensities for 10-layer measurements in the water column.



Source: ESL Nearshore ADCP data collected for MAS (October – December 2017

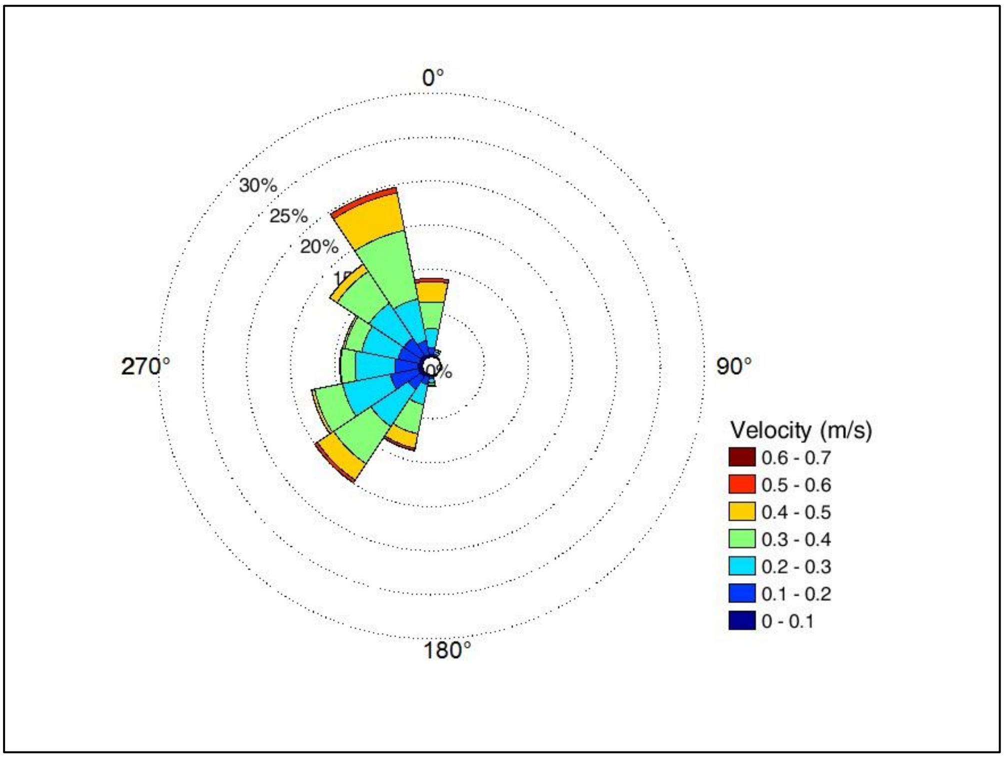
Figure 5-33: Stick Plots showing Current Direction and Current Speed (Vector Size) for the Water Column of Measured Currents (based on ADCP Data; October – December 2017)

Figure 5-34 below shows that the U component (E-W) was negative for most of the data collection period, indicating that the current flowed westward, in accordance with the main dynamics of the study area (the Guiana Current). Component V (N-S) was found to be more energetic at this location, and oscillated with the tides, as a result of the mooring location being close to shore (see Figure 5-34 below). For this layer, the highest observed velocities are less than 0.7 m/s (Figure 5-35 below).



Source: ESL Nearshore ADCP data collected for MAS (October – December 2017

Figure 5-34: Current Velocity Components (N-S and E-W) Time Series, in cm/s, for the Intermediate Layer of Measurements (based on ADCP Data; October – December 2017)



Source: ESL Nearshore ADCP data collected for MAS (October – December 2017

Figure 5-35: Current Direction Histogram, showing the Velocity (m/s) for the Intermediate layer of Measurements (based on ADCP Data; October – December 2017)

5.3.9 Marine Sediment Quality

5.3.9.1 Introduction

The ambient sediment quality within Nearshore Blocks A to D is described below using primary data from baseline surveys conducted for this Project within the area over the long wet and long dry seasons, and is supplemented with the findings of previously conducted studies within the 5-year window indicated as acceptable by NIMOS (see Appendix A.1) for comparative analysis.

The methodology of the 2017 baseline assessment and the results (including the comparative analysis) are summarised in the relevant sub-sections below. Detailed methodologies and test results are presented in the relevant appendices as indicated below.

5.3.9.2 Methodology

5.3.9.2.1 Sampling Plan Design

The sampling plan for this study is shown in Figure 5-36 below. A total of 245 stations were assessed for sediment quality, for which the GPS coordinates (WGS 1984 datum) are also presented in Appendix D.3. Sample locations were placed throughout Blocks A to D in order to provide data for a Block-wide assessment (see Figure 5-36 below). The sample design utilised a uniform layout (5x5 km grid spacing within focus areas and 15x15 km grid spacing outside of focus areas) for siting sediment sampling locations. The summary of methods and analyses presented below apply to both sampling events (long wet season: June – August 2017; and long dry season (September – November 2017).

Source: ESL Database 2018 and Teunissen 2000a, adapted from Lowe-McConnell 1962 and Froidefond et al. 2002

Figure 5-36: Baseline Sampling Plan for the Long Wet & Dry Seasons' Water & Sediment Quality Assessment for Staatsolie's Nearshore Exploration Drilling Project 2019 (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)

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5.3.9.2.2 Sampling Method

Sediment sampling was conducted at each of the 245 stations identified in Figure 5-36 above during the periods June 28th – August 11th, 2017 (long wet season) and September 24th – October 20th, and November 10th – 13th, 2017 (long dry season), using a van Veen grab (0.1 m^2). At each station, the grab was attached to ESL's winch system and lowered in the open position. When it came to rest on the seabed, the release of tension on the bridle enabled the triggering bar to drop. Once tension was applied again to the bridle, the jaws were drawn together and a sample was taken. The winch was then used to return the grab to the surface and the sediment sample was then removed from the grab.

This process was repeated 4 times; 3 grabs were utilised for triplicate benthic sampling (see further below) and the 4th was used for laboratory analysis of sediment chemistry. Each sample for chemical laboratory analysis was placed in separate gallon-sized Ziploc bags, labelled and double-bagged. All samples were then stored at 4°C until delivery to ESL's accredited laboratory for analysis. Additional details on the sampling method are presented in Appendix D.3.

All sediment sampling utilised standardised and scientifically robust methods as outlined in '*EPA-823-B-01-002: Methods for Collection, Storage and Manipulation of Sediments for Chemical and Toxicological Analyses: Technical Manual*' (USEPA 2001). To assist in reliability, analytical accuracy and valid interpretation of data, a program of quality control measures was implemented in sample collection and handling / preservation procedures. These are presented in Appendix D.3.

5.3.9.2.3 Assessment Parameters

The 245 sediment samples retrieved at the locations presented in Figure 5-36 above were analysed for the following parameters:

- Sediment grain size (see Appendix D.4 for analysis methodology);
- Benzene, Toluene, Ethylbenzene and Xylene (BTEX);
- TPH;
- Hexavalent chromium; and
- The total form of the metals, cadmium, chromium, lead, zinc, mercury and aluminium.

Specific test methods, detection limits, and test results are presented in Appendix D.5, Appendix D.6, Appendix D.7 and Appendix D.8. All analyses utilised standardised and scientifically robust methods as outlined in '*Standard Methods for the Examination of Water and Wastewater 22nd Ed.*' (Rice *et al*. 2012), for the analysis of sediment metals, specifically) and '*EPA-823-B-01-002: Methods for Collection, Storage and Manipulation of Sediments for*

Chemical and Toxicological Analyses: Technical Manual' (USEPA 2001). To assist in reliability, analytical accuracy and valid interpretation of data, a program of quality control measures was implemented in sample handling / preservation and laboratory procedures. This is presented in Appendix D.3.

5.3.9.2.4 Treatment of Data

The parameter level data retrieved for sediment at the various sampling stations, as presented in ESL's laboratory reports (see Appendix D.5 and Appendix D.6) was inputted into MS Excel® for basic statistical analysis and ArcGIS 10.1 for contour analysis by season. The findings are discussed in Section 5.3.9.3 below.

It should be noted that findings represent baseline conditions of sediment quality at the time of sampling, particularly for Blocks A, B and D, because there are no previous data pertaining to these areas to which to compare. For Block C, a comparative analysis (in keeping with the requirements of the Final Scoping Report; see Appendix A.1) is possible between the 2017 baseline results (long wet season) and those obtained from the assessment of sediment quality at 3 proposed well-sites within Block IV (the western half of Block C; see Figure 5-37 below) which was assessed by ESL in early February 2013 (short wet season) as part of the POC ESIA for Nearshore Exploration Drilling within Block IV (ESL 2013b). Previously collected data are also available from assessment of sediment quality across Block IV at 8 stations sampled at the same time as the 3 proposed well-sites mentioned above, as part of the post seismic monitoring event for the POC ESIA for 2D and 3D Seismic Program within Nearshore Block IV (ESL 2013a; see Figure 5-37 below). These 2013 datasets were the only ones available for comparison to the 2017 dataset, given the NIMOS stipulations that the most recent available data (for comparison) must not be older than 5 years and site-specific (see Section 5.2 above).

Figure 5-37 below shows that several of the stations sampled during the long wet season in 2017 were situated in close proximity with those sampled in 2013 (for both Post Seismic and Exploration ESIA sampling). As a result, direct comparisons are possible. These are provided in Table 5-7 and Table 5-8 below.

Table 5-7: Stations between which Direct Comparisons are possible for the 2013 POC Post Seismic and 2017 Staatsolie Exploration ESIA Baseline Assessments of Sediment & Benthic Macrofauna

Post Seismic Station (Feb '13; Short Wet Season)	Staatsolie Exploration ESIA Baseline Station (Jun-Aug '17; Long Wet Season)	Distance between both Stations (km)
P4	239	1.68
P7	236	2.64
P11	224	1.22
P15	228	1.09
P22	183	4.03
P26	184	5.75
P27	184	4.13
P30	186	1.24

Source: ESL Database 2018 and ESL 2013a

Table 5-8: Stations between which Direct Comparisons are possible for the 2013 POC Nearshore Exploration Drilling ESIA and 2017 Staatsolie Exploration ESIA Baseline Assessments of Sediment & Benthic Macrofauna

Staatsolie Exploration ESIA Baseline Station (Jun-Aug '17; Long Wet Season)	POC Exploration ESIA Baseline Station (Feb '13; Short Wet Season)	Area over which the Comparison is made (km^2)
184	Stations 1 to 12 (Well-site 2)	13.80
118 **119**	Stations 13 to 23 (Well-site 4)	12.50
234	Stations 24 to 34 (Well-site 9)	6.20

Source: ESL Database 2018 and ESL 2013b

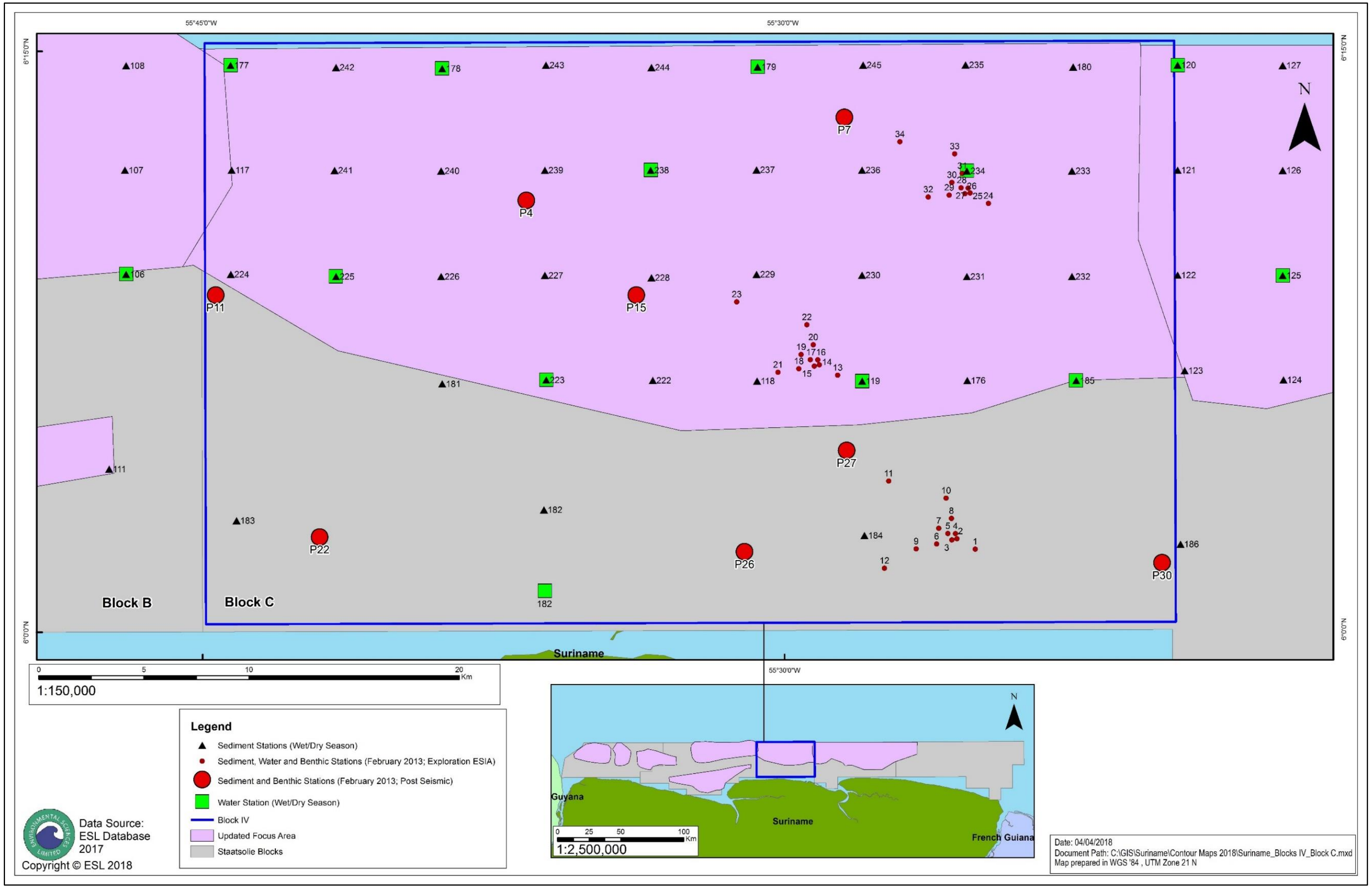
Comparisons were restricted to parameters in common between the various datasets. All of the parameters tested during 2017 baseline (long wet season) were tested for the POC exploration drilling baseline assessment in February 2013 (POC Exploration ESIA; short wet season), the only exception being BTEX. TPH was the only parameter which was available for both 2013 datasets and the 2017 baseline assessment.

Finally, sediment parameter levels were compared to the USEPA Mid-Atlantic Risk Assessment Marine Sediment Screening Benchmarks[15] (USEPA 2006),

[15] *The USEPA Mid-Atlantic Risk Assessment Marine Sediment Screening Benchmarks are screening values or guidelines which have been generated for Region 3 (Mid-Atlantic Region,*

for BTEX and the total metals, cadmium, chromium, lead, mercury and zinc (none exists for TPH, hexavalent chromium, or total aluminium).

which can be applied to Suriname). These screening values, where specified, indicate the levels of parameters above which some adverse impact may be experienced by ecological receptors.



Source: ESL Database 2018; ESL 2013a and ESL 2013b

Figure 5-37: Stations Sampled in February 2013 (Post Seismic and Exploration Drilling within Block IV) and 2017 (Nearshore Exploration Drilling Project 2019 within Blocks A – D, for the Purposes of Comparative Analysis of Water, Sediment and Benthic Macrofaunal Analyses

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5.3.9.3 Results & Discussion

Sediment Grain Size

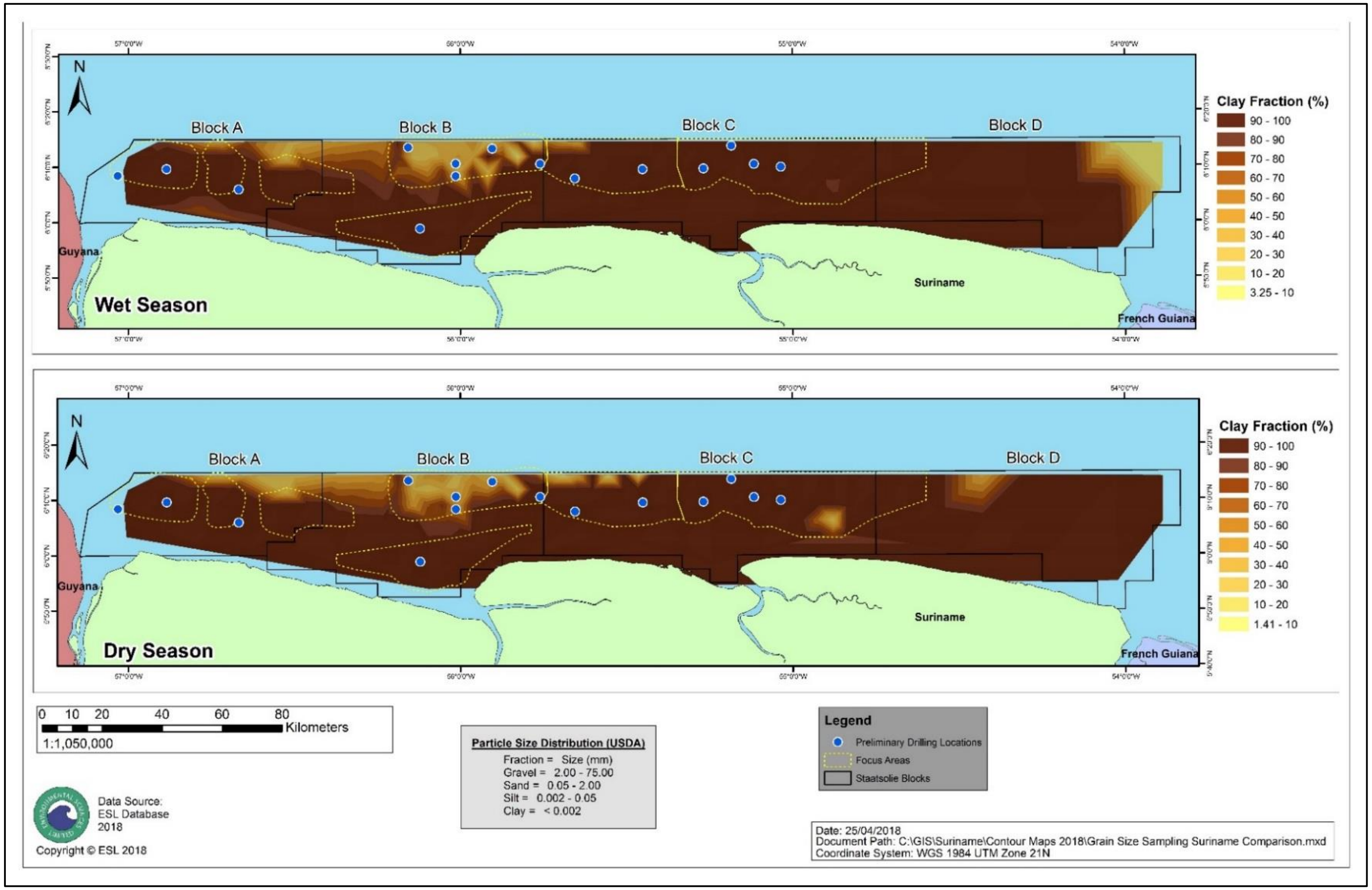
Sediment grain size results indicated that clay was the sediment type found at 91% of the stations sampled in Jun-Aug 2017 (223 of 245 samples) and 89% of the stations sampled in Sep-Nov 2017 (218 of 245 samples; Figure 5-38 below). Figure 5-38 below presents a contour gradient analysis showing the distribution of clay across the study area; the corresponding contour gradient maps for the sand and silt fractions are shown in Figure 5-39 and Figure 5-40 below.

Where clay was not dominant, the sediment type was found to be sandy clay loam. These areas of sandy clay loam coincide with areas at which the sand fraction was found to be higher than the surrounding areas (see Figure 5-39 below). The proportion of silt within the sediment within the sandy clay loam samples was also found to be higher than at the other stations throughout the study area, and this is expected, given that a loam is composed of all 3 fractions of sand, silt and clay. Contour gradient analyses also showed that the majority of the preliminary drilling locations occur in areas where clay sediment was found; the exceptions are the 4 preliminary drilling locations in the northern portion of Block B (see Figure 5-38 below). Thus, the sand and silt content at these locations was found to be higher than at the other preliminary drilling locations.

Table 5-9 below presents the ranges and averages of the clay, sand and slit fractions (%) for the long wet and dry seasons. The data show that the results of the wet and dry seasons were very similar at the time of sampling, and this is corroborated by the contour gradient maps for the respective fractions (see Figure 5-38, Figure 5-39 and Figure 5-40 below). Thus, the stations at which clay was not dominant were found to be similar between seasons.

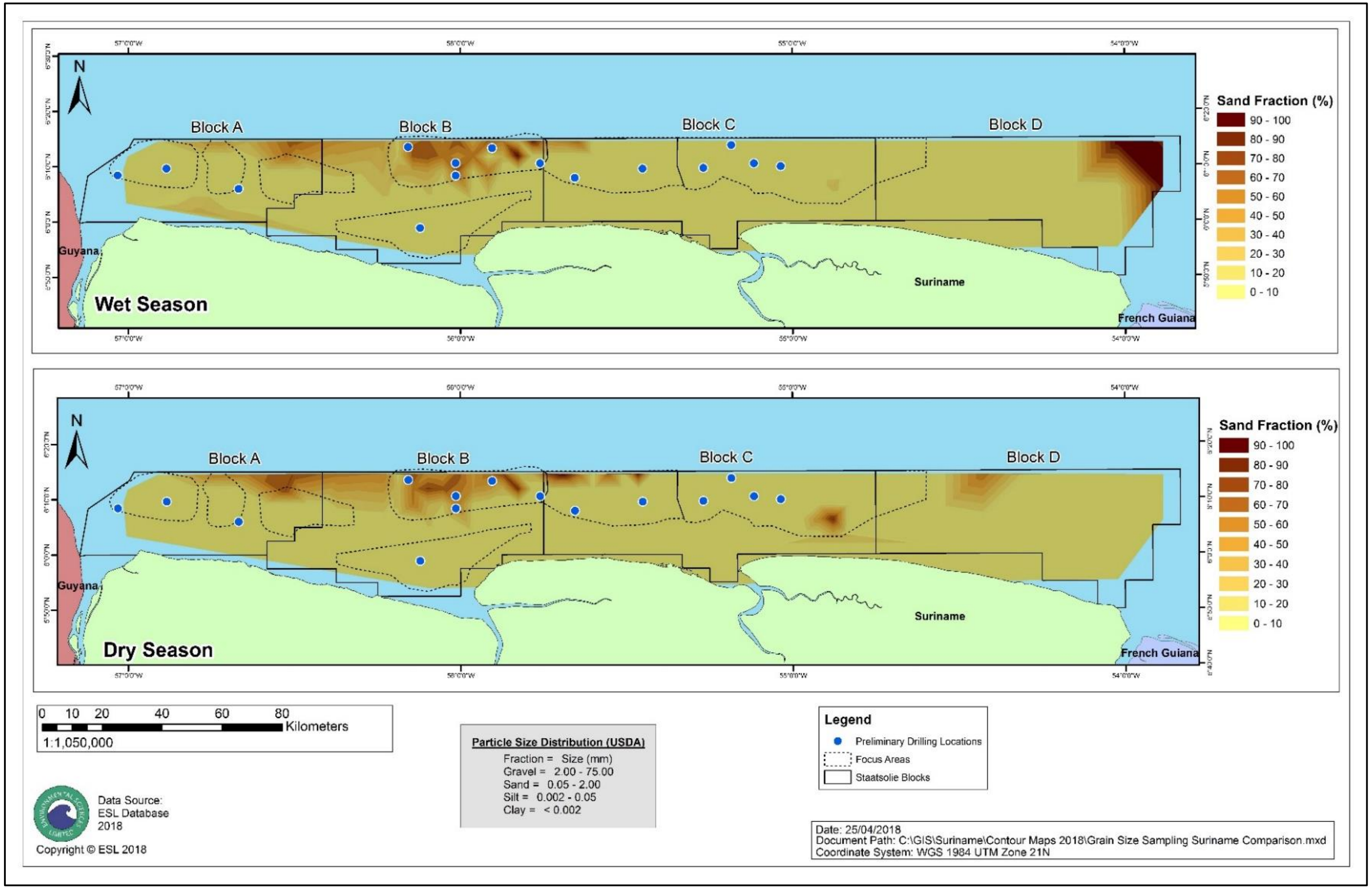
Table 5-9: Basic Statistics for Sediment Fractions within Samples retrieved during the Long Wet and Long Dry Seasons (LWS: Jun-Aug 2017; and LDS: Sep-Nov 2017)

Statistic	Sand Fraction (%)		Silt Fraction (%)		Clay Fraction (%)	
	LWS (Jun-Aug '17)	LDS (Sep-Nov '17)	LWS (Jun-Aug '17)	LDS (Sep-Nov '17)	LWS (Jun-Aug '17)	LDS (Sep-Nov '17)
Range	0.00 - 96.39	0.00 - 96.15	0.00 - 27.64	0.00 - 35.59	3.25 - 100.00	1.41 - 99.97
Average	8.26 ± 19.852	8.41 ± 20.184	1.98 ± 4.494	1.98 ± 4.677	89.76 ± 22.801	89.66 ± 23.180



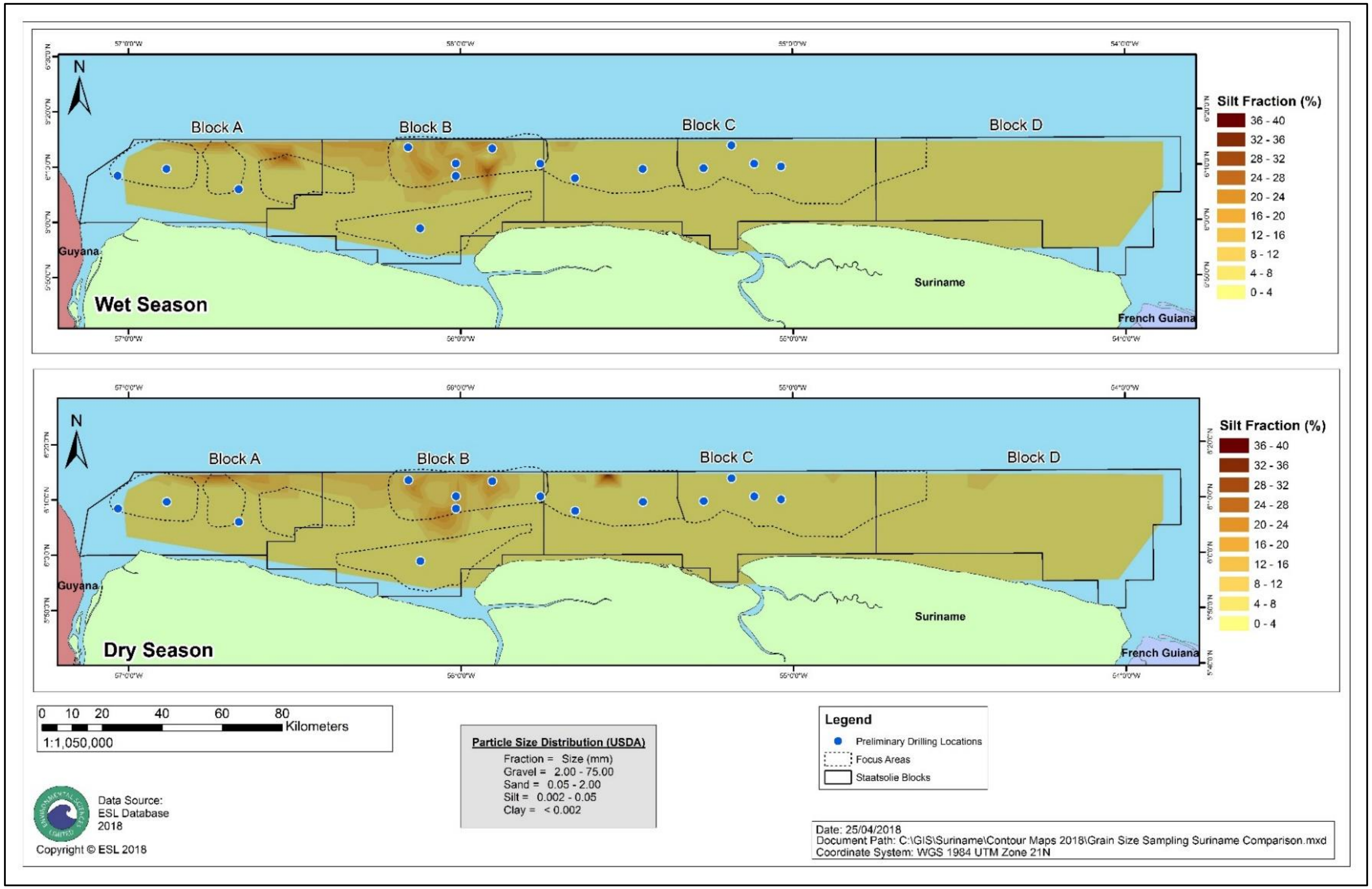
Source: ESL Database 2018 and 2017 Sediment Grain Size Results (see Appendices D.7 and D.8)

Figure 5-38: Contour Gradient Map for Clay Sediment Fraction (%) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)



Source: ESL Database 2018 and 2017 Sediment Grain Size Results (see Appendices D.7 and D.8)

Figure 5-39: Contour Gradient Map for Sand Sediment Fraction (%) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)



Source: ESL Database 2018 and 2017 Sediment Grain Size Results (see Appendices D.7 and D.8)

Figure 5-40: Contour Gradient Map for Silt Sediment Fraction (%) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)

Table 5-10 below presents a comparison of the ranges, averages and discrete values amongst the various stations identified for comparative analysis within the western half of Block C, to which Block IV corresponds (see Table 5-8 and Figure 5-37 above). The data show that there were minimal differences in the % fractions of sand, silt and clay between the 2013 and 2017 stations, and so, generally, the discrete values obtained for 2017 did not vary significantly from those recorded in the various 2017 station clusters. The clay fraction was found to be marginally higher at Stations 184 and 119 (2017) as compared to the values detected within 2013 Well-sites 2 and 4 clusters, respectively, but at Stations 118 and 234 (2017), it was marginally lower than at 2013 Well-sites 4 and 9 clusters, respectively.

Table 5-10: Comparative Analysis of Sediment Fractions (%) Between 2013 and 2017 Baseline Sampling Events

Event	Station	Statistic / Value	Fraction (%)		
			Sand	Silt	Clay
Baseline 2013	Stations 1 – 12 (Well-site 2)	Range	0.66 - 10.48	0.00 - 3.54	86.29 - 99.12
		Average	4.82 ± 3.812	1.21 ± 1.071	93.98 ± 4.532
Baseline 2017	Station 184	Discrete Value	0.35	0.17	99.48
Baseline 2013	Stations 13 – 23 (Well-site 4)	Range	0.00 - 1.40	0.00 - 1.30	98.60 - 99.59
		Average	0.58 ± 0.477	0.29 ± 0.446	99.12 ± 0.350
Baseline 2017	Station 118	Discrete Value	0.43	0.34	99.23
	Station 119	Discrete Value	0.16	0.16	99.68
Baseline 2013	Stations 24 – 34 (Well-site 9)	Range	0.00 - 0.87	0.00 - 0.97	98.59 - 99.54
		Average	0.31 ± 0.373	0.55 ± 0.332	99.14 ± 0.336
Baseline 2017	Station 234	Discrete Value	0.31	0.23	99.46

Source: ESL 2013b and 2017 Sediment Grain Size Results (see Appendices D.7 and D.8)

5.3.9.3 Sediment Chemistry

Table 5-11 below presents a summary of the ranges and averages of the various parameters tested across the study area during the long wet and dry seasons for the Staatsolie Nearshore Exploration Drilling Project 2019. Table 5-12 below presents the comparative analysis of these parameters between the 2013 POC ESIA & 2017 Staatsolie ESIA baseline sampling events, for the short wet season (February 2013) and long wet season (June – August 2017), respectively. BTEX was not presented within Table 5-12 since it was not tested in 2013.

The constituents of BTEX displayed different trends between the long wet and dry seasons. Benzene and ethylbenzene were below the detectable limit (BDL) of the analytical test used, during both sampling events; toluene and xylene were absent in the long wet season, but were detected at 14 and 7 of the 245 stations sampled, respectively. Xylene was detected at 7 of the 14 stations at which toluene was detected; the majority of these were detected at Stations situated within Block D and so are not located in proximity to any potential drilling locations. Two of these were located with 17.5 km of potential drilling locations in the western portion of Block C.

Where detected in the long dry season, toluene values ranged from 0.010 – 0.460 mg/kg, and xylene, from 0.020 – 0.033 mg/kg. BTEX was not tested in either of the 2013 sampling events (post seismic and ESIA baseline), and so this precluded further comparison. Levels of toluene detected during the long dry season did not exceed its USEPA Benchmark of 1.09 mg/kg. There is no USEPA benchmark for total xylenes, and the BDL values for benzene and ethylbenzene did not warrant further comparison to their relevant USEPA Benchmarks (0.137 mg/kg and 0.305 mg/kg, respectively).

Table 5-11: Summary of Sediment Results for the Long Wet and Dry Seasons' Baseline Sampling Events (June-August & September-November 2017)

Parameter (mg/kg)	Range of Parameters (mg/kg)		Average ± SD of Parameters (mg/kg)		USEPA 2006 Benchmark (mg/kg)
	Long Wet Season Jun - Aug '17	Long Dry Season Sep - Nov '17	Long Wet Season Jun - Aug '17	Long Dry Season Sep - Nov '17	
Benzene	BDL	BDL	N/A	N/A	0.137
Toluene	BDL	BDL - 0.460	N/A	N/A	1.090
Ethylbenzene	BDL	BDL	N/A	N/A	0.305
Xylene	BDL	BDL - 0.033	N/A	N/A	-
TPH	BDL - 160.00	BDL	N/A	N/A	-
Hexavalent chromium	BDL - 120.00	BDL - 27.00	N/A	N/A	-
Total cadmium	BDL	BDL	N/A	N/A	0.68
Total chromium	4.90 - 98.00	2.90 - 34.00	30.28 ± 6.758	27.18 ± 4.698	52.30
Total lead	2.70 - 77.00	2.30 - 25.00	21.87 ± 6.279	19.28 ± 4.342	30.20
Total zinc	3.60 - 280.00	2.80 - 94.00	79.25 ± 23.367	71.06 ± 17.274	124.00
Total mercury	BDL - 0.230	BDL - 0.065	N/A	N/A	0.13
Total aluminium	1,000.00 - 73,000.00	870.00 - 27,000.00	22,665.31 ± 6,463.116	20,211.55 ± 4,999.899	-

Source: 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6) and USEPA 2006

Table 5-12: Comparative Analysis of Sediment Results between the 2013 POC ESIA & 2017 Staatsolie ESIA Baseline Sampling Events (Short Wet Season: February 2013; and Long Wet Season: June – August 2017)

Event	Station	Statistic	TPH	Hexavalent Chromium	Total Cadmium	Total Chromium	Total Lead	Total Zinc	Total Mercury	Total Aluminium
Baseline 2013	Stations 1 – 12 (Well-site 2)	Range	20.00 - 65.00	4.00 - 15.80	BDL	BDL	2.60 - 5.30	4.00 - 9.60	BDL	21,000.00 - 24,000.00
		Average	43.75 ± 12.084	7.28 ± 3.466	N/A	N/A	3.69 ± 0.794	6.33 ± 1.557	N/A	22,583.33 ± 1,240.112
Baseline 2017	Station 184	Discrete Value	BDL	BDL	BDL	31.00	22.00	79.00	0.033	24,000.00
Baseline 2013	Stations 13 – 23 (Well-site 4)	Range	25.00 - 100.00	5.10 - 17.80	BDL	BDL	2.70 - 4.70	3.00 - 11.70	BDL	19,000.00 - 25,000.00
		Average	70.00 ± 24.083	7.62 ± 3.836	N/A	N/A	3.83 ± 0.768	6.87 ± 3.126	N/A	21,818.00.18 ± 1,601.136
Baseline 2017	Station 118	Discrete Value	BDL	BDL	BDL	27.00	28.00	74.00	0.035	17,000.00
	Station 119	Discrete Value	BDL	BDL	BDL	35.00	25.00	94.00	0.039	27,000.00
Baseline 2013	Stations 24 – 34 (Well-site 9)	Range	15.00 - 100.00	5.50 - 18.40	BDL	BDL	3.40 - 4.80	8.00 - 18.20	BDL	20,000.00 - 26,000.00
		Average	52.73 ± 27.419	12.05 ± 4.764	N/A	N/A	4.09 ± 0.493	11.96 ± 3.215	N/A	21,454.55 ±1,694.912
Baseline 2017	Station 234	Discrete Value	BDL	BDL	BDL	37.00	28.00	100.00	BDL	31,000.00

Source: 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6) and ESL 2013b

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TPH was BDL at all stations during the long dry season and at all except one station in the long wet season. It was recorded at a value of 160.00 mg/kg at Station 38, located closer to the shore, at the western margin of Block A, outside of the focus area for this Block.

Table 5-12 above presents TPH results obtained during 2013 post seismic sampling; the results show that TPH was detected at each station at varying levels within Block IV, and that the 2017 levels at the comparable stations were lower than those observed in 2013 during this event. The same was observed for the comparative stations between 2017 (long wet season) and the 2013 results within Block IV (short wet season; Table 5-13 below).

Table 5-13: Comparative Analysis of Sediment TPH Results between the 2013 Post Seismic & 2017 ESIA Baseline Sampling Events (Short Wet Season: February 2013; & Long Wet Season: June – August 2017)

Staatsolie ESIA Baseline Sampling June – August 2017 Long Wet Season		POC Post Seismic Sampling February 2013 Short Wet Season	
Station No.	**TPH (mg/kg)**	**Station No.**	**TPH (mg/kg)**
239	BDL	**P4**	40
236	BDL	**P7**	70
224	BDL	**P11**	150
228	BDL	**P15**	105
183	BDL	**P22**	10
184	BDL	**P26**	10
184	BDL	**P27**	265
186	BDL	**P30**	265

Source: 2017 Chemical Analysis Laboratory Report (Long Wet Season; see Appendix D.5) and ESL 2013a

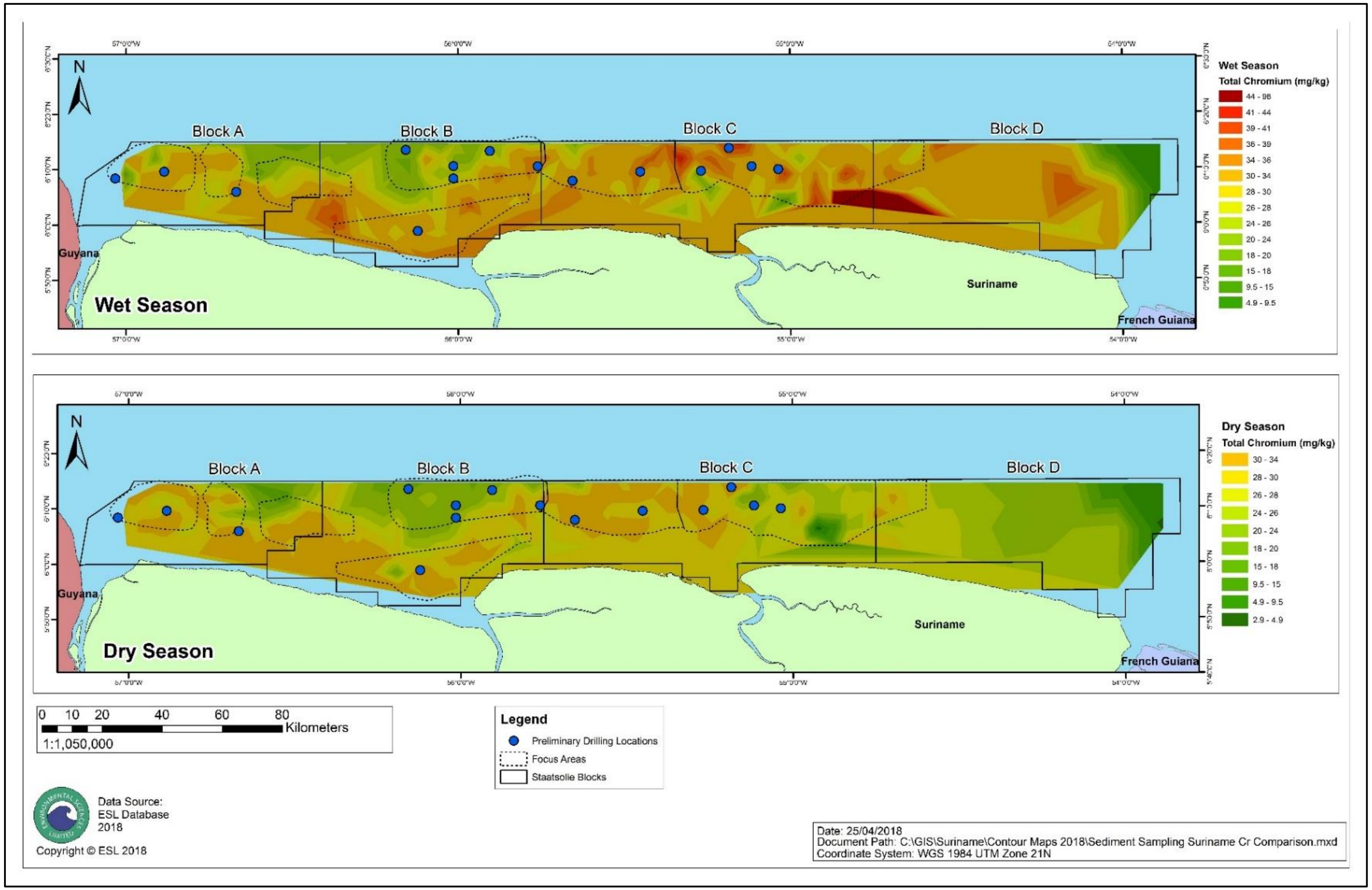
Hexavalent chromium was BDL at most stations sampled during the long wet and dry seasons in 2017. During the long wet season, it was detected at 2 stations, Station 151 (120.00 mg/kg) and Station 154 (15.00 mg/kg). These stations are located 15 km to the SE of the most easterly preliminary drilling location, within Block C (see Figure 5-36 above). During the long dry season, it was detected at Station 121 (12.00 mg/kg) and Station 129 (27.00 mg/kg), where these stations are located within 10 km of the preliminary drilling locations within the focus area of Block C (see Figure 5-36 above). There is no USEPA Benchmark for hexavalent chromium.

Table 5-12 above shows that the values of hexavalent chromium obtained during baseline sampling in 2017 at the comparable stations within Block C were lower than those observed during baseline sampling in 2013 within Block IV.

Total cadmium was BDL at all 245 stations sampled across the study area, during both the long wet and long dry seasons (see Table 5-11 above). It was also found to be BDL at all stations sampled during the 2013 baseline sampling event (see Table 5-12 above). These results precluded further analysis and comparison to the corresponding USEPA Benchmark (0.68 mg/kg).

Total chromium was detected at all 245 stations sampled during the 2017 long wet and long dry seasons' baseline sampling events. Table 5-11 and the contour gradient map for this parameter shown in Figure 5-41 below show that values of total chromium were higher during the long wet season, as compared to the long dry season (with ranges of 4.90 – 98.00 mg/kg and 2.90 – 34.00 mg/kg, respectively). Figure 5-41 also shows that the highest values are concentrated towards the eastern portion of Block C and western portion of Block D (towards the centre of these Blocks), where no preliminary drilling locations are observed. Figure 5-41 further illustrates that values which are marginally higher (during the wet season, as opposed to the dry) occur towards the northern central portion of Block C, within which 4 preliminary drilling locations are located. The lowest concentrations of total chromium occurred at the easternmost boundary of the study area, within Block D, during both seasons. Lower values (both seasons) were also noted within the northern portions of Blocks A, B and D. The majority of preliminary drilling locations within Block B occur in areas where total chromium levels were found to be lower than those within Blocks A and C.

Total chromium was found to exceed its USEPA Benchmark of 52.30 mg/kg at a single location (during the long wet season), Station 167 (98.00 mg/kg), within the focus area of Block C, but almost 25 km to the SE of the nearest preliminary drilling location (see Figure 5-36 above). A closer examination of the data revealed that the value of this station may in fact be an outlier to the dataset, and when it was removed from statistical analysis, the revised range and average for the long wet season was found to be 4.90 – 43.00 mg/kg and 30.01 ± 5.187 mg/kg. A comparison of this average with that of the long dry season (27.18 ± 4.698 mg/kg), revealed that the values recorded in the long wet season were still marginally higher than those recorded in the long dry season, even when taking the outlier into account, and so, corroborating the findings of the contour analysis presented in Figure 5-41 below. Total chromium was found to be BDL at all 34 stations sampled during the short wet season during 2013 (see Table 5-12 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-41: Contour Gradient Map for Sediment Total Chromium (mg/kg) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)

Total lead was detected at all 245 stations sampled during the 2017 long wet and long dry seasons' baseline sampling events. Table 5-11 and the contour gradient map for this parameter shown in Figure 5-42 below show that values of total lead were higher during the long wet season, as compared to the long dry season (with ranges of 2.70 – 77.00 mg/kg and 2.30 – 25.00 mg/kg, respectively). These differences in the levels of total lead across seasons also led to a higher average value of lead in the long wet season as opposed to the long dry season (with values of 21.87 ± 6.279 mg/kg and 19.28 ± 4.342 mg/kg, respectively).

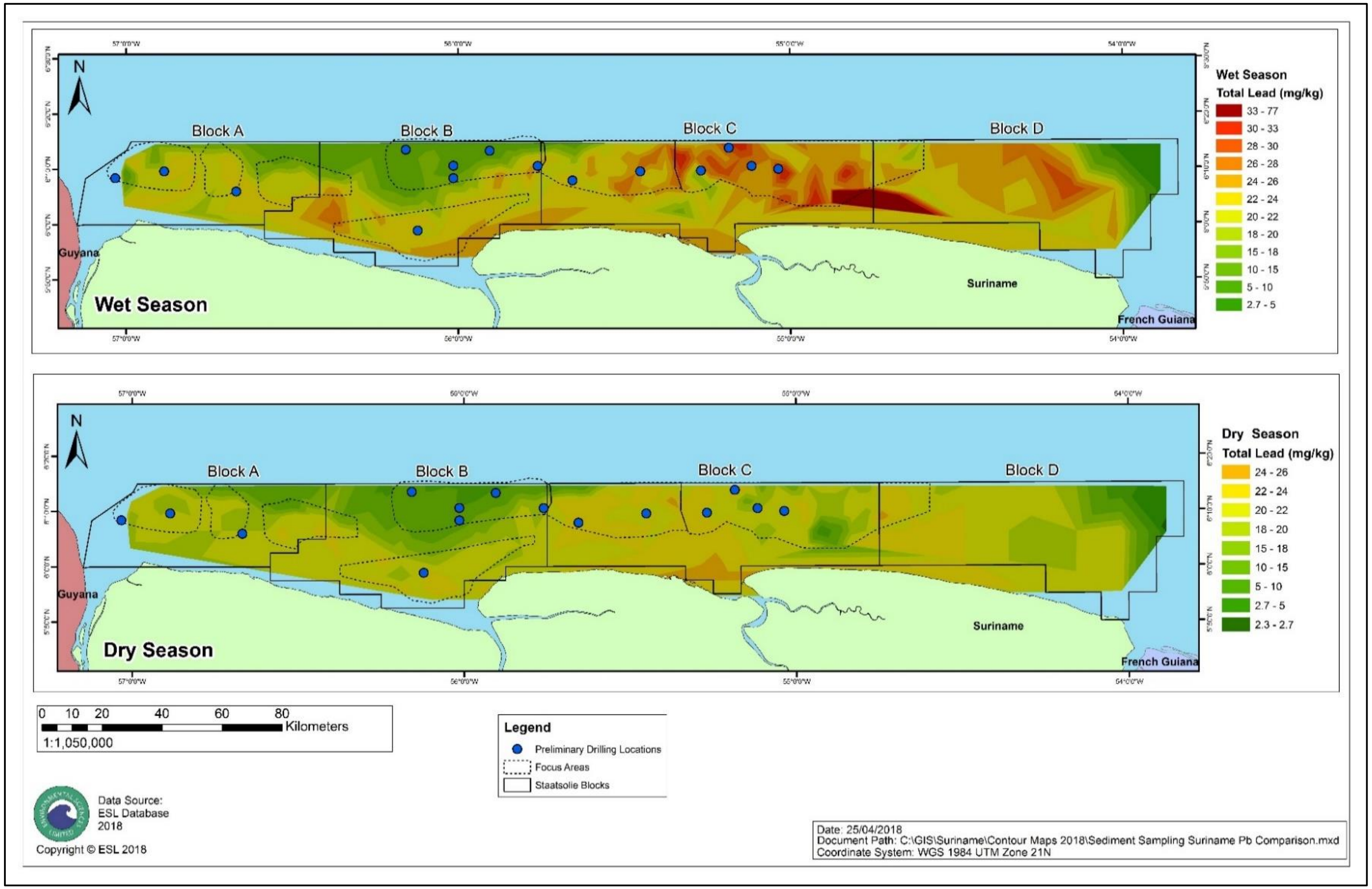
A closer examination of the total lead dataset for the long wet season revealed the presence of an outlier, in which the value of this parameter at Station 167 (77.00 mg/kg) was significantly higher than all other recorded values for that season. When the outlier was excluded from statistical analyses, the revised range and average for total lead for the long wet season was found to be 2.70 - 33.00 mg/kg and 21.65 ± 5.199 mg/kg. Comparing the latter statistic to the corresponding value for the dry season (19.28 ± 4.342 mg/kg; see Table 5-11 above), the average value for the long wet season was still higher than that for the dry season, corroborating the findings of the contour gradient analysis as mentioned above (see Figure 5-42 below).

The upper limits of the ranges (unadjusted and revised, based on the outlier) for total lead for the long wet season correspond to the areas where the values were higher (in relation to other parts of the study area), as shown in Figure 5-42 below. The values recorded in these areas (central and eastern portions of Block C, and the western portion of Block D) also exceeded the USEPA Benchmark of 30.20 mg/kg. This occurred at a total of 6 stations (Stations 121, 135, 149, 153, 167 and 169; see Figure 5-36 above). Also noteworthy is that the stations at which the relatively higher values were found (relative to the rest of the Blocks) are proximal to the 3 most easterly preliminary drilling locations within Block C, but no preliminary drilling locations occur where the values were highest (see Figure 5-42 below).

Regarding the exceedance of the USEPA Benchmark, 5 of the 6 stations recorded values marginally higher than the Benchmark (30.20 mg/kg); Stations 121, 135, 149, 153, and 169 ranged from 32 – 33 mg/kg. It was only at Station 167 (77.00 mg/kg), in which the value significantly exceeded the Benchmark.

The lowest concentrations of total lead occurred at the easternmost boundary of the study area, within Block D, during both seasons. Lower values (both seasons) were also noted within the northern portions of Blocks A and B. Also noteworthy is that the area which showed the highest level of total lead in the wet season (eastern portion of Block C), showed relatively lower levels compared to the surrounding areas in the dry season. The majority of preliminary drilling locations within Block B occur in areas where total lead levels were lower than those within Blocks A and C.

Total lead was found to be significantly higher at Stations 184, 118 and 119, and 234 during the long wet season of 2017, in comparison to the values recorded within the cluster of stations for Well-sites 2, 4 and 9, respectively, during the short wet season of 2013 (see Table 5-12 and Figure 5-37 above.



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-42: Contour Gradient Map for Sediment Total Lead (mg/kg) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)

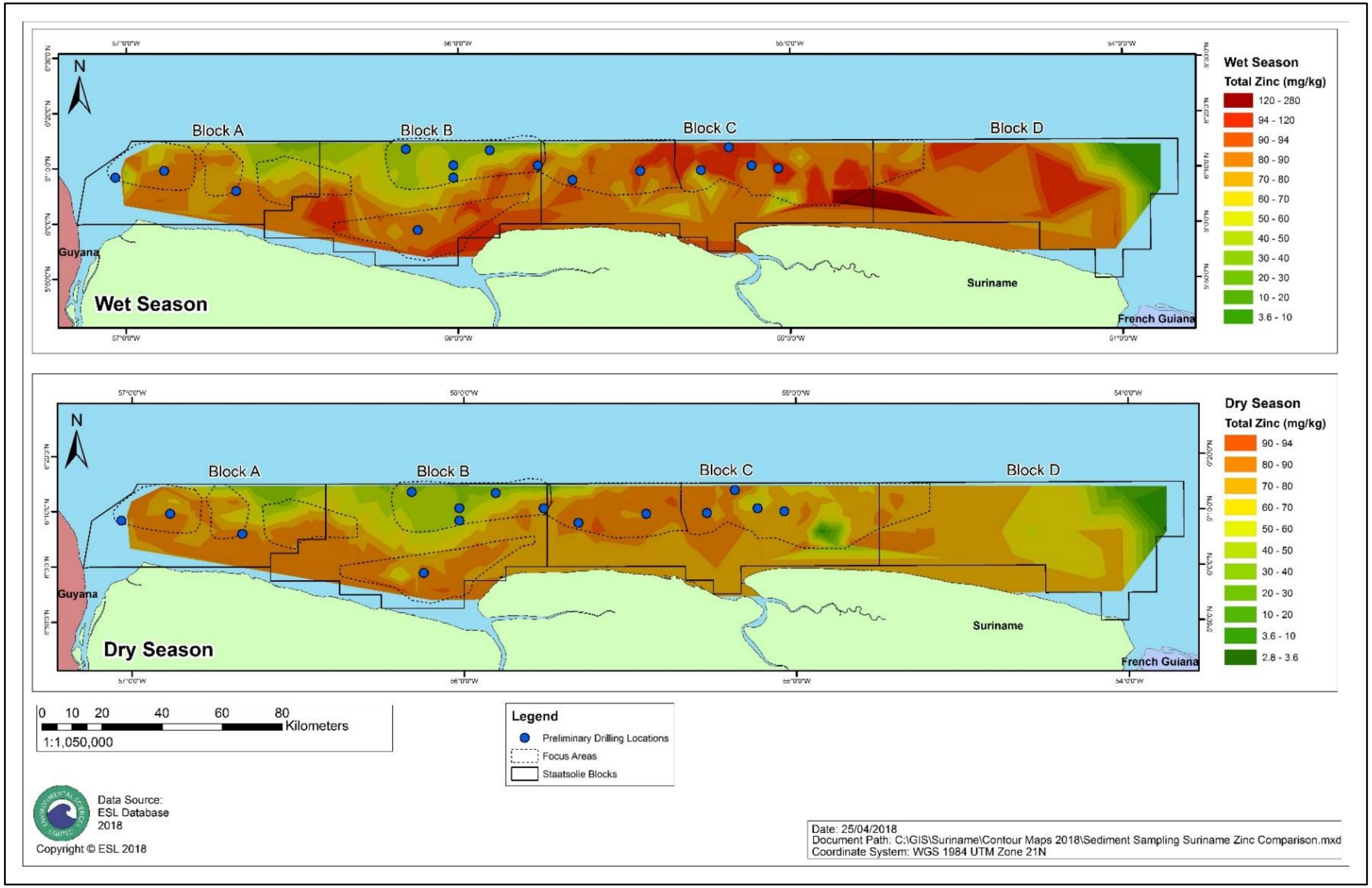
Total zinc was detected at all 245 stations sampled during the 2017 long wet and long dry seasons' baseline sampling events. Table 5-11 and the contour gradient map for this parameter shown in Figure 5-43 below show that values of total zinc were higher during the long wet season, as compared to the long dry season (with ranges of 3.60 – 280.00 mg/kg and 2.80 – 94.00 mg/kg, respectively). This was also reflected in the average values for the long wet and dry seasons (79.25 ± 23.367 mg/kg and 71.06 ± 17.274 mg/kg, respectively).

The value of total zinc at Station 167 nearer to the shore within Block C (280.00 mg/kg; see Figure 5-36 above) proved to be an outlier to the long wet season dataset, since this value was significantly higher than all other recorded values. When the range and average were recalculated to exclude this outlier value, the revised statistics were 3.60 – 120.00 mg/kg and 78.42 ± 19.54 mg/kg, respectively. Thus, even when the outlier was removed from the dataset for statistical analysis, the range and average for this parameter for the long wet season was still found to be higher than those for the long dry season (see Figure 5-43 below).

The value of total zinc at Station 167 within Block C (280.00 mg/kg) was the only detected value which exceeded its USEPA Benchmark (124.00 mg/kg); none of the dry season values of this parameter exceeded this Benchmark value.

The contour gradient analysis for this parameter presented in Figure 5-43 below shows that the highest levels of total zinc occurred in the eastern portion of Block C and western portion of Block D (towards the centre of these Blocks), with relatively higher levels spread over Blocks B, C and D, for the long wet season. For the long dry season, the highest levels were observed in the western portions of Block C and the Nearshore portions of Block B. The lowest levels of the total zinc were observed at the eastern portion of Block D, with other relatively low values occurring in the more northerly portions of Blocks A and B, during both seasons. None of the preliminary drilling locations coincide with the highest values of this parameter, but the majority of preliminary drilling locations within Block C coincide with areas of relatively high levels of total zinc (in both seasons, but this is more pronounced in the long wet season). For both seasons, the drilling locations within Block B occur in areas where the levels of total zinc were observed to be relatively lower, in comparison to other areas within the study area (see Figure 5-43 below).

Total zinc was found to be significantly higher at Stations 184, 118 and 119, and 234 during the long wet season of 2017, in comparison to the values recorded within the cluster of stations for Well-sites 2, 4 and 9, respectively, during the short wet season of 2013 (see Table 5-12 and Figure 5-37 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-43: Contour Gradient Map for Sediment Total Zinc (mg/kg) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)

Total mercury was BDL at 81 of 245 stations sampled in the long wet season (33%), and at 154 stations sampled in the long dry season (63%). A total of 64 of the 245 stations were BDL during both seasons (26%). Contour gradient analysis was not conducted for this parameter given that large portions of the datasets for both seasons were BDL. BDL values were observed throughout all Blocks, for both the long wet and dry seasons.

Where detected, values for the long wet season ranged from 0.018 – 0.230 mg/kg; the with an average value of 0.038 ± 0.0232 mg/kg. The corresponding values for the long dry season were 0.019 – 0.065 mg/kg and 0.029 ± 0.0059 mg/kg. Thus, where detected, levels of total mercury were found to be marginally higher in the long wet season as compared to the long dry season.

Total mercury exceeded its USEPA Benchmark of 0.13 mg/kg at only one station during the long wet season (Station 191 within Block D); none of the values detected during the long dry season exceeded the USEPA Benchmark. This station is not situated in proximity to any of the preliminary drilling locations (see Figure 5-36 above).

Total mercury was found to be higher at Stations 184, 118 and 119, and 234 during the long wet season of 2017, in comparison to the values recorded within the cluster of stations for Well-sites 2, 4 and 9, respectively, during the short wet season of 2013 (see Table 5-12 and Figure 5-37 above).

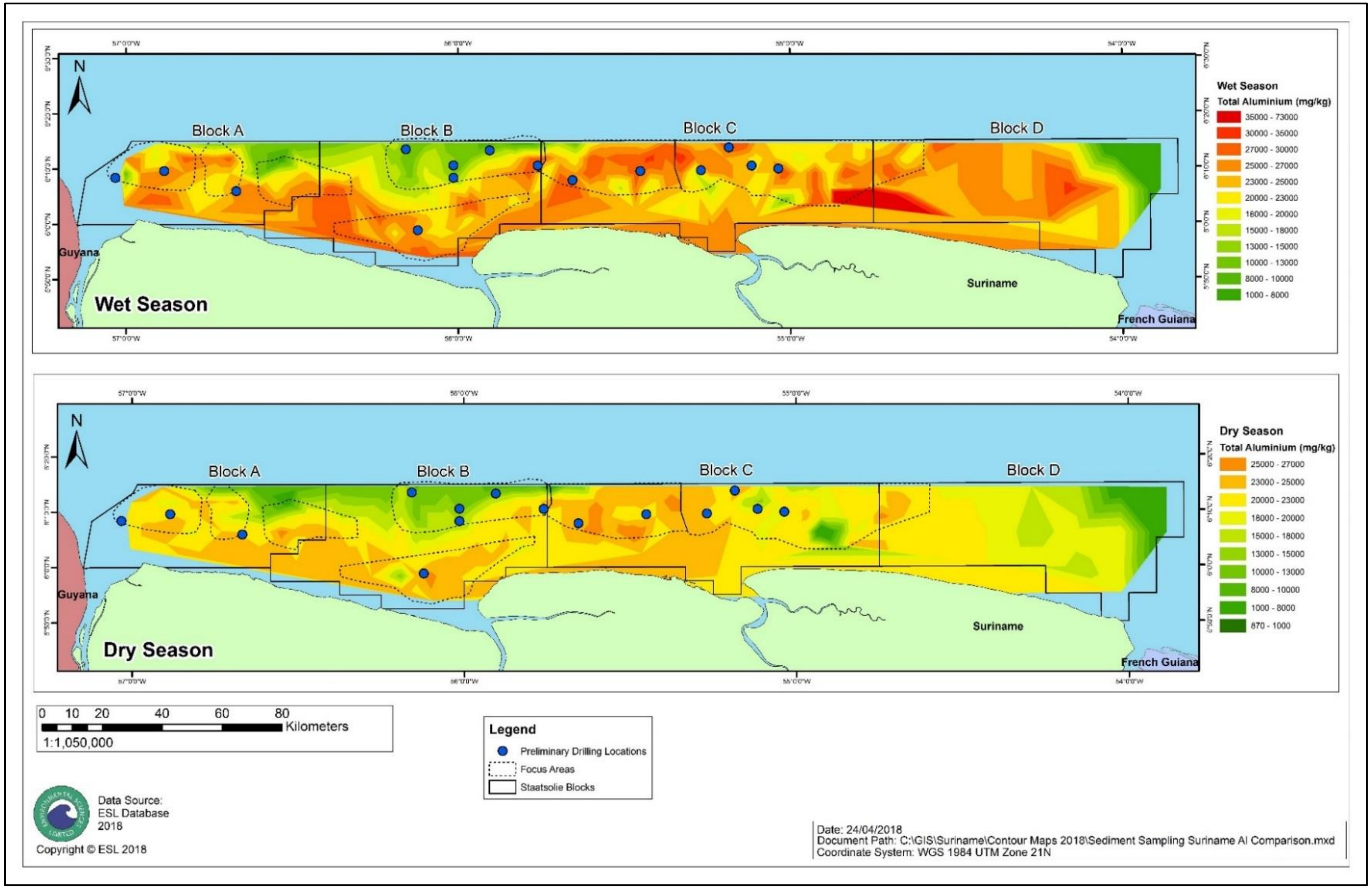
Total aluminium was detected at all 245 stations during the long wet and dry seasons in 2017. Table 5-11 and Figure 5-44 below show that the levels detected during the long wet season (1,000.00 – 73,000.00 mg/kg) were higher than the values recorded during the long dry season (870.00 – 27,000.00 mg/kg). This was also reflected in the average values per season: 22,665.31 ± 6,463.116 mg/kg for the long wet season, and 20,211.55 ± 4,999.899 mg/kg, for the long dry season.

The level of total aluminium at Station 167, closer to shore within Block C (73,000.00 mg/kg; see Figure 5-36 above) was significantly higher than all the other recorded values during the long wet season. This was determined to be an outlier and the range and average values for this parameter were recalculated excluding this datum. The revised range and average for this parameter for the long wet season were 1,000.00 - 32,000.00 mg/kg, and 22,459.02 ± 5,610.238 mg/kg, respectively, which was still higher than the average value for the long dry season (20,211.55 ± 4,999.899 mg/kg). There is no USEPA Benchmark for total aluminium.

The contour gradient analysis for this parameter presented in Figure 5-44 below shows that the highest levels of total aluminium occurred in the eastern portion of Block C and the western portion of Block D, respectively. Higher levels were also spread over Blocks A, B, C and D. For the long dry season, the highest levels were observed in the western portions of Block C and the Nearshore portions of Block B. The lowest levels of the total aluminium were observed at the eastern portion of Block D and the northern portion of Block A and B, with other relatively low values occurring in the more northerly portions of Block D, as well as in the area of Block C with the highest values in the long wet season.

None of the preliminary drilling locations coincide with the highest values of this parameter, but the majority of preliminary drilling locations within Block C coincide with areas of relatively high levels of total aluminium during the long wet season. For both seasons, the drilling locations within Block B occur in areas where the levels of total zinc were observed to be relatively lower, in comparison to other areas within the study area (see Figure 5-44 below).

Total aluminium at Station 184 during the 2017 long wet season was the same as the upper limit of the range observed for station cluster surrounding Well-site 2 in the short wet season of 2013 (24,000.00 mg/kg). The value of total aluminium at Station 118 (17,000.00 mg/kg) was lower than that detected within the station cluster for Well-site 4 (19,000.00 – 25,000.00 mg/kg) but the value at Station 119 (27,000.00 was higher than this range, as was the value recorded at Station 234 (31,000.00 mg/kg) as compared to the range detected within the station cluster for Well-site 9 (see Table 5-8, Table 5-12 and Figure 5-37 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-44: Contour Gradient Map for Sediment Total Aluminium (mg/kg) across the Study Area (Long Wet Season: June – August 2017; and Long Dry Season: September – November 2017)

There were several similarities observed during the analysis of the total metals, chromium, lead, zinc and aluminium. These parameters were detected at all stations during the long wet and long dry seasons of 2017 and values detected during the long wet season were higher than those detected in the long dry season (this being noted for total mercury also). Contour gradient analyses also showed that the highest values of total chromium, lead, zinc and aluminium were concentrated towards the eastern portion of Block C and western portion of Block D, for the long wet and dry seasons, with minor differences in the spread of relatively higher values of total zinc and total aluminium during the long dry season.

None of the preliminary drilling locations coincide with the highest values of these 4 metals; but the relatively higher levels (in comparison to the other parts of the study area) coincided with the preliminary drilling locations within Block C. The majority of preliminary drilling locations within Block B occur in areas where these 4 parameters were found to be lower than those within Blocks A and C.

The lowest concentrations of these parameters occurred at the easternmost boundary of the study area, within Block D, during both seasons, with relatively lower values (in comparison to the other parts of the study area) occurring within the northern portions of Blocks A and D. During the long dry season, low levels of total lead and total aluminium were observed in the area of Block C with the highest levels during the long wet season.

Station 167 proved to be an outlier for all 4 datasets during the long wet season; these parameters were highest at this location, and, the value recorded exceeded the USEPA Benchmarks for all 4 parameters. There were other exceedances within the study area, in the case of total lead, in the long wet season. Total mercury also excceded its USEPA Benchmark, but not at this station. None of the values recorded during the long dry season exceeded the respective USEPA Benchmarks.

The levels of total chromium, lead, zinc, mercury and aluminium recorded during the long wet season of 2017 were higher than the values recorded in the short wet season of 2013 (the exception being aluminium at Stations 184 and 118 in 2017). It is unclear as to what was the definitive source of these 5 metals within the Nearshore sediments of Suriname during the long wet and dry seasons' sampling events. However, it is likely that these sediments contain total metals from oil and gas seepages which are known to occur along the eastern coast of Suriname (see Section 5.3.1 and Figure 5-5 above), which were detected using Landsat, spot optical and radar images, as described in Bassias 2016. This seepage distribution is consistent with the NNW – SSE faulting direction, direction of the channels formed, and hydrocarbon shows Nearshore Guyana and Suriname (Bassias 2016).

5.3.10 Marine Water Quality

5.3.10.1 Introduction

The Marine Zone of Suriname stretches from the boundary of the Exclusive Economic Zone (EEZ) up to the coastline and has a surface area that equals the land area of Suriname (see Figure 5-45 below). It consists of the Deep and Continental Seas. The Deep Sea is found from the northern boundary of the EEZ, at 370 km offshore, up to the Continental Slope found at 150 km offshore. This area has depths between 200 m to over 4,000 m and covers about 75,000 km^2. From the relatively steep continental slope (between the 200 m and 100 m depth contour), the continental sea floor gradually climbs over a distance of 150 km up to the coastline. The Continental Sea has an area of about 65,000 km^2.

In the Continental Sea, 3 sub-zones, each approximately 50 km wide, are distinguished based on water depth; suspended material; clarity of water; and presence of planktonic biota (Teunissen 2000a). Although these zones have been distinguished based on depth classes, the actual locations of the boundaries have not been checked in the field. Therefore, the depth classes of the zones are rather arbitrary; moreover, they are subject to changes over the season and in time. Variations in mud supply, waves and currents, wind direction and speed all have influence on the boundaries of the zones.

The zones include the following:

- The Blue Water or Outer Zone: Covers an area of about 25,000 km^2. It is situated between the continental slope and the 60 m depth contour. The water is clear and sunlight penetrates to the ocean floor. Along the edge of the continental shelf, fossil coral reefs are found;

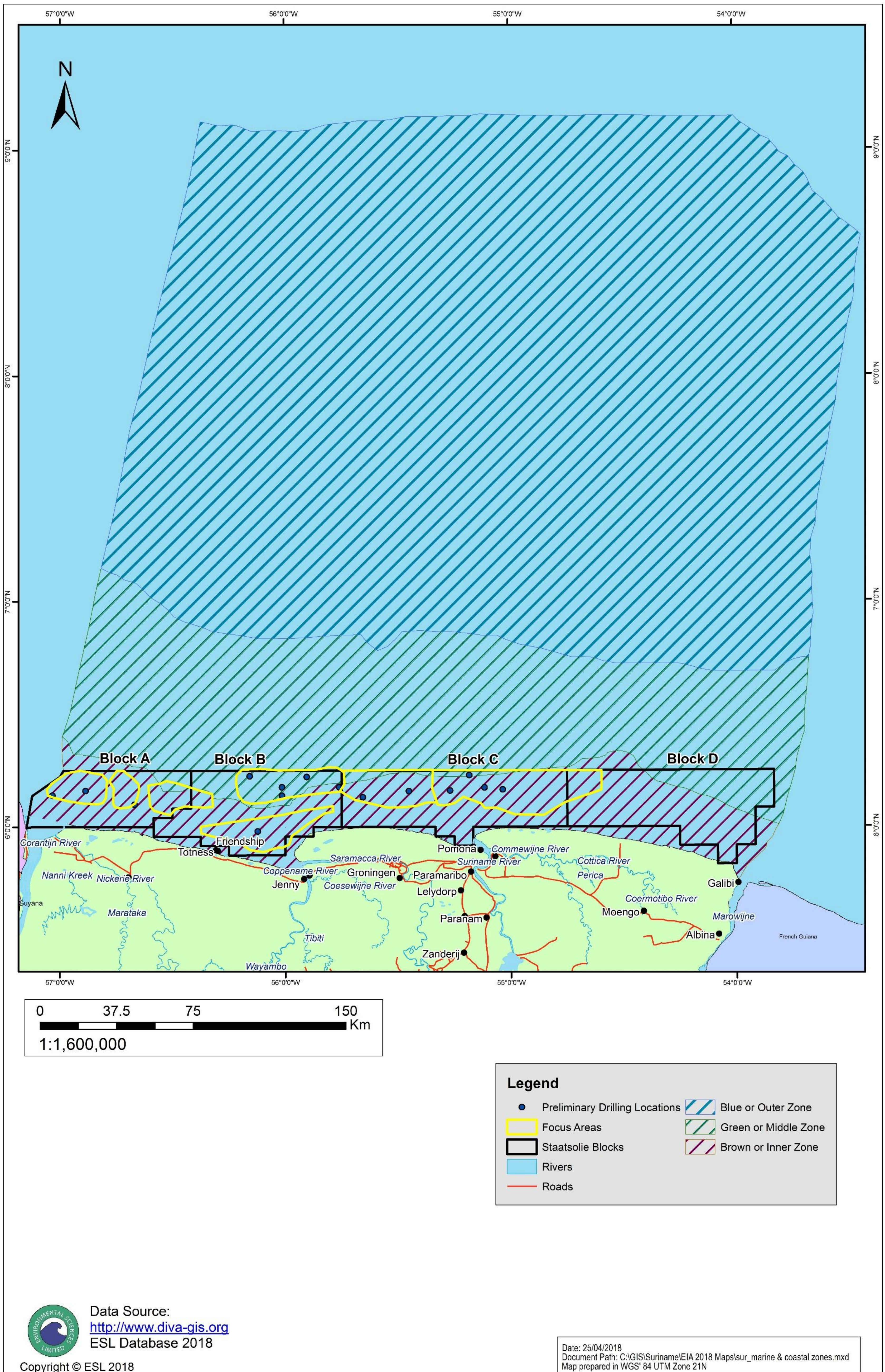
- The Green Water or Middle Zone: consists of green water due to an abundance of green algae as a result of the combination of the availability of nutrients from the land zone (which is very limited in the Blue Zone) and rather deep light penetration compared to that in the Brown Zone. It has a surface area of 20,000 km^2 and is situated between the 60 and 30 m depth contour; and

- The Brown Water or Inner Zone: with a surface area of 20,000 km^2, it is situated between the 30 m depth contour and the coastline. It consists of silt deposited by the Amazon River. Light penetration is less than 0.1 m. Within the Brown Water zone, the Surinamese Territorial Waters are found. This is 22.2 km (12 nautical miles) wide along the coast and has an area of 8,500 km^2.

Blocks A to D falls within the Brown and Green water zones (Figure 5-45 below), but the majority of the Blocks are located in the Brown water zone.

The ambient water quality within Nearshore Blocks A to D is described below using primary data from baseline surveys conducted for this Project within the area over the long wet and long dry seasons, and is supplemented with the findings of previously conducted studies within the 5-year window indicated as acceptable by NIMOS (see Appendix A.1) for comparative analysis.

The methodology of the 2017 baseline water quality assessment and the results (including the comparative analysis) are summarised in the relevant sub-sections below. Detailed methodologies and test results are presented in the relevant appendices as indicated below.



Source: ESL Database 2018 and Teunissen 2000a, adapted from Lowe-McConnell 1962 and Froidefond et al. 2002

Figure 5-45: Marine and Coastal Zones of Suriname

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5.3.10.2 Methodology

5.3.10.2.1 Sampling Plan Design

The sampling plan for this study is shown in Figure 5-36 above (see Section 5.3.9 above). A total of 61 stations were assessed for water quality, for which the GPS coordinates (WGS 1984 datum) are also presented in Appendix D.3. Water sampling locations were placed throughout Blocks A to D in order to provide data for a Block-wide assessment, and formed a subset of the sediment sampling locations (see Figure 5-36 above). The sample design for water quality assessment utilised a randomised distribution based on the sediment sampling locations, with more stations sited within the focus areas, as opposed to outside of the focus areas. The summary of methods and analyses presented below apply to both sampling events (long wet season: June – August 2017; and long dry season (September – November 2017).

5.3.10.2.2 Sampling Method

Water sampling was conducted at each of the 61 stations identified in Figure 5-36 above during the periods July 27th – August 11th, 2017 (long wet season) and October 21st – November 11th, 2017 (long dry season), using a Niskin Non-Metallic Water Sampler. The water sampler was deployed into the water column after being attached to a cable that was spooled onto a mechanical winch. The water sampler was then set, and lowered to the top, middle and bottom of the water column (see Appendix D.3 for further information). On reaching the desired depth, it was then triggered using a messenger device that closed the sampler, thereby collecting the water at that depth.

Each sample (from each level of the water column at each station) was retrieved from the water sampler using the winch. Water samples to be analysed for nutrient and metal parameters in the laboratory were filled into nalgene plastic containers, whilst samples for O&G and TPH were filled into Borosillicate glass bottles. Similarly, bottles used to collect water samples for metals analysis were pre-treated with nitric acid, whilst the bottles used to collect water samples for COD, ammoniacal nitrogen, phenol and phosphorus were pre-treated with sulphuric acid. Water samples for TSS were filled into nalgene plastic containers and stored at 4°C. Nutrients analysed on the vessel were filled into nalgene plastic containers and analysed within 48 hours. These included nitrates, nitrites and hexavalent chromium. Further details on treatment and analysis on-board the vessel are provided in Appendix D.3.

In-situ sampling was also conducted at the 61 water stations referenced above, for the long wet and dry seasons, concurrent to water sampling as specified above (see Appendix D.3 for additional information). This was conducted with the use of an RBR CTD profiler, which was deployed into the water column at a steady rate from the surface to the sea floor, and recorded data continuously once sensors were exposed to water. When completed, the probe was retrieved from the water, and data were checked to ensure values were obtained for the applicable parameters.

All water samples were then stored at 4°C until delivery to ESL's accredited laboratory for analysis. Additional details on the sampling method are presented in Appendix D.3. All water sampling utilised standardised and scientifically robust methods as outlined in '*Standard Methods for the Examination of Water and Wastewater 22nd Ed*.' (Rice *et al*. 2012). To assist in reliability, analytical accuracy and valid interpretation of data, a program of quality control measures was implemented in sample collection and handling / preservation procedures. These are presented in Appendix D.3.

5.3.10.2.3 Assessment Parameters

The 61 water samples retrieved at the locations presented in Figure 5-36 above were analysed for the following parameters:

- Nutrients, including: nitrate, nitrite, total phosphorus and ammoniacal nitrogen;
- TSS;
- COD;
- Total oil and grease (O&G);
- TPH;
- Phenol;
- Hexavalent chromium; and
- The total forms of the following metals: copper, nickel, zinc, cadmium, chromium, lead, mercury, barium, iron, arsenic and aluminium.

Profile data at the 61 stations identified in Appendix D.3 consider the following *in-situ* parameters with depth:

- pH;
- Temperature;
- Dissolved oxygen (DO);
- Salinity;
- Specific conductivity; and
- Chlorophyll-a.

Specific test methods, detection limits, and test results are presented in Appendix D.5 and Appendix D.6; *in-situ* parameter profiles are presented in Appendix D.9. All analyses utilised standardised and scientifically robust methods as outlined in '*Standard Methods for the Examination of Water and Wastewater 22nd Ed.*' (Rice *et al.* 2012) and USEPA. To assist in reliability, analytical accuracy and valid interpretation of data, a program of quality control measures was implemented in sample handling / preservation and laboratory procedures. This is presented in Appendix D.3.

5.3.10.2.4 Treatment of Data

The parameter level data retrieved for water at the various sampling stations, as presented in ESL's laboratory reports (see Appendix D.5 and Appendix D.6) was inputted into MS Excel® for basic statistical analysis and ArcGIS 10.1 for contour analysis by season. The findings are discussed in Section 5.3.10.3 below.

It should be noted that findings represent baseline conditions at the time of sampling, particularly for Blocks A, B and D, because there are no previous data pertaining to these areas to which to compare. For Block C, a comparative analysis (in keeping with the requirements of the Final Scoping Report; see Appendix A.1) is possible between the 2017 baseline results (long wet season) and those obtained from the assessment of water quality at 3 proposed well-sites within Block IV (the western half of Block C; see Figure 5-37 above) which was assessed by ESL in early February 2013 (short wet season) as part of the POC ESIA for Nearshore Exploration Drilling within Block IV (ESL 2013b). This 2013 short wet season dataset was the only one available for comparison to the 2017 dataset, given the NIMOS stipulations that the most recent available data (for comparison) must not be older than 5 years and site-specific (see Section 5.2 above).

Figure 5-37 above shows that 2 of the stations sampled during the long wet season in 2017 were situated in close proximity with those sampled in 2013 (for the POC Exploration ESIA sampling). As a result, direct comparisons are possible. These are provided in Table 5-14 below.

Table 5-14: Stations between which Direct Comparisons are possible for the 2013 POC Nearshore Exploration Drilling ESIA and 2017 Staatsolie Exploration ESIA Baseline Assessments of Water Quality

Staatsolie Exploration ESIA Baseline Station (Jun-Aug '17; Long Wet Season)	POC Exploration ESIA Baseline Station (Feb '13; Short Wet Season)	Area over which the Comparison is made (km²)
119	Stations 1 to 12 (Well-site 2) and Stations 13 to 23 (Well-site 4) combined	50
234	Stations 24 to 34 (Well-site 9)	6.20

Source: ESL Database 2018 and ESL 2013b

Comparisons were restricted to parameters in common between the various datasets. All of the parameters tested during 2017 baseline (long wet season) were tested for the POC exploration drilling baseline assessment in February

2013 (POC Exploration ESIA; short wet season), the only exception being O&G. Similarly, BOD was tested in 2013 but not in 2017.

At present, there are no local guidelines for ambient marine water quality, and international ambient water quality standards are not used as they are not directly applicable to Suriname (given local and regional environmental conditions). The comparative analysis was included, as described above, for this reason.

5.3.10.3 Results & Discussion

5.3.10.3.1 In-situ Parameters

Table 5-15 and Table 5-16 below present the ranges for all *in-situ* parameters measured at the 61 stations during the long wet and long dry seasons, respectively. Table 5-17 and Table 5-18 present the averages with standard deviation for the datasets. The following sub-sections present the findings of the analysis for pH, temperature, salinity, specific conductivity, DO and chlorophyll-a and present typical depth profiles for each parameter. The depth profiles generated at each station for each *in-situ* parameter are presented in Appendix D.9. The 2017 sampling locations are presented in Figure 5-36 above, and the 34 stations sampled during the short wet season of 2013 for comparative purposes are presented in Figure 5-37 above, alongside the relevant 2017 stations used for comparison.

Table 5-15: Ranges of Values of *In-Situ* Parameters (pH, Temperature, Salinity & Specific Conductivity) across Nearshore Blocks A to D, for the Long Wet & Long Dry Seasons of 2017 (June – August & September – November 2017, respectively)

Station No.	*In-situ* Parameter							
	pH		Temperature (˚C)		Salinity (psu)		Specific Conductivity (µS/cm)	
	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season
4	7.28 - 7.96	7.62 - 7.81	26.96 - 28.87	26.27 - 27.54	23.87 - 36.20	35.63 - 35.95	37,782.65 - 54,758.22	54.692.00 - 54750.72
5	7.81 - 7.97	8.06 - 8.10	27.07 - 28.16	28.29 - 28.30	25.90 - 36.18	35.76 - 35.81	40,642.18 -54,740.28	54,220.37 - 54,291.48
9	7.77 - 7.85	8.02 - 8.05	27.38 - 28.53	28.77 - 28.82	29.85 - 35.70	35.79 -35.82	46,177.73 - 54,100.63	54,282.59 - 54,326.87
10	7.75 - 7.97	7.65 - 7.86	27.04 - 28.04	25.90 - 27.93	32.19 - 36.22	35.31 - 36.10	49,369.81 - 54,794.22	54729.75 - 54750.72
19	7.78 - 8.06	8.10 - 8.14	26.97 - 29.65	28.18 - 28.58	31.72 - 36.15	36.00 - 36.05	48,731.75 - 54,701.55	54,541.47 - 54,636.09
23	7.79 - 7.92	7.71 - 8.09	26.99 - 27.41	26.88 - 28.72	33.70 - 36.17	35.96 - 36.78	51, 401.46 - 54,724.19	54,480.65 - 55,551.30
25	7.76 - 7.90	8.01 - 8.16	26.79 - 27.43	27.62 - 27.96	34.06 - 36.28	35.37 - 36.17	51, 401.46 - 54,724.19	53,667.27 - 54,740.14
27	7.76 - 7.86	7.82 - 8.09	26.82 - 27.03	28.11 - 30.24	34.51 - 36.28	35.13 - 35.97	52,475.60 - 54,860.71	53,411.76 - 54,491.68
31	7.72 - 7.90	8.04 - 8.15	26.68 - 28.11	27.62 - 27.96	35.04- 36.33	36.04 - 36.17	53,246.22 - 54,918.03	54,581.64 - 54,744.40
40	7.79 - 7.87	8.03 - 8.07	27.21- 28.42	28.08 - 29.96	33.20- 34.96	34.42 - 35.84	50,761.29 - 53,095.55	52,481.63 - 54,316.89
46	7.65 - 7.91	8.09 - 8.12	26.52- 28.18	27.96 - 28.04	34.93- 36.33	35.98 - 36.01	53,093.55 - 54,924.52	54,525.30 - 54,750.63
48	7.68 - 7.78	7.98 - 8.05	27.00- 28.09	28.93 - 28.79	34.93- 36.33	34.91 - 35.78	50,757.34 - 53,835.03	53,093.11 - 54,231.73
51	7.65 - 7.74	8.05 - 8.07	26.76- 27.36	27.61 - 27.89	32.25- 36.10	35.24 - 35.93	49,426.36 - 54,612.50	53,494.57 - 54,424.84
56	7.66 - 7.73	8.05 - 8.06	26.74- 26.94	27.93 - 28.00	35.57- 35.92	35.17 - 35.19	53,908.59 - 54,368.51	53,403.64 - 53,440.43
61	7.68 - 7.76	7.87 - 7.98	26.76- 27.37	28.26 - 28.83	29.72- 36.03	33.69 - 34.41	45,942.11 - 54,526.21	51,446.34 - 52,398.19
66	7.66 - 7.87	8.01 - 8.08	26.39- 27.20	27.45 - 27.47	35.76 - 36.36	35.91 - 36.05	54,167.05- 54,956.37	54,386.27- 54,578.90
68	7.63 - 7.94	8.00 - 8.06	26.14- 27.91	27.42 - 27.80	31.19 - 36.40	35.98 - 36.11	47,987.20- 55,002.72	54,484.03- 54,649.83
72	7.61 - 7.89	7.84 - 7.86	26.16- 28.92	27.98 - 28.58	28.67 - 36.35	35.53 - 35.55	44,557.05 - 54,920.21	54745.59 - 54,756.67
74	7.64 - 7.87	7.69 - 7.76	26.41- 27.80	27.18 - 27.94	33.54 - 36.21	35.27 - 35.46	51,196.34 - 54,750.34	54750.66 - 54,965.70
75	7.65 - 7.96	8.08 - 8.09	26.54- 27.68	27.80 - 27.86	35.78 - 36.38	36.16 - 36.20	54,216.76 - 55,005.18	54,747.50 - 54,791.77
81	7.64 - 7.97	8.07 - 8.08	26.38- 27.81	27.73 - 27.94	35.86 - 36.38	36.09 - 36.17	54,329.66 - 54,988.83	54,650.07 - 54,749.41
89	7.72 - 7.96	8.08 - 8.11	26.53- 27.48	27.76 - 27.88	35.83 - 36.36	35.88 - 36.23	54,279.73 - 54,971.14	54,375.14 - 54,822.84
94	7.64 - 7.96	7.93 - 8.10	26.23- 27.90	27.77 - 28.09	35.48 - 36.41	29.83 - 36.25	53,819.11 - 55,029.18	46,125.50 - 54,862.47
97	7.71 - 8.00	7.76 - 7.80	26.41- 28.13	26.95- 27.45	35.94 - 36.41	35.61 - 36.26	54,436.87 - 55,023.68	54,737.95 - 54,767.72
100	7.62 - 7.93	7.79 - 7.97	26.13- 28.25	26.66 - 27.57	35.13 - 36.45	35.98 - 36.58	53,360.29 - 55,064.94	54746.88 - 54751.84
103	7.64 - 7.94	7.96 - 8.02	26.06- 28.24	26.88 - 27.56	34.98 - 36.43	35.72 - 36.00	53,164.52 - 55,043.63	54345.72 - 54866.73
106	7.59 - 7.91	7.79 - 7.91	26.35- 27.62	25.83 - 29.26	34.20 - 36.39	35.52 - 35.74	52,090.99 - 54,996.77	54283.75 - 54,699.08
112	7.69 - 7.89	8.09 - 8.11	26.54- 27.50	27.48 - 27.72	35.75 - 36.34	36.10 - 36.20	54,166.67 - 54,935.98	54,642.90 - 54,780.58
119	7.93 - 7.94	7.92 - 7.92	28.90- 29.00	28.20 - 28.27	35.67 - 35.72	35.40 - 35.46	54,129.41 - 54,187.87	54,789.40 - 54,817.14
120	7.84 - 7.90	7.90 - 7.92	26.68- 27.63	28.18 - 28.57	36.07 - 36.35	35.39 - 35.44	54,605.69 - 54,953.16	54,774.98 - 54,805.83
125	7.86 - 7.86	7.92 - 7.93	28.19- 28.21	28.50 - 28.95	35.87 - 35.92	35.68 - 35.80	54,366.81 - 54,432.95	54,595.20 - 54,798.47
130	7.84 - 7.89	7.87 - 7.91	27.14- 27.77	27.04 - 27.30	35.98 - 36.16	35.29 - 36.36	54,492.42 - 54,711.19	54,712.80 - 54,804.62
135	7.80 - 7.94	7.81 - 7.90	26.58- 28.16	26.94 - 27.87	35.65 - 36.31	35.67 -36.20	54,065.27 - 54,892.86	54,047.36 - 54,8801.41
137	7.92 - 7.95	7.77 - 7.81	28.36- 28.97	27.15 - 27.53	35.75 - 35.78	35.91 - 36.02	54,214.30 - 54,266.61	54,189.52 - 54,917.36

Station No.	*In-situ* Parameter							
	pH		Temperature (˚C)		Salinity (psu)		Specific Conductivity (µS/cm)	
	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season
143	7.84 - 7.89	7.97 - 8.01	28.04- 28.57	28.37 - 29.75	35.58 - 35.66	35.60 - 36.00	53,980.46 - 54,070.71	53809.65 - 54,541.28
145	7.79 - 7.91	7.74 - 7.94	26.85- 28.22	26.87 - 28.83	35.59 - 36.10	33.93 - 36.26	53,967.07 - 54,615.98	53,534.01 - 54,557.24
151	7.89 - 7.90	7.85 - 7.98	28.11- 28.18	28.19 - 29.51	35.50 - 35.52	34.99 - 35.77	53,868.02 - 53,893.70	53,226.03 - 54,231.73
156	7.85 - 7.86	7.99 - 8.01	28.01- 28.07	28.10 - 28.32	35.43 - 35.44	35.89 - 36.05	53,760.12 - 53,771.78	54,385.76 - 54,607.91
159	7.78 - 7.86	8.05 - 8.08	26.06- 27.19	26.64 - 27.78	35.62 - 36.35	36.00 - 36.31	53,985.30 - 54,982.00	54,472.10 - 54,917.36
163	7.73 - 7.88	7.73 - 7.96	26.61- 28.23	28.10 - 28.72	34.58 - 35.97	35.62 - 35.91	52,629.95 - 54,429.60	54,047.36 - 54,415.69
165	7.89 - 7.93	7.98 - 8.02	27.46 - 28.46	27.96 - 28.63	35.30 - 35.80	36.03 - 36.20	53,599.45 - 54,242.49	54,595.20 - 54,804.62
172	7.86 - 7.98	7.19 - 7.93	27.51- 29.05	28.56 - 28.64	34.44 - 35.68	29.43 - 35.47	52,473.96 - 54,076.21	45,598.79 - 53,835.28
175	7.92 - 7.93	8.05 - 8.05	27.44- 28.06	27.73 - 27.79	35.47 - 35.81	35.55 - 36.22	53,812.71 - 54,249.69	53,921.94 - 54,817.14
177	7.65 - 7.94	7.52 - 7.83	26.07- 27.60	27.10 - 28.38	35.40 - 36.44	32.42 - 36.45	53,706.91 - 55,065.69	54718.42 - 54755.29
178	7.75 - 7.92	7.36 - 7.91	26.65 - 27.34	25.78 - 28.68	36.12 - 36.37	29.09 - 36.77	54,656.39 - 54,979.10	53274.41 - 5455.38
179	7.85 - 7.91	7.50 - 8.03	26.74- 27.33	26.08 - 27.47	36.06 - 36.34	33.69 - 36.65	54,579.82 - 54,946.61	54,763.67 - 54,862.47
182	7.97 - 7.99	7.73 - 7.85	29.21- 29.61	25.92 - 27.56	35.83 - 35.95	36.06 - 36.48	54,353.13 - 54,518.79	54,788.33 - 54,794.97
185	7.92 - 7.92	7.78 - 7.81	28.78- 28.85	26.76 - 28.02	35.55 - 35.61	34.78 - 35.81	53,956.86 - 54,041.18	54796.66 - 54,801.61
187	7.95 - 7.97	7.98 - 8.03	28.53- 28.92	26.97 - 28.01	35.25 - 35.30	34.75 - 35.80	53,553.22 - 53,613.11	54736.52 - 54749.41
189	7.86 - 7.97	7.95 - 7.96	27.36- 28.69	27.82 - 28.37	34.42 - 35.83	35.81 - 36.13	52,431.32 - 54,280.17	54,283.75 - 54,699.08
193	7.88 - 7.88	7.79 - 7.98	27.06- 27.59	27.89 - 28.62	35.39 - 36.06	36.03 - 36.12	53,694.69 - 54,572.94	54,590.24 - 54,690.02
198	7.84 - 7.92	7.86 - 8.00	26.90- 28.21	27.69 - 28.11	34.70 - 36.18	28.82 - 36.18	53,694.69 - 54,572.94	44,709.65 - 54,761.67
206	7.92 - 7.98	7.89 - 7.91	28.44- 29.10	27.97 - 28.09	33.05 - 34.00	35.12 - 35.20	50,588.48 - 51,846.36	53,345.72 - 53,451.97
211	7.94 - 7.97	8.00 - 8.01	27.95- 28.27	27.21 - 27.25	33.26 - 35.60	36.11 - 36.17	53,544.47 - 53,987.10	54,645.38 - 54,731.93
213	7.80 - 7.98	7.98 - 8.10	27.10- 28.16	27.39 - 27.73	36.18 - 36.30	35.95 - 36.19	54,759.09 - 54,901.92	54,438.56 - 54,770.38
216	7.88 - 7.90	8.07 - 8.10	27.74- 27.99	26.91 - 27.63	35.01 - 36.19	36.18 - 36.35	53,192.82 - 54,767.66	54,745.59 - 54,965.70
221	7.96 - 7.97	8.04 - 8.19	27.49- 27.64	27.00 - 27.45	36.12 - 36.14	36.14 - 36.19	54,666.93 - 54,701.50	54,692.25 - 54,750.72
223	7.95 - 7.98	7.91 - 8.02	29.17 - 29.66	27.03 - 27.88	35.81 - 35.94	33.85 -35.96	54,326.36 - 54,499.51	54,736.24 - 54,741.63
225	7.85 - 7.89	7.51 - 7.80	26.77 - 27.15	27.00 - 28.92	35.04 - 36.33	35.34 - 36.02	53,195.02 - 54,928.00	54747.50 - 54,789.33
234	7.84 - 7.93	7.81 - 7.90	26.73 - 27.66	26.36 - 27.43	35.78 - 36.31	35.95 - 36.23	54,220.16 - 54,899.60	54,390.89 - 54,578.90
238	7.84 - 7.88	8.00 - 8.00	27.24 - 27.68	27.95 - 28.52	36.03 - 36.14	35.44 - 36.10	54,548.35 - 54,687.44	54,496.57 - 54,534.48

Source: 2017 In-situ Probe Data (see Appendix D.9)

Table 5-16: Ranges of Values of *In-Situ* Parameters (Dissolved Oxygen & Chlorophyll-a) across Nearshore Blocks A to D, for the Long Wet & Long Dry Seasons of 2017 (June – August & September – November 2017, respectively)

Station No.	*In-situ* Parameter			
	DO (mg/l)		Chlorophyll-a (µg/l)	
	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season
4	4.18 - 5.40	3.92 - 5.01	1.48 - 4.96	0.16 - 11.22
5	4.00 - 5.08	3.92 - 5.01	1.16 - 7.69	1.82 - 2.96
9	4.06 - 5.19	4.03 -4.87	1.76 -2.94	1.83 -2.79
10	4.01 - 5.16	3.93 - 5.02	1.45 - 8.53	1.11 - 6.54
19	4.01 - 5.60	3.73 - 5.08	1.94 - 11.61	1.46 - 6.04
23	4.26 - 5.43	4.16 - 5.47	1.88 - 21.39	0.82 - 3.50
25	4.02 - 5.88	3.94 - 5.22	1.72 - 15.01	1.82 - 3.86
27	4.02 - 5.39	4.22 - 5.39	1.49 - 17.83	1.73 - 6.33
31	3.92 - 5.21	4.09 - 5.13	1.33 - 2.71	1.90 - 6.20
40	4.06 - 5.56	4.16 - 5.20	0.43 - 11.85	1.37 - 2.94
46	4.01 - 5.32	3.92 - 5.28	1.33 - 2.71	1.45 - 2.55
48	4.08 - 5.32	4.28 - 5.74	2.53 - 6.10	2.17 - 6.88
51	4.03 - 5.22	4.10 - 5.27	2.99 - 6.27	1.96 - 3.28
56	3.96 - 4.99	5.15 - 5.44	3.30 - 7.19	2.43 - 3.63
61	4.07 - 5.07	4.27 - 5.25	3.50 - 9.82	4.02 - 6.43
66	4.00 - 5.13	3.85 - 4.88	1.52 - 2.49	1.49 - 2.66
68	4.01 - 5.40	0.50 - 5.18	0.50 - 5.18	1.07 - 2.60
72	4.01 - 5.32	4.36 - 4.97	4.99 - 15.96	2.54 - 7.51
74	4.13 - 5.15	4.61 - 5.54	8.05 - 19.31	2.54 - 7.51
75	3.88 - 5.55	3.84 - 5.38	0.64 - 2.34	0.54 - 2.23
81	4.17 - 5.294	3.99 - 5.76	0.92 - 3.11	0.56 - 2.00
89	4.05 - 5.36	3.89 - 5.23	0.84 - 2.32	0.66 - 1.05
94	4.03 - 5.49	3.88 - 5.05	0.85 - 8.88	0.60 - 3.19
97	4.00 - 5.59	4.11 - 5.18	0.49 - 1.84	0.88 - 2.28
100	4.01 - 5.36	4.03 - 5.27	1.13 - 6.61	0.74 - 3.31
103	3.96 - 5.38	3.73 - 5.16	0.90 - 20.57	1.37 - 19.76
106	4.00 - 5.12	4.02 - 5.10	0.94 - 7.34	5.42 - 11.31
112	4.00 - 5.34	3.86 - 5.05	0.42 - 5.42	0.89 - 1.99
119	4.03 - 5.31	3.95 - 5.15	2.18 - 3.10	1.89 - 2.13
120	4.04 - 5.21	4.00 - 4.77	2.15 - 5.49	3.68 - 7.91
125	4.09 - 5.49	4.12 - 5.03	2.95 - 5.38	5.09 - 8.99
130	4.01 - 5.20	4.87 - 5.34	0.17 - 11.68	1.68 - 6.36
135	4.00 - 5.02	4.17 - 5.06	2.82 - 6.81	1.17 - 2.81
137	4.33 - 5.23	4.33 - 4.99	2.65 - 7.82	1.66 - 6.18
143	4.02 - 5.33	4.10 – 5.48	3.86 - 11.97	1.63 - 5.63
145	4.04 - 5.15	3.90 - 5.47	3.97 - 10.83	1.41 - 4.71
151	4.04 - 5.15	4.10 - 4.97	4.27 - 12.55	1.24 - 3.14
156	4.03 - 5.44	3.88 - 4.72	3.38 - 9.02	1.21 - 3.44
159	4.06 - 5.26	3.90 - 4.94	1.12 - 7.13	0.99 - 3.44
163	4.20 - 5.31	3.96 - 4.99	1.26 - 4.58	1.20 - 2.98
165	4.02 - 5.47	4.00 - 5.17	1.05 - 3.92	0.91 - 2.45
172	4.07 - 5.02	3.93 - 5.13	2.28 - 16.56	2.04 - 2.88
175	4.05 - 5.24	3.84 - 5.41	1.58 - 2.93	2.84 ± 2.00
177	4.06 - 5.17	4.05 - 5.18	0.65 - 18.71	1.09 - 8.19
178	4.04 - 5.13	4.02- 5.52	0.76 - 3.52	2.11 - 4.05
179	4.13 - 5.28	4.29 - 5.37	1.40 - 4.82	0.86 - 3.14
182	4.15 - 5.58	4.30 - 4.93	5.70 - 11.66	0.48 - 1.72
185	4.00 - 5.51	4.44 - 5.23	1.95 - 2.22	1.28 - 6.48
187	4.28 - 5.28	3.92- 5.14	3.75 - 8.07	1.11 - 5.07
189	4.01 - 5.02	4.14 - 5.32	1.96 - 10.49	1.01 - 2.42
193	4.02 - 5.06	3.95 - 5.00	2.10 - 3.06	0.96 - 2.54
198	4.01 - 5.16	3.86 - 5.28	0.05 - 3.42	0.77 - 2.54
206	4.01 - 5.33	4.37 - 4.97	0.10 - 6.58	2.39 - 3.82
211	4.09 - 5.30	3.95 - 4.97	4.22 - 20.19	0.38 - 2.32
213	4.00 - 5.06	3.91 - 5.01	0.57 - 3.50	0.61 - 2.55
216	4.12 - 5.59	3.96 - 4.83	1.99 - 2.84	2.04 - 4.26
221	4.16 - 5.17	3.76 - 4.63	0.39 - 2.18	0.52 - 2.84
223	4.05 - 5.10	4.06 - 5.17	0.03 - 9.45	0.92 - 7.05
225	4.04 - 5.21	4.01 - 5.15	1.17 - 6.62	2.07 - 3.34
234	4.23 - 5.06	4.05 - 4.95	1.02 - 2.87	2.28 - 2.91
238	4.51 - 5.57	3.99 - 5.48	1.70 - 6.30	2.58 - 5.12

Source: 2017 In-situ Probe Data (see Appendix D.9)

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Table 5-17: Average & Standard Deviation of Values of *In-Situ* Parameters (pH, Temperature, Salinity & Specific Conductivity) across Nearshore Blocks A to D, for the Long Wet & Long Dry Seasons of 2017 (June – August & September – November 2017, respectively)

Station No.	*In-situ* Parameter							
	pH		Temperature (˚C)		Salinity (psu)		Specific Conductivity (µS/cm)	
	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season
4	7.77 ± 0.176	7.75 ± 0.05	27.55 ± 0.84	27.17 ± 0.44	34.13 ± 3.89	35.74 ± 0.13	51,926.81 ± 5,332.04	54737.42 ± 16.65
5	7.86 ± 0.062	8.09 ± 0.01	27.39 ± 0.45	28.30 ± 0.00	34.48 ± 2.92	35.80 ± 0.01	52,432.94 ± 3,979.63	54,272.03 ± 18.57
9	7.80 ± 0.035	8.05 ± 0.01	27.81 ± 0.50	28.80 ± 0.01	34.46 ± 2.13	35.82 ± 0.01	52,430.96 ± 2,880.50	54,317.35 ± 11.86
10	7.80 ± 0.064	7.76 ± 0.08	27.21 ± 0.28	26.92 ± 0.73	35.70 ± 1.10	35.67 ± 0.30	54,097.92 ± 1,473.92	54737.69 ± 5.63
19	7.87 ± 0.100	8.11 ± 0.01	27.44 ± 0.76	28.25 ± 0.10	35.37 ± 1.30	36.05 ± 0.02	53,644.07 ± 1,752.24	54,612.87 ± 21.34
23	7.84 ± 0.055	7.99 ± 0.16	27.17 ± 0.19	27.98 ± 0.57	35.30 ± 1.00	36.09 ± 0.30	53,553.66 ± 1,343.48	54,601.31 ± 315.26
25	7.81 ± 0.051	8.11 ± 0.05	26.96 ± 0.20	27.82 ± 0.15	35.81 ± 0.84	36.05 ± 0.17	53,553.66 ± 1,343.48	54,594.10 ± 222.65
27	7.80 ± 0.040	8.07 ± 0.07	26.90 ± 0.08	28.45 ± 0.61	35.96 ± 0.61	35.70 ± 0.23	54,431.14 ± 821.05	54,143.86 ± 302.19
31	7.84 ± 0.050	8.10 ± 0.04	27.31 ± 0.46	27.82 ± 0.15	35.82 ± 0.42	36.10 ± 0.05	54,261.24 ± 544.61	54,651.62 ± 68.80
40	7.83 ± 0.026	8.05 ± 0.01	27.49 ± 0.43	28.50 ± 0.57	34.29 ± 0.59	35.40 ± 0.45	52,200.18 ± 777.45	53,746.59± 582.72
46	7.88 ± 0.099	8.11 ± 0.01	27.05 ± 0.61	27.99 ± 0.02	35.96± 0.52	36.00 ± 0.01	54,441.63 ± 673.46	54,594.31 ± 93.30
48	7.74 ± 0.033	8.03 ± 0.02	27.53 ± 0.34	28.37 ± 0.33	35.96 ± 0.52	35.24 ± 0.37	51,599.16 ± 1,158.94	53,523.27 ± 479.98
51	7.71 ± 0.032	8.07 ± 0.01	27.03 ± 0.21	27.78 ± 0.10	34.68 ± 1.19	35.48 ± 0.26	52,705.64 ± 1,602.41	53,813.81 ± 344.84
56	7.70 ± 0.017	8.05 ± 0.00	26.82 ± 0.05	27.96 ± 0.02	35.75± 0.10	35.18 ± 0.01	54,139.59 ± 134.68	53,424.97 ± 12.23
61	7.74 ± 0.023	7.94 ± 0.04	26.96 ± 0.17	28.61 ± 0.21	35.02± 2.02	33.98 ± 0.26	53,153.99 ± 2,749.71	51,821.60 ± 344.43
66	7.76 ± 0.085	8.07 ± 0.02	26.74 ± 0.34	27.46 ± 0.01	36.09 ± 0.26	35.96 ± 0.06	54,601.64 ± 342.92	54,455.15 ± 79.92
68	7.71 ± 0.108	8.05 ± 0.02	26.61 ± 0.71	27.59 ± 0.14	35.62 ± 1.57	36.01 ± 0.05	53,961.36 ± 2,112.51	54,529.77 ± 58.74
72	7.69 ± 0.111	7.85 ± 0.01	26.84 ± 1.07	28.17 ± 0.25	34.72 ± 3.01	35.54 ± 0.01	52,732.45 ± 4,066.11	54750.42 ±3.73
74	7.69 ± 0.086	7.72 ± 0.03	26.69 ± 0.55	27.51 ± 0.29	35.73 ± 1.07	35.37 ± 0.08	54,104.00 ± 1,425.31	54,801.29 ± 81.17
75	7.84 ± 0.142	8.09 ± 0.00	27.19 ± 0.48	27.81 ± 0.02	36.14 ± 0.25	36.19 ± 0.01	54,694.67 ± 324.15	54,780.05 ± 12.05
81	7.84 ± 0.147	8.08 ± 0.00	27.17 ± 0.60	27.78 ± 0.07	36.14 ± 0.24	36.15 ± 0.02	54,691.05 ± 307.54	54,730.90 ± 25.44
89	7.92 ± 0.074	8.1 ± 0.01	27.26 ± 0.29	27.87 ± 0.02	36.10 ± 0.24	36.19 ± 0.06	54,638.37 ± 310.59	54,780.80 ± 78.68
94	7.81 ± 0.139	8.08 ± 0.03	26.89 ± 0.59	27.86 ± .12	36.18 ± 0.34	35.92 ± 1.28	54,729.28 ± 445.36	54,411.77 ± 1,735.54
97	7.88 ± 0.110	7.79 ± 0.01	27.11 ± 0.55	27.07 ± 0.15	36.25 ± 0.19	36.00 ± 0.21	54,835.81 ± 241.73	54752.12 ± 8.67
100	7.81 ± 0.122	7.91 ± 0.07	26.82 ± 0.58	27.23 ± .30	36.15 ± 0.37	36.17 ± 0.21	54,688.33 ± 481.77	54749.43 ± 1.67
103	7.85 ± 0.117	7.99 ± 0.03	26.99 ± 0.58	27.29 ± 0.24	36.05 ± 0.49	35.86 ± 0.12	54,561.76 ± 643.23	54,594.77 ± 179.48
106	7.83 ± 0.107	7.86 ± 0.05	26.88 ± 0.37	27.96 ± 1.46	35.96 ± 0.63	35.65 ± 0.08	54,427.97 ± 842.41	54,492.57 ± 141.87
112	7.82 ± 0.079	8.1 ± 0.01	27.13 ± 0.38	27.64 ± .08	36.08 ± 0.22	36.17 ± 0.02	54,603.45 ± 283.11	54,746.55 ± 23.11
119	7.94 ± 0.003	7.90 ± 0.00	28.94 ± 0.04	28.22 ± 0.03	35.70± 0.01	35.45± 0.02	54,161.85 ± 17.80	54,799.61 ± 9.18
120	7.88 ± 0.019	7.90 ± 0.01	27.28 ± 0.34	28.27 ± 0.14	36.18 ± 0.12	35.42 ± 0.02	54,737.01 ±146.55	54,798.76 ± 9.74
125	7.86 ± 0.001	8.00 ± 0.00	28.20 ± 0.01	28.62 ± 0.17	35.91 ± 0.02	35.74 ± 0.04	54,418.26 ±21.19	54,742.79 ± 72.62
130	7.88 ± 0.017	7.89 ± 0.01	27.63 ± 0.24	27.16 ± 0.09	36.03 ± 0.07	35.85 ± 0.39	54,547.38 ± 85.21	54,776.99 ± 38.99
135	7.89 ± 0.045	7.81 ± 0.04	27.50 ± 0.50	27.37 ± 0.44	35.88 ± 0.23	35.96 ± 0.25	54,347.54 ± 286.09	54,477.81 ± 321.73

Station No.	*In-situ* Parameter							
	pH		Temperature (˚C)		Salinity (psu)		Specific Conductivity (µS/cm)	
	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season
137	7.94 ± 0.007	7.80 ± 0.01	28.49 ± 0.22	27.25 ± 0.13	35.77 ± 0.01	35.99 ± 0.03	54,237.81 ± 15.90	54,832.78 ± 40.19
143	7.86 ± 0.019	7.99 ± 0.01	28.26 ± 0.22	28.73 ± 0.48	35.62 ± 0.03	35.86 ± 0.16	54,023.57 ± 33.47	54,133.84 ± 196.16
145	7.84 ± 0.041	7.79 ± 0.07	27.37 ± 0.47	27.51 ± 0.84	35.87 ± 0.19	35.55 ± .96	54,325.35 ± 242.31	54,551.73 ± 6.77
151	7.89 ± 0.004	7.94 ± 0.04	28.13 ± 0.02	28.82 ± 0.55	35.51 ± 0.00	35.36 ± 0.32	53,877.40 ± 5.29	53,702.42 ± 402.59
156	7.86 ± 0.004	8.00 ± 0.01	28.02 ± 0.02	28.13 ± 0.06	35.43 ± 0.00	36.01 ± 0.04	53,767.30 ± 2.60	54,543.29 ± 50.19
159	7.81 ± 0.035	8.06 ± 0.01	26.52 ± 0.48	27.34 ± 0.51	36.05 ± 0.32	36.21 ± 0.08	54,539.33 ± 406.98	54,783.08 ± 112.46
163	7.77 ± 0.059	7.93 ± 0.08	27.04 ± 0.67	28.40 ± 0.23	35.59 ± 0.56	35.77 ± 0.11	53,945.44 ± 732.96	54,229.57 ± 138.10
165	7.91 ± 0.014	8.01 ± 0.01	27.88 ± 0.43	28.19 ± 0.23	35.56 ± 0.23	36.17 ± 0.05	53,928.89 ± 292.53	54,758.75 ± 60.00
172	7.92 ± 0.052	7.77 ± 0.26	27.17 ± 0.64	28.58 ± 0.02	35.04 ± 0.57	33.77 ± 2.37	53,245.98 ± 742.18	51,525.97 ± 3226.93
175	7.92 ± 0.005	8.05 ± 0.00	27.73 ± 0.23	27.75 ± 0.02	35.61 ± 0.13	36.17 ± 0.16	53,993.58 ± 161.76	54,742.14 ± 219.01
177	7.89 ± 0.089	7.64 ± 0.08	27.00 ± 0.39	27.49 ± 0.31	36.05 ± 0.33	35.95 ± 1.03	54,556.31 ± 436.07	54,745.16 ± 9.50
178	7.87 ± 0.060	7.69 ± 0.25	27.06 ± 0.24	26.43 ± 0.78	36.24 ± 0.09	35.89 ± 2.07	54,813.97 ± 114.28	54,000.15 ± 496.61
179	7.88 ± 0.025	7.77 ± 0.20	27.04 ± 0.23	26.65 ± 0.45	36.20 ± 0.11	36.34 ± 0.67	54,763.44 ± 141.00	54,800.75 ± 20.07
182	7.98 ± 0.006	7.80 ± 0.05	29.29 ± 0.14	26.88 ± 0.62	35.89 ± 0.05	36.28 ± 0.20	54,435.64 ± 60.75	54792.83 ± 2.34
185	7.92 ± 0.003	7.79 ± 0.01	28.80 ± 0.03	27.11 ± 0.54	35.60 ± 0.02	35.42 ± 0.43	54,019.20 ± 29.14	54,799.93 ± 1.66
187	7.95 ± 0.010	8.00 ± 0.02	28.62 ± 0.14	27.26 ± 0.37	35.28 ± 0.02	35.27 ± 0.45	53,592.69 ± 22.71	54,740.24 ± 4.17
189	7.93 ± 0.047	7.95 ± 0.00	28.14 ± 0.54	28.10 ± 0.19	34.90 ± 0.59	35.97 ± 0.11	53,054.83 ± 777.94	54,492.573 ± 141.87
193	7.88 ± 0.003	7.95 ± 0.06	27.44 ± 0.18	28.18 ± 0.32	35.59 ± 0.23	36.09 ± 0.03	53,958.43 ± 307.22	54,661.98 ± 29.60
198	7.87 ± 0.035	7.98 ± 0.04	27.47 ± 0.48	27.82 ± 0.16	35.50 ± 0.59	35.46 ± 1.95	53,958.43 ± 307.22	53,788.98 ± 2,656.54
206	7.96 ± 0.023	7.90 ± 0.01	28.86 ± 0.28	27.99 ± 0.04	33.35 ± 0.41	35.17 ± 0.02	50,977.58 ± 539.67	53,414.87 ± 33.15
211	7.96 ± 0.009	8.00 ± 0.00	28.13 ± 0.11	27.23 ± 0.01	33.38 ± 0.12	36.16 ± 0.02	53,702.65 ± 158.17	54,715.85 ± 27.30
213	7.93 ± 0.064	8.09 ± 0.02	27.65 ± 0.28	27.47 ± 0.13	36.22 ± 0.04	36.17 ± 0.05	54,807.66 ± 46.91	54,735.19 ± 63.18
216	7.89 ± 0.008	8.08 ± 0.01	27.79 ± 0.09	27.15 ± 0.29	36.00 ± 0.41	36.21 ± 0.04	54,519.92 ± 551.26	54,771.47 ± 51.98
221	7.96 ± 0.002	8.05 ± 0.03	27.53 ± 0.06	27.14 ± 0.19	36.12 ± 0.00	36.18 ± 0.01	54,674.71 ± 5.33	54,736.82 ± 10.47
223	7.97 ± 0.007	8.00 ± 0.03	29.31 ± 0.17	27.31 ± 0.25	35.87 ± 0.04	35.47 ± 0.68	54,417.78 ± 54.62	54,738.68 ± 1.71
225	7.88 ± 0.013	7.73 ± 0.11	26.89 ± 0.13	28.28 ± 0.64	35.99 ± 0.43	35.72 ± 0.32	54,467.66 ± 577.51	54,779.37 ± 11.34
234	7.88 ± 0.038	7.85 ± 0.04	27.09 ± 0.43	27.04 ± 0.39	36.11 ± 0.24	36.09 ± 0.10	54,637.15± 309.75	54,450.95 ± 75.94
238	7.86 ± 0.008	8.00 ± 0.00	27.33 ± 0.12	28.14 ± 0.23	36.12 ± 0.03	35.63 ± 0.20	54,665.39± 31.99	54,521.26 ± 9.64

Source: 2017 In-situ Probe Data (see Appendix D.9)

Table 5-18: Average & Standard Deviation of Values of *In-Situ* Parameters (Dissolved Oxygen & Chlorophyll-a) across Nearshore Blocks A to D, for the Long Wet & Long Dry Seasons of 2017 (June – August & September – November 2017, respectively)

Station No.	*In-situ* Parameter			
	DO (mg/l)		Chlorophyll (µg/l)	
	Long Wet Season	Long Dry Season	Long Wet Season	Long Dry Season
4	4.61 ± 0.45	4.21 ± 0.34	2.64 ± 0.99	6.55 ± 2.98
5	4.25 ± 0.33	4.15 ± 0.29	3.33 ± 1.59	2.25 ± .36
9	4.61 ± 0.45	4.20 ± 0.26	2.39 ± 0.49	2.14 ± 0.30
10	4.44 ± 0.40	4.22 ± 0.29	3.20 ± 2.05	3.65 ± 1.77
19	4.57 ± 0.58	4.01 ± 0.26	5.57 ± 3.21	3.19 ± 1.03
23	4.80 ± 0.44	4.66 ± 0.53	10.72 ± 8.12	2.40 ± .92
25	4.58 ± 0.62	4.21 ± 0.32	5.89 ± 4.52	2.70 ± .62
27	4.35± 0.42	4.83 ± 0.39	6.38 ± 5.98	3.00 ± 1.31
31	4.45± 0.46	4.46 ± 0.32	1.75 ± 0.44	2.97 ± 1.04
40	4.63± 0.57	4.71 ± 0.36	6.88 ± 3.42	2.24 ± .48
46	4.41± 0.50	4.42 ± 0.46	1.75 ± 0.44	1.84 ± 0.31
48	4.55± 0.45	4.76 ± 0.49	4.53 ± 1.27	3.66 ± 1.38
51	4.37± 0.38	4.68 ± 0.42	4.42 ± 1.09	2.30 ± .37
56	4.23± 0.32	5.31 ± 0.12	4.50 ± 1.19	2.82 ± .40
61	4.40± 0.35	4.68 ± 0.37	4.40 ± 1.92	5.45 ± .81
66	4.28± 0.36	4.21 ± 0.36	2.14 ± 0.26	2.06 ± 0.36
68	4.29± 0.45	2.96 ± 1.35	2.96 ± 1.35	1.33 ± .41
72	4.55± 0.54	4.71 ± 0.23	11.40 ± 4.41	3.96 ± 1.86
74	4.46± 0.41	5.01 ± 0.36	14.73 ± 4.34	3.96 ± 1.86
75	4.61± 0.58	4.19 ± 0.41	1.21 ± 0.40	1.09 ± 0.31
81	4.66± 0.37	4.38 ± 0.46	1.88 ± 0.72	0.77 ± 0.33
89	4.67 ± 0.47	4.15 ± 0.29	1.54 ± 0.47	0.82 ± 0.08
94	4.55 ± 0.51	4.26 ± 0.37	2.71 ± 1.88	1.07 ± 0.67
97	4.39 ± 0.50	4.43 ± 0.32	1.16 ± 0.44	1.66 ± 0.48
100	4.45 ± 0.46	4.33 ± 0.44	1.95 ± 1.14	1.96 ± 0.90
103	4.59 ± 0.52	4.15 ± 0.41	4.59 ± 5.67	3.15 ± 4.08
106	4.52 ± 0.43	4.47 ± 0.36	2.75 ± 2.38	8.23 ± 2.11
112	4.23 ± 0.35	4.12 ± 0.22	3.06 ± 1.75	1.32 ± 0.25
119	4.60 ± 0.50	4.41 ± 0.49	2.59 ± 0.34	2.01± 0.10
120	4.60 ± 0.46	4.38 ± 0.30	3.72 ± 1.36	5.76 ± 1.71
125	4.48 ± 0.50	4.48 ± 0.29	3.73 ± 0.78	7.03 ± 1.26
130	4.54 ± 0.48	5.13 ± 0.15	7.25 ± 3.56	3.50 ± 1.98
135	4.48 ± 0.33	4.52 ± 0.24	4.66 ± 1.19	1.88 ± 0.60
137	4.55 ± 0.27	4.65 ± 0.22	3.78 ± 1.61	3.47 ± 1.56
143	4.27 ± 0.40	4.56 ± 0.44	6.02 ± 2.30	3.12 ± 1.43
145	4.39 ± 0.36	4.36 ± 0.52	7.66 ± 2.18	2.48 ± 0.98
151	4.39 ± 0.36	4.43 ± 0.26	8.55 ± 2.14	2.19 ± 0.53
156	4.33 ± 0.36	4.12 ± 0.22	6.48 ± 1.64	1.95 ± 0.67
159	4.57 ± 0.39	4.16 ± 0.30	3.51 ± 2.36	1.81 ± 0.62
163	4.49 ± 0.34	4.36 ± 0.32	2.36 ± 1.28	2.08 ± 0.66
165	4.61 ± 0.59	4.54 ± 0.42	2.96 ± 0.95	1.40 ± 0.46
172	4.53 ± 0.37	4.41 ± 0.41	8.52 ± 5.21	2.51 ± 0.26
175	4.57 ± 0.35	4.33 ± 0.55	2.50 ± 0.40	1.26 ± 0.31
177	4.49 ± 0.36	4.34 ± 0.38	2.28 ± 3.90	2.84 ± 2.00
178	4.35 ± 0.30	4.45 ± 0.42	2.12 ± 0.90	2.96 ± 0.74
179	4.53 ± 0.33	4.63 ± 0.32	2.18 ± 0.69	1.89 ± 0.75
182	4.59 ± 0.47	4.59 ± 0.22	7.77 ± 2.36	1.12 ± 0.40
185	4.57 ± 0.57	4.67 ± 0.26	2.07 ± 0.11	2.56 ± 1.76
187	4.62 ± 0.34	4.26 ± 0.54	5.92 ± 1.72	2.33 ± 1.36
189	4.31 ± 0.31	4.64 ± 0.35	6.51 ± 3.07	1.65 ± 0.45
193	4.39 ± 0.37	4.33 ± 0.34	2.38 ± 0.35	1.45 ± 0.24
198	4.37 ± 0.36	4.25 ± 0.35	2.28 ± 0.93	1.37 ± 0.46
206	4.38 ± 0.41	4.64 ± 0.20	4.48 ± 1.66	2.76 ± 0.43
211	4.38 ± 0.32	4.23 ± 0.31	7.73 ± 4.29	1.75 ± 0.47
213	4.36 ± 0.23	4.32 ± 0.26	1.93 ± 0.86	1.71 ± 0.51
216	4.62 ± 0.48	4.38 ± 0.32	2.47 ± 0.32	2.97 ± 0.66
221	4.47 ± 0.22	4.18 ± 0.20	0.91 ± 0.33	1.55 ± 0.68
223	4.41 ± 0.35	4.37 ± 0.37	6.43 ± 2.68	2.93 ± 2.60
225	4.50 ± 0.35	4.30 ± 0.29	2.42 ± 1.72	2.75 ± 0.42
234	4.66 ± 0.22	4.41 ± 0.24	1.81 ± 0.65	2.53 ± 0.22
238	4.85 ± 0.25	4.29 ± 1.19	3.28 ± 1.19	3.29 ± 0.62

Source: 2017 In-situ Probe Data (see Appendix D.9)

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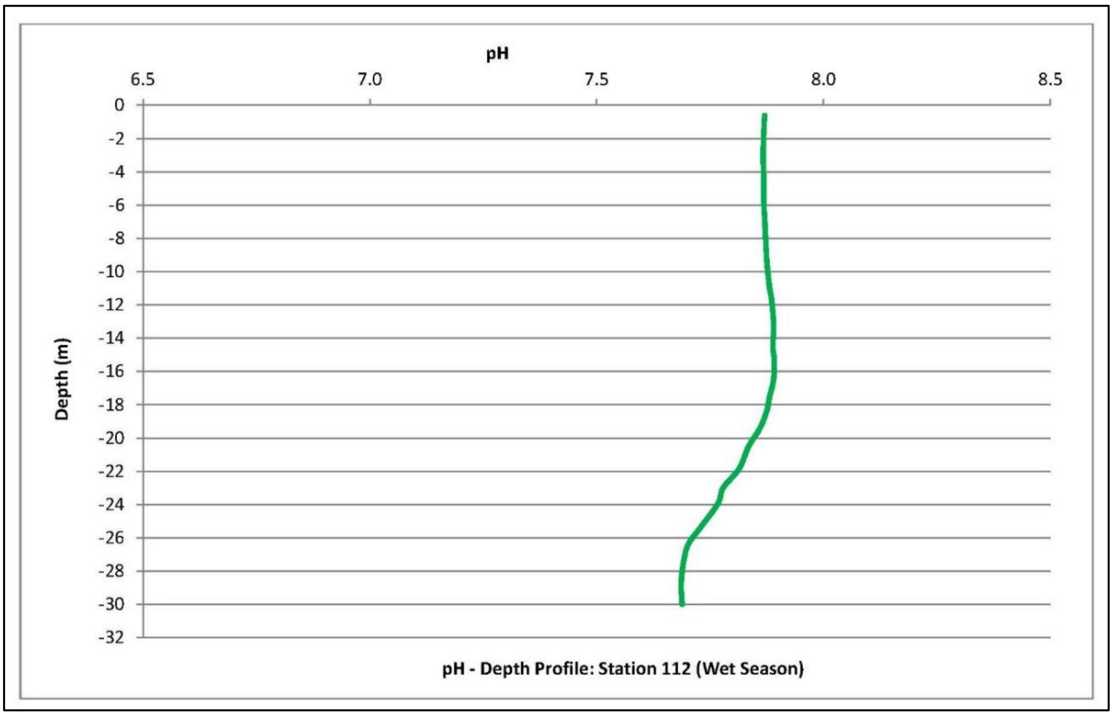
pH

pH-depth profiles showed minimal variability in form; stations exhibited similar profiles during the long wet season, and the same was observed within the dry season dataset (see Appendix D.9). Additionally, the profiles tended to be similar between stations during both seasons. In general, pH was either constant throughout the water column, or was marginally higher at the top of the water column and decreased marginally with depth. These 2 variants of the pH-depth profiles are illustrated in typical profiles presented in Figure 5-46 and Figure 5-47 below.

For the long wet season, pH ranged from 7.28 – 8.06 overall, and the corresponding range for the long dry season was 7.19 – 8.16. Thus, during both seasons, the pH was found to be neutral to slightly alkaline, the ranges were comparable and changes within the datasets and between the datasets minimal. Values recorded during both seasons conformed to the expected levels of pH in the marine environment (where seawater pH can range from 6.5 to 8.5 (Open University 1989; USEPA 1976; Anderson 2004; and OzCoasts Geoscience Australia 2012a).

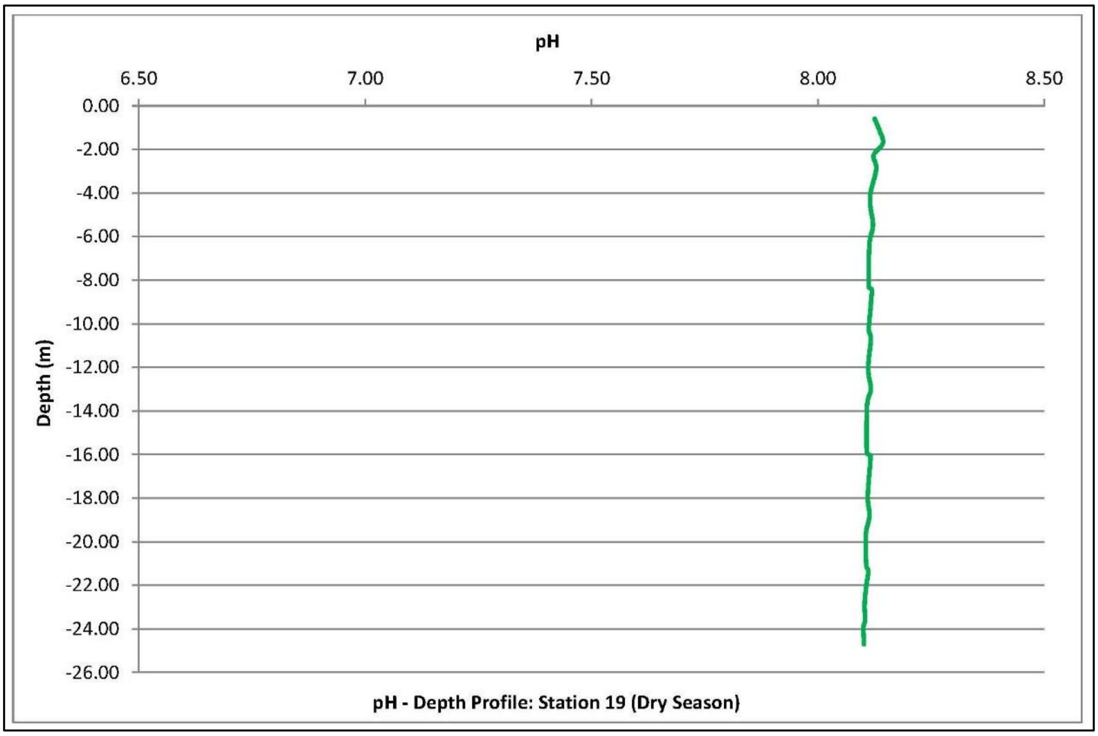
The trend of pH being marginally higher throughout the upper portion of the water column at some stations (see Figure 5-46 below) is also expected, as pH may be typically higher in surface water layers due to the consumption of CO_2 through photosynthesis, and may decrease in subsurface waters due to the release of the CO_2 by respiration processes (Omer 2010).

The overall pH range detected for the long wet season 2017 (7.28 – 8.06; see Table 5-15 above) was comparable to the overall range observed throughout the water column at the 34 stations sampled during the short wet season of 2013 (7.75 – 8.16). Stations profiled in 2013 did not show the marginal decrease in pH with depth during the short wet season, and so tended to conform more with the variant shown in Figure 5-47 below. In general, this latter variant is indicative of a well-mixed water column within the Brown water zone, which was the location of the stations sampled in 2013.



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-46: Typical pH-Depth Profile (Variant 1 – pH decreased slightly with Depth at Station 112; Wet Season)



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-47: Typical pH-Depth Profile (Variant 2 – pH was constant throughout the Water Column at Station 19; Dry Season)

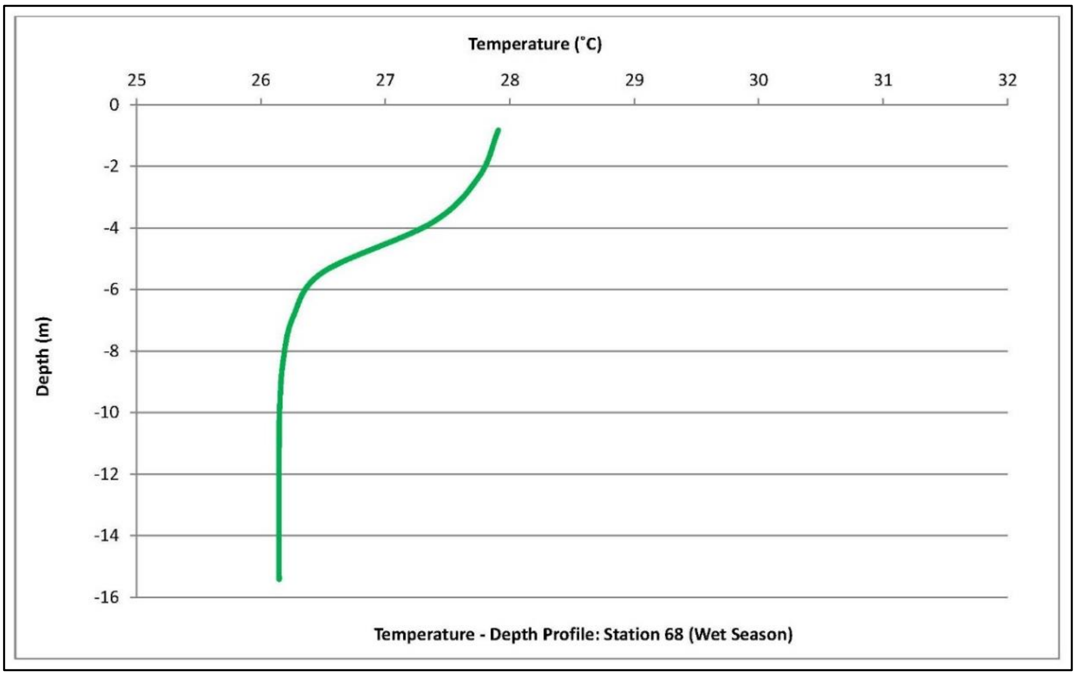
Temperature

Review of the temperature-depth profiles for the long wet and long dry seasons of 2017 revealed 3 variants, and these are presented in Figure 5-48, Figure 5-49 and Figure 5-50 below. Variant 1 (see Figure 5-48 below) was only detected during the long wet season, irrespective of the location of the stations within the Green and Brown water zones. This variant revealed that there was some evidence of a generally rapid decrease with depth within the water column within the upper portion of the water column, but this change was not of a sufficient magnitude to indicate the presence of a thermocline, particularly because the change in temperature ranged from 2 – 5°C, whereas thermoclines generally display rapid changes in temperature over a greater magnitude of change, typically in deeper waters (Bergman 2011; NOAA 2012).

Variant 2 (see Figure 5-49 below) was detected at the majority of stations during both the long wet and long dry seasons, and showed a very gradual decrease in temperature with depth, where the change in temperature ranged from 2 – 5°C. Variant 3 (see Figure 5-50 below) was also detected during both seasons and showed that, for some stations, there was no change in temperature with depth.

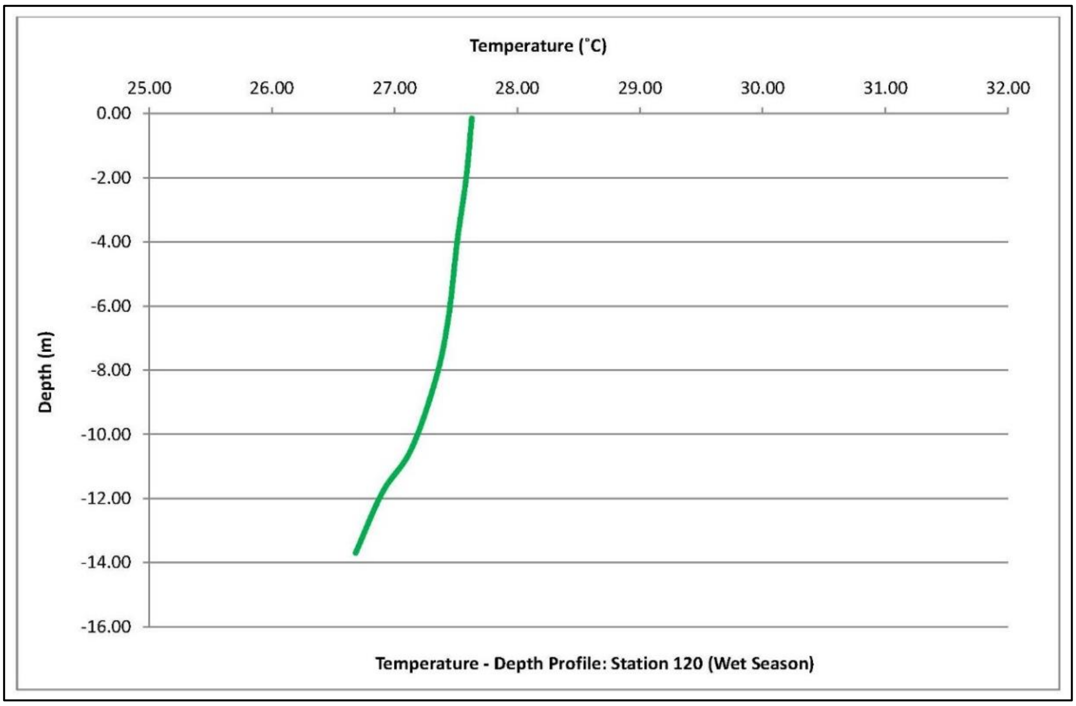
Overall, the temperature-depth profiles do not indicate the existence of a thermocline (a vertical zone in the water column indicating a rapid change in the temperature of seawater with depth, as opposed to the relatively steady, but gradually decreasing, temperatures of the surface (mixed) layer and deeper, colder water) within the water column at the stations sampled for the long wet and long dry seasons, and confirm a well-mixed water body at the times of sampling. Overall, temperatures ranged from 26.06 – 29.65°C during the long wet season, and 25.78 – 30.24°C during the long dry season. Values were found to be typical of the marine environment, where, in tropical latitudes, surface seawater temperatures can range from 27 – 30°C (Gordon 2004; marinebio.org; n.d.).

The ranges detected during the long wet season were similar to those detected at the 34 stations sampled during the short wet season of 2013 (26.27 – 27.87°C), and the 2013 profiles also showed no evidence of a thermocline. Both datasets therefore showed well mixed conditions throughout the water column.



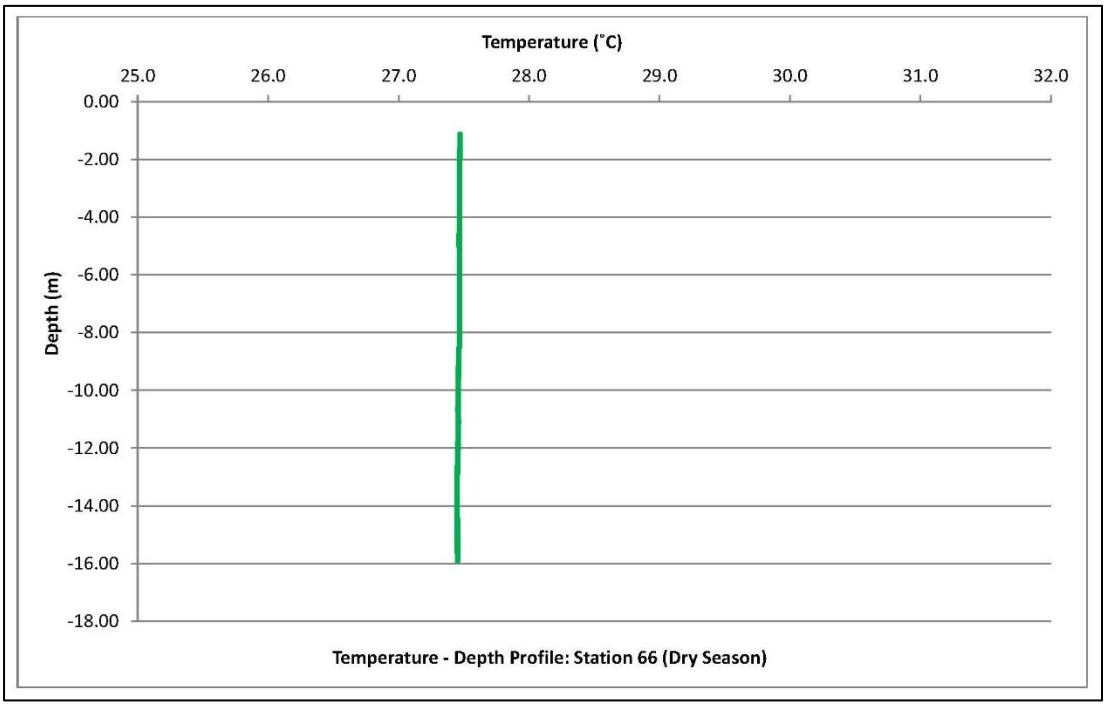
Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-48: Typical Temperature-Depth Profile (Variant 1 – Temperature showed Moderate to Weak Levels of Stratification within the Water Column (Station 68; Wet Season)



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-49: Typical Temperature-Depth Profile (Variant 2 – Temperature decreased steadily throughout the Water Column (Station 120; Wet Season)



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-50: Typical Temperature-Depth Profile (Variant 3 – Temperature was constant throughout the Water Column at Station 66; Dry Season)

Salinity & Specific Conductivity

Three salinity-depth profile variants occurred during the long wet and long dry seasons, and these are illustrated in Figure 5-51, Figure 5-52 and Figure 5-53 below. For the long wet season, Variant 1 (see Figure 5-51 below) displayed a markedly lower salinity at the top of the water column, and showed a gradual increase in salinity within the first 5 m of the water column, after which the salinity values stabilised beyond this depth to the bottom of the water column. This variant was exhibited by stations associated with the outflow of the Corantijn River (Stations 4, 5, 9, 10 and 19), and whose influence in depressing salinities extended to the stations sampled northernmost within Block A (see Figure 5-36 above). This variant was also observed at stations associated with the Coppename River outflow, although the decrease in salinity from top to bottom was not as pronounced at these stations (Stations 49, 51, 56, 61, 66, 68, 72 and 74). This may be because the average estimated discharge volume of the Coppename River is approximately one-third that of the Corantijn River (490 m^3/s versus 1,580 m^3/s, respectively; see Amatali and Naipal 1999 in Noordam 2018c).

For the long dry season, Variant 1 was only observed at 2 stations, Stations 178 and 179 (see Appendix D.9), which are located at the northernmost portion of Block C. However, the majority of the stations within the dry season dataset (including those surrounding Stations 178 and 179) displayed Variants 2 and 3, as described below, and it is unclear as to what factors influenced the surface depression of salinity at these 2 stations during the long dry season.

Variant 2 of the salinity-depth profile (see Figure 5-52 below) was encountered at a few of the stations during the long wet and long dry seasons and displayed a marginally lower level of salinity within the first 2 – 3 m of the water column, followed by a marginal increase in salinity beyond this point, which did not change with depth. This variant was observed at a few stations located within the northernmost portion of Block B during the long wet season (Stations 100, 103, 106 and 177), and possibly shows the influence of the outflow of the Coppename River on the study area (and so, may be directly related to Variant 1 as described above, with distance from the shore being the influencing factor in variability of the change in salinity with depth).

The majority of the stations profiled during the long wet and long dry seasons displayed Variant 3 of the salinity-depth profile, in which salinity did not change with depth, but rather, was at a constant value (with low standard deviation values) throughout the water column (see Table 5-17 and Figure 5-53 below).

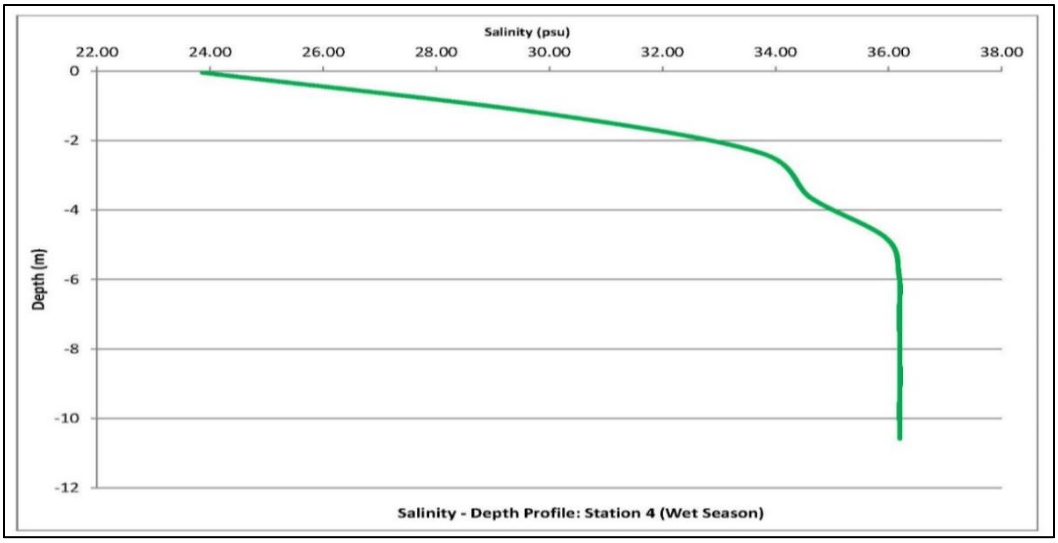
During the long wet season, salinity ranged overall between 23.87 – 36.45 psu; the corresponding range for the long dry season was marginally higher at 28.82 – 36.78 psu, the influence of riverine outflow evident when considering that the average salinity was marginally higher during the long dry season, as opposed to the long wet season, for 50% of the stations sampled (see Table 5-17 above). There was no evidence of the formation of a halocline within the water column (a vertical zone in the water column in which salinity changes rapidly with depth, typically located below a well-mixed, uniformly saline surface water layer; Gordon 2004). This was expected given the well-mixed conditions within the water column as evidenced by the dominance of Variant 3 of the salinity-depth profile (see Figure 5-53 below). Haloclines are also typically formed due to vertical stratification influenced by the presence of a thermocline (Gordon 2004), and the absence of both further support a well-mixed water column during the sampling periods.

The recorded values for salinity during the long wet and long dry seasons compared very well to those quoted in various studies, which indicate that ocean salinity may be, on average, 34.7 to 35 ppt (NIO; n.d.; marinebio.org; n.d.; and Gordon 2004), whilst ranging from 28 – 41 ppt (marinebio.org; n.d.). Surface salinities may be slightly lower at the surface of the water column, owing to the influence of fresh water, which is less dense. Local riverine output and regional oceanographic factors (such as the outflows of large South American mainland rivers and the influence of the NBC retroflection) may have an impact on the quantity of fresh/salt water interface at the sea surface, and hence the degree of surface salinity.

Salinity readings obtained during the short wet season of 2013 (29.29 – 35.93 ppt[16]) were very similar to the range observed during the long wet season of 2017 (23.87 – 36.45 psu), with the latter data showing the influence of riverine inputs on the depression of salinity over a wider area (as the 2017 stations were spread over a larger area in comparison to the stations sampled in 2013).

Changes in conductivity and salinity tend to be similar, since the ions measured to give salinity readings are a subset of those which give specific conductivity measurements. This was reflected in all profiles for the long wet and long dry seasons of 2017 (see Appendix D.9). Thus, the specific conductivity data displayed the same variants as for salinity, and the similarities can be observed between each variant for both parameters (see Figure 5-54, Figure 5-55 and Figure 5-56 below for Variants 1, 2 and 3 for specific conductivity-depth profiles, and compare these to Figure 5-51, Figure 5-52 and Figure 5-53 for salinity-depth profiles below). For most stations, the similarities between the profiles for the 2 parameters were obvious. For some stations, there were minor variations between the profiles for the 2 stations, and this may be because the ions which comprise salinity are only a subset of the ions which are measured for specific conductivity.

Overall, during the long wet season, specific conductivity ranged from 37,782.65 – 55,065.69 µS/cm. The corresponding range for the long dry season was 44,709.65 – 55,551.30 µS/cm. Specific conductivity was not measured at Well-sites 2, 4 and 9 during the short wet season of February 2013, and so this precluded further comparison.



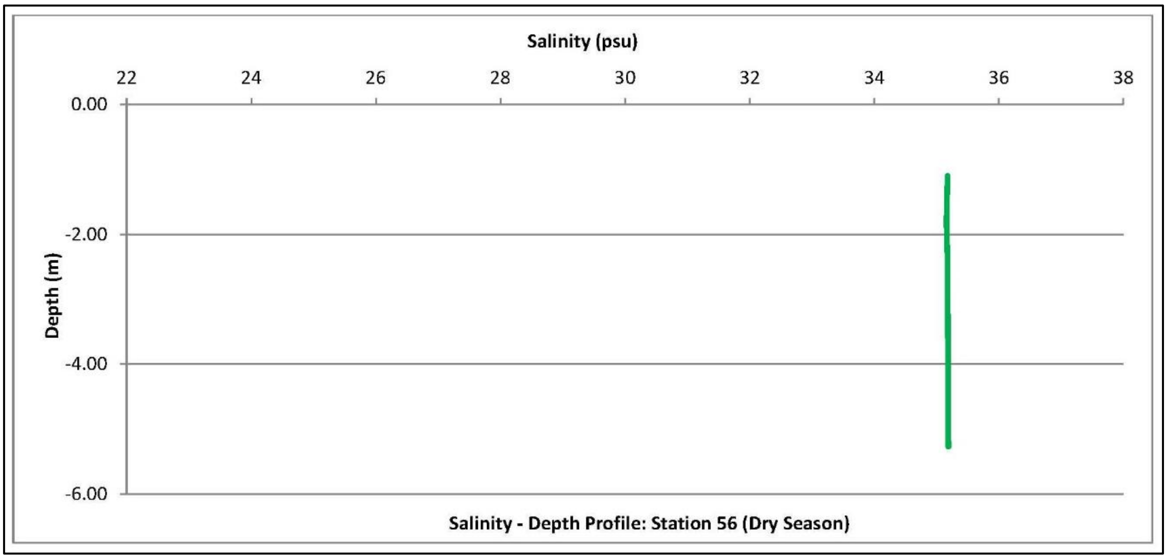
Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-51: Typical Salinity-Depth Profile (Variant 1 – Salinity was significantly lower at the top of the Water Column at Station 4; Wet Season)

[16] *It should be noted that there is minimal numerical difference in values quoted in psu and ppt (of the order of 0.01).*

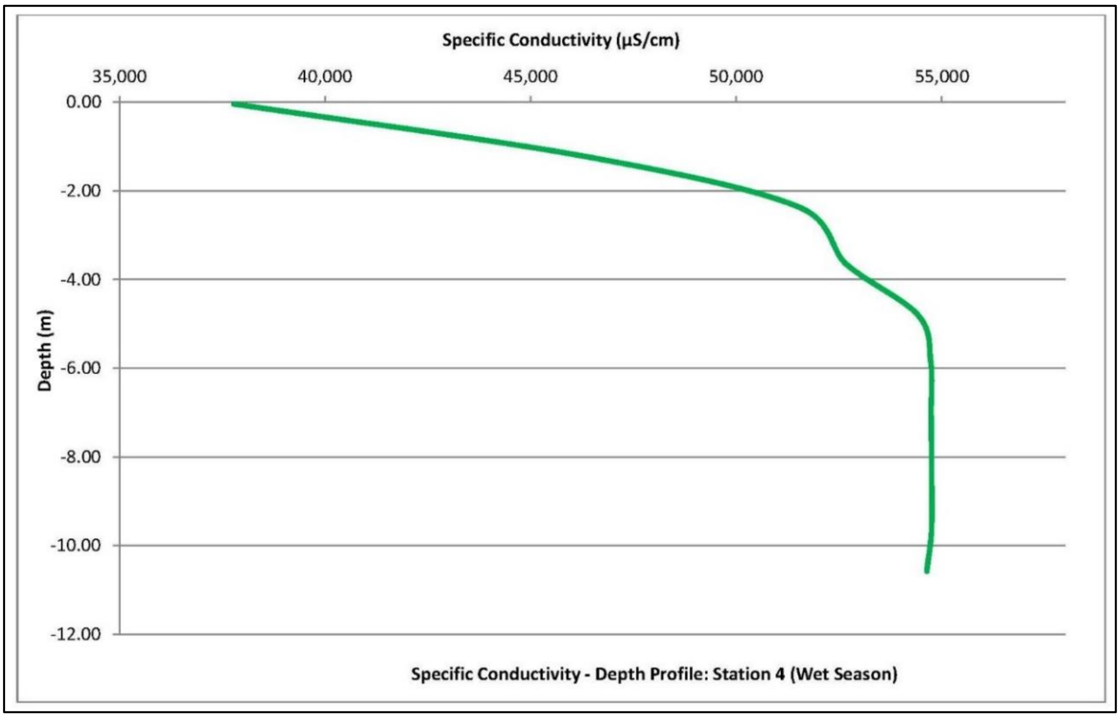
Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-52: Typical Salinity-Depth Profile (Variant 2 – Salinity was marginally lower at the top of the Water Column at Station 100; Wet Season)



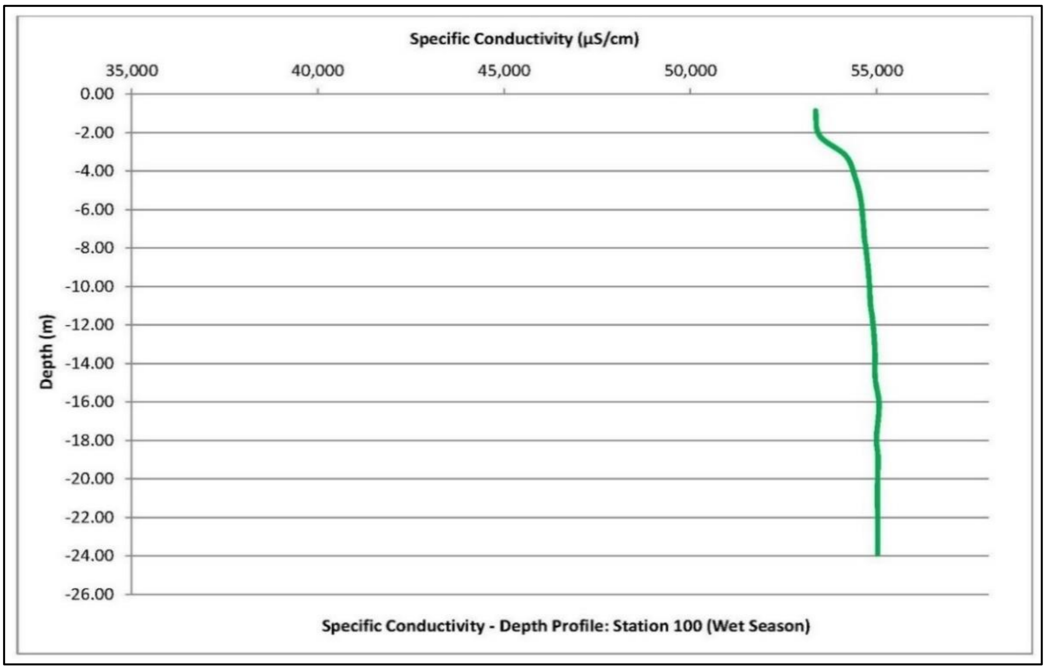
Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-53: Typical Salinity-Depth Profile (Variant 3 – Salinity was constant throughout the Water Column at Station 56; Dry Season)



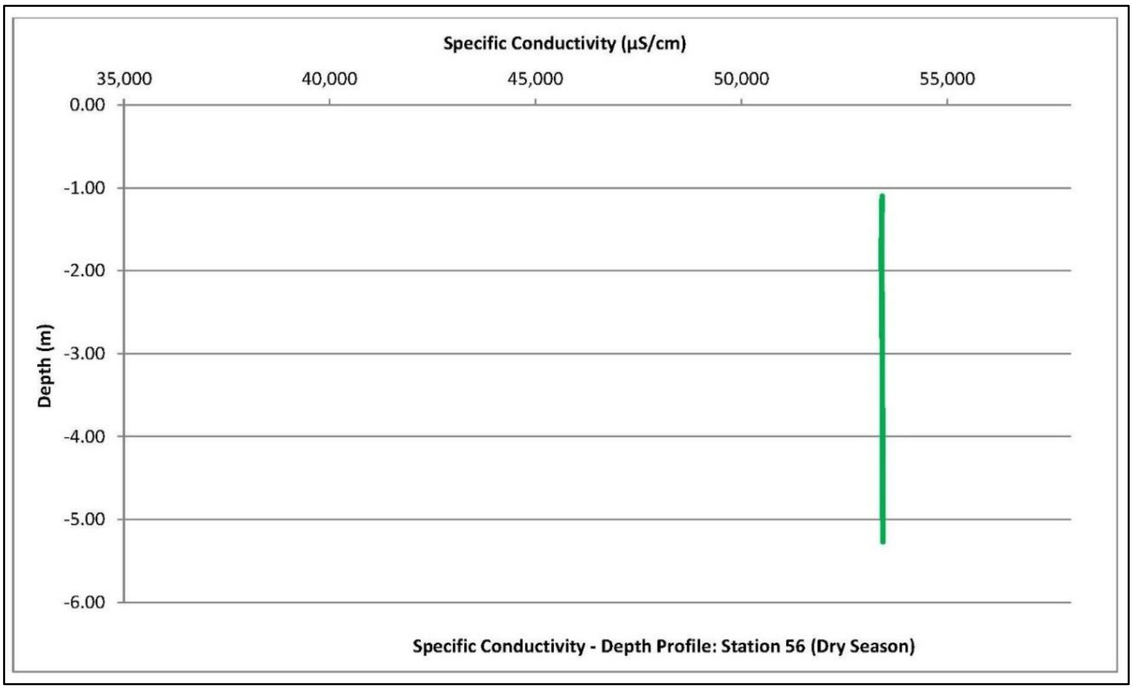
Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-54: Typical Specific Conductivity-Depth Profile (Variant 1 – Specific Conductivity was significantly lower at the top of the Water Column at Station 4; Wet Season)



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-55: Typical Specific Conductivity-Depth Profile (Variant 2 – Specific Conductivity was marginally lower at the top of the Water Column at Station 100; Wet Season)



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-56: Typical Specific Conductivity-Depth Profile (Variant 3 – Specific Conductivity was constant throughout the Water Column at Station 56; Dry Season)

DO

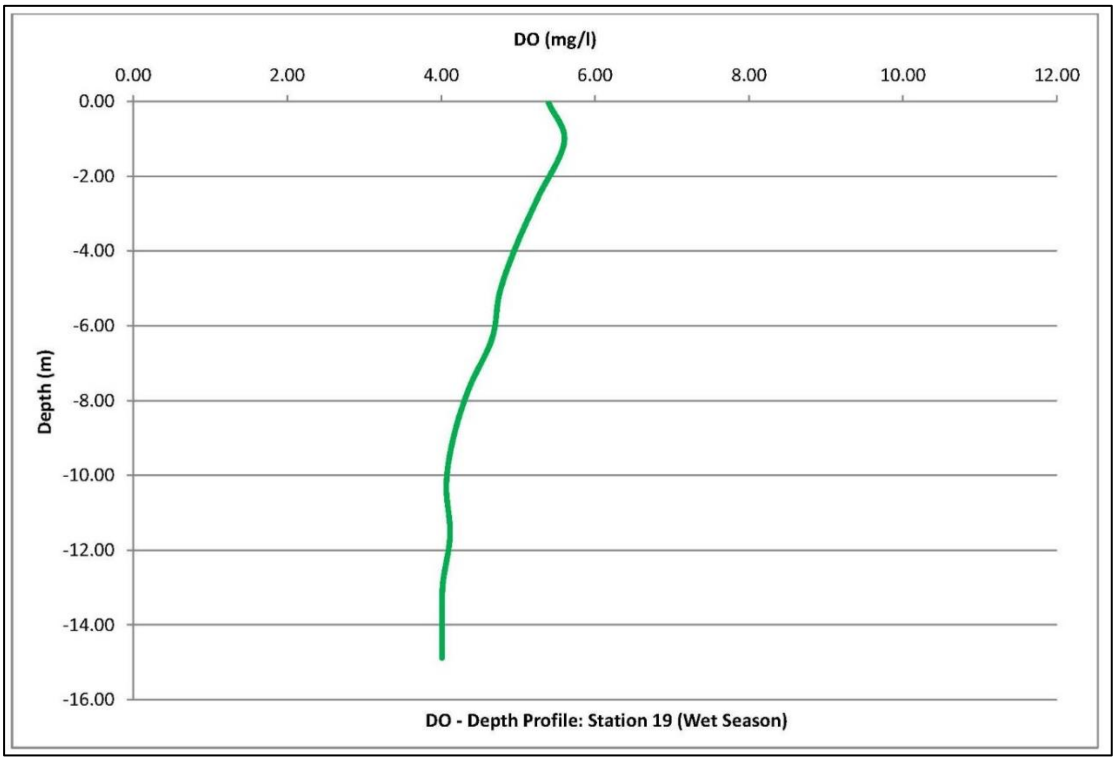
DO-depth profiles were consistent across all stations during the long wet and long dry seasons; a typical DO-depth profile is shown in Figure 5-57 below, in which it can be observed that DO was higher at the top of the water column and decreased marginally with depth. The overall range of variation within DO values at each station (from top to bottom) was within 2 mg/l, but the majority of the values recorded were less than the 5 mg/l threshold indicative of a healthy environment for aquatic organisms (Kemker 2013). Kemker 2013 also indicates that DO may be lower within the surface layer of the water column, increasing at a faster rate throughout the middle of the water column, before steadying off at the highest recorded values in the bottom layer. This is typically explained when taking into account that (i) more oxygen can be dissolved in colder waters, found at the bottom of the water column, owing to reduced insolation; and (ii) DO is typically lower in surface waters due to higher rates of respiration (Kemker 2013) by heterotrophic organisms, as well as autotrophic organisms at night. However, the DO-depth profiles obtained from both seasonal datasets do not appear to reflect these conditions.

DO being instead higher at the top of the water column (and so, lower at the bottom) may be explained when considering the evidence presented on temperature and salinity (see above), which indicated a well-mixed water column during both sampling events. DO may be expected to be higher at the top of the water column when there is sufficient surface agitation / mixing as a result of wind and wave action, leading to limited to no vertical stratification (particularly in relatively shallow water bodies, such as the Nearshore area) based on temperature (thermocline) and density (halocline). Thus, the absence of vertical stratification would also mean that there would be no drastic reduction in temperature throughout the water column to facilitate the increased rate of solution of oxygen. This theory is supported by rough weather and oceanographic conditions reported by the Field Team during the sampling periods.

However, the actual recorded values of DO at the top of the water column are lower than expected if taking surface agitation into account, since surface agitation can sometimes lead to super-saturation, typically reflected as values in excess of 10 mg/l (Kaill and Frey 1973), which were not detected during either season. Instead, as mentioned above, DO values tended to be supressed at the threshold indicative of low oxygen conditions.

In fact, DO levels indicate high levels of respiration by heterotrophs and/or reduced production of oxygen as a by-product of photosynthesis by autotrophs, which one might expect to find within the turbid environment of the Brown water zone (Atkinson *et al*. 2015). A comparative examination of the datasets for stations within the Green and Brown water zones revealed that there was no significant difference in the levels of DO, chlorophyll (see below) and zooplankton densities (see Section 5.4.2 below). This therefore suggests that the boundary between the Green and Brown water zones identified in Figure 5-36 above is actually more to the north, and that all the stations sampled in the long wet and long dry seasons of 2017 fell into the Brown water zone. Lowe-McConnell 1962 and Froidefond *et al*. 2002 support the theory that these zones are flexible, i.e. capable of shifting spatially and temporally in the marine offshore environment, based on the volume of freshwater discharge from local rivers and that of the Amazon River. Physico-chemical changes (related to salinity, turbidity and DO) may also arise as a result of the operation of the NBC retroflection (see Section 5.3.8.3 above).

Overall, during the long wet season, DO ranged from 3.88 – 5.55 mg/l and during the long dry season, 3.73 – 5.76 mg/l. The range for the long wet season of 2017 was marginally lower than the range detected for the 34 stations sampled in the short wet season of 2013 (4.56 – 5.13 mg/l). The 2013 dataset also demonstrated higher levels of DO at the top of the water column, as opposed to the bottom, as was seen in the 2017 dataset.



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-57: Typical DO-Depth Profile (DO was marginally higher at the top of the Water Column at Station 19; Wet Season)

Chlorophyll-a

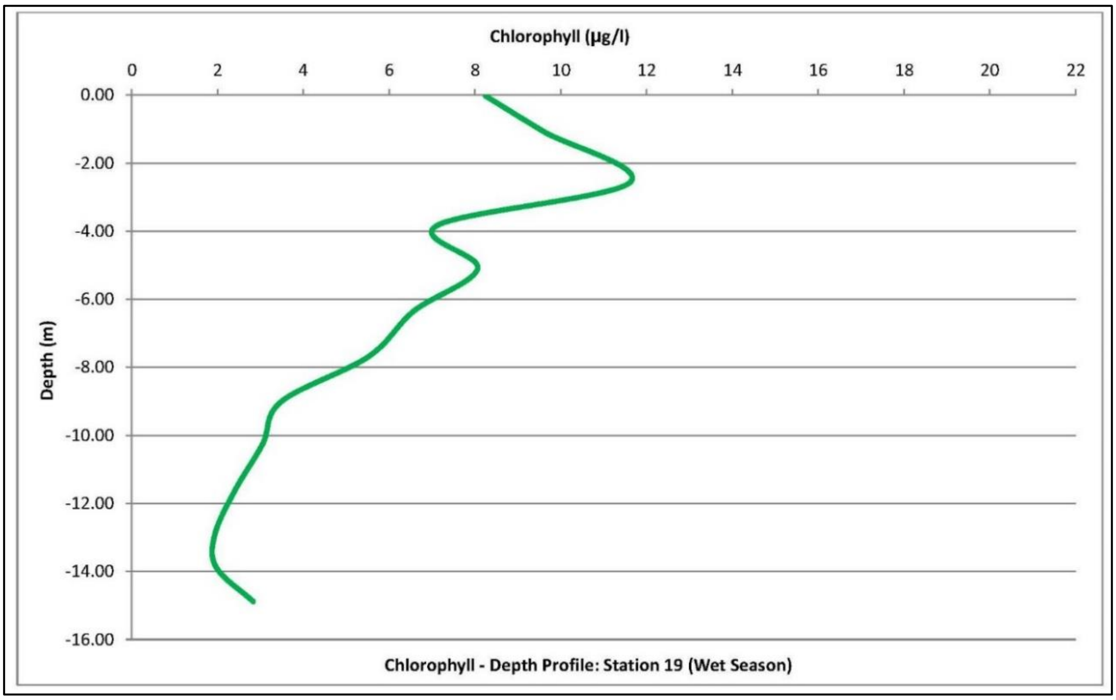
Chlorophyll is a key biochemical component in the molecular apparatus that is responsible for photosynthesis, and can be found in autotrophic organisms such as algae and some species of bacteria. Thus, the measurement of chlorophyll-a (the most abundant form of chlorophyll within photosynthetic organisms) is an indirect measure of primary productivity (YSI; nd).

The chlorophyll-a-depth profiles were highly variable in form within each individual seasonal dataset, as well as in comparison between both seasons (see Appendix D.9). Except for a few stations profiled within the long dry season, all of the depth profiles generally demonstrated a ‘bump’ along the profile, (see Figure 5-58 below) corresponding to an overall depth range of approximately 1 – 8 m, and this is known as the photic zone, or the zone in which maximum productivity is expected within the water column, as a result of light penetration being optimal for photosynthesis within this zone. The profiles obtained also demonstrated levels of chlorophyll-a which were lower than that within the photic zone (hence the ‘bump’) above and below the photic zone (see Figure 5-58 below).

The reduction in chlorophyll-a levels above and below the photic zone is as a result of light attenuation and other physical factors. The surface mixed layer, the ocean region adjacent to the air–sea interface, is well mixed, driven by wave and wind action (Kantha and Clayson 2000), and in the case of Suriname, turbid as a result of local and regional riverine inputs. This level of turbidity combined with light attenuation during agitation limits photosynthetic activity within this upper layer, resulting in relatively lower levels of photosynthesis. Light also continues to be attenuated with depth, as light waves penetrate the water column, reducing light available for photosynthesis below the photic zone.

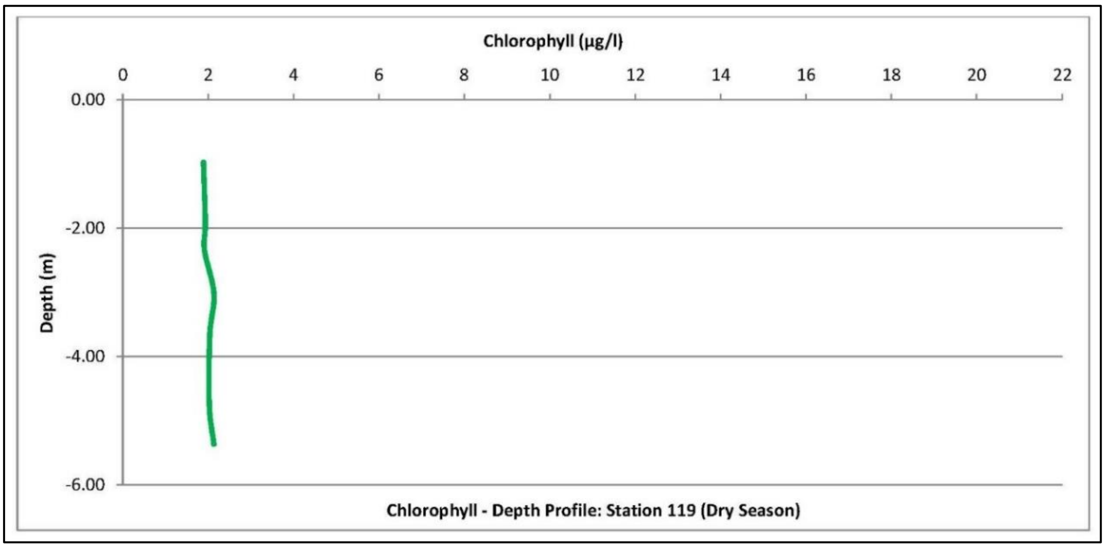
A few of the stations profiled during the long dry season did not demonstrate the occurrence of the photic zone bump; these included Stations 75, 81, 89, 119 and 234 (see Figure 5-36 above). Instead, the chlorophyll-a-depth profiles from these stations exhibited the variant reflected in Figure 5-59 below, in which the level of chlorophyll-a did not change with depth. It is unclear what were the physical conditions within the water column at the time of sampling which may have resulted in this form of profile.

Overall, for the long wet season, chlorophyll-a values ranged from 0.03 – 21.39 µg/l; the corresponding range for the long dry season was 0.16 – 19.76 µg/l. Though there is no established range for the expected background levels of chlorophyll-a in the marine environment, it is useful to consider one study conducted within the San Francisco Bay area (Alpine and Cloern 1988), in which levels of chlorophyll-a were measured within the northern and southern areas of the Bay. This study was selected based on the fact that San Francisco Bay has a high degree of spatial variability in physical properties such as suspended sediment concentrations, water depths and vertical mixing rates) which affect biological processes, including a light limited environment, which is similar to the conditions occurring within the Brown water zone. The environment also consists of a broad expanse of subtidal flats, and there are periods of high seasonal river discharges (which, as in the case of Suriname, provides nutrients as inputs for photosynthesis). Finally, there are areas within the study area in which the water is found to be well-mixed or weakly stratified. Alpine and Cloern 1988 found that levels of chlorophyll-a ranged from 1.9 – 18.40 µg/l, across the San Francisco Bay area, and this level is comparable to that observed during the long wet and long dry seasons of 2017. Chlorophyll-a was not measured at the 34 stations profiled during the short wet season of 2013, and so this precluded further comparison.



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-58: Typical Chlorophyll-a-Depth Profile (Chlorophyll-a displayed a 'bump' within 1 – 4 m of the Surface, corresponding to the Photic Zone at Station 19; Wet Season)



Source: 2017 In-situ Probe Data (see Appendix D.9)

Figure 5-59: Typical Chlorophyll-a-Depth Profile (Chlorophyll-a was marginally higher at the top of the Water Column at Station 119; Dry Season)

5.3.10.3.2 Water Chemistry

Table 5-19 summarises the water quality results for the long wet and dry seasons' baseline sampling events (June-August and September-November 2017). Table 5-20 and Table 5-21 present the comparative analysis of water quality results for nutrients, organics and metals, between the 2013 POC ESIA & 2017 Staatsolie ESIA Baseline Sampling Events, of which the former was sampled during the short wet season of 2013, and the latter, the long wet season of 2017.

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Table 5-19: Summary of Water Quality Results for the Long Wet and Dry Seasons' Baseline Sampling Events (June-August & September-November 2017)

Parameter (mg/l)	Water Level	Range of Parameter (mg/l) Long Wet Season Jun – August '17	Range of Parameter (mg/l) Long Dry Season Sep – Nov '17	Average ± SD of Parameter (mg/l) Long Wet Season Jun – August '17	Average ± SD of Parameter (mg/l) Long Dry Season Sep – Nov '17
Nitrate	T	0.010 - 0.030	0.010 - 0.030	0.0210 ± 0.0072	0.0230 ± 0.0059
	M	0.010 - 0.030	0.010 - 0.030	0.0208 ± 0.0074	0.0249 ± 0.0054
	B	0.010 - 0.030	0.010 - 0.030	0.0205 ± 0.0056	0.0236 ± 0.0063
Nitrite	T	0.005 - 0.008	0.005 - 0.007	0.00659 ± 0.0008	0.0057 ± 0.0006
	M	0.005 - 0.007	0.005 - 0.007	0.0061 ± 0.0008	0.0059 ± 0.0007
	B	0.005 - 0.007	0.005 - 0.007	0.0058 ± 0.0007	0.0059 ± 0.0007
Total Phosphorus	T	0.020 - 1.080	0.020 - 0.860	0.1292 ± 0.1610	0.0757 ± 0.1095
	M	0.020 - 1.020	0.020 - 0.740	0.1241 ± 0.1528	0.0772 ± 0.0934
	B	0.020 - 1.020	0.030 - 0.920	0.1241 ± 0.1438	0.0851 ± 0.1176
Ammoniacal Nitrogen	T	BDL - 0.050	BDL - 0.050	N/A	N/A
	M	BDL - 0.060	BDL - 0.040	N/A	N/A
	B	BDL - 0.040	BDL - 0.040	N/A	N/A
TSS	T	BDL - 81.000	1.000 - 92.000	N/A	16.9508 ± 17.2264
	M	BDL - 89.000	3.000 - 84.000	N/A	18.3115 ± 17.4112
	B	2.000 - 128.000	2.000 - 104.000	28.2459 ± 27.9330	25.5246 ± 21.2991
COD	T	BDL - 310.000	BDL - 230.000	N/A	N/A
	M	BDL - 300.000	BDL - 220.000	N/A	N/A
	B	BDL - 300.000	BDL - 230.000	N/A	N/A
Oil & Grease	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A
TPH	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A
Phenol	T	BDL - 0.012	BDL - 0.009	N/A	N/A
	M	BDL - 0.012	BDL - 0.007	N/A	N/A
	B	BDL - 0.009	BDL - 0.012	N/A	N/A
Hexavalent Chromium	T	0.010 - 0.030	0.010 - 0.030	0.0143 ± 0.0064	0.0157 ± 0.0062
	M	0.010 - 0.030	0.010 - 0.030	0.0164 ± 0.0058	0.0162 ± 0.0061
	B	0.010 - 0.030	0.010 - 0.030	0.0167 ± 0.0057	0.0175 ± 0.0051
Total Copper	T	BDL	BDL	N/A	N/A
	M	BDL - 0.280	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A

Parameter (mg/l)	Water Level	Range of Parameter (mg/l) Long Wet Season Jun – August '17	Range of Parameter (mg/l) Long Dry Season Sep – Nov '17	Average ± SD of Parameter (mg/l) Long Wet Season Jun – August '17	Average ± SD of Parameter (mg/l) Long Dry Season Sep – Nov '17
Total Nickel	T	BDL - 1.280	BDL	N/A	N/A
	M	BDL - 1.100	BDL	N/A	N/A
	B	BDL - 0.510	BDL	N/A	N/A
Total Zinc	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL - 0.700	BDL	N/A	N/A
Total Cadmium	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A
Total Chromium	T	BDL	BDL	N/A	N/A
	M	BDL - 0.350	BDL - 0.230	N/A	N/A
	B	BDL - 0.270	BDL - 0.230	N/A	N/A
Total Lead	T	BDL - 0.770	BDL - 0.580	N/A	N/A
	M	BDL - 1.470	BDL - 0.340	N/A	N/A
	B	BDL - 0.450	BDL - 0.770	N/A	N/A
Total Mercury	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A
Total Barium	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A
Total Iron	T	BDL - 0.970	BDL - 1.150	N/A	N/A
	M	BDL – 1.150	BDL – 1.030	N/A	N/A
	B	BDL - 1.290	BDL - 0.990	N/A	N/A
Total Arsenic	T	BDL	BDL	N/A	N/A
	M	BDL	BDL	N/A	N/A
	B	BDL	BDL	N/A	N/A
Total Aluminium	T	BDL - 3.500	BDL - 3.300	N/A	N/A
	M	BDL - 4.200	BDL - 3.400	N/A	N/A
	B	BDL - 5.100	BDL - 4.000	N/A	N/A

Source: 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Note: BDL: Below the Detectable Limit of the analytical test used; N/A: The average and standard deviation could not be calculated for this parameter, given the occurrence of BDL values.

Table 5-20: Comparative Analysis of Water Quality Results (Nutrients & Organics) between the 2013 POC ESIA & 2017 Staatsolie ESIA Baseline Sampling Events (Short Wet Season: February 2013; and Long Wet Season: June – August 2017)

Event	Station No.	Water Level	Statistic	Nitrate	Nitrite	Total Phosphorus	Ammoniacal Nitrogen	TSS	COD	TPH	Phenol
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	T	Range	BDL - 0.03	BDL	BDL - 1.13	BDL - 0.01	31.70 - 121.00	BDL	BDL - 0.21	BDL
			Average	N/A	N/A	N/A	N/A	60.17 ± 21.9506	N/A	N/A	N/A
Baseline 2017	119		Discrete Value	0.02	0.007	0.14	0.01	29.00	220.00	BDL	BDL
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	M	Range	BDL - 0.04	BDL	BDL - 0.44	BDL - 0.01	35.70 - 136.70	BDL	BDL - 0.10	BDL
			Average	0.02 ± 0.0090	N/A	N/A	N/A	66.91 ± 23.3916	N/A	N/A	N/A
Baseline 2017	119		Discrete Value	0.02	0.005	0.11	BDL	33.00	210.00	BDL	BDL
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	B	Range	BDL - 0.02	BDL	BDL - 0.24	BDL - 0.01	39.30 - 157.30	BDL	BDL - 0.10	BDL
			Average	N/A	N/A	N/A	N/A	82.49 ± 29.2055	N/A	N/A	N/A
Baseline 2017	119		Discrete Value	0.02	0.006	0.12	0.01	128.00	220.00	BDL	0.007
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	T	Range	BDL - 0.03	BDL	BDL - 0.28	BDL	5.00 - 23.00	BDL	BDL- 0.31	BDL
			Average	N/A	N/A	N/A	N/A	10.64 ± 6.4458	N/A	N/A	N/A
Baseline 2017	234		Discrete Value	0.03	0.005	0.10	0.01	13.00	BDL	BDL	BDL
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	M	Range	BDL - 0.03	BDL	BDL - 0.32	BDL	5.30 - 20.00	BDL	BDL - 0.10	BDL
			Average	N/A	N/A	N/A	N/A	10.96 ± 5.7457	N/A	N/A	N/A
Baseline 2017	234		Discrete Value	0.02	0.006	0.10	0.01	6.00	BDL	BDL	BDL
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	B	Range	0.01 - 0.03	BDL	BDL - 0.23	BDL	3.30 - 35.70	BDL	BDL - 0.10	BDL
			Average	0.02 ± 0.0069	N/A	N/A	N/A	14.15 ± 8.6554	N/A	N/A	N/A
Baseline 2017	234		Discrete Value	0.01	0.006	0.10	0.01	2.00	BDL	BDL	BDL

Source: 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6) and ESL 2013b

Table 5-21: Comparative Analysis of Water Quality Results (Metals) between the 2013 POC ESIA & 2017 Staatsolie ESIA Baseline Sampling Events (Short Wet Season: February 2013; and Long Wet Season: June – August 2017)

Event	Station No.	Water Level	Statistic	Hexavalent Chromium	Total Copper	Total Nickel	Total Zinc	Total Cadmium	Total Chromium	Total Lead	Total Mercury	Total Barium	Total Iron	Total Arsenic	Total Aluminium
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	T	Range	BDL - 0.03	BDL - 0.24	BDL	BDL	BDL	BDL	0.22 - 0.38	BDL	0.61 - 2.00	0.66 - 6.90	BDL	1.20 - 9.40
			Average	N/A	N/A	N/A	N/A	N/A	N/A	0.30 ± 0.0417	N/A	1.51 ± 0.3720	2.52 ± 1.6682	N/A	3.70 ± 2.4581
Baseline 2017	119		Discrete Value	0.01	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.23	BDL	1.30
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	M	Range	BDL - 0.02	0.20 - 0.24	BDL	BDL	BDL	BDL	0.25 - 0.41	BDL	0.94 - 2.40	0.91 - 7.00	BDL	1.10 - 9.10
			Average	N/A	0.23 ± 0.0173	N/A	N/A	N/A	N/A	0.32 ± 0.0419	N/A	1.65 ± 0.3370	2.69 ± 1.7067	N/A	4.05 ± 2.4587
Baseline 2017	119		Discrete Value	0.01	BDL	BDL	BDL	BDL	BDL	0.17	BDL	BDL	0.27	BDL	1.40
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	B	Range	BDL - 0.03	BDL - 0.24	BDL	BDL	BDL	BDL	0.20 - 0.45	BDL	1.20 - 2.10	0.80 - 22.00	BDL	3.40 - 51.00
			Average	N/A	N/A	N/A	N/A	N/A	N/A	0.32 ± 0.0634	N/A	1.61 ± 0.2448	5.28 ± 5.4385	N/A	9.55 ± 10.1249
Baseline 2017	119		Discrete Value	0.02	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.36	BDL	4.20
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	T	Range	BDL - 0.02	0.21 - 0.25	BDL	BDL	BDL	BDL	0.28 - 0.43	BDL	1.10 - 1.70	0.65 -1.30	BDL	0.55 - 0.99
			Average	N/A	0.23 ± 0.0135	N/A	N/A	N/A	N/A	0.38 ± 0.0478	N/A	1.51 ± 0.1814	0.98 ± 0.1963	N/A	0.75 ± 0.1443
Baseline 2017	234		Discrete Value	0.01	BDL	BDL	BDL	BDL	BDL	0.35	BDL	BDL	BDL	BDL	BDL
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	M	Range	BDL - 0.02	0.22 - 0.26	BDL	BDL	BDL	BDL	0.21 - 0.44	BDL	1.10 - 1.90	0.56 - 1.70	BDL	BDL - 1.30
			Average	N/A	0.24 ± 0.0129	N/A	N/A	N/A	N/A	0.38 ± 0.0717	N/A	1.53 ± 0.2412	1.07 ± 0.3824	N/A	N/A
Baseline 2017	234		Discrete Value	0.02	BDL	BDL	BDL	BDL	BDL	0.37	BDL	BDL	BDL	BDL	BDL
Baseline 2013	Stations 1 to 23 (Well-sites 2 & 4)	B	Range	BDL - 0.03	0.22 - 0.25	BDL	BDL	BDL	BDL	0.32 - 0.43	BDL	1.20 - 1.80	0.61 - 1.20	BDL	0.52 - 0.97
			Average	N/A	0.23 ± 0.0093	N/A	N/A	N/A	N/A	0.37 ± 0.0385	N/A	1.55 ± 0.1695	0.94 ± 0.2112	N/A	069 ± 0.1790

Event	Station No.	Water Level	Statistic	Hexavalent Chromium	Total Copper	Total Nickel	Total Zinc	Total Cadmium	Total Chromium	Total Lead	Total Mercury	Total Barium	Total Iron	Total Arsenic	Total Aluminium
Baseline 2017	234		Discrete Value	0.01	BDL	BDL	BDL	BDL	BDL	0.32	BDL	BDL	BDL	BDL	BDL

Source: 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6) and ESL 2013b

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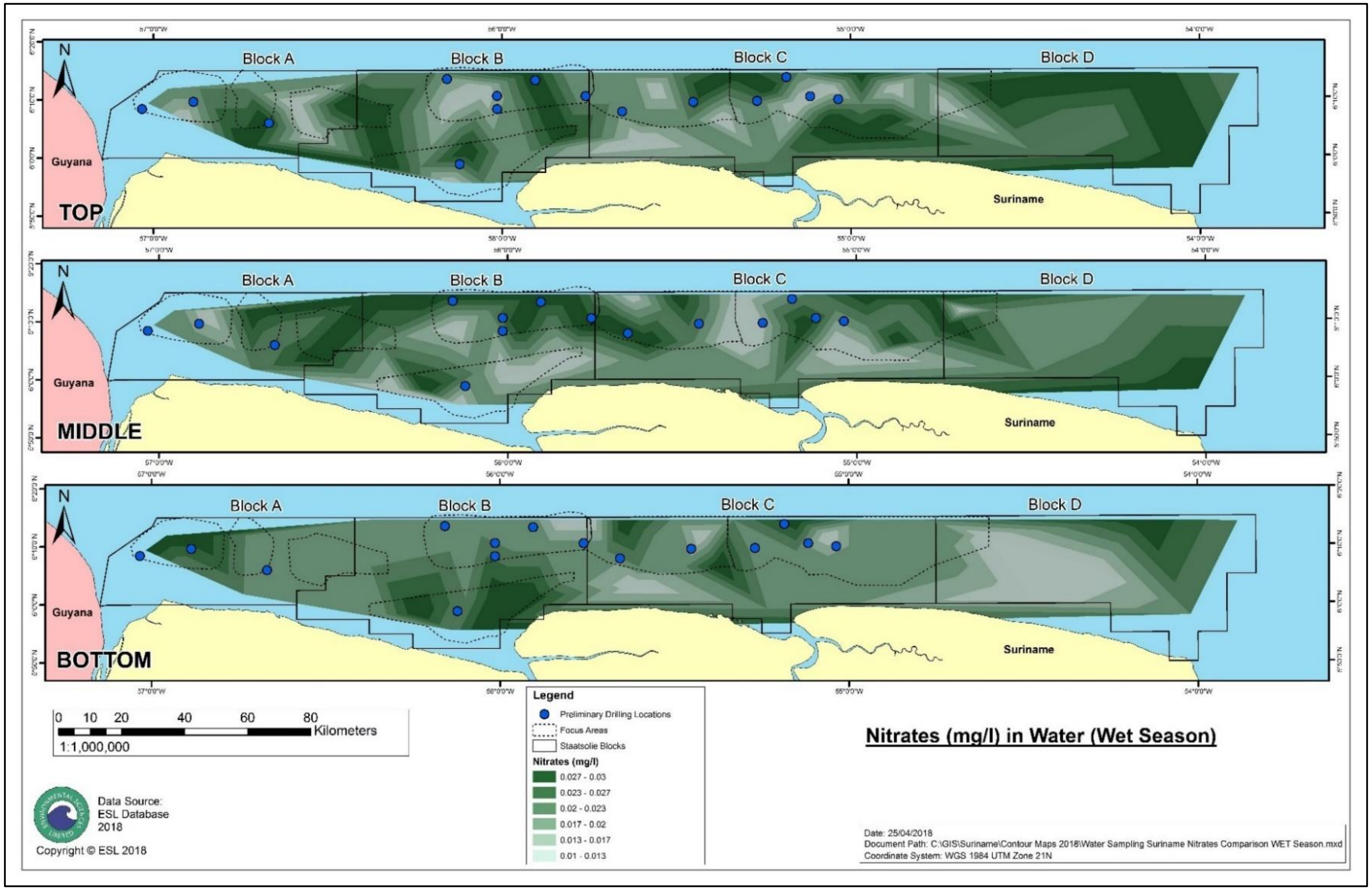
Nutrients & Organics

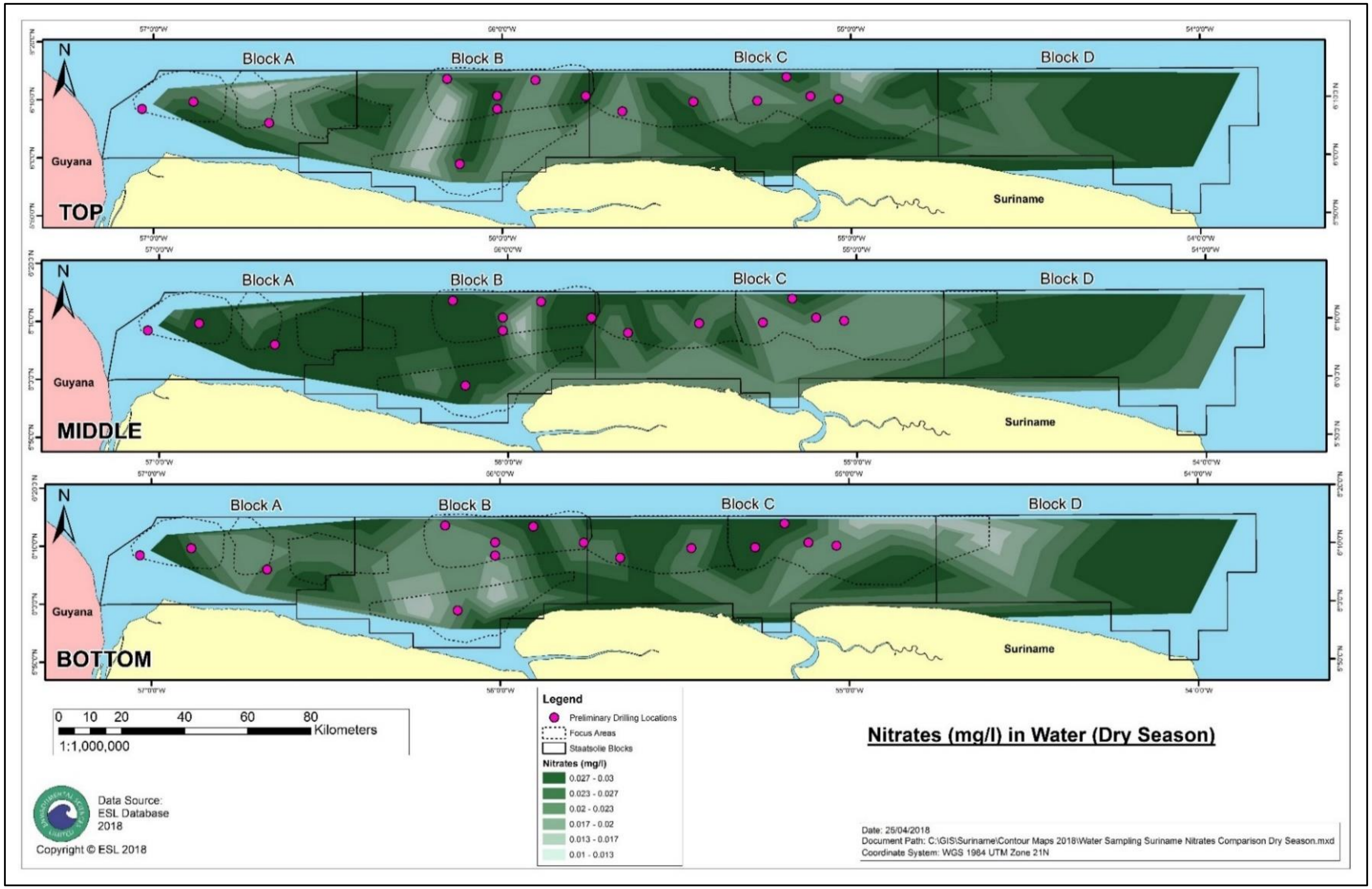
Nitrate was detected at all stations, at all levels of the water column during the long wet and long dry seasons of 2017, and the ranges were identical across the top, middle and bottom layers of the water column, in both seasons (see Table 5-19 above). The differences in the distribution of the levels of this parameter (by level of the water column and by season) are shown in the contour gradient maps presented in Figure 5-60 and Figure 5-61 below. These figures show that higher concentrations of nitrate are dispersed throughout the Blocks in both seasons, with higher values occurring more frequently during the long dry season as opposed to the long wet season. This is also demonstrated by the marginally higher average value for this parameter in the dry season (0.0230 ± 0.0059 mg/kg, at the top of the water column) as compared to that for the wet season (0.0205 ± 0.0056 mg/kg, at the bottom of the water column; see Table 5-19 above). Figure 5-60 and Figure 5-61 below also show that higher value of nitrate was detected at greater frequency at the top of the water column in the wet season, and at the middle of the water column during the dry season. Lower values were detected at the greatest frequency at the bottom of the water column during the long wet season, and at the top of the water column during the long dry season (see Table 5-19 above). Overall, however, these differences are marginally different, across the water column and between the long wet and long dry seasons, and so do not appear to be statistically significant.

None of the values of nitrate recorded at the top, middle and bottom of the water column at Station 119 during the long wet season of 2017 exceeded the values recorded within station cluster for Well-sites 2 and 4, recorded during the short wet season of 2013 (see Table 5-20 above). The same trend was observed between Station 234 (long wet season of 2017) and the station cluster for Well-site 9 (short wet season of 2013). Thus, the values were generally similar within the 2 datasets.



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-60: Contour Gradient Map for Nitrate (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)

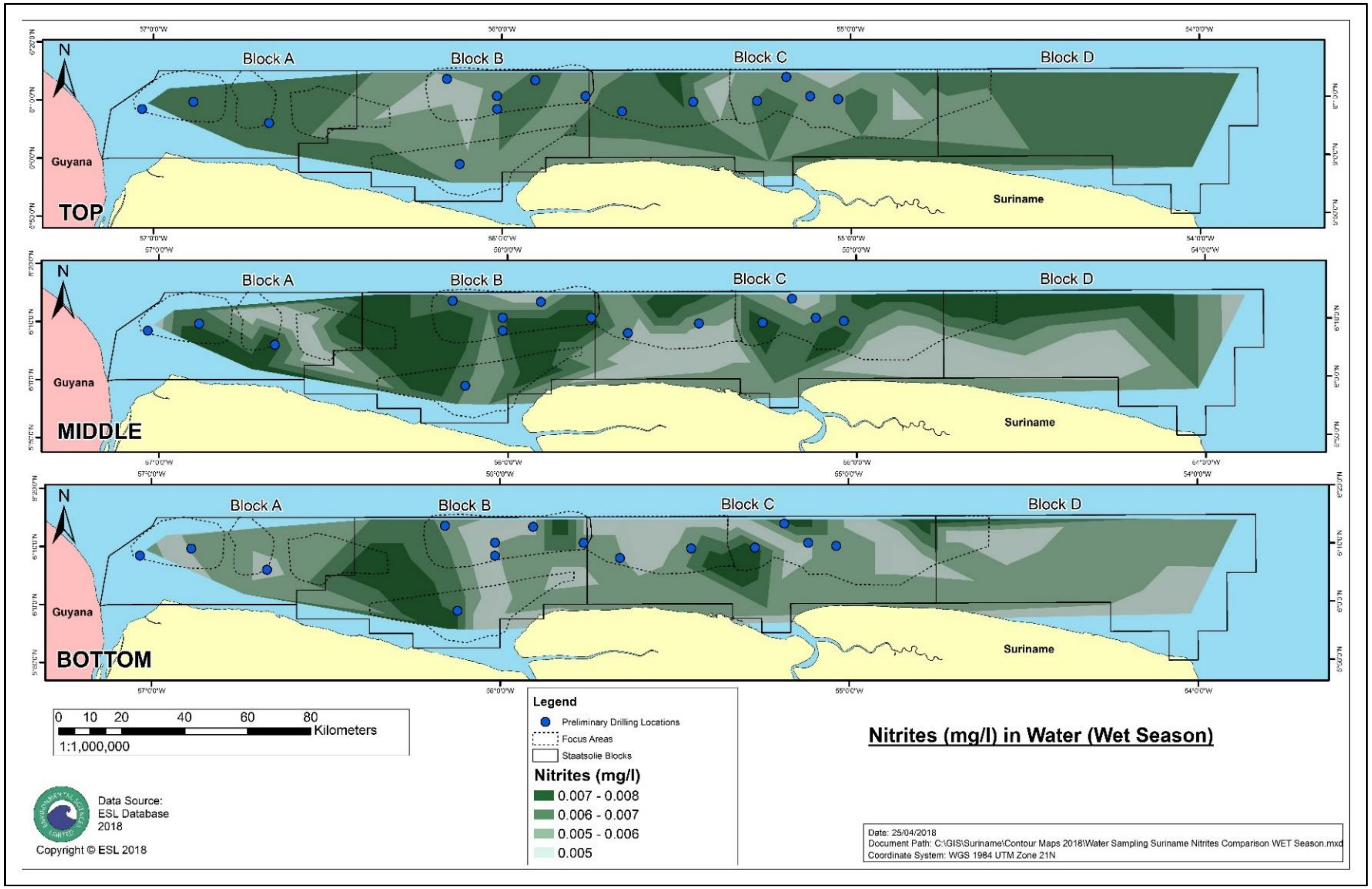


Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-61: Contour Gradient Map for Nitrate (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

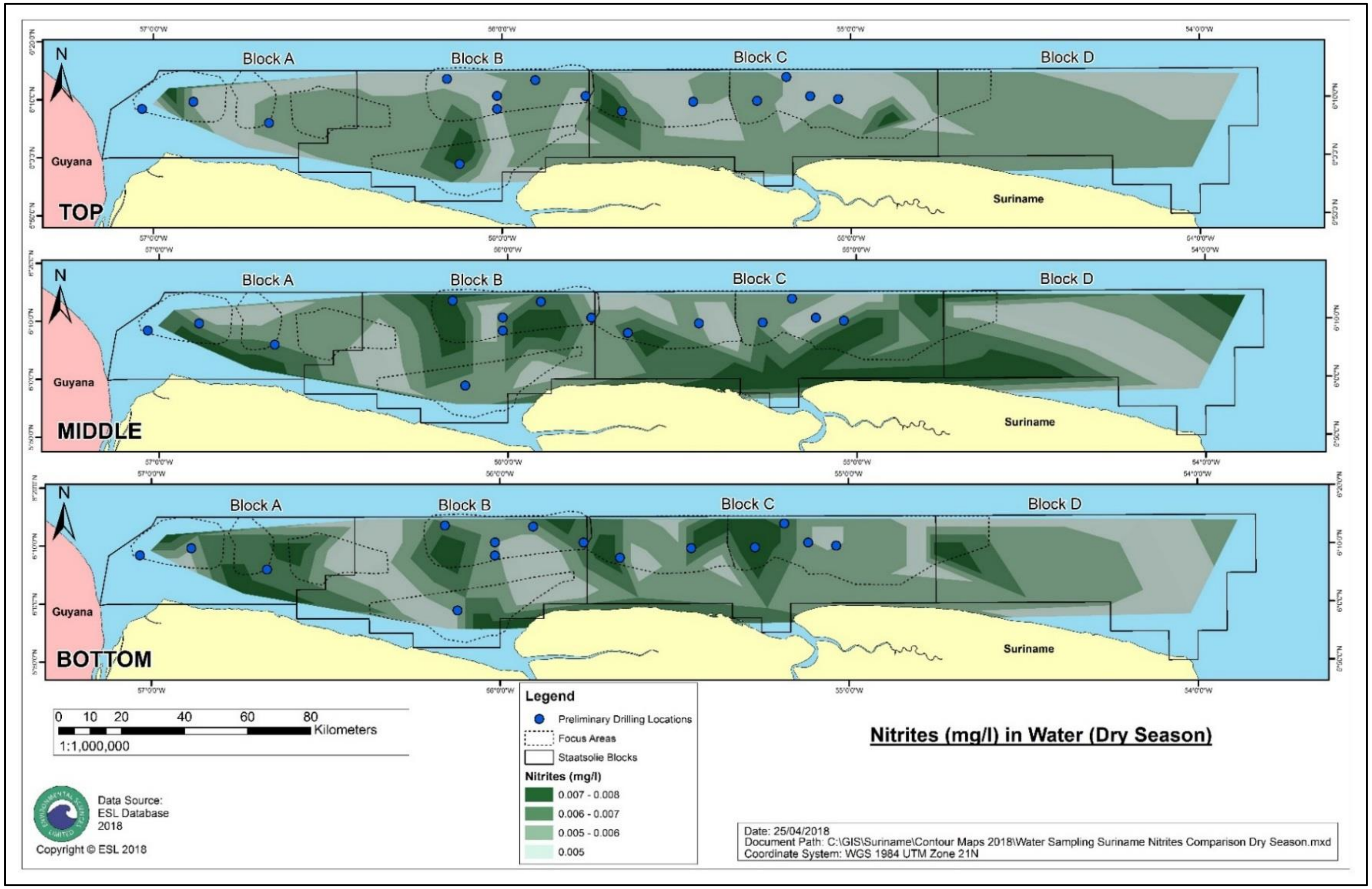
There was marginal variability in the levels of nitrite across the water column in each season, and between both seasons (see Table 5-19 above for comparable ranges and averages). The contour gradient maps for this parameter shows that, during both seasons, the middle layer displayed higher values in the greatest frequency (see Figure 5-62 and Figure 5-63 below). During the long dry season, the top layer had the greatest frequency of lower values, whereas in the long wet season, lower values tended to be more frequent at the bottom of the water column. As with nitrate, these differences do not appear to be statistically significant.

Nitrate was not detected at any of the stations within the clusters for Well-sites 2 and 4, and Well-site 9 during the short wet season of 2013. Thus, the results obtained for the long wet season of 2017 (see Table 5-20 above) indicate some unknown source of this nutrient within the Nearshore environment which occurred during the sampling periods of 2017.



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-62: Contour Gradient Map for Nitrite (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)



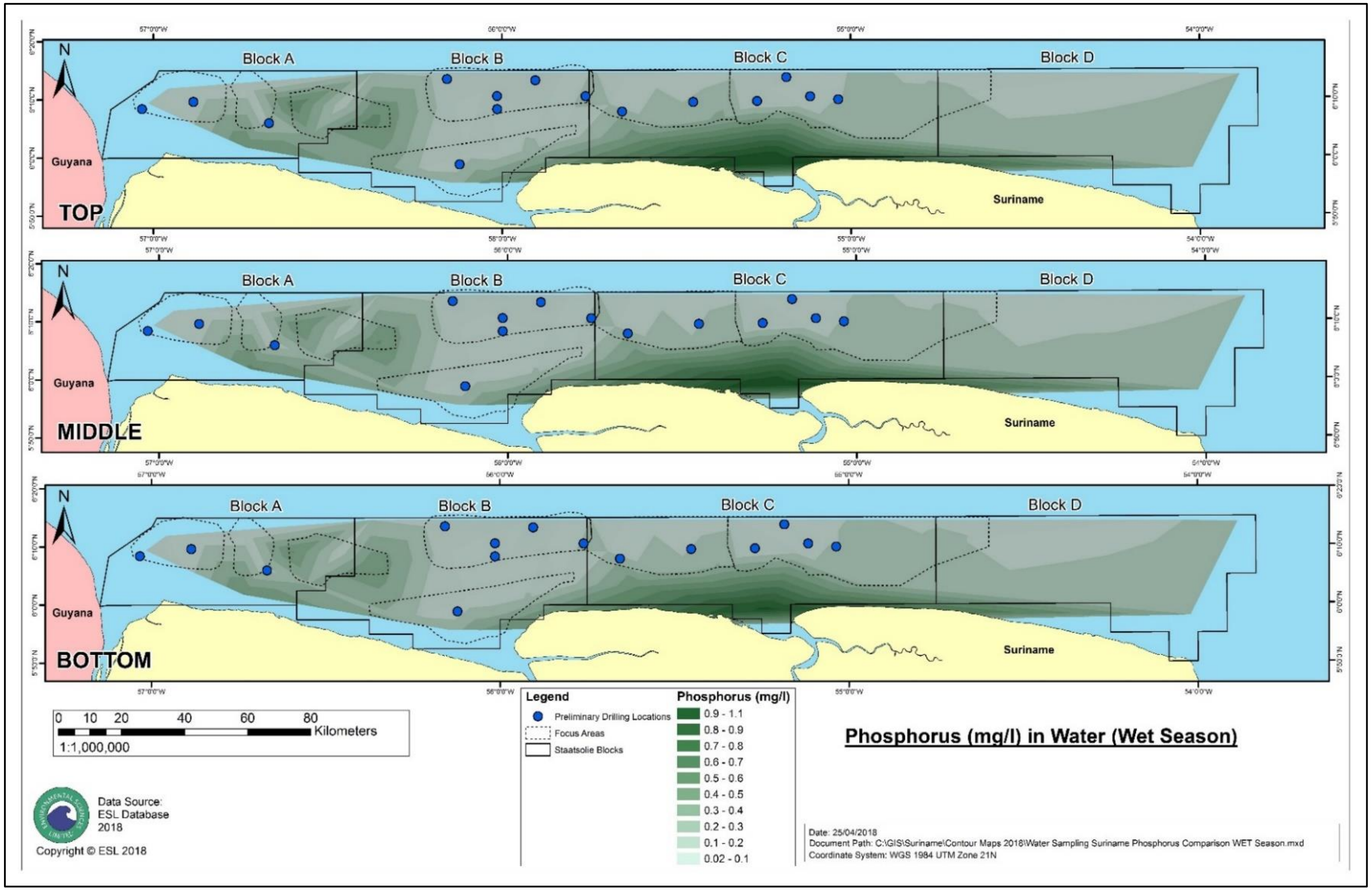
Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-63: Contour Gradient Map for Nitrite (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

Total phosphorus levels were similar across the top, middle and bottom layers of the water column during both the long wet and long dry seasons (see Table 5-19 above), but the variability was more pronounced across the study area, as shown in the contour gradient maps presented in Figure 5-64 and Figure 5-65 below. These figures show that, during both seasons, the highest values of total phosphorus occurred closer to the shore within Block C, which coincides with the Suriname River mouth (which is confluent with the Commewijne River). This zone of highest total phosphorus also occurred to the S of the preliminary drilling locations within Block C.

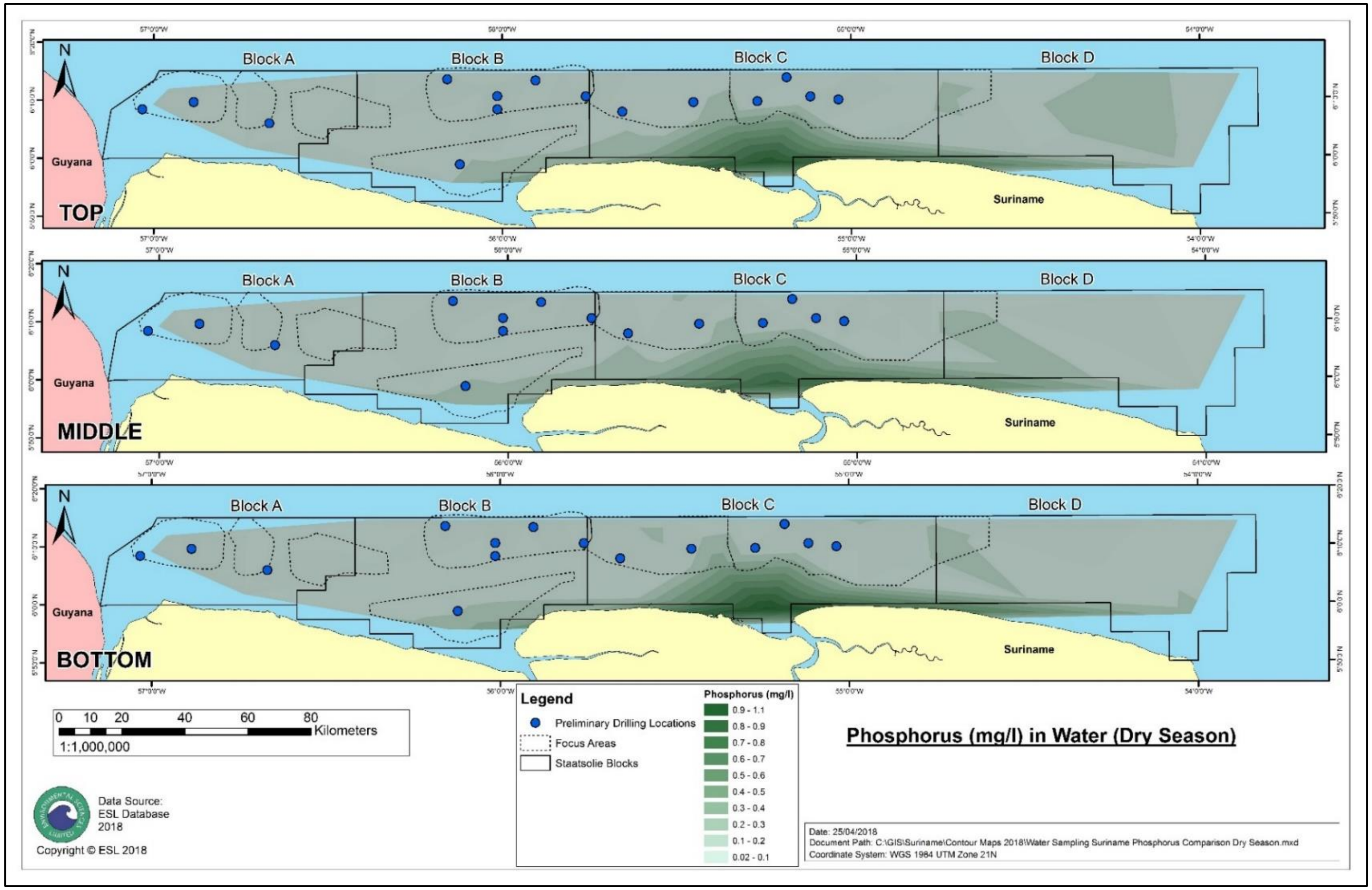
The contour gradient analysis also shows that higher values occurred in the eastern and western portions of Blocks A and B, across the top, middle and bottom of the water column in the long wet season (see Figure 5-64 below), but the values of this parameter in these areas in the long dry season are relatively lower in comparison (see Figure 5-65 below). The analysis also shows that the values of total phosphorus was higher during the long wet season as compared to the long dry season, where, in the long wet season, values were marginally higher at the top of the water column, whereas in the long dry season, the values were marginally higher at the bottom of the water column (see Table 5-19 above and Figure 5-64 and Figure 5-65 below). The higher values observed at the top of the water column during the long wet season may be explained by riverine inputs into the Nearshore area as a result of increased riverine flow into the sea, owing to increased rainfall across the country during the long wet season.

The levels of total phosphorus recorded at Stations 119 and 234 during the long wet season of 2017 were lower than the values recorded within the station clusters for Well-sites 2 and 4, and Well-site 9, respectively, recorded during the short wet season of 2013 (see Table 5-20 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-64: Contour Gradient Map for Total Phosphorus (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)



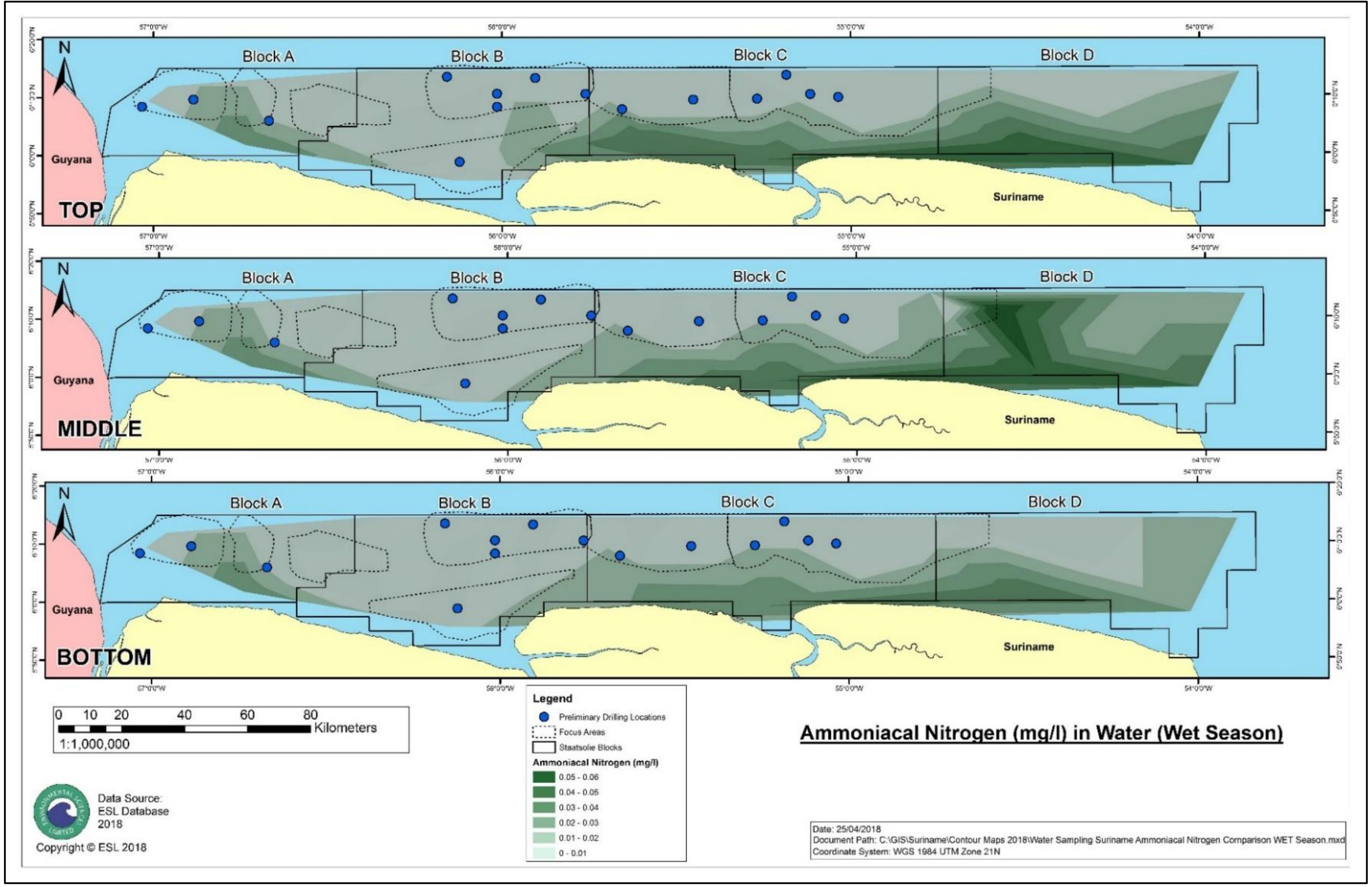
Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-65: Contour Gradient Map for Total Phosphorus (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

Ammoniacal nitrogen was detected at the majority of the stations sampled, at the top, middle and bottom of the water column, during both seasons, but the absence of some values precluded the calculation of the average values for the relevant water column levels, for both seasons (see Table 5-19 above). Where detected, values ranged from 0.010 – 0.060 mg/l, overall (across all levels and both seasons), and there appeared to be limited variability in the levels across the various levels and between both seasons.

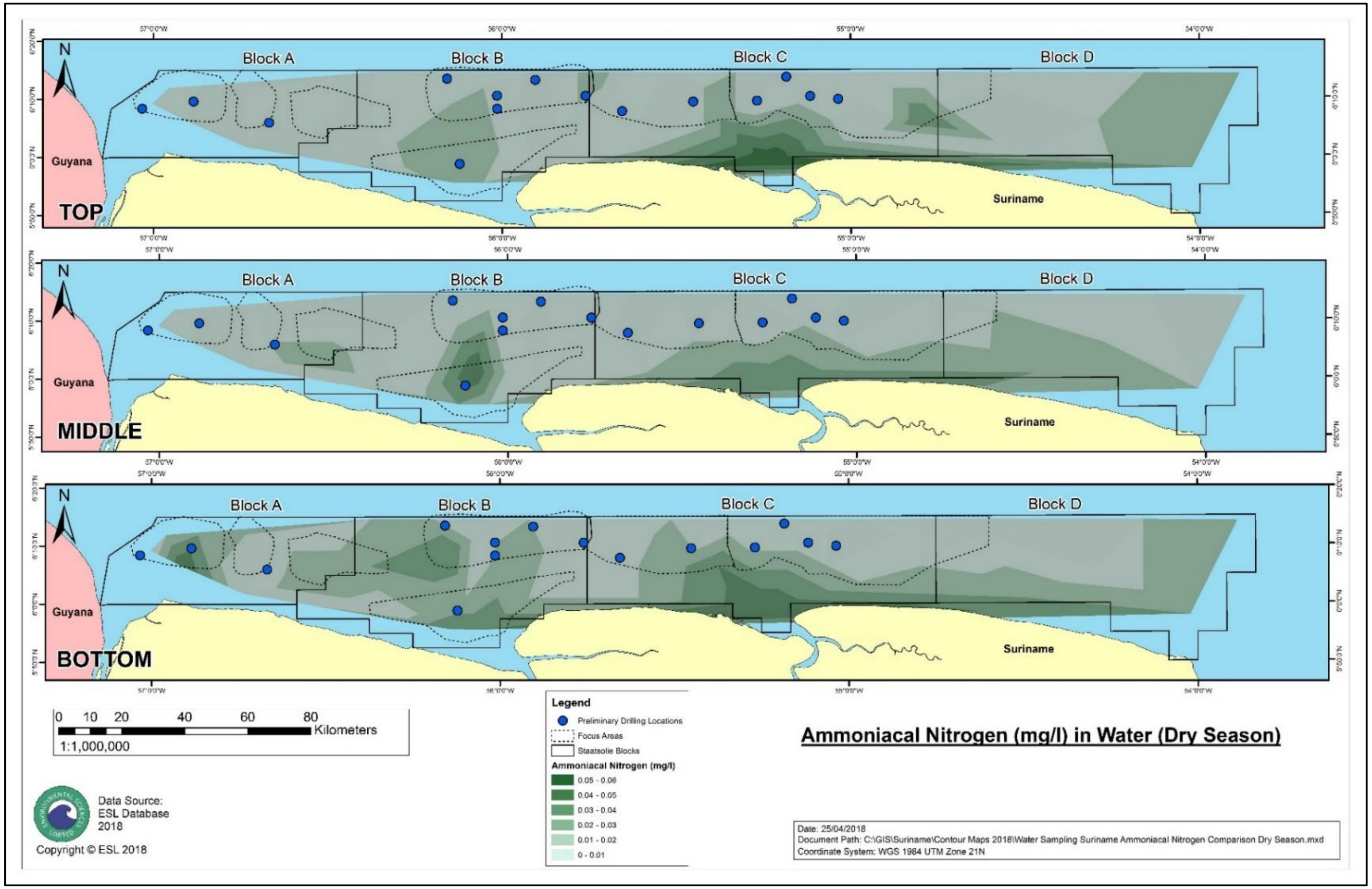
The contour gradient maps for this parameter (see Figure 5-66 and Figure 5-67 below) show that the levels of ammoniacal nitrogen were marginally higher during the long wet season as compared to the long dry season, and that these higher values tended to be concentrated within the middle layer within Block D, where no preliminary drilling locations are proposed. During the long dry season, the highest values to ammoniacal nitrogen were found within the top layer of the water column closer to the shore in Block C, and was associated with the outflow of the confluence of the Suriname and Commewijne Rivers. The levels of this parameter were also found to be marginally lower in areas where the preliminary drilling locations are situated (the exceptions being those closer to shore in Block B and further offshore in Block A during the long dry and long wet seasons, respectively.

The levels of ammoniacal nitrogen detected at Station 119 during the long wet season of 2017 did not exceed the levels detected within the station cluster for Well-sites 2 and 4, recorded during the short wet season of 2013 (see Table 5-20 above). However, levels detected at Station 234 in 2017 did exceed those recorded in 2013 (where the latter values were BDL and the former were recorded at 0.10 mg/l).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-66: Contour Gradient Map for Ammoniacal Nitrogen (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

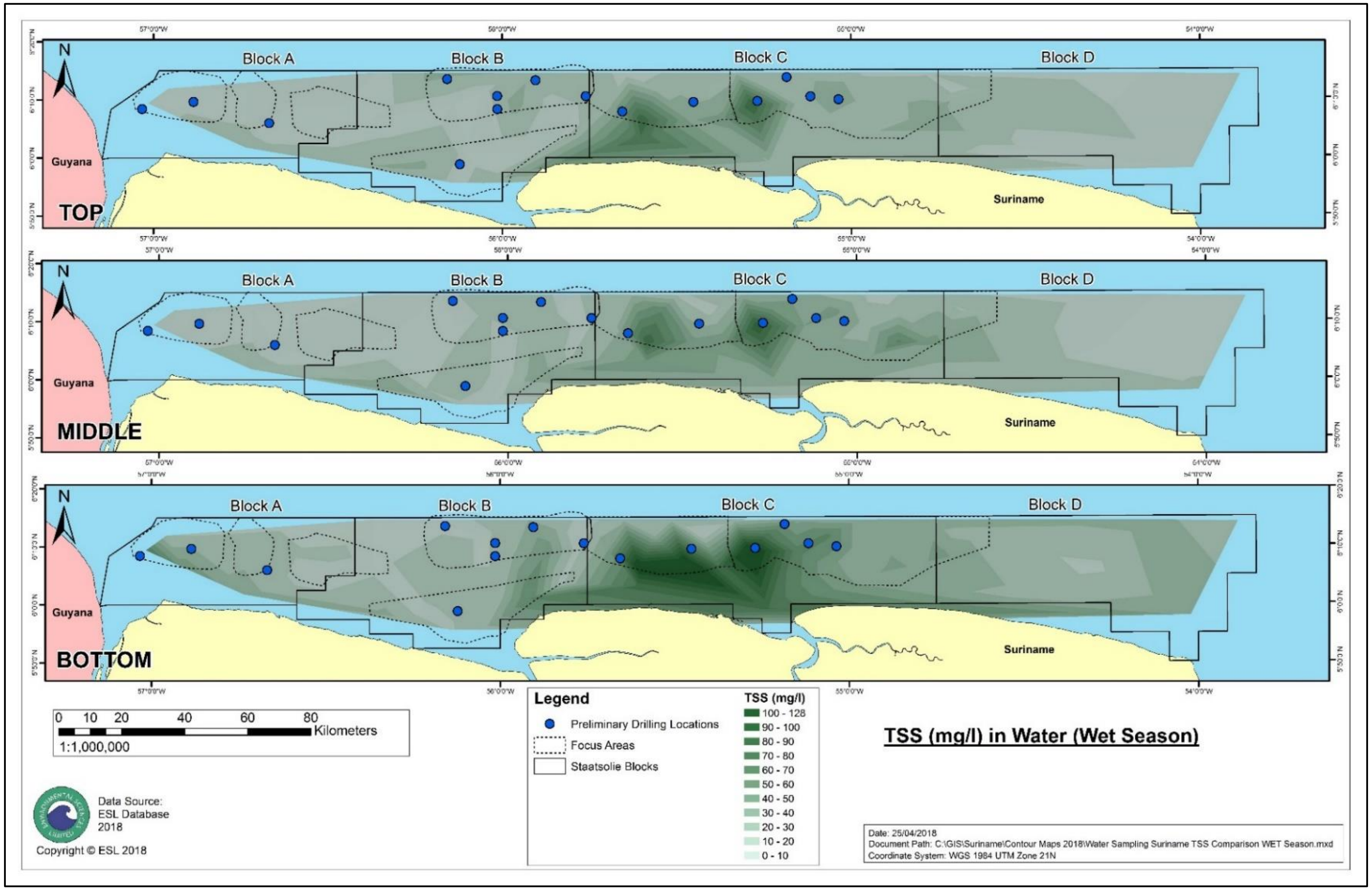
Figure 5-67: Contour Gradient Map for Ammoniacal Nitrogen (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

TSS levels exhibited a high level of variability within each level of the water column, as evidenced by the ranges for the long wet and dry seasons, and the high standard deviation values (where applicable; see Table 5-19 below). The bottom level of the water column showed the greatest level of variability, during both seasons.

The contour gradient maps for the parameter shows that the highest levels of TSS occurred within the central portion of Block C, closer to the shore and further offshore, and this was consistent across all levels of the water column and for both seasons (see Figure 5-68 and Figure 5-69 below). During both seasons, the highest values occurred at the bottom of the water column, but the values observed during the long wet season were marginally higher than those observed during the long dry season. Three of the preliminary drilling locations within the western portion of Block C coincided with areas with relatively high levels of TSS.

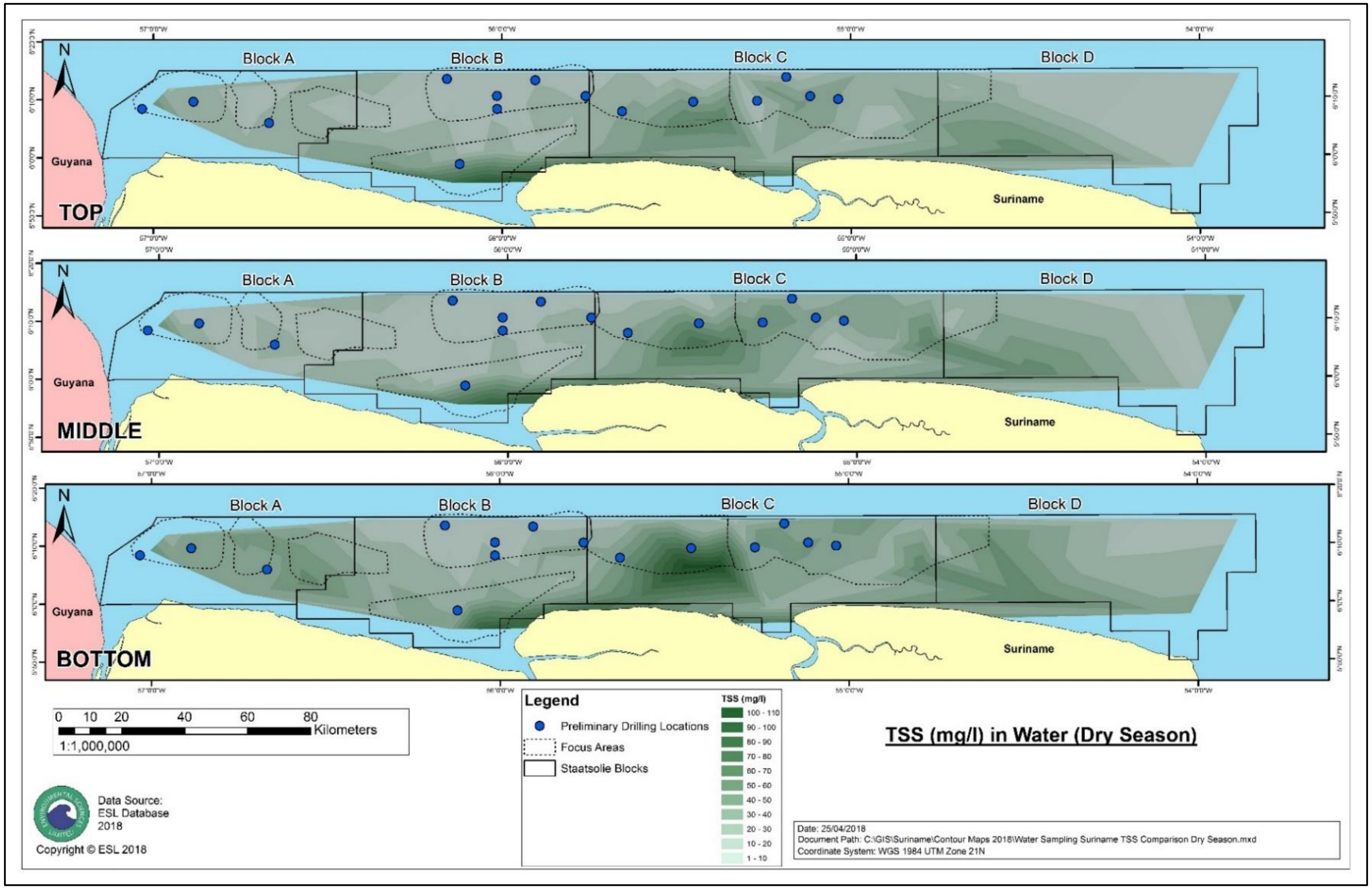
Higher levels of TSS were also observed in the area closer to shore within Block B during the dry season. Overall, the levels of TSS may be attributed to the outflows of rivers along the shoreline, where the higher levels occurred during the long wet season, as a result of increased sediment load from runoff.

The levels of TSS recorded at Stations 119 and 234 during the long wet season of 2017 were lower than the values recorded within the station clusters for Well-sites 2 and 4, and Well-site 9, respectively, recorded during the short wet season of 2013 (see Table 5-20 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-68: Contour Gradient Map for TSS (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-69: Contour Gradient Map for TSS (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

COD was BDL at 53 of the 61 stations (87%) sampled during the long dry season, and at 37 of the 61 stations (61%) sampled during the long wet season; this precluded contour gradient analysis for this parameter. Where detected, values ranged from 200.00 – 310.00 mg/l during the long wet season, and 200.00 – 230.00 mg/l during the long dry season; this indicated that values were marginally higher during the former, as opposed to the latter (see Appendix D.5 and Appendix D.6).

A review of the stations at which values were detected indicated that COD was recorded at stations which are found to the north of the mouths of the Coppename and Suriname Rivers, within the areas closer to shore of Blocks B and C, respectively, during the long wet season. These include Stations 51, 56, 61, 66, 68 and 72 within Block B (see Figure 5-36 above), which are in close proximity to a single preliminary drilling location in the Nearshore area of Block B. COD was also detected at Stations 182, 223 and 187 within Block C. During the long dry season, COD was detected at one or two of the stations mentioned above, but not at all (see Appendix D.5 and Appendix D.6).

The data suggests that the source of COD at various levels of the water column may be the rivers from which runoff enters the Nearshore areas within Blocks B and C, and that the effect is more pronounced during the long wet season, as opposed to the long dry season.

COD was not detected at any of the stations sampled during the short wet season of 2013, but it was detected at all levels of the water column at Station 119, and these ranged from 210.00 – 220.00 mg/l. COD was not detected at Station 234 during the long wet season (see Table 5-20 above).

O&G and TPH were not detected at any level of the water column at any station during the long wet and dry seasons of 2017. The former was not sampled in 2013, so this precluded further comparison. As for TPH, this parameter was detected during the short wet season of 2013; values ranged from BDL – 0.31 mg/l, overall. Thus, there was some source of TPH in the waters of the Nearshore environment but this was no longer present within the area compared by 2017.

Phenol was detected at approximately 10 of the 61 stations (16%; at various levels of the water column) during both the long wet and long dry seasons. The same trend was observed for phenols as for COD; stations at which phenols were detected were located to the N of the Suriname and Coppename River mouths (Stations 182 and 187 within Block C; Suriname River) and Stations 51, 56, 61 and 66; Coppename River), during both seasons. As mentioned, this is in close proximity to the most southerly drilling location within Block B, and the potential source of the parameter is the outflow of the rivers along the shoreline.

Phenols were BDL at all stations within the clusters for Well-sites 2, 4 and 9, sampled during the short wet season of 2013; and this was also the case at all levels of the water column at Station 234 and at the top and middle of the water column at Station 119 recorded during the long wet season of 2017. It was only at the bottom of the water column at Station 119 was phenol detected, at a value of 0.007 mg/l (see Table 5-20 above).

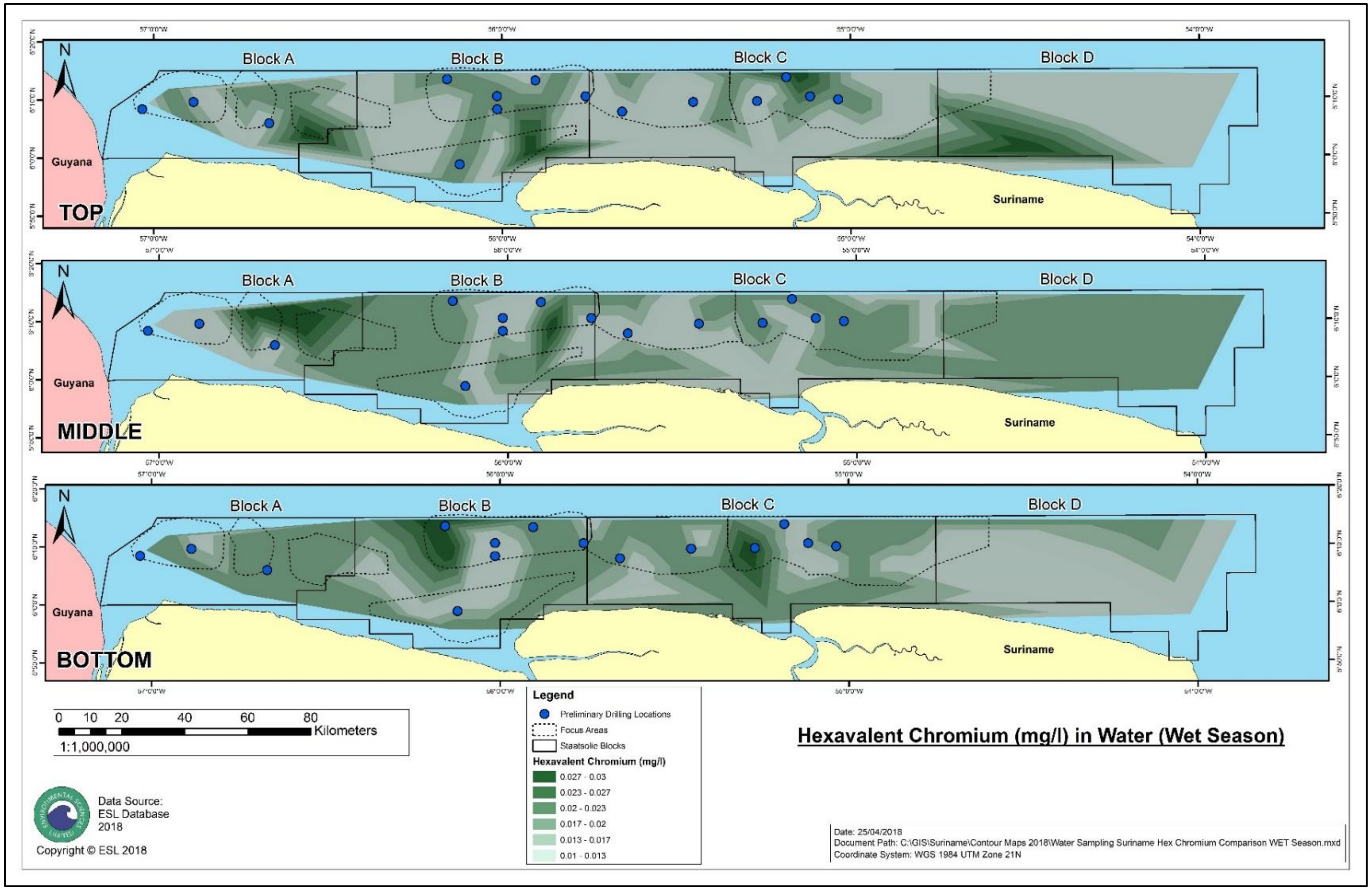
Metals

The total metals, cadmium, mercury, barium and arsenic were BDL at all levels of the water column at all stations sampled during both the long wet and long dry seasons of 2017. Total cadmium, mercury and arsenic were also BDL at all stations within the clusters for Well-sites 2, 4 and 9, sampled in the short wet season of 2013. Total barium was detected within the range of 0.61 – 2.40 mg/l (all levels of the water column and all stations combined). Thus, the source of total barium in the 2013 dataset does not appear to affect the areas within which Stations 119 and 234 are located.

Hexavalent chromium was detected at all stations, at all levels of the water column during the long wet and long dry seasons of 2017, and the ranges were identical across the top, middle and bottom layers of the water column, in both seasons (see Table 5-19 above). Though the ranges were identical, the distribution of the higher values occurred throughout all Blocks in the long wet season, and within Blocks A, B and C in the long dry season (see Figure 5-70 and Figure 5-71 below). Values appeared to be reduced within Block D during the long dry season, as compared to the long wet season. The data also show that the highest values of this parameter were more frequent within the top layer of the water column across the study area (during the long wet season), but the variability within this layer was greater than that observed within the middle and bottom layers (for both seasons; see standard deviation values presented in Table 5-19 above). Overall, however, these differences are marginally different, across the water column and between the long wet and long dry seasons, and so do not appear to be statistically significant.

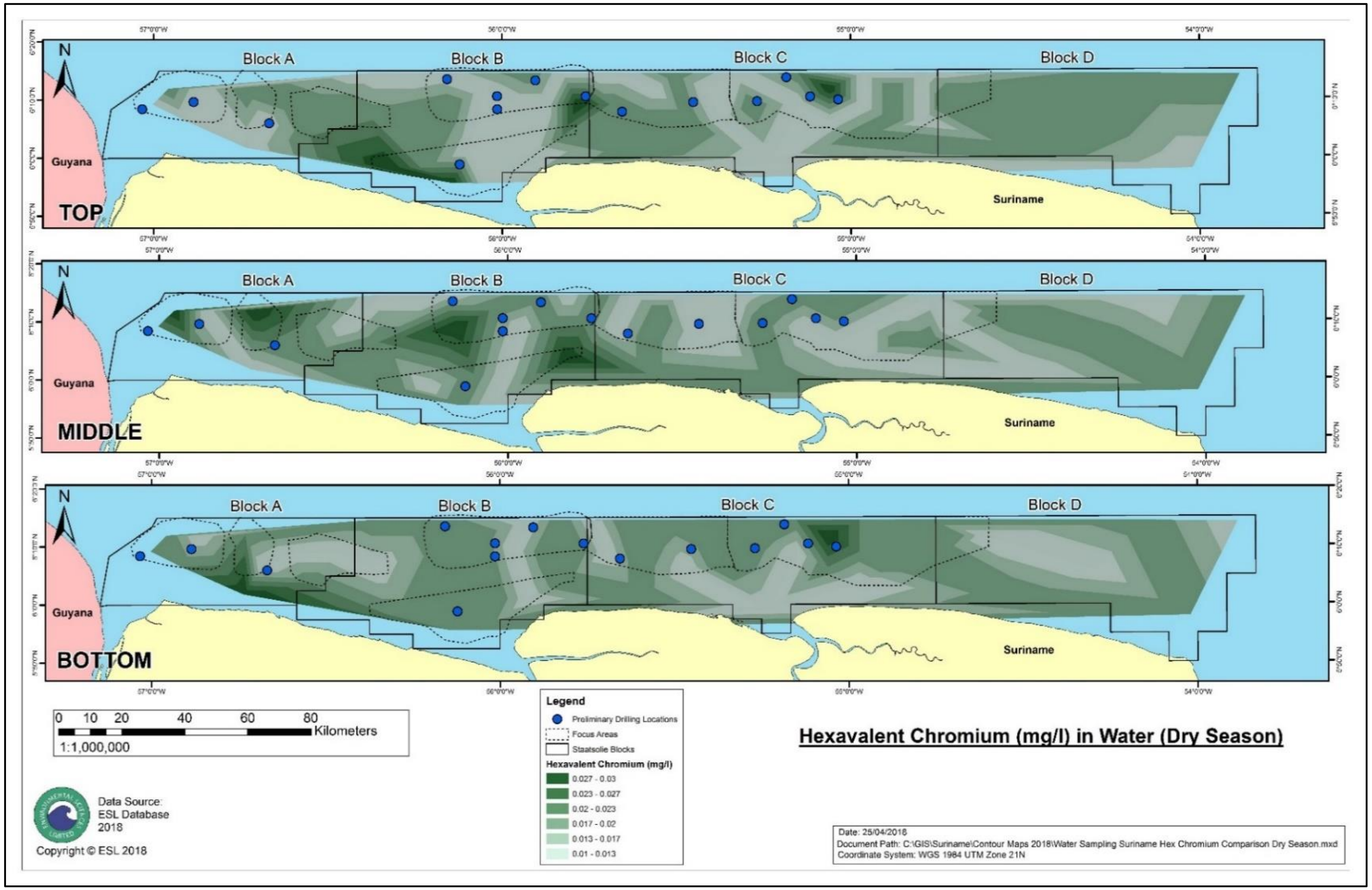
When taking the preliminary drilling locations into account, it appears that the most easterly locations within Block C and the most westerly location within Block B (further from the shore; see Figure 5-36 above) tended to intersect with relatively higher levels of hexavalent chromium.

The levels of hexavalent chromium recorded at Stations 119 and 234 during the long wet season of 2017 were lower than the values recorded within the station clusters for Well-sites 2 and 4, and Well-site 9, respectively, recorded during the short wet season of 2013 (see Table 5-21 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-70: Contour Gradient Map for Hexavalent Chromium (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-71: Contour Gradient Map for Hexavalent Chromium (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

Total copper was recorded as BDL at all levels of the water column at all stations, during the long wet and long dry seasons of 2017; the only exceptions were at the middle of the water column at Stations 135 and 156, which are proximal to the 3 most easterly preliminary drilling locations within Block C (see Figure 5-36 above). At these stations, the values recorded was 0.23 mg/l and 0.28 mg/l, respectively.

The levels of total copper at Stations 119 and 234 measured during the long wet season of 2017 were recorded as BDL but this parameter was detected at a maximum value of 0.26 mg/l within the station clusters for Well-sites 2, 4 and 9 recorded during the short wet season of 2013 (see Table 5-21 above). Thus, there was some source of total copper within Block IV (the western portion of Block C) in the waters of the Nearshore environment in 2013 but this was no longer present within the area compared by 2017.

Total nickel was BDL at all levels of the water column at all stations, during the long dry season, and was only detected at 12 stations, at various layers of the water column during the long wet season. Where detected, values ranged from 0.240 – 1.28 mg/l (all detected values combined). These included Stations 75, 89, 97, 103, 106, 120, 125, 143, 145, 151, 156 and 163 (see Figure 5-36 above). These stations did not appear to be associated with any riverine inputs, but were in very close proximity to the preliminary drilling locations within Block B (further offshore) and the 4 most easterly locations within Block C.

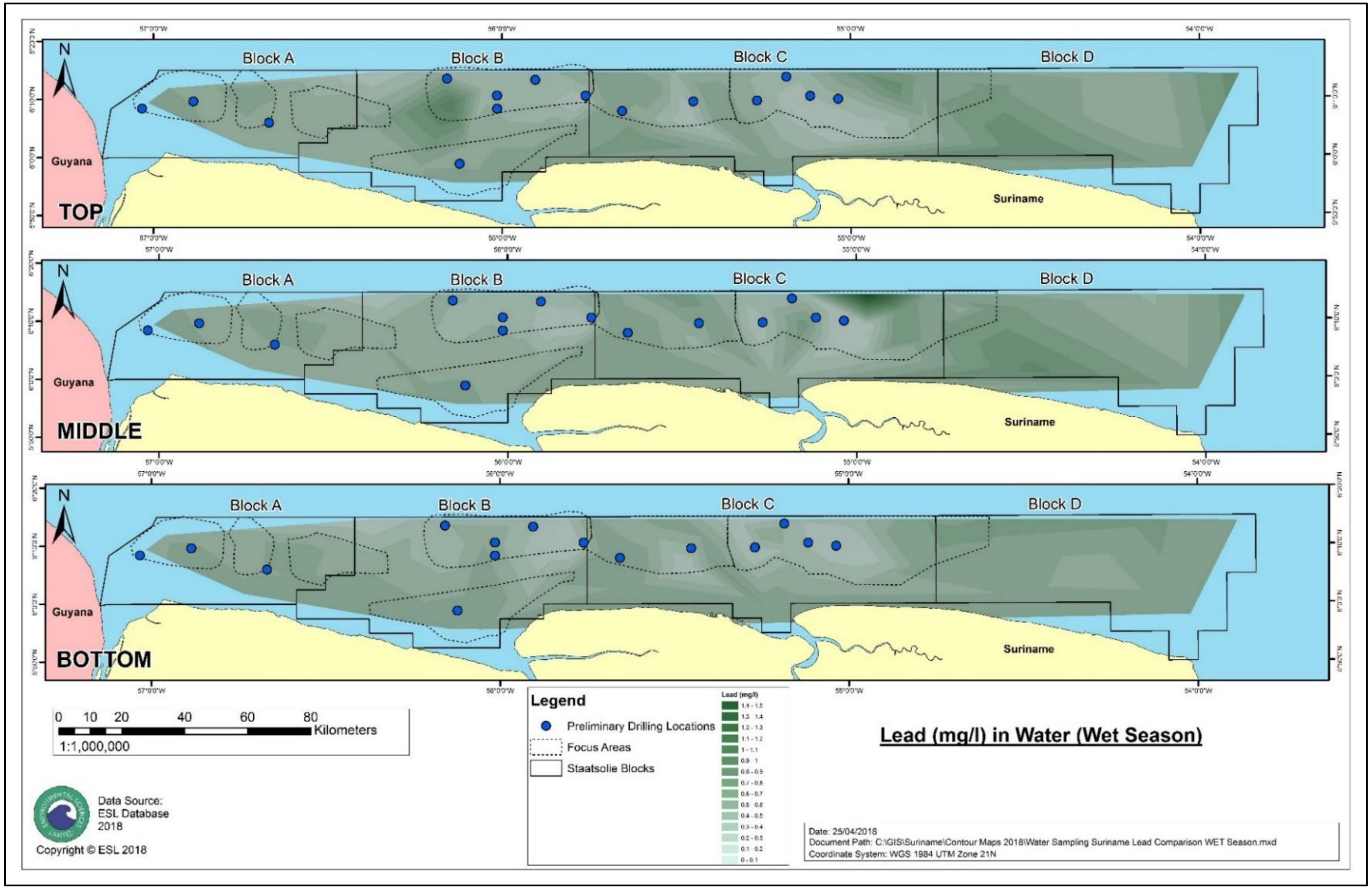
Total nickel was recorded as BDL at all stations within the clusters for Well-sites 2, 4 and 9 recorded during the short wet season of 2013, as well as at Stations 119 and 234 recorded during the long wet season in 2017 (see Table 5-21 above).

Total zinc was recorded as BDL at all levels of the water column at all stations, during both long wet and long dry seasons of 2017. The only exception was at Station 75, located proximally to the NW of the most westerly preliminary drilling location within Block B (further offshore; see Figure 5-36 above), at which the level detected was 0.70 mg/l. This parameter was also recorded as BDL at all stations within the clusters for Well-sites 2, 4 and 9 recorded during the short wet season of 2013, as well as at Stations 119 and 234 recorded during the long wet season in 2017 (see Table 5-21 above).

Total chromium was recorded as BDL at all levels of the water column at all stations, during both the long wet and long dry seasons of 2017. The only exceptions were: at the middle and bottom of the water column at Station 151 (0.35 mg/l and 0.27 mg/l, respectively, during the long wet season; and at Station 156 (0.23 mg/l), during the long dry season. These stations are located proximally to the most easterly preliminary drilling location within Block C (see Figure 5-36 above). Total chromium was also recorded as BDL at all stations within the clusters for Well-sites 2, 4 and 9 recorded during the short wet season of 2013, as well as at Stations 119 and 234 recorded during the long wet season in 2017 (see Table 5-21 above).

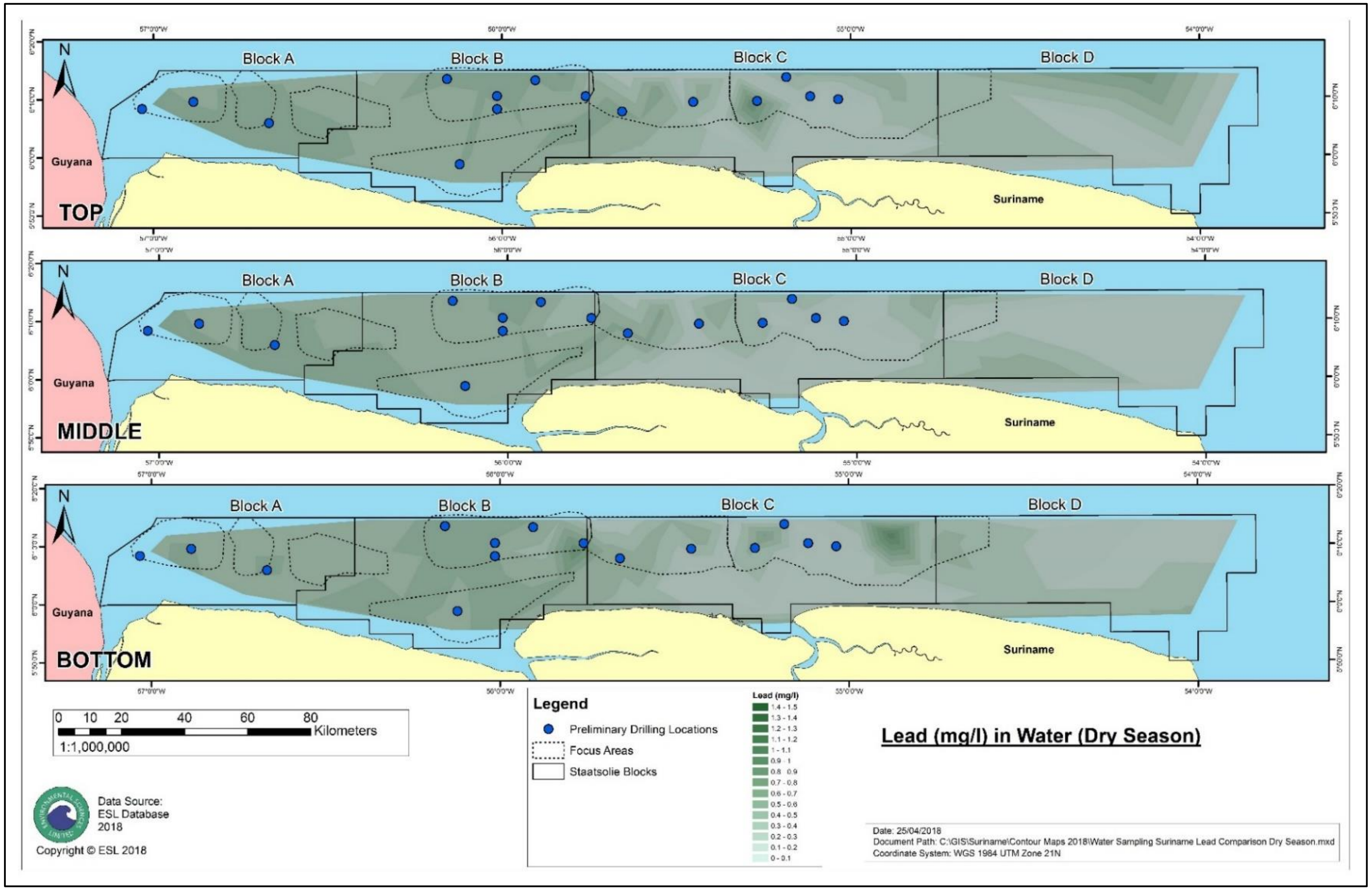
Total lead was detected at the majority of stations, at all levels of the water column, during both the long wet and long dry seasons of 2017. The contour gradient maps for this parameter, presented in Figure 5-72 and Figure 5-73 below, show that levels were marginally higher during the long dry season, as compared to the long wet season, with values spread throughout the study area, and with Blocks A and D showing a marginal increase in the levels of this parameter between the wet and long dry seasons, at all levels of the water column. The highest levels were detected at the middle of the water column during the long wet season in the eastern portion of Block C (further offshore); and in the same location at the bottom of the water column during the dry season (see Figure 5-72 and Figure 5-73 below). The majority of preliminary drilling locations were located in areas where the values of total lead tended to be lower in relation to other areas of the Block.

Levels of total lead detected at Stations 119 and 234 recorded during the long wet season of 2017 were found to be lower than the levels recorded within the station clusters for Well-sites 2, 4 and 9, recorded during the short wet season of 2013 (see Table 5-21 above).



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-72: Contour Gradient Map for Total Lead (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Wet Season (June – August 2017)



Source: ESL Database 2018 and 2017 Chemical Analysis Laboratory Reports (see Appendices D.5 and D.6)

Figure 5-73: Contour Gradient Map for Total Lead (mg/l) in Water Sampled across the Study Area, at the Top, Middle and Bottom of the Water Column for the Long Dry Season (September – November 2017)

Total iron was BDL at 33 of the 61 stations sampled during the long wet season (54%) and 19 stations (31%) during the long dry season; as a result, contour gradient analysis was not conducted for this parameter. In general, stations at which values were detected were common between the long wet and long dry seasons. Values were detected at stations which were associated with the outflows of the Coppename River (Stations 51, 61 and 68), and the Suriname River (Station 187), as well as at stations associated with preliminary drilling locations within Block C (Stations 125, 137, 143 and 145; see Figure 5-36 above and Appendix D.5 and Appendix D.6). Values were also detected at some stations at which total nickel was recorded, such as Stations 189, 97, 103, 106, 120, 151 and 156, the latter 2 of which are proximal to the most easterly preliminary drilling location within Block C (see Figure 5-36 above). In general, for all levels of the water column combined, total iron was detected within the range 0.20 – 1.29 mg/l, with marginally higher levels recorded during the long wet season (at the bottom of the water column; see Table 5-19 above).

Levels of total iron detected at Stations 119 and 234 recorded during the long wet season of 2017 were found to be lower than the levels recorded within the station clusters for Well-sites 2, 4 and 9, recorded during the short wet season of 2013 (see Table 5-21 above).

Total aluminium was BDL at the majority of the stations at all levels of the water column during the long wet and long dry seasons of 2017, with values detected at more stations during the long wet season (33 of 61 or 54%) as opposed to the dry season (10 of 61 or 16%). Stations at which values were detected in the long dry season also had values recorded during the long wet season.

Values were detected at stations to the N of the Coppename River mouth (Stations 61 and 72), which are proximal to the preliminary drilling location closest to the shore within Block B (see Figure 5-36 above). Values were also detected N of the Suriname River mouth (Station 187), and in proximity to the most easterly preliminary drilling locations within Block C (Stations 137, 143 and 145) and within Block A (Stations 4 and 9; see Figure 5-36 above).

Values for this parameter were detected at stations at which total nickel and total iron were also detected, including Stations 151, 156, 163, and 172, at which some of the sediment parameters were also found to be highest (see further below and Section 5.3.9.3 above).

Levels of total aluminium detected at Stations 119 and 234 recorded during the long wet season of 2017 were found to be lower than the levels recorded within the station clusters for Well-sites 2, 4 and 9, recorded during the short wet season of 2013 (see Table 5-21 above).

The stations at which the highest values of individual parameters (all levels combined, both seasons) were found to occur within Block C (see Figure 5-36 above), proximally to the preliminary drilling locations located therein. These include:

- Station 182 (total aluminium; long wet season);
- Station 185 (total aluminium; long dry season);
- Station 172 (total iron; both seasons);
- Station 159 (total lead; long wet season);
- Station 165 (total lead; long dry season);
- Station 151 (total chromium; long wet season);
- Station 163 (total nickel; long wet season);
- Station 135 (total copper; long wet season);
- Station 187 (phenols and total phosphorus; both seasons, and ammoniacal nitrogen; long dry season);
- Station 119 (TSS; both seasons);
- Station 198 (ammoniacal nitrogen; long wet season); and
- Station 179 (nitrite; long wet season).

There were also a few stations within Block B at which the highest levels of some parameters were found, located proximally to the westernmost preliminary drilling location within Block B (further offshore), as well as the one closest to the shore within Block B. These included:

- Station 75 (total zinc; long wet season);
- Station 61 (COD; long wet season); and
- Station 66 (COD; long dry season).

It is noteworthy that the highest levels of the total metals, aluminium, iron, lead, chromium, nickel, copper, as well as phenols, total phosphorus, ammoniacal nitrogen and nitrite (in either the long wet or dry seasons, or both, as specified above) also occurred in generally the same area of Block C within which the highest levels of sediment parameters were found, including the total forms of aluminium, chromium, lead and zinc (see Section 5.3.9.3 above). Whilst the nutrient and organic parameters listed above may be accounted for within the study area as a result of the outflow of the Coppename and Suriname Rivers, the metal parameters within the water and sediment may be explained by oil and gas seepages which are known to occur within the Nearshore area of Block C (Bassias 2016), as described within Section 5.3.9.3 and Section 5.3.1 and Figure 5-5 above.

Finally, the comparative analysis of the 2013 and 2017 datasets within Block C revealed that the 2017 levels of the parameters, nitrate, total phosphorus, TSS, TPH, hexavalent chromium, and the total metals, copper, lead, iron and aluminium were lower than the values recorded in 2013, whereas the parameters, nitrite, and phenols were higher in 2017 as compared to 2013. In the case of ammoniacal nitrogen, it was only the values at 2017 Station 234 which was higher than the 2013 values; and for COD, it was the values at 2017 Station 119 only which was higher than the 2013 values. Overall, the data suggests that there may have been one or more sources of these parameters within the Nearshore environment within the western portion of Block C, which affected water quality in 2013 but no longer did so in 2017. Alternatively, there may be sources which reflected an increase in 2017 levels but which did not previously affect the area in 2013.

When taking all of the above into account, it can be concluded that, over time, prevailing (natural) environmental conditions within the Nearshore environment played a significant role in influencing the quality of marine water and sediment, including the changes which may have occurred within the western portion of Block C between 2013 and 2017. These natural environmental conditions include, as specified above, runoff from the Coppename and Suriname Rivers and naturally occurring oil and gas seepages, both of which would be affected by regional oceanographic conditions along the Guiana coast.

5.3.11 Ambient Air Quality (Offshore)

The ambient air quality of the Nearshore and offshore marine environment of Suriname is described below using previously conducted studies, as per the requirements of the Final Scoping Report for this ESIA (which was based upon advice provided by NIMOS to Staatsolie, during the scoping phase of this Project). This decision was made in light of the evidence presented within the previously conducted studies, which showed that offshore ambient air quality is negatively affected in a very insignificant manner, owing to rapid dispersal of potential contaminants by high wind speeds offshore.

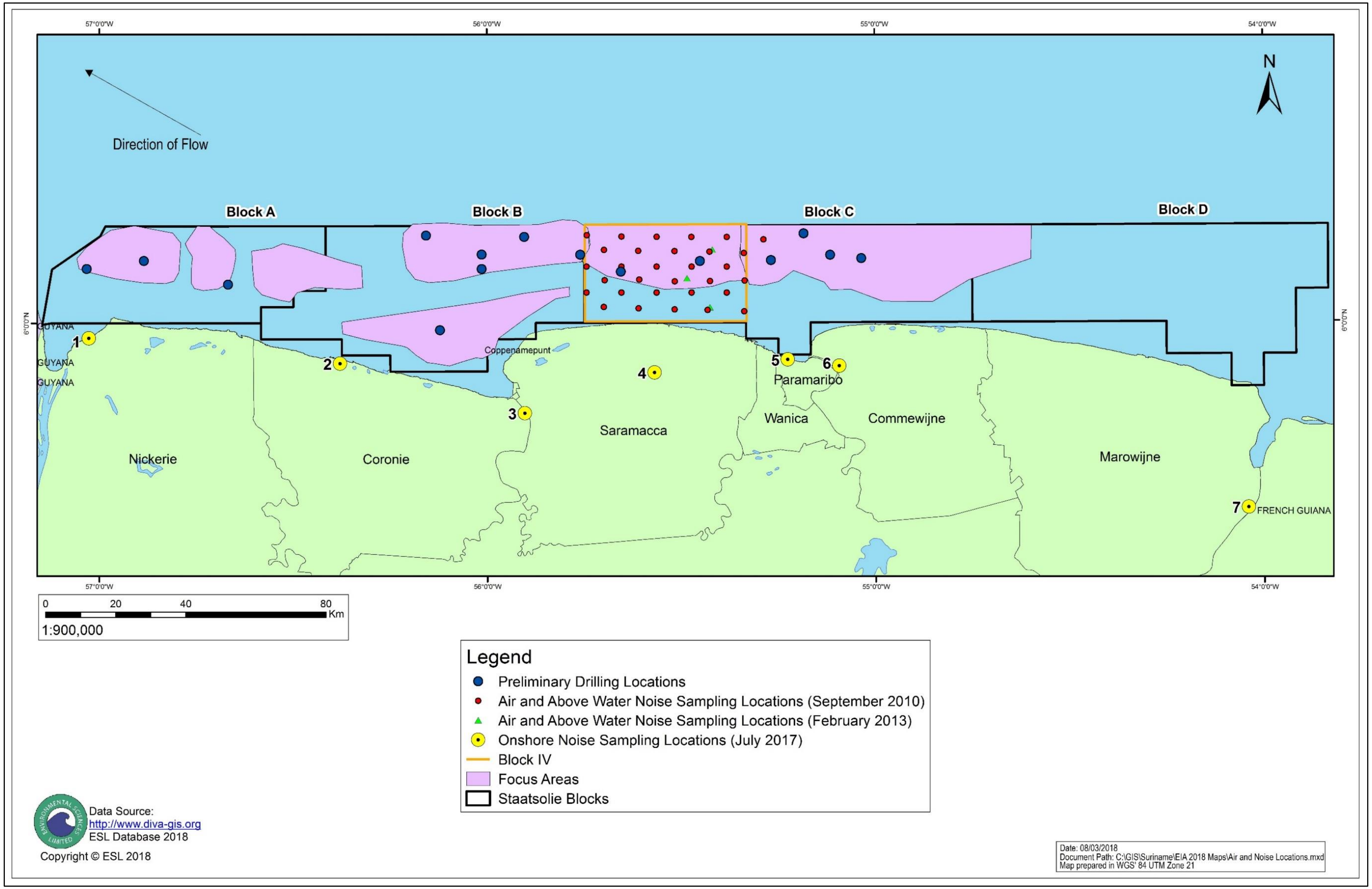
The previously conducted studies which therefore serve to describe the ambient air quality conditions in the Nearshore area include:

- Ambient air quality monitoring at 31 stations in September 2010 (long dry season) across the western portion of Nearshore Block C (or what was formerly known as Block IV), as part of the baseline assessment for the POC ESIA for 2D and 3D Seismic Program within Block IV (ESL 2012); and
- Ambient air quality monitoring at 3 proposed exploration well-sites in early February 2013 (end of short wet season) across the western portion of Nearshore Block C (or what was formerly known as Block IV), as part of the baseline assessment for the ESIA for POC ESIA for Nearshore Exploration Drilling within Block IV (ESL 2013b).

In both studies, the parameters tested included: carbon monoxide (CO); Volatile Organic Compounds (VOCs); and hydrogen sulphide (H_2S), using a Multi Rae Multi Gas Monitor (PGM 50-5P); as well as nitrogen dioxide (NO_2) and sulphur dioxide (SO_2) using a QRae Multi Gas Analyser (PGM 2000). The locations of these sampling locations are shown in Figure 5-74 below.

At each sampling location (both studies), the instruments were held approximately 1.5 m above vessel deck level with the sensors exposed to the atmosphere, and the monitors were set at logging intervals of 1 minute. Sampling periods were set at 60 minutes per site. The time-weighted average (TWA), defined as *'the average air concentration of contaminants during a given period of time*' (USEPA 2009) was provided (for each parameter) by the equipment used in sampling. Recorded in ppm, TWA values were then converted to $\mu g/m^3$, and then compared to maximum permissible limits (MPLs in $\mu g/m^3$) outlined in the First Schedule of the Trinidad & Tobago Air Pollution Rules (TTAPR), 2014 (GORTT 2014), for CO, NO_2, SO_2 and H_2S. Comparisons were also made to the MPLs listed in the USEPA National Ambient Air Quality Standards (NAAQS; USEPA 2008), for CO, NO_2, SO_2 (there is no MPL for H_2S). These standards were applied because there is no local air pollution legislation for Suriname. There is no applicable standard for VOCs, and so these values represented the baseline condition at the time of sampling.

Both sampling events in 2010 and 2013 yielded NO_2, SO_2, H_2S, CO and VOCs readings of 0 µg/m^3 at all stations sampled (see Figure 5-74 below) and this precluded comparison to TTAPR 2014 and NAQQS 2008. It can therefore be stated that there was good ambient air quality in the western portion of Block C at the times of sampling, and this may be extrapolated for the Nearshore region in general, given that these air quality parameters are likely to be highly dynamic, spatially and temporally, owing to dispersal by wind and other factors.



Source: ESL Database 2018, ESL 2012 and ESL 2013b

Figure 5-74: Ambient Air & Noise Monitoring Stations in the Nearshore and Coastal Areas (September 2010, February 2013 & July 2017)

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5.3.12 Ambient Surface Noise (Above Water; Offshore)

The ambient noise quality (above-water) of the Nearshore and offshore marine environment of Suriname is described below using previously conducted studies, as per the requirements of the Final Scoping Report for this ESIA (which was based upon advice provided by NIMOS to Staatsolie, during the scoping phase of this Project; see Appendix A.1). This decision was made based on Expert advice to NIMOS that above-water noise in the Nearshore and offshore area may not be relevant, and recommended the monitoring of coastal (onshore) noise levels instead (see Section 5.3.13 below). Thus, the use of previously conducted studies to assess this parameter is suitable, given that offshore, ambient above-water noise may be generated sufficiently far away from the coast such that sensitive coastal receptors may not be affected (owing to attenuation of sound waves from the point of origin i.e. from Project activities taking place within the immediate Project footprint).

The previously conducted studies which therefore serve to describe the ambient above-water noise quality conditions in the Nearshore area include:

- Ambient noise monitoring at 31 stations in September 2010 (long dry season) across the western portion of Nearshore Block C (or what was formerly known as Block IV), as part of the baseline assessment for the POC ESIA for 2D and 3D Seismic Program within Block IV (ESL 2012); and
- Ambient noise monitoring at 3 proposed exploration well-sites in early February 2013 (end of short wet season) across the western portion of Nearshore Block C (or what was formerly known as Block IV), as part of the baseline assessment for the ESIA for POC ESIA for Nearshore Exploration Drilling within Block IV (ESL 2013b).

For both studies, the equivalent continuous sound pressure level (SPL L_{eq}) was recorded in dBA, using an ExTech Instrument 407735 Digital Sound Level Meter. This meter was set on the ‘Fast’ response and the ‘A-weighted’ frequency characteristic to determine continuous sound expressed as the equivalent continuous sound pressure level (SPL) in the unit of dBA. At each location, SPL values were recorded at one-minute intervals for a period of 30 minutes. The locations of these monitoring stations are the same as those sampled for air quality (since the sampling of air and noise were done concurrently, during both studies; see Figure 5-74 above). For both studies, no potentially interfering meteorological variables such as precipitation or thunder were present in the prevailing conditions under which the SPL measurements were recorded (nor was the vessel engine engaged). Additionally, sampling was conducted 1.5 m above deck level to reduce any level of interference.

In February 2013 (ESL 2013b), monitoring was conducted at Station 2 during the day, and during the night at Stations 4 and 9 (see Figure 5-74 above). In September 2010 (ESL 2012), monitoring was done at all stations shown in Figure 5-74 above, during the day only. Values were compared to the industrial

L_{eq} SPL MPLs (75 dBA at any time) as per the First Schedule of the Trinidad & Tobago Noise Pollution Rules (NPR), 2001 (GORTT 2001).

In September 2010, daytime readings throughout the study area ranged from 53.8 dBA to 54.9 dBA, and represented a very narrow range of variability within the dataset. None of the recorded values exceeded the MPL specified above. Based on wind data collected from 1961 – 1970 at the offshore Station Lichtschip, it was ascertained that the month of September represents fairly average wind speeds (see Section 5.3.6.2). In addition to which, only a few smaller-sized fishing boats were encountered during monitoring in September 2010. Therefore, the results obtained during this time may represent relatively quiet conditions. Low levels of noise may also be attributed to limited shipping and or fishing activities present in the vicinity of Block IV at the time of sampling.

Station 28 sampled in September 2010 was located very close to Station 2 sampled in February 2013, and so were directly comparable (see Figure 5-74 above). The L_{eq} value recorded at Station 2 in February 2013 (63.4 dBA) was found to be higher than that at Station 28 in September 2010 (54.4 dBA), and this was attributed to an overall increase in the level of noise within the study area, owing to an increase in the level of activity within Block IV over the elapsed 3-year period.

Given that only night-time noise was recorded at Stations 4 and 9 in February 2013, and no night-time noise was recorded in September 2010, no comparisons could be made. Thus, the values of night-time noise recorded at Stations 4 and 9 (57.0 and 72.2 dBA) represent the baseline conditions. However, these appeared to be higher than the range for day-time noise in September 2010, as well as higher than the day-time value at Station 2 (63.4 dBA, when compared to Station 9 at 72.2 dBA). It is possible that the noise level at the stations sampled in February 2013 were representative of anomalous activities during monitoring. These may be from several sources, including mechanical noises made from marine vessels' engines in passing; noises made from interactions of oceanic water and marine vessels; or noises made from wind.

5.3.13 Ambient Surface Noise Quality (Above Water, Onshore)

The ambient noise quality (above-water) of the coastal (onshore, shoreline) area adjoining the Nearshore Blocks A to D is described below using primary data collected by ESL, as part of the baseline assessment for this ESIA, as recommended by NIMOS during the Scoping phase of this Project. The coastal area (shoreline) will serve as the boundary at which noise (generated in the Nearshore or offshore) may or may not affect sensitive coastal receptors such as humans and roosting or nesting avifauna, as well as other fauna present along the shoreline. There are no previously conducted studies along the shoreline, and so this precludes comparative analysis.

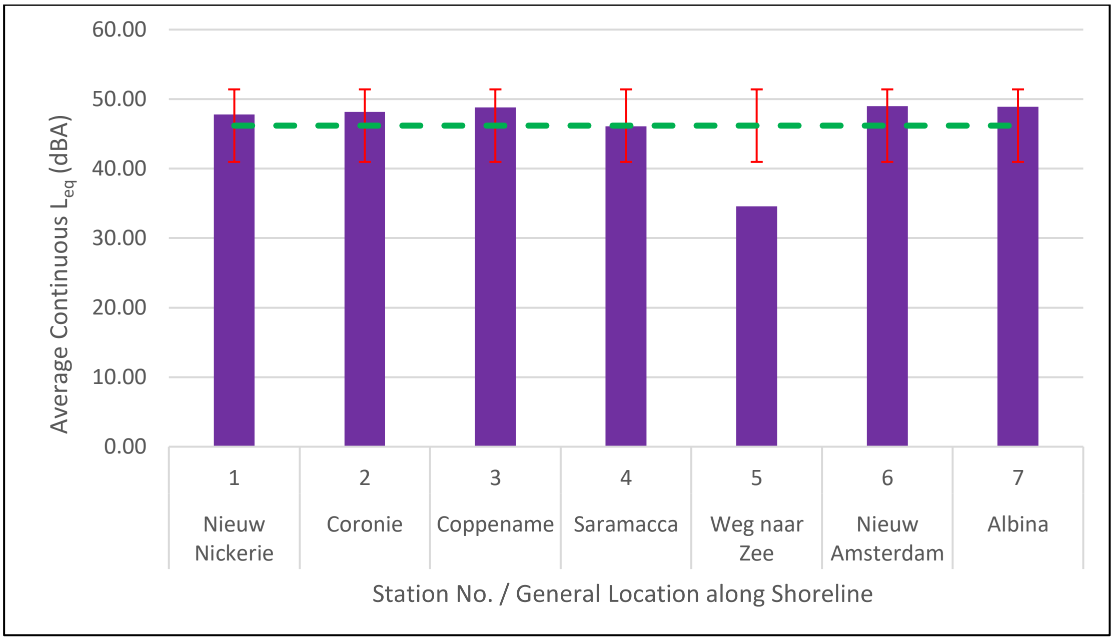
Noise was monitored during the daytime at 7 locations along the shoreline, from Nieuw Nickerie in the west to Albina in the east, during the period July 13th – 15th, 2017 (see Figure 5-74 above). The equivalent continuous sound pressure level (SPL L_{eq}) was recorded in dBA, using an ExTech Instrument 407735 Digital Sound Level Meter. This meter was set on the 'Fast' response and the 'A-weighted' frequency characteristic to determine continuous sound expressed as the equivalent continuous sound pressure level (SPL) in the unit of dBA. At each location, SPL values were recorded at one-minute intervals for a period of 30 minutes. No potentially interfering meteorological variables such as precipitation or thunder were present in the prevailing conditions under which the SPL measurements were recorded. Additionally, sampling was conducted 1.5 m above ground level to reduce any level of interference.

Table 5-22 below presents the results of the July 2017 coastal onshore noise monitoring exercise, and Figure 5-75 is a graphical representation of these results. The data revealed that the average Leq ranged from 34.85 dBA at Station 5 (Weg naar Zee) to 49.01 dBA at Station 6 (Nieuw Amsterdam), with values averaging 46.18 ± 5.22 dBA. The standard deviation of the dataset was very low, indicating minimal variability in the SPL values over the study area. Overall, these daytime SPL values indicate quiet ambient conditions at the time of sampling.

Table 5-22: Average Ambient Equivalent SPL (Leq in dBA) recorded at Coastal (Shoreline) Stations (July 2017)

Date Monitored	Time Monitored		Station No./General Location	Sampling Locations (WGS '84, Zone 21N)		Average L_{eq} (dBA)
	Start	End		Easting	Northing	
15/7/17	01:17 pm	01:46 pm	1 (Nieuw Nickerie)	0497003	0658951	47.78
15/7/17	11:11 am	11:40 am	2 (Coronie)	0568681	0651782	48.15
15/7/17	09:43 am	10:12 am	3 (Coppename)	0621403	0637643	48.79
13/7/17	12:11 pm	12:40 pm	4 (Saramacca)	0658409	0649250	46.07
13/7/17	09:45 am	10:14 am	5 (Weg naar Zee)	0696401	0652972	34.58
14/7/17	05:00 pm	05:29 pm	6 (Nieuw Amsterdam)	0711110	0651189	49.01
14/7/17	01:53 pm	02:22 pm	7 (Albina)	0827978	0611044	48.91

Source: ESL 2017 Noise Monitoring Dataset



Source: ESL 2017 Noise Monitoring Dataset

Figure 5-75: Average Continuous Equivalent SPL (L_{eq}) in dBA at the Coastal Monitoring Stations (July 2017)

5.3.14 Underwater Noise

The ambient noise quality (underwater) of the Nearshore and offshore marine environment of Suriname is described below using previously conducted studies, as per the requirements of the Final Scoping Report for this ESIA (which was based upon advice provided by NIMOS to Staatsolie, during the scoping phase of this Project; see Appendix A.1). These studies include:

- A baseline underwater noise assessment to determine the baseline level of underwater noise within Block IV (which corresponds to the western half of Block C), as well as to conduct short- and long-range noise propagation studies within the Block in September 2010 (ESL 2012; see Figure 5-1 above); and
- *In-situ* sound measurements of airgun output within Blocks 1, 3 and 5 (which roughly correspond to Blocks A, B, and the eastern portion of Block C) in the Nearshore area of Suriname, during June – December 2014, concurrent to the 2D seismic ongoing within the Nearshore area (CSA 2015b).

These studies were deemed sufficient to describe the ambient underwater noise levels within the Nearshore and marine environment, given that there is fairly low activity within Blocks A to D in general, and that noise from vessel activity within Block IV (port and vessel routes) would have been captured as part of the first study (ESL 2012). Additionally, CSA 2015b satisfies the NIMOS' requirement that data used to describe baseline conditions must not be older than 5 years.

For both studies, sound recordings were collected and analysed to obtain sound pressure levels (SPLs) measured in decibels relative to 1 micropascal (dB re 1 μPa) but for CSA 2105b, the data were converted to root mean square (rms). This means that the data were not directly comparable for both studies (but see further below).

In September 2010, the background or baseline underwater noise levels within Block IV were found to have third-octave band spectrum levels between 90 – 100 dB re 1μPa at most frequencies and an average background underwater noise level of 112 dB re 1μPa for a frequency range of 50 – 10,000 Hz. Over the frequency range of 10 – 10,000 Hz, the overall average background noise levels were recorded as 133 dB re 1μPa. A large rise in the level is seen at frequencies below 50 Hz. This level of background noise is indicative of an area with distant shipping which may be attributed to shipping noise and/or artificial hydrophone noise.

CSA 2015b found the baseline ambient SPL_{rms} ranged from 115 dB re 1μPa within Block 3 to 125 dB re 1μPa within Block 5. Within both Blocks 3 and 5, the maximum recorded SPL_{peak} values from the sound source (air gun array) was recorded as 185 dB re 1μPa, and so the sound generated from the air gun array exceeded the baseline conditions specified by 60 – 70 dB re 1μPa for the duration of the study. As for individual impulses from the sound source (air gun array), SPL_{peak} ranged from 164 – 178 dB re 1μPa at 500 m, with an average SPL_{rms} of 174 dB re 1μPa at 500 m. Overall, at 500 m, the sound source array caused an average increase of 53 dB re 1μPa above average ambient SPL_{rms}.

It should be noted that the baseline levels recorded in September 2010 (112 dB re 1μPa for a frequency range of 50 – 10,000 Hz) and June – December 2014 (115 – 125 dB re 1μPa) are not directly comparable, since CSA 2015b did not specify the frequency range over which the data was recorded. However, it can be generally concluded that the baseline level recorded in June -December 2014 was higher than that recorded in September 2010, since the value quoted in 2010 (90 – 100 dB re 1μPa was recorded over most frequencies.

5.4 Ecological Environment

This Section discusses the various components of the biological environment which may be impacted by the proposed Project. It will be discussed under the following main headings:

- Benthic Habitats & Fauna (including Other Benthic Habitats & Fauna);
- Plankton;
- Marine Mammals;
- Sea Turtles;
- Fish & Shellfish;
- Vegetation Types & Coastal Ecosystems;
- Avifauna;
- Terrestrial Mammals;
- Herpetofauna; and
- Summary of Sensitive Species & Habitats.

5.4.1 Benthic Habitats & Fauna

5.4.1.1 Introduction

The term '*benthic*' refers to anything associated with or occurring on the surface at the bottom of a body of water. The animals and plants that live on or in the bottom are known as the '*benthos'*. Benthic habitats can best be defined as bottom environments with distinct physical, geochemical, and biological characteristics. Benthos is mostly composed of molluscs (gastropods and bivalves), arthropods such as crustaceans, and marine worms (e.g. polychaetes), some of which inhabit both soft-bottom and hard-bottom marine environments. Benthos also includes fauna such as corals (soft and hard) and marine flora such as seagrass beds and macroalgae. For the purposes of this report, soft-bottom macrobenthos (soft-bottom dwelling and feeding macroinvertebrates such as polychaetes, bivalves and gastropods) detected within the focus areas surrounding the proposed well-sites, within the Staatsolie Blocks are described. The results below characterise the benthos for both the wet (June - August 2017) and dry (September - November 2017) seasons (see Section 5.3.9.2 above), and compares these findings to data collected from previous environmental baseline studies conducted in February 2013.

Marine benthic ecosystems are invaluable from an ecological standpoint; they form complex interactions between various physical parameters (e.g. depth, dissolved oxygen and pH) and biological components of the seabed and the sea. These include predator and prey interactions and fluxes of nutrients and sediments. For example, there may be key inter-relationships between faunas and their habitats. Such interactions may include:

- Physical interactions
- Interactions involving nutrients, Dissolved Organic Matter (DOM) and Particulate Organic Matter (POM) and
- Animal migrations (Ogden and Gladfelter 1982)

Many marine benthic fauna are also considered important because they are bio-indicators of marine ecosystem health. The most susceptible benthic taxa are sessile and sedentary organisms (e.g. corals, sponges, burrowing worms, bivalves, hydroids and bryozoans) because they are unable to avoid impacts from activities which directly affect the seabed (such as the deposition of the cuttings pile associated with drilling activities), leading to the smothering and burial of organisms.

5.4.1.2 Method

The methodology employed for the wet season (June – August 2017) and the dry season (September – November 2017) macrobenthic surveys are described in Table 5-23 below. For both seasons macrobenthic samples were retrieved in triplicate at each of the 245 stations (see Figure 5-36 above), resulting in a total of 735 samples per season. The method of grab retrieval was the same as that outlined in ESL's adapted Benthic Methodology (see Appendix D.10). In each case, when the grab was retrieved by the winch, checks were made to ensure that the grab was acceptable (see Appendix D.10). If deemed acceptable, the sample was collected in a basin and then transferred to the sieve setup (4 mm, 1 mm and 0.5 mm). The sample was then washed gently to remove excess sediment and fixed with 10% formalin buffered with sodium borate, and stored for return to shore. Samples were then washed and sorted at ESL's laboratory, and organisms were identified to the lowest practical identification level (LPIL).

ESL's benthic methodology is adapted from Franson *et al.* (2005) Standard Test Method 10500, and is provided in Appendix D.10. Appendix D.10 also provides ESL's justification for the non-use of Rose Bengal for the processing of benthic samples, as a result of consultations with UK-based international EIA Specialist, Dr. Lynne Barratt and benthic and aquatic specialists Drs. Phil & Anne Smith of the UK-based Aquatonics Limited.

Table 5-23: Summary of Methods for ESL's Macrobenthic Survey within the Staatsolie Blocks, Offshore Suriname (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Aspect	ESL's Baseline Sampling Event
Sampling Objective	To determine community structure and identify dominant taxa
No. of Stations Sampled	245 stations located within the Staatsolie Blocks, offshore Suriname
No. of Replicates	3
Type of Grab	van Veen (0.25 m^2)
Size of Sieve	0.5 mm
Method of Preservation	10% Formalin buffered with sodium borate
Rose Bengal used	No
Washing Procedure	Thoroughly washed, collected in sieve and placed in container
Other Information	Benthic specimens retrieved were then identified to the LPIL*

Source: ESL's Field Sampling and Processing Methodologies (see: Appendix D.3 and Appendix D.10

**LPIL-Lowest Practical Identification Limit*

For the purposes of this report, results for both the wet and dry seasons have been analysed and compared. Subsequent to this, the data for each season was then sub-divided into 4 Blocks (A, B, C and D), which would target stations within the focus areas surrounding the proposed well-sites. The findings for each Block is presented in the relevant sub-sections below, with the Block-specific benthic macrofaunal species lists (by season) are presented in Appendix D.11.

5.4.1.3 Results & Discussion

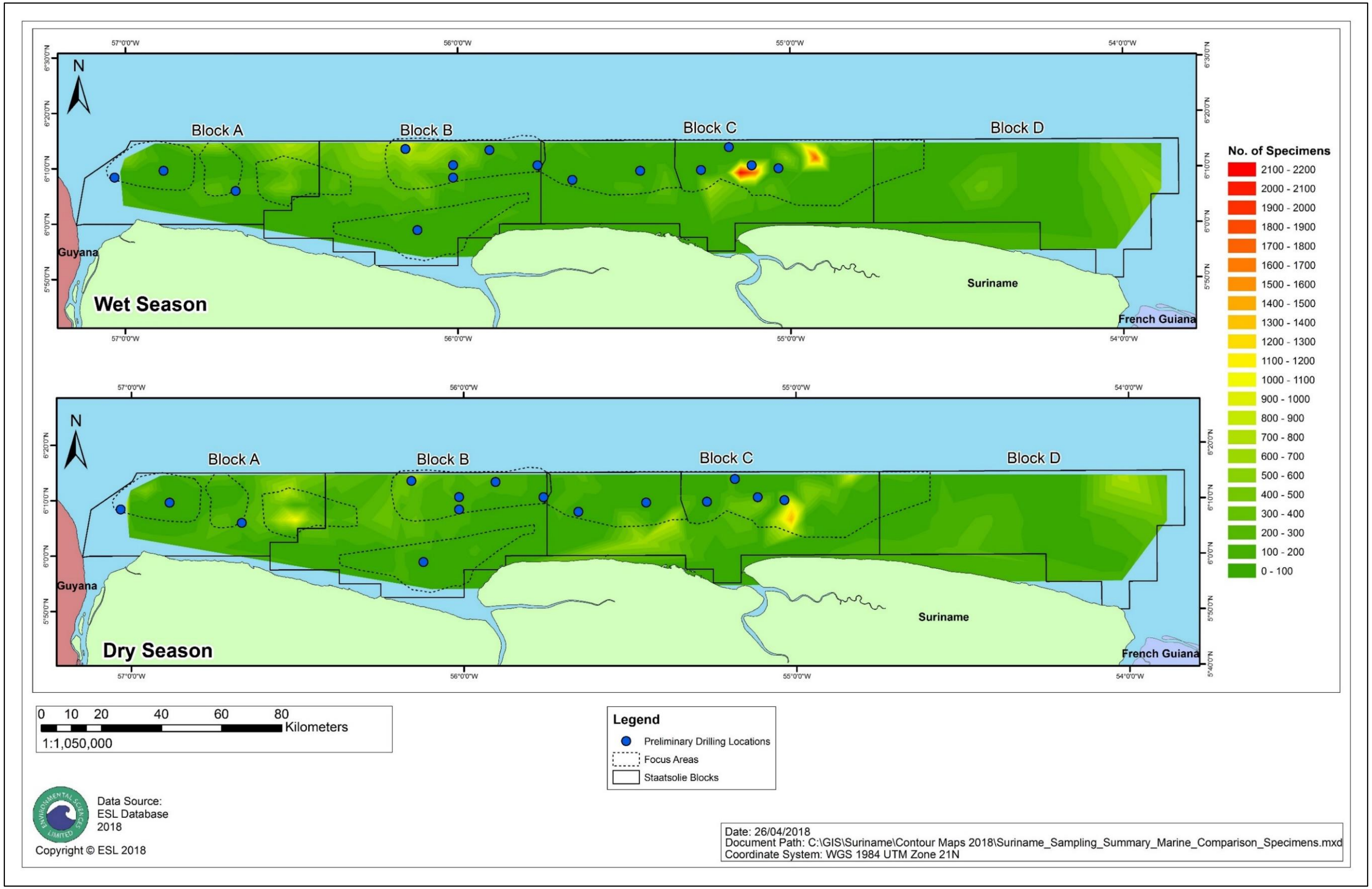
A summary of the baseline assessment is presented in Table 5-24 below; 245 stations were monitored within the Staatsolie Blocks. Wet season samples were collected during the period June – August 2017, while dry season samples were collected during the period September – November 2017. The high standard deviation values derived in Table 5-24 below indicate that the number of specimens and taxa recorded per grab and per station were highly variable, with values being spread over a large range.

Table 5-24: Summary of ESL's Baseline Assessment for the Wet Season (June - August 2017) & Dry Season (September - November 2017)

Parameter	Results- Wet Season	Results- Dry Season
Total # of stations	245	245
Total # of grabs	735	735
Total # of specimens	35,549	37,163
Total # of taxa	164	160
Average # of specimens per grab	48.36 ± 111.19	50.55 ± 84.25
Range of # of specimens per grab	0 – 1,495	0 – 665
Average # of taxa per grab	8.06 ± 8.27	8.59 ± 7.93
Range of # of taxa per grab	0 – 39	0 – 46
Average # of specimens per station	145.09 ± 267.27	151.67 ± 218.42
Range of # of specimens per station	0 – 2,154	0 – 1,427
Average # of taxa per station	15.24 ± 13.39	16.15 ± 12.53
Range of # of taxa per station	0 – 62	0 – 62
Station with highest # of specimens	Station 137 (2,154 specimens)	Station 148 (1,427 specimens)
Station with lowest # of specimens	Stations 48, 59, 60, 61, 62, 63, 173, 181, 183, 210, 229 (0 specimen)	Stations 48, 59, 167, 182 (0 specimen)
Station with highest # of taxa	Station 44 (62 taxa)	Station 221 (62 taxa)
Station with lowest # of taxa	Stations 48, 59, 60, 61, 62, 63, 173, 181, 183, 210, 229 (0 taxa)	Stations 48, 59, 167, 182 (0 taxa)
Most abundant organism	Ampeliscidae (Arthropoda; 7,357 specimens)	Ampeliscidae (Arthropoda; 7,968 specimens)
Second most abundant organism	Onuphidae (Annelida; 5,919 specimen)	Onuphidae (Annelida; 4,944 specimens)

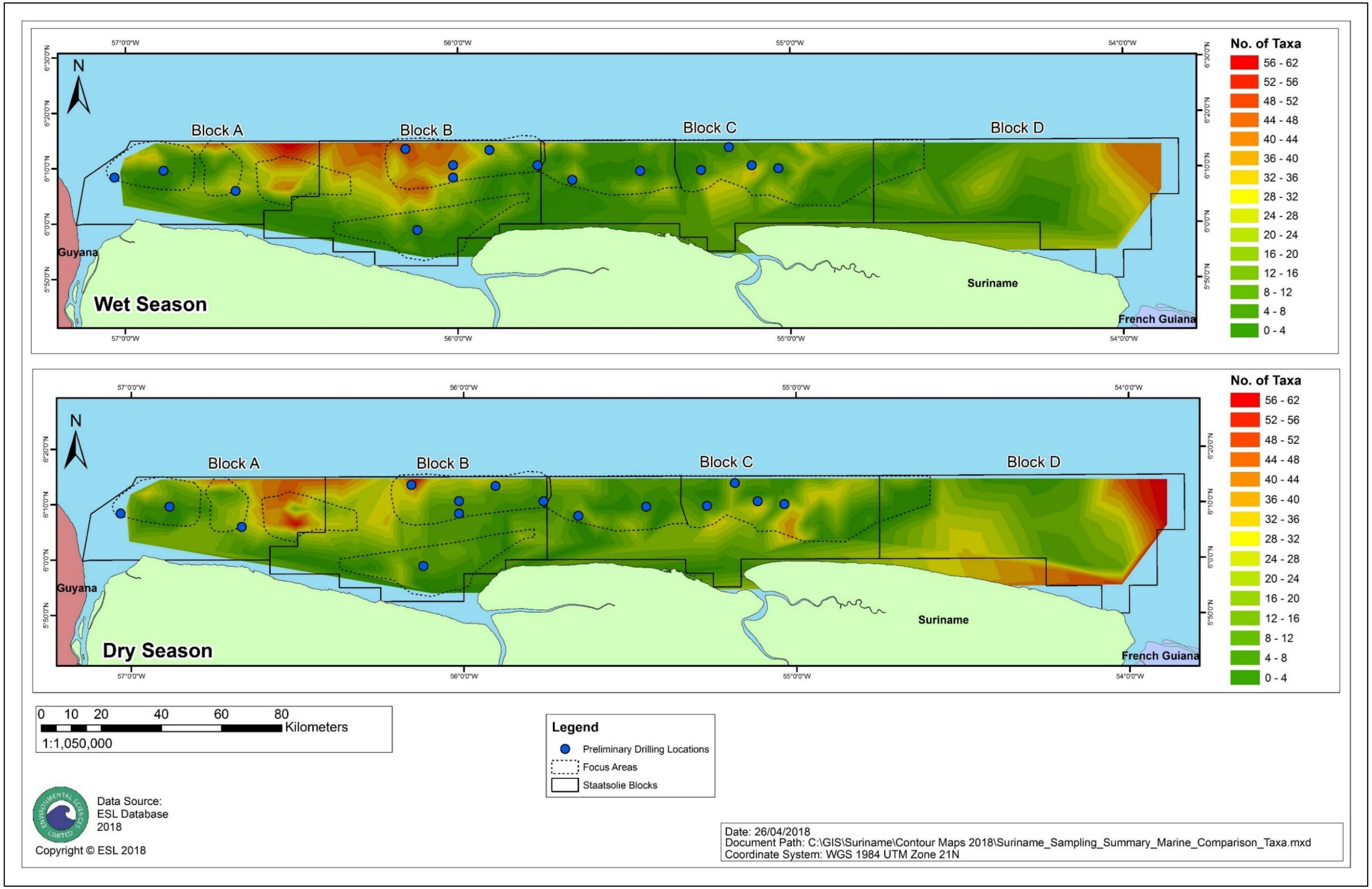
Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

The number of specimens and taxa recorded throughout the entire Staatsolie Block per season were examined and compared. The wet season sampling event recorded a higher number of taxa; however, the dry season event recorded a higher number of specimens. It should be noted, that the average number of specimens and taxa per grab were similar during both sampling events. The contour map below (Figure 5-76) displays the distribution of specimens across the entire study area for the wet and dry seasons. In the wet season, specimens were essentially evenly distributed across the study area. Blocks B and C recorded areas of higher concentrations. However, Block C had the highest concentration of specimens, this cluster was located close to the centre of the block. Similarly, the concentration of specimens for the dry season was evenly distributed; areas of higher concentrations can be seen within Blocks A and C, with Block C recording the highest concentration. Taxa distributions for both seasons were similar, with the areas of higher concentrations being consistent between the wet and dry seasons. In both seasons, Blocks A, B and D recorded the highest concentrations of different taxa, however the size of these highly concentrated areas fluctuated between seasons (Figure 5-77).



Source: ESL Database 2018 and 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-76: Number of Specimens Recorded for the Wet Season (June - August 2017) & Dry Season (September - November 2017)



Source: ESL Database 2018 and 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-77: Number of Taxa Recorded for the Wet Season (June - August 2017) & Dry Season (September - November 2017)

Phyla distributions based on the number of specimens and taxa recorded for both seasons are presented in Table 5-25 below. Sixteen different phyla were documented in the wet season. Arthropods were the most abundant organisms recorded in the wet season, accounting for 44.823% of all benthic specimens, followed by annelids (39.85%). Taxonomically, the % distribution of arthropods was also dominant, accounting for 32.31% of the taxa recorded. A total of 14 phyla were identified in the dry season, showing a negligible decrease from the wet season. Arthropods were also the most abundant organisms recorded in the dry season and accounted for 45.20% of all benthic specimens, again followed by annelids (37.50%). Taxonomically, the % distribution of arthropods was also dominant, accounting for over 35% of the taxa recorded; see Table 5-25). Together these two phyla (arthropods and annelids) accounted for over 80% of the specimens collected and 60% of the taxa recorded in both seasons. The percentage distribution of the number of specimens and taxa recorded for both seasons were comparable, as values fluctuated only slightly.

Table 5-25: Phyla Distributions based on Number of Specimens & Number of Taxa Recorded in the Wet Season & Dry Season

Phylum	Wet Season	Dry Season	Wet Season	Dry Season
	% Specimens		% Taxa	
Annelida	39.85	37.5	26.21	26.25
Arthropoda	44.823	45.2	32.31	37.5
Brachiopoda	0.07	0.161	0.61	0.625
Bryozoa	0.1	0.32	1.82	1.875
Chaetognatha	0.02	0.037	0.61	0.625
Chordata	0.66	0.57	2.43	1.875
Cnidaria	0.13	0.115	4.94	5
Echinodermata	1.13	0.333	3.04	3.125
Entoprocta	0.005	0.013	1.21	1.25
Hemichordata	0.008	-	0.61	-
Mollusca	5	8.6	21.34	18.125
Nemertea	1.02	0.514	0.61	0.625
Phoronida	0.01	0.032	0.61	0.625
Platyhelminthes	0.002	0.005	0.61	0.625
Porifera	0.002	-	0.61	-
Sipuncula	7.17	6.6	2.43	1.875

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

The most abundant taxon observed in the wet season was Ampeliscidae (arthropod family), accounting for 20.69% of all specimens documented (Figure 5-78a). Onuphidae (Figure 5-78b), which belongs to an annelid family, was recorded as the second most abundant taxon, accounting for 16.65% of all specimens documented. Similarly, Ampeliscidae and Onuphidae were the first and second most abundant taxa observed in the dry season, accounting for

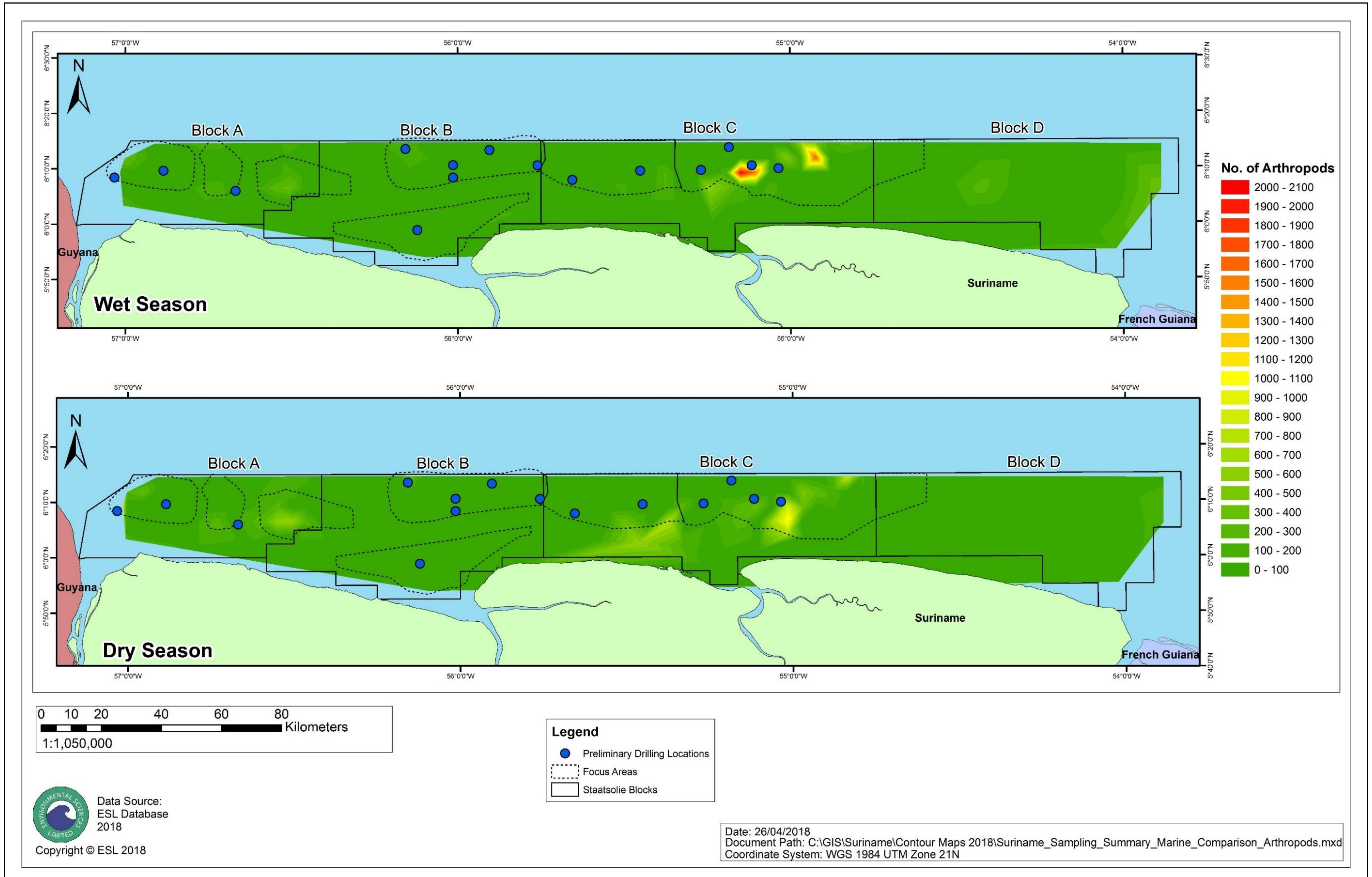
21.44% and 13.30% of all specimens documented, respectively. Both organisms are typically found in environments that are characterised by fine sediment and mud like conditions.

Source: ESL 2017 Macrobenthic Dataset Reference Library

Figure 5-78a: Ampeliscidae Specimen **Figure 5-78b: Onuphidae Specimen**

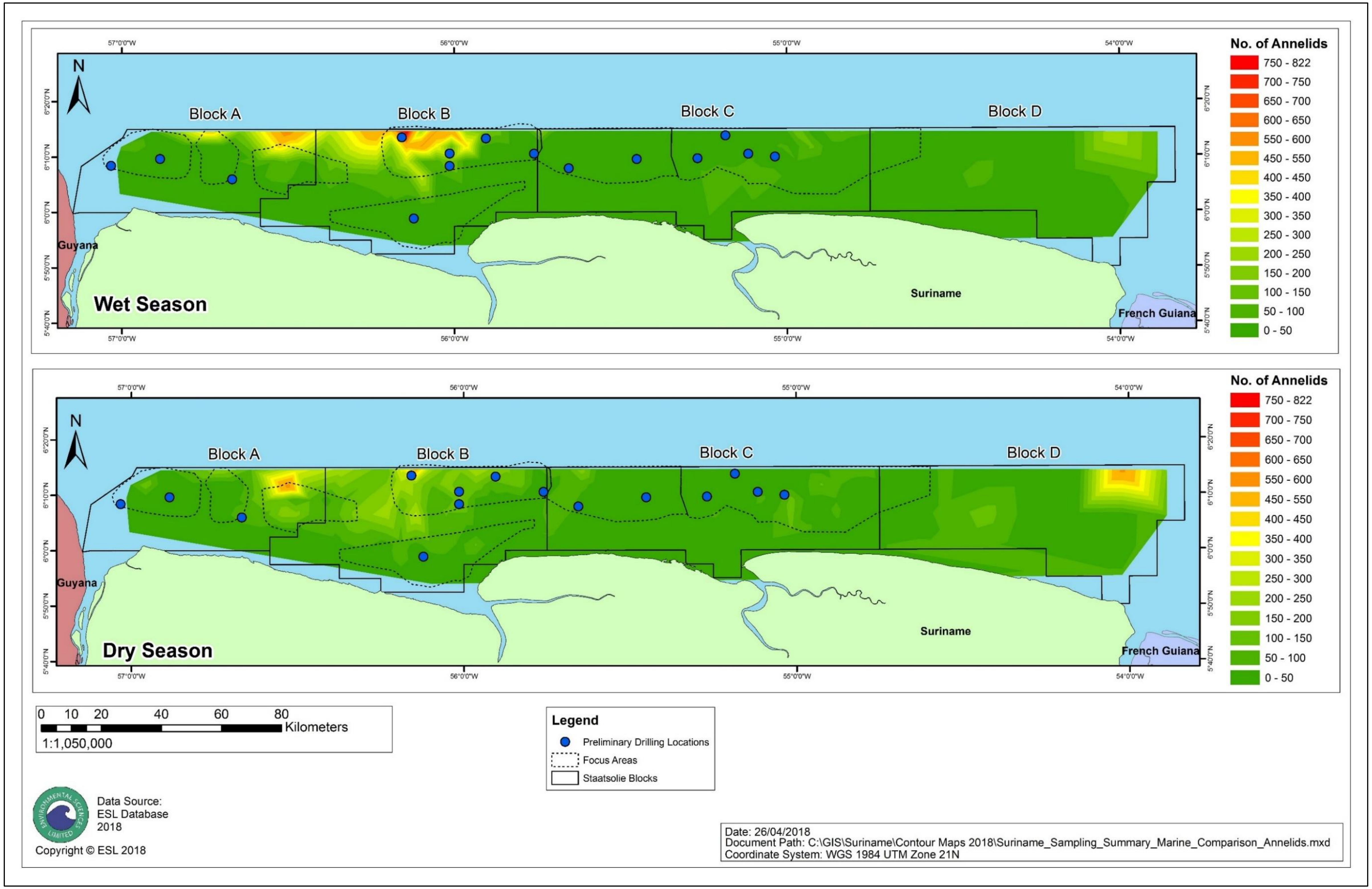
Figure 5-78: Most Abundant Taxa Recorded during the Baseline Assessment in the Wet Season & Dry Season

Arthropods, Annelids and Molluscs were the 3 largest groups identified. Arthropods and annelids were co-dominant, while molluscs made up the third largest group numerically, with respect to species composition for both the wet and dry seasons. The distribution of each phyla is displayed on the contour maps below. Arthropods were essentially evenly distributed across the entire study area in the wet season, with Block C recording 2 small highly concentrated areas (Figure 5-79). Data collected for the dry season revealed that Blocks A and C had areas where the concentration of the arthropod population was higher, when compared to the rest of the study area. These areas of higher concentrations coincided with the areas of higher concentrations presented in the number of specimens' contour map (Figure 5-76). This would suggest that the number of arthropods dictated the distribution of specimens. Distribution of the annelid populations for both the wet and dry seasons were even throughout the study area; with the exception of 3 small highly concentrated areas located on the outer parameters of Blocks A, B and D (Figure 5-80). This distribution mirrored the distribution of the number of taxa (Figure 5-77), which suggests that the distribution of annelids influenced the number of different taxa observed within the study area. In the wet season, the population of mollusc was evenly distributed across the entire study area. Likewise, in the dry season distribution was even, however 3 areas of higher concentrations were detected. Data showed the point of highest concentration as being located along the boundary of Blocks A and B; 2 smaller areas of higher concentrations of mollusc were also observed within Block C (Figure 5-81).



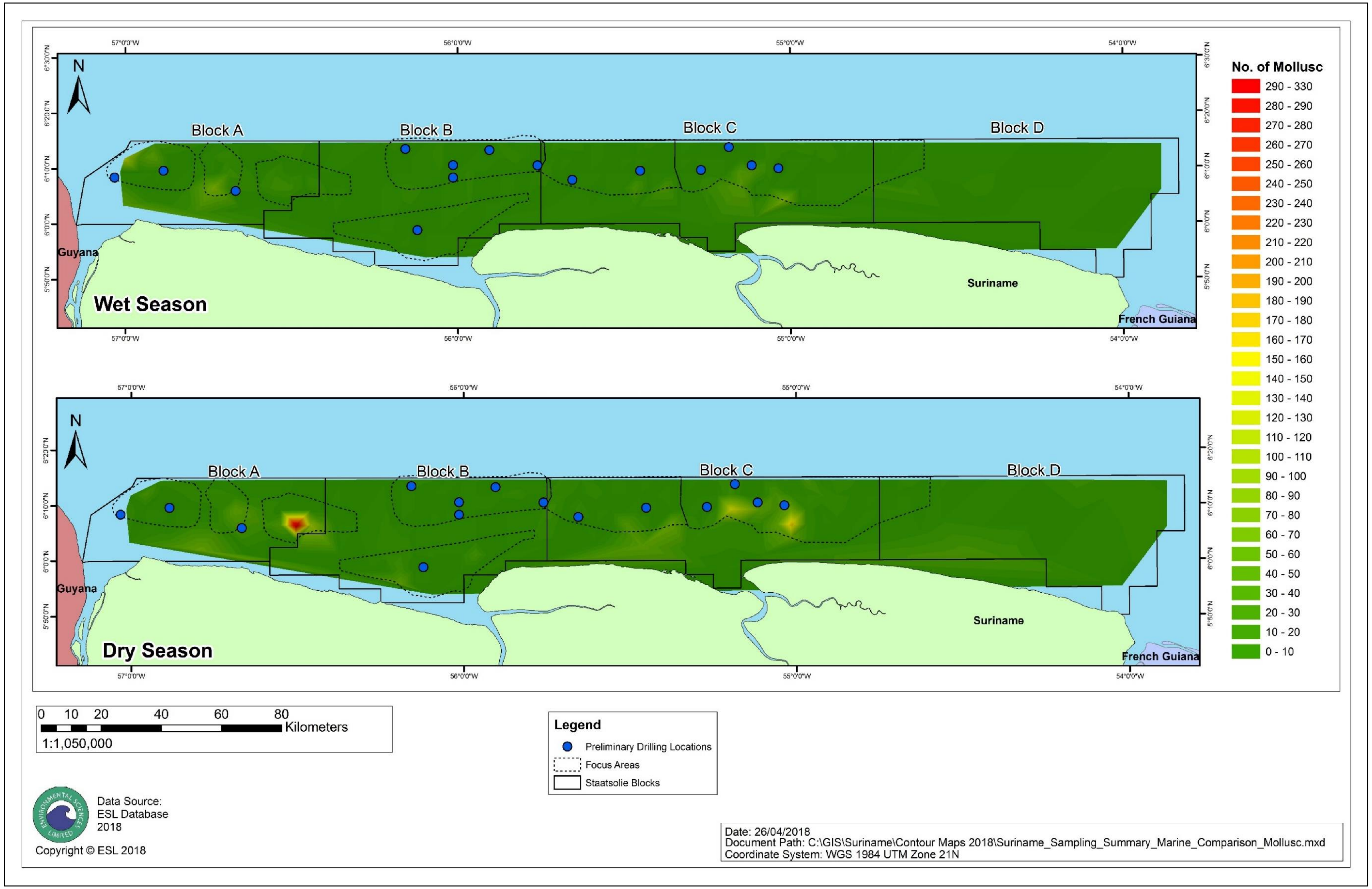
Source: ESL Database 2018 and 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-79: Number of Arthropods Recorded for the Wet Season (June - August 2017) & the Dry Season (September - November 2017)



Source: ESL Database 2018 and 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-80: Number of Annelids Recorded for the Wet Season (June - August 2017) & the Dry Season (September - November 2017)



Source: ESL Database 2018 and 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-81: Number of Mollusc Recorded for the Wet Season (June - August 2017) & the Dry Season (September - November 2017)

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5.4.1.3.1 Block A

A summary of the baseline assessment for the focus area within Block A is presented in Table 5-26 below. The high standard deviation values derived in Table 5-26 below indicate that the number of specimens and taxa recorded per grab and per station were variable, with values being spread over a large range.

The number of specimens collected in the wet season sampling event was 4,998, however this number was almost doubled, as 8,099 specimens were collected in the dry season. The number of taxa identified per season varied only slightly; 110 taxa were identified in the wet season and 106 taxa in the dry season.

Table 5-26: Summary of ESL's Baseline Assessment for Block A (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September-November 2017)
Total # of stations	36	36
Total # of grabs	108	108
Total # of specimens	4,998	8,099
Total # of taxa	110	106
Average # of specimens per grab	45.02 ± 71.53	72.96 ± 117.31
Range of # of specimens per grab	0 – 361	0 – 640
Average # of taxa per grab	9.23 ± 8.15	11.58 ± 9.40
Range of # of taxa per grab	0 – 34	0 – 37
Average # of specimens per station	135.08 ± 175.87	218.89 ± 285.81
Range of # of specimens per station	1 – 652	2 – 1,100
Average # of taxa per station	18.21 ± 13.56	21.08 ± 14.18
Range of # of taxa per station	1 – 47	2 – 58
Station with highest # of specimens	Station 20 (652 specimens)	Station 35 (1,100 specimens)
Station with lowest # of specimens	Station 7 (1 specimen)	Station 12 (2 specimens)
Station with highest # of taxa	Station 20 (47 taxa)	Station 35 (58 taxa)

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September-November 2017)
Station with lowest # of taxa	Stations 7 & 27 (1 taxa)	Station 12 (2 taxa)
Most abundant organism	Ampeliscidae (Arthropoda; 800 specimens)	Ampeliscidae (Arthropoda; 1,904 specimens)
Second most abundant organism	Microprotopidae (Arthropoda; 699 specimens)	Microprotopidae (Arthropoda; 1,391 specimens)

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Phyla distributions based on the number of specimens and taxa recorded are presented in Table 5-27 below. A total of 11 phyla were identified in the wet season. Arthropods were the most abundant organisms recorded, accounting for 46.63% of all benthic specimens, followed by annelids (36.95%). Taxonomically, the % distribution of arthropods and annelids were the same, with each individual taxon accounting for 34.54% of all specimens documented; see Table 5-27). Dry season data recorded 10 different phyla, with arthropods (54.2%) being the most abundant organism documented, followed by annelids (31.65%). Taxonomically, arthropods dominated the percentage distribution accounting for 34.9% of all specimens collected.

Table 5-27: Phyla Distributions based on Number of Specimens & Number of Taxa Recorded for Block A (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Phylum	Wet Season	Dry Season	Wet Season	Dry Season
	% Specimens		% Taxa	
Annelida	36.95	31.65	34.54	29.28
Arthropoda	46.63	54.2	34.54	34.9
Brachiopoda	0.2	0.19	0.9	0.94
Chaetognatha	0.02	0.02	0.9	0.94
Chordata	0.04	-	1.81	-
Cnidaria	0.3	0.12	3.63	4.71
Echinodermata	0.96	0.5	2.77	4.71
Entoprocta	0.02	-	0.9	-
Mollusca	10.94	10.84	17.3	19.81
Nemertea	0.9	0.4	0.9	0.94
Phoronida	-	0.02	-	0.94
Sipuncula	3.04	2.06	1.81	2.83

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Ampeliscidae and Microprotopidae, both members of the arthropod family, were the first and second most abundant taxa recorded in the wet season, accounting for 16% and 13.98% of all specimens documented, respectively (Figure 5-82). Similarly, the first and second most abundant taxa recorded in the dry season were Ampeliscidae and Microprotopidae (Figure 5-82), accounting for 23.50% and 17.17% of all specimens documented, respectively.

Source: ESL 2017 Macrobenthic Dataset Reference Library

Figure 5-82a: Ampeliscidae Specimen **Figure 5-82b: Microprotopidae Specimen**

Figure 5-82: Most Abundant Taxa Recorded during the Baseline Assessment of Block A (Wet Season; August 2017 and Dry Season; October 2017)

Baseline benthic data collected for the wet and dry seasons were subjected to multivariate analysis using PRIMER (Clarke and Gorley 2006). The PRIMER (Plymouth Routines in Multivariate Ecological Research) software is a statistical tool designed to analyse community ecology and environmental science data which are multivariate in character. Multivariate datasets include information on many species and multiple environmental variables.

A number of tools were utilised within PRIMER to assist in the analysis of the biotic data. These include diversity indices and cluster analysis (dendrograms and MDS plots). Two of the most common diversity indices, the Shannon Weiner Index (SWI) and the Pielou Index, were calculated (using log base e), the results of which are displayed in Table 5-28 below. SWI is a measure of diversity within an ecological community; with typical values ranging between 1.5 and 3.5. The values for both seasons derived in the table below suggested that at specific sample stations, the present community was dominated by a few species, as the values were on the lower end of the expected range of values. The Pielou Index is a measure of the evenness in the distribution of species throughout a community. Values range between 0 and 1; the presence of dominant species within a community lowers the Pielou value; therefore, values closer to 1 would indicate evenness in the numerical distribution of species. The relatively high values at most sample stations for both seasons derived in the table below would suggest that the species in Block A were close to being evenly distributed at the sample stations.

Table 5-28: Shannon Wiener and Pielou Indices for Block A (Wet Season; June - August 2017 & Dry Season; September - November 2017)

	Station	1	2	3	4	5	6	7	8	9	10	11	12
SWI	Wet Season	2.35	2.91	0.50	1.04	2.17	1.38	0.00	1.95	1.85	1.65	1.04	0.98
Pielou	Wet Season	0.80	0.82	0.72	0.95	0.65	0.86	0.00	0.94	0.95	0.79	0.95	0.71
SWI	Dry Season	2.52	2.28	1.63	1.27	2.23	1.28	1.04	2.22	1.58	2.11	0.86	0.69
Pielou	Dry Season	0.87	0.74	0.91	0.92	0.64	0.79	0.95	0.82	0.46	0.88	0.78	1.00

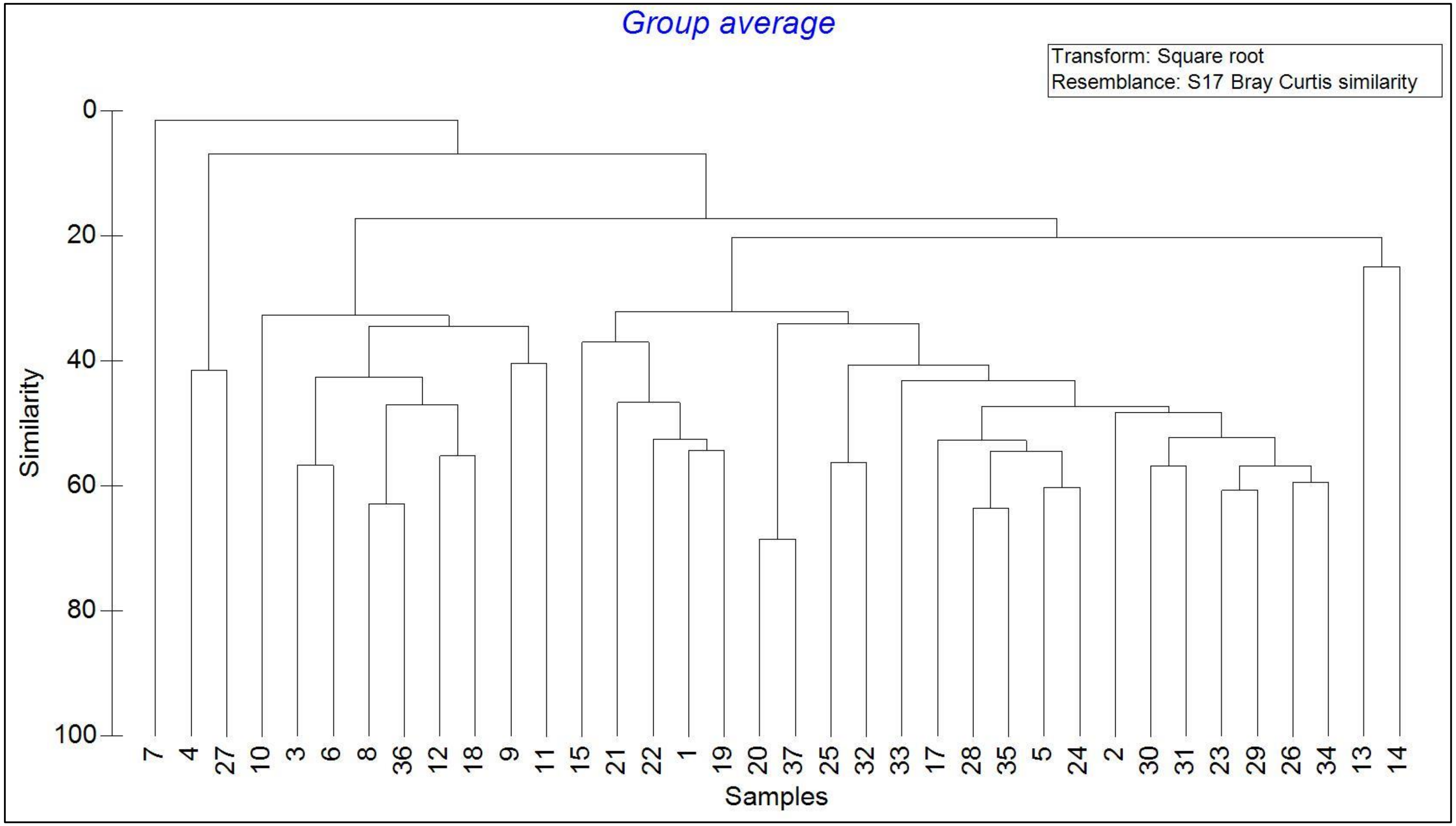
	Station	13	14	15	17	18	19	20	21	22	23	24	25
SWI	Wet Season	1.96	1.73	1.77	2.03	1.84	2.71	2.77	1.75	2.67	2.78	2.33	2.76
Pielou	Wet Season	0.94	0.89	0.58	0.65	0.95	0.94	0.72	0.79	0.85	0.83	0.65	0.86
SWI	Dry Season	1.88	1.05	2.65	1.79	2.50	1.69	2.83	2.26	2.14	2.59	1.60	2.97
Pielou	Dry Season	0.71	0.54	0.92	0.61	0.87	0.87	0.74	0.91	0.69	0.83	0.55	0.81

	Station	26	27	28	29	30	31	32	33	34	35	36	37
SWI	Wet Season	2.26	0.00	2.62	2.83	2.36	2.87	2.35	2.02	2.14	2.48	1.64	2.49
Pielou	Wet Season	0.72	0.00	0.72	0.83	0.70	0.84	0.76	0.70	0.76	0.67	0.92	0.65
SWI	Dry Season	2.06	1.49	2.13	2.39	2.30	2.78	2.42	2.47	2.61	2.32	1.94	2.02
Pielou	Dry Season	0.58	0.60	0.57	0.65	0.81	0.84	0.85	0.73	0.72	0.57	0.84	0.52

Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

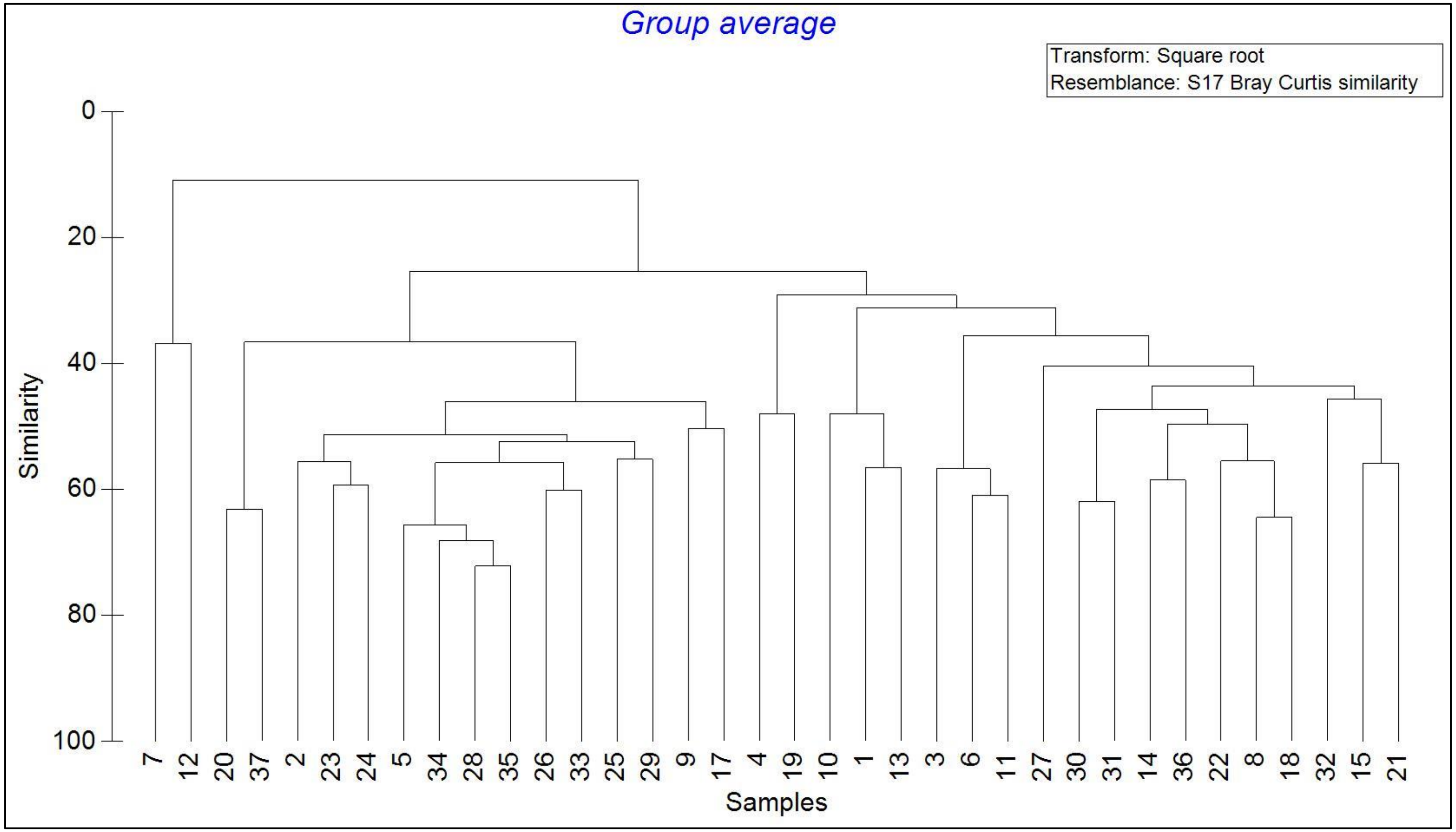
A cluster analysis was performed using the Bray-Curtis similarity coefficient to identify stations considered to be most similar based on species composition. The resulting dendrograms present the data collected for the wet season (Figure 5-83) and the dry season (Figure 5-84). In the wet season, the most similar stations were Station 20 and Station 37, which demonstrated the highest percentage similarity (68.46%). However, 3 groups of stations can be seen clustered together. Each group is comprised of stations that are most similar to each other. In the dry season the most similar stations were Station 28 and Station 35, which demonstrated the highest percentage similarity (72.24%).

However, 4 groups of stations can be seen clustered together. Each group is comprised of stations that are similar to each other.



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

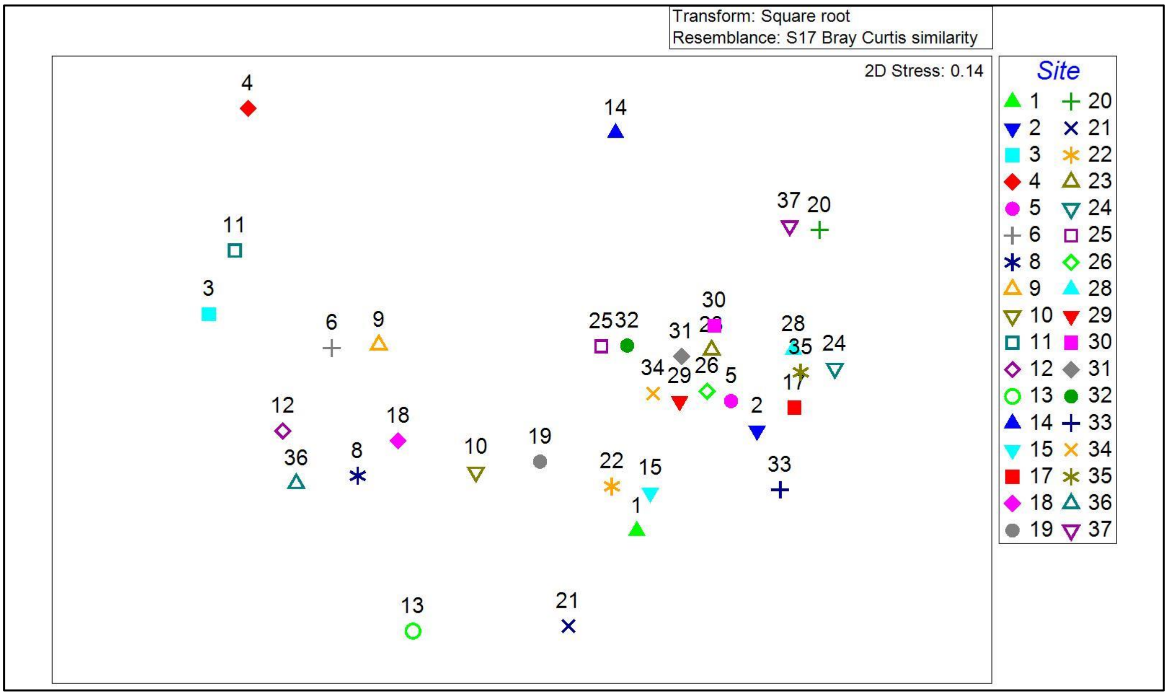
Figure 5-83: Dendrogram Plot of the Wet Season for Block A (Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

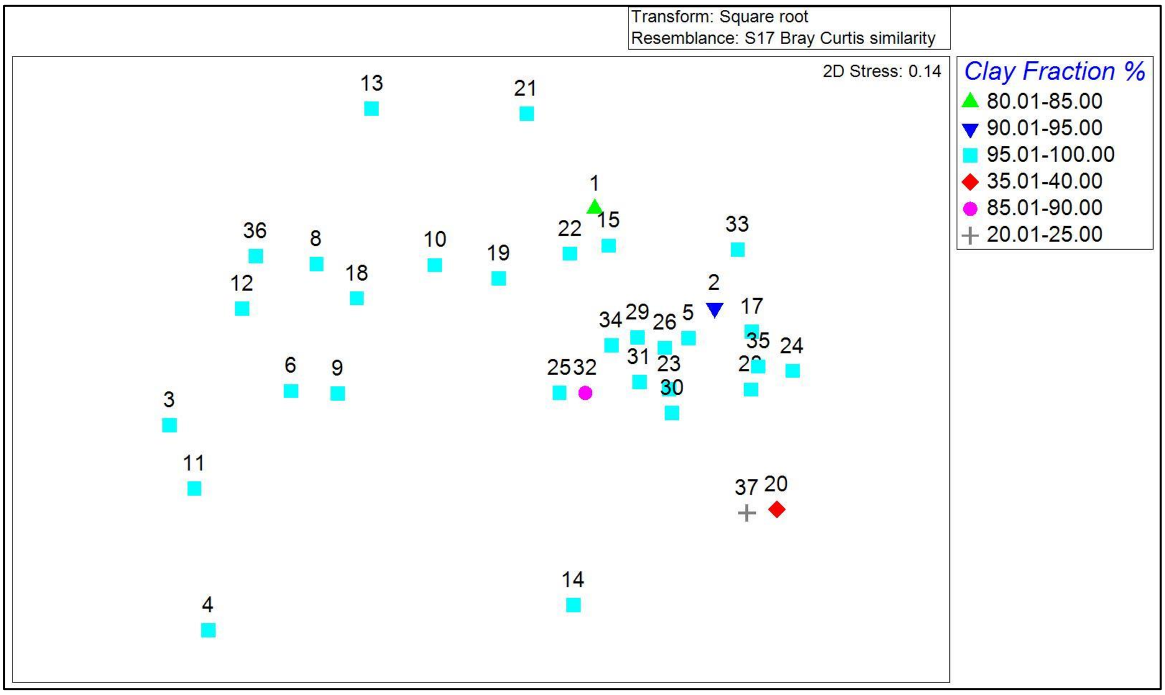
Figure 5-84: Dendrogram Plot of the Dry Season for Block A (Replicates Combined)

Species composition, the predominant grain size fraction (clay) and water depth (ft) were used to create MDS plots to determine if significant clustering occurred among stations based on these factors. Wet season data was analysed and the resultant MDS plots showed that there was significant clustering among 3 groups of stations; with Stations 20 (652 specimens; 47 taxa) and 37 (518 specimens; 45 taxa) being positioned closest together as they were the most similar. These 2 stations had comparable numbers of taxa and specimens. Stations 4 and 14 were the most dissimilar as they were located furthest away from the 3 cluster of stations. The predominant grain size fraction and the water depth appear to have no influence on the clustering of stations. (Figure 5-85, Figure 5-86 and Figure 5-87 below).



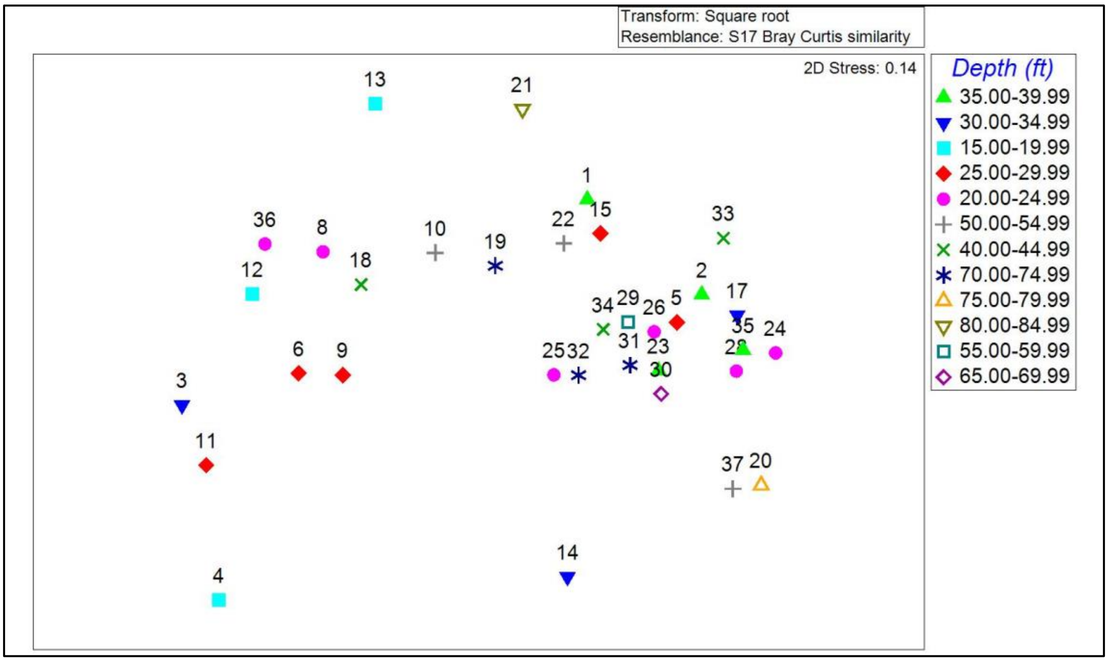
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-85: MDS Plot of Species Composition for Block A (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

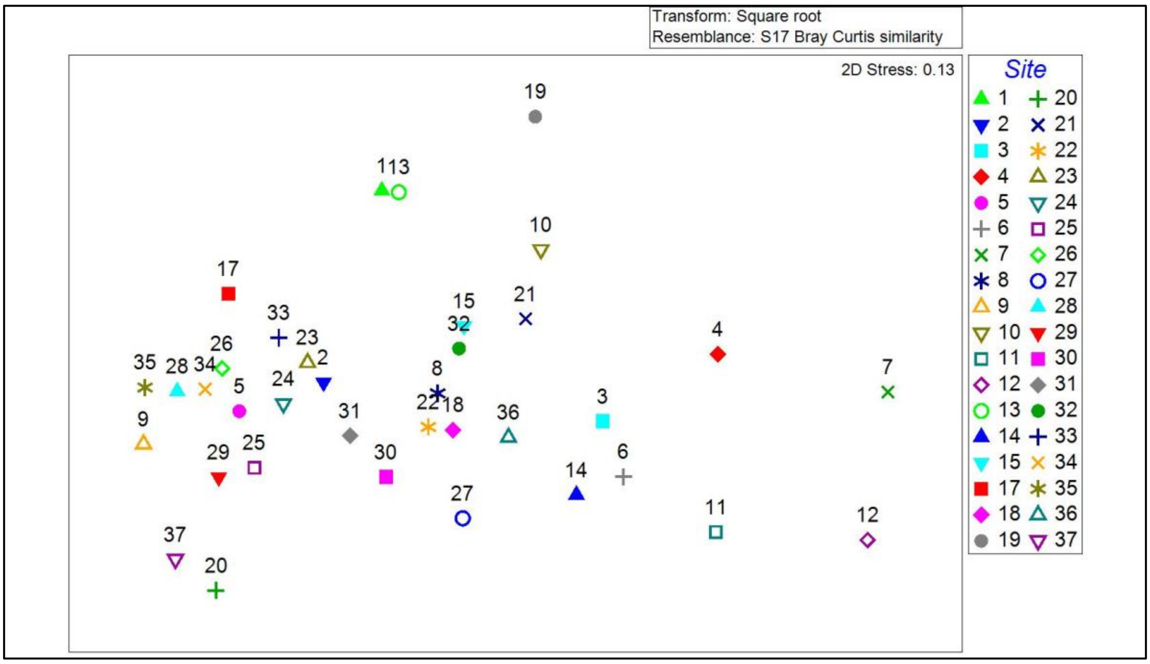
Figure 5-86: MDS Plot of Predominant Grain Size Fraction for Block A (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

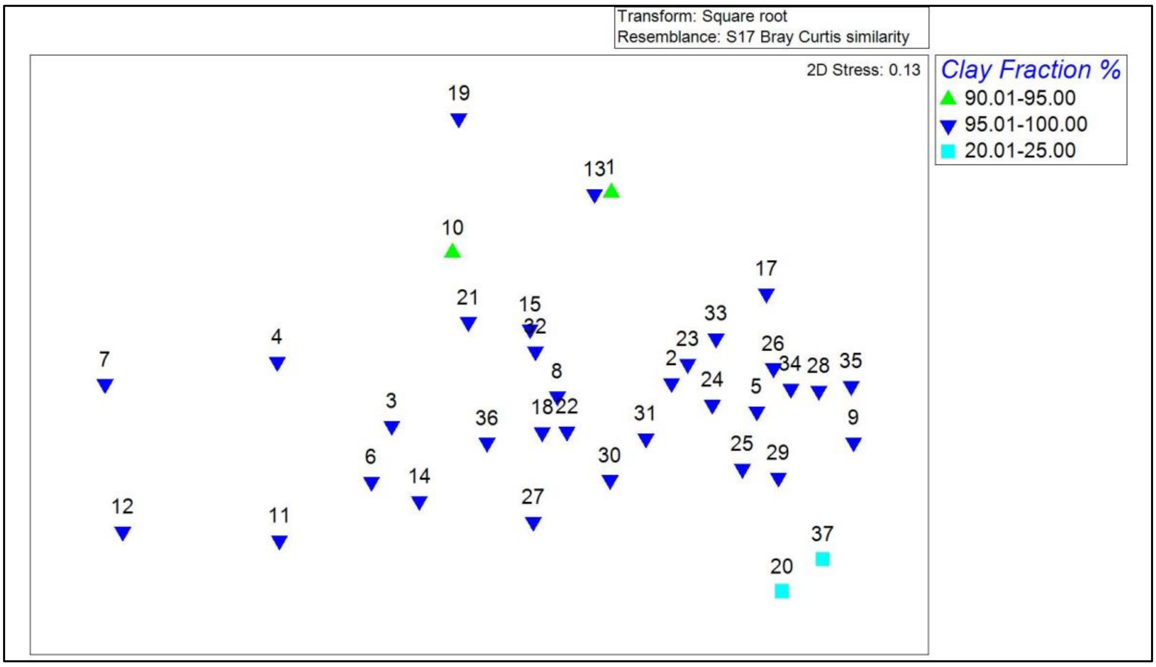
Figure 5-87: MDS Plot of Water Depth for Block A (Wet Season; Replicates Combined)

Dry season data was analysed and the resultant MDS plots showed that there was significant clustering among 4 groups of stations; with Stations 28 (783 specimens; 41 taxa) and 35 (1,100 specimens; 58 taxa) being positioned closest together as they were the most similar. These 2 stations had comparable numbers of taxa and specimens. Stations 7 and 12 were the most dissimilar as they were located furthest away from the 4 cluster of stations; these 2 stations had the lowest number of taxa and similar grain size fractions. It should be noted, that Stations 20 and 37 were positioned together and away from the main groups of stations, these 2 stations shared the same grain size fraction, and this similarity may have contributed to pattern observed (Figure 5-88, Figure 5-89 and Figure 5-90 below).



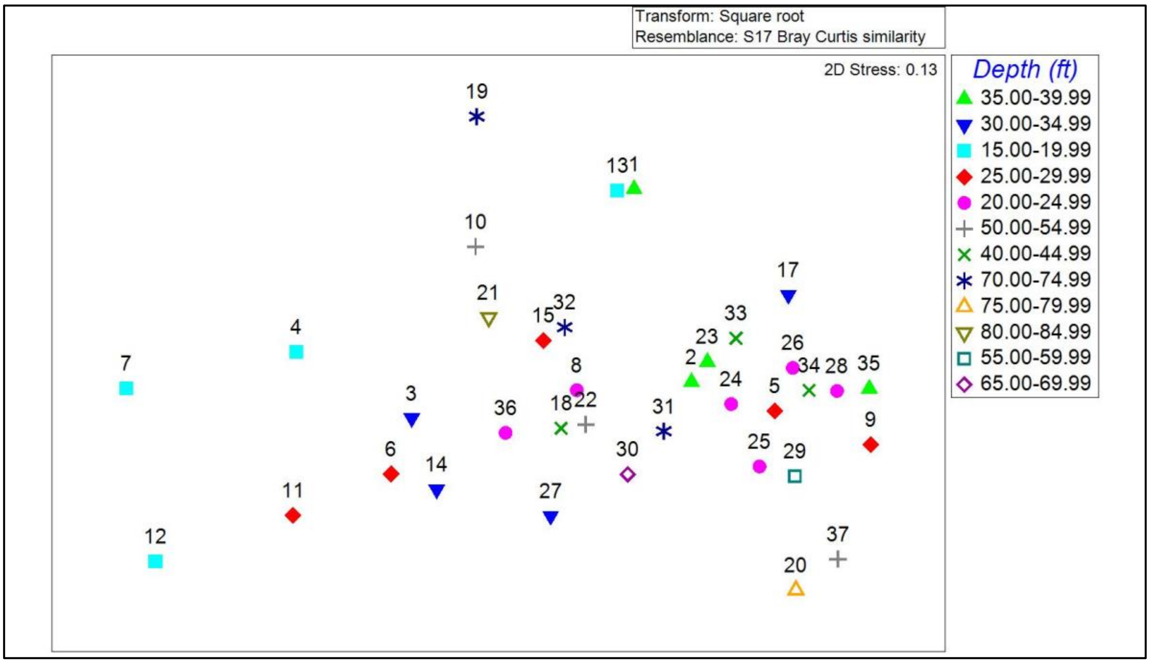
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-88: MDS Plot of Species Composition for Block A (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-89: MDS Plot of Predominant Grain Size Fraction for Block A (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-90: MDS Plot of Water Depth for Block A (Dry Season; Replicates Combined)

The Draftsman Plot is a method used for examining correlations between variables in multivariate data. The results show any positive or negative correlations between abiotic data taken from water and sediment for both the wet and dry seasons at benthic sampling points. The highest correlation was found between zinc and chromium in sediment, with a correlation value of 0.98. This suggests an almost perfect positive linear relationship between the 2 parameters, i.e. as zinc increased in sediment, an increase in chromium was also observed.

The BEST (Bio-Env) Analysis sought to find the best match between multivariate sample patterns of an assemblage and that from the environmental variables associated with those samples. When biotic and abiotic data (water and sediment quality) were combined to determine the most significant variables, the abiotic factor which formed the highest correlation with the biotic data was found to be total phosphorus in water. This correlation value indicates a moderately weak linear relationship (0.227), but it must be kept in mind that correlations do not prove a causal link

5.4.1.3.2 Block B

A summary of the baseline assessment for the focus area within Block B is presented in Table 5-29 below. The high standard deviation values derived in Table 5-29 below indicate that the number of specimens and taxa recorded per grab and per station were highly variable, with values being spread over a large range.

The number of specimens collected in the wet season sampling event was 11,245. The dry season however, recorded a decline as 8,315 specimens were collected. The number of taxa identified per season also varied; 121 taxa were identified in the wet season with 103 recorded in the dry season. The number of specimens in the wet season was almost doubled that of the dry season, however relative abundance remained similar.

Table 5-29: Summary of ESL's Baseline Assessment for Block B (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September- November 2017)
Total # of stations	66	66
Total # of grabs	198	198
Total # of specimens	11,245	8,315
Total # of taxa	121	103
Average # of specimens per grab	56.79 ± 82.54	41.99 ± 46.76
Range of # of specimens per grab	0 – 404	0 – 323
Average # of taxa per grab	10.81 ± 9.94	8.07 ± 6.84
Range of # of taxa per grab	0 – 37	0 – 43
Average # of specimens per station	170.37 ± 230.52	125.98 ± 128.68
Range of # of specimens per station	0 – 1,003	0 - 790
Average # of taxa per station	19.62 ± 15.63	15.15 ± 11.43
Range of # of taxa per station	0 – 48	0 – 59
Station with highest # of specimens	Station 82 (1,003 specimens)	Station 82 (790 specimens)
Station with lowest # of specimens	Stations 48,59,60,61,62,63 (0 specimens)	Stations 48, 59 (0 specimen)
Station with highest # of taxa	Station 81 (48 taxa)	Station 82 (59 taxa)
Station with lowest # of taxa	Stations 48,59,60,61,62,63 (0 taxa)	Stations 48, 59 (0 taxa)
Most abundant organism	Onuphidae (Annelida; 3,380 specimens)	Spionidae (Annelida; 2,733 specimens)
Second most abundant organism	Aspidosiphonidae (Sipuncula; 1,282 specimens)	Onuphidae (Annelida; 1,502 specimens)

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Phyla distributions based on the number of specimens and taxa recorded are presented in Table 5-30 below. A total of 12 phyla were identified in the wet season. Annelids were the most abundant organisms recorded in wet season and accounted for 64.28% of all benthic specimens, followed by arthropods (17.27%). Taxonomically, the % distribution of annelids and arthropods were the same, with each individual taxon accounting for 33% of all specimens documented; see Table 5-30). Similarly, dry season data recorded 12 different phyla, with annelids (69.99%) being the most abundant organism documented, followed by sipunculids (13.29%). Taxonomically, annelids dominated the percentage distribution accounting for 34.95% of all specimens collected. In both seasons annelids and arthropods accounted for 80% of the specimens collected (annelids being dominant) and 66% of the taxa (annelids and arthropods being co-dominant). Numerically, sipunculid values were almost equal to that of arthropods, with respect to the number of specimens collected.

Table 5-30: Phyla Distributions based on Number of Specimens & Number of Taxa Recorded for Block B (Wet Season; June - August 2017 & Dry Season; September - November 2017

Phylum	Wet Season	Dry Season	Wet Season	Dry Season
	% Specimens		% Taxa	
Annelida	64.28	69.99	33.88	34.95
Arthropoda	17.27	10.01	33.06	32.04
Brachiopoda	0.07	0.28	0.83	0.97
Bryozoa	-	0.04	-	1.94
Chaetognatha	0.05	0.05	0.83	0.97
Chordata	0.06	0.01	0.83	0.97
Cnidaria	0.15	0.12	3.31	2.91
Echinodermata	2.49	0.17	4.1	3.89
Mollusca	2.57	4.91	17.36	18.45
Nemertea	1.57	1.09	0.83	0.97
Phoronida	0.01	0.05	0.83	0.97
Platyhelminthes	0.01	-	0.83	-
Sipuncula	11.47	13.29	3.31	0.97

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Onuphidae (annelid family) and Aspidosiphonidae (sipunculid family), were the first and second most abundant taxa recorded in the wet season, accounting for 30% and 11.40% of all specimens documented, respectively (Figure 5-91). Conversely, the first and second most abundant taxa recorded in the dry season were Spionidae and Onuphidae both members of the annelid family (Figure 5-91), accounting for 32.86% and 18.06% of all specimens documented, respectively.

Figure 5-91a: Onuphidae Specimen

Figure 5-91b: Aspidosiphonidae Specimen

Figure 5-91c: Spionidae Specimen

Source: ESL 2017 Macrobenthic Dataset Reference Library

Figure 5-91: Most Abundant Taxa Recorded during the Baseline Assessment of Block B (Wet Season; June - August 2017 & Dry Season; September - November 2017)

The data was subjected to multivariate analysis using PRIMER; the Shannon Weiner and Pielou Indices, were calculated (using log base e), the results of which are displayed in Table 5-31 below. The SWI values derived in the table below would suggest that the distribution of species varied between sample stations and seasons; as some stations recorded lower values (less diverse), while other stations recorded values that fell within the upper end of the expected diversity range (higher diversity). The Pielou values observed for both seasons ranged from 0.00 at stations that recorded no organisms to 1, at stations that exhibited perfect evenness in the distribution of species.

Table 5-31: Shannon Wiener and Pielou Indices for Block B (Wet Season; June - August 2017 & Dry Season; September - November 2017)

	Station	45	46	47	48	49	50	51	52	53	54	55	56
SWI	Wet Season	2.80	2.57	2.72	0.00	1.06	0.69	1.04	2.25	2.17	2.41	1.25	1.89
Pielou	Wet Season	0.78	0.77	0.84	0.00	0.77	1.00	0.95	0.70	0.91	0.91	0.78	0.76
SWI	Dry Season	2.11	2.40	1.97	0.00	1.33	0.00	1.77	1.96	2.36	2.41	2.40	1.01
Pielou	Dry Season	0.68	0.71	0.61	0.00	0.96	0.00	0.81	0.72	0.75	0.91	0.77	0.92

	Station	57	58	59	60	61	62	63	64	65	66	67	68
SWI	Wet Season	1.52	1.55	0.00	0.00	0.00	0.00	0.00	1.80	1.56	2.74	2.36	2.40
Pielou	Wet Season	0.95	0.67	0.00	0.00	0.00	0.00	0.00	0.93	0.97	0.92	0.92	0.87
SWI	Dry Season	1.43	1.75	0.00	1.05	0.00	1.31	1.04	1.44	1.76	1.85	1.96	2.12
Pielou	Dry Season	0.73	0.68	0.00	0.96	0.00	0.81	0.64	0.66	0.71	0.80	0.74	0.80

	Station	69	70	71	72	73	74	75	76	77	78	79	80
SWI	Wet Season	1.22	0.00	0.00	1.99	1.28	2.26	2.00	2.41	2.41	2.51	2.78	2.19
Pielou	Wet Season	0.76	0.00	0.00	0.91	0.92	0.88	0.52	0.70	0.71	0.70	0.73	0.61
SWI	Dry Season	1.15	1.68	1.71	1.31	0.76	2.63	1.83	2.02	1.76	1.34	1.20	2.08
Pielou	Dry Season	0.52	0.81	0.88	0.73	0.69	0.84	0.52	0.59	0.55	0.49	0.41	0.65

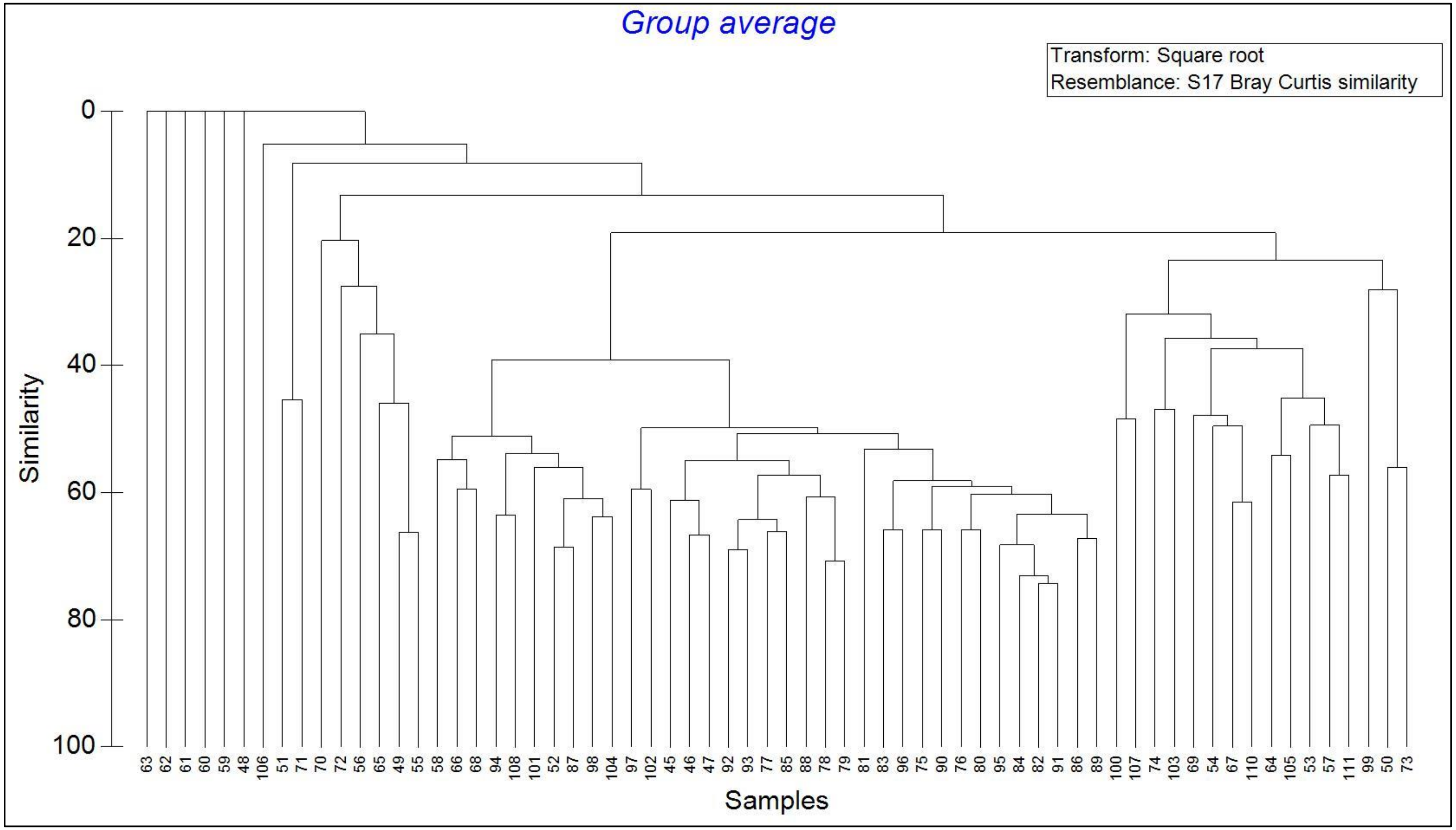
	Station	81	82	83	84	85	86	87	88	89	90	91	92
SWI	Wet Season	2.39	2.33	2.39	1.86	2.45	2.75	2.64	2.84	2.76	2.44	2.00	2.78
Pielou	Wet Season	0.62	0.61	0.66	0.50	0.71	0.72	0.80	0.78	0.73	0.64	0.54	0.77
SWI	Dry Season	1.92	2.61	2.19	2.07	1.16	1.26	1.08	0.90	1.74	2.22	2.07	1.85
Pielou	Dry Season	0.54	0.64	0.63	0.70	0.49	0.55	0.49	0.43	0.58	0.67	0.64	0.65

	Station	93	94	95	96	97	98	99	100	101	102	103	104
SWI	**Wet Season**	2.76	2.77	2.34	2.49	1.83	2.33	2.10	0.67	2.11	2.59	1.83	2.15
Pielou	**Wet Season**	0.78	0.92	0.65	0.75	0.59	0.70	0.95	0.97	0.73	0.75	0.74	0.73
SWI	**Dry Season**	1.05	1.48	1.39	2.40	2.34	1.19	1.66	1.33	1.38	2.10	1.90	1.19
Pielou	**Dry Season**	0.48	0.68	0.49	0.69	0.70	0.54	0.76	0.96	0.55	0.66	0.61	0.48

	Station	105	106	107	108	110	111
SWI	**Wet Season**	1.49	0.00	1.85	2.89	2.05	1.63
Pielou	**Wet Season**	0.93	0.00	0.95	0.91	0.89	0.84
SWI	**Dry Season**	1.11	1.40	1.88	1.58	1.68	2.61
Pielou	**Dry Season**	0.62	0.78	0.90	0.76	0.81	0.90

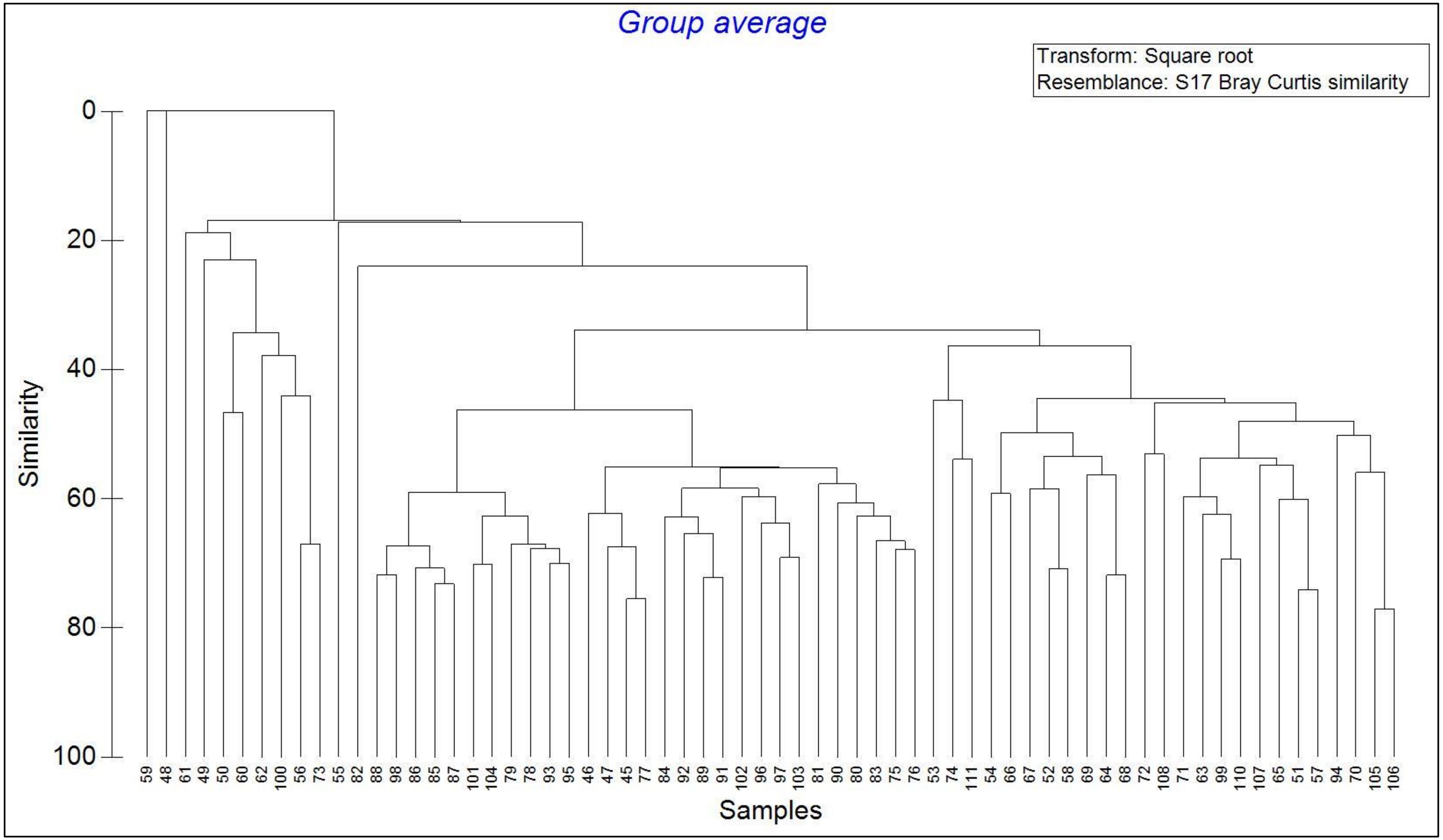
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

A cluster analysis was performed using the Bray-Curtis similarity coefficient to identify stations considered to be most similar based on species composition. The resulting dendrograms present the data collected for the wet season (Figure 5-92) and the dry season (Figure 5-93). In the wet season, the most similar stations were Station 82 and Station 91, which demonstrated the highest percentage similarity (74.29%). However, 2 groups of stations can be seen clustered together. Each group is comprised of stations that are similar to each other with respect to species composition. In the dry season the most similar stations were Station 105 and Station 106, which had the highest percentage similarity (77.08%). Two groups of stations can also be seen clustered together. Each group is comprised of stations sharing a similar species composition.



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

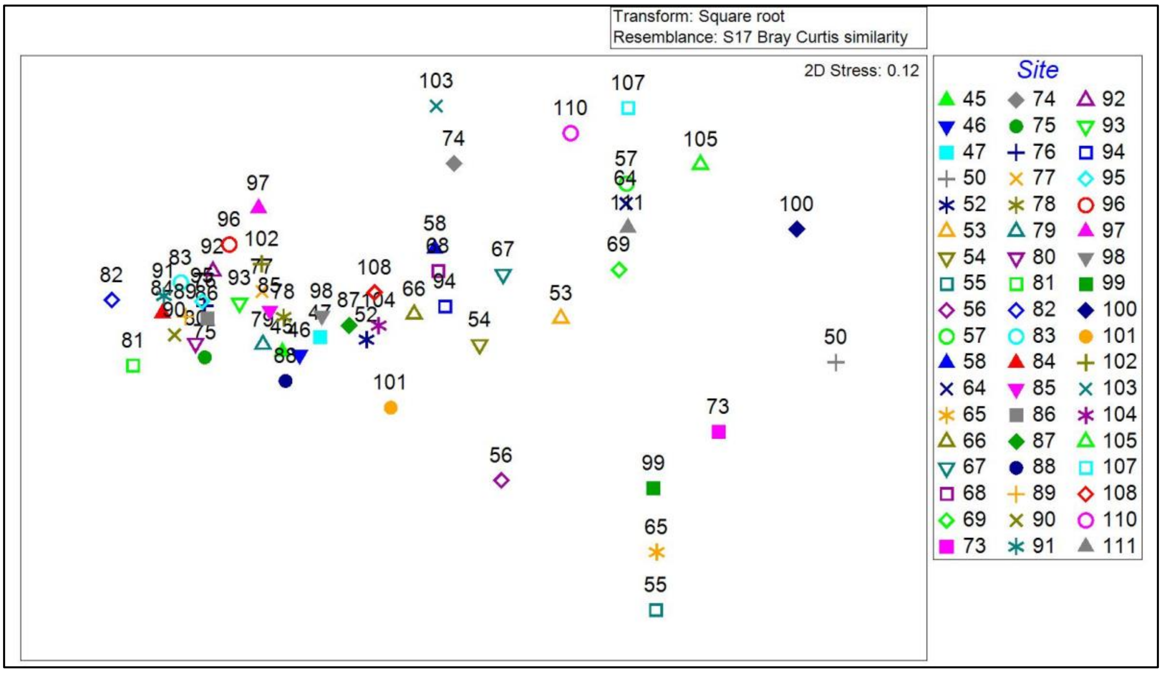
Figure 5-92: Dendrogram Plot of the Wet Season for Block B (Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

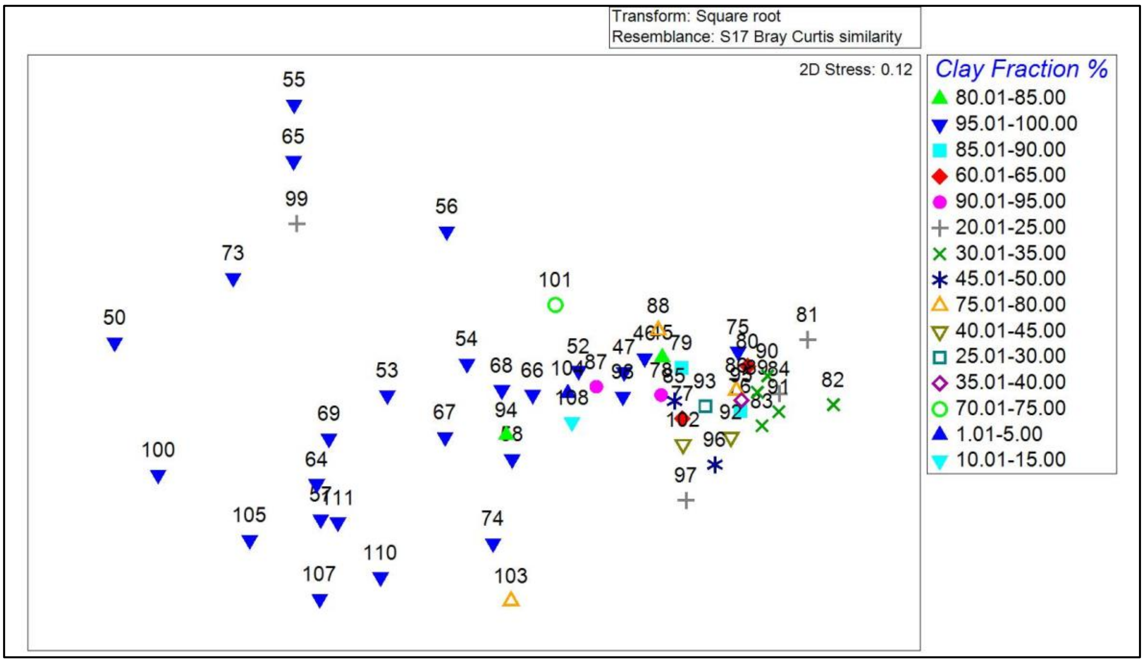
Figure 5-93: Dendrogram Plot of the Dry Season for Block B (Replicates Combined)

Species composition, the predominant grain size fraction (clay) and water depth (ft) were used to create MDS plots to determine if significant clustering occurred among stations based on these factors. In an attempt to achieve the MDS plots, outlier stations that resulted in the distortion of the plots were removed. Wet season data was analysed and the resultant MDS plots showed that there was significant clustering among 2 groups of stations; with Stations 82 (1,003 specimens; 45 taxa) and 91 (613 specimens; 41 taxa) being positioned closest together (corroborating the findings of the dendrogram). However, the MDS plot illustrating the predominant grain size fraction shows a relationship between the highest clay fraction and species composition; with stations having over 95% clay clustering to the left of the plot. Water depth appears to have no influence on the clustering of stations in Block B (Figure 5-94, Figure 5-95 and Figure 5-96 below).



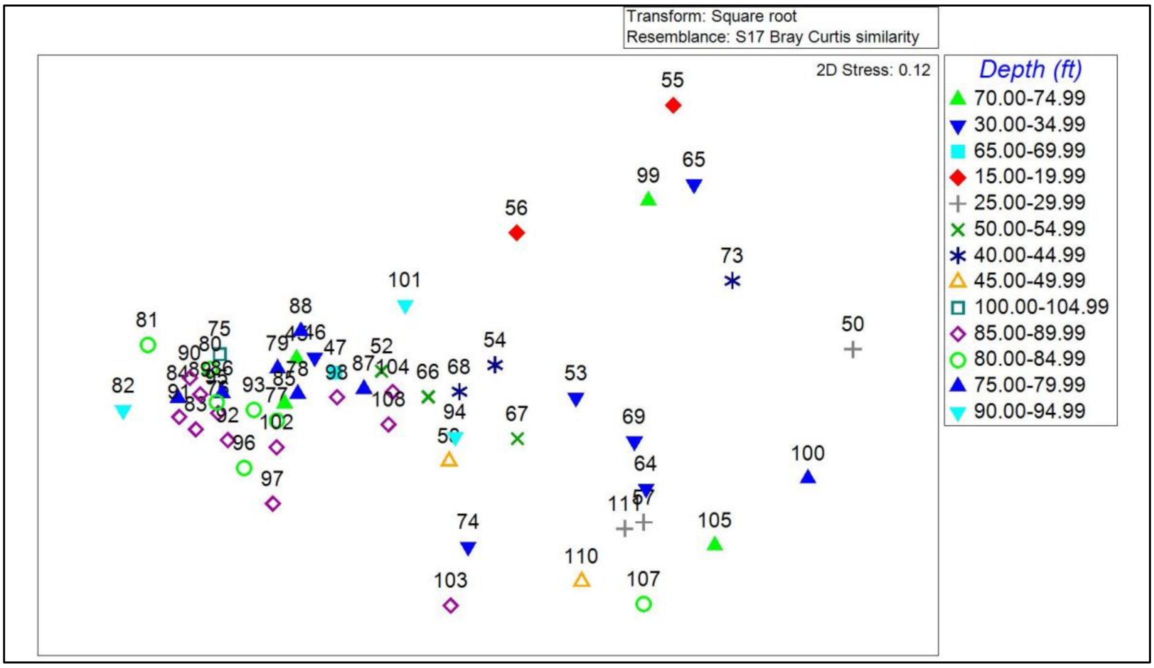
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-94: MDS Plot of Species Composition for Block B (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

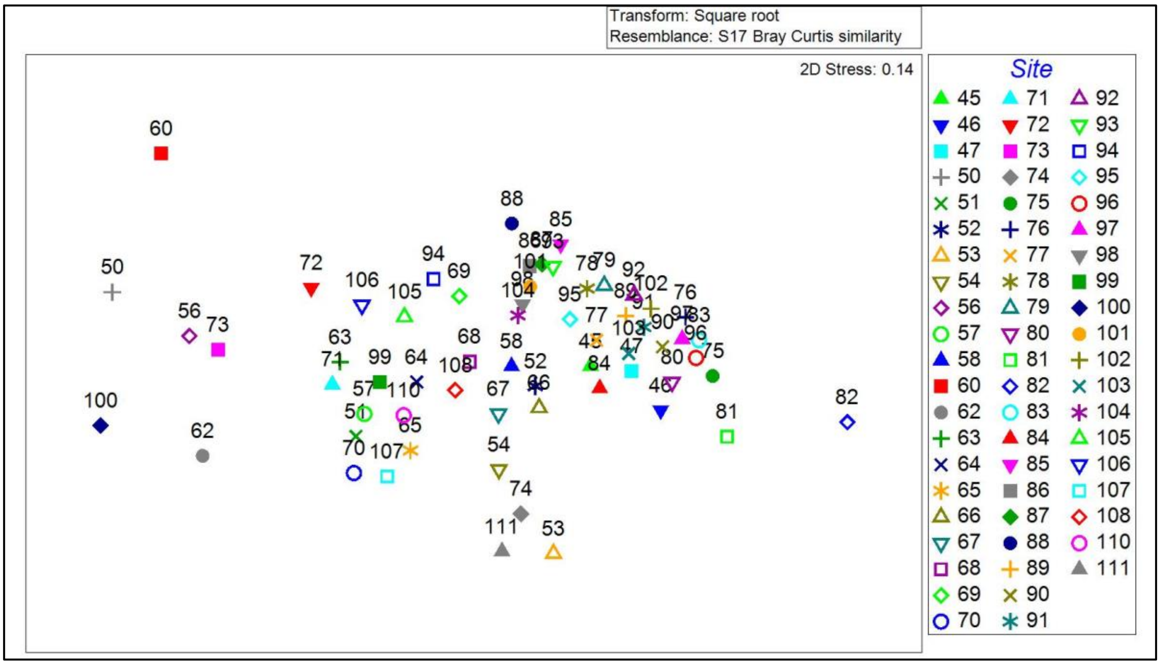
Figure 5-95: MDS Plot of Predominant Grain Size Fraction for Block B (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

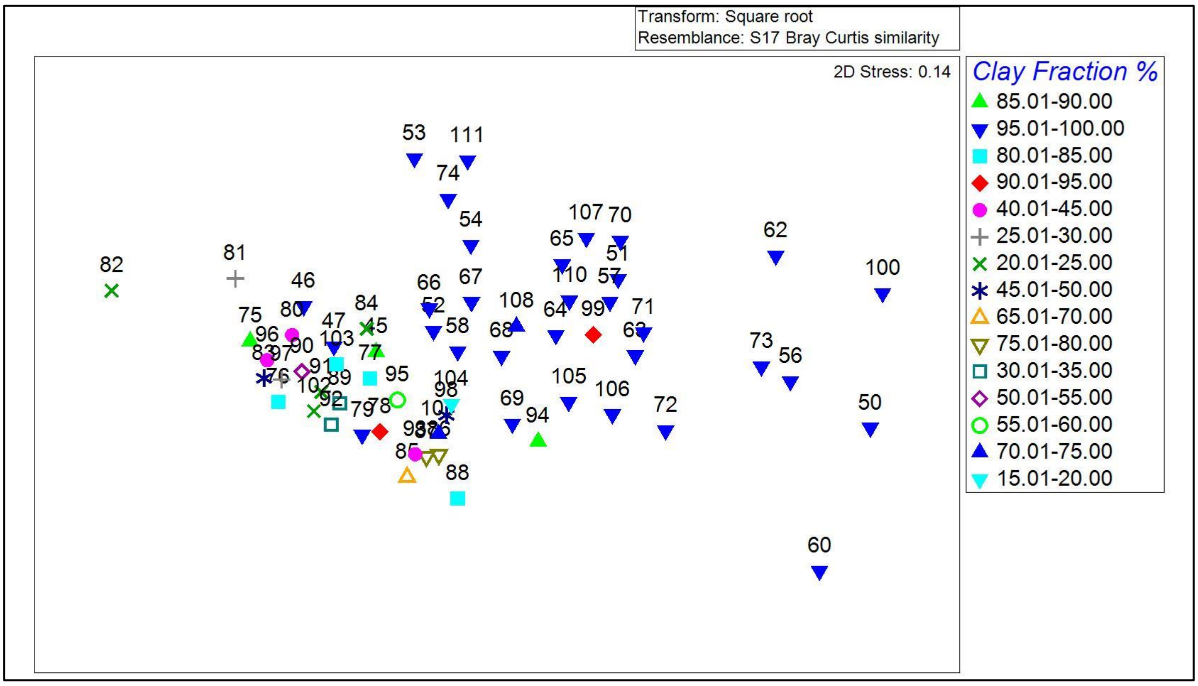
Figure 5-96: MDS Plot of Water Depth for Block B (Wet Season; Replicates Combined)

Dry season data was analysed and the resultant MDS plots showed that there was significant clustering among 2 groups of stations; with Stations 105 (36 specimens; 6 taxa) and 106 (32 specimens; 6 taxa) showing the highest similarity with respect to species composition (corroborating the findings of the dendrogram). Station 82 was the most dissimilar to stations presented in the plot; as the number of taxa and specimens was significantly higher at this station (790 specimens; 59 taxa). The MDS plot illustrating the predominant grain size fraction shows a relationship between the highest clay fraction and species composition; with stations having over 95% clay clustering to the right of the plot. Water depth appears to have no influence on the clustering of stations in Block B (Figure 5-97, Figure 5-98 and Figure 5-99 below).



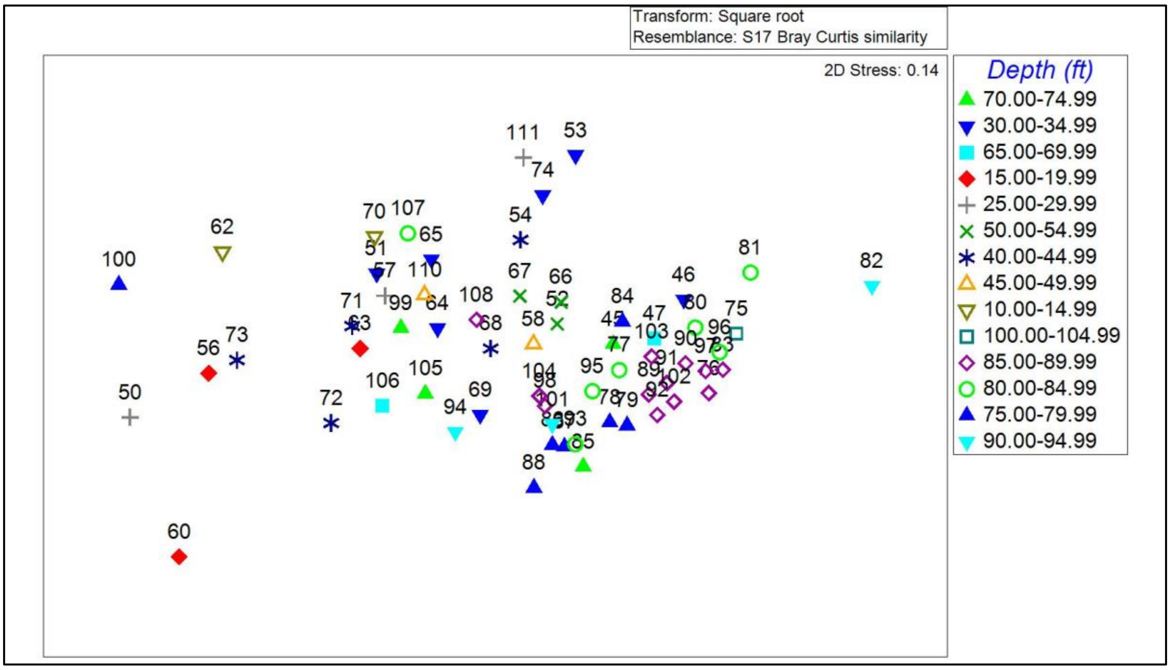
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-97: MDS Plot of Species Composition for Block B (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-98: MDS Plot of Predominant Grain Size Fraction for Block B (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-99: MDS Plot of Water Depth for Block B (Dry Season; Replicates Combined)

Abiotic data from both seasons were analysed, the Draftsman Plot results revealed that the highest correlation occurred between lead and aluminium in sediment, with a correlation value of 0.928. This suggests an almost perfect positive linear relationship between lead and aluminium in sediment.

When biotic and abiotic data (water and sediment quality) were combined to determine the most significant variables using the BEST (Bio-Env) Analysis, the abiotic factor which formed the highest correlation with the biotic data was found to be total phosphorus in water. This correlation value was low (0.355), suggesting a weak positive linear relationship between the 2; and it must be kept in mind that correlations do not prove a causal link.

5.4.1.3.3 Block C

A summary of the baseline assessment for the focus area within Block C is presented in Table 5-32 below. The high standard deviation values derived in Table 5-32 below indicate that the number of specimens and taxa recorded per grab and per station were highly variable, with values being spread over a large range.

The number of specimens collected in the wet season sampling event was 13,332. The dry season however, recorded an increase as, 14,212 specimens were collected. The number of taxa identified per season also varied; 105 taxa were identified in the wet season with 113 taxa recorded in the dry.

Table 5-32: Summary of ESL's Baseline Assessment for Block C (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September-November 2017)
Total # of stations	89	89
Total # of grabs	267	267
Total # of specimens	13,332	14,212
Total # of taxa	105	113
Average # of specimens per grab	49.93 ± 155.01	53.22 ± 99.67
Range of # of specimens per grab	0 – 1,495	0 – 665
Average # of taxa per grab	6.11 ± 5.84	7.49 ± 6.50
Range of # of taxa per grab	0 – 33	0 – 31
Average # of specimens per station	149.79 ± 355.63	159.66 ± 260.58

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September-November 2017)
Range of # of specimens per station	0 – 2,154	0 – 1,427
Average # of taxa per station	11.51 ± 9.25	14.15 ± 9.77
Range of # of taxa per station	0 – 40	0 – 40
Station with highest # of specimens	Station 137 (2,154 specimens)	Station 148 (1,427 specimens)
Station with lowest # of specimens	Stations 173, 229 (0 specimen)	Station 167 (0 specimen)
Station with highest # of taxa	Station 177 (40 taxa)	Station 148 (40 taxa)
Station with lowest # of taxa	Stations 173, 229 (0 taxa)	Station 167 (0 taxa)
Most abundant organism	Ampeliscidae (Arthropoda; 5,372 specimens)	Ampeliscidae (Arthropoda; 5,176 specimens)
Second most abundant organism	Microprotopidae (Arthropoda; 3,242 specimens)	Microprotopidae (Arthropoda; 2,685 specimens)

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Phyla distributions based on the number of specimens and taxa recorded are presented in Table 5-33 below. A total of 13 phyla were identified in the wet season. Arthropods were the most abundant organisms recorded in wet season and accounted for 74.06% of all benthic specimens, followed by annelids (17.57%). Taxonomically, the % distribution of arthropods and annelids were comparable, accounting for 32.38% and 29.52% respectively, of all specimens documented; see Table 5-33). Similarly, dry season data recorded 13 different phyla, with arthropods (66.84%) being the most abundant organism documented, followed by annelids (19.21%). Taxonomically, arthropods dominated the percentage distribution accounting for 30.10% of all specimens collected. In both seasons arthropods and annelids accounted for almost 90% of all specimens collected and 60% of all taxa observed. Molluscs closely followed arthropods and annelids with respect to dominance in the number of taxa observed for each phylum.

Table 5-33: Phyla Distributions based on Number of Specimens & Number of Taxa Recorded for Block C (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Phylum	Wet Season	Dry Season	Wet Season	Dry Season
	% Specimens		% Taxa	
Annelida	17.57	19.21	29.52	28.32
Arthropoda	74.06	66.84	32.38	30.10
Brachiopoda	-	0.01	-	0.89
Bryozoa	0.02	0.04	1.90	1.77
Chaetognatha	0.02	0.01	0.95	0.89
Chordata	0.02	0.05	0.95	2.66
Cnidaria	0.05	0.08	3.81	4.42
Echinodermata	0.26	0.28	3.81	4.42
Entoprocta	0.01	0.01	0.95	0.89
Hemichordata	0.02	-	0.95	-
Mollusca	4.97	10.15	20.95	22.12
Nemertea	0.37	0.36	0.95	0.89
Phoronida	0.02	0.04	0.95	0.89
Sipuncula	2.61	2.93	1.90	1.77

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Ampeliscidae and Microprotopidae (both arthropod families), were the first and second most abundant taxa recorded in the wet season, accounting for 40.29% and 24.31% of all specimens documented, respectively (Figure 5-100). Similarly, the first and second most abundant taxa recorded in the dry season were Ampeliscidae and Microprotopidae (Figure 5-100), accounting for 36.41% and 18.89% of all specimens documented, respectively.

Source: ESL 2017 Macrobenthic Dataset Reference Library

Figure 5-100a: Ampeliscidae Specimen

Figure 5-100b: Microprotopidae Specimen

Figure 5-100: Most Abundant Taxa Recorded during the Baseline Assessment of Block C (Wet Season; June - August 2017 & Dry Season; September - November 2017)

The data were subjected to multivariate analysis using PRIMER; the Shannon Weiner and Pielou Indices, were calculated (using log base e), the results of which are displayed in Table 5-34 below. The SWI values derived in the table below would suggest that the distribution of species varied between sample stations and seasons; as some stations recorded lower values (less diverse), while other stations recorded values that fell within the upper end of the expected diversity range (higher diversity). The Pielou values observed for both seasons ranged from 0.00 at stations that recorded no organisms to 1, at stations that exhibited perfect evenness in the distribution of species.

Table 5-34: Shannon Wiener and Pielou Indices for Block C (Wet Season; June - August 2017 & Dry Season; September - November 2017)

	Station	117	118	119	120	121	122	123	124	125	126	127	128
SWI	**Wet Season**	1.93	1.33	2.48	1.51	0.64	0.00	1.05	2.02	1.31	0.95	1.78	1.21
Pielou	**Wet Season**	0.93	0.49	0.79	0.85	0.92	0.00	0.65	0.88	0.82	0.86	0.92	0.35
SWI	**Dry Season**	2.02	1.31	1.72	1.85	1.37	0.73	2.61	2.51	1.62	0.67	2.09	2.91
Pielou	**Dry Season**	0.81	0.42	0.60	0.80	0.76	0.29	0.87	0.91	0.83	0.97	0.91	0.83

	Station	129	130	131	132	133	134	135	136	137	138	139	140
SWI	Wet Season	2.13	2.11	1.15	1.98	1.75	1.50	2.21	2.51	0.94	1.63	1.97	1.87
Pielou	Wet Season	0.93	0.92	0.83	0.65	0.84	0.84	0.86	0.75	0.28	0.66	0.95	0.75
SWI	Dry Season	1.97	0.64	1.64	1.89	2.48	2.32	2.30	1.81	1.94	1.28	2.32	1.05
Pielou	Dry Season	0.90	0.92	0.92	0.60	0.80	0.77	0.90	0.59	0.59	0.92	0.93	0.96

	Station	141	142	143	144	145	146	147	148	149	150	151	152
SWI	Wet Season	1.32	1.04	2.40	1.97	2.22	2.10	2.52	2.23	1.46	1.07	1.28	2.14
Pielou	Wet Season	0.37	0.43	0.75	0.82	0.82	0.88	0.79	0.77	0.91	0.36	0.92	0.89
SWI	Dry Season	2.11	2.28	1.57	1.51	1.12	1.47	1.91	1.99	1.66	1.96	2.55	1.59
Pielou	Dry Season	0.60	0.89	0.46	0.69	0.62	0.91	0.52	0.54	0.48	0.85	0.78	0.69

	Station	153	154	155	156	157	158	159	160	161	162	163	164
SWI	Wet Season	0.00	1.00	0.70	2.50	1.52	1.64	1.91	0.68	0.66	1.15	0.94	0.74
Pielou	Wet Season	0.00	0.72	0.51	0.79	0.58	0.79	0.54	0.26	0.21	0.83	0.52	0.67
SWI	Dry Season	1.01	1.74	1.80	1.56	1.00	0.96	2.32	2.12	2.30	1.07	1.93	2.42
Pielou	Dry Season	0.92	0.97	0.75	0.47	0.30	0.87	0.82	0.83	0.67	0.51	0.68	0.76

	Station	165	166	167	168	169	170	171	172	173	174	175	176
SWI	Wet Season	2.54	2.55	0.00	0.00	1.54	1.67	2.11	1.55	0.00	1.80	1.77	1.95
Pielou	Wet Season	0.88	0.77	0.00	0.00	0.86	0.70	0.66	0.96	0.00	0.87	0.57	0.76
SWI	Dry Season	2.38	1.52	0.00	0.00	1.82	2.41	1.13	1.08	1.04	1.94	2.19	0.00
Pielou	Dry Season	0.69	0.49	0.00	0.00	0.83	0.80	0.35	0.67	0.94	0.68	0.68	0.00

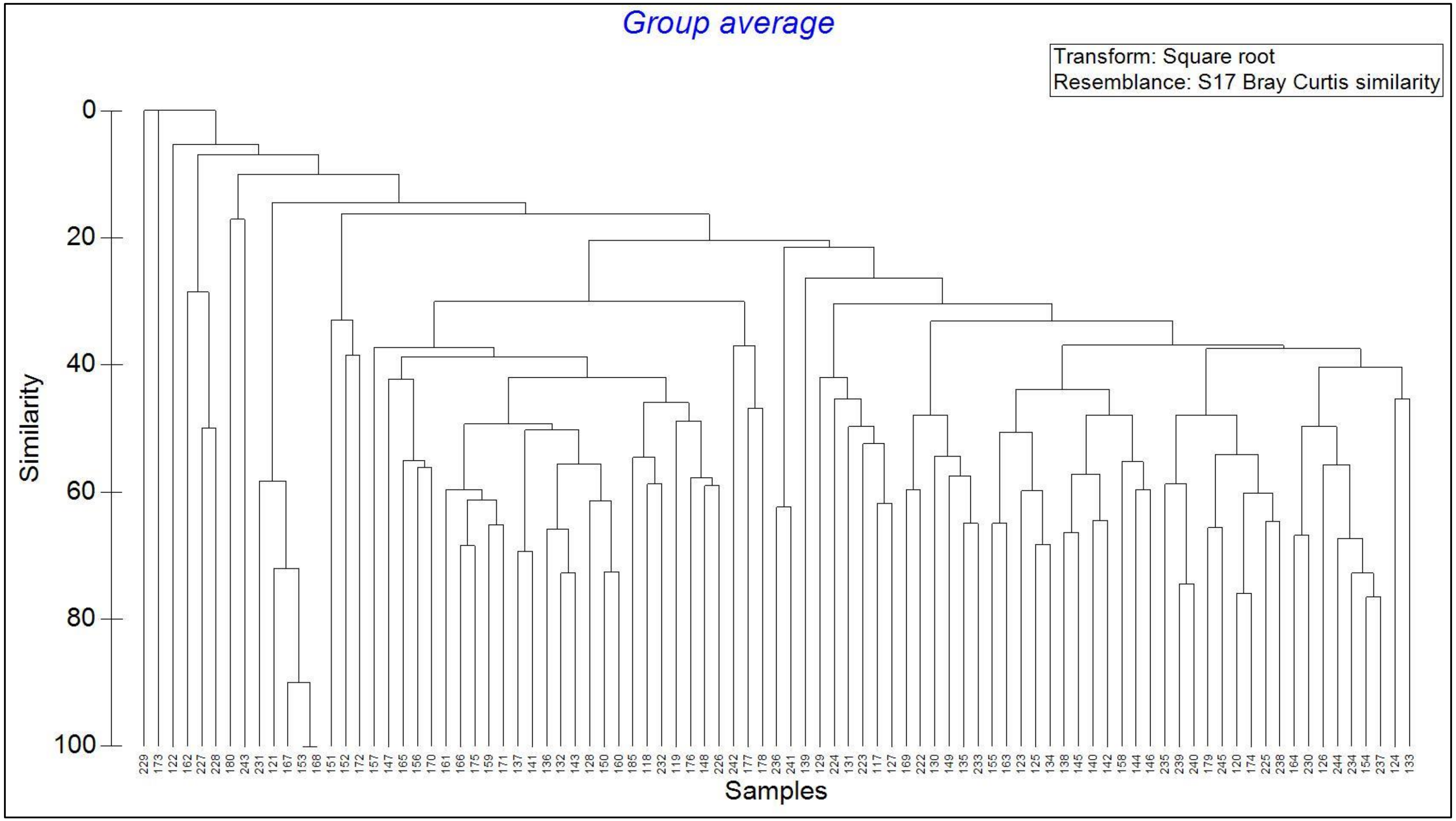
	Station	177	178	179	180	185	222	223	224	225	226	227	228
SWI	Wet Season	2.94	2.50	1.03	1.29	1.81	1.40	1.48	1.59	1.93	2.77	0.69	0.69
Pielou	Wet Season	0.80	0.75	0.64	0.62	0.54	0.78	0.92	0.76	0.84	0.87	1.00	1.00
SWI	Dry Season	2.11	2.16	2.11	1.02	1.49	1.72	2.35	1.04	1.25	2.57	1.04	1.00
Pielou	Dry Season	0.66	0.67	0.88	0.42	0.50	0.69	0.77	0.50	0.49	0.86	0.95	0.91

	Station	229	230	231	232	233	234	235	236	237	238	239	240
SWI	**Wet Season**	0.00	1.07	0.67	0.86	1.78	1.51	1.91	1.33	1.67	1.17	0.82	1.45
Pielou	**Wet Season**	0.00	0.77	0.97	0.39	0.81	0.77	0.65	0.96	0.86	0.73	0.42	0.60
SWI	**Dry Season**	0.00	1.83	1.39	0.64	1.96	1.34	1.82	1.50	1.22	1.45	1.42	1.64
Pielou	**Dry Season**	0.00	0.94	1.00	0.92	0.94	0.83	0.71	0.68	0.88	0.75	0.52	0.66

	Station	241	242	243	244	245
SWI	**Wet Season**	0.69	2.64	1.91	1.24	1.17
Pielou	**Wet Season**	1.00	0.91	0.98	0.89	0.65
SWI	**Dry Season**	2.01	2.54	1.88	1.25	1.26
Pielou	**Dry Season**	0.78	0.79	0.68	0.70	0.57

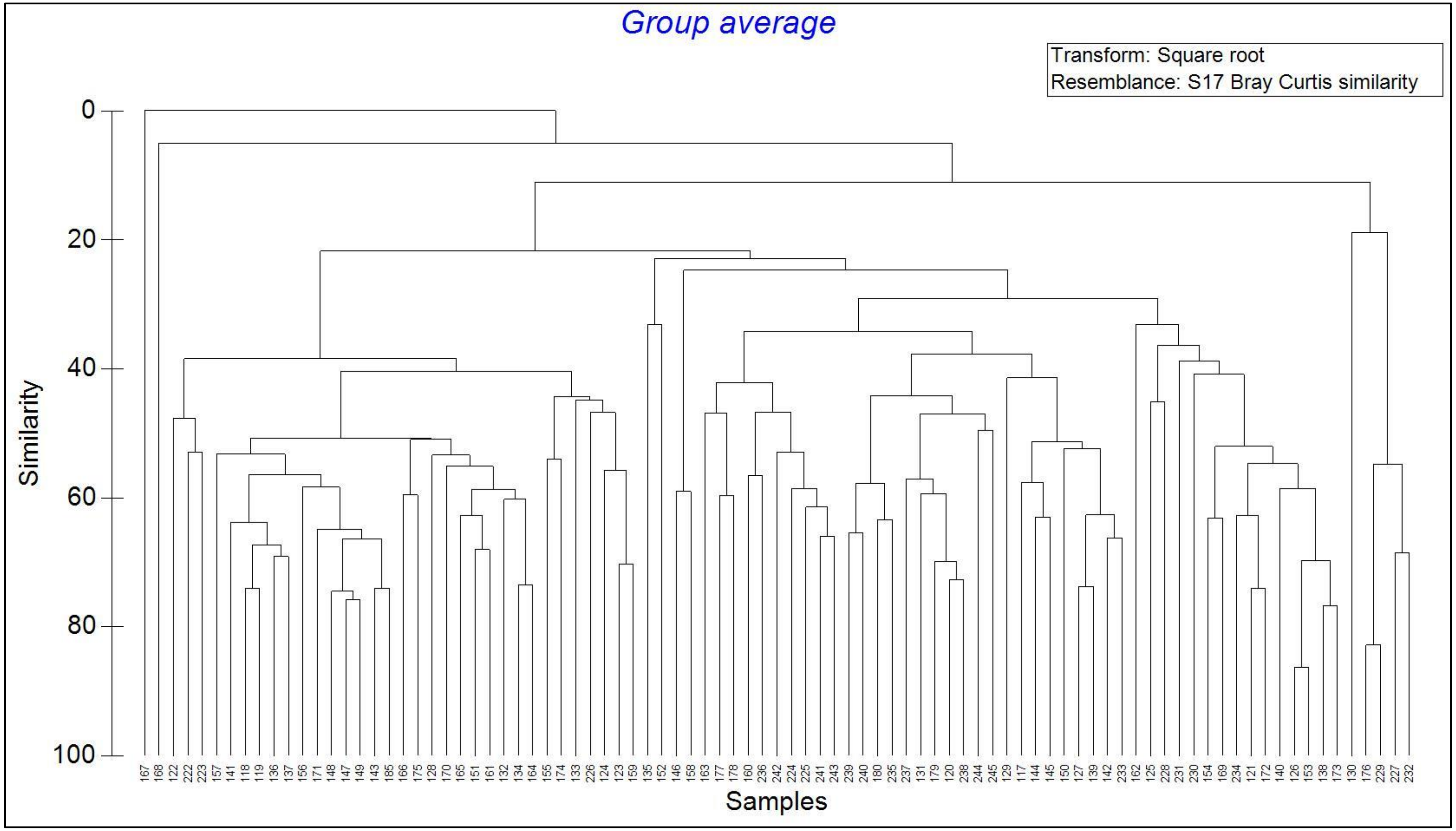
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

A cluster analysis was performed using the Bray-Curtis similarity coefficient to identify stations considered to be most similar based on species composition. The resulting dendrograms present the data collected for the wet season (Figure 5-101) and the dry season (Figure 5-102). In the wet season, the most similar stations were Station 153 and Station 168, which were completely identical and demonstrated the highest percentage similarity (100%). However, 2 groups of stations can be seen clustered together. Each group is comprised of stations that are most similar to each other with respect to species composition. In the dry season the most similar stations were Station 126 and Station 153, which had the highest percentage similarity (86.29%). However, 3 groups of stations can be seen clustered together. Each group is comprised of stations sharing a similar species composition. Generally, the clustering of all stations suggested a significant level of similarity between each sample location.



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

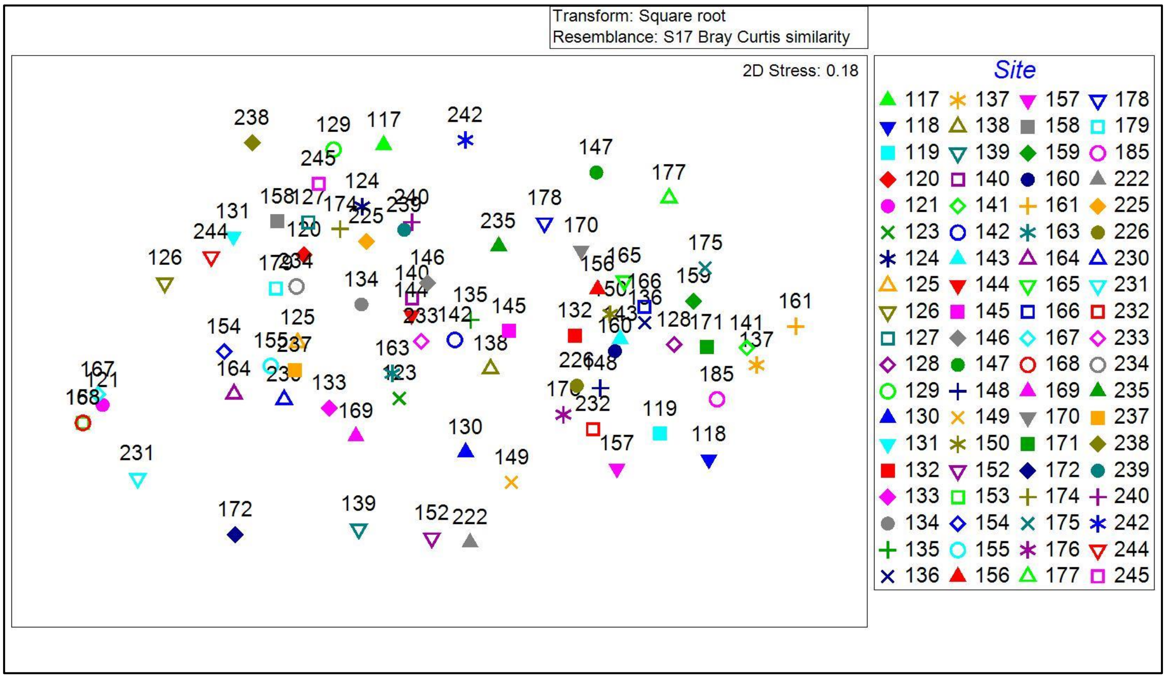
Figure 5-101: Dendrogram Plot of the Wet Season for Block C (Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

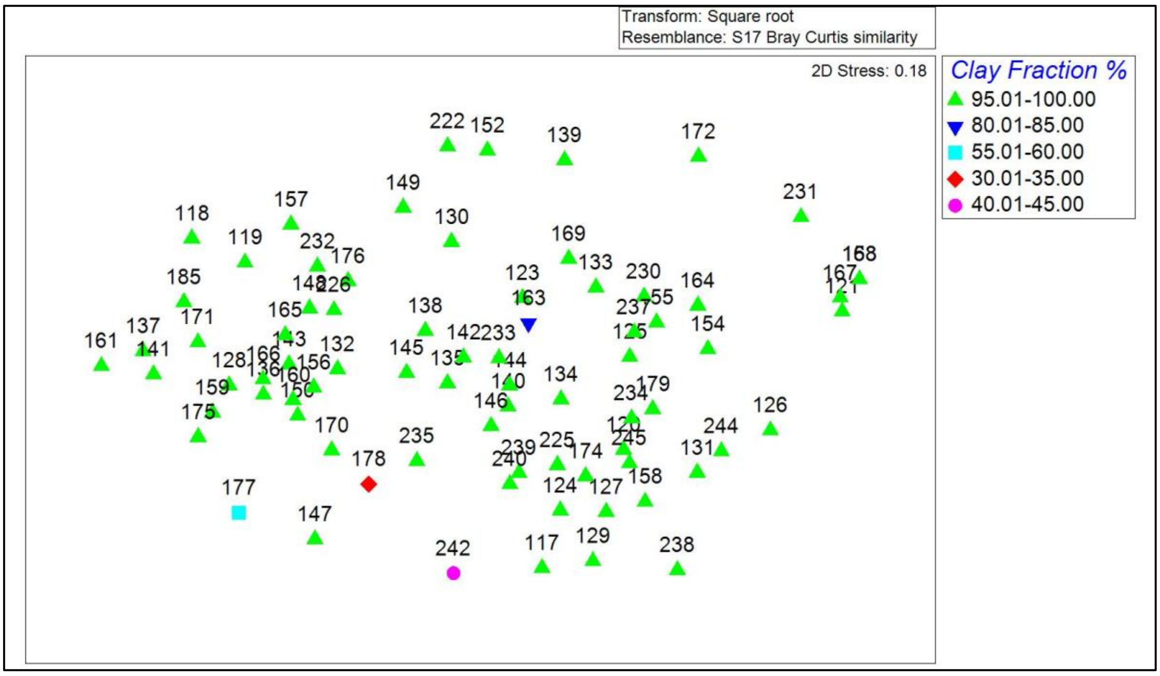
Figure 5-102: Dendrogram Plot of the Dry Season for Block C (Replicates Combined)

Species composition, the predominant grain size fraction (clay) and water depth (ft) were used to create MDS plots to determine if significant clustering occurred among stations based on these factors. In an attempt to achieve the MDS plots, outlier stations that resulted in the distortion of the plots were removed. Wet season data was analysed and the resultant MDS plots showed that there was significant clustering among 2 groups of stations; with Stations 153 (2 specimens; 1 taxon) and 168 (2 specimens; 1 taxon) being positioned closest together as they exhibited 100% similarity (corroborating the findings of the dendrogram). The predominant grain size fraction and the water depth appear to have no influence on the clustering of stations in Block C (Figure 5-103, Figure 5-104 and Figure 5-105 below).



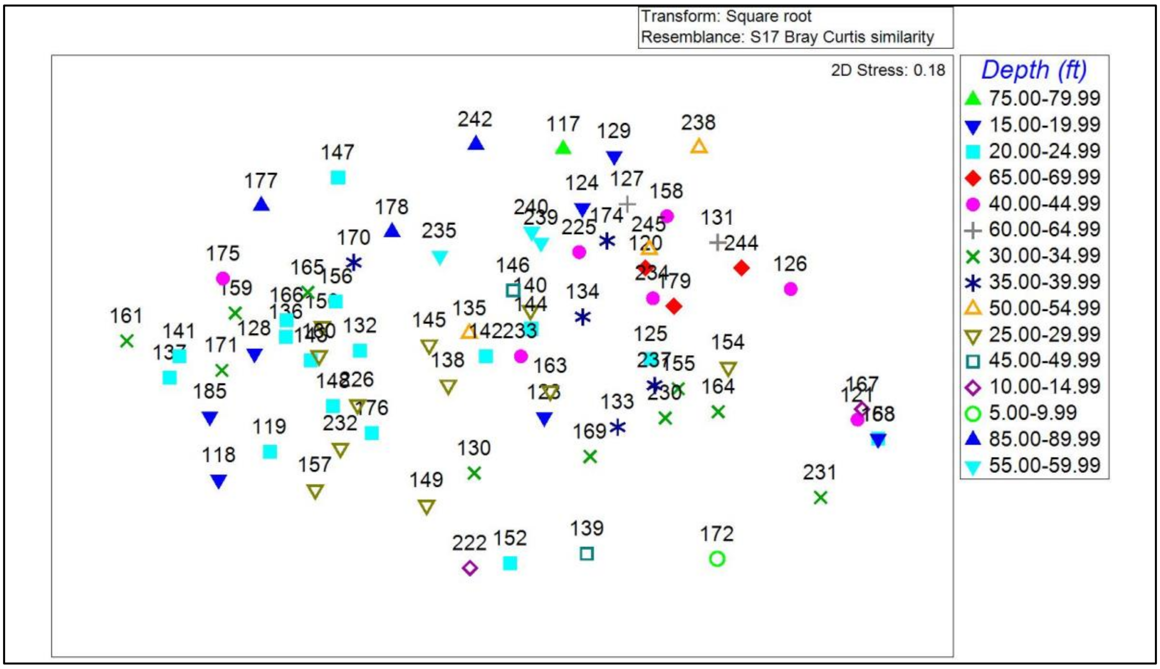
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-103: MDS Plot of Species Composition for Block C (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

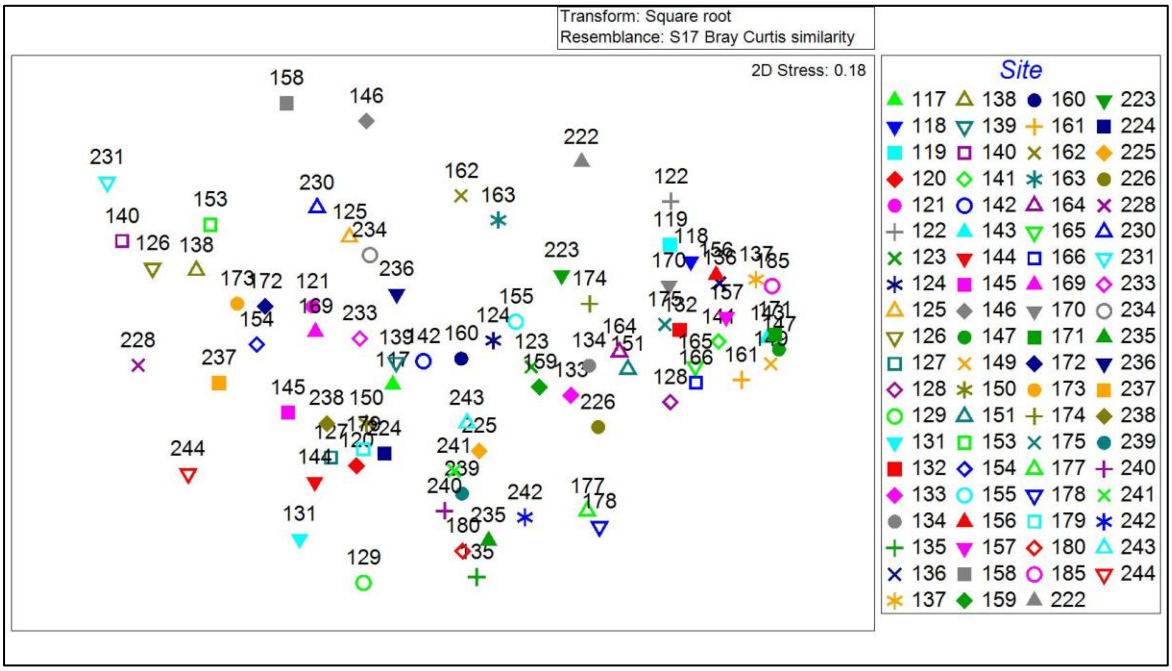
Figure 5-104: MDS Plot of Predominant Grain Size Fraction for Block C (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

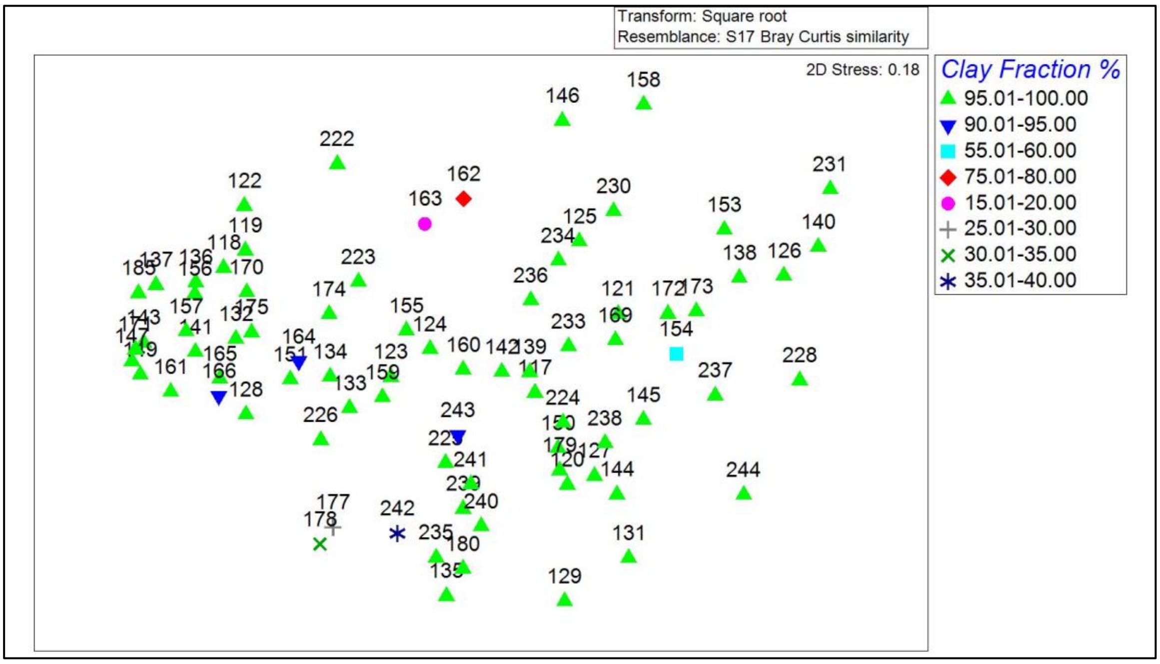
Figure 5-105: MDS Plot of Water Depth for Block C (Wet Season; Replicates Combined)

Dry season data was analysed and the resultant MDS plots showed that there was significant clustering among 3 groups of stations; with Stations 126 (5 specimens; 2 taxa) and 153 (6 specimens; 3 taxa) showing highest similarity with respect to species composition (corroborating the findings of the dendrogram). The grain size fraction and the water depth appear to have no influence on the clustering of stations in Block C (Figure 5-106, Figure 5-107 and Figure 5-108 below).



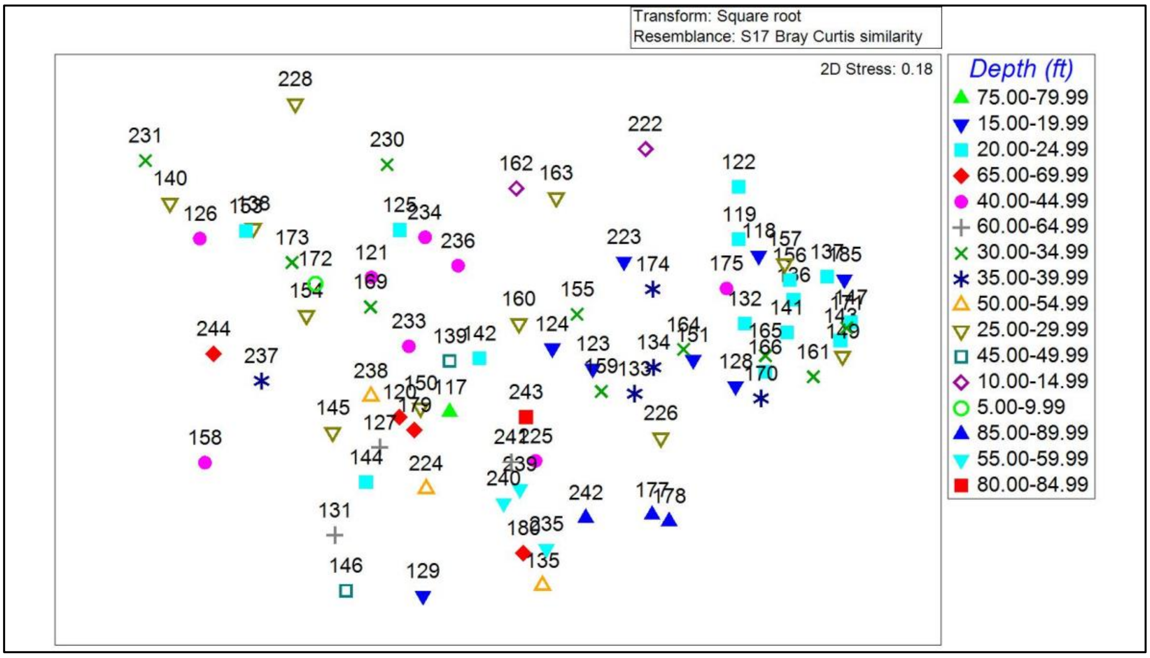
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-106: MDS Plot of Species Composition for Block C (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-107: MDS Plot of Predominant Grain Size Fraction for Block C (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-108: MDS Plot of Water Depth for Block C (Dry Season; Replicates Combined)

Abiotic data from both seasons were analysed, the Draftsman Plot results revealed that the highest correlation occurred between lead and aluminium in sediment, with a correlation value of 0.930. This suggests an almost perfect positive linear relationship between lead and aluminium in sediment.

When biotic and abiotic data (water and sediment quality) were combined to determine the most significant variables using the BEST (Bio-Env) Analysis, the abiotic factor which formed the highest correlation with the biotic data was found to be total phosphorus in water. This correlation value was low (0.093), suggesting a weak positive linear relationship between the 2; and it must be kept in mind that correlations do not prove a causal link.

5.4.1.3.4 Block D

A summary of the baseline assessment for the focus area within Block D is presented in Table 5-35 below. The high standard deviation values derived in Table 5-35 below indicate that the number of specimens and taxa recorded per grab and per station were highly variable, with values being spread over a large range.

The number of specimens collected in the wet season sampling event was 575. The dry season values were comparable, as 579 specimens were documented. The number of taxa identified per season were also comparable; 30 taxa were identified in the wet season, with the dry season recording 34 taxa.

Table 5-35: Summary of ESL's Baseline Assessment for Block D (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September-November 2017)
Total # of stations	12	12
Total # of grabs	36	36
Total # of specimens	575	579
Total # of taxa	30	34
Average # of specimens per grab	15.97 ± 23.59	16.08 ± 24.94
Range of # of specimens per grab	0 – 84	0 – 100
Average # of taxa per grab	3.72 ± 3.70	3.80 ± 4.39
Range of # of taxa per grab	0 – 15	0 – 13
Average # of specimens per station	47.91 ± 67.24	48.25 ± 72.51

Parameter	Results- Wet Season (June - August 2017)	Results- Dry Season (September-November 2017)
Range of # of specimens per station	5 – 184	1 - 200
Average # of taxa per station	7.58 ± 5.86	7.75 ± 7.77
Range of # of taxa per station	2 – 21	1 – 21
Station with highest # of specimens	Station 197 (184 specimens)	Station 197 (200 specimens)
Station with lowest # of specimens	Station 196 (5 specimens)	Stations 192, 198, 200 (1 specimen)
Station with highest # of taxa	Station 191 (21 taxa)	Station 194 (21 taxa)
Station with lowest # of taxa	Station 196 (2 taxa)	Stations 192, 198, 200 (1 taxa)
Most abundant organism	Aspidosiphonidae (Sipuncula; 277 specimens)	Aspidosiphonidae (Sipuncula; 300 specimens)
Second most abundant organism	Spionidae (Annelida; 45 specimens) & Microprotopidae (Arthropoda; 45 specimens)	Onuphidae (Annelida; 52 specimens)

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Phyla distributions based on the number of specimens and taxa recorded are presented in Table 5-36 below. A total of 6 phyla were identified in the wet season. Sipunculids were the most abundant organisms recorded in wet season and accounted for 48.18% of all benthic specimens, followed by annelids (24.17%). Taxonomically, the % distribution of annelids and arthropods were the same, with each individual taxon accounting for 33% of all specimens documented; see Table 5-36). Dry season data recorded 5 different phyla, with sipunculids (51.81%) being the most abundant organism documented, followed by annelids (25.04%). Taxonomically, arthropods dominated the percentage distribution accounting for 35.30% of all specimens collected. In both seasons annelids and sipunculids accounted for over 70% all organisms collected, however arthropods and annelids were co-dominant with respect to the number of taxa observed, accounting for over 60%.

Table 5-36: Phyla Distributions based on Number of Specimens & Number of Taxa Recorded for Block D (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Phylum	Wet Season	Dry Season	Wet Season	Dry Season
	% Specimens		% Taxa	
Annelida	24.17	25.04	33.33	32.35
Arthropoda	23.3	15.2	33.33	35.3
Echinodermata	0.35	-	3.33	-
Mollusca	3.3	7.43	23.35	26.47
Nemertea	0.7	0.52	3.33	2.94
Sipuncula	48.18	51.81	3.33	2.94

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11)

Aspidosiphonidae (sipunculid family) was the most abundant taxon recorded in the wet season, with Spionidae (annelid family) and Microprotopidae (arthropod family) being the second most abundant taxa collected. Each accounting for 48.17%, 7.82% and 7.82% of all specimens documented, respectively (Figure 5-109). Similarly, the most abundant taxon recorded in the dry season was Aspidosiphonidae (sipunculid family). This was followed by Onuphidae, the second most abundant taxon (Figure 5-109), both accounting for 51.81% and 8.98% of all specimens documented, respectively.

Figure 5 – 109a: Aspidosiphonidae Specimen

Figure 5 – 109 b: Spionidae Specimen

Source: ESL 2017 Macrobenthic Dataset Reference Library

Figure 5 – 109c: Microprotopidae Specimen

Figure 5 – 109d: Onuphidae Specimen

Figure 5-109: Most Abundant Taxa Recorded during the Baseline Assessment of Block D (Wet Season; June - August 2017 & Dry Season; September - November 2017)

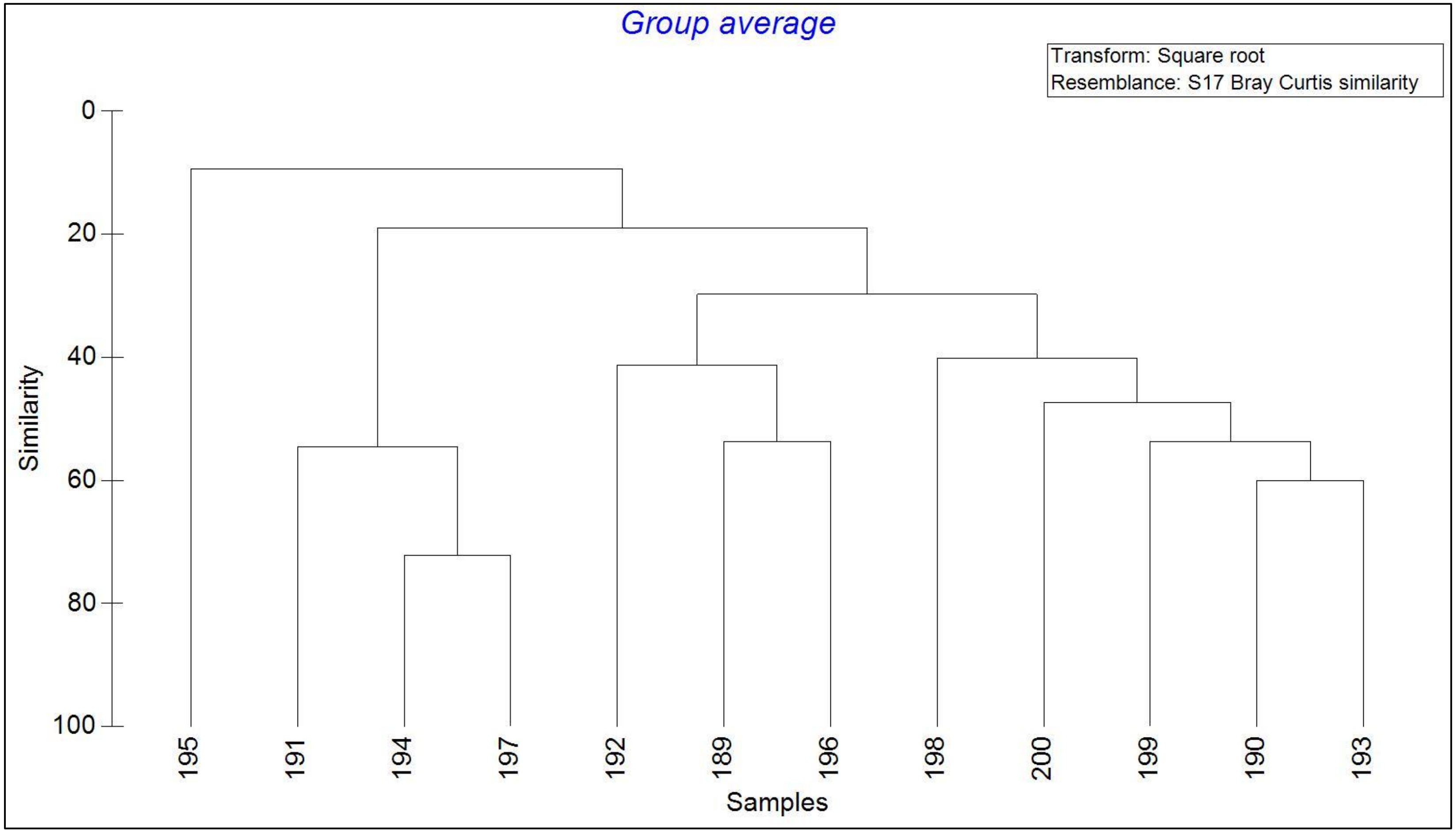
The data was subjected to multivariate analysis using PRIMER; the Shannon Weiner and Pielou Indices, were calculated (using log base e), the results of which are displayed in Table 5-37 below. The SWI values derived in the table below would suggest that the distribution of species varied between sample stations and seasons; as some stations recorded lower values (less diverse), while other stations recorded values that fell within the upper end of the expected diversity range (high diversity). The Pielou values observed for both seasons ranged from 0.00 at stations that recorded no organisms to 1, at stations that exhibited perfect evenness in the distribution of species.

Table 5-37: Shannon Wiener and Pielou Indices for Block D (Wet Season; June - August 2017 & Dry Season; September - November 2017)

	Station	189	190	191	192	193	194	195	196	197	198	199	200
SWI	**Wet Season**	0.74	1.12	2.30	1.24	0.78	1.08	0.90	0.50	1.04	1.24	1.41	2.34
Pielou	**Wet Season**	0.67	0.81	0.76	0.90	0.48	0.43	0.65	0.72	0.38	0.90	0.79	0.98
SWI	**Dry Season**	1.10	1.97	1.32	0.00	0.69	2.02	1.01	0.69	1.69	0.00	1.68	0.00
Pielou	**Dry Season**	1.00	0.75	0.49	0.00	1.00	0.66	0.92	1.00	0.56	0.00	0.86	0.00

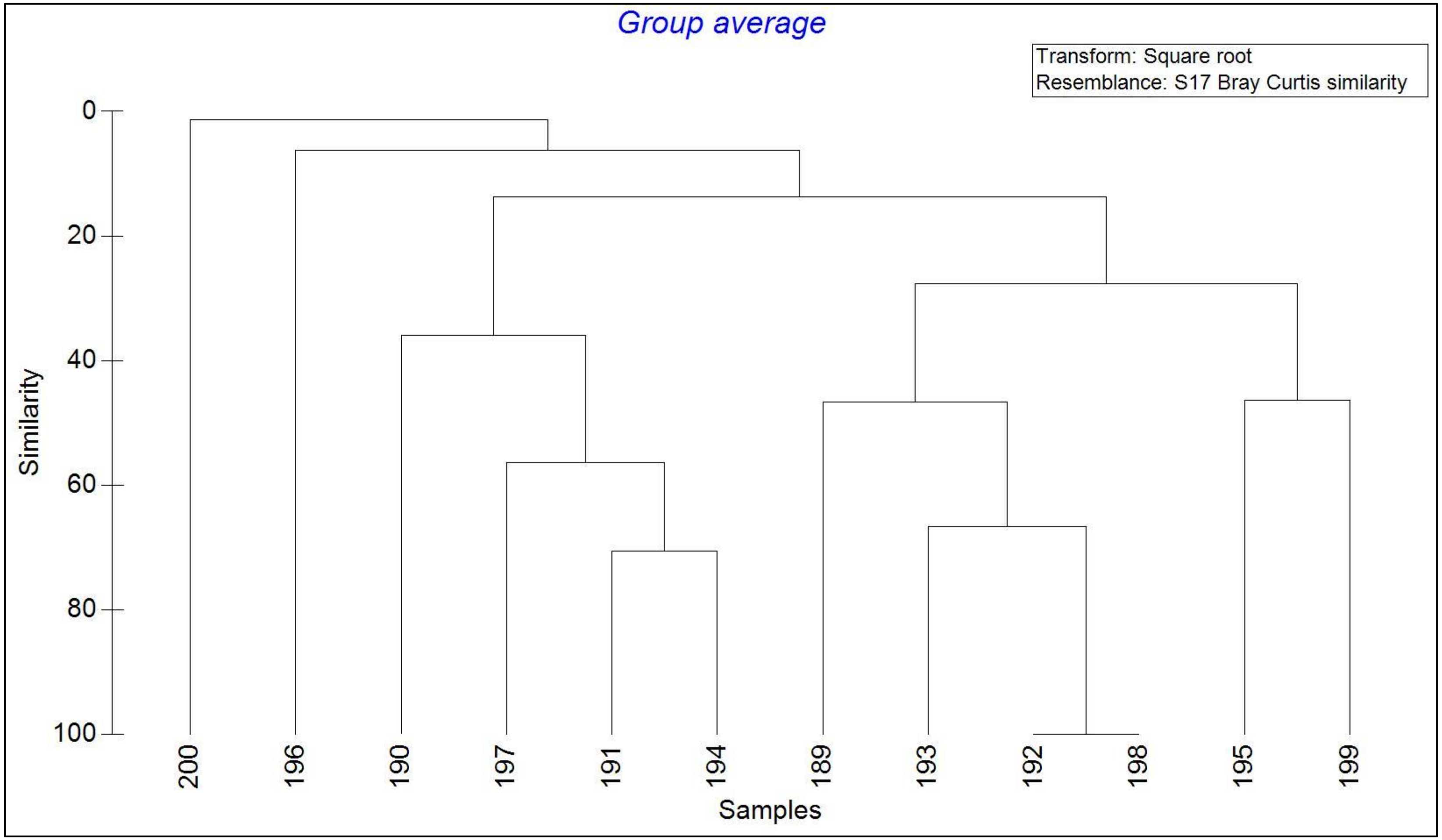
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

A cluster analysis was performed using the Bray-Curtis similarity coefficient to identify stations considered to be most similar based on species composition. The resulting dendrograms present the data collected for the wet season (Figure 5-110) and the dry season (Figure 5-111). In the wet season, the most similar stations were Station 194 and Station 197, which demonstrated the highest percentage similarity (72.21%). However, 3 groups of stations can be seen clustered together. Each group is comprised of stations that are similar to each other with respect to species composition; with Station 195 being the most dissimilar from the other groupings and stations. In the dry season the most similar stations were Station 192 and Station 198, which had an identical species composition (100% similarity). However, 2 groups of stations can be seen clustered together. Each group is comprised of stations sharing a similar species composition.



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

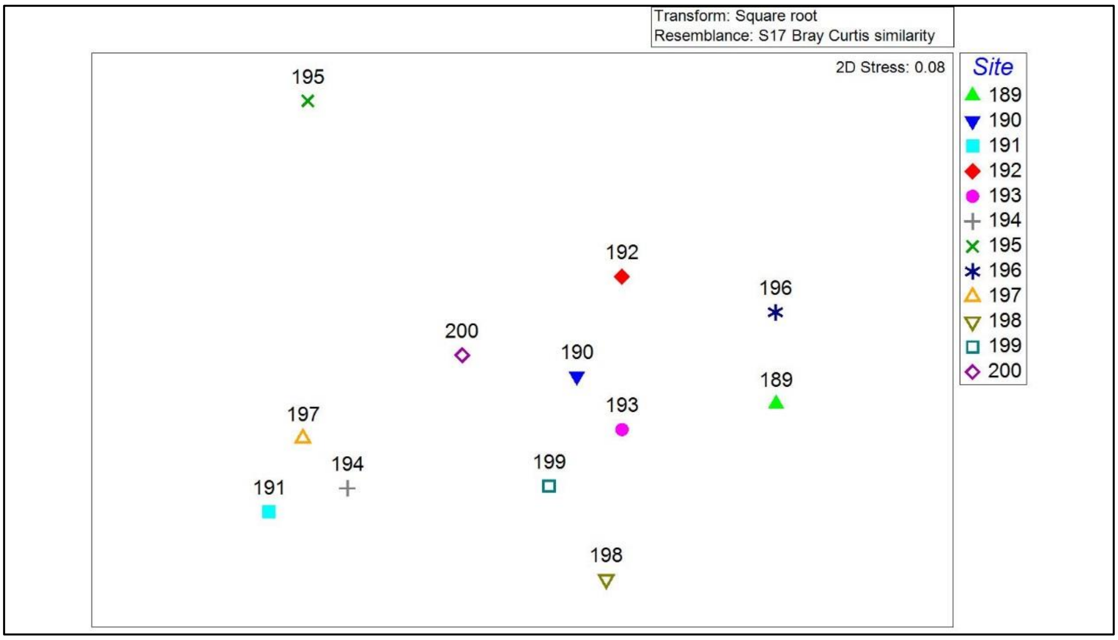
Figure 5-110: Dendrogram Plot of the Wet Season for Block D (Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

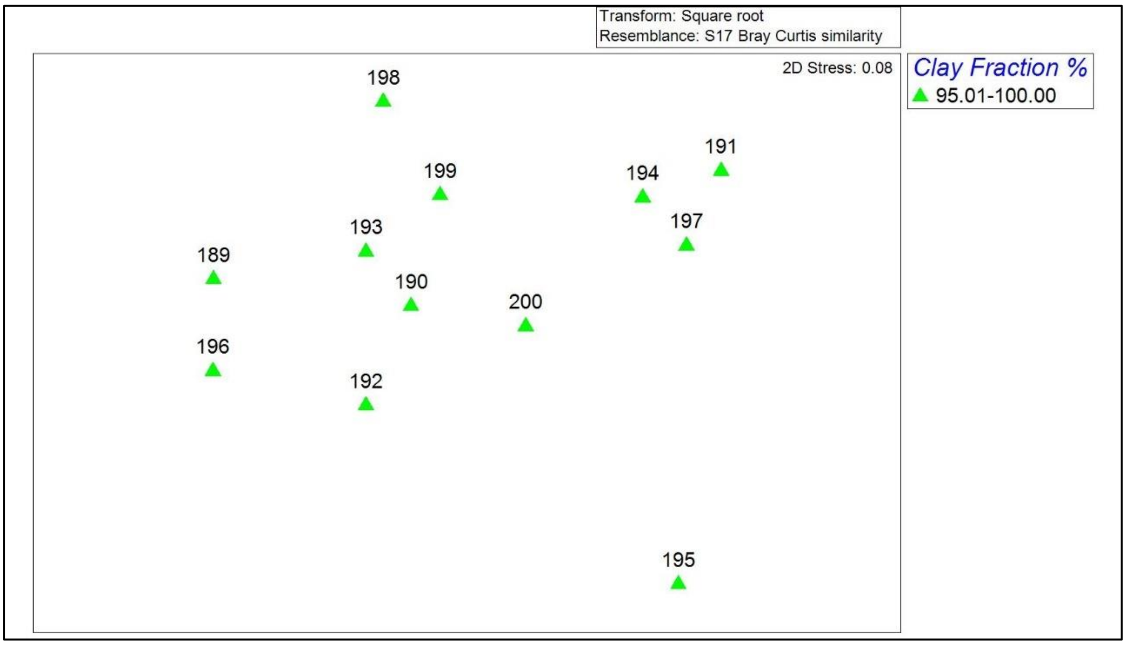
Figure 5-111: Dendrogram Plot of the Dry Season for Block D (Replicates Combined)

Species composition, the predominant grain size fraction (clay) and water depth (ft) were used to create MDS plots to determine if significant clustering occurred among stations based on these factors. Wet season data was analysed and the resultant MDS plots showed that there was significant clustering among 3 groups of stations; with Stations 194 (120 specimens; 12 taxa) and 197 (184 specimens; 15 taxa) being positioned closest together as they were the most similar (corroborating the findings of the dendrogram). These 2 stations had comparable numbers of taxa and specimens. Station 195 was the most dissimilar as it was located furthest away from the 3 cluster of stations. The predominant grain size fraction; which was identical for all sample stations and the water depth appear to have no influence on the clustering of stations in Block D (Figure 5-112, Figure 5-113 and Figure 5-114 below).



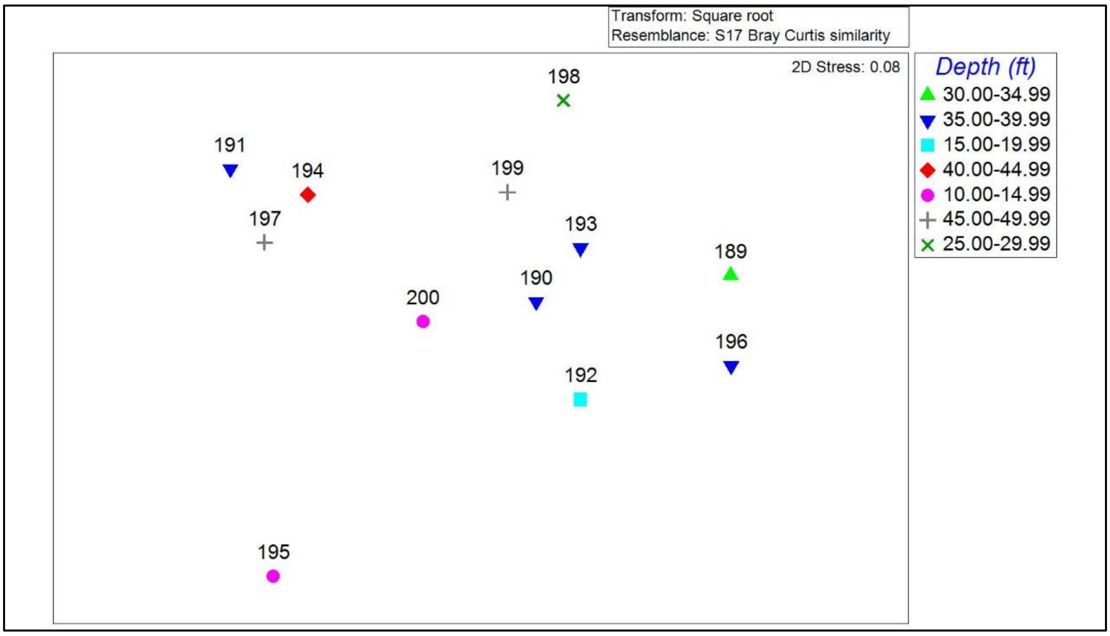
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-112: MDS Plot of Species Composition for Block D (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

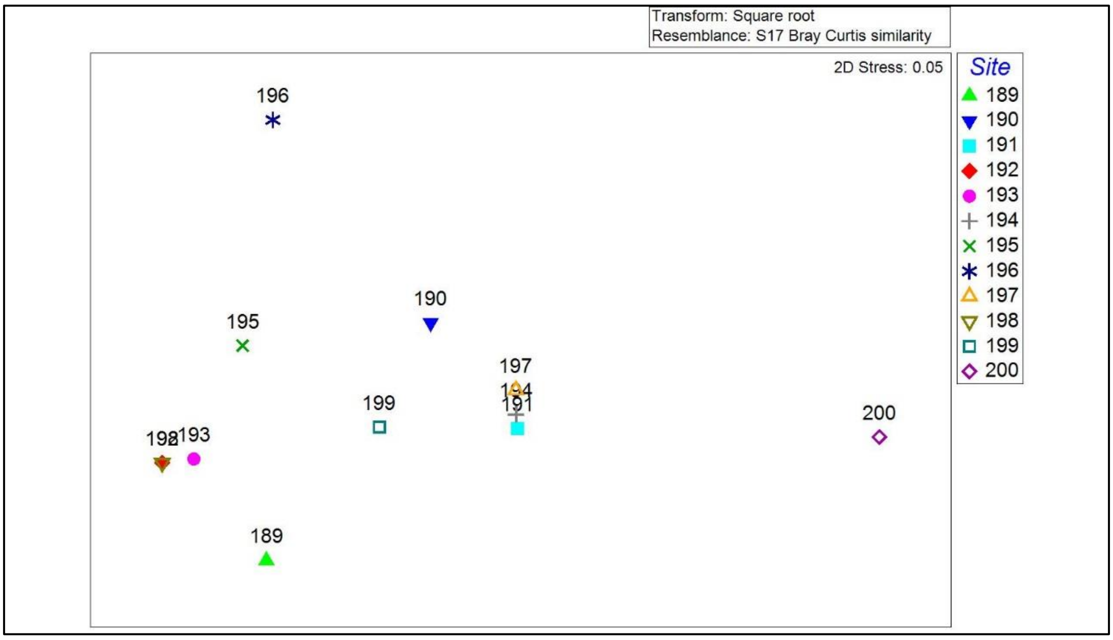
Figure 5-113: MDS Plot of Predominant Grain Size Fraction for Block D (Wet Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

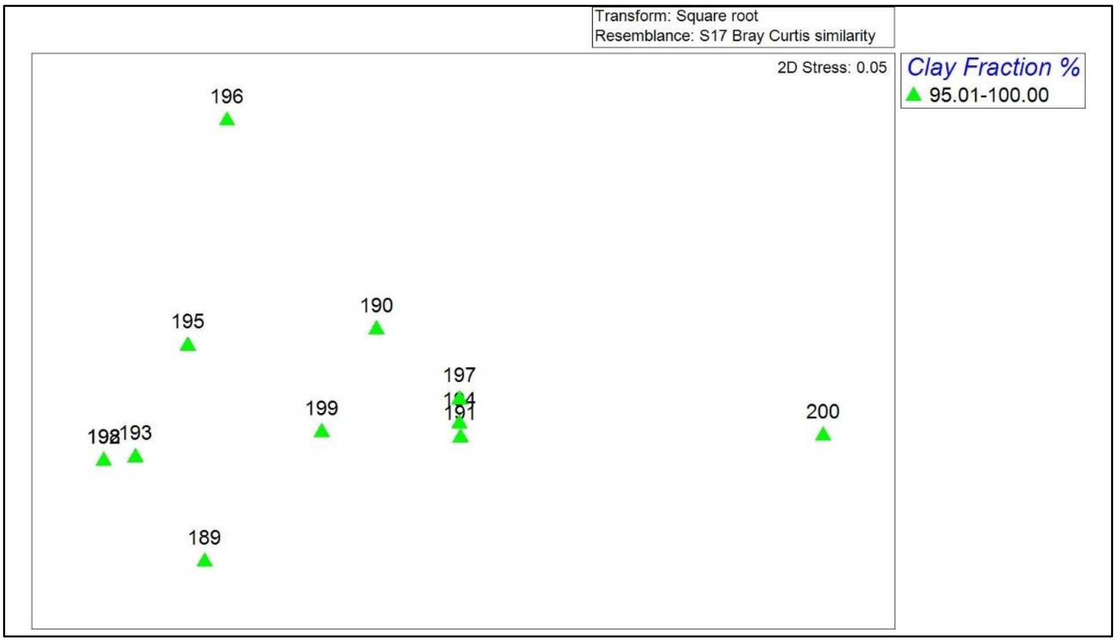
Figure 5-114: MDS Plot of Water Depth for Block D (Wet Season; Replicates Combined)

Dry season data was analysed and the resultant MDS plots showed that there was significant clustering among 2 groups of stations; with Stations 192 (1 specimen; 1 taxon) and 198 (1 specimen; 1 taxon) being identical with respect to species composition (corroborating the findings of the dendrogram). Stations 196 and 200 were the most dissimilar as they were located furthest away from the 2 cluster of stations; these 2 stations recorded a low number of taxa and the specimens recorded were different from the other groupings (Figure 5-115, Figure 5-116 and Figure 5-117 below). The grain size fraction which was identical for all sample stations and the water depth appear to have no influence on the clustering of stations in Block D.



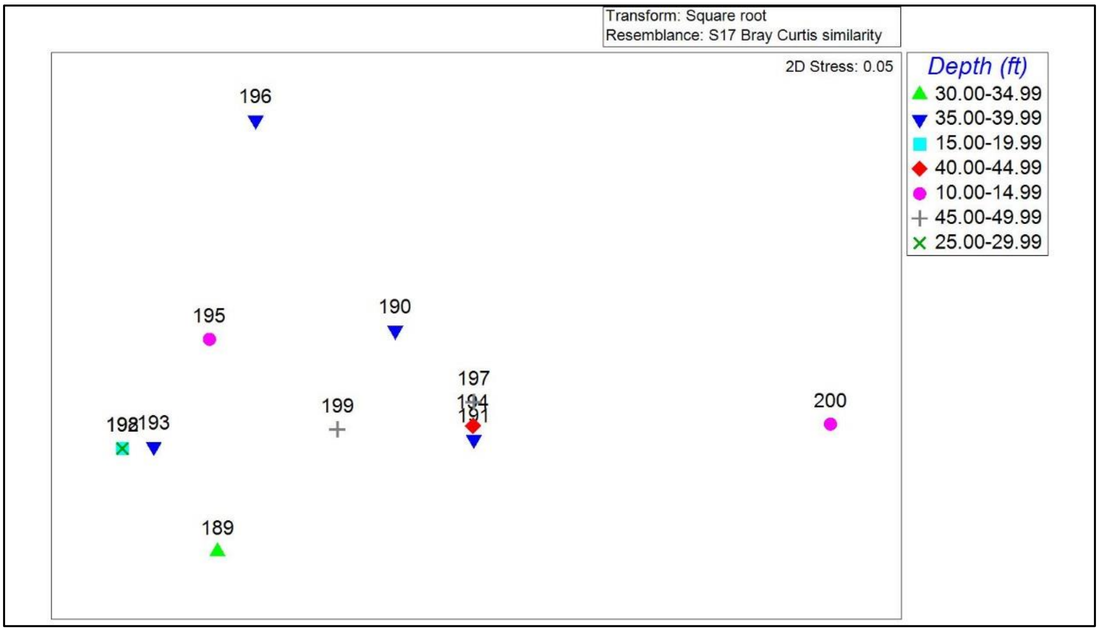
Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-115: MDS Plot of Species Composition for Block D (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-116: MDS Plot of Predominant Grain Size Fraction for Block D (Dry Season; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Macrobenthic Dataset (see Appendix D.11)

Figure 5-117: MDS Plot of Water Depth for Block D (Dry Season; Replicates Combined)

Abiotic data from both seasons were analysed, the Draftsman Plot results revealed that the highest correlation occurred between zinc and chromium in sediment, with a correlation value of 0.917. This suggests an almost perfect positive linear relationship between zinc and chromium in sediment.

When biotic and abiotic data (water and sediment quality) were combined to determine the most significant variables using the BEST (Bio-Env) Analysis, the abiotic factor which formed the highest correlation with the biotic data was found to be lead in water. This correlation value was (0.656), suggesting a moderately positive linear relationship between the 2; and it must be kept in mind that correlations do not prove a causal link.

5.4.1.4 Comparison of Baseline Assessment, Staatsolie Blocks, Offshore Suriname to Post Seismic Monitoring Programme for Block IV (February 2013) and POC ESIA Block IV Exploration Drilling (February 2013)

A comparison was made between the data collected during the baseline assessment within the Staatsolie Blocks and previously collected data from the Post Seismic Monitoring Programme for Block IV (February 2013a) and POC ESIA Block IV Exploration Drilling (February 2013b). A general comparison was made between specific stations in Block C and stations from the previous datasets located within Block C, that were closest to the baseline sample locations (see Figure 5-37 in Section 5.3.9 above). It should be noted, that the comparative analysis of this data is limited as the sample station coordinates for the baseline assessment and previous survey stations were not identical.

Post seismic monitoring was conducted in February 2013 at 8 stations within the southern portion of Block IV. Data collected from these 8 sample stations were compared to the 8 Block C stations that were closest the February 2013 sample locations. Table 5-38 below is a comparative list of the number of taxa, number of specimens and SWI values for the previously collected dataset and the baseline dataset (both wet and dry seasons). Generally, the number of taxa and the number of specimens varied between datasets, however the SWI values recorded for the previous dataset were higher than those recorded in the baseline surveys.

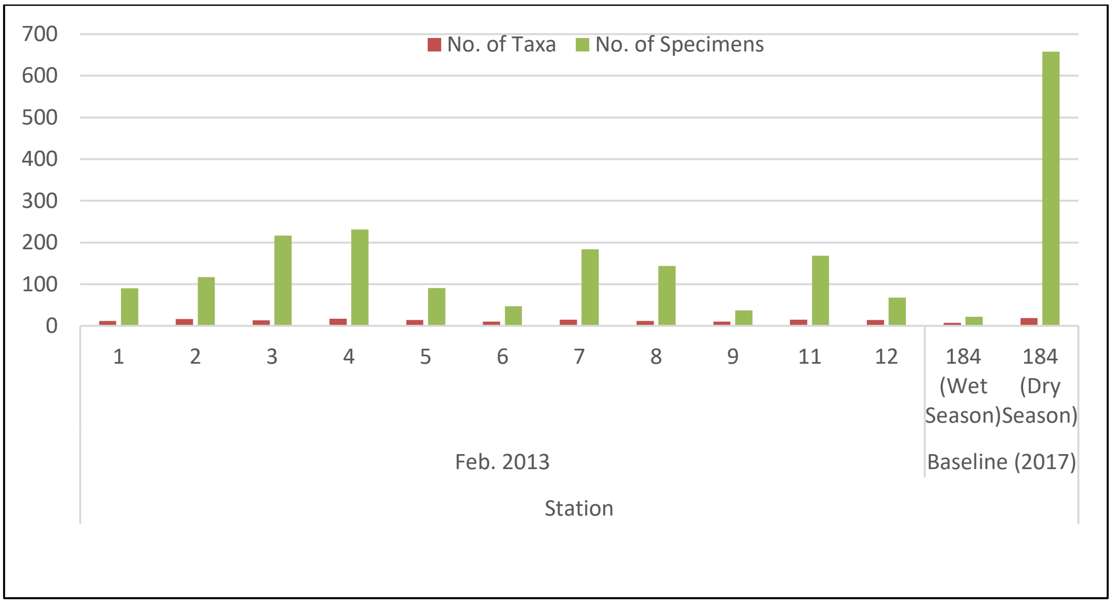
Table 5-38: Comparison of Baseline and Previous Datasets

Study	Season	Station	No. of Taxa	No. Of Specimens	SWI
POC 2013	Feb. 2013	4	17	132	2.13
Staatsolie 2017	Wet Season	239	7	105	0.81
	Dry Season		15	145	1.41
POC 2013	Feb. 2013	7	6	47	1.25
Staatsolie 2017	Wet Season	236	4	5	1.33
	Dry Season		9	39	1.5

Study	Season	Station	No. of Taxa	No. Of Specimens	SWI
POC 2013	Feb. 2013	11	11	50	2.09
Staatsolie 2017	Wet Season	224	8	24	1.58
	Dry Season		8	99	1.04
POC 2013	Feb. 2013	15	4	25	1.04
Staatsolie 2017	Wet Season	228	2	2	0.69
	Dry Season		3	7	1
POC 2013	Feb. 2013	22	17	144	2.34
Staatsolie 2017	Wet Season	183	0	0	0
	Dry Season		17	79	2.1
POC 2013	Feb. 2013	26	13	62	2.04
Staatsolie 2017	Wet Season	184	7	22	1.61
	Dry Season		19	658	1.44
POC 2013	Feb. 2013	27	15	219	1.9
Staatsolie 2017	Wet Season	184	7	22	1.61
	Dry Season		19	658	1.44
POC 2013	Feb. 2013	30	13	56	1.95
Staatsolie 2017	Wet Season	186	7	24	1.21
	Dry Season		17	223	1.93

Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11) and ESL 2013a

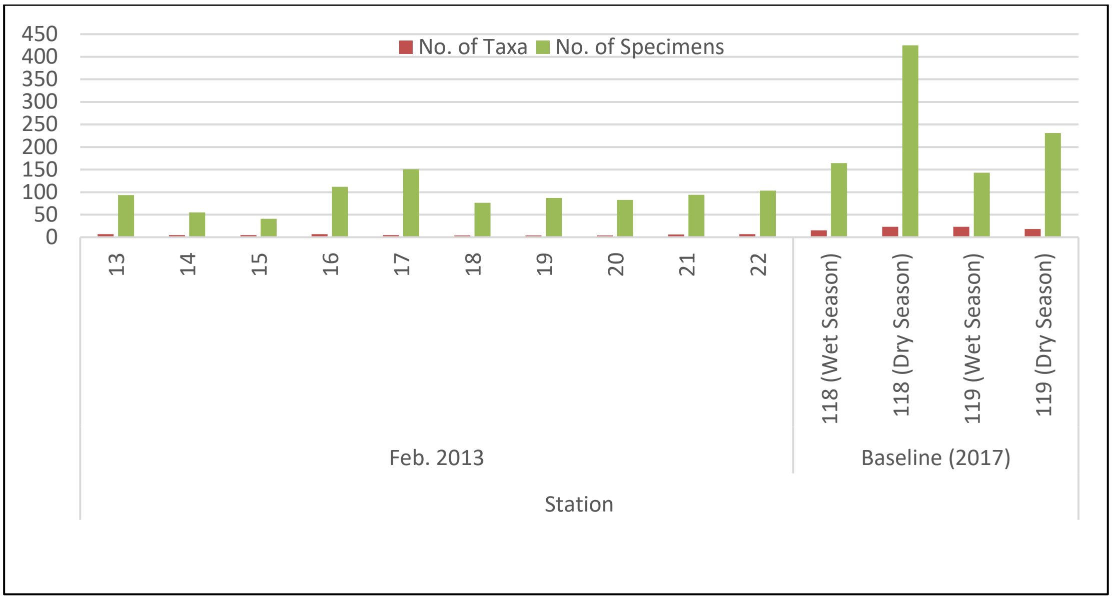
Data collected during the POC ESIA Block IV Exploration Drilling (February 2013) survey was used for comparison to determine if any changes in species composition and numbers occurred. Thirty-one stations from this sampling event were sub-dived into 3 groups; these 3 groups were then compared to the Block C stations that were in close proximity. Station 184 when compared to data from February 2013 showed that the number of taxa between datasets were comparable. However, the number of specimens recorded in the dry season for the baseline survey was significantly higher than all other values recorded (Figure 5-118).



Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11) and ESL 2013a

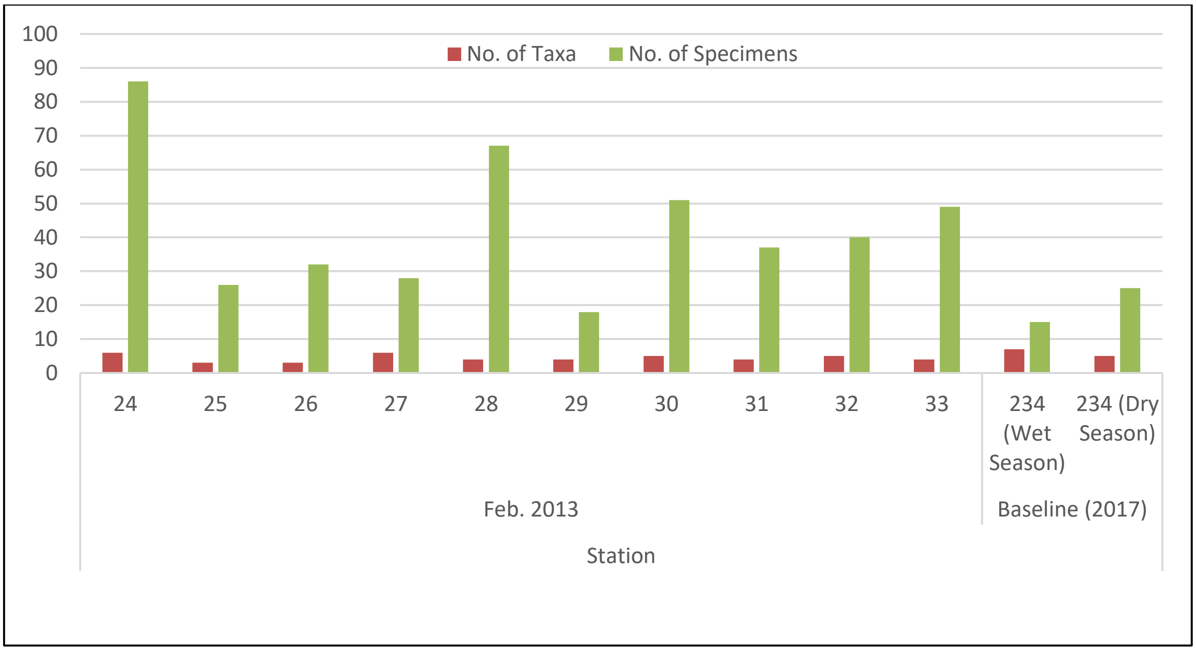
Figure 5-118: Comparison of Total No. of Specimens and Total No. of Taxa for February 2013 and Baseline Assessment Station 184 (Wet Season; June - August 2017 & Dry Season; September - November 2017)

Baseline values for Stations 118 and 119 reflected a significant increase in the number of taxa and specimens recorded, when compared to the February 2013 dataset Figure 5-119). However, Station 234 when compared to the February 2013 stations that were in close proximity, reflected a general decrease in the number of specimens, while the values recorded for the number of taxa fell within the ranges observed in 2013 (Figure 5-120). It should be noted, that caution must be taken in comparing these datasets, as the season, time of year and sample locations were variable.



Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11) and ESL 2013a

Figure 5-119: Comparison of Total No. of Specimens and Total No. of Taxa for February 2013 and Baseline Assessment Station 118 & 119 (Wet Season; June - August 2017 & Dry Season; September - November 2017)



Source: ESL 2017 Macrobenthic Dataset (see Appendix D.11) and ESL 2013a

Figure 5-120: Comparison of Total No. of Specimens and Total No. of Taxa for February 2013 and Baseline Assessment Station 234 (Wet Season; June - August 2017 & Dry Season; September - November 2017)

In conclusion, results indicate that the benthic macrofaunal community was relatively diverse at the time of the baseline assessment sampling, as the number of specimens and taxa recorded per season was high. Blocks A, B, C and D showed significant trends in faunal distribution. Overall, arthropods were the most abundant organisms recorded. At each Block the Draftsman Plots that were generated showed high correlation values, whereas the results of the BEST analyses were more varied, ranging from weak to positive linear relationships.

A general comparison to previously collected data in February 2013 suggests that changes to benthic composition and diversity did occur as values for SWI, number of taxa and number of specimens fluctuated.

5.4.1.5 Other Benthic Habitats & Fauna

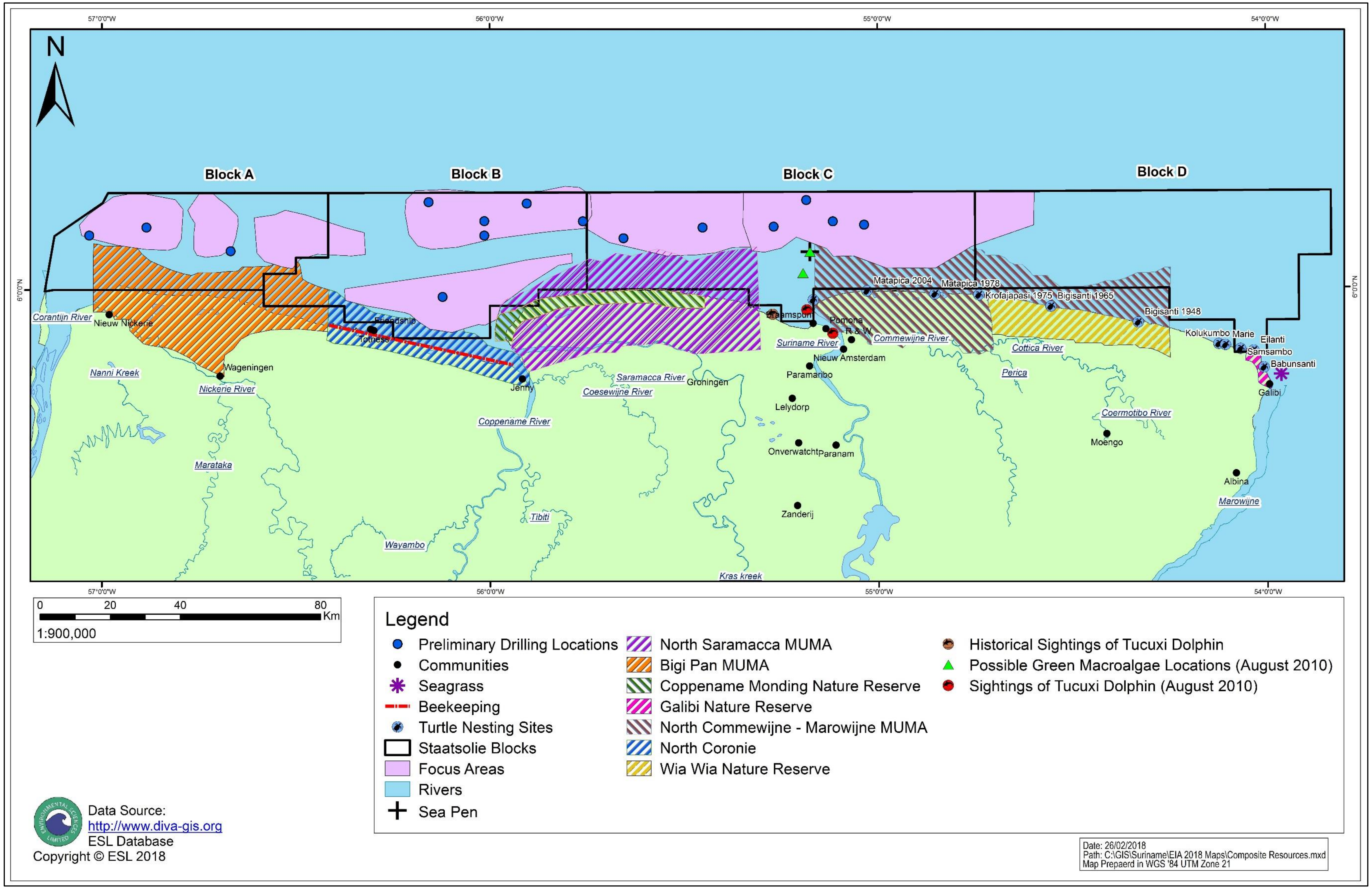
The shallow Nearshore marine waters of Suriname are turbid from Amazon-derived sediments and thus are not favourable for the establishment of seagrass beds. No seagrass beds are known to occur within Blocks A to D. Baglee *et al.* 2004 indicated that seagrass beds occur at 2 localities in Suriname immediately the east (down-current) of the Marowijne River Estuary which is 90 km to the east of Block C (Figure 5-121 below). These beds may be composed of the 2 main seagrass taxa known to be present in Suriname: Turtle grass (*Thalassia testudinum*) and Manatee grass (*Syringodium filiforme*; CSA 2017). Based on their location, it is unlikely that these beds will be affected by Project activities.

There is no published information to support the occurrence of macroalgal beds in the Nearshore coastal waters of Suriname; this is further substantiated by the nature of the seafloor sediment (muddy sediments which shift with oceanographic conditions), leading to an absence of solid substrate for the growth of macroalgae. The coastal ecological survey conducted in August 2010 (ESL 2012) indicated 2 possible locations for the presence of green macroalgae in the Nearshore area (see Figure 5-121 below), which occur in the central portion of Block C, approximately 11 – 22 km to the south of the 4 preliminary drilling locations within the focus area of the eastern portion of Block C. CSA 2015a noted the location of *Sargassum* macroalgae with patchy distribution on the seafloor within the southern portion of Block 52 (see Figure 5-168 in Section 5.4.4 below).

Generally, reef building corals are characteristic of clear, nutrient-poor oceanic conditions and warm (>20°C) tropical water (Dudley 2003). Development of coral reef ecosystems is restricted on the Atlantic coast of South America by freshwater run-off of major rivers, which include the Orinoco and Amazon Rivers. The coastal waters of South America receive large influxes of freshwater from extensive mainland river systems. The ambient suspended sediment concentrations are generally high and sediment deposition is dominated by material derived from these systems (Warne *et al.* 2002; Steven & Brooks 1972). High concentrations of nutrients are also deposited, enabling the coastal waters to become mesotrophic (green) or eutrophic (brown). The conditions of high turbidity and nutrient richness do not favour coral growth and reef development, and as a result, coral growth is almost absent along the coast of Suriname.

Observations during the ecological survey in the Nearshore area in August 2010 (ESL 2012), include a single specimen of the soft coral taxon, *Renilla reniformis* (Sea pen; Figure 5-121 below), which is known to inhabit turbid waters. The observed specimen occured in the central portion of Block C, approximately 11 km to the south of the 4 preliminary drilling locations within the focus area in the eastern portion of Block C.

Fossil coral reefs are found along the edge of the Continental Shelf within the Blue water zone. Here, remnants of coral reefs (consisting mostly of fossilised limestone; CSA 2017) are locally present at a depth of 30 m (which corresponds to approximately the 18 fathom line shown in Figure 5-169 of Section 5.5.7 below), roughly 30 km to the north of Blocks A to D. Reworked reef material occurs in abundance near the shelf at depths of 80-90 m (which corresponds to the 45 fathom line shown in Figure 5-169 of Section 5.5.7 below), and relatively steep-sided elongated reef bodies were also observed (Nota 1971; Wong *et al.* 1998). Based on the foregoing, these fossil reefs are outside the zone of influence of the Project. Given the proximal locations of green macroalgae and the sea pen (soft coral), these benthic habitats and fauna are given some consideration in the impact assessment exercise for this Project, although it is anticipated that, based on the distance of these from the preliminary drilling locations, the impact may be insignificant.



Source: ESL Database 2018

Figure 5-121: Composite Resources of the Suriname Offshore Area in relation to Nearshore Blocks A to D

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5.4.2 Plankton

5.4.2.1 Introduction

Plankton are freshwater and marine organisms which are non-motile or very weak swimmers. The term plankton is derived from ‘planktos’ meaning wanderer water dwellers. They are categorised into two main groups: phytoplankton, which are marine plants that capture sunlight with chlorophyll, consume carbon dioxide and release oxygen, and are primary producers. Common types of phytoplankton include diatoms, green algae and dinoflagellates. Phytoplankton are the basis for the marine food web. The other group is zooplankton which include invertebrate animals and include larval stages of organisms which spend part of their life cycle as plankton, such as echinoderms, crustaceans and fishes; they are called meroplankton. Holoplankton live their entire life cycle as plankton examples are copepods, chaetognaths and some cnidarians. Zooplankton are consumers feeding on either phytoplankton or smaller zooplankton.

For the purposes of this report, zooplankton detected in the offshore area of Suriname are described, see Figure 5-36 above, which were collected during one month in the Wet season (August) and one month during the Dry season (October), with comparisons made between A.M. and P.M. densities for each season and between Wet and Dry seasons (August A.M and October A.M. and August P.M and October P.M.). Sampling took place both A.M. and P.M. as Plankton behave diurnally. Sampling occurred twice per station, one before noon (A.M.), the other after noon (P.M.). The results below characterise the plankton as part of the environmental baseline assessment of water quality.

Phytoplankton and zooplankton are sensitive to environmental changes such as nutrient availability, sunlight, pollution, predation and temperature, and changes to these factors can affect their concentration. Populations also fluctuate naturally due to seasonal and annual changes. Changes to phytoplankton concentrations can have other effects on other aspects of the marine food web, and zooplankton species diversity, abundance and biomass changes can affect overall health of an ecosystem.

5.4.2.2 Methodology

The methodology employed for the August and October 2017 sampling Phase 1 and 2 are described in Table 5-39 below and in Appendix D.12. Sampling occurred twice per station, one before noon (A.M.), the other after noon (P.M.). Plankton sampling occurred for one month in the Wet season (August) and one month for the Dry season (October). Planktonic samples were retrieved at different depths in quadruplicate for 6 stations and 36 out of 48 samples were analysed (see Table 5-40 below). The method of bongo net retrieval was the same as that outlined in ESL’s adapted Plankton Methodology (see Appendix D.12). Each sample was fixed in 4% formalin (and stained with Rose Bengal) for a minimum of 24 hours before analysis. The samples were sieved over a 45µm sieve to remove the excess formalin and stored in 75% isopropanol. The volume of each sample was increased 300 ml for standardisation. Each sample was homogenised and subsampled. The subsample volume was 3 ml (1% of the total volume). The samples were analysed using a stereo microscope using a Bogorov counting chamber. Taxa identification was confirmed under a phase contrast compound microscope. The count in the total volume (300 ml) of samples was calculated multiplying by one hundred. Large or delicate taxa were not subsampled to avoid interference with the subsampling. These were also analysed with a multiplier of one for the total volume. The densities per metre cubed were calculated using the measured flow of water through the 61 cm diameter Bongo nets. Taxa identification was conducted by UK-based Ocean Ecology Limited (OEL). Lists of the planktonic taxa detected (by time of day and by season) are presented in Appendix D.13.

Table 5-39: Summary of Methods for ESL's Plankton Baseline Assessment Survey off shore Suriname (August and October 2017)

Aspect	ESL's Plankton Survey (August and October 2017)
Sampling Objective	To determine community structure and identify dominant taxa within which drilling activities will occur
No. of Stations Sampled	6 stations
No. of Replicates	4
Type of Net	61 cm diameter Bongo
Size of Sieve	45µm
Method of Preservation	4% Formalin buffered with sodium borate
Rose Bengal used	Yes
Washing Procedure	Thoroughly sieved with isopropanol and placed in container with isopropanol

ESL's Field Sampling and Processing Methdologies (see Appendix D.3 and Appendix D.12)

Table 5-40: Summary of sampling depths for Plankton stations for Baseline Assessment Survey Offshore Suriname (August and October 2017)

Station No.	Depth (m / ft)
5	8.5 (28)
31	21.3 (70)
66	15.8 (52)
89	26.2 (86)
130	10 (33)
193	10.6 (35)

Source: ESL Database 2017 and Field Sampling Methdologies (see Appendix D.3)

5.4.2.3 Results & Discussion

A summary of the August and October 2017 Baseline Assessment Survey is presented in Table 5-41 below. The high standard deviation values derived in the table below indicate that the number of specimens and taxa recorded per grab and per station were highly variable, with values being spread over a large range. Three out of 4 grabs which were taken were analysed; the fourth was an additional replicate.

Table 5-41: Summary of August and October 2017 Baseline Assessment Survey Phase 1 and Phase 2

Summary of Baseline Assessment	Result (Baseline; August 2017) Phase 1		Result (Baseline; October 2017) Phase 2	
	A.M.	P.M.	A.M.	P.M.
Total # of stations	6	6	6	6
Total # of grabs	24	24	24	24
Total # of grabs analysed	18	18	18	18
Total density of plankton /m³	112,823.01	98,658.93	24,825.50	49,493.71
Total # of taxa	45	47	59	59
Average density of plankton per grab /m³	6,267.94 ± 5,175.11	5,481.05 ± 7,725.97	1,379.19 ± 1,372.71	374.84 ± 1,159.74
Range of # of plankton specimens per grab /m³	1,021 ± 219,471	33 ± 26,001	120 ± 4,616	68. 78 ± 4,761.22
Average # of taxa per grab	10.94 ± 3.15	11.22 ±3.39	13.5 ± 5.2	13.83 ± 4.51
Range of # of taxa per grab	5 ± 18	3 ±15	6 ± 23	6 ± 21
Average density of specimens per station	18,803.83 ± 13,178.69	16,443.16 ± 22,375.34	4,137.58 ± 3,999.72	4,124.52 ± 2,962.18
Range of # of plankton specimens per station	8,793 ± 44,159	2,266 ± 61,575	597 ± 10,035	314 ± 8,351.26

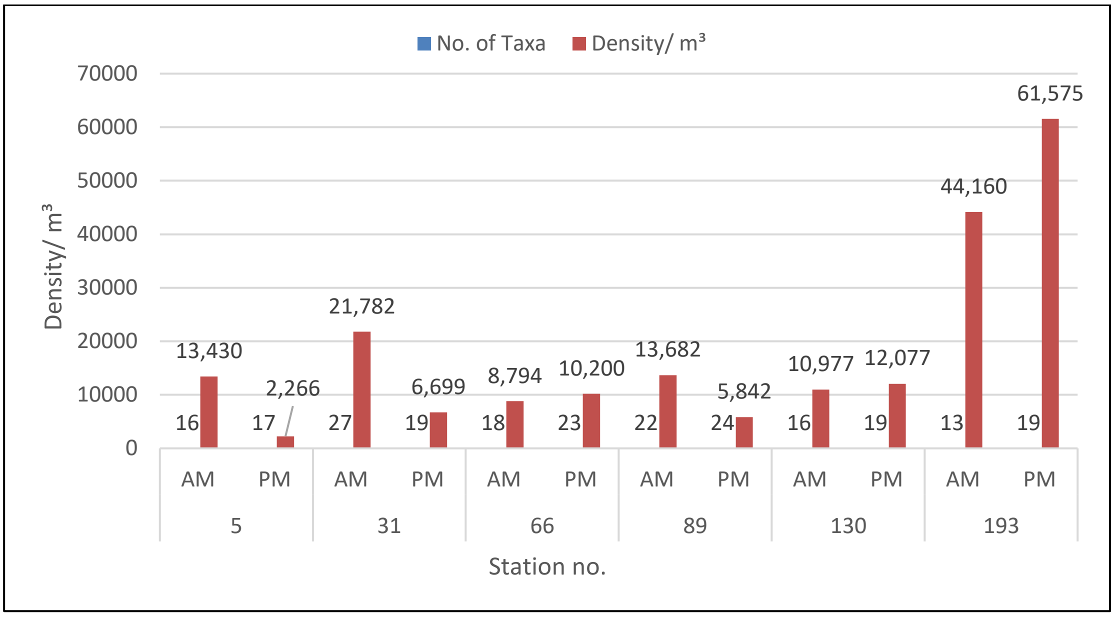
Summary of Baseline Assessment	Result (Baseline; August 2017) Phase 1		Result (Baseline; October 2017) Phase 2	
	A.M.	P.M.	A.M.	P.M.
Average # of taxa per station	18.67 ± 5.05	20.17 ± 2.71	23.33 ± 5.20	23.83 ± 5.85
Range of # of taxa per station	13 ± 27	17 ± 24	18 ± 30	14 ± 30
Station with highest density of plankton	193 (44,160 specimens)	193 (61,575 specimens)	193 (10,035 specimens)	193 (8,351 specimens)
Station with lowest density of plankton	66 (8,794 specimens)	5 (2,266 specimens)	31 (597 specimens)	31 (314 specimens)
Station with highest # of taxa	31 (27 taxa)	89 (24 taxa)	193 (30 taxa)	193 (30 taxa)
Station with lowest # of taxa	193 (13 taxa)	5 (17 taxa)	89 (18 taxa)	89 (14 taxa)
Most abundant organism	Temoridae (65.63%)	Temoridae (68.81%)	Eucalanidae (37.67%)	Sagittidae (7.65%)
Second most abundant organism	Luciferidae (4.07%)	Eucalanidae (7.23%)	Temoridae (9.90%)	Temoridae (6.65%)

Source: ESL 2017 Plankton Dataset (see Appendix D.13)

Figure 5-122 below shows the taxa and density for different Stations for Phase 1 sampling periods, both A.M. and P.M. Station 193 (PM) showed the highest density 61,575/m³ and Station 5 (P.M.) the lowest (2,266/m³). Station 89 (P.M.) recorded the highest number of taxa (24) and Station 193 (A.M.) the lowest (13). The overall density for August was 211,481/m³.

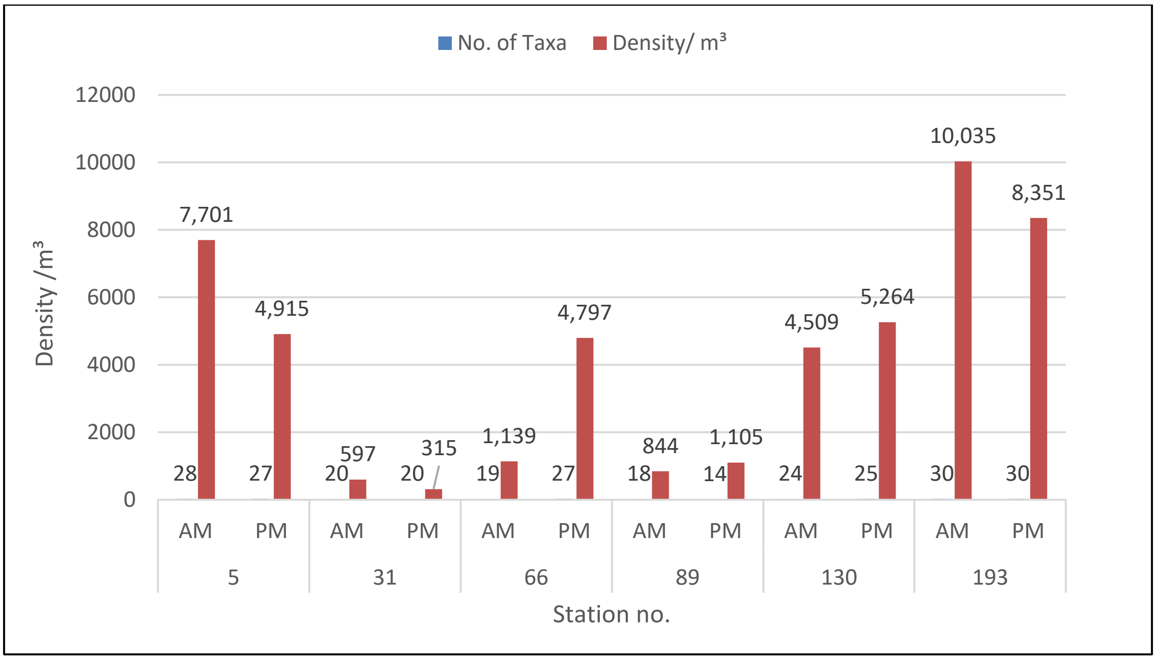
Figure 5-123 below shows the taxa and density for different stations for Phase 2 sampling periods, both A.M. and P.M. Station 193 (A.M.) showed the highest density (10,035/m³) and Station 31 (P.M.) the lowest (315/m³). Station 193 (A.M. and P.M.) recorded the most number of taxa (30) and station 89 the lowest (14). The overall density for October was 74,319/m³. Phase 1 recorded the highest density of plankton sampled. Stations 5 (A.M.) 31, 66, 89, 130 and 193 (P.M.) showed a decrease in planktonic density from Phase 1 to Phase 2 (Wet season to Dry season) while Stations 5 (P.M.) and 193 (A.M.) showed an increase in planktonic density from Phase 1 to Phase 2 (Wet season to Dry season).

Stations 5, 31 (P.M.), 66 (A.M.), 130 and 193 showed an increase in number of taxa from Phase 1 to Phase 2, while Stations 31 (A.M.) and 89 showed a decrease in number of taxa from Wet to Dry season.



Source: ESL 2017 Plankton Dataset (see Appendix D.13)

Figure 5-122: Graph Showing No. of Taxa and Density for August Sampling (Phase 1; A.M. and P.M.)



Source: ESL 2017 Plankton Dataset (see Appendix D.13)

Figure 5-123: Graph Showing No. of Taxa and Density for October Sampling (Phase 2; A.M. and P.M.)

Phyla distributions based on number of specimens as well as taxa recorded are presented in Table 5-42 below. A total of 10 phyla were identified. Arthropods were the most abundant organisms recorded for Phase 1 both A.M. and P.M sampling. and Phase 2 A.M. (August A.M. 91.66%, August P.M. 90.06%; October A.M. 77.4%); Chordata was the most abundant for Phase 2 P.M. sampling, 51.46%. Arthropods accounted for 53.33% of all planktonic specimens during August A.M. period, 53.19% for August P.M.; 42.37% for October A.M. and 44.07% for October P.M period.

Table 5-42: Phyla Distributions based on Number of Specimens & Number of Taxa Recorded (Phase 1 and 2 – August and October 2017)

Phylum	% Specimens				% Taxa			
	August 2017		October 2017		August 2017		October 2017	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
Animalia	0.03	0.03	0.33	0.10	2.22	2.13	1.70	1.70
Annelida	0.70	1.00	0.15	0.05	6.66	4.26	3.39	3.39
Arthropoda	91.66	90.06	77.4	33.55	53.33	53.19	42.37	44.07
Brachiopoda	0.02	0.02	0.56	1.03	2.22	2.13	1.70	1.70
Chaetognatha	5.12	6.28	13.25	11.81	8.88	8.51	8.47	6.77
Chordata	1.43	1.88	1.41	51.46	11.36	10.64	11.86	11.86
Cnidaria	0.22	0.14	2.57	1.64	4.44	4.26	20.34	20.34
Ctenophora	0.00	0.20	4.28	0.19	0.00	6.38	6.78	3.39
Hemichordata	0.05	0.07	0.00	0.00	2.22	2.13	0.00	0.00
Mollusca	0.76	0.33	0.06	0.17	6.66	6.38	3.39	6.78

Source: ESL 2017 Plankton Dataset (see Appendix D.13)

For August 2017, Phase 1, Temoridae, an arthropod, was the most abundant taxa recorded for A.M. sampling, accounting for 65.63% (74,042 of 112,823 total density/m³). Luciferidae, an arthropod was the second most abundant organism, 4.07% (4,589 of 112,823 total density/m³). Temoridae was the most abundant taxa for P.M. sampling accounting for 68.81% (67,888 of 98,658 total density/m³), Eucalanidae, an arthropod, was the second most abundant taxa, accounting for 7.23% (7,128 of 98,658 total density/m³), see Figure 5-124a,

Figure 5-124b and Figure 5-124c respectively. These pictures were taken from Phase 1 and 2 sampling.

For October 2017, Phase 2, Eucalanidae was the most abundant taxa recorded for A.M. sampling, accounting for 37.67 % (9,352 of 24,825 total density/m^3); Temoridae was the second most abundant organism, 9.90% (2,458 of 24,825 total density/m^3); while Sagittidae, a chaetognatha, was the most abundant taxa for P.M. sampling, accounting for 7.65% (3,784 of 49,493 total density/m^3); Temoridae was the second most abundant organism, 6.65% 3,293 of 49,493 total density/m^3). See Figure 5-124a, Figure 5-124c and Figure 5-124d respectively. These pictures were taken from Phase 1 and 2 sampling.

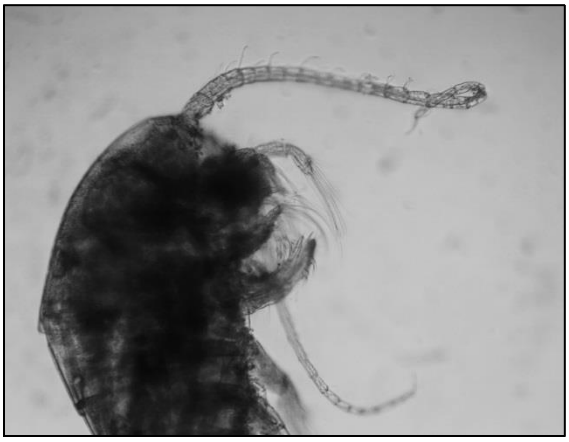


Figure 5 – 124a: A Temoridae Specimen

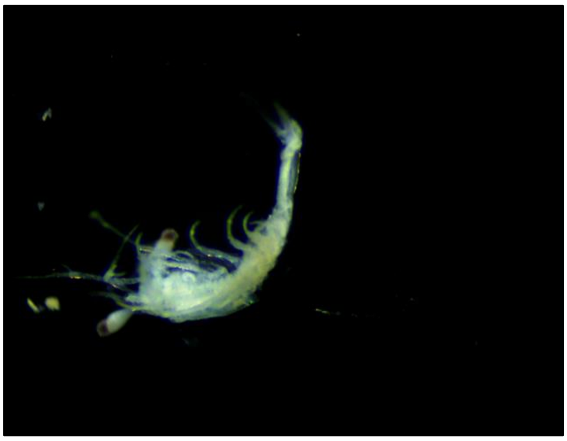


Figure 5 – 124b: A Luciferidae Specimen

Figure 5 – 124c: A Eucalanidae

Figure 5 – 124d: A Sagittidae feeding on Specimen Eucalanidae

Source: ESL 2017 Macrobenthic Dataset Reference Library

Figure 5-124: Most Abundant Taxa Recorded for Baseline Assessment Survey (August and October 2017)

Phase 1 and 2 planktonic data were subjected to multivariate analysis using PRIMER (Clarke and Gorley 2006). The PRIMER (Plymouth Routines in Multivariate Ecological Research) software is a statistical tool designed to analyse community ecology and environmental science data which are multivariate in character. Multivariate datasets include information on many species and environmental variables.

A number of tools were utilised within PRIMER to assist in the analysis of the biotic data. These include diversity indices and cluster analysis (dendrograms and MDS plots). One of the most common diversity indices, the Shannon Weiner Index (SWI), was calculated (using log base e), the results of which are displayed in Table 5-43 below. The average SWI was found to be 1.25 ± 0.48 for August A.M., 1.67 ± 0.56 for August P.M., 2.11 ± 0.28 for October A.M., 2.21 ± 0.2 for October P.M. Low SWI values can indicate a decrease in diversity, as the community may be dominated by a few taxa i.e. there isn't species evenness in the analysed samples. See Table 5-42 above.

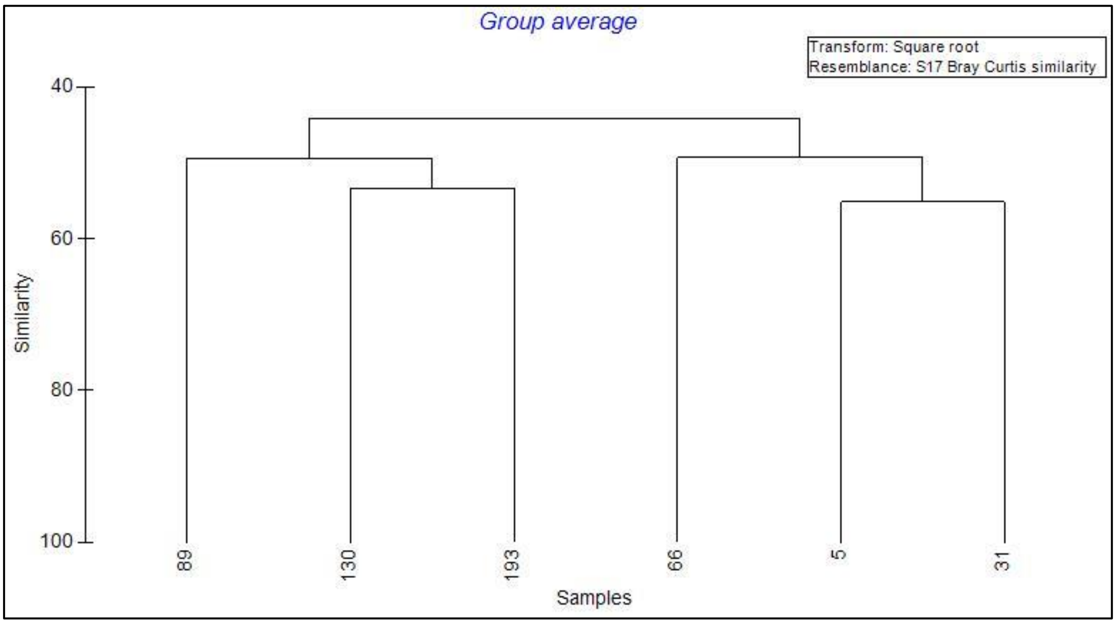
Table 5-43: Shannon Wiener Indices for the August and October 2017 Dataset

Station	Time	5	31	66	89	130	193
SWI August	A.M.	1.95	1.32	1.61	1.11	0.90	0.61
	P.M.	2.27	1.30	2.08	1.80	1.84	0.75
SWI October	A.M.	1.79	1.96	1.88	2.20	2.48	2.36
	P.M.	2.21	2.42	2.16	1.88	2.40	2.17

Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

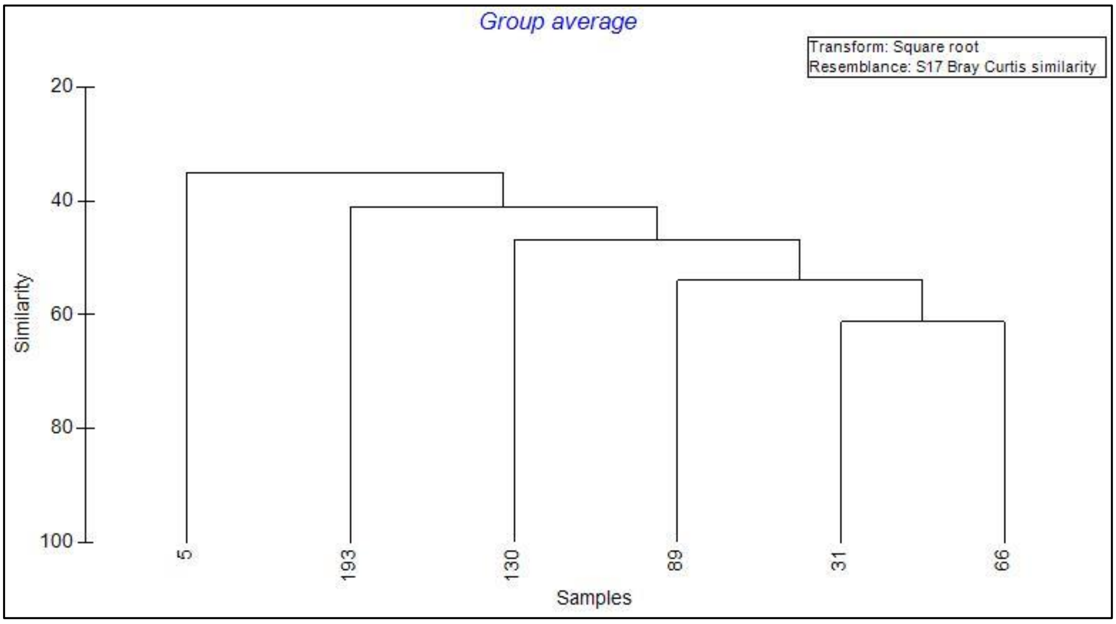
A cluster analysis was performed using the Bray-Curtis similarity coefficient to identify stations considered to be most similar based on species composition (Figure 5-125 to Figure 5-128 below). For Phase 1 Sampling, the resulting August A.M. dendrogram shows the most similar Stations were 5 and 31, with the highest similarity matrix of 55.12%. The resulting dendrogram for Phase 1 sampling of August P.M. shows the most similar Stations were 31 and 66, with the highest similarity matrix of 61.22%, suggesting stations were dissimilar.

For Phase 2 sampling, the resulting October A.M. dendrogram shows the most similar Stations were 5 and 193, with the highest similarity matrix of 46.65%, suggesting there was no significant clustering and the stations were dissimilar. The resulting dendrogram for Phase 2 sampling of October P.M. shows the most similar Stations were 5 and 66 with the highest similarity matrix of 59.81%. Two groups cluster out from each other i.e. their taxonomic composition is different from each other, but within the cluster may be similar.



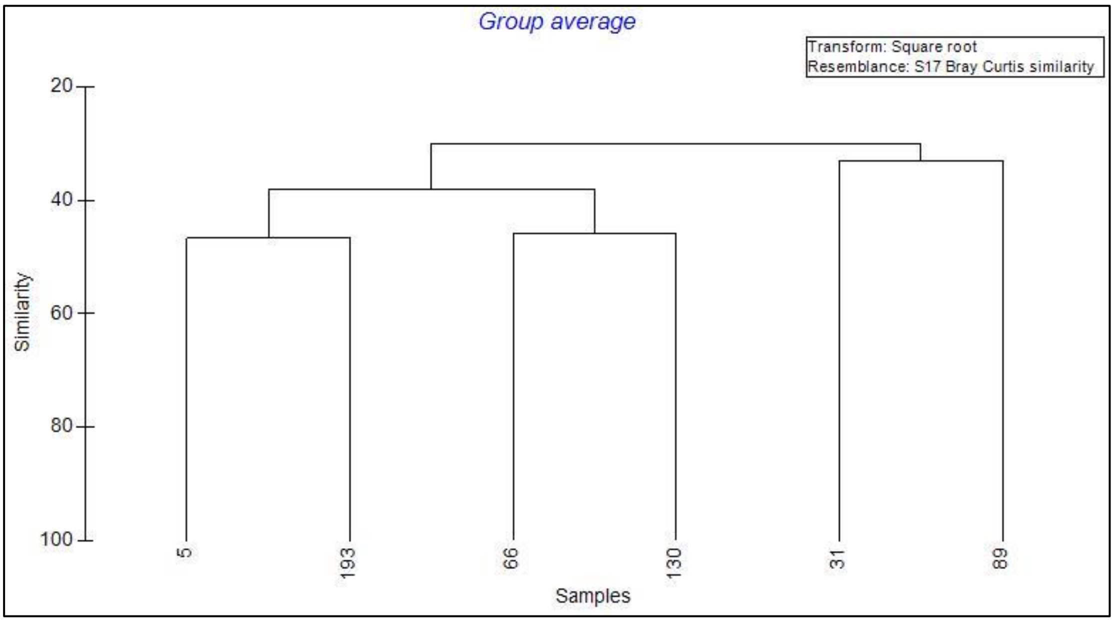
Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-125: Dendrogram Plot for Phase 1 (August A.M. 2017; Replicates Combined)



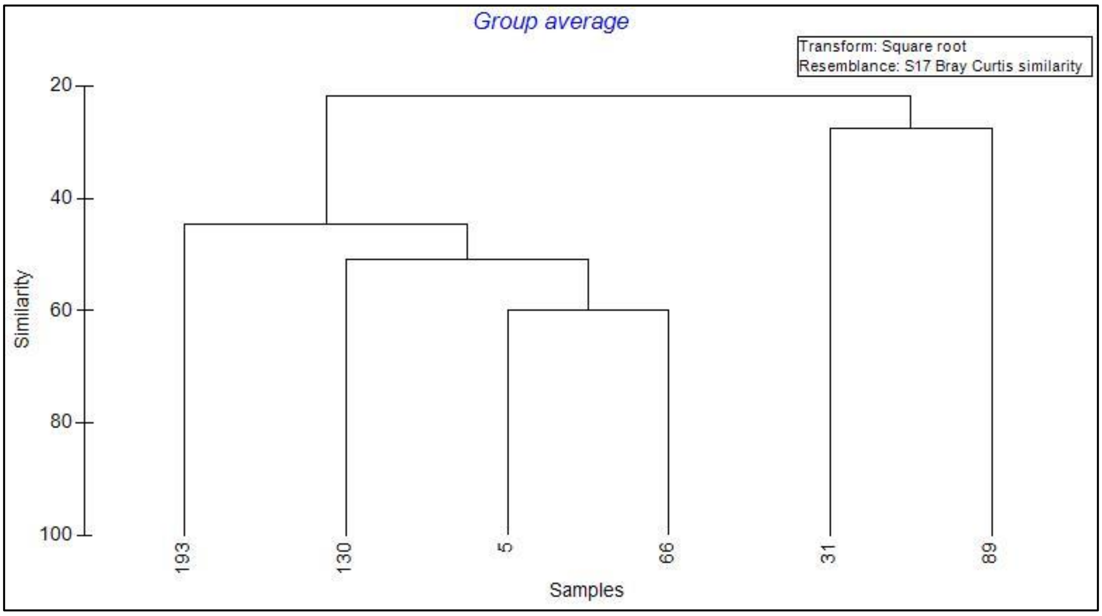
Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-126: Dendrogram Plot for Phase 1 (August P.M. 2017; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

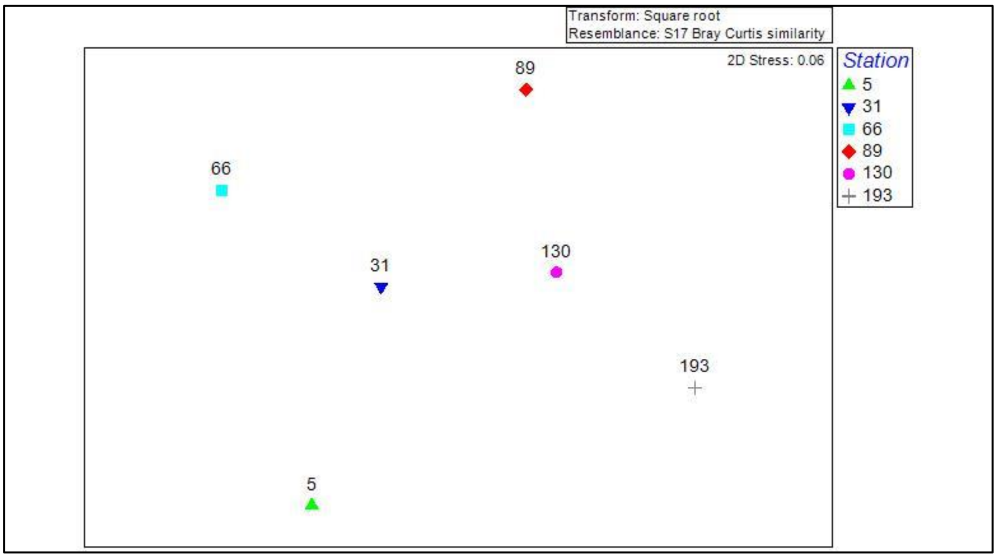
Figure 5-127: Dendrogram Plot for Phase 2 (October A.M. 2017; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

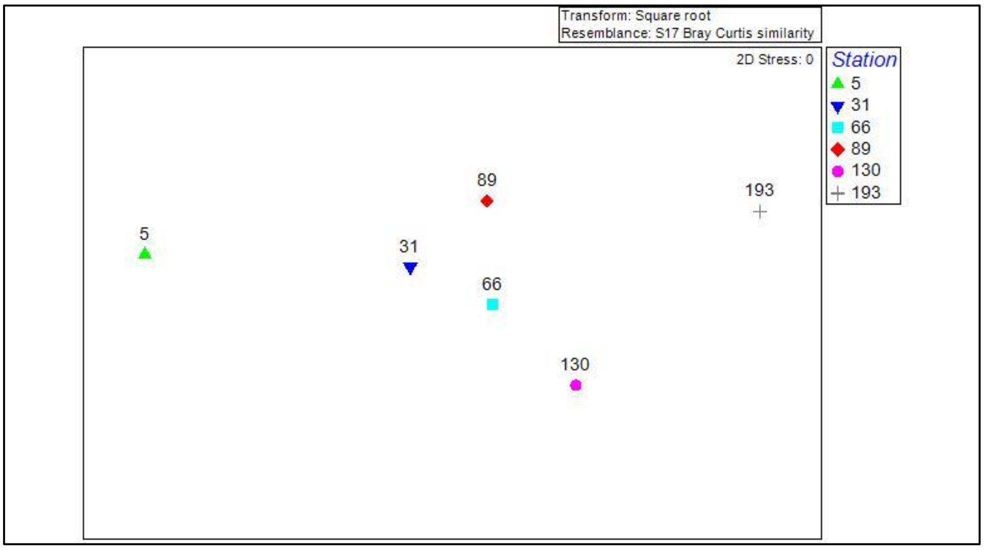
Figure 5-128: Dendrogram Plot for Phase 2 (October P.M. 2017; Replicates Combined)

Species composition was used to create MDS plots. These plots were then analysed to determine if significant clustering occurred among stations. The MDS plots showed that no significant clustering occurred for either A.M. or P.M. for Phase 1 (August 2017) and Phase 2 (October 2017). However, for the August P.M. MDS plot, Stations 31, 89 and 66 were closer together though there was no significant clustering observed. For October P.M. MDS plot, Stations 5 and 66 were closest together than for the A.M. MDS plot, though there was no significant clustering observed. See Figure 5-129 to Figure 5-132 below.



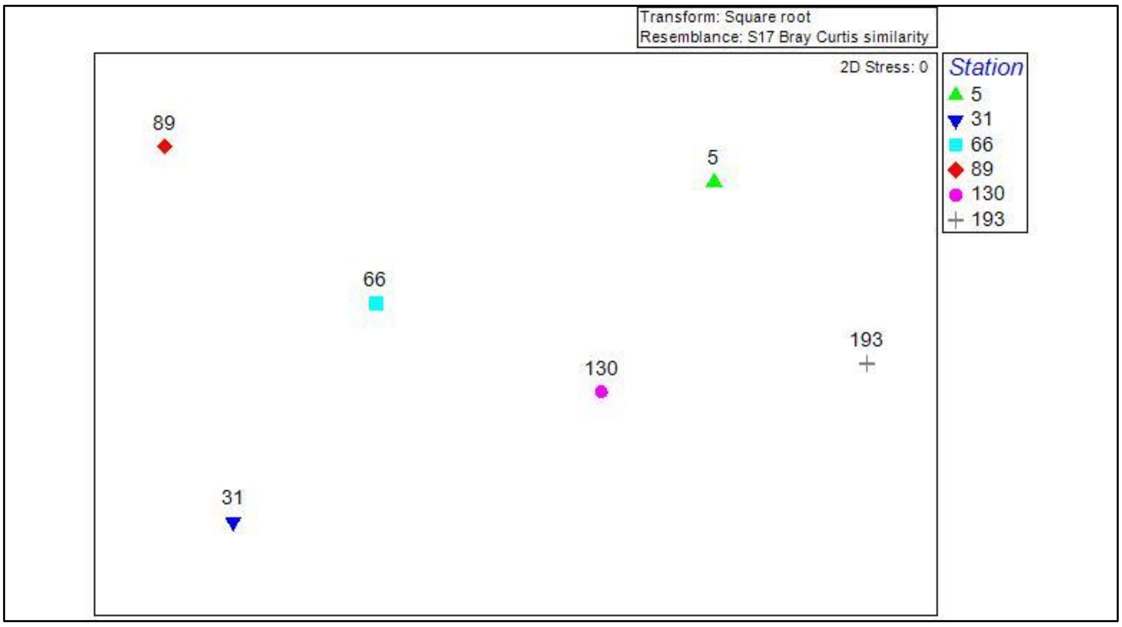
Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-129: MDS Plot of Species Composition for Phase 1 (August A.M. 2017; Replicates Combined)



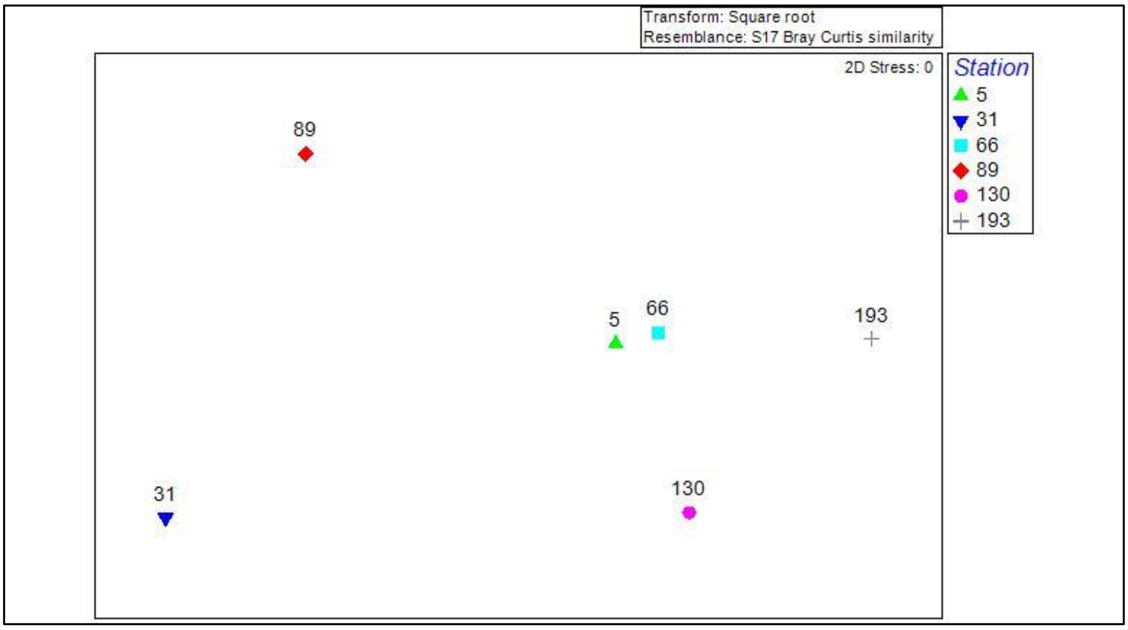
Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-130: MDS Plot of Species Composition for Phase 1 (August P.M. 2017; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-131: MDS Plot of Species Composition for Phase 2 (October A.M. 2017; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-132: MDS Plot of Species Composition for Phase 2 (October P.M. 2017; Replicates Combined)

The Draftsman Plot is a method used for examining correlations between variables in multivariate data. The results show any positive or negative correlations between abiotic data taken from water at sampling points. For Phase 1 sampling in August (Wet Season) the highest correlation was found between NH_3-N and COD in water, with a correlation value of 0.229. For Phase 2 sampling in October (Dry Season) the highest correlation was found between NH_3-N and COD in water, with a correlation value of 0.100. This means that as NH_3-N increased in water, an increase in COD was also observed for both sampling events.

The BEST (Bio-Env) Analysis sought to find the best match between multivariate sample patterns of an assemblage and that from the environmental variables associated with those samples. When biotic and abiotic data (water quality) were combined to determine the most significant variables, the abiotic factor which formed the highest correlation with the biotic data was found to be water Cr^{6+} for August A.M. and P.M. Phase 1 sampling, and the correlation value was 0.675 and 0.425 respectively**.** For Phase 2 sampling, October A.M., the abiotic factor which formed the highest correlation with the biotic data was found to be water NO^{2-} with a correlation value of 0.661. For October P.M. sampling, the abiotic factor which formed the highest correlation with the biotic data was found to be water COD with a low correlation value (0.325). It must be kept in mind that correlations do not prove a causal link.

5.4.2.3.1 Comparison of Phase 1 and Phase 2 (August and October 2017, respectively) for Baseline Assessment Survey

A general comparison was made between data collected for Phase 1 and 2 (August and October 2017, respectively). For Phase1 (August 2017) which occurred during Wet Season, a total density of 112,823/m^3 and 45 taxa were observed for A.M. sampling, and 98,658/m^3 and 47 taxa were observed for P.M. sampling see Table 5-41 above. The most abundant taxa and specimen density was Arthropoda for both A.M. and P.M. sampling for August. Chaetognatha was the second most abundant specimen density for both August A.M. and P.M. sampling (5.12% and 6.28% respectively). The second most abundant taxa for A.M. and P.M. sampling was Chordata (11.36% and 10.64% respectively). However, Ctenophora was found in August P.M. sampling only accounting for 0.20% of all specimen density and 6.38% of taxa detected. See Table 5-42.

For Phase 2 (October 2017) which occurred during the Dry Season, a total density of 24,825/m^3 and 59 taxa were recorded for A.M. sampling and 49,494/m^3 and 59 taxa were recorded for P.M. sampling. For October A.M. period, the most abundant taxa was Arthropoda, 77.4% and the second most abundant taxa was Chaetognatha, 13.25%. For P.M. sampling, Chordata was the most abundant taxa, 51.46% followed by Arthropoda, 33.55%. Hemichordata were not found for any October (Dry season) sampling. See Table 5-42 above.

There was an overall decrease in plankton density from Phase 1 sampling (August A.M.) through Phase 2 sampling (October A.M). Similarly, August P.M recorded a higher plankton density than October P.M. The highest density overall was August A.M. (112,823/m^3). August A.M. recorded the least number of taxa (45), and subsequent sampling showed an increase with the highest number of taxa recorded for October both A.M. and P.M. (59).

Similar organisms were found to be most abundant throughout the sampling event; Temoridae was found for all events as either most abundant (August A.M. and P.M.) or second most abundant (October A.M. and P.M.). A similar trend was observed for Eucalanidae; most abundant in October A.M., and second most abundant August P.M. Sagittidae was most abundant for October P.M. and Luciferidae was second most abundant for August A.M.

Station 193 recorded the highest plankton density for all events. Station 31 recorded the lowest density for October A.M. and P.M. sampling, and Stations 66 and 5 for A.M. and P.M. respectively for August. Stations 193 and 5 recorded the lowest number of taxa for Phase1 A.M. and P.M. respectively, and Station 89 recorded the lowest number of taxa for October sampling both A.M. and P.M.

Phase 1 and 2 were compared for A.M. and P.M; August A.M. with October A.M. and August P.M. with October P.M. Arthropods had the highest density for both A.M. sampling with October recording the higher number (103,417/m^3). Chaetognatha was the second most dense taxa, which was found in higher numbers in October (5,784/m^3). Cnidaria and Ctenophora had higher densities in August 637/m^3 and 1,061/m^3 respectively; see Figure 5-133 below.

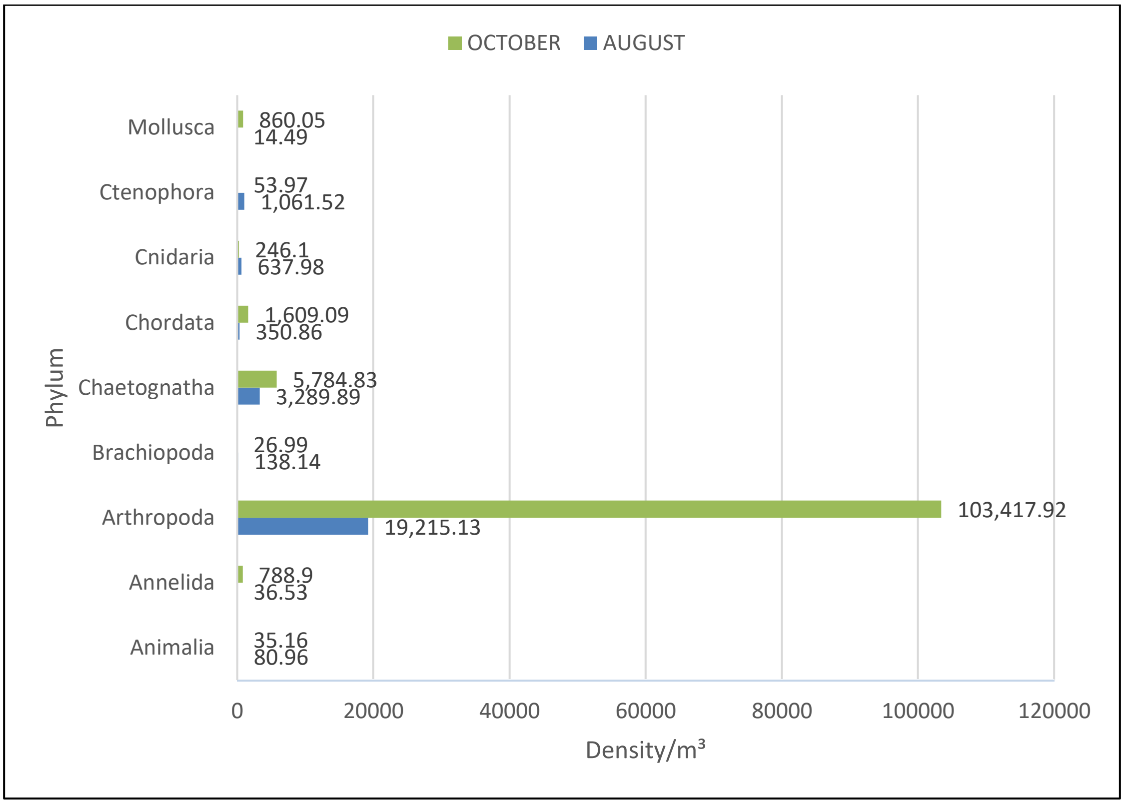
For P.M. sampling comparison, Arthropods had a higher density in August (88,849/m^3) than October (16,606/m^3); the same was also observed for Chaetognatha (6,195/m^3). Chordata recorded a higher density in October (25,470/m^3) than August (1,850/m^3; see Figure 5-134 below.

A difference in Arthropod densities from August A.M. to P.M., were observed, it showed an increase during the P.M. sampling event (88,849/m^3 total density). In October, the A.M. total density was higher (103,417/m^3) than the P.M. total density, which could be suggestive of diurnal movements.

The presence of 3 water zones offshore Suriname suggests an influence on plankton density. The first zone, the inner or Brown water zone, is one of high turbidity, low chlorophyll and DO levels (see Section 5.3.10.1 and Figure 5-45 above). The second zone, the Green water zone, is one of high primary productivity. These zones are not static, but rather dynamic, since their boundaries may shift in space and time depending on oceanographic conditions. It is possible that the recorded plankton densities may be a function of the study area comprising the Brown water zone, as opposed to some stations occurring in the Green water zone (see Section 5.3.10.3 and

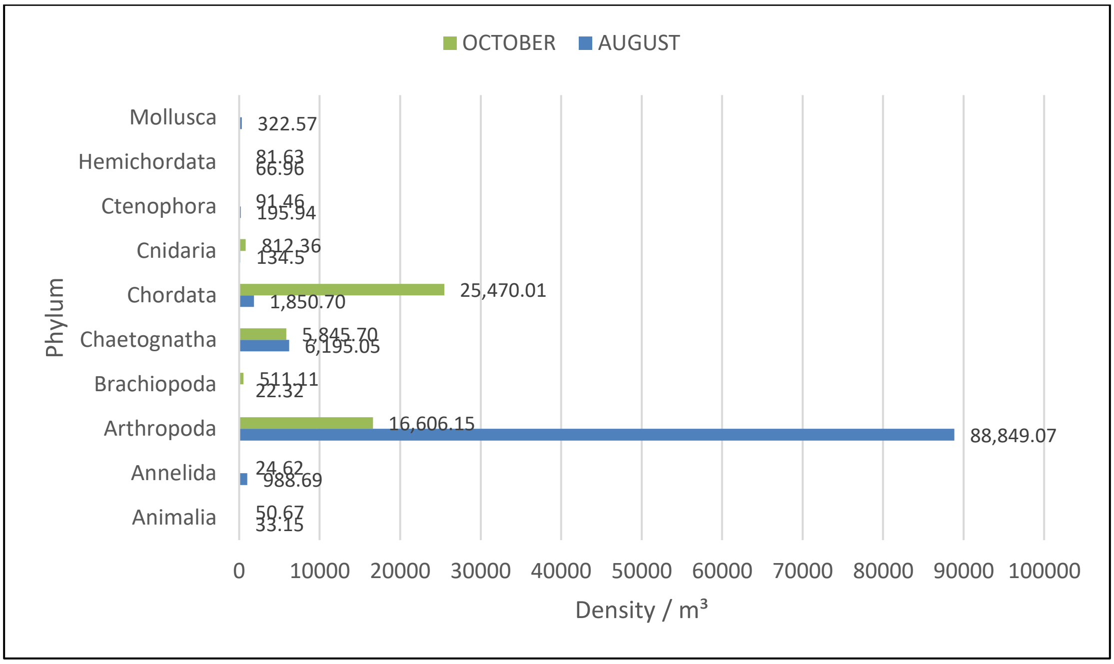
Figure 5-36 above). For example, the presence of Stations 5, 31 and 66 in the Brown water zone may possibly account for their low Plankton densities.

The shifting of these water zones may possibly account for the differences in taxa (Family) recorded, with station 193 recording the highest number of taxa for October A.M. and P.M. sampling but for August A.M. recorded the lowest number of taxa. Station 89 recorded the highest number of taxa for August P.M. but the lowest number of taxa for October A.M. and P.M. (see Table 5-41 above).



Source: ESL 2017 Plankton Dataset (see Appendix D.13)

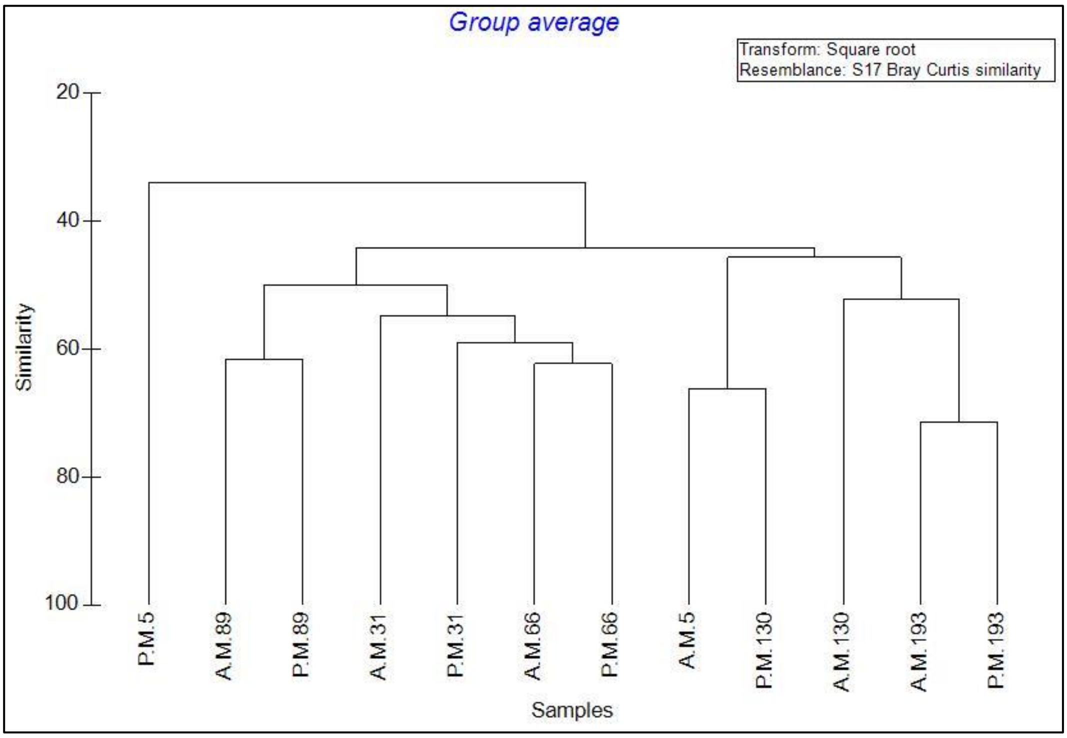
Figure 5-133: Bar graph showing Phylum and Density for August and October Sampling A.M.



Source: ESL 2017 Plankton Dataset (see Appendix D.13)

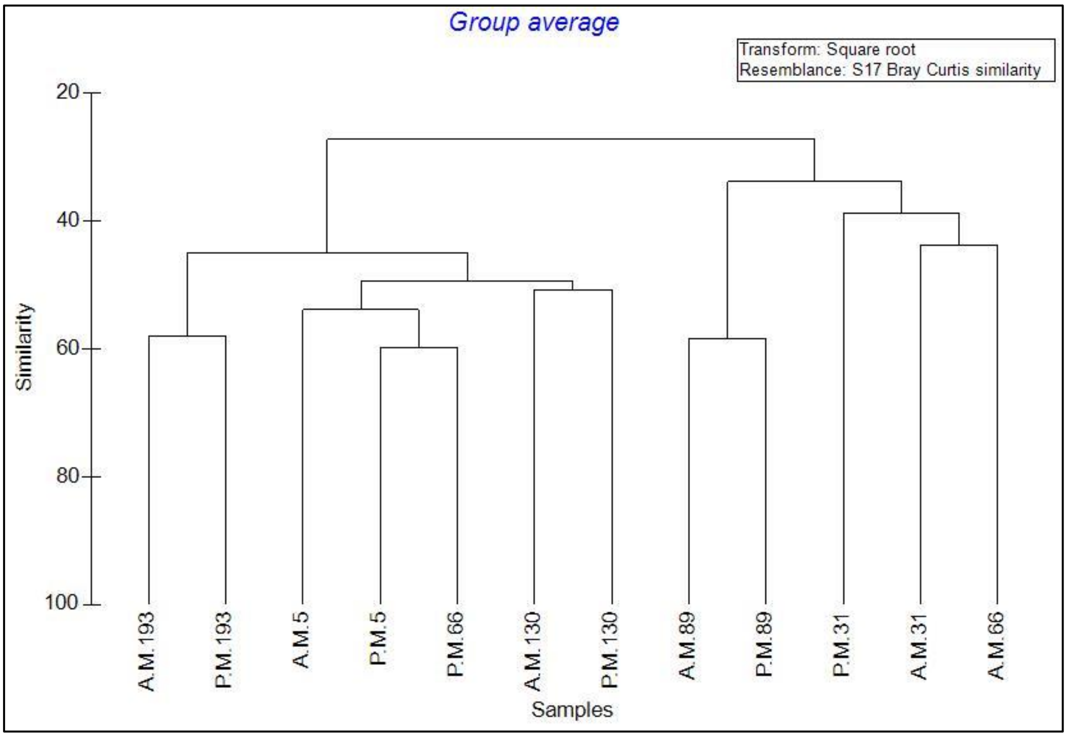
Figure 5-134: Bar graph showing Phylum and Density for August and October Sampling P.M.

Biotic datasets for Phase 1 and 2 were compared using cluster analyses in PRIMER. The resultant dendrogram and MDS plots (indicating A.M. and P.M. for each event) are presented in Figure 5-135 and Figure 5-136 below. For August, the most similar Stations were 193, with the highest similarity matrix of 71.45%, suggesting they are similar. Stations such as P.M. 5 cluster out differently from the rest suggesting a difference in species composition. For October, the most similar Stations were P.M. 5 and P.M. 66, with the highest similarity matrix of 59.81%. Other groups cluster out from the rest such as Stations 89 A.M. and P.M. and Stations 193 A.M. and P.M. suggesting their taxonomic composition is different from the rest. The resulting MDS plot for August showed the Stations which were closest together were 193. The MDS plot for October showed no significant clustering. See Figure 5-137 and Figure 5-138 below.



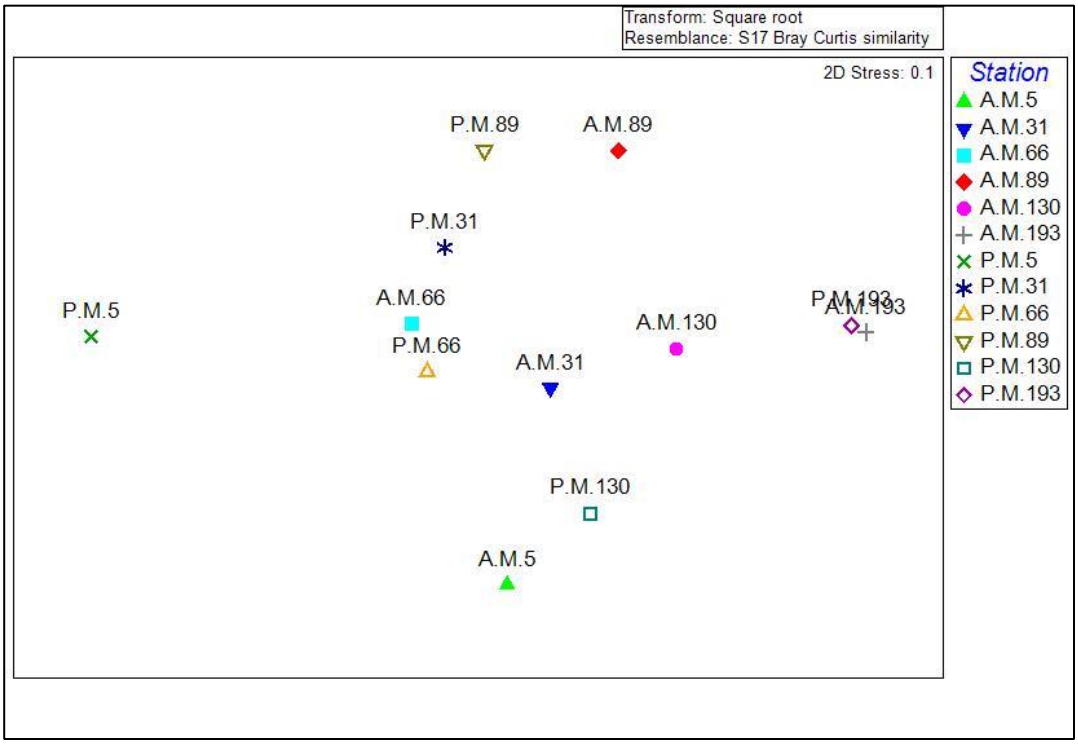
Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-135: Dendrogram Plot for Phase 1 (August A.M. and P.M.; Replicates Combined)



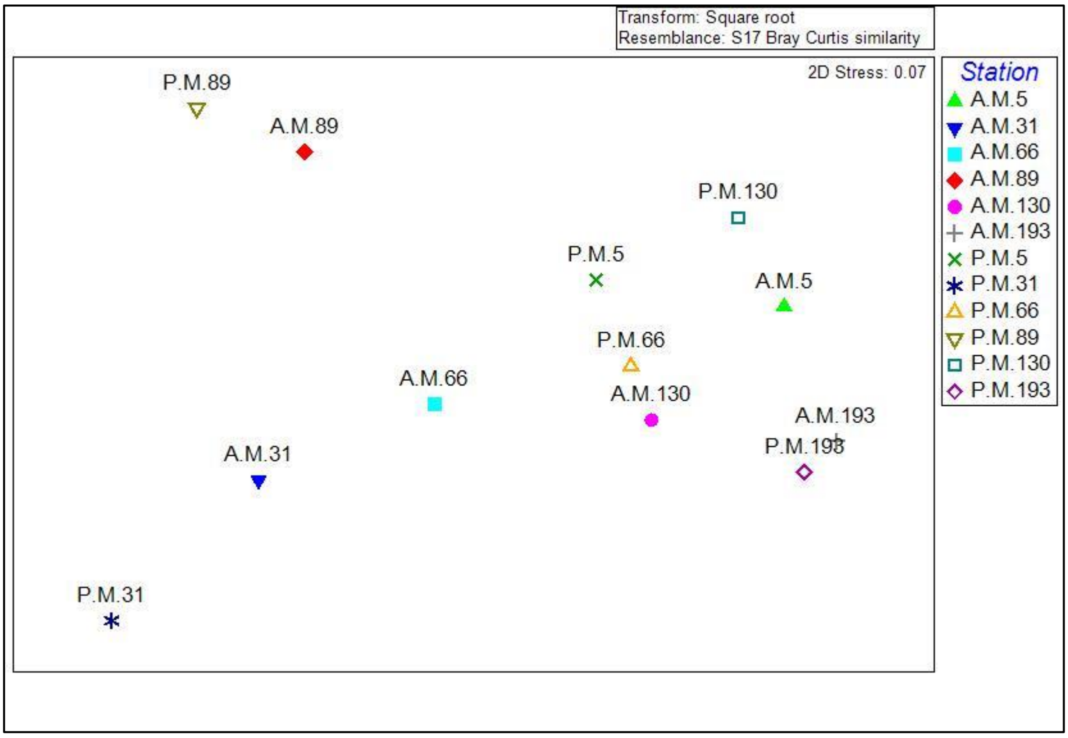
Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-136: Dendrogram Plot for Phase 2 (October A.M. and P.M.; Replicates Combined)



Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-137: MDS Plot of Species Composition for Phase 1 (August A.M. and P.M.)



Source: PRIMER Analyses run on ESL's 2017 Plankton Dataset (see Appendix D.13)

Figure 5-138: MDS Plot of Species Composition for Phase 2 (October A.M. and P.M.)

In conclusion, results indicate that the planktonic community was diverse at the time of Baseline Sampling Phase 1 and Phase 2 (August and October 2017) due to the presence of the inner water zone, with the highest density recorded for Phase 1 August A.M. This was followed by a decrease in plankton density for August P.M. and October A.M. then an increase in October P.M. There was also an increase in number of taxa from Phase 1 to Phase 2 sampling, with Phase 2 sampling recording 59 taxa for both events. There were no apparent significant correlations between biotic and abiotic data. Limits to sampling times and stations, coupled with little resources available on plankton studies in Suriname can hinder detailed interpretations of plankton data collected.

5.4.3 Marine Mammals

5.4.3.1 Sources of Data

Data regarding marine mammals within the Caribbean region and the Nearshore and offshore areas of Suriname is taken from several secondary data sources, including the following:

- '*Marine Mammals of Suriname*' by Husson 1978;
- '*Mammals of Suriname*' as compiled by the World Institute for Conservation and Environment (WICE 2010);
- '*Preliminary report to cetaceans and marine turtles observed in Suriname*' (de Boer 2013);
- '*Cetaceans observed in Suriname and adjacent waters*' (de Boer 2015);
- '*Environmental and Social Impact Assessment for Exploratory Drilling in Blocks 42 and 45, Offshore Suriname*' (CSA 2017);
- 'Environmental and Social Impact Assessment for Exploratory Drilling in Block 52 Offshore Suriname' (CSA 2015a);
- '*Marine Protected Species Survey as Part of the Nearshore 2D Seismic Acquisition Project Along the Coast of Suriname*' (CSA 2015c);
- IUCN Red List of Threatened Species (version 2017.3);
- CITES Appendices and Species Lists (2018);
- '*Elements for the Development of A Marine Mammal Action Plan for the Wider Caribbean: A review of Marine Mammal Distribution*' by Ward *et al.* 2001;
- '*Acoustic and Visual Survey of Humpback Whales (Megaptera novaeanglidae) in the Eastern and Southern Caribbean Sea'* by Swartz *et al.* 2003;
- '*Distribution and Status of Marine Mammals of the Wider Caribbean Region: An update of UNEP documents*' by Reeves 2005, which served as a review of Ward *et al.* 2001 and Swartz *et al.* 2003, among others;
- '*Preliminary Report on the IFAW Song of the Whale Caribbean Project, January-April, 2006*' by the International Fund for Animal Welfare (IFAW);
- '*Regional Management Plan for the West Indian Manatee, Trichechus manatus'* by UNEP/Caribbean Environment Programme by Khan 1995;

- '*FAO Species Identification Guide: Marine Mammals of the World*' by Jefferson *et al*. 1993; and
- Information on the ecology of the West Indian manatee, provided by the Manatee Conservation Trust website.

During the June to August 2017 (long wet season) and September to November 2017 (long dry season) water, sediment and macrobenthic field sampling program throughout Blocks A – D, offshore field technicians were asked to take note of any marine mammals observed, as well as record the GPS location of such sightings. A coastal ecological survey conducted in August 2010 for the POC ESIA for 2D and 3D Seismic Program (ESL 2012) also included incidental observations within the vicinity of Nearshore Block IV (which corresponds to roughly the western half of Block C). The results of these are summarised in Section 5.4.3.2 below. No other formal primary data collection exercise was undertaken to ascertain the presence of marine mammals in the Nearshore and offshore marine area of Suriname.

5.4.3.2 Review of Available Data

Marine mammals are large organisms with a long life expectancy. They also produce few offspring that tend to require some degree of parental care until maturity. They also exhibit slow maturity, and this, along with the fact that they produce few young, makes them particularly vulnerable to changing environmental conditions (UNEP CEP; n.d.). These taxa are considered to demonstrate the characteristics of K-selection, which apply to organisms whose reproductive and life history strategies are primarily adapted to life in an unchanging and limited environment where there is intense competition for resources (Beeby and Brennan 1997).

Most marine mammals are also migratory in nature and many species tend to be cosmopolitan (meaning that they can be found in all major oceans of the world). They include the orders Cetacea (whales, dolphins and porpoises) and Sirenia (manatees and dugongs). Other groups are not relevant in the Suriname context.

Appendix D.14 lists the 12 taxa of whales, 17 taxa of dolphins and the single sirenian which are found in the waters of Suriname and the Southern Caribbean in general, based on the work of: Husson 1978; WICE 2010; Ward *et al.* 2001; de Boer 2013; de Boer 2015; and information on distribution compiled from the IUCN Red List (Version 2017.3). These data indicate that the offshore waters of Suriname are taxonomically diverse with regard to cetaceans. This includes the shallower waters of the continental shelf area (which is approximately 100 m in depth and extends 150 km offshore) and the deeper waters of the Demerara Rise (4,000 m depths). These bathymetric features provide suitable conditions for the movement of cetaceans, where whales typically prefer deeper waters and dolphins can typically be found closer to shore within the shallower waters of the continental shelf (ERL 2002; 2003).

Taxa present in the offshore waters of Suriname include:

- Baleen whales, which are not toothed but filter food through baleen plates in the mouth;
- Toothed whales (odontocetes), which include Sperm whales, beaked whales and dolphins (which produce high-frequency vocalizations and utilises echolocation, unlike baleen whales); and
- The sirenian, West Indian manatee.

Baleen whales found in the offshore waters of Suriname include: Fin whale (*Balaenoptera physalus*); Sei whale (*B. borealis*); and Blue whale (*B. musculus*; see Figure 5-139 below); all of which are endangered (IUCN Red List 2017.3) and listed on CITES Appendix I (i.e. these taxa are threatened with extinction; therefore, trade is only permitted in exceptional circumstances). Other baleen whales known to occur in Suriname's offshore waters, such as the Humpback whale (*Megaptera novaeanglidae*) and Bryde's whale (*B. edeni*) are classified as Least Concern and Data Deficient, respectively (IUCN Red List 2017.3) and are on CITES Appendix 1[17]. de Boer 2015 recorded 3 sightings of Bryde's whale during May – September 2012 in water depths of 1,225 m (i.e. further offshore of Suriname and not in the vicinity of the Nearshore Blocks), but this species was not observed in the visual surveys conducted in June – November 2014 in the Nearshore area (CSA 2015c). Based on the foregoing, Bryde's whale may be found in the deeper waters of Suriname (further south of Blocks A to D during the proposed Project (April – December 2019).

Source: National Geographic 2018

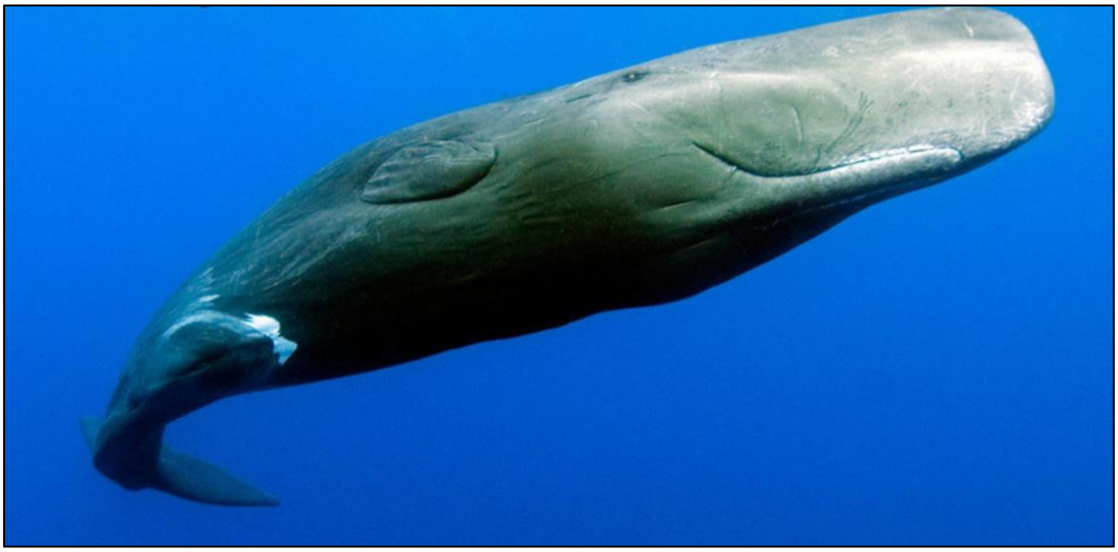
Figure 5-139: Blue Whale (*Balaenoptera musculus*)

Of the toothed whales, the Sperm whale (*Physeter macrocephalus;* Figure 5-140), as well as the Pygmy and Dwarf sperm whales (*Kogia breviceps* and *K. sima*) are found in Suriname's offshore waters. de Boer 2015 recorded

[17] *CITES Appendix I: Species is threatened with extinction; trade in specimens of these species is permitted only in exceptional circumstances.*

67 Sperm whale sightings in the deep waters of the Demerara Plateau, (including several subadults and at least 3 calves, but no adult males) between June and August 2012. CSA 2015c did not note the presence of this species in the Nearshore area. Based on the foregoing, it is likely that the Sperm, Pygmy and Dwarf sperm whales may be found in the deeper waters (further north of Blocks A to D) during the proposed Project (April – December 2019).

Of the toothed whales, the Sperm whale is listed as vulnerable, whilst the Pygmy and Dwarf sperm whales are Data Deficient on the IUCN Red List (2017.3). CITES entries also exist for these taxa: Appendix I (Sperm whale) and II[18] (Pygmy and Dwarf sperm whales).



Source: Allinson 2009

Figure 5-140: Sperm Whale (*Physeter macrocephalus*)

Beaked whales which occur include: Cuvier's, Gervais' and Blainville's beaked whales (*Ziphius cavirostris*, *Mesoplodon europaeus* and *M. densirostris*, respectively). These are listed as either Least Concern or Data Deficient (IUCN Red List version 2017.3) and are on CITES Appendix II.

Oceanic dolphins are the most taxonomically diverse group of cetaceans in the offshore waters of Suriname. Taxa are cosmopolitan, tropical and pantropical species; and include: Killer whale (*Orcinus orca*), Short-finned pilot whale (*Globicephala macrorhynchus*), Atlantic spotted dolphin (*Stenella frontalis*), Coastal dolphin (*Sotalia guianensis*) and Clymene dolphin (*Stenella clymene*), the latter of which is endemic to the Atlantic Ocean.

Most of the sightings recorded in de Boer 2015 were of dolphin taxa in Suriname waters during the period June – August 2012, in water depths ranging from 1,140 – 3,063 m): Melon-headed whale (*Pepenocephala electra*; 485 sightings, including subadults and calves); Fraser's dolphin (*Lagenodelphis hosei*; 520

[18] *CITES Appendix II: Species is not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilisation incompatible with their survival.*

sightings (often associated with *Sargassum* mats); False killer whale (*Pseudorca crassidens*; 3 sightings; Rough-toothed dolphin (*Steno bredanensis*; 65 sightings, including subadults and calves); Pantropical spotted dolphin (*Stenella atenuata*; 3 sightings of large groups of 30 – 200 individuals in 1); Spinner dolphin (*Stenella longirostris*; 9 sightings (in deep waters but also in the Nearshore area); Long-beaked common dolphin (*Delphinus capensis*; 2 sightings in the Nearshore area in June 2013); Guiana dolphin (*Sotalia guianensis*; 2 sightings at the mouth of the Suriname River). The Common bottlenose dolphin (*Tursiops truncatus*) was also observed in a group of 14 individuals off the coast of Trinidad in water depth of 48 m, and in the Nearshore area of Suriname in July 2013 (de Boer 2015).

CSA 2015c is the most recent available marine protected species survey (June to November 2014) within the Nearshore area of Blocks A to D, for which results are available, and its data support the taxonomic diversity of the marine mammals of the Nearshore area. The study recorded a total of 23 live animal sightings within Nearshore Blocks A to D, most of which were Guiana dolphins (17 sightings, with a total of 57 individuals recorded; see Figure 5-141 below). Other dolphin taxa which were observed in the Nearshore area during the study included: False killer whales (12 individuals); Atlantic spotted dolphins (43 individuals); and other dolphins which were not identified beyond the family level (45 individuals). All dolphin taxa known to occur in the waters of Suriname are either classified as Data Deficient or Least Concern on the IUCN Red List (version 2017.3) and are listed on CITES Appendix II. Thus, based on the foregoing, these dolphin taxa may be found within the Nearshore and offshore waters of Suriname, during the proposed Project duration (April – December 2019).

Source: Santos et al. 2010

Figure 5-141: Guiana Dolphin (*Sotalia guianensis*)

The offshore waters of the Southern Caribbean are considered to be an important region for the feeding, breeding and the migration of marine mammals (Ward *et al.* 2001). Some cetaceans may be resident in the Caribbean all year round; others, such as the Humpback whale migrate to the Caribbean region during the period January to May, which coincides with the breeding, birthing and nursing of calves (IFAW 2006). Humpbacks are considered regular non-residents in Caribbean waters (i.e. seasonal migrants). There are also indications that a few juvenile humpbacks may migrate to mid-Atlantic Nearshore waters to feed during winter when the majority of the population is heading towards the West Indies (Walsh 2002). Other whales, such as Bryde's whale (*B. edeni;* observed in May – September 2012; de Boer 2015), are known to feed in Caribbean waters, but it remains unknown if this taxon migrates throughout the region seasonally (Reeves 2005). Thus, based on the foregoing, it is likely that Humpback whales may be found in the deeper waters (further north of Blocks A to D) during the early part of the Proposed Project (April – December 2019).

Likewise, it remains unknown as to whether the Fin whale and Sei whale (verified in Surinamese waters by Husson 1978 actively migrate to the region for a particular purpose (for example, feeding). The Sperm whale has been commonly observed throughout the Caribbean region; Husson 1978 and de Boer 2015 note its presence in Surinamese waters (the latter during surveys in May – September 2012, in an area of deep water on average, about 2,152 m deep). Deep-diving taxa also noted as being present in offshore waters include Cuvier's beaked whale, which feeds on mesopelagic and deepwater benthic organisms (this taxon being considered as the most cosmopolitan of the beaked whales (Ward *et al.* 2001).

As indicated above, the diversity of odontocetes is higher than that of baleen whales in the waters of Suriname. Odontocetes feed mainly on squid, fish and other marine mammals (Ward *et al.* 2001). Particularly important to odontocetes is the use of echolocation; these species produce sound waves using a complex system of nasal sacs and passages, whose echoes are used for navigation and for location of food sources (University of California 2009). These odontocete species therefore are particularly vulnerable to high intensity underwater sound, or exposure to continuous vibration associated with offshore oil and gas exploration and development (Reeves 2005).

Sirenians are the only herbivorous marine mammals; they tend to be less dependent on marine environment than members of other marine mammal groups. Manatees spend much or all of their lives in fresh or brackish water (Jefferson *et al.* 1993) and move freely between these and marine conditions (Nathai-Gyan and Boodoo 2002). They are known to enter open waters to migrate (particularly during the wet season, when salinity levels are lower). It is believed that migrants from Venezuela or the Guianas supplement the manatee populations elsewhere in the Caribbean e.g. Trinidad (Khan 1995). Distribution of the West Indian manatee (*Trichechus manatus manatus*) is therefore limited to coastal marine, brackish, and freshwater areas of the tropical and subtropical waters of the southeastern United States, Gulf of Mexico, Caribbean Sea, and north-eastern coast of South America (Jefferson *et al.* 1993).

There are 2 subspecies of the West Indian manatee: the Florida manatee (*T. manatus latirostris*) and the Antillean manatee (*T. manatus manatus*), the latter of which is found in Suriname. In Suriname, the manatee does not occur in near-coastal waters, but is restricted to the lower freshwater reaches of rivers (i.e. downstream of the first rapids) and in the estuaries of rivers (Husson 1978). This is most likely as a result of the absence of its food (seagrasses) in the turbid coastal waters of Suriname. The West Indian manatee, which is classified as vulnerable on the IUCN Red List (Version 2017.3) and listed on CITES Appendix I, is not likely to be affected by the exploration drilling in Blocks A – D.

Based on the information presented above, toothed cetaceans may be affected by the proposed exploration drilling activities within Blocks A to D, albeit to varying extents. Coastal dolphins (which show high site fidelity and tend to enter or occupy shallower waters) in particular may be affected; however, the likelihood of finding larger marine mammals such as whales in the shallower waters of the continental shelf of Suriname is relatively low. Marine mammal species are considered protected species in Suriname, as decreed by the Game Act of 1954 and the Game Resolution of 2002.

Although 29 cetacean taxa may occur in or travel through Blocks A to D, the coastal dolphin *Sotalia guianensis* is probably the only taxon that is continuously (permanently) present in the area, although this taxon is apparently mostly restricted to river estuaries (used for feeding and breeding; ESL 2013b). This is also the taxon with the most restricted distribution of the cetaceans of Suriname (Caballero *et al.* 2007). *S. guianensis* is commonly observed within the Suriname River Estuary; it was observed there at 2 locations (one within Block C and one within the river mouth to the south of the Block) during a coastal ecological survey in August 2010 (ESL 2013b; see Figure 5-121 above). Its presence in this area was also confirmed by fisherfolk and a representative of the Green Heritage Fund Suriname (ESL 2013b), as well as specified above in de Boer 2015 and CSA 2015c. However, neither this taxon, nor any other taxon known to occur in Suriname's waters (see Appendix D.14) were observed during the long wet and dry seasons' field sampling programs for this ESIA study.

5.4.4 Sea Turtles

5.4.4.1 Sources of Data

Data regarding marine turtles along the coast of Suriname which is presented here is taken from several secondary data sources, including the following:

- '*An Assessment of the Leatherback Turtle Population in the Atlantic Ocean*' by the Turtle Expert Working Group of the NOAA National Marine Fisheries Service (TEWG 2007);
- '*An Atlas of Sea Turtle Nesting Habitat for the Wider Caribbean Regio*n' by Dow *et al*. 2007, particularly for information on nesting locations of the marine turtles along the west coast;
- '*Preliminary report to cetaceans and marine turtles observed in Suriname*' (de Boer 2013);
- '*Environmental and Social Impact Assessment for Exploratory Drilling in Blocks 42 and 45, Offshore Suriname*' (CSA 2017);
- '*Environmental and Social Impact Assessment for Exploratory Drilling in Block 52 Offshore Suriname*' (CSA 2015a);
- '*Marine Protected Species Survey as Part of the Nearshore 2D Seismic Acquisition Project Along the Coast of Suriname*' (CSA 2015c);
- '*Estimated turtle by-catch by the coastal fishing fleet of Suriname*', prepared by Madarie 2006 for the World Wildlife Fund (WWF) Guianas;
- '*EIA for Exploratory Drilling Project, Block 30, Offshore Suriname*', prepared by ESL for Repsol YPF (ESL 2007); and
- '*Environmental Impact Statement, 2D Seismic Survey, Offshore Suriname*', prepared by Baglee *et al.* 2004.

During the June to August 2017 (long wet season) and September to November 2017 (long dry season) water, sediment and macrobenthic field sampling program throughout Blocks A – D, offshore field technicians were asked to take note of any sea turtles observed, as well as record the GPS location of such sightings. A coastal ecological survey conducted in August 2010 for the POC ESIA for 2D and 3D Seismic Program (ESL 2012) also included incidental observations within the vicinity of Nearshore Block IV (which corresponds to roughly the western half of Block C). The results of these are summarised in Section 5.4.4.2 below. No other formal primary data collection exercise was undertaken to ascertain the presence of sea turtles in the Nearshore and offshore marine area of Suriname.

5.4.4.2 Review of Available Data

Sea turtles are late-maturing and long-lived, and are among the most migratory of all Caribbean fauna (Dow *et al.* 2007). Six of the 7 species of sea turtles which are known to exist are indigenous to the wider Caribbean region (Dow *et al.* 2007). Of these, 5 are known to occur in Suriname's waters:

- Leatherback turtle (*Dermochelys coriacea*)

- Green Turtle (*Chelonia mydas*)
- Hawksbill (*Eretmochelys imbricata*)
- Olive Ridley (*Lepidochelys olivacea*) and
- Loggerhead turtle (*Caretta caretta*)

The first 4 nest regularly along the coast; however, the Loggerhead turtle has been observed only occasionally in Suriname waters and has only been known to nest on one occasion, preferring to nest instead along the coast of Venezuela (Reichart *et al.* 2003). Notes (inclusive of photographs) on these 5 marine turtle species are presented in Appendix D.15.

Turtle nesting takes place along the eastern portion of the Surinamese coastline, from the Marowijne River estuary to Braamspunt, just east of the Suriname River estuary (see Figure 5-121 above). The Galibi Nature Reserve (GNR) and the beaches within it are internationally important nesting habitats for Leatherback (see Figure 5-142 below), Green and Olive Ridley turtles, and to a lesser extent, Hawksbill turtles (see Figure 5-143 below). The Olive Ridley in particular is known to come ashore within the GNR in waves of hundreds (referred to locally as 'arribada'). High turtle nesting density along this stretch of coast may be as a result of suitable beach morphological conditions for nesting (sediment type, beach slope etc.) as well as the relatively undisturbed nature of the habitat (as a result of limited to no human development in the coastal area).

Source: Nichols 2015

Figure 5-142: A Leatherback Turtle (*Dermochelys coriacea*) during Nesting

Source: Freund 2018

Figure 5-143: *Eretmochelys imbricata*, Hawksbill Turtle (Freund 2018)

Turtle nesting density is also high at Matapica and Danica Beach within the Commewijne MUMA (see Figure 5-121 above), and there are also several nesting sites within the Wia-Wia Nature Reserve (Bigisanti; see Figure 5-121 above). Between February and June 2010, STINASU registered approximately 32,000 sea turtles on the beaches of Galibi and Matapica, which was double that recorded the following year (February – August 2009; 17,000; CSA 2017). It has also been estimated that over 40% of the world Leatherback population nests in Suriname and French Guiana (Spotila *et al.* 1996); passive integrated transponder tagging studies have shown that at least 1,500 – 5,000 females per year nest in Suriname, with an increase in the number of Leatherbacks nesting from 201 in 1968 to 12,401 in 1985 (Reichart and Fretey 1993), owing to the loss of French Guiana nesting beaches to coastal erosion (Schulz 1975). Between 1999 and 2005, the number of Leatherbacks nests ranged from 6,000 to 31,000 (Hilterman and Groverse 2007).

The turtle nesting beaches shown in Figure 5-121 above occur shoreward of Blocks C and D, and therefore, these may potentially be affected by Project activities. It is important to note that the dynamic nature of the Suriname coastline results not in stationary nesting beaches, but in a gradual east-west shift of nesting beaches along the coast. However, no beaches were observed along the coast of the district Saramacca (J. Mol, *pers. comm*. in ESL 2013b) which is adjacent to the eastern portion of Block C and the western portion of Block B. Turtle nesting beaches are also not known to occur to the west of the

Suriname River Estuary (although turtles are known to have been nesting at a beach near the village Nieuw Nickerie (called ‘Turtle Bank’; Hielkema 2009).

Nesting seasons can be used to infer the presence of marine turtles in the Nearshore and offshore areas. In general, nesting occurs along the eastern Suriname coast from February to August, but different taxa nest at different times. For example, Leatherback turtles (whose nesting density is very high), nests from March to August, with peak nesting from April to June, though other sources cite minor variances, such as Reichart and Fretey 1993, which states nesting can begin as early as January; and Hilterman and Groverse 2007, which states that the nesting season is from April to early August, peaking from May to June. The Green turtle nesting season commences in February and ends in July (Reichart *et al.* 2003), with peak nesting in April and May. This species also nests very heavily along the coast. Leatherback and Green turtles nest at the majority of the sites along the coast (Figure 5-121 and Appendix D.15). The nesting season of the Olive Ridley is relatively shorter and lasts from Mid-May to end of July/August (Reichart *et al.* 2003). Nesting by this species shows wide fluctuations and the number of nesting events is believed to be declining, but beaches in the GNR remain critical nesting habitat for this taxon. Hawksbill turtle nests during generally the same period as the Olive Ridley, but, on average, only 25 – 30 nests are made per year by this species. It should also be noted that young turtles (all taxa) may emerge as late as October.

Unlike the other sea turtles, the Green turtle is mostly herbivorous, and, due to the absence of seagrass beds in the offshore area (see Section 5.4.1.5 above), this taxon is not expected to linger in Surinamese coastal waters after nesting. Leatherback, Olive Ridley and Hawksbill turtles are more carnivorous, and feed on fish, crustaceans and jellyfish. Research conducted by the Turtle Expert Working Group (TEWG 2007) of the US NOAA indicated that turtles may be found within the offshore area of the Wider Caribbean (including Suriname) outside of the nesting season (February to August).

Tagging studies indicate that marine turtle taxa (Leatherback turtles, in particular) utilise the whole of the North Atlantic Ocean for movement between nesting locations and breeding and feeding grounds (TEWG 2007). In addition, WWF Guianas and Sea Turtle Conservancy have been involved in the satellite tracking of marine turtles in Suriname, particularly during the nesting seasons. The data (from 2005 – 2006 and 2012) revealed that turtles move through the offshore area, with turtles migrating from Shell Beach in Guyana to beaches in Suriname (Sea Turtle Conservancy 2011), and that Leatherback turtles migrate north across the Atlantic towards the Gulf Stream area, Africa, Canada or the Caribbean, whilst Green turtles follow the coastline easterly then southerly towards Brazil (Ferraroli *et al.* 2004; Baudouin *et al.* 2015). Tracking data from tagged adult female Leatherback turtles obtained in 2012 confirmed the northerly movement of this taxon from Matapica Beach (see Figure 5-121), as well as the movement of Green turtles eastwards away from Suriname after nesting (Sea Turtle Conservancy & WWF Guianas 2016).

Available satellite tracking data showing the migration routes for 3 adult female Leatherback turtles which nested in nearby French Guiana (see maps provided in Appendix D.16) indicate that this species moves to its feeding grounds in the Atlantic Ocean almost immediately after nesting (Sea Turtle Conservancy 2010). To date, no such satellite tracking data are available for the Olive Ridley and Hawksbill turtles from Surinamese beaches. Thus, it can be inferred that the Leatherback and Green turtles do not remain in the offshore area of Suriname for any extended period of time after nesting, but rather move to feeding grounds located elsewhere in the Caribbean. Appendix D.16 shows that the 2005 – 2006 satellite track data for 2 adult female Leatherback turtles left Suriname after nesting via Samsambo Beach, which is shoreward of Block D (see Figure 5-121 above). Thus, it is likely that turtles may use the eastern margin of the Project Area for migration through the Nearshore and offshore area. Additionally, fisherfolk indicated in ESL 2013b that marine turtles are occasionally caught in fishing nets within Block IV (the western half of Block C).

Regarding observations within Blocks A to D, no marine turtles were observed incidentally[19] by the Field Team during the long wet and dry seasons' 2017 field sampling programs for this ESIA study, nor were any observed within Block IV (western half of Block C) during the August 2010 coastal ecological survey (part of the scope of which was to observe the area for marine turtles; ESL 2012). No marine turtles were observed incidentally[20] during the September 2010 marine field surveysfor the POC ESIA for Exploration Drilling within Block IV (ESL 2013b).

However, 4 sightings of Leatherback turtles (4 individuals) were recorded within Blocks A to D during June – November 2014, during the marine protected species survey as part of the Staatsolie Nearshore 2D seismic acquisition project (CSA 2015c). Marine turtles were also observed further offshore during May – September 2012 in water depths ranging from 1,322 – 1,349 m, during a dedicated observation study (de Boer 2013; 2015). This study recorded 3 sightings of which the taxa were unconfirmed, but based on general characteristics of carapace and proximity to *Sargassum* beds on the Continental Plateau of Suriname and Guyana (Feuillet and de Thoisy 2007), these specimens were thought to be either Green, Loggerhead of Olive Ridely turtles. An additional 5 sightings were recorded in shallower waters ranging is depths of 45 – 65 m, during the period December 2008 to February 2009 during a previous study (de Boer 2013), in which Green, Loggerhead and Leatherback turtles were recorded. Based on the foregoing, marine turtles are expected to be found within the Nearshore area during the proposed Project (April to December 2019).

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[19] *Incidental observations refer to observations made by members of the Field Team while sampling is ongoing, i.e. there is no dedicated personnel carrying out watches to determine the presence of these species. The 2010 and 2017 field surveys mentioned above refer to incidental observations. The August 2010 coastal ecological survey was executed with one of the aims being to actively search for these species, hence this was not considered to be incidental.*

[20] *See Footnote directly above.*

Taking the foregoing into account, and given that no wells are proposed to be drilled within Block D (see Figure 5-121 above), it is expected that the marine turtles would not suffer a significant impact from exploration drilling outside the nesting seasons identified above. However, given the sensitive nature of the taxa (see below), and the fact that drilling (proposed to occur from April – December 2019) will coincide with the turtle nesting season (January/February – August, all taxa combined, with peak nesting in April – June), full consideration will be provided to these taxa during the impact assessment exercise.

It remains useful to keep in mind the sensitive nature of marine turtle taxa. The Leatherback, Olive Ridley and Loggerhead turtles are classified as vulnerable on the IUCN Red List (Version 2017.3). This represents a decrease in the vulnerability of Leatherbacks (previously classified as critically endangered since 2000), owing to the estimation of global population change based on subpopulations globally (Wallace *et al.* 2013). In fact, Hawksbill and Green turtles are classified as more vulnerable taxa in comparison; both are classified as endangered on the IUCN Red List (Version 2017.3). In addition, all 5 species are listed on CITES Appendix I.

Locally, marine turtles suffer from several human and natural threats, the most important being death caused by drowning in shrimp trawls and drifting gill nets, and over-exploitation of turtle eggs by local Amerindians (Hielkema 2009). The most recently available data on the capture of marine turtles indicate that, before the introduction of Turtle Exclusion Devices (TEDs) in 1999, Surinamese shrimp trawlers captured an estimated 3,200 turtles per year, of which 50% died (Tambiah 1994 cited in Baglee *et al.* 2004; see Madarie 2006 for turtle by-catch by SK gill netters). The high number of by-catch related deaths is indicative of the high abundance of turtles in the offshore area.

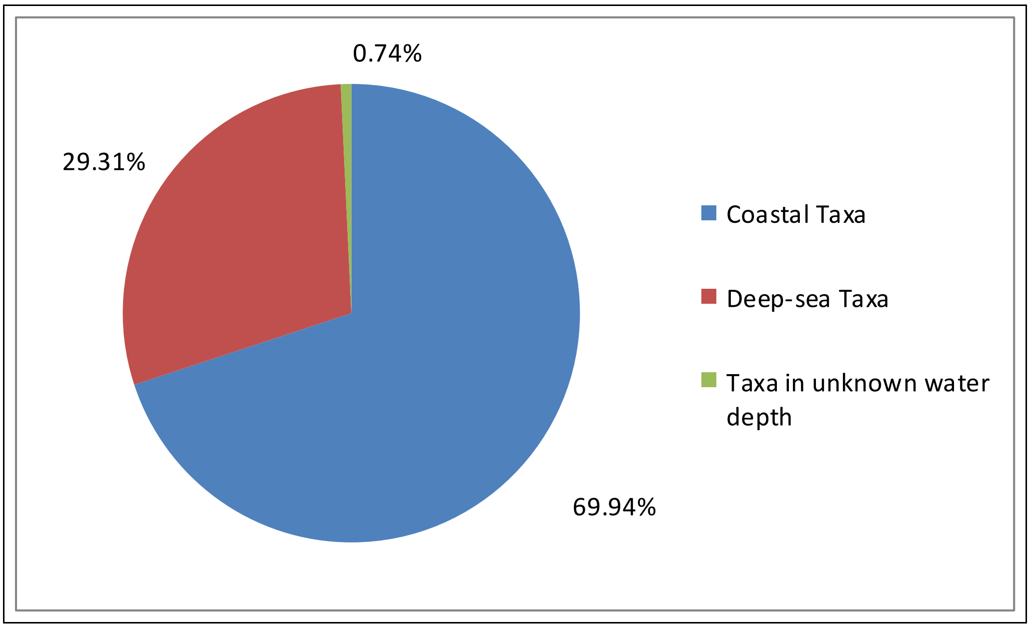
Several local legislative provisions have been put in place to ensure the overall protection and conservation of marine turtles in Suriname. Marine turtles are designated protected species under the Game Act of 1954 and Game Resolution of 2001. Additionally, the Sea Fisheries Law has regulations in place for the creation of a 'no-fishing zone' within 15 km from the shore near the Galibi beaches (where kilometre-long drifting gill nets used by SK boats are forbidden, though smaller nets of local fishermen are still allowed; see Section 5.5.7 and Figure 5-169 below).

The use of TEDs in trawl nets has also been made compulsory since 1999 (as a result of the pressure of shrimp-export restrictions by the USA and EU). Under the Nature Protection Act of 1954, nature reserves with turtle nesting beaches are established at Galibi and Wia-Wia. Protected areas other than nature reserves were established under the Planning Act (e.g. the Commewijne MUMA which includes the important Matapica/Danica beaches).

5.4.5 Fish & Shellfish

There are several sources of published information on the fish fauna of Suriname. These include: Uyeno *et al.* 1983; several publications by Boeseman (1948; 1952; 1953; 1954; 1956; and 1963) for marine species; Vari 1982 and MAS 2007 for estuarine species; and Lowe-McConnell 1962, Leopold 2004, Keith *et al.* 2000 and Menezes *et al.* 2003 for species found on neighbouring shelf areas. In total, 539 fish taxa are known from Suriname's marine ecosystems (see Figure 5-144 below and Appendix D.17). Of these, 158 taxa (29.31%) are known to occur in the deep sea (> 150 m depth) based on Uyeno *et al.* 1983. These deep sea taxa are not considered to occur in the relatively shallower continental shelf ecosystems of Suriname, though some marine fish species undertake up-river migrations to freshwater habitats to reproduce, for example, several anchovy taxa belonging to the family Engraulidae (Vari 1982; J. Mol *pers. comm*. in ESL 2012). Others migrate up-river to feed, e.g. Tarpon (*Megalops atlanticus*; J. Mol *pers. comm*. in ESL 2012).

The fish taxa of the continental shelf off Suriname (coastal species) comprise the bulk of total number of taxa (377 of 539) and consists of 16 sharks (most in the order Carcharhiniformes and one in the order Orectolobiformes); 14 rays (order Rajiformes; and 347 bony fishes (see Appendix D.17). A further 4 taxa (0.74%) belonging to the order Lophiiformes (Anglerfish) are known to occur but at unknown water depths.



Source: Adapted from data presented in Uyeno et al. 1983

Figure 5-144: Proportion of Fish Taxa in the Waters of Suriname

The Decapoda (shrimp and crabs) of Suriname have been described by Holthuis 1959 and are listed in Appendix D.17. In total, there are approximately 115 decapod taxa present in the marine, brackish and freshwater environments, and these are distributed amongst 27 families. Approximately 100 of the 115 taxa are marine and brackish water ones. Commercially important marine decapod taxa belong to the family Penaeidae. Commercial invertebrate species in the area also includes squids (Cervigon *et al.* 1993).

A full listing of marine fish taxa (including game, commercial, endemic and threatened taxa) is presented in Appendix D.17. Froese and Pauly 2008 indicates that a large proportion of marine fish taxa found off the coast of Suriname is game taxa, while considerably fewer are commercial marine taxa. Additionally, there are 11 endemic fish taxa and 81 threatened taxa. Most of the sharks and rays which are expected to occur in Surinamese coastal waters (57 species) are listed on the IUCN Red List (version 2017.3). Regarding marine bony fishes of Suriname, 24 taxa are threatened, including Queen trigger fish, Red porgy (*Pagrus pagrus*), Lined seahorse (*Hippocampus erectus*), Creole fish (*Paranthias furcifer*; see Figure 5-145 below), 4 Tuna (*Thunnus* spp.) and 12 groupers (Serranidae; see Appendix D.17). There is evidence that the Giant jewfish or Goliath grouper, *E. itajara* (see Figure 5-146 below), critically endangered according to IUCN's 2017.3 Red list (and also commercially important; see Table 2 of Appendix D.17) occurs in healthy populations in Surinamese coastal waters, as large specimens are regularly caught by fishers (Debidien 2009). This species is caught both in the estuaries and in offshore coastal waters, and one specimen was observed within the Nearshore area (Block C), during the August 2010 coastal ecological survey; ESL 2012).

Source: Stuart-Smith 2018

Figure 5-145: Creole Fish (*Paranthias furcifer*)

Source: Doubilet and Hays 2014

Figure 5-146: Goliath Grouper (*Epinephelus itajara)*

The coastal waters of Suriname are important breeding grounds of fish and shellfish. Published sources indicate that the northern coastal and offshore waters of Suriname support valuable fisheries resources; fishing activity occurs within Blocks A to D, as well as further offshore. The important commercial fish and invertebrate taxa that are registered by the Fisheries Department of Suriname are presented in Table 2 of Appendix D.17. Commercially important taxa are soft-bottom demersal taxa, some of which are benthopelagic (i.e. able to float just above the water surface); these species obtain food from the benthic infauna and epifauna (i.e. organisms that live in or on the seafloor sediment). Pelagic species captured by gillnet are also valuable. Additionally, some taxa move freely between brackish and marine waters, with a few being catadromous (e.g. *Mugil carema* and *Mugil liza*). Some weakfish taxa are also able to enter freshwater (e.g. Bang bang).

Artisanal fishing occurs within Blocks A to D (see Section 5.5.7 below), and the most commercially important families which occur within the Blocks and which are captured by this type of fishing include: Sciaenidae (weakfishes) e.g. Acoupa weakfish or Bang bang, which is one of the most valuable species; Ariidae (catfishes, which are of a lower commercial value); Lutjanidae (snappers); and Mugilidae (mullets). Of the catfishes, Jarabaku (Aspistor perkeri) is listed as vulnerable on the IUCN Red List of Threatened Species (version 2017.3). Of the snappers, Lane snapper (*Lutjanus synagris*) and Vermillion snapper (*Rhomboplites aurorobens*; Red snapper) are near threatened and vulnerable, respectively. Tarpons (*Megalops atlanticus*; Trappoen) and Bluefishes (*Pomatomus saltatrix*; Haring) are also listed as vulnerable. The Jewfish (*E. itajara*; critically endangered), may also occur within the Blocks' waters are classified as vulnerable (IUCN Red List 2017.3).

Penaeidae (shrimp) are the most valuable target catch of industrial trawling, which occurs along the northern portions of the Blocks (within the 10 – 18 fathom lines; see Section 5.5.7 and Figure 5-169 below). Willems 2016 states that, of these, the most valuable is the Atlantic seabob (*Xiphopenaeus kroyeri*), a small, fast growing penaeid shrimp (approximately 10 cm in total length). This taxon is widely distributed in the Western Atlantic from North Carolina (USA) through the Gulf of Mexico and Caribbean Sea to Southern Brazil (Holthuis 1980). Adult *X. kroyeri* live in estuarine shallow waters and move further offshore to spawn (Costa *et al*. 2007; Freire *et al.* 2011). The planktonic larvae and juveniles are found in brackish, inshore nursery grounds (Dall *et al.* 1990; Castro *et al.* 2005). The Atlantic seabob is sexually dimorphic, with females being significantly larger than males (Branco *et al.* 1994) and having a longer lifespan averaging 21 months compared to 16 months for males (Heckler *et al.* 2013b). *X. kroyeri* is not a single species but includes several sub-species (Gusamo *et al*. 2006; Gusamo *et al*. 2013) and is the single most dominant epifaunal organism (at the 30 m depth or 15 fathom line; see Section 5.5.7 below), hence its accessibility as a resource for coastal fisheries (Branco 2005), both artisanal and industrial in nature. Further information on commercial fish taxa and their associated fisheries is presented in Section 5.5.7 below.

With respect to spawning, seasonality of fish (reproductive) behaviour has not been studied in the coastal seas off Suriname (Mol 2010 in Noordam 2013d) but given the similarities in offshore conditions between Guyana and Suriname, it is useful to consider data on this topic related to Guyana in relation to Suriname. It was noted that, in offshore Guyana, there were no regular seasonal fluctuations in fish numbers in trawl catches, but some seasonal movements were noted. There was a general tendency for fish in the sciaenid zone (also called the golden fish zone, which corresponds to 10 – 30 fathom or 18.3 – 54.8 m depth (Lowe-McConnell 1962; Geijskes; nd; see Figure 5-169 in Section 5.5.7 below) to move inshore during the period June – August, when trade winds cease to blow and when the rivers discharge most freshwater to the sea. The species which occupy the sciaenid zone are commercially important, and this inshore movement coincides with the proposed drilling period of April – December 2019). On the other hand, there tends to be an offshore movement into deeper water during the period January – March, when NE trade winds blow most strongly, stirring up the bottom mud in inshore waters.

Within this zone, a diversity in spawning rhythms has been observed. Many taxa (e.g. sciaenids including croaker, carangids, pomadasyids and gerrids) appear to be capable of spawning at any time of year, and ripe fish[21] were typically found to be present in the catches. But some taxa (including some

[21] *Ripe fish refers to female fish with enlarged, fully mature eggs ready to be fertilized, also referred to as `running ripe', or ready to spawn as evidenced by a slight pressure on the abdomen causing eggs or milt to be shed.*

sciaenids) have much more restricted spawning seasons. Many taxa spawned in the main rainy seasons and small fish were abundant in the estuaries from June to September (also coinciding with the proposed Project drilling period of April – December 2019). Many live-bearing elasmobranchs (sharks and rays) contained young almost ready to be born around March (Mol 2010 in Noordam 2013d). In Suriname, it has been observed that, during February – March, anchovies (Engraulidae), seem to migrate up-river to spawn in freshwater (Mol 2010 cited in ESL 2012).

Based on the foregoing, and given the proposed Project timeline for drilling (April to December 2019), it is likely that drilling will take place during: inshore and offshore movement of sciaenids; spawning of sciaenids; and potential live births of elasmobranchs. Juvenile sciaenids and spawning anchovies will also be present in the estuaries along the Nearshore during drilling.

5.4.6 Vegetation Types & Coastal Ecosystems

5.4.6.1 Sources of Data

Information and data on terrestrial flora and coastal ecosystems were gathered from various published sources (including maps) as well as primary data gathered for this study. Secondary sources include data gathered from previously conducted field studies for environmental studies along the coast (Noordam and Teunissen 2005 and 2006; Noordam 2010b in ESL 2012; and Noordam 2013b in ESL 2013b). Other secondary data sources include satellite imagery obtained from Google Earth (September 2009 and 2016); Landsat satellite images; ortho-photographs (2005) and older aerial photographs. These data were then verified and supplemented with aerial photography obtained during an aerial flyover conducted by ESL, along the entire coast of Suriname, during July 13th – 14th, 2017. The various images were used to map the mudflats and the various vegetation types along the coastline. Subsequent to this, a field survey along the coast was conducted by ESL during February 5th - 7th, 2018, to verify the mapped features. In general, research and field reconnaissance was restricted to a 2 km-wide stretch along the coastline (Young Coastal Plain or YCP), from Nieuw Nickerie in the west to Albina in the east. The following sub-sections provide: a summary of ecosystem development along the shoreline; the vegetation types and coastal ecosystems which may be found therein; and the value and importance of these ecosystems, based on published literature and features mapped in 2013 and 2017. Additional information related to ecosystems is presented in Noordam 2018d (see Appendix D.18).

5.4.6.2 Ecosystem Development along the Coast

Blocks A to D are situated immediately adjacent to (north of) the coastline of the YCP and is located on the Continental Shelf. The YCP comprises the land area within the 7 coastal districts of (from W to E) Nickerie, Coronie, Saramacca, Wanica, Paramaribo, Commewijne and Marowijne. In all districts, the YCP exceeds the width of the 2 km study boundary, for example, in Saramacca district, the YCP has a width of 25 – 35 km (ESL 2013b).

The YCP is dominated by flat and low-lying clay flats (see Figure 5-147a) with a variety of swamp habitats. Locally, slightly higher land is found in the form of sand and shell ridges and river levees. The ridges feature a variety of seasonally flooded and dry land habitats, depending upon drainage conditions. River levees are usually dominated by seasonally flooded habitats.

Teunissen 1978 distinguishes 3 main zones in the YCP:

- Ecosystems of salt to brackish water areas;
- Ecosystems of brackish to fresh water areas; and
- Ecosystems of fresh water areas.

The combined area of the first 2 ecosystems comprises the estuarine zone, i.e. the zone with influence of both saline and fresh water. This zone covers an area of approximately 2,000 km^2, which equates to approximately 1% of Suriname's land area (see further below in text, Section 5.4.6.3 and Section 5.4.6.4 for further details on the components of these zones).

The development of ecosystems on clay soils in the YCP occurs in succession which starts at the mudflats. Figure 5-147 presents photographs of the various vegetation types and development stages discussed below.

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(a) Bare Mudflat


(b) Mudflat with germinating Black Mangrove


(c) Coastal Black Mangrove Forest with Tidal Creek


(d) Mature Black Mangrove Forest


(e) Lagoon surrounded by Mature Blocked Black Mangrove Forest


(f) Died-off Black Mangrove Stumps in a Brackish Water Area with Partly Brackish Vegetation And Partly Open Water Lagoon (dry season)


(g) Eroding Black Mangrove Forest


(h) Cat-tail Swamp with Black Mangrove Background (Southern Edge of Mangrove) Forest


(i) Open Freshwater Herbaceous Swamp


(j) Low Freshwater Swampwood


(k) High Swampwood along Airboat Trail


(l) High Swamp Forest

Source: Noordam 2018d (see Appendix D.18); and ESL's Coastal Flyover (July 2017) executed as part of the Field Surveys for the Staatsolie Nearshore Exploration Drilling Project 2019

Figure 5-147: Vegetation Types found within the Young Coastal Plain (YCP) along the Suriname Coast

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Seedlings of Black mangrove (*Avicennia germinans*; locally called ‘Parwa’) establish themselves rapidly on those parts of accreting mudbanks that emerge at about mean high water level up to the high water spring level Figure 5-147b and Figure 5-147c above). Further inland from the coastline, Black mangrove can form substantially tall and dense (mature) mangrove forests up to areas that are inundated only at spring high water (Figure 5-147d above). The influence of the tides decreases going landward and at a certain point the mangrove forest is no longer inundated with sea water. How far this point is off the coastline depends upon the physical build-up of the coast and on the season. For instance, at certain locations the intrusion of the tide is stopped by the presence of a ridge (former beach). The season in particular is important with respect to the amount of excess water that needs to be discharged from the freshwater swamps to the south of the mangrove zone. High swamp levels (rainy season) mean a high discharge of water that will push back the incoming seawater, resulting in a narrower zone of tidal intrusion. Low swamp levels (end of the dry season) result in a deeper penetration of the sea into the mangroves. In addition, deeper penetration also occurs during spring tide. Thus, the depth of intrusion will vary in time and place. But at a certain distance from the coast, Black mangrove forest may be found that is no longer within the reach of tides. These have been indicated as ‘blocked mangrove forest’ (Figure 5-147e above; background).

Blocked mangrove forest occurs in coastal zones with coastal accretion, such as is the case in Saramacca. The Black mangrove trees in this zone will gradually die off as a result of increasing water levels (Figure 5-147f above) which are the result of the absence of tidal action (the forest is no longer drained twice a day) and the increase of water levels that is caused by water supply from the southern freshwater swamp. In addition to that, subsidence of the clay soil causes the land surface to lower, resulting in higher water levels at subsided locations. The subsidence is the result of irreversible water loss from the soft mud that starts as soon as the soils are drained and plants start to remove water.

Where the coast is eroding rather than accreting, part or all of the recently established mangrove forest may become uprooted again by erosion processes and the forest will disappear (Figure 5-147g above). In some cases, erosion is so severe that mature mangrove forest is also eroded.

Within this Black mangrove zone, localised pure stands of White Mangrove (*Laguncularia racemosa*; locally known as Akira) are found along the muddy banks of tidal creeks and levees. A third type of mangrove, Red mangrove (*Rhizophora* spp.; locally known as Mangro) does not occur along the ocean coast, but only in the estuaries and lower river stretches.

Further from the coastline, the influence of the sea decreases and hydrology and water quality will change. Due to worsening of the drainage conditions caused by soil subsidence and/or blocking of tidal creeks by recent mudflats, the mangrove trees will start to die.

When most of the trees have died, salt water lagoons (local name "pannen") are formed (see Figure 5-147e and Figure 5-147f above). Deep lagoons will contain water throughout the year. However, some lagoons may silt up again with sediments brought in by the sea during high tide (see Figure 5-148 below). As soon as lagoons are completely silted up and water depth becomes shallower, Black mangrove forest may re-establish next to other halophytic herbaceous species. Extensive areas with lagoons are found in Nickerie, Coronie and Matapica. Other areas have smaller and/or fewer lagoons.

Source: ESL's Aerial Flyover (July 2017)

Figure 5-148: Lagoon in Nickerie with Renewed Sedimentation from the Sea

Where there is less soil subsidence, the die-off is more gradual and Black mangrove forest becomes more open in time. It is gradually replaced by brackish vegetation (Figure 5-147f above). These open swamps are usually comprised of: (i) brackish short grass swamps, dominated by *Eleocharis mutata*, *Cyperus articulatus* or *Paspalum vaginatum*; (ii) brackish fern swamps dominated by *Acrostichum aureum;* (iii) brackish to freshwater short grass swamps, dominated by *Cyperus articulatus* or *Leersia hexandra; or (iv)* tall grass swamps dominated by Cat tails (*Typha domingensis*; see Figure 5-147h above). Locally brackish to freshwater swamp scrub (dominated by *Machaerium lunatum* or swampwood (dominated by *Erythrina glauca*) may also be found. Grass and peat fires, which may occur during dry seasons, often prevent the development of woody vegetation in this zone.

Ridges occur as higher land within the estuarine zone. The ridges along the sea form beaches with herb vegetation of *Ipomoea pes-caprae, Canavalia* *maritima*, scattered *Hibiscus tiliaceus* scrub and *Avicennia germinans* forest fragments. More inland, in the brackish zone ridges are found with mixed xerophytic (due to the brackish groundwater) coastal wood and forest, such as is observed in eastern Suriname, which is rich in cactuses (*Cereus hexagonus*). Prominent beaches are only observed east of the Suriname River, while in Coronie and Nickerie only low and narrow overwash bars (straight or as “guirlande”) are found along sections of their coastline (see Section 5.3.2 above). Sand deposits along the coast are virtually lacking along the coast of central Suriname (Paramaribo, Wanica and Saramacca and eastern Coronie). Inland ridges in the estuarine zone are also most outstanding in eastern Suriname, with fewer and lower ridges in central and west Suriname.

Further inland, with increasing fresh water, open freshwater herbaceous swamps (‘grass swamps’) are found that are richer in species than the brackish swamps (Figure 5-147i above). In the absence of fire, a species-rich *Chrysobalanus-Annona* swampwood will gradually develop in these grass swamps (Figure 5-147j above). In addition to this type of swampwood, other swampwood types also occur, often dominated by a single species. These swampwoods may eventually develop into species-rich high swamp forest in Suriname known as *Virola-Symphonia-Euterpe* forest, which is considered the climax vegetation for the swamps of the YCP (Figure 5-147k and Figure 5-147l above).

5.4.6.3 Ecosystems of the YCP

Figure 5-149, Figure 5-150 and Figure 5-151 below maps the ecosystems of the YCP of northern Suriname, as discussed above, presented as 3 discrete sections for ease of presentation and understanding. This classification is based upon the work of Teunissen 1978. As mentioned prior, the land area south of Blocks A to D (up to 2 km south of the coastline) falls completely within the estuarine zone and displays mudflats, beaches and brackish ridges, mangrove forest, dying mangrove forest, lagoons, brackish open water swamps, riverside mangrove, freshwater swamps (including “swampwood and swamp forest”) and freshwater ridges. Note that the legend of Figure 5-149, Figure 5-150 and Figure 5-151 shows only the ecosystems of the YCP.

The ecosystems of the YCP which are considered as sensitive in the context of the potential impacts of this Project, may be broadly grouped into the following categories, and these are described in the relevant sub-sections below:

- Coastal mudflats;
- Sandy Coastlines;
- Mangrove Forests; and
- Lagoons.

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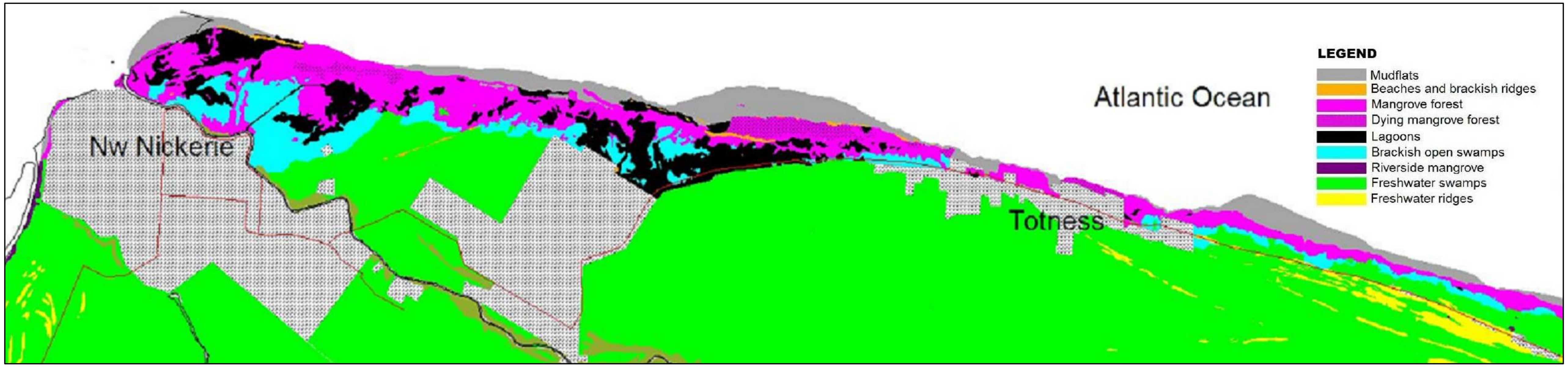
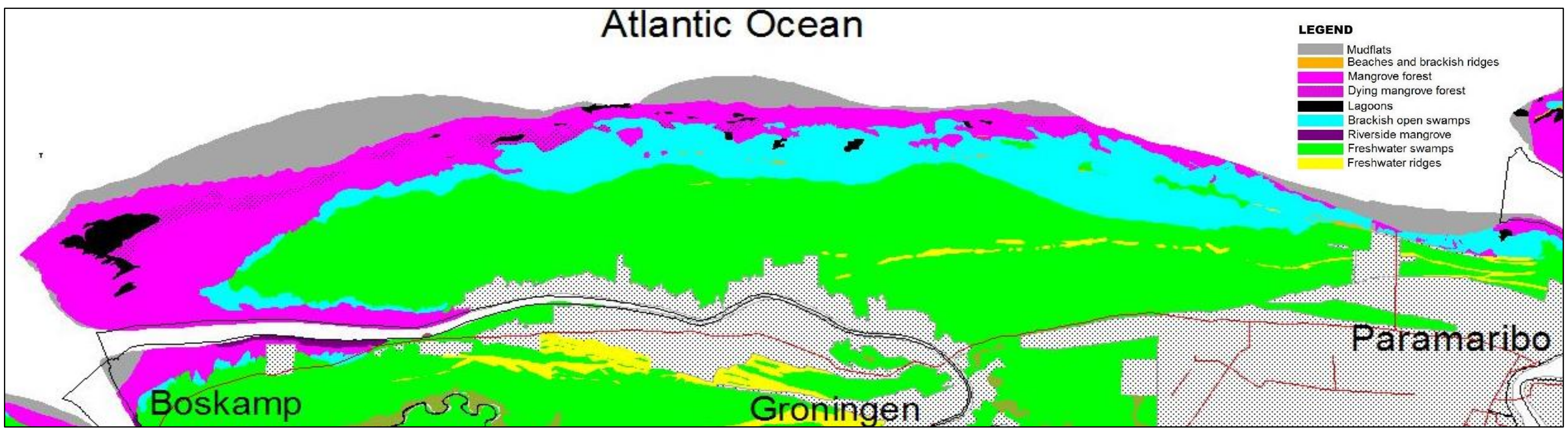


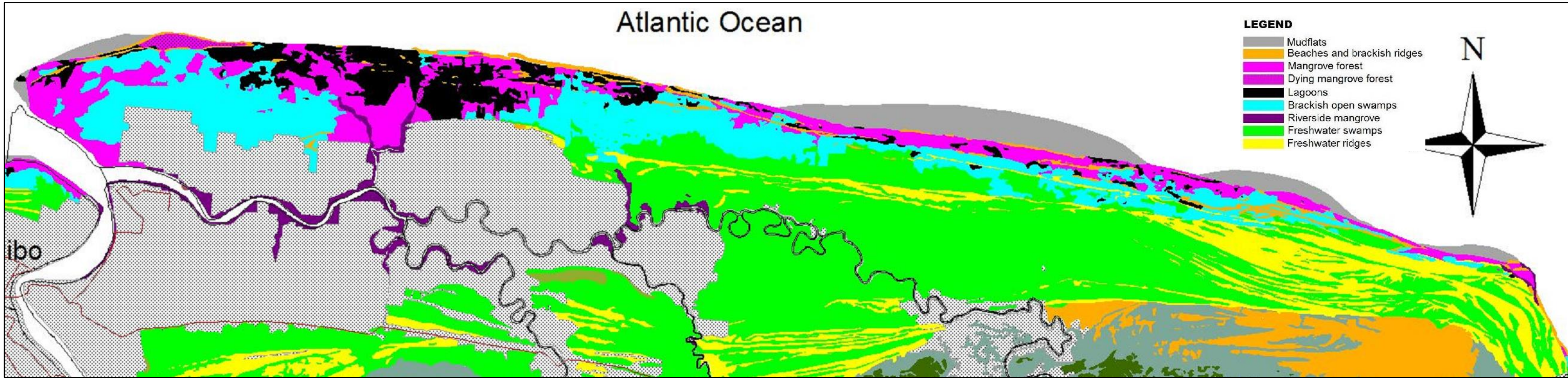
Source: Noordam 2018d (see Appendix D.18), based on an adaptation from Teunissen 1978, using shapefiles generated by the Stichting Bosbeheer en Bostoezicht - Foundation for Forest Management and Production Control)

Figure 5-149(a): General Overview of the Ecosystems of North Suriname (adapted from Teunissen 1978), from Nieuw Nickerie to Boskamp (where Mudflats, Mangrove Forests and Lagoons are Dominant along the Shoreline)



Source: Noordam 2018d (see Appendix D.18), based on an adaptation from Teunissen 1978, using shapefiles generated by the Stichting Bosbeheer en Bostoezicht - Foundation for Forest Management and Production Control)

Figure 5-150(b): General Overview of the Ecosystems of North Suriname (adapted from Teunissen 1978), from Boskamp to Paramaribo (where Mudflats and Mangrove Forests are Dominant along the Shoreline)



Source: Noordam 2018d (see Appendix D.18), based on an adaptation from Teunissen 1978, using shapefiles generated by the Stichting Bosbeheer en Bostoezicht - Foundation for Forest Management and Production Control)

Figure 5-151(c): General Overview of the Ecosystems of North Suriname from Paramaribo to Albina (Mudflats, Mangrove Forests and Lagoons are Dominant along the Shoreline, with Beaches Interspersed)

5.4.6.3.1 Coastal Mudflats

A number of mudflats occur as a strip of 200 m to over 1,000 m wide along the coast of Suriname. A total of 10 mudflats were identified on recent aerial photographs taken by ESL in July 2017, with lengths ranging from 11 – 58 m. Approximately 50% of Suriname's coastline is currently covered by mudflats (233 of 386 km).

The mudflats are formed by soft, grey, saline mud and are only visible at low tide. The portions of these mudflats which are more southerly (i.e. more landward) have silted up to approximately the mean high tide mark. The mud along the shoreline is therefore slightly firmer than in the seaward portions of the mudflats.

The mudflats are rapidly covered by mats of micro-algae that find the light conditions optimal for their growth. These micro-algae, dominated by colony forming diatoms, have the ability to migrate into the sediments, according to the tidal and daily irradiation cycles. Micro-phytobenthos, mainly diatoms, play a major role in binding the sediment by secretion of extra-cellular polymeric substances (EPS). The diatoms give the mudflats a yellowish to brownish-green colour when they are uncovered. Progressively, a benthic community of worms, small crustaceans and foraminifera becomes established within the mudflat.

A large number of other animal taxa use the tidal cycles to benefit from these resources, such as birds and crabs at low-tide, and numerous fish and post-larval and juvenile shrimp at high water. Also characteristic of the mudflats are the Four-eyed fish (*Anableps* spp.) that crawl from the water to graze on the diatoms.

Firm mudflats that are formed as a result of coastal erosion of already consolidated (ripened) clay are locally present within the study area. These are not individually mapped due to their small magnitude.

5.4.6.3.2 Sandy Coastlines

Sand deposits along the coastline form different features with beaches, straight and guirlande overwash bars (see Section 5.3.2 above). Beach ecosystems constitute the other significant land form at the shoreline (along with mudflats). The straight overwash bars are intergrades between the beaches and ecosystems developed on mud, while the guirlande overwash bars can be considered as a subordinate part of the ecosystems developed on mud.

Beaches are only found in eastern Suriname, between the Suriname and Marowijne Rivers. In this region, they cover about 20% of the coastline, while another 20% is formed by overwash bars. The beaches are raised to the spring tide level, but overwash bars are lower, due to lower availability of sand. Except for the herb vegetation (see Section 5.4.6.2 above) on higher ground, beaches are largely bare. Overwash bars normally have no vegetation cover, but Black mangrove trees can often be seen, partly buried in the overthrown sand.

Beaches are of particular importance as nesting areas for sea turtles (see Section 5.4.4 above). Important nesting beaches are located in areas where the beaches are higher or raised, so long as there is no mudflat in front of the coast. Beaches which match this description and so, which are important for turtles nesting, include: Galibi (east) and Diana Beach-Braamspunt (west).

5.4.6.3.3 Mangrove Forests

Mangrove forest, dominated by Black mangrove, forms a 1 – 6 km wide belt along most of Suriname's coast. The mangrove soils comprise very poorly drained, soft (nearly unripe) to slightly harder (half ripe), saline to brackish clay with a saline subsoil. Going inland, the firmness of the clay of the mangrove forest gradually increases and the salinity gradually decreases.

Distinction has been made between young to medium, and mature Black Mangrove forest (see Section 5.4.6.2 above). Where younger mangrove forest is present along the coastline, it is bounded by mature Black Mangrove forest further landward, to the south (Figure 5-152). The northern part of the mature mangrove forest comprises closed forest, while the southern part is more open, due to gradual die-off of mangrove trees.

Source: ESL's Aerial Flyover (July 2017)

Figure 5-152: Young Black Mangrove in front of Medium and Mature Black Mangrove

The mangrove forest along some sections of the Saramacca and Coronie coastline shows localised patches of forest with die-off (Figure 5-153). This phenomenon is usually restricted to a small patch along the ocean. The origin is currently unknown, but is likely to be caused by the blanketing of the pneumatophores (aerial roots) with fresh sediment, resulting in the smothering of the trees.

Source: ESL's Aerial Flyover (July 2017)

Figure 5-153: Die-off of Black Mangrove (Parwa) in a Small Patch along the Ocean (West Coronie)

Inside the mangrove zone, a number of small lagoons are found, most of which tend to be overgrown (see further below). Tidal creeks are present in zones of young and medium Black Mangrove indicating the presence of tidal action.

Mangroves shelter many taxa of fish, crabs and shrimps. Some of them live in these habitats permanently, while others, e.g. fish and crustaceans, temporarily visit the mangroves to feed, to protect themselves from predatory pressure, or to achieve part of their life cycle. In combination with the mudflats, the mangroves provide conditions to ensure part of the development cycle of shrimp, post-larval and juvenile fish, and the adult stages of crabs. The mangrove ecosystem and adjacent shallow coastal mudflats are important 'nursery areas' for early stages of some marine fishes and macro invertebrates (e.g. penaeid shrimp; Nagelkerken *et al.* 2008, Artigas *et al.* 2003, Primavera 1998, Lhomme 1994, Longhurst and Pauly 1987) and thus are important for sustainable marine fisheries.

Currently, it is still not possible to make a clear distinction between the contributions of the mangrove forest and the shallow mud flats to the nursery function of the coastal ecosystem. Early life stages of penaeid shrimp enter the mangrove forest with the flood tide via natural creeks and withdraw from the mangroves with the ebb tide (Dumas 2006). Thus, residence times of the young shrimp in the mangrove can be short (3-4 hours per tidal cycle; Dumas 2006), but in brackish-water lagoons (e.g. Bigi Pan Lagoon, district Nickerie) they may stay for a much longer time (months) in the mangrove forest. The best indication for the nursery function of the mangrove forest in Suriname is the important fishery for juvenile Southern brown shrimp (*Farfantepenaeus subtilis*) in the Bigi Pan lagoon (Jan Mol, *pers. comm*. in ESL 2013b; Mario Ijspol, Suriname Fisheries Department, *pers. comm*., in ESL 2013b). The Southern brown shrimp is the most important target species in the commercial shrimp fisheries off Suriname and it also features prominently in Surinamese fisheries export (Charlier 1996). Presently, Seabob shrimp *(Xiphopenaeus kroyeri*) dominate the shrimp catches (2,000,000 kg *X. kroyeri* vs. 700,000 kg of *F. subtilis* in 2008; Mario Ijspol, *pers. comm*. in ESL 2013b) and export, but the Seabob shrimp has the same life cycle as *P. subtilis* and is also highly dependent on the mangrove / shallow adjacent shelf nursery (Lhomme 1994, Dumas 2006).

The mangrove forest has also an important function in the protection of the coast from wave-induced erosion. Thus, it is important that the mangrove forests and especially its tidal creeks and brackish-water lagoons are either not removed and/or disturbed or disturbance is restricted as much as possible. Removal of the mangrove ecosystem will have an impact on both protection of the coast against erosion and the nursery function for marine fisheries resources.

The coastal mangroves are also very important for water birds and other bird species, many of which breed, roost and/or feed in the mangroves (see Section 5.4.7 below). Other animals are less conspicuous in the mangroves and their diversity is low. Taxa that may utilise mangrove forests include: the Crab-eating raccoon, certain monkey species (Red howler monkey, Brown capuchin, Squirrel monkey) and the Spectacled caiman.

5.4.6.3.4 Lagoons

Within the mangrove zone, a number of smaller (less than 2 ha in area) and larger (almost 500 ha) open water areas can be found. Locally, these open areas are known as ‘pannen’. For this study, the term ‘lagoon’ has been used to indicate open water areas, but also areas that are partly bare and partly covered with a low growth. Lagoons have formed where subsidence of the clay (due to ripening) has resulted in areas with a slightly lower elevation than the surrounding land.

Lagoons cover less than 10% (approx. 20,000 ha) of a 6 km wide coastal zone in Figure 5-149, Figure 5-150 and Figure 5-151 above (and so even less when considering the 2 km zone applied to this study). As indicated previously, lagoons range from deep to shallow open water areas to relatively open areas with a variable coverage of young Black Mangrove and halophytic herb vegetation. The latter can often be considered as former open water lagoons that have become silted up.

The large lagoons at west Nickerie (Figure 5-154 below), west Saramacca and Matapica (Figure 5-155 below) are connected to the sea, but most of the others tend to be smaller and no longer in contact with sea water. The larger ones also display renewed sedimentation from the sea (see Figure 5-148 above).

The larger lagoons are characterised by a variety of brackish to saline open water, bare surfaces of renewed sedimentation, areas with halophytic vegetation and spot-wise occurrences of Black mangrove. Smaller ones are dominated by open water of variable salinity, depending upon the season, with low salinity in the rainy season and higher one during dry periods. Lagoons – especially the open water lagoons, form important feeding areas for many bird species due to the abundance of plant and animal life, in particular fishes, shrimps and crabs.

Source: ESL's Aerial Flyover (July 2017)

Figure 5-154: Lagoon with Opening to the Sea (Nickerie)

Source: ESL's Aerial Flyover (July 2017)

Figure 5-155: Lagoon with Opening to the Sea (Matapica)

5.4.6.4 Description of the Coastline

This Section describes the current coastline, based on recent aerial photographs taken in July 2017 by ESL during a coastal flyover. It should be noted that these photographs s how an area of limited extent. The pictures show only a small section of the coast (YCP) and, as a result, the data from the photos was used to generate Figure 5-156 below, which shows the various ecosystems along the shoreline.

The Nickerie coastline (Figure 5-156 below) is characterised by the presence of open lagoons near the coastline (over about half of their coastline, starting at the mouth of the Nickerie River, going east). The coastline at the lagoons is open with low halophytic growth, patches of Black mangrove and open water. Guirlande overwash bars are present all along its extent. The remaining coastline of the district is covered by mature, and young and medium-sized Black mangrove. Lagoons are common in the coastal area. The mudflats in front of the coast are usually bare, but some places show initial development of Black mangrove.

Coronie (Figure 5-156 below) is almost completely covered with mature to young Black mangrove, with some guirlande overwash bars in the western section. The Coronie polder area is protected by a sea dyke, which has mangrove forest and some isolated spots with low halophytic growth in front of it. Some parts of the mudflats show initial development of Black mangrove. Lagoons are found in the west of the district; all are land-locked.

The coastline of the Saramacca and Wanica Districts (Figure 5-156 below) has young to medium-sized Black mangrove throughout, and mudflats in front of 85% of its land. Except for a large sea-connected lagoon in the west, the districts have only few small, land-locked lagoons.

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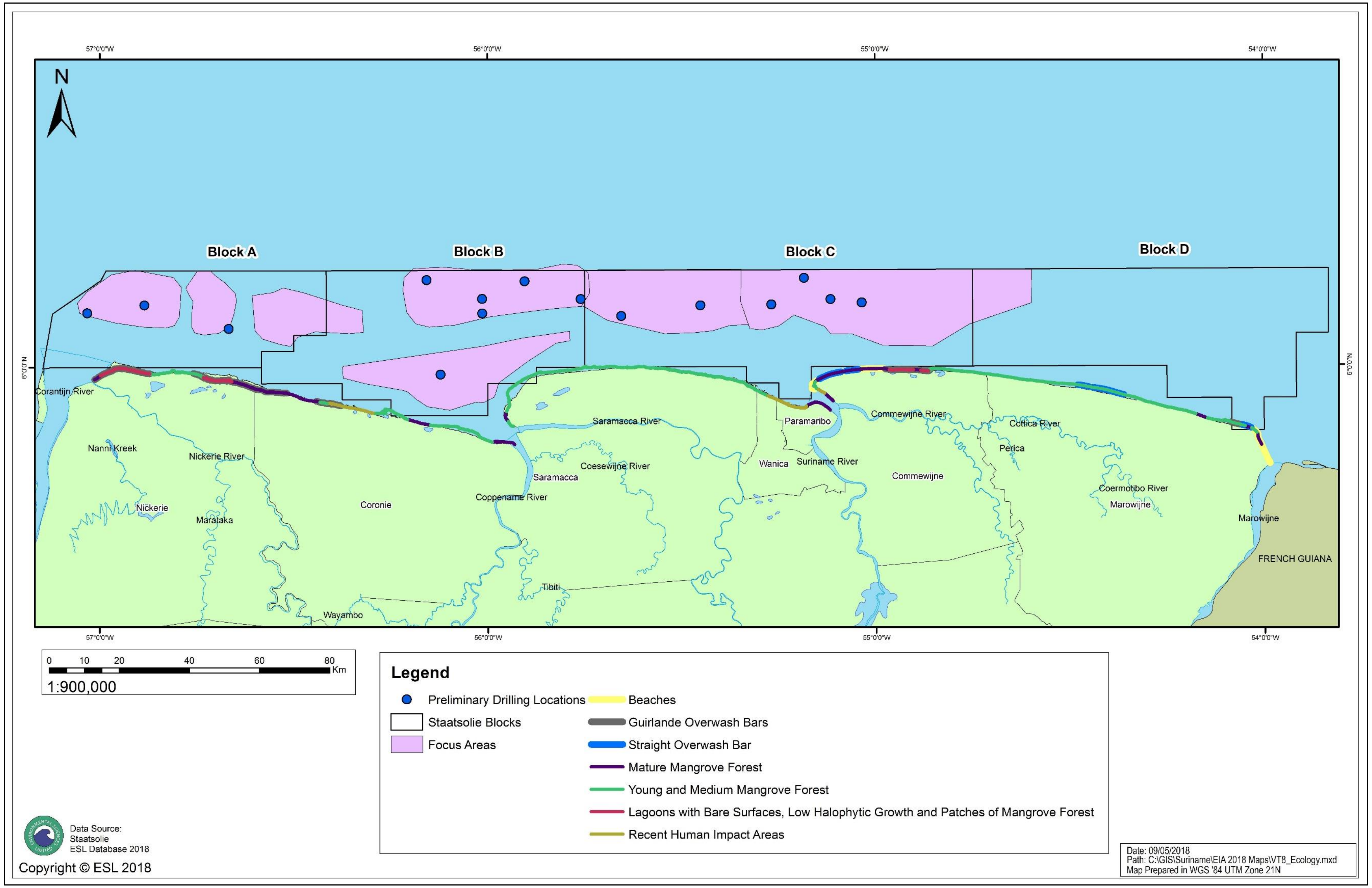

Source: Adapted from ESL's Aerial Flyover (July 2017)

Figure 5-156: Ecosystems along the Suriname Coastline

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The Wanica and Paramaribo (Figure 5-156 above) coastline is severely affected by human activities in the Weg naar Zee area. Land development has led to significant erosion of the land that was developed during the last decades of the 20th Century. Only recently, a mudflat has appeared in front of the coast, but Black mangrove is not yet developing and accretion is not taking place. A number of sediment trapping units have also been placed here, which are part of a trial to investigate whether such units will promote mudflat development and coastal accretion. The Weg naar Zee coast has been developed for agriculture (Figure 5-157 below, which shows parcelling). The only protected land in the area is found at the location of the pilgrimage place, once situated along the coast (south of the coastline), but now protruding in the ocean and forming a kind of peninsula (see Figure 5-157 below). Erosion during the past 30 years amounts some 300 – 500 m.

Source: ESL's Aerial Flyover (July 2017)

Figure 5-157: Weg Naar Zee Area with Pilgrimage Place (extending into the Ocean), with Sediment Trapping Units (Squares on the Mudflat) and Eroded Land (The Coastline once ran along the Tip of the Pilgrimage Place)

Like Nickerie, Commewijne also has lagoons that are connected to the sea, while the remaining coastline has mature, and young to medium-sized Black mangrove (Figure 5-156 above). The lagoons are found at Matapica, where bare surfaces, low halophytic growth and spot-wise Black mangrove occur along the coastline. West of the Matapica Creek, sand is found along the

Commewijne coastline, in the form of beaches, straight overwash bars and guirlande overwash bars. The latter are predominantly found in the area with sea-connected lagoons. The eastern beaches have a mudflat in front which prevents the use of these beaches for turtle nesting. Only the Braamspunt beaches are currently accessible for sea turtles.

The Marowijne coastline (Figure 5-156 above) is dominated by young and medium-sized Black mangrove. Significant beaches are only found at the eastern end of the coastline, in the Galibi area. Along the central Marowijne coastline, only straight overwash bars are found. Also along the Marowijne coast extensive mudflats are found (50% of the total coastline). The beaches of Galibi are, however, accessible for sea turtles.

5.4.6.5 Importance of the Estuarine Zone

Multiple values and functions of coastal ecosystems are provided by the estuarine zone, such as: (i) coastal protection; (ii) natural productivity; (iii) natural value; (iv) high degree of biodiversity; and (v) production of goods and services. Mangrove forests protect the coast and river estuaries against erosion, enhance sedimentation and stimulate coastal accretion. The coastal protection function of the mangrove forest along Suriname’s coast is clearly demonstrated. For example, the presence of mangroves along the shoreline adjacent to Block C is undisturbed and still accreting, compared to the strongly eroded Weg naar Zee coastline, where mangrove is absent (see Section 5.4.6.4 above).

The contribution of the coastal zone to the natural productivity and the production of goods and services for Suriname is relatively high, because of the extensive estuarine zone that is found here. Biologically, the estuarine ecosystems belong to the most productive ecosystems in the world. Their productivity is related to tidal action and the mixing of ocean and outwelling inland waters, both providing the estuarine zone with nutrients, organics, spawn and juvenile fish and shrimp.

A prominent role of mangrove communities is the production of leaf litter and detritus, which are exported to the Nearshore coastal waters. The organic matter, produced by the mangrove trees and by plankton, epiphytic and benthic algae, provides the base of the food chain that involves many species of commercial importance, for example the commercially exploited penaeid shrimp. Micro-algae are extremely important for primary production within intertidal habitats and constitute a major food source for higher trophic levels. Important with respect to this are the bare mudflats which are often covered by mats of micro-algae that support diverse communities of small benthic invertebrates. But it is the mosaic of vegetated and “bare” estuarine substrates together that provides the complete habitat needs for organisms. Estuarine ecosystems are particularly important as spawning and nursery grounds for the marine fauna.

The Surinamese Coastal Zone harbours the most extensive and pristine mangrove forests of the Guiana Ecoregion. According to the 2002 Consensus on Conservation Priorities for the Guyana Shield (Huber and Foster 2003), the coastal wetlands have the highest priority rating for biological importance and conservation opportunities.

Estuarine ecosystems in Suriname form also important nesting sites for local coastal birds like several taxa of herons and scarlet ibises, and feeding grounds for over one million of migratory birds from the North. Estuarine ecosystems provide food for several fish, crab and shrimp taxa living as juveniles in the brackish swamps, lagoons, tidal creeks and river estuaries, and as adults in the sea or even in fresh water ecosystems. Biodiversity is expected to be highest in the western part of Saramacca and Nickerie, where extensive lagoons are found.

Seafood abundance is directly related to the extent of the estuarine zone, including mudflats, mangroves and lagoons. In a review of global studies, estimates of the amount of commercial catch explained by the presence of mangroves or estuaries range from 20 – 90% (Nagelkerken *et al.* 2008). Studies in Suriname indicate that 60-80% of all fish sold at coastal fish markets originate from estuarine areas (Finlayson & Moser 1991, cited in Erftemeijer & Teunissen 2009). Also, large-scale industrial deep-sea fisheries benefit from the nursery function of these ecosystems. In addition, the mangrove forests are the main source of honey in Suriname; bee keeping is concentrated in the Coronie district, where the coastal zone is readily accessible. Black mangrove is the most important source of honey and other products that the hive produces. Beekeeping is one of the most important economic activities of the district. Hives are found throughout the district, in the area shown on Figure 5-121 above (Mr. Dors[22], LVV Coronie, *pers. comm.*).

Finally, coastal ecosystems also provide an important but under-utilised resource for ecotourism, education and scientific research. The value for tourism and recreation is particularly found at accessible sections of the estuarine zone, such as Bigi Pan in Nickerie (landscape and birds), Coronie (landscape, birds and history), Braamspunt (landscape and sea turtles), Warapa/Matapica (landscape, history and birds) and Galibi (landscape, cultural and sea turtles).

5.4.6.6 Vulnerability of Ecosystems within the Estuarine Zone

The mudbanks and mangroves which are found within the study area may be influenced by Project activities within the Nearshore area, and these coastal forms exhibit some level of vulnerability. Mudbanks along the Suriname coast are constantly migrating towards the west as a result of erosion (resuspension) of their eastern part and deposition on the western part. This results in a movement of mud from the ‘tail’ (eastern side) to the ‘nose’ (western side) of

[22] *Mr. Dors, Ministry of Agriculture (LVV), Coronie.*

the mudbank (Augustinus 1978). However, movement also takes place within the mudbank. A study in French Guiana reveals that sedimentation along the coast depends on 3 different processes: mass deposition when a mudbank reaches an area; seasonal exchange between the mudbank and the shoreline; and the effect of tide cycles (Debenay *et al.* 2007).

Once a mudbank has been deposited, sediment processes are dominated by reworking of the muddy sediment. The influence of the periodical sedimentation processes is sometimes shown in very thin laminae with alternating dark and clear colours. Erosion and deposition processes are governed by tidal cycles and depend on threshold speeds of tidal currents.

Upon physical disturbance, such as by the trunk of an uprooted mangrove tree, it is likely that any changes to the mudflat will be rapidly undone by the sedimentation and erosion processes that continuously take place. Moreover, the benthic algae have a very high turnover rate and they are able to migrate into the sediments and to adapt to changing conditions. Primary production of the mudflats and the associated infauna is not likely to be significantly affected as a result of temporary and localised activities that could result in some physical disturbance of the mud.

Mudflats should not be considered as steady-state ecosystems, but rather as pulsing steady-state or pulse-stabilised ecosystems. The organisms present in the mud are adapted to ever-changing environmental conditions, and usually changes occur without dramatic consequences. For instance, the micro-phytobenthos migrate to the sediment surface during low tide, after a new mud layer has been deposited during high tide on the mud flat (Debenay *et al.* 2007).

Mudflats and mangroves may therefore be more vulnerable to chemical, rather than physical disturbances. Though the potential impacts of an accidental oil spill will typically vary depending upon the size of the spill and the type of oil that has been spilled, oil slicks generated in the Nearshore area may float across mudflats and enter mangrove forests when the tide is high, and oil may then be deposited on the aerial roots and the sediment surface as the tide recedes. This process commonly leads to a patchy distribution of the oil and its effects. Oil contamination could impact the entire food chain in (sections of) mangrove forests, sea bound lagoons and on mudflats and thus affect bird and fish life throughout these zones and beyond. In addition to this, these ecosystems are typically ranked as the most vulnerable according to the US NOAA Environmental Sensitivity Index (ESI) ranking system (Petersen *et al*. 2002), owing to the ability of the fine substrate (clay) to trap oil; the general inaccessibility of mudbanks and mangroves for clean-up; and the level of difficulty in clean-up efforts.

5.4.7 Avifauna

5.4.7.1 Sources of Data

Information and data on the avifauna along the Suriname coast were predominantly obtained from the following publications, which provided descriptions of the birdlife along the coast by habitat type:

- '*Kustvogels van Suriname/Coastal birds of Suriname*' by Spaans 2003;
- '*Annotated Checklist of the Birds of Suriname*' by Ottema *et al.* 2009 (which also provides information on taxonomic abundance);
- '*Field guide to the birds of Suriname*' by Spaans *et al.* 2016;
- '*Waterbirds in Suriname'* by Ottema 2006;
- '*Birds in Suriname, South America*' by Ribot 2017 (which provides information on breeding seasons);

Other data used include Google Earth imagery (2006 – 2016) and photographs obtained by ESL during an aerial flyover during July 13th – 14th, 2017, along with a verification field survey conducted along the shoreline during February 5th – 7th, 2018, and supplemented by previously data from a field survey along 28 km of the the Saramacca coastline in August 2010 by Mr. Serano Ramcharan (Noordam 2010c in ESL 2012).

The various data and images were used to map the mudflats and the various vegetation types within the 2 km zone of the YCP along the coastline, and avifauna were then described by habitat type (see Section 5.4.6 above). Limited access to most of the land area hampered the collection of primary data, hence the use of the aerial survey. However, this was not executed within the peak nesting period owing to logistics. As a result, avifauna data from breeding colony surveys along the Saramacca coast conducted in June 2017 by Staatsolie was used to supplement the dataset. Unpublished data from avifauna field surveys conducted by Dr. Spaans in 2009 and 2017 were also utilised.

The sub-sections below summarise the findings, and presents information on the importance of the Suriname coast for avifauna; a description of the avifaunal taxa which can be found in the various habitat types in the estuarine zone; and discusses migration and breeding along the shoreline. The full report (inclusive of taxonomic listings by habitat type) is presented in Appendix D.19 (Noordam 2018e), and Appendix D.20 provides a list of the taxa observed along with their classification on the IUCN Red List (2017.3). Section 5.5.8 discusses protected areas for bird conservation.

5.4.7.2 Importance of the Suriname Coast

As indicated in Section 5.4.6.2 above, the 2 km strip of coastline along the Suriname shoreline subject to ecosystem and avifaunal analysis is situated within the YCP, comprising entirely the estuarine zone, which is considered the life zone of coastal birds in Suriname. The 5 habitats within the estuarine zone (see Figure 5-149, Figure 5-150, Figure 5-151 and Figure 5-156 above) for which avifauna are described include:

- Marine waters
- Soft mudflats
- Mangrove forest
- Sandy beaches and hard clayflats
- Coastal brackish lagoons and swamps

It is important to note that the proposed exploration drilling program will occur in the Nearshore area and will potentially affect only the marine waters, the mudflats and the mangrove forest along the coast. However, most birds are not restricted to one habitat, but use several different habitats for different activities, including inland habitats.

Of the 729 taxa of avifauna that can be found along Suriname's coast, 209 are either partly, essentially or completely dependent on habitats within the estuarine zone (Spaans *et al.* 2016; Ribot 2017). However, 40 of these taxa are restricted to the marine water habitat, and only some of these taxa may be seen in the inshore area of the Brown Water zone (see Section 5.3.10.1 above). Of the 209 estuarine zone taxa, 137 are considered common or uncommon, and the remainder 72 are classified as either rare or accidental[23]. Many taxa are residents of the area south of the estuarine zone – in particular of the freshwater zone of the Young Coastal Plain (YCP) – and they also use habitats of the estuarine zone for certain activities, or during certain seasons. Certain taxa from the coastal zone are widely distributed over Suriname and may even be found as far south as the Southern (Sipaliwini) savanna (e.g. certain birds of prey, vultures, antbirds, storks, sandpipers, plovers, woodpeckers and kingfishers).

In the bio-geographical coastal region between the mouths of the Amazon and Orinoco Rivers, the coast of Suriname contains the most important feeding and nesting sites for resident coastal birds, and the most important feeding grounds for migratory birds, especially from the North. Spaans *et al.* 2016 lists 66 northern migrants (i.e. migrating from the North of Suriname) and 17 southern migrants (i.e. migrating from the South of Suriname).

[23] *The relative abundance of a taxon has bearing on the chance that an experienced birder will be able to record a species in prime habitat and during the right season in the various life zones. Abundance can be classified as: common (usually encountered during a single visit); uncommon (regularly encountered, but several visits may be needed before the taxon is observed); rare: seldom encountered and many visits required for an observation); and accidental (normally not encountered and so only used for vagrants.*

According to De Jong, Spaans & Held 1984, the Surinamese coastal area is of special importance as feeding and nesting ground for more than 118 taxa of coastal birds, of which more than 70 taxa are defined as waterfowl according to the criteria of the Ramsar Convention (2002). According to the criterion for international importance, parts of the Surinamese coastal area are of international importance for 21 waterfowl taxa. This criterion is that 20,000 or more individuals, or 1% of the flyway population of a given species, regularly occur in that area (Ramsar 2002, Spaans 2003).

The Surinamese coast may be considered as one of the principal South American wintering grounds for migratory shorebirds from Nearctic regions. These migratory birds breed on North American breeding grounds. During the northern spring (March to May), they re-migrate to their northern breeding grounds and return later, followed by their young, southward to Suriname by the end of the northern summer (late August to Early September). This latter return will mean that these migrants will occur along the shoreline while the Project is ongoing (April – December 2019).

Numbers of shorebirds vary greatly throughout the year, with peak numbers during the southbound (July–November) and northbound (February–May) migration periods (see Table 2 of Annex 1 in Appendix D.19). Many taxa, however, are also present in relatively high numbers during the northern winter (December – February) and summer (June – August) periods. Based on the foregoing, shorebirds (at peak levels) will also be found along the shoreline during the proposed drilling period for this Project (April – December 2019).

During the period 1982-1986, by means of aerial surveys, Morrison and Ross counted more than 2.9 million Nearctic shorebirds along the entire South American coastline (approximately 28,000 km). Along Suriname's coast (386 km) alone, they counted 1.5 million shorebirds, equalling 52% of the total of shorebird populations wintering in South America (Morrison & Ross 1989).

However, current shorebird numbers are lower than in the 1970s and 1980s. Aerial counts during the southbound migration peak since 2000 estimate the total number of shorebirds at 1.3 million (Ottema 2006). In Suriname, numbers of at least 5 taxa have decreased by 40–80%. In neighbouring French Guyana, 7 taxa show a negative trend (Ottema & Spaans 2008).

The causes for the decrease for Suriname are not clear, but may not be related to habitat loss; possible causes may be overhunting as well as predation by the Peregrine falcon above the mudflats. The Peregrine falcon usually preys on birds other than shorebirds; the latter are scared by this predation, resulting in reduced food intake and lower survival during the spring migration (Ottema and Spaans 2008). In Suriname, Peregrine Falcon numbers have increased substantially during the last few decades (Ribot 2017), and the birds are now common along the entire coast (Spaans 2003).

The Suriname coast is also of international importance for 7 North American shorebird taxa (Ottema & Spaans 2008). These include:

- Short-billed Dowitcher (*Limnodromus griseus*);
- Semipalmated Sandpiper (*Calidris pusilla*);
- Tricolored Heron (*Egretta tricolor;* see Figure 5-158 below);
- Scarlet Ibis (*Eudocimus ruber*; see Figure 5-159 below);
- Common Tern (*Sterna hirundo*);
- Rufous Crab-eating Hawk (*Buteogallus aequinoctialis*); and
- Snail Kite (*Rostrhamus sociabilis*).

Source: Charlton 2017

Figure 5-158: Tri Coloured Heron (*Egretta tricolor)*

Source: Abdool 2017

Figure 5-159: Scarlet Ibis (*Eudocimus ruber*)

Less numerous, but present around the year and much more conspicuous, are the ciconiiform birds, consisting of: herons; ibises (among which the well-known Scarlet Ibis); storks; and the Roseate Spoonbill (*Platalea ajaja*). The sum of estimated maximum numbers of individuals for these species is 600,000 (De Jong, Spaans & Held 1986). Between the Orinoco and the Amazon River mouths, the coast of Suriname shows the highest density of nesting colonies of ciconiiform birds. For the South American endemic Scarlet Ibis, the coast of Suriname is of critical importance with up to 35,000 breeding pairs during top years (e.g. 1986), but the number of nests fluctuates strongly, from a few thousand up to some tens of thousands (Spaans 2003). During a survey conducted in June 2009 by Dr. Spaans, the number of nests estimated was 3,500 – 7,000 and over 85% of Scarlet ibis that nest in Suriname were observed in the Saramacca area (Block C; Noordam 2013 in ESL 2013b). A more recent survey conducted in June 2011, the number of nests was estimated at 4,500 for the Saramacca coast (Spaans, *pers. comm.* 2011; see Appendix D.19). June coincides with the proposed drilling period for this Project (April – December 2019), and hence these herons and ibises will be present along the shoreline during this time.

Other groups of waterfowl that are present in relatively large number are ducks, gulls and terns and one species of skimmer, each group represented by about tens of thousands individuals. An aerial count of North American Stilt birds (December 2008) showed that 45% of the total population for Suriname is present between the Coppename and Suriname Rivers.

Many more bird species occur in the estuarine zone and belonging to a large number of families. These are not discussed in detail, as they are present in small numbers only (in relation to other places) and/or because they normally do not occur in relevant habitats of the study area.

A review of the Red List (2017.3) classification of the avifaunal taxa known to occur within the estuarine zone revealed that there are 10 threatened taxa (see Appendix D.20). These include the endangered Yellow-nosed albatross; the vulnerable Leach's storm petrel and Black-legged Kittiwake; and near-threatened taxa including the Rufous crab-eating hawk, Arrowhead piculet, Fea's petrel, Red knot, Semi-palmated sandpiper, Buff-breasted sandpiper and Bicoloured conebill. Of these, the Semi-palmated sandpiper and the Rufous crab-eating hawk are internationally important shorebird taxa, as specified above. The taxa which form the major nesting colonies (Scarlet ibis and herons; see Section 5.4.7.5) are all listed as Least Concern on the IUCN Red List (2017.3).

Two avifaunal taxa are listed on CITES Appendix I: the Jabiru and the Peregrine falcon. A total of 24 taxa are listed on Appendices II and III, including: Scarlet ibis; American flamingo; Osprey; all parrots, hawks (except the Peregrine falcon, hummingbirds, new world vultures and owls (see Appendix D.19).

Birdlife International also lists a total of 13 approved Important Birding Areas in Suriname, of which 4 occur within the Project area (see Section 5.5.8 for additional information and Appendix D.19 for criteria for assessment):

- SR001: Bigi Pan, which covers the northern part of the Nickerie District (Bigi Pan MUMA);
- SR002: Northern Coronie, Coronie District (North Coronie MUMA);
- SR003: Northern Saramacca, an area that covers the North Saramacca MUMA, and the northern part of the Wanica and the Paramaribo Districts; and
- SR004: Northern Commewijne/Marowijne an area that covers the North Commewijne MUMA, and the northern part of the Marowijne District.

Finally, The Game Act gives full protection to all mammals, birds and sea turtles, except to those species mentioned in the Game Resolution of 2002 and indicated as (a) game species, (b) predominantly harmful species, or (3) pets ('cage birds'). All birds in the estuarine zone are fully protected, except for Blue-winged Teal, Black-bellied Whistling-Duck, Muscovy Duck, White-cheeked Pintail, Limpkin, Anhinga and Neotropic Cormorant. Hunting (with bag limits) for the mentioned species is only allowed in certain seasons.

5.4.7.3 Avifauna within the Habitats of the Estuarine Zone

The sub-sections below discuss the birdlife within the various habitats (based on Spaans 2003) within the estuarine zone, keeping in mind that each ecosystem provides a habitat for different type of birdlife, but usually more than one habitat is used for different activities of birds (such as feeding, resting, roosting, breeding and hiding[24]).

5.4.7.3.1 Inshore (Marine) Waters

True oceanic birds do not occur in the inshore waters of Suriname, as the water here is too turbid. True oceanic species tend to be confined to clear water for fishing. However, several other species of birds are at home in the Brown water zone. Laughing Gulls (Sedoifi[25]), various species of terns, and the Black Skimmer (Sleepmannetje; Fisman) can be observed in this zone in large numbers. Frigate birds (Fregatvogel) and Brown Pelicans (Kodyo) are also regularly present, but in lower numbers. Finally, the Osprey (Fis-aka) is common in this habitat, fishing in inshore waters, river mouths and further upstream.

5.4.7.3.2 Soft Tidal Mudflats

The tidal mudflats of Suriname provide feeding grounds for over one million birds, including the North American shorebirds, herons and scarlet ibises. The food source comprises fishes, shrimp, crabs, crustaceans and worms. The Snowy Egret and the Little Blue Heron (both Sabaku) are the most numerous herons feeding on the flats. From the shorebirds, the Semi-palmated Sandpiper (Snepi) can be seen in very large flocks during the migration period, while also the Semi-palmated Plover, the Willet, the Greater and Lesser Yellowlegs and the Common Dowitcher (all Snepi's) are present in large numbers. Also, large groups of American Flamingos (Segansi) can sometimes be seen feeding on the mudflats, in particular in the Wia-Wia and the Coppename-Monding Nature Reserves. Other birds (such as the birds of the inshore waters) use the mudflat predominantly to rest.

Foraging is dependent upon the water level. During high tide, the birds are obliged to go to the higher parts of the mudflat, or even to leave the mudflat to settle on so-called 'high-tide refuge areas' along the coast, where large flocks of birds wait for the withdrawal of the high water (Figure 5-160 below). Shorebirds feed both during the day and at night, as long as allowed by the water level. Naturally, the vast quantities of birds attract birds of prey that feed on them, such as the Peregrine Falcon.

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[24] *Hiding is done by birds when they experience danger and try to avoid being seen by predators, including humans. Most species show this to some extent. Hiding is easier in forested areas than in open areas.*

[25] *These refer to the local name of the bird taxon in Dutch.*

Source: Noordam 2018e; See Appendix D.19

Figure 5-160: Herons on a Mudflat in front of Mangrove Forest

5.4.7.3.3 Firm Clay Flats

The numbers and composition of birds feeding on this habitat is different from that of the soft mudflats. Species of birds that are typically found here are those that are able to penetrate the harder clay and that are relatively too heavy to walk on the soft clay. Species that can be observed here include: several species of plovers and sandpipers, as well as some egrets and herons. Like the soft mudflats, also the firm clayflats provide a good resting place for terns and skimmers. Firm clayflats are present in the Weg naar Zee area, but the recent arrival of a mudbank is now causing the coverage of this bank with soft sediment (Appendix D.19).

5.4.7.3.4 Young Coastal Mangrove

The young mangroves are the habitat for the large breeding colonies of herons, especially the smaller ones such as the Snowy Egret, the Tricolored Heron, the Cattle Egret, the Striated Heron and the Little Blue Heron (all referred to as Sabaku’s); the Scarlet Ibis (Korikori, Rode Ibis); and sometimes small numbers of Roseate Spoonbills (Lepelbek). Furthermore, the young coastal mangroves are used as a resting place during high tide and for roosting at night. Naturally, the large breeding colonies will attract various birds of prey, as well as scavengers such as the Black vulture and the Turkey vulture. These vultures can be seen across all coastal habitats.

In addition to the above-mentioned species of birds, a large number of other birds live in the young coastal mangrove, such as the Clapper Rail (Anamu), the Plain-bellied Emerald (a Kolibri), the American Pygmy Kingfisher (a

Fisman), the Yellow-chinned Spinetail (Fityo), the Yellow Warbler (Koprofowru), the Yellow Oriole (Banafowru) and the Great Kiskadee (a Grietjebie; see Table 1 of Annex 1 in Appendix D.19).

5.4.7.3.5 Older Mangrove Forests

Bird composition is different between young and old mangrove forests. Within older mangrove, avifaunal species found are those that rest in large trees, and/or nest in holes and in tall trees. Characteristic bird species comprise the Rufous Crab-hawk (Krabu Aka), Great Black-hawk (Blaka Aka), Orange-winged Parrot (Kulekule), Greater Ani (Bigi Kawfutuboy), Great Horned Owl (an Owrukuku), a number of Woodpeckers (Temreman) and the Streaked Flycatcher (a Grietjebie; see Table 1 of Annex 1 in Appendix D.19). Tall mangrove forests near swamps with open water are often important nesting sites of large fish-eating birds, including colony breeders, such as Cocoi Heron (Kumawari), Great Egret (Galin) and Anhinga (Anhinga).

5.4.7.3.6 Brackish Swamps and Lagoons

Lagoons with large areas of open water are choice feeding areas for large fish-eating birds. In these areas, considerable numbers of the Neotropic Cormorant (Doiklari, Duikelaar), Cocoi Heron (Kumawari), Scarlet Ibises (Korikori, Rode Ibis), Greater Egret (Galin) and Wood Stork (Nengrekopu) are found, the latter 2 often in very large flocks. Lagoons are also the main feeding habitat for the Roseate Spoonbills (Lepelbek) and Jabirus (Blaasman) in Suriname. High numbers of ducks can be found here, such as the Black-bellied and Fulvous Whistling-duck (Doksi) and Blue-winged Teal (Bluewing).

Shallow lagoons are the preferred feeding habitat for a number of shorebirds and herons, such as the Common Stilt (Tyalita) and a number of species of sandpipers (Snepi’s). Lagoons also serve as resting areas (and occasionally also as feeding area) for certain species of the inshore waters and as ‘refugee’ roosting place for many shorebirds. Where dead and decaying (Black mangrove) trees are present, hole-nesting birds such as some species of woodpeckers (Temreman), swallows (Zwaluwen) and the House wren (Gadofowru) are characteristic. Avifauna of the brackish swamps is not discussed, as these fall outside the 2 km zone of the study area.

5.4.7.4 Migratory Birds

There are a number of true migratory birds that come to the Suriname coast. Birds that migrate in a fixed direction from their breeding sites in temperate and arctic areas to Suriname, and later return to these breeding sites, either follow the same route or sometimes take a different route (Spaans 2003). Table 2 of Annex 1 of Appendix D.19 provides a detailed list of migratory avifaunal taxa in the relevant habitats of the estuarine zone of Suriname, including the period of highest number / records in Suriname.

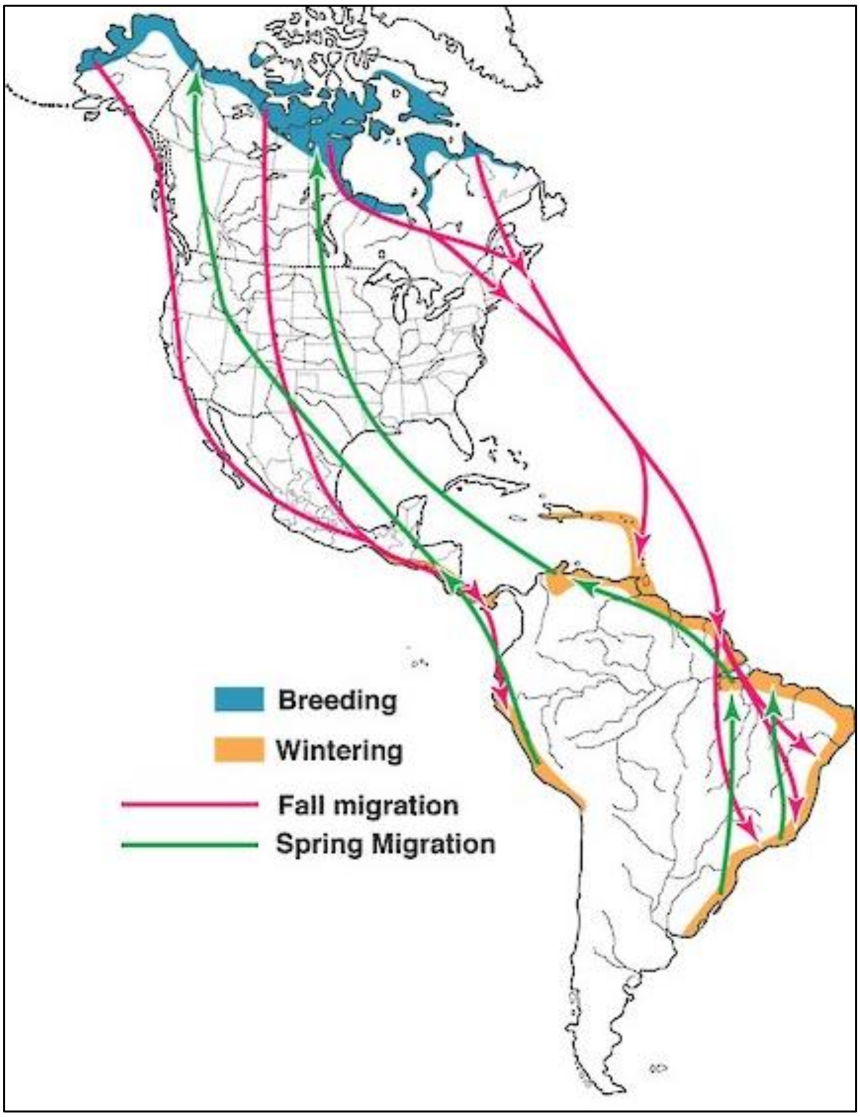
Migrants from North America and the Caribbean as well as from southern South America can be found along the coast of Suriname. The number of taxa, however, from southern South America is small (12 taxa; see Appendix D.19) and include the Great Shearwater, Wilson's storm petrel, Variegated flycatcher, Fork-tailed flycatcher and the Gray-breasted Martin, among others. These migrants are absent from Suriname during the southern summer (i.e. northern winter which spans December to February and which corresponds to the short wet season and the beginning of the short dry season in Suriname), which is the breeding season for these taxa of birds. This period of December – February, in which these species are absent, does not coincide with the proposed drilling period for this Project (April – December 2019).

Conversely, the number of migrants from the north of South America is much greater (about 49 taxa). Among those, shorebirds form the most important group, with about 20 taxa and more than 2 million birds (Spaans 2003).

Other prominent migrants from the north are the Osprey, Peregrine Falcon, Blue-winged Teal, various species of Terns, such as the Black Tern, Gull-billed Tern, Common Tern, Least Tern, Yellow-billed Cuckoo, Barn Swallow and Yellow Warbler. Of most species (in particular shorebirds and terns), small numbers remain in Suriname during the northern summer (June to August; which corresponds to the long wet season of Suriname, as well as the proposed drilling period of April – December 2019). These are always juvenile, sexually immature birds. Adult birds remaining behind are either sick birds or birds with shot-gun wounds (Spaans 2003).

As indicated above, the peak in south-bound migration is July to November, however this coincides with the proposed schedule for exploration drilling within Blocks A to D (April – December 2019; see Table 3-3 of Section 3.5 above). Thus, migratory birds will be expected in the Nearshore area during the Project. It should be noted that south-bound migrants which occur in Suriname utilise the "American Atlantic Flyway" migration route (Brown *et al.* 2001), which is a general route from North America to the Caribbean and South America. Specific migratory pathways to the CMNR Western Hemisphere Shorebird Reserve Network (WHSRN) which intersects the southern boundary of Blocks A to D are not known for all migratory taxa. However, it is expected that most birds utilise the general routes highlighted in Figure 5-161 below (which shows the migration pathway for the Semi-Palmated Sand-Piper to and from Suriname).

Given the general routes, it is expected that migratory pathways may dissect Blocks A to D as birds attempt to land within the CMNR WHSRN.



Source: Hicklin and Gratto-Trevor 2010

Figure 5-161: Expected Migratory Pathways for Birds to and from Suriname (based on the Migratory Pathway of the Semi-Palmated Sand-Piper)

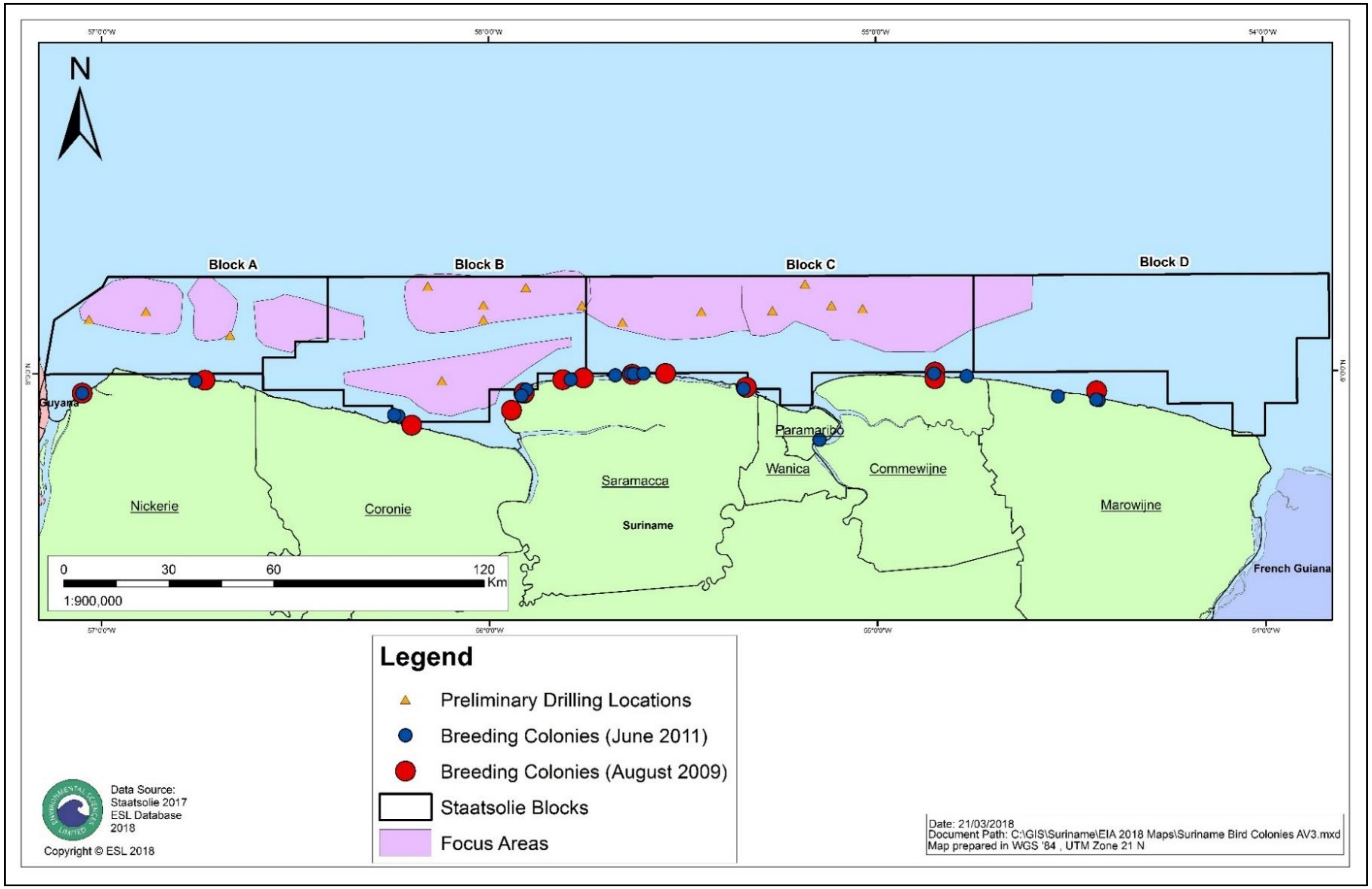
5.4.7.5 Breeding along the Suriname Coast

Table 3 in Annex 1 of Appendix D.19 lists the avifaunal taxa which breed within the estuarine zone of Suriname (and excludes those which breed in their northern or southern breeding areas and vagrants). This table also presents the breeding status by taxon, and shows that a total of 106 avifaunal taxa may breed within the estuarine zone: 89 have confirmed breeding status; 13 have assumed breeding status; and for 4 taxa, the breeding status is unclear (Ottema *et al*. 2009; Ribot 2017).

Most bird taxa are solitary breeders, but the ciconiiform birds (consisting of herons, ibises, storks and the Roseate spoonbill) breed in colonies (see Appendix D.19). Herons and ibises typically establish colonies within the young mangrove, while the Roseate spoonbill and the Wood stork (for which there is only one record) usually breed in older mangrove forest. The heron taxa are often found in mixed colonies; smaller herons also tend to breed together with the Scarlet Ibis. Colonies are of particular importance (in comparison to solitary nests), given that they may be impacted to a greater degree than solitary nests (owing to high numbers of birds in a large area, and also dependent on the sensitivity of these species, either at the taxonomic level, or in the context of the colony occurring in a locally or internationally protected area).

Records of the periods of highest numbers for taxa presented in Table 3 of Annex 1 in Appendix D.19 indicate that breeding occurs throughout the year, although most birds breed during the long wet season (late April to mid-August; with peak breeding during May – June) and in the months shortly after (the beginning of the long dry season, which spans in total mid-August to early December). The breeding season of the majority of colony breeders starts between March and April and ends between August and September, with peak breeding from May to June. Thus, based on the projected timelime for the duration of drilling (April – December 2019; see Table 3-3 of Section 3.5 above), it is likely that drilling will occur during the breeding seasons of colony and non-colony forming birds known to occur along the Suriname shoreline.

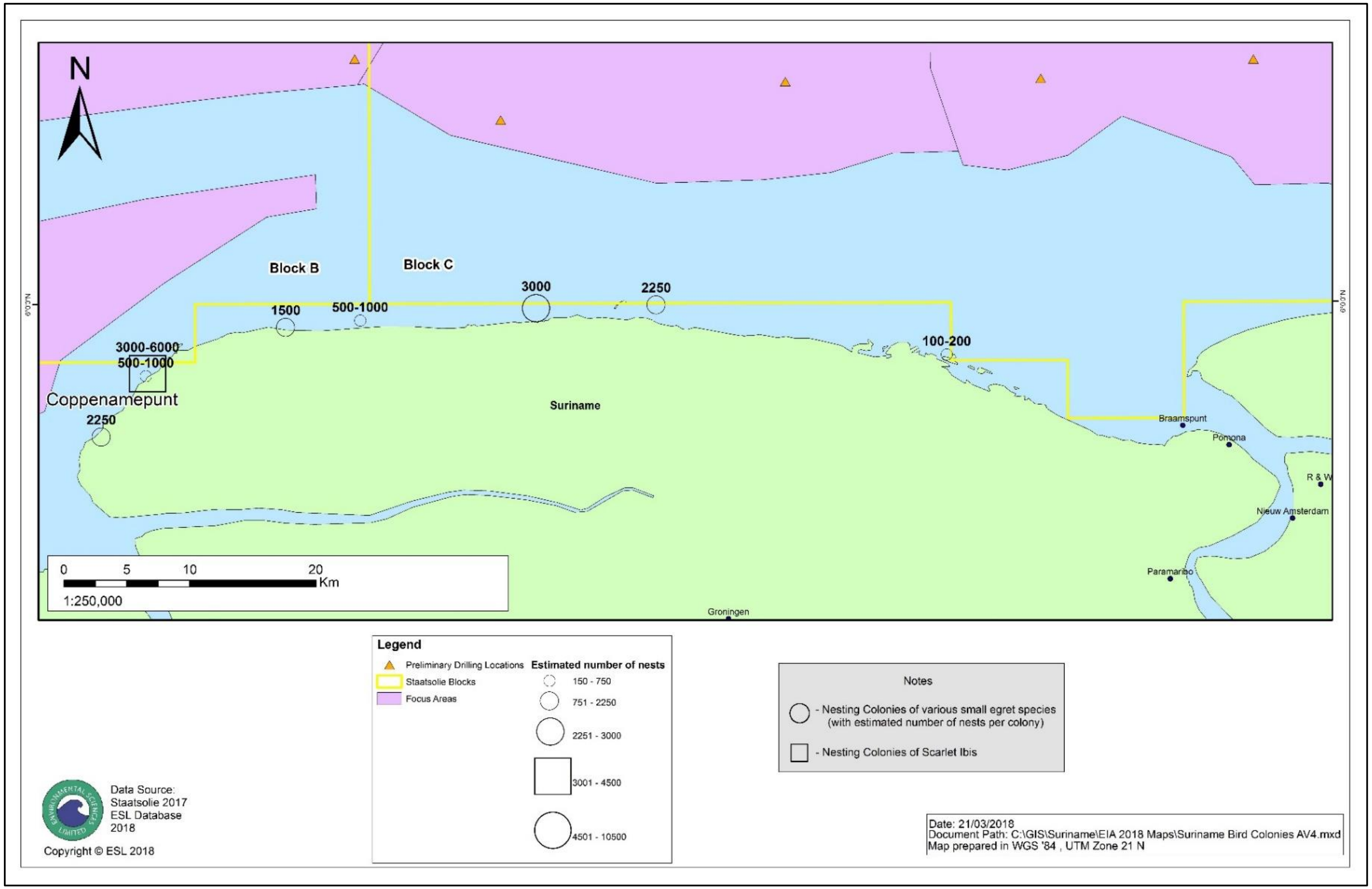
The location of the breeding colonies in June 2009 and 2011 (based on unpublished data collected by Dr. Spanns; see Appendix D.19) is presented in Figure 5-162 below. In 2011, more than 50% of the colonies (30-35% of heron nests and 85% of the Scarlet Ibis nests in Suriname), were observed in the Saramacca/Wanica area (shoreward of the eastern portion of Block B and the western portion of Block C).



Source: ESL Database 2018 and Unpublished Data collectec by Dr. Arie Spanns in 2009 and 2011 (see Noordam 2018e in Appendix D.19)

Figure 5-162: Avifauna Nesting Colonies along the Suriname Coast in August 2009 and June 2011

The data from 2009 also revealed that there were 2 nesting colonies for various small egret taxa to the south of Block C, with an estimated number of nests ranging from 2,250 – 3,000. Four small egret nesting colonies and one Scarlet ibis nesting colony, were observed to the south of Block B, with egrets' nest densities ranging from 500 – 2,250 (the largest colony occurring at Coppenamepunt, located at the black square in Figure 5-163 below). The 2009 Scarlet ibis colony had an estimated 3,000 – 6,000 nests (Figure 5-163 below).



Source: ESL Database 2018 and Unpublished Data collectec by Dr. Arie Spanns in 2009 (see Noordam 2018e in Appendix D.19)

Figure 5-163: Avifauna Nesting Colonies along the Suriname Coast in August 2009

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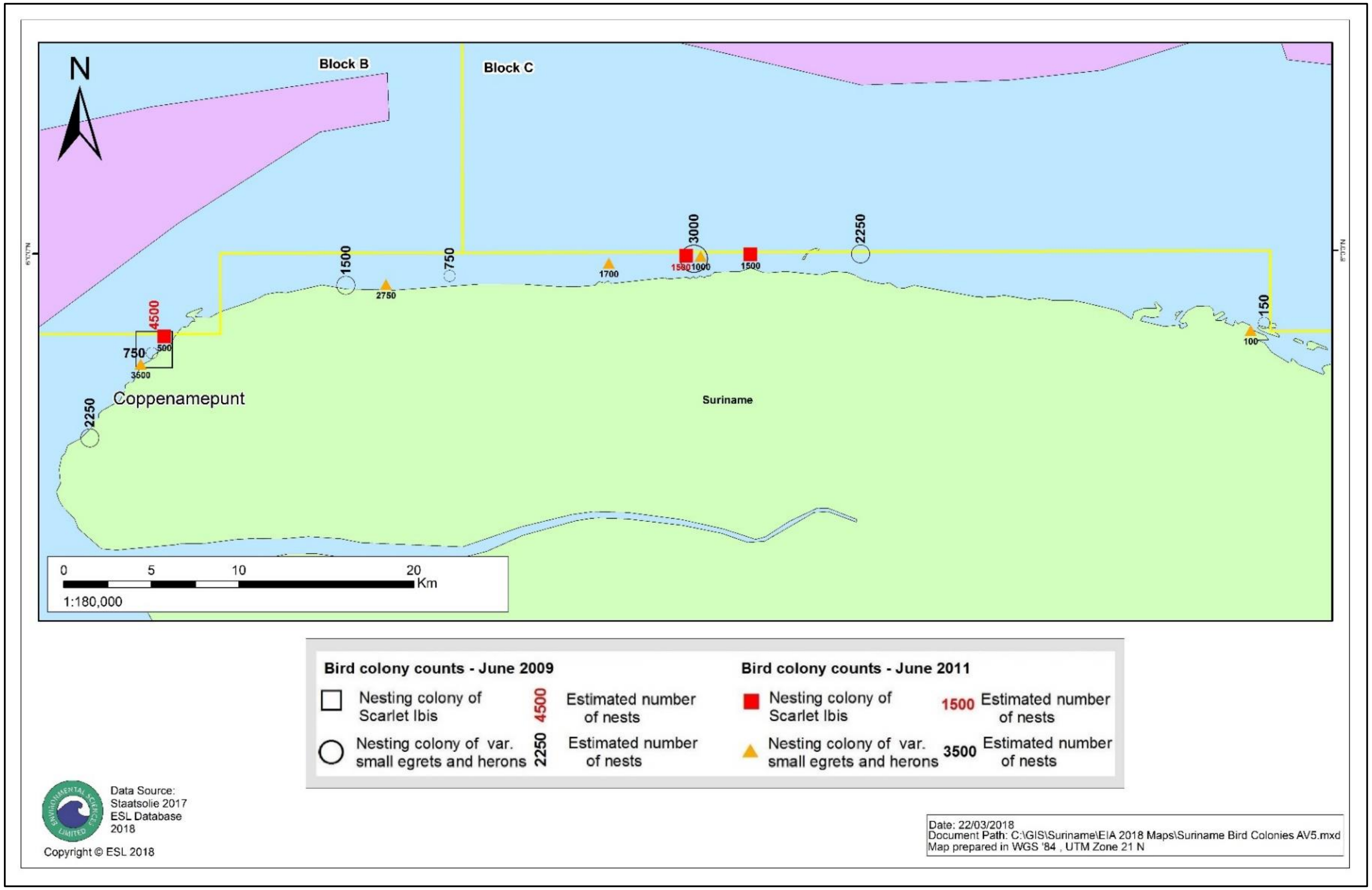
2011 data revealed that there were 5 nesting colonies south of Block C; 4 belonging to smaller egrets, with an estimated number of nests ranging from 100 – 1,500, and one Scarlet ibis nesting colony with an estimated 1,500 nests. Two of the colonies (one smaller egret and the Scarlet ibis colony) coincided with one of the larger 2009 colonies for smaller egrets (see Figure 5-164 below). The data also showed that 3 colonies were recorded to the south of Block B; 2 smaller egret nesting colonies, with an estimated number of nests ranging from 2,750 – 3,500; and one Scarlet Ibis nesting colony with an estimated number of 500 nests. A 2011 colony cluster was observed in the same location as in 2009, at Coppenamepunt (located at the black square in Figure 5-164 below). Disturbance of breeding and roosting colonies may lead to loss of nestlings and desertion of the breeding/roosting site.



Source: ESL Database 2018 and Unpublished Data collectec by Dr. Arie Spanns in 2011 (see Noordam 2018e in Appendix D.19)

Figure 5-164: Avifauna Nesting Colonies along the Suriname Coast in June 2011

Since 2011, no breeding colony surveys along the full length of Suriname's coast have been conducted. However, as part of monitoring for their oil production development in Saramacca, Staatsolie has undertaken breeding colony surveys along the Saramacca coast. Results are only available for June 2017, in which a single breeding colony with 1,000 Snowy Egrets and 5,000 Scarlet Ibises was observed near Coppenamepunt.

Some more recent information on the distribution of birds along the coastline was gathered from the aerial photographs that were taken during the coastal flyover on July 13th – 14th, 2017. The only birds that were clearly identifiable were white birds, probably white egrets and herons (see further below in Figure 5-166 for locations of 2017 observations). Flying and foraging birds were relatively easy to be seen, but roosting birds were only detected when on the top of the trees. Smaller and larger groups were observed, but it was not possible to decipher whether larger groups were roosting or breeding. However, the larger gatherings were more likely to present breeding colonies. Such colonies are typically found between March and September. Figure 5-165(a) and Figure 5-165(b) below illustrate 2 of the observations during the flyover (elevation 700 ft).

Source: ESL's Aerial Flyover (July 2017)

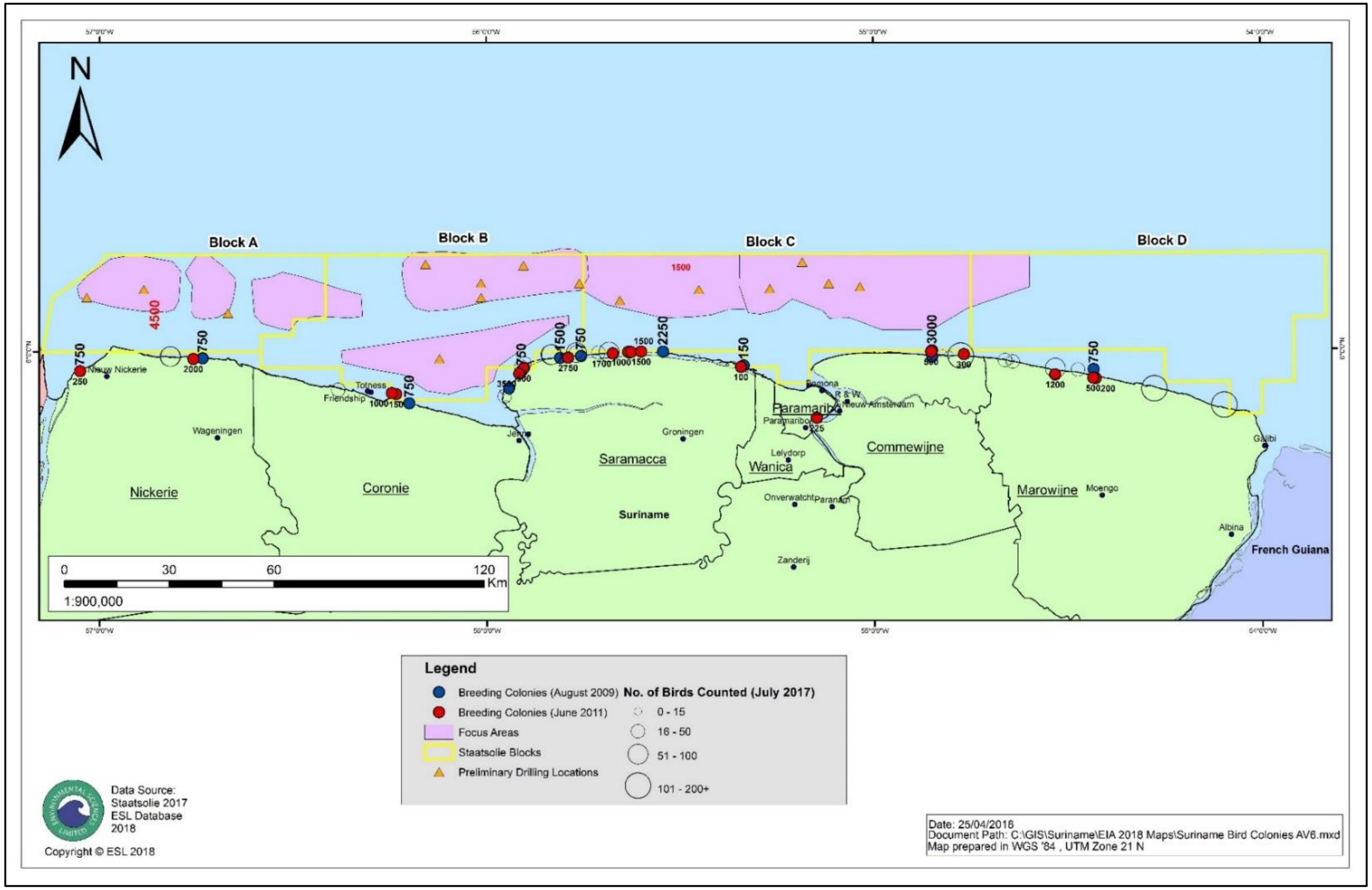
(a) Aerial view of a Large Gathering of White Birds at a Colony observed in July 2017

(b) A Flock of Flying White Birds observed in July 2017

Figure 5-165: Avifaunal Observations from Aerial Photography (July 2017)

The result of the counts are presented in Figure 5-166 below. When compared with the colonies from 2009 and 2011 (Figure 5-163 and Figure 5-164 above), there was a general similarity amongst 3 datasets regarding the locations of identified bird colonies. These areas with bird presence are probably the preferred zones for the observed bird species. Most of these zones have the combination of 2 or more of the following characteristics:

- A mudflat is present;
- Young to medium mangrove;
- A creek in the neighbourhood; and
- Lagoons in the neighbourhood.



Source: ESL Database 2018; ESL's Aerial Flyover (July 2017) and Unpublished Data collectec by Dr. Arie Spanns in 2009 and 2011 (see Noordam 2018e in Appendix D.19)

Figure 5-166: Result of Birds Counts using Aerial Photography (Dirk Noordam; July 2017), along with the Results of Bird Surveys conducted in 2009 and 2011 (from Unpublished Data collected by Dr. Arie Spaans in 2009 & 2011)

On August 3rd, 2010, an aerial field survey was undertaken along the Saramacca coast south of Block IV (which corresponds to the eastern part of Block B and the western half of Block C) in order to identify and enumerate avifaunal taxa within the study area in areas identified as either eroding or non-eroding coastline (ESL 2013b). Birds were then counted along the coastline (28 km in total) based on this classification. A total of 844 specimens were identified, belonging to 18 taxa, where the non-eroding coast contained a higher number of individuals per km, as compared to the eroding coast (43.3% versus 23.3% of all specimens recorded), but this was not found to be statistically significant (through the use of the Wilcoxon ranking test; ESL 2013b).

Ciconiiform birds were found to dominate, with the Snowy Egret accounting for 70% of the total counted birds. These birds and other herons were seen in small groups resting along the coastline (at the time, mudbanks were not visible). The Scarlet Ibis, representing over 10% of the count, was seen flying above the mangrove along some sections of the coast, as were the vultures and the ducks. Other species were seen flying close to the coast, or slightly further out.

Based on the foregoing information presented on colony-forming birds surveyed during the period June – August (across the various studies mentioned), these colonies will be present during the proposed drilling Project (April – December 2019.

5.4.8 Terrestrial Mammals

Appendix D.21 lists the 173 terrestrial mammalian taxa known to occur in Suriname (WICE 2010). Families include: Didelphidae (opossums); Bradypodidae (sloths); Dasypodidae (armadillos); Atelidae, Cebidae and Pithecidae (New World monkeys); Canidae (wolves, foxes and their relatives); Felidae (cats); Mustelidae (weasels); Procyonidae (raccoons, coatis and their relatives); Tayassuidae (peccaries); Cervidae (deer); Sciuridae (squirrels); and Muridae (mice, rats, gerbils and their relatives), among others. Suriname is also home to approximately 100 taxa of bats, distributed amongst 9 families.

Appendix D.21 is not intended to be an exhaustive list of Suriname's terrestrial mammals. Though there have been many studies conducted within the estuarine zone (such as Husson 1978; Mittermeier 1977; Duplaix 1978, Duplaix and Reichart 1978 and De Smet 1990), there is no systematic inventory of the mammalian fauna of the estuarine and coastal zones of Suriname. In addition, not all of the taxa listed in Appendix D.21 will occur within the coastal zone, as some of the named species are forest-specific (such as some species of bats and felids). Taxa which are known to occur in the different habitats within the estuarine zone include (among others):

- The Crab-eating racoon (*Procyon cancrivorus*): located in littoral mangrove swamps and cultivated land
- The Red howler monkey (*Alouatta seniculus*): located in the forested sand ridges

- The Jaguar (*Panthera onca*): commonly found in swamps, ridges and sea turtle beaches
- The White-tailed deer (*Odocoileus virginianus*)
- Spectral bat (*Vampyrum spectrum*), known to occur in swampy areas
- Bush dog (*Speothos venaticus*), which can be found in various habitat types
- White-lipped peccary (*Tayassu pecari*); considered a generalist species
- Giant ant-eater (*Myrmecophaga tridactyla*) and
- Giant otter (*Pteronura brasiliensis;* see below for IUCN 2017.3 classification)

Teunissen 2000, in summary, specifies that there are 7 taxa of marsupials, 13 bats, 4 monkeys, 4 edentates (ant-eaters, sloths, armadillos and the like); 8 carnivores (including the Jaguar); 4 ungulates (including the White-tailed deer) and 12 rodents as occurring in the estuarine zone of Suriname.

There are no known endemic mammalian species in Suriname (Groombridge and Jenkins, 1994). Locally, the Game Act of 1954 provides protection for all mammalian species of Suriname, except those mentioned in the Game Resolution of 2002 and named as (a) game species and (b) predominantly harmful species. In addition, the IUCN Red List (Version 2017.3) indicates that there are several threatened species. These include:

- The critically endangered Black bearded saki (*Chiropotes satanas*);

- The endangered Giant otter (*Pteronura brasiliensis*);

- Vulnerable taxa:
  - Giant armadillo (*Priodontes maximus*);
  - Giant anteater (*Myrmecophaga tridactyla*);
  - White-lipped peccary (*Tayassu pecari*);
  - Guiana spider monkey (*Ateles paniscus*); and
  - Northern tiger cat (*Leopardus tigrinus*)

- Near Threatened taxa:
  - Spectral bat (*Vampyrum spectrum*);
  - Hairy little fruit bat (*Rhinophylla alethina*);
  - Bush dog (*Speothos venaticus*);
  - Margay (*Leopardus wiedii*); and
  - Jaguar (*Panthera onca*).

5.4.9 Herpetofauna

Groombridge and Jenkins 1994 indicate that there are 95 amphibian taxa known to occur in Suriname. Eight of these are considered endemic, though records for only 4 could be found (see Table 5-44 below). Given the habitat preferences of these taxa, it is unlikely that specimens would be found within the estuarine zone of Suriname.

Table 5-44: Endemic Frog Taxa of Suriname

Taxon		Environment	IUCN Status (2017.3)
Scientific Name	Common Name		
Cochranella geijskesi	Wilhelmina Cochran Frog	Primary forest	Data Deficient
Dendrobates tinctorius	Dyeing Poison Frog	Tropical rainforest	Least Concern
Microcaecilia taylori	Tiny Taylor's Caecilian	Subterranean forest	Least Concern
Hypsiboas fuentei	Fuente's Powakka Tree Frog	Riverine forest	Data Deficient

Source: Groombridge and Jenkins 1994 and IUCN 2017

Groombridge and Jenkins 1994 specified a total of 151 reptilian taxa known to occur in Suriname, but this number differs from that provided by Uetz and Hallerman 2005 (73). Groombridge and Jenkins 1994 also state that none of these taxa are endemic to Suriname. However, Uetz and Hallerman 2015 specifies that the Worm lizard (*Amphisbaena myersi*) is endemic.

Of the 73 taxa noted by Uetz and Hallerman 2015, 23 occur on the IUCN Red List (version 2017.3). Five of these are turtles and are dealt with in Section 5.4.4 above. The remaining 18 are mostly classified as Least Concern or Data Deficient, with 3 taxa showing some level of vulnerability. These include: Arnour’s anole (*Anolis cybotes*; Near Threatened); Tabasco mud turtle (*Kinosternon scorpioides*; Vulnerable) and Yellow-spotted River Turtle (*Podocnemis unifilis*; Near Threatened). IUCN’s version 2017.3 records for these species are limited in information related to where these taxa may be found within Suriname, and as a result, it is difficult to say conclusively if these vulnerable taxa may be found in the estuarine zone of Suriname (though the latter 2 are considered semi-aquatic freshwater taxa).

5.4.10 Summary of Sensitive Species & Habitats

Review of the baseline information presented above indicates that there are several sensitive taxa (exposed to some level of threat, based on IUCN Red List 2017.3) which may be present within the offshore area of Suriname. These include marine mammals such as the Fin, Sei, Blue and Sperm whales and West Indian manatee. The Leatherback, Green, Olive Ridley, Hawksbill and Loggerhead turtles are also sensitive taxa which may also traverse offshore waters, particularly during the nesting season (generally February to August), with peak nesting occurring during April to June. Thus, the majority of the turtle nesting period will coincide with the proposed drilling period for this Project (April – December 2019).

A total of 81 threatened fish taxa may be found in the waters of Suriname; these include sharks and rays, Queen trigger fish, Red porgy, Lined seahorse, Creole fish, 4 taxa of tuna and 12 taxa of groupers (including the Goliath grouper. Ten threatened avifaunal taxa are known to occur in Suriname, including: Yellow-nosed albatross, Leach's storm petrel, Black-legged Kittiwake, Rufous crab-eating hawk, Arrowhead piculet, Fea's petrel, Red knot, Semi-palmated sandpiper, Buff-breasted sandpiper and Bicoloured conebill. Of these, the Semi-palmated sandpiper and the Rufous crab-eating hawk are internationally important shorebird taxa (for the establishment of WHSRN sites).

Migratory shorebirds can be found in peak numbers in Suriname during the southbound (July–November) and northbound (February–May) migration periods; the proposed drilling period of April – December 2019 coincides with the peak southbound migration, and with the latter part of the northbound migration. Breeding occurs throughout the year, although most birds breed during the long wet season (late April to mid-August and as late as September), with peak breeding during May – June. Based on this, breeding (colony and non-colony forming birds) will occur for the duration of the drilling period (April – December 2019).

The terrestrial area to the south of Blocks A to D is habitat-diverse and species-rich. Ecosystems which are critical in the support of biodiversity include: mudflats, mangroves and lagoons. More specifically, marine waters, soft mudflats, firm clay flats, young coastal mangrove, older stands of Black mangrove and brackish water lagoons and swamps provide habitat for over 729 avifaunal species. Of these 209 are either partly or entirely dependent on the Suriname coastal area for survival. The coast of Suriname contains the most important feeding, breeding and nesting sites for resident coastal birds, and is internationally important for North and South American migrant species. A total of 118 species utilise this coastal area for nesting, 70 of which are waterfowl species. The coastal area is critical (internationally important) for 7 waterfowl species, and there are very high nesting colony densities for herons and ibises along the Saramacca coast, based on unpublished data from Spanns for 2009 (3,000 – 6,000 nests) and 2011 (2,750 – 3,500 nests).

Finally, the following protected areas overlap with Blocks A to D: 4 MUMAs (Bigi Pan, North Coronie, North Saramacca and North Commewijne – Marowijne) and 4 NRs (Peruvia, Coppename Monding, Wia-Wia and Galibi). Most of these are very important feeding and breeding areas for birds (Bigi Pan MUMA and CMNR are WHSRN sites, and the latter is also a Ramsar site, while the former is proposed); while Galibi is so designated for the protection of turtles nesting areas.

5.5 Socio-Cultural Environment

This Section discusses the various components of the socio-cultural environment which may be impacted by the proposed Project. It will be discussed under the following main headings:

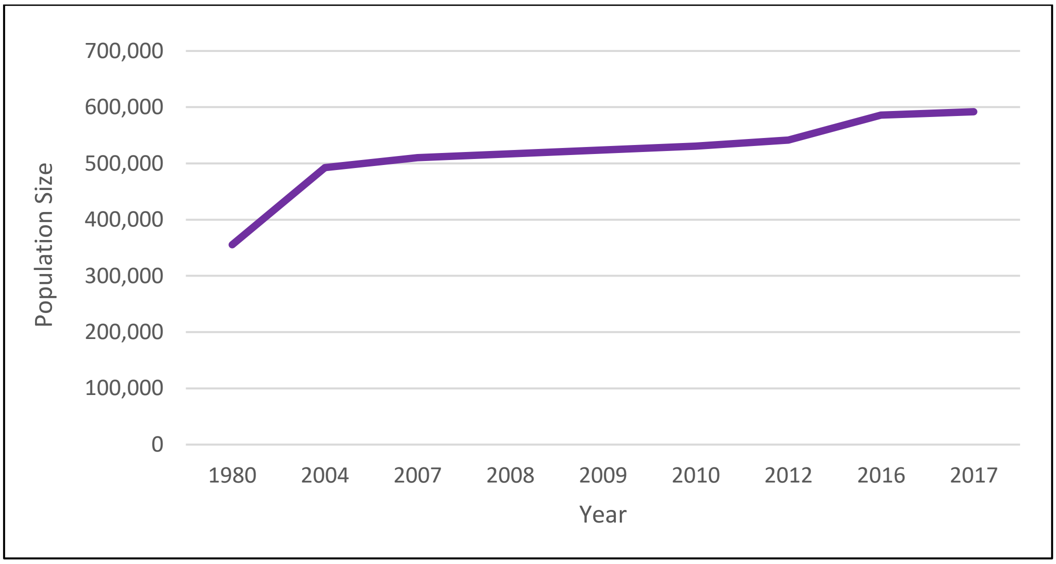
- Population Demographics;
- Economy, Employment & Income;
- Resource Users;
- Mineral Resources;
- Oil & Gas Activities;
- Emergency Resources;
- Fisheries;
- Protected Areas;
- Recreation & Tourism;
- Archaeological & Historical Resources; and
- Ports & Transportation.

5.5.1 Population Demographics

Table 5-45 below presents total population figures (estimated) for Suriname over the period 1980 to 2017, obtained from a range of sources. The data reveal an increase in the total population over the 37-year period, with a reduction in the rate of increase over time, as shown in Figure 5-167 below. The data reveal that the steepest increase in population was experienced during 1980 – 2004, at an annual population growth rate of 1.37% (ABS 2004), compared to 1.20% estimated as of July 2016, and 1.02%, estimated as of July 2017 (CIA 2018).

Table 5-45: Estimated Total Population of Suriname (1980 – 2017)

Year	Population	Data Source
1980	355,420	ABS 2004
2004	492,464	ABS 2004
2007	510,000	ABS 2013, ABS 2014
2008	517,052	CIA 2018
2009	524,000	ABS 2013, ABS 2014
2010	531,000	ABS 2013, ABS 2014
2012	541,638	ABS 2012
2016	585,824	CIA 2018
2017	591,919	CIA 2018



Source: See sources listed in Table 5-45 above

Figure 5-167: Total Estimated Population of Suriname (1980 – 2017)

Overall, for the total land acreage of Suriname, the population density is recorded as approximately 4 persons per km^2 (CIA 2018) but the majority of the population resides in the narrow coastal strip, whilst the remainder of the population is sparsely distributed across the interior. In fact, approximately 66% of the total population is confined to the urban and semi-urban coastal districts of Paramaribo and Wanica, which occupy less than 1% of the total land area of Suriname (Table 5-46 below; SIMS 2014). When other rural coastal areas are taken into account, the population confined to the narrow coastal strip increases to around 95% of the total population (Spaans and Baal 1990).

Table 5-46: Comparison of Population Statistics by District (2016)

District		Area (km^2)	Area (% of Total Land Area)	Population	Population (% of Total Population)	Population Density
1	Brokopondo	7,364	4.50	15,909	2.90	2.20
2	Commewijne	2,353	1.40	31,420	5.80	13.40
3	Coronie	3,902	2.40	3,391	0.60	0.90
4	Marowijne	4,627	2.80	18,294	3.40	4.00
5	Nickerie	5,353	3.30	34,233	6.30	6.40
6	Para	5,393	3.30	24,700	4.60	4.60
7	Paramaribo	182	0.10	240,924	44.50	1,323.80
8	Saramacca	3,636	2.20	17,480	3.20	4.80
9	Sipaliwini	130,567	79.70	37,065	6.80	0.30
10	Wanica	443	0.30	118,222	21.80	266.90

Source: SIMS 2014

Suriname is a pluralistic society[26], and is home to a diverse composition of population, which has its origins in the plantation economy. The current population comprises: 27.4% Hindustani or 'East Indians' (whose ancestors emigrated from northern India in the latter part of the 19th Century); 21.7% Maroons (whose African ancestors were brought to the country in the 17th and 18th Centuries as slaves and escaped to the interior); 15.7% Creole (mixed white and black); 13.7% Javanese; 13.4% Mixed; 7.6% Other, including Amerindian, Chinese, Filipinos, Whites, Brazilians, Dominicans (Republic) and Haitians; and 0.6% unspecified (CIA 2018).

5.5.2 Economy & Employment

Suriname's economy is dominated by the mining industry, with exports of oil and gold accounting for approximately 85% of exports and 27% of government revenues (CIA 2018). Gross Domestic Productivity or GDP for 2016 (purchasing power parity or PPP, based on 2016 dollars[27]) was estimated at $7.885 billion, a decrease over the figure for 2015, $8.669 billion. GDP real growth has also declined significantly over the last 3 years, and was estimated at -10.5% for 2016, compared to -2.7% and 0.4% for 2015 and 2014, respectively. As a consequence, the GDP per capita (purchasing power parity) also showed a declining trend over the period 2014 – 2016, with a value of $16,400 for 2014, reduced to $15,800 for 2015, and further reduced to $14,000 for 2016 (CIA 2018).

For the 3 major economic sectors, the service sector contributed 57.5% of GDP (estimated for 2016), whilst industry contributed 30.7%. The agricultural sector contributed 11.8%. The majority of GDP earned (64.3%) has end use in investment in fixed capital, and exports of goods and services (45.2%) followed by household consumption (32.7%).

The total labour force of Suriname stood at 144,000 persons, based on a 2014 estimate, 69.3% of which was employed in the service sector, followed by industry (19.5%) and agriculture (11.2%). The agricultural sector is dominated by the production of rice, bananas, palm kernels, coconuts, plantains, and

[26] *The term 'pluralistic' relates to a system in which two or more states, groups, principles, sources of authority, etc., coexist. In the context used above, the term indicates that Suriname's society is a diverse and multi-cultural one.*

[27] *Countries use different currencies, and so the GDP of a country typically has to be measured in a manner which makes it comparable to that of other countries. Alternatively, cost of living and inflation can cause changes in the value of a single currency over time, making it difficult to compare 2 currency values (same country) over time. One way to make values comparable is by applying purchasing power parity (PPP). The purchasing power of a currency refers to the quantity of the currency needed to purchase a given unit of a good, or common basket of goods and services. Purchasing power is clearly determined by the relative cost of living and inflation rates in different countries or over time. Purchasing power parity means equalising the purchasing power of two currencies by taking into account these cost of living and inflation differences (Economics Online; n.d.). Thus, in the context above, the GDP PPP of Suriname for 2016 was found to be lower than that for 2015, but in order to make this comparison, the figure for 2015 was adjusted to reflect cost of living and inflation based on 2016 dollars, so as to be directly comparable to the figure for 2016.*

peanuts, as well as livestock (beef, chicken), and shrimp. The industrial sector comprises of gold and bauxite mining, alumina production, oil, lumbering, food processing and fishing. The service sector comprises public administration, defence, trade and tourism. The unemployment rate for Suriname was estimated at 11% in 2016, up from 8.5% in 2013.

The economy's reliance on exports of oil and gold makes it highly vulnerable to mineral price volatility, and this is borne out by the economic indicators discussed above. Some of the contributing factors to the decline in the economy are a global decrease in international commodity prices and the closure of Suralco (alumina mining) in 2017 (ALCOA 2017; CIA 2018). From 2011 onwards, the Government of Suriname began making a series of adjustments at the macro-economic level, including currency devaluation and increase in taxation, along with foreign currency interventions by the Central Bank, which eventually resulted in the flotation of the Suriname dollar against the US dollar in March 2016. Over a period of 9 months, the dollar had lost 46% of its value against the US dollar, and depreciation contributed to an increase in inflation by December 2016. It is in this context that the development of the oil sector (industry) in Suriname by Staatsolie is paramount to lifting the economy, and the increase in international oil prices will further positively contribute to the growth in the economy.

5.5.3 Resource Users

In general, the resources which comprise the YCP relate to the physical, ecological and socio-economic and cultural environments. These resources are considered intrinsically valuable and directly and indirectly beneficial to resource users. These resources include: fish and shellfish, shore birds, sea turtles, marine mammals, mangroves and other coastal wetland ecosystems, archaeological and cultural resources, and physical resources such as oil, sand and gravel, and the sea as a water way.

Table 5-47 below lists the resource users who can be found within terrestrial, Nearshore and marine environments which comprise the baseline study area (where the terrestrial area is defined as the narrow coastal strip 2 km wide from the coastline; see Figure 5-1 above). The table also provides the manner of use of resources by users. The aspects of the socio-economic and cultural environment which are of relevance to resources users in the context of this Project are described further in Sections 5.5.4 to 5.5.11 below.

The resource users identified in Table 5-47 below utilise and benefit from the natural and built environment through the use of land and sea for subsistence and derivation of income, as well as for leisure and traditional use. In some cases, the preservation of the environment in its natural form is required, in order to ensure that use and value of these resources are not diminished or lost. For example, bird watching may derive significant income for local tour guides, and activities which have the potential to impact upon bird nesting and roosting populations may impact upon tourism and consequently, the income derived from it. Indirect benefits may also be affected, such as food vendors who derive income from the tourists who visit these sites.

Table 5-47: Resource Users within the Project Area (Terrestrial, Nearshore & Offshore)

Resource User	Manner of Use
Local residents	Persons who live in coastal villages, towns, and city (within the 2 km zone) and travel throughout their communities and from part of the country to another, for work or leisure. This includes persons who engage in subsistence livelihoods or who engage in traditional use and practices
Local (national) users	Persons who live outside of the 2 km zone identified but travel to or through the coastal plain zone for work or leisure (including local tourists)
Tourists (regional/international)	Persons who reside in regional or international countries and visit the coastal plain for work or leisure (such as bird watching, turtle nesting, marine mammals)
Tour operators and guides	Persons who derive income from arranging and managing transportation of locals and tourists to various tourist attractions (birds and other wildlife, and historical sites, including Paramaribo)
NGO & CBO groups	Persons who work with an interest in preserving and conserving the natural and built environment and who work with communities to improve the lives of residents
Farmers	Persons who derive income from agriculture, including rearing of crops and livestock farming, and who use the transportation network within the coastal plain to distribute agricultural products (including for export), and the persons employed by these.
Fisherfolk	Persons who derive income from artisanal and industrial fishing and who use the transportation network within the coastal plain to distribute fish and fishing products (including for export), and the persons employed by these. This also includes sport fishers, who fish for leisure.
Agricultural and Fish Processing and Distribution/Export Companies	Businesses which derive income from the processing of agricultural and fish products, and who distribute/export such derived products; or who distribute imported goods (as inputs into other processes or as final products) related to

Resource User	Manner of Use
	these sectors, and the persons employed by these.
Oil & gas companies	Businesses which are involved in the exploration and development of the oil industry, including service support industries, and the persons employed by these.
Mining companies	Businesses which are involved in mining based on concessions granted by the Mining Department (GMD), and the persons employed by these.
Service sector companies	Businesses dealing with transportation, defence, public administration, finance and commerce, tourism and hospitality and other related service-oriented fields, and the persons employed by these
Marine transport users	Governmental departments/agencies and businesses involved in the shipping and maritime industry, including freight, import and export (local, regional and international), transportation and defence of waterways and the sea (fisherfolk are captured as a separate lime item in this table; see above)
Government	Employer of the public service (including Local Government), and administrator for the various sectors, with the seat of power located in Paramaribo. The local Government District Commissioner offices and their employees and Local Representatives of the various Ministries also play an important role in the various districts.

5.5.4 Mineral Resources

Suriname is a mineral-rich country whose outputs include alumina, bauxite, cement (produced from imported clinker), clay, crude oil, crushed stone, gold, gravel, refined petroleum products (premium diesel and gasoline, Staatsolie diesel, fuel oil, bitumen and sulphuric acid), and sand (Mobbs 2016). Of these, the major contributors to real GDP include crude oil, alumina/bauxite, gold and cement. Table 5-48 below presents a summary of Suriname's production of these mineral commodities based on data for Suriname, provided by the United States Geological Survey (USGS), for the period 2010 to 2015 (Matzko 2017 and USGS 2017). The relevant values for 2016 – 2017 were not available as published data from the USGS, and so the table below presents the most recent available published data.

Table 5-48: Production of Mineral Commodities in Suriname (2010 – 2015)

Commodity		Year					
		2010[1]	2011[1]	2012[1]	2013[1]	2014[1]	2015[2]
Aluminium	Bauxite (gross weight)	3,140	3,236	2,873	2,706	2,708	1,600
	Alumina	1,486	1,421	1,203	1,149	1,149	748
Hydraulic cement		45	74	114	131	160	-
Gold, (mine output, gold content)		31,048	32,208	33,474	34,213	33,000	-
Petroleum	Crude	5,800	5,990	5,940	5,980	6,130	-
	Refined petroleum products	2,700	2,630	2,310	2,780	1,460	-

Sources: 1: Matzko 2017; 2: USGS 2017

Notes:
** These data are rounded estimates and dashes indicate that data were not available.*
*** Values listed in thousand metric tons, unless otherwise stated*
**** Data on other mineral commodities such as clay, gravel, sand and crushed stone were not available*

The figures presented above do not account for recent factors which have influenced the contribution of the mineral (industrial) sector to real GDP of Suriname. As indicated in Section 5.5.2 above, Suriname's economy is dependent on this industry, but the decline in the international commodities prices of gold and crude oil and the closure of the ALCOA's Suralco operations (alumina processing; ALCOA 2017) have reduced the contribution of this industry to real GDP over the period 2015 – 2017. Conversely, the establishment and start-up of the Merian gold mine in October 2016 (of which Staatsolie has 25% ownership; Newmont 2017; Kuipers 2016), and the recent increases in commodities prices for gold and crude, along with Staatsolie's investment (over the period 2018 – 2019) in Nearshore exploration with the advent of this proposed Project, may collectively provide an avenue for an increase in real GDP to Suriname over the period 2017 – 2019 and beyond. The continued operations of Vensur N.V. (cement), Rosebel N.V. (gold mines) and artisanal miners, Kaloti Suriname Mint House (refined metals), and Staatsolie (continued operations at Calcutta, Tambaredjo, and Tambaredjo NW in Saramacca district, as well as crude oil refinery at Tout Lui Faut) will also contribute to the upliftment of Suriname's economy over this period.

The various operations listed above are also critically important as employers of the people of Suriname, whose income and expenditure also affect the economy of their country. USGS data (Matzko 2017) also provided an indication of the total number of persons employed in the mineral industry of Suriname, for 2014. This included: 1,918 persons in the bauxite sector; 1,052 persons in the oil sector; 2,035 persons (including contractors) at Rosebel gold mine operations alone; 20,000 small scale miners and 12,000 artisanal miners from Brazil, as immigrants to Suriname.

5.5.5 Oil & Gas Activities

During the 1960s, deposits of oil were found along the YCP near the small town of Calcutta in the District of Saramacca, but at that time no significant or sustainable further steps were taken. To diversify the economy and tap into this valuable resource, Staatsolie Maatschappij Suriname N.V. (Staatsolie), the State Oil Company, was incorporated in December 1980. Since then, Staatsolie has been involved in all aspects of exploration and production, with refining and marketing of crude oil and refined products coming on stream in 1997. Proved reserves stand at 83.98 million bbls, estimated as of January 2017 (CIA 2018). As of December 31st, 2016, proved reserves remained at 84 million stock tank barrels (MMSTB), the same as for year-end 2015 (Staatsolie 2017b; 2016). Staatsolie produced approximately 17,000 bbl of crude oil per day in 2015, with a total production of 6.189 MMbbl (Staatsolie 2016), whereas the comparative figures for 2016 stood at 16,327 bopd and 5.98 MMbbl. Therefore, an overall reduction in production over 2015 – 2016, which translated into a decrease in gross revenues of US$ 223 million (US$591 million realised in 2015, as opposed to US$368 million in 2016; Staatsolie 2017b). The reasons for this included: the decrease in the international commodity price of crude and Staatsolie’s strategy for long-term growth by investing in upgrades to the refinery at Tout Lui Faut as well as in the Merian gold mine project (of which Staatsolie owns 25%).

The refinery at Tout Lui Faut produces diesel, heavy vacuum gas-oil, fuel oil, and asphalt-bitumen. In 2015, the refinery processed 2.9 million bbl of Saramacca Crude into the following end products: 18,000 bbl of premium gasoline; 73,000 bbl of Staatsolie diesel; 71,000 bbl of premium diesel; 32,000 bbls of bitumen; and the rest into fuel oil (Staatsolie 2016), but these figures are not available for 2016, given the operational challenges posed by the refinery upgrade during 2016 (Staatsolie 2017b).

Whilst Suriname’s offshore acreage is large, at 150,000 km^2, only 25 exploration wells have been drilled by multinational companies active within this area (Matzko 2017). This acreage has been divided into Blocks (with Staatsolie’s interest noted, as shown in (Figure 5-168 below, which also shows the locations of petroleum deposits within the Nearshore area of Suriname). Exploration activity began in 2013 with Staatsolies’s announcement of the signature of a 30-year offshore exploration and production agreement with the Spanish oil company Repsol-YPF, relating to Block 30, located 100 km off the north coast of Suriname. In addition, Staatsolie has signed other Production Sharing Contracts (PSC), including one with Maersk Oil from Denmark in November 2004, Tullow Oil in September 2010; Kosmos Energy; and Murphy Oil in December 2011. More recently, additional contracts were signed with Kosmos Energy Suriname (for exploration within offshore Blocks 42 and 45), Apache Corporation (Block 53 and 58), and Petronas Suriname E&P B.V. (Block 52) (CSA 2015a; CSA 2017).

Staatsolie owns the sole rights for the development of the oil industry from the Nearshore area. The 4 contiguous Blocks (A to D), which make up the Nearshore area cover an area of approximately 11,133 km^2, and is shown in Figure 5-168 below. The discovery in May 2015 by ExxonMobil of high quality oil-bearing sandstone at the Liza-1 well-site and the confirmation of same at Liza-2 within Stabroek Block, offshore Guyana has raised interest in the hydrocarbon potential of Guyana and surrounding areas, including Suriname. This is one of the main factors in the drive to discover new resources within the offshore and Nearshore areas of Suriname

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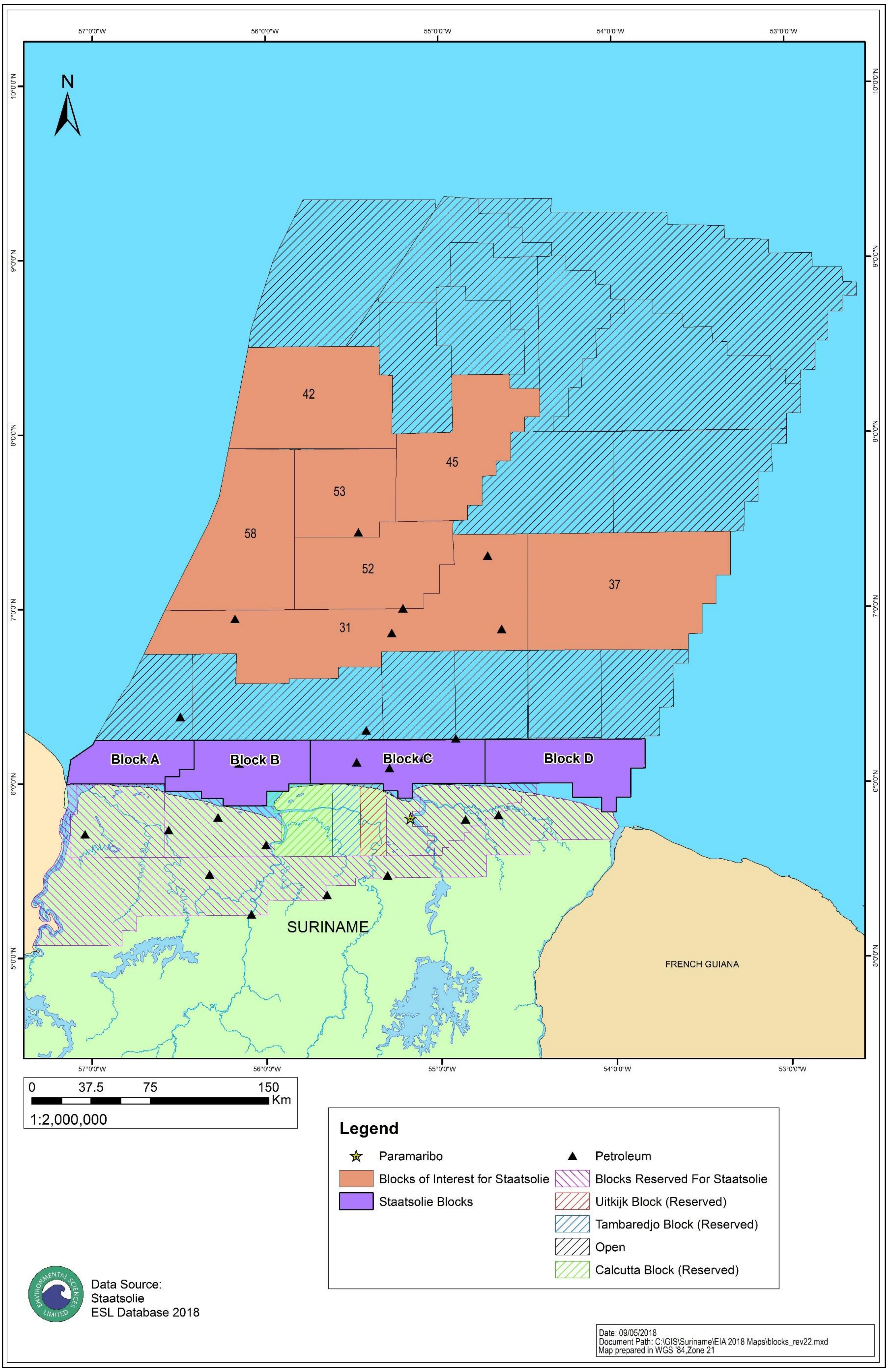

Source: ESL Database 2018 and Staatsolie 2018c

Figure 5-168: Location of Nearshore Blocks A to D, Relative to Other Marine Exploration Blocks

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5.5.6 Emergency Resources

During the various activities associated with this exploration drilling Project, a number of emergency situations can arise and may result in serious harm to personnel or substantial damage to property (see Chapter 6 below). These emergencies (and others as identified) will be addressed in Staatsolie's project-specific Emergency Response Plan (ERP), which is to be developed prior to Project start-up (see Section 7.3.1 below).

The ERP will provide details on the arrangements for response, based on the scale of the emergency and these may require the involvement of any or all of the following: the Police Corps, the Fire Department, the Coast Guard, MAS, the National Army, primary health care facilities and NCCR as the coordinating agency (for large-scale emergencies) as well as any other response agency designated by Staatsolie (for example, in the case of an oil spill, the agency responsible for spill clean-up and recovery). With respect to the latter, a national oil spill contingency plan has been developed for Suriname but has not yet been approved (ITOPF 2015). The remainder of this section provides some details on the emergency resources of Suriname.

5.5.6.1 Health Care Facilities

Suriname's largest hospital is the Academic Hospital, which has a capacity of 465 beds. This hospital also houses the country's only emergency unit. Other hospitals which may be accessed during an emergency include the 227-bed Diakonessen Hospital, Stichting's lands Hospital and St. Vicentius Hospital (all in Paramaribo). There is also the Military Hospital, and 2 hospitals based in Nieuw Nickerie (the 75-bed Nieuw Nickerie Hospital and the Lachmipersad Mungra Regional Hospital). In 1990, there were an estimated 2.7 hospital beds per 1,000 people. In 1997, there were 2.5 doctors per 1,000 people (ESL2103b). Relevant contact information for health care facilities to be accessed in the event of an emergency will be provided in the Project-specific ERP.

5.5.6.2 Armed Forces

Suriname's armed forces consist of the national army, air force, navy, and military police, which are collectively referred to as the "National Army". The National Army falls under the control of the Ministry of Defence and is comprised of some 2,500 personnel, the majority of whom are deployed as light infantry security forces. These forces may be accessed during an offshore emergency. Apart from the operational aspect described above, the Ministry of Defence also plays a role as the policy centre, is responsible for the care of the National Army so that it can carry out its duties mandated by law in an efficient and effective manner in a timely and adequate manner. The relevant contact information for armed forces (including police stations) will be provided in the ERP.

5.5.6.3 Police Corps

The Police Corps Suriname falls under the Ministry of Justice & Police, and is legally constituted to, among other core values, protect the rule of law for the entire community of Suriname. This arm of the Ministry will work with other organisations, such as the Coast Guard, in order to adequately respond to any incidents contravening the rule of law in the Nearshore and offshore areas of Suriname. Relevant contact information will be provided in the Project-specific ERP.

5.5.6.4 Fire Department

As with the Police Corps, the Fire Department of Suriname falls under the Ministry of Justice & Police, which serves, assists and protects society against fire, accidents and disasters. The Department is charged with preventive and repressive fire safety and support for emergency response and other forms of public disturbance and crisis management in both a proactive and reactive sense, capable of guaranteeing fire safety in an effective and efficient manner, helping to manage crisis and disasters and supporting public order. Thus, the Fire Department will be involved in inspections of the drilling rig as well as other equipment (proactive role), and will also work with other agencies in emergency response (reactive role). The relevant contact information will be provided in the Project-specific ERP.

5.5.6.5 Coast Guard

Established in 2013, the Coast Guard Authority Suriname functions to protect the rule of law, security and privacy, by undertaking the following activities (at times with other agencies of Suriname, such as MAS: border surveillance; law enforcement in the maritime area; supervision of shipping, fishing and the environment; customs supervision; emergency relief and disaster management in the maritime area; and search and rescue operations in the maritime area. The Coast Guard Authority Suriname is in possession of 3 vessels and 7 vehicles, and will work with other agencies towards securing the Nearshore and offshore areas (proactive role) and in emergency response if needed (reactive role). The relevant contact information will be provided in the Project-specific ERP.

5.5.7 Fisheries

The fishing industry is an important economic sector in Suriname. In 2004, the gross value of the fisheries' output was estimated at 36.6 million USD. The sector continued to grow; by 2006, an estimated 45.7 million USD worth of fish production was exported (FAO 2008). In 2014, the corresponding figure was estimated at 87.1 million USD (FAO 2018a).
The fishing industry is divided into 2 types, namely:

- Industrial (offshore) fishery; and
- Artisanal fishery.

5.5.7.1 Artisanal Fishery

Artisanal fishers typically fish with a driftnet, fyke/hoop net, seine net or line fishing. Artisanal fishers fish under 2 types of licenses: inland waterways or BV (Binnenvaart), and Suriname Coast or SK (Surinaamse Kust).

5.5.7.1.1 BV Fishing Boats

According to permit conditions, BV boats are allowed to fish in creeks and rivers, including river mouths. Because the concept “river mouth” is not defined by law, BV fishers also fish in the shallow parts of the Nearshore zone, if weather conditions are favourable (LVV 2013). Larger vessels (typical SK boats) than the standard BV boat are also utilised for BV fishing along the shoreline of Coronie district, owing to the absence of a river there. Overall, stakeholders consulted during this Project agreed that BV boats do not fish further than 4 – 5 km from the shore, and it is unlikely that they will enter the Project area. Nonetheless, BV fishers may be potentially affected if the Project impacts upon coastal fish and shrimp resources. Additionally, though they may not fish within the Project area, they may move through the area during Project activities, and so communication with these fishers is also essential during Project execution.

5.5.7.1.2 SK Fishing Boats

Vessels with an SK license are allowed to fish in the offshore zone between 0 and 10 fathoms depth (0 – 16.6 m), with the exception of the estuarine areas of the Suriname, Coppename, Corantijn Rivers, shown in Figure 5-169 below, based on coordinates provided by Fisheries Department in December 2017; see Appendix D.23). The fishing which takes place within the allowed areas depends on: (i) the season (see further below); (ii) the tide level; (iii) catch results by other fishers; and (iv) perceived risk of piracy.

SK fishing is done under 4 sub-categories and fishers target different species, using different techniques, as presented in Table 5-49 below. Additional information on the areas in which fishing is allowed for these SK subcategories area also presented in Table 5-49 below.

SK fishers generally fish all year round, using 2 types of boats:

- Decked wooden vessels named ‘*closed type Guyanese*’ vessels or ‘*inboard*’. This type of boat typically stays at sea for 2 – 3 weeks, and up to 1 month in exceptions circumstances; and
- Open wooden vessels named ‘*open type Guyanese*’ vessels or ‘*cabin cruiser*’, which remains at sea for approximately 2 weeks.

Table 5-49: Fishing Techniques, Type of Fish and Fishing Periods/Times used by SK Fishers & SK Sub-categories

License	Fishing Technique	Type of Fish	Fishing periods/times	Fishing Area / Allowed Depth in fathom and m
SK; schutbank	Bank fishing using pin seine (*Njawarie*)	Butterfish *(Nebris microps)*, Pike (*Centropomus* spp*)*	With high tide, fishers place gillnets in a U-form on the mud bank. When the tide returns, fish are drawn in the net	0 – 5 fathom (9.1 m)
SK	Ocean drift net fishing	Kandratiki *(Cynoscion virescens)*, Bang-Bang *(Cynoscion acoupa)*	SK fisher generally stay away for 1-2 weeks, but may remain at sea up to three weeks in a row	0 – 5 fathom (9.1 m) or 5 – 9 fathom (16.6 m), depending on the fishing gear
SKL	Long-line sea fishing	Tuna (*Thunnus* spp) but also Kandratiki (*Cynoscion virescens)*, Bang-Bang (*Cynoscion acoupa*), small sharks (*various types*)	Undetermined; may stay at sea for several days to 2 weeks	0 – 9 fathom (16.6 m)
SKB	Bangamary fishing uses Drifting gillnet (*Drijfnet*)	Bangamary (*Macrodon ancylodon, local: dagoetifi*) and Butterfish (*Nebris microps*)	With ice, fishers may stay away 3-4 days; without ice, fishers only go for a day or day-share (tide fishers)	3 – 5 fathom (5.5 – 9.1 m)

Source: Fisheries Department, Ministry of Agriculture, Fishing and Animal Husbandry 2017; see Appendix D.23

5.5.7.2 Industrial Fishery

Suriname's industrial fishery includes: shrimp trawling; fishing trawling; red snapper and mackerel manual line fishing; and large pelagic line fishing (LVV 2013). Industrial fishery is only allowed beyond the 15 fathom line (27.4 m), with the exception of Seabob fishing, which is allowed between the 10 and 18 fathom lines (see Figure 5-169 and Table 5-51 below). Most caught species in 2016 are presented in Table 5-50 below.

Table 5-50: Most Caught Fish Species by Industrial Fishers in 2016

Scientific Name	Local Name	Catch (kg; 2016)
Cynoscion jamaicensis / Cynoscion similis	Jamaica weakfish/Tonkin weakfish (Wit wittie)	1,810,532.3
Cynoscion virescens	Kandratiki	1,193,165.5
Macrodon ancylodon	Bangamary (Dagoetifi)	1,022,373.8

Source: Fisheries Department, Ministry of Agriculture, Fishing and Animal Husbandry 2017; see Appendix D.23

The following figures (based on 2017 data) for the number of licenses issued to industrial fishers were provided by the Fisheries Department:

- Line fishing: 197
- Shrimp trawling: 22
- Seabob trawling: 26
- Fish trawling: 29

Table 5-51 below presents an overview of industrial fishing in Suriname, according to license, with target catch, method, season, boat type and fishing area (maximum allowed depth in fathoms and m.

Table 5-51: Overview of Industrial Fish Category according to License with their Catch, Method, Season, Boat Type and Fishing Area (Maximum Allowed Depth in Fathoms and m)

Fishery	Catch	Method	Season	Boot type	Fishing Area / Allowed Depth in fathoms and m
Shrimp Bottom Trawl Fishery	Large sea shrimp	Bottom trawl	All year round	Trawler	≥ 200 fathoms (365.6 m)
	Penaeus shrimp	Bottom trawl	All year round	Trawler	≥ 18 fathoms (32.9 m)
	Seabob shrimp	Bottom trawl	All year round	Trawler	West: 10 – 15 fathoms (18.3 – 27.4 m)

Fishery	Catch	Method	Season	Boot type	Fishing Area / Allowed Depth in fathoms and m
					East from Matapica: 10 – 18 fathoms (18.3 – 32.9 m)
Bottom Trawl Fishery	Demersal fish	Bottom trawl	200 days a year	Trawler	15 – 35 fathoms (27.4 – 64 m)
Large Pelagic Line Fishery	Large pelagic fish	Up to 2,000 horizontal lines, maximum hook no. 5	All year round	Trawler	≥ 35 fathoms (64 m)
Line Fishery	Red snapper	2,000 hooks on the horizontal lines and 20 on the vertical hand lines.	All year round	Venez-uelan and Korean boats	≥ 18 fathoms (32.9 m)
	Mackerel	2,000 hooks on the horizontal lines and 20 on the vertical hand lines	All year round	Venez-uelan and Pana-manian boats	≥15 fathoms (27.4 m)
Pelagic Purseine and Jigging Fishery	*Scombridae* sp and *Clupeidae* sp	Purseiner	All year round	Trawler	≥28 fathoms (51.2 m)
	Logilo plei	Jigging with light	All year round	Trawler	≥28 fathoms (51.2 m)

Source: Fisheries Department, Ministry of Agriculture, Fishing and Animal Husbandry 2017; see Appendix D.23

Apart from local industrial fishers, foreign vessels are another important stakeholder in the industrial fishing sector. By law, all fishing vessels sailing under a foreign flag are obliged to moor at the Central Fish Supply Port of Suriname (Centrale Visaanvoer Haven Suriname; CEVIHAS). CEVIHAS is a parastatal[28] organisation whose main function is registration and control of foreign fishing boats that fish in Suriname waters.

Foreign fishing vessels which moor at CEVIHAS include:

[28] *An organisation can be considered parastatal if it has some political authority and indirectly serves the State or Government of the country under whose laws it operates.*

- Venezuelan line fishing vessels, also referred to as “snapper-boats”. In total 130-150 boats; each boat has about 10 fishers;
- Trawlers or “high-long boats” that work under Chinese flag. In total 6, of which 5 are owned by China National Fisheries Corporation (CNFC), and one by a Suriname owner; and
- Tuna boats (line fishing); about 40-50. These work under Panamanian flag but the boat owners are Taiwanese, and the fishing crew are mostly Indonesian and Taiwanese.

Other stakeholders include processors of sea bob shrimp, executed by 2 Surinamese companies, Suriname American Industries Limited (SAIL) and Heiploeg Suriname (both of which also own fleets). De Surinam Seafood Association (SSA) is an umbrella organisation consisting of various interest groups within the fisheries sector. The SSA represents all industrial ships and processing companies.

5.5.7.3 Sport Fishing

NB reported that catch and release (sport fishing) is increasing in frequency offshore, and typically occurs > 13 km from the shore (see Figure 5-169 below), and this means that sport fishing may occur within Blocks A to D, since the northern boundary of the Blocks are located approximately 28 km from the shore. Though other methods may be used, sport fishers typically fish with rails for tuna. As indicated in Section 5.5.9 below, sport fishing trips are organised through the outdoors’ store Tomahawk, or via the Association for Sports Hunters and Fishers. Typically, 2 day-trips are held per month, though this increases to 2 to 3 times a week around April – May and in the long dry season (usually after September).

5.5.7.4 Commercially Important Taxa

Annex 4 of Appendix D.23 provides a list of commercially important taxa known to be the target species of the various sub-categories of artisanal and industrial fishing (see Table 5-49 and Table 5-51 above). As indicated in Section 5.4.5 above, one of the most valuable taxa is the Atlantic seabob (*X. kroyeri*). Willems 2016 states that, because of the exploitation of other *Penaeus* species, commercial shrimp trawling has shown increased interest in *X. kroyeri*. Global landings of Atlantic seabob has increased considerably from approximately 11,000 tons in 1990 to about 50,000 tons in 2013, making it one of the top 10 caught Penaeus species (Silva *et al.* 2013; FAO 2014a). Suriname, the third largest global seabob producer, lands 8,000 to 10,000 tons annually, making it one of the most important fishery resources for both artisanal and industrial fishing fleets (FAO 2014a). Approximately one tenth of these landings are generated by artisanal fishermen in river estuaries using fyke nets (LVV 2010), whilst the majority is caught via shrimp trawlers further offshore (Jagroop and Heimans, *pers. comm*. in Willems 2016).

5.5.7.5 Seasonality

According to the Fisheries Department, March – August is considered the high season for the artisanal fishery, with a peak around mid-July; there is no preferred season for trawler fishing. Both types of fishing generally take place year-round (though bottom trawling for the demersal fishery takes place 200 days of the year; see Table 5-49 and Table 5-51 above). The SSA also confirmed the general lack of a season for trawling, but did indicate that November-December is a relatively good season for trawl fishing. As indicated above, though sport fishing occurs with increased frequency in April – May and after September in the long dry season, the Association for Sports Hunters and Fishers stated that sports fishers have no high or low season and fishers fish based on preference and leisure.

As indicated in Section 5.4.5 above, the seasonality of fish (reproductive) behaviour has not been studied in the coastal seas of Suriname (Mol 2010 in Noordam 2013d) but may be similar between Guyana and Suriname, given the similar offshore conditions. Mol 2010 (cited in Noordam 2013d) found some seasonal movements. Primarily fish in the sciaenid zone (which is the target of Suriname fisheries) move inshore during the period June – August (due to absence of trade winds and highest river discharge to sea). Offshore movement into deeper water of sciaenids also occurred during the period January – March (correlating to high NE trade winds, increased currents and subsequent stirring up of bottom mud in inshore waters).

Mol 2010 (cited in Noordam 2013d) also noted that, within the sciaenid zone, many taxa spawned in the main rainy seasons (corresponds to April to August), with abundance of juvenile fish in estuaries from June to September, and with live birth of a few elasmobranch taxa (sharks and rays) around March. It has also been observed that, during February – March, anchovies (Engraulidae), seem to migrate up-river to spawn in freshwater (Mol, cited in ESL 2012).

As indicated in Section 5.4.5above, based on the foregoing, and given the proposed Project timeline for drilling (April – December 2019), it is likely that drilling will take place during: inshore and offshore movement of sciaenids; spawning of sciaenids; and potential live births of elasmobranchs (June to August). Juvenile sciaenids and spawning anchovies will also be present in the estuaries along the Nearshore during drilling.

5.5.7.6 Regulation of the Fishery Sector

A large part of the jurisdiction and responsibilities with regard to fishing policy in Suriname is entrusted to the Ministry of LVV and is implemented by the Fisheries Department. This Department has indicated that no legislative and policy changes have occurred between 2013 and 2017 besides the adaptation of fathom line 18 (see seabob shrimp trawl fishery in Table 5-51 above and Figure 5-169 below). This fathom line marks the sailing area of seabob trawlers who are only allowed to fish between the 10-18 fathom line (see Figure 5-169 below). There is also a ‘no fishing zone’ which applies during the peak nesting period for sea turtles (March 1st – July 31st) in the Galibi Nature Reserve for all types of fishing vessels (UNEP 2012; see Figure 5-169 below).

Illegal, Unreported and Unregulated fishing (IUU) is one of the biggest threats to marine biodiversity and sustainable fishing (see Appendix D.23 for the EU definition of illegal fishing, accepted by the Fisheries Department). This type of activity occurs in 2 main ways: the selling or leasing of licences; and fishing without licences. Selling or leasing of licences (not strictly considered illegal) typically involve Guyanese fishers. Representatives of the Fisheries Department estimated that 10 – 15% of artisanal fishing vessels fish without a license (including local fishers).

Representatives in the various districts confirmed that a relatively large number of illegal fishers with large driftnets (mostly from Guyana but also from Suriname), are active in the Nearshore area. There is also evidence that control mechanisms executed within Commewijne district, by the Ministry of LVV, police and National Army have pre-empted illegal fishing at this time.

Along this and other areas of the coast, Coast Guard patrols do occur, but efforts are hindered by the current inoperability of the Vessel Monitoring System (VMS) for artisanal fishers.

5.5.7.7 Applicability of Fishing Zones to the Project

Table 5-52 below presents the 3 fishing zones, based on type of vessel, which may be potentially impacted by this Project. Figure 5-169 below shows Blocks A to D, the focus areas and preliminary drilling locations aligned with the fathom lines of importance for Suriname fisheries. Overall, the data show SK, SKL and SKB fishers (who fish within allowed areas between the shore and the 10 fathom line), seabob trawlers (who operate between the 10 – 18 fathom lines), and sport fishers, may be adversely affected by drilling activities within the Block. Industrial fishers (who operate beyond the 15 fathom line) may not be disrupted by drilling activities, except perhaps in the topmost portion of Block B, where the 15 fathom line intersects its northern boundary. It should be noted that there is the potential for all fishers to be affected if marine traffic is halted to accommodate movement of the rig and equipment etc, but this is not anticipated to be problematic as there are other routes which can be used to access landing sites.

Table 5-52: Type of Vessel and Allowed Fishing Area, according to Fathom Lines

Type of Vessel	Allowed Fishing Area
SK, SKL and SKB (subcategories of SK)	< 10 fathom (18.3 m)
Seabob trawlers	Between 10-18 fathom (18.3 – 32.9 m)
Industrial	> 15 fathom (27.4 m)

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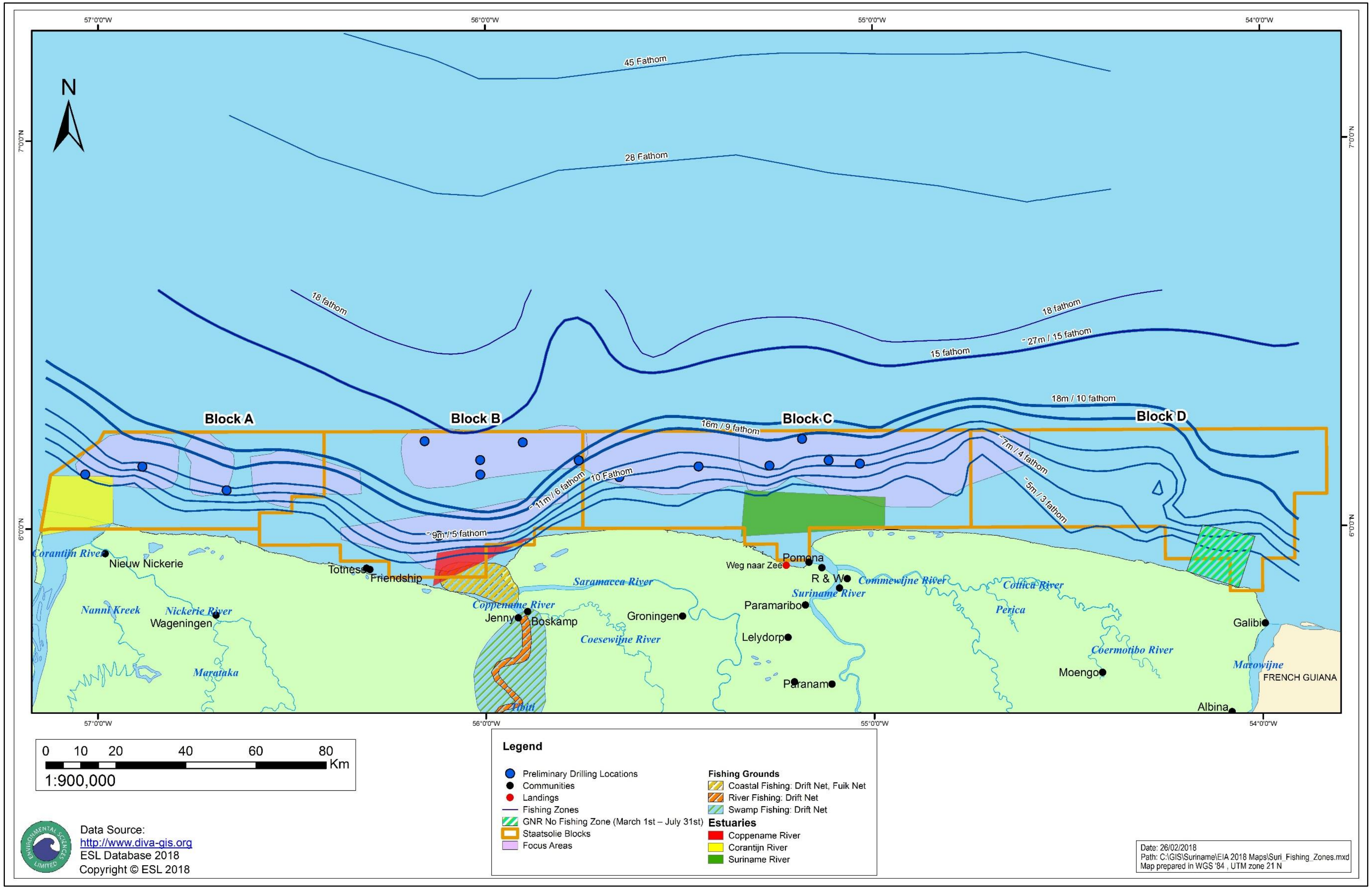

Source: ESL Database 2018 and Fisheries Department, Ministry of Agriculture, Fishing and Animal Husbandry 2017; see Appendix D.23

Figure 5-169: Fishery Zones as determined by the Fathom Lines named in the Fishing Code of 2010

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5.5.8 Protected Areas

Along the coast of Suriname, the Government of Suriname has established 2 different types of protected areas: Nature Reserves (NRs) and Multiple Use Management Areas (MUMAs). Both NRs and MUMAs are designated to maintain biological productivity, ensure the health of globally significant wildlife, and protect resources for sustainable livelihoods. Both MUMAs and NRs are managed by the head of the State Forest Department (LBB) and the Nature Conservation Division (Natuurbeheer - NB). In practice, NB does not regularly monitor the MUMAs or the NRs owing to financial constraints, and is inactive in the offshore area (Heemskerk and Duijves 2018; see Appendix D.23).

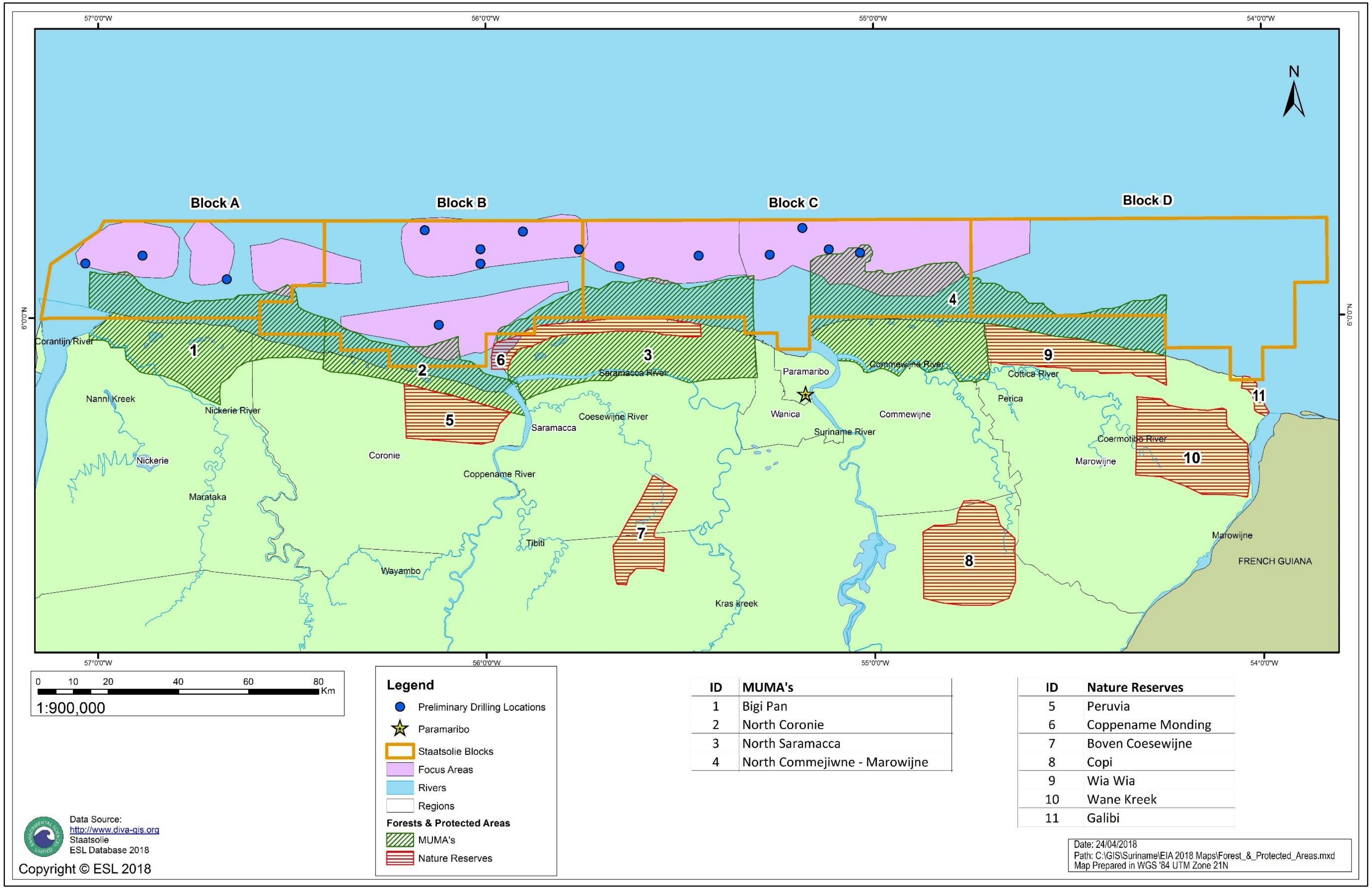
The difference between MUMAs and NRs is that NRs are strictly protected, and no livelihood activities (e.g. hunting) or industrial economic activities (e.g. oil drilling) are allowed. MUMAs, by contrast, are intended to be multiple-use areas. Although the conservation of biodiversity and maintenance of ecosystem services is the ultimate management objective, MUMAs may be commercially utilised within sustainable limits set by the government. There are no specific regulations with regard to drilling activities in the MUMA. However, the Ministry of Spatial Planning, Land and Forest Management and within this institution, specifically the head of the National Forest Service (LBB), determines the activities which may or may not occur within MUMAs. A permit is required to use the area, which is issued for specific activities in specific areas, determined by various guidelines set forth to regulate use (see Section 2.4.3)

The MUMAs are important places for the conservation of mangrove stands, crucial for fish and shrimp taxa to lay their eggs, and thus vital to the survival and health of the various fish populations (see Section 5.4.6.5 above). The mudflats and swamps also are important to numerous North American shore birds that migrate to these coasts (see Section 5.4.7.2 and Section 5.4.7.4 above).

The following protected areas overlap with or border the study area for this Project (from W to E; see Figure 5-170 below):

- Bigi Pan MUMA;
- North Coronie MUMA;
- Peruvia NR;
- Coppename Monding NR;
- North Saramacca MUMA;
- North Commewijne – Marowijne MUMA;
- Wia-Wia NR; and
- Galibi NR.

The coastal zone of the Wanica-Paramaribo districts is not protected because there is no law or regulation in place that protects this coastal area and its ecosystems. The area between the eastern border of the Wia-Wia NR and the western border of the Galibi NR is claimed as tribal territory by the indigenous people of the villages of Christiaankondre and Langamankondre, and has not been included in a MUMA (see Figure 5-170 below).



Source: ESL Database 2018 and Heemskerk & Djuives 2018 in Appendix D.23)

Figure 5-170: Protected Areas in the Coastal Region of Suriname

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All MUMAs occupy terrestrial and Nearshore marine areas. The Bigi Pan MUMA (683 km^2), located partly in the districts of Nickerie and Coronie is an Important Birding Area (IBA SR001) and a Western Hemisphere Shorebird Reserve Network (WHSRN) site of hemispheric importance. It is also a proposed Ramsar site (UNDP; nd). It is an area mainly used by local fishing interests and a location targeted for oil exploration (UNDP; nd). A portion of its Nearshore component intersects with Block A and Block B (the size of the marine area is determined by the 6 m depth line during low tide, which fluctuates due to coastal dynamics of the presence and absence of mudflats), but no preliminary drilling locations occur within this MUMA (for which permitting will be required; see Figure 5-170 above). As indicated in Section 3.2 above, drilling may occur anywhere within the focus area, and it can be seen from Figure 5-170 below, that the focus areas within Block A intersect with the northern boundary of the Bigi Pan MUMA in 2 locations.

The North Coronie MUMA occupies land of the district Coronie, and, along with its Neashore component, covers an area of 272 km^2 (UNEP 2012). The MUMA, like the others, is part of the highly productive estuarine zone of Suriname, and consists of several coastal wetland ecosystems: mudflats, mangrove forest, open lagoons and brackish grass swamps. The area is an important breeding and feeding area for Scarlet ibises, egrets and herons, and, during northern winters, it also serves as an important feeding ground for migratory shorebirds from the North. As a result, it is also an IBA (SR002). The ecosystems and their biodiversity offer a range of ecotouristic activities that should be further developed. The Coronie mangrove forests protect the coast against erosion; and enhance sedimentation and stimulate coastal accretion. Its ecosystems are particularly important as spawning and nursery grounds for marine fauna and these ecosystems add value to the Nearshore small-scale and offshore industrial fisheries (Teunissen 2000). A portion of its Nearshore component intersects with Block B and its focus area but no preliminary drilling locations occur within this MUMA (see Figure 5-170 above).

The Peruvia NR (310 km^2) is located at the front of the Coppename River in the freshwater part of the coast in the district Coronie. It is home to a large number of Peruvia Mauritia palms (*Mauritia flexuosa*), Possentri forests (*Hura crepitans*) and blue and yellow macaws (*Ara ararauna*). This NR does not intersect the study area, but it remains under consideration, given that potential contaminants can enter the NR via the Coppename River (STINASU 2018).

The Coppename Monding Nature Reserve (CMNR, 120 km^2; 1966) provides breeding and feeding grounds to many migratory bird species including North American shore birds and different species of herons. It houses an important colony of Scarlet ibis that breed in the Reserve (see Section 5.4.7.2 and Section 5.4.7.4 above). In 1985, the area became the first site in Suriname to be included in the "*Ramsar List of Wetlands of International Importance*" (RAMSAR Convention 1996, 1997), and to date is the only Ramsar site in the country. In 1989, the CMNR was dedicated as a “Hemispheric Reserve" within WHSRN. It is also part of the IBA (SR003) that forms the North Saramacca

MUMA (see below). This protected area is shoreward of the easternmost portion of Block B and the western half of Block C. Figure 5-170 above shows that no preliminary drilling locations are located within this NR.

The North Saramacca MUMA (884 km^2) is an important location for fish and shrimp taxa to lay their eggs and thus, vital to the survival and health of the different fish populations. The mudflats and swamps are important to numerous North American shorebirds that migrate to these coasts, and the North Saramacca MUMA corresponds directly in aerial extent to the North Saramacca (IBA SR003). It is noteworthy that no specific management resolutions have been issued for the Nearshore marine portion of this MUMA; fishers are allowed to fish provided they comply with regulations set in the general Fish Stock Protection Act. Figure 5-170 above shows that the Nearshore component of this MUMA intersects the easternmost portion of Block B and the western half of Block C (and intersects the focus areas in 3 places), but no preliminary drilling locations are situated within the MUMA.

The North Commewijne – Marowijne MUMA (615 km^2) is the coastal belt between the Suriname and Marowijne Rivers, to the north of the Commewijne and the Cottica rivers. This MUMA is important because of the mangrove forest that protects the coast and river estuaries against erosion; as a breeding and feeding area for specified fish which have their larval stage in the brackish coastal waters; and for the protection of sea turtles which nest on various beaches along the stretch. It also serves as an important feeding ground for migratory shore birds (and forms part of IBA SR004); has high potential for aquaculture, apiculture, animal husbandry and agriculture; and because the ecosystems and their biodiversity offer a range of ecotouristic activities that should be further developed (del Prado 2012). Figure 5-170 above shows that the Nearshore component of this MUMA intersects with eastern part of Block C (and its focus area) and the western part of Block D, and that one preliminary drilling location occurs within this MUMA, whilst another is to the immediate north of its northern marine boundary.

Wia-Wia NR (360 km^2), located in Marowijne District, is known for high biological productivity. This NR is a WHSRN site of Hemispheric Importance which protects breeding and feeding grounds for large numbers of local and migratory bird species, and nursery grounds for fish and shrimp (STINASU 2018). It has a rich population of fish, shrimp, crabs, and other wildlife. The mudflats and swamps within the NR are important for numerous migratory shorebirds breeding or stopping over in North America (supporting more than 500,000 shorebirds annually). Along with the North Commewijne – Marowijne MUMA, it forms part of the IBA SR004 and is also an Endemic Bird Area (EBA) due to the common occurrence of three range-restricted species: Guyanan Piculet, Blood-coloured Woodpecker, and Rufous Crabhawk. This NR is landward of Block D (WHSRN; nd; see Figure 5-170 above).

Galibi NR (40 km^2) is located at the northeast coast of Suriname, in the district of Marowijne. This NR was established to protect the sea turtles that use the beaches of Galibi as their breeding ground; during nesting, controlled ecotourism is allowed, along with research (owing to the construction of 2 research stations there; (STINASU 2018)). The northeastern tip of Galibi NR adjoins the southernmost portion of Block D, but no drilling is targeted for this area (see Figure 5-170 above).

5.5.9 Recreation & Tourism

Information obtained from stakeholders during meetings held for this Project suggests that tourism (national and international) in the Nearshore area is rare (Heemskerk & Duijves 2018). The coastline of Suriname consists of sandy beaches, mudflats, clay banks and other geomorphological features. The beaches are not of the highest standard and only a few are suitable for swimming. There are no sandy beaches suitable for recreation along the Saramacca coast, though locals do frequent Braamspunt and Matapica Beaches to the east, as well as Galibi, to which visitors primarily go to observe turtle nesting (see Section 5.4.4 above).

By contrast, the mudflats adjoining the Suriname coast are feeding grounds for large numbers of migratory and resident waterfowl. The high bird diversity and occurrence of rare and endemic species, including the Scarlet ibis, attracts bird watchers and other tourists. Stakeholders indicated that occasional tourist trips leave from Coppename punt, and travel towards the mouth of the Coppename River and Coronie district for bird watching at the Coppename Monding Nature Reserve and the North Coronie MUMA (see Figure 5-170 above). Boats typically stay close to shore and do not venture as far as the proposed focus areas for this Project. Bird watching occurs throughout the year, most often during low tide; there is no specific bird watching season. These trips are typically organised via tour operators in Paramaribo (Heemskerk & Duijves 2018) though the price per trip and the tourists' countries of origin are unknown. Previously, local tourists and those from the Netherlands and the United States partook in similar trips offered by fishers and other tour guides (from Boskamp) which were priced at USD $125 per day trip, including a meal of barbequed own catch. Tours took place irregularly (<1/week), depending primarily on the season (Heemskerk & Duijves 2010).

It appears that these tours no longer occur, nor do bird watching tours previously organised by the Governmental Foundation for Nature Conservation in Suriname (STINASU) and by Movement for Ecotourism in Suriname (METS) who conducted tours from Weg naar Zee in the early 2,000's (Heemskerk & Duijves 2010). Fisherfolk interviewed in January 2012 indicated that bird watching tours in general were suspended as birds had shifted to other locations along the coast (Heemskerk & Duijves 2010 in ESL 2012).

Interviews conducted with personnel of Nature Conservation Division (NB) of the Suriname Forest Service reported that catch and release (sport) fishing is now becoming more popular at sea, not more than 13 km from shore. This includes line fishing for tuna. These trips are organised through the outdoors' store Tomahawk, or the Association of Hunters and Fishers (see Heemskerk & Duijves 2018 in Appendix D.23 and Section 5.5.7 for additional information).

Other tourist attractions (in the onshore area) include visits to the historical inner city of Paramaribo, forts, plantations and nature parks, as well as the pilgrimage site located at the end of the Henry Fernandesweg at Weg naar Zee near Paramaribo. Information on these sites is provided in Section 5.5.10 below.

A survey in various coastal districts found that tourism employs less than 1% of residents of Saramacca district, and even fewer people in the district of Coronie (CSA 2010a,b). Recent data are not available for the tourism sector of Suriname to date, as ABS census data (2012) are not disaggregated to provide statistics for tourism sector employees as a discrete category).

5.5.10 Archaeological & Historical Resources

The northern edge of the YCP (at the coastline) has a very dynamic character, its fluidity attributed to the migration of mudbanks and colonisation and die-off of mangroves. Thus, the land at the coastline is virtually uninhabited, and very few archaeological and historical resources are present at the ever-changing shoreline. There are resources of note which occur further inland from the shoreline.

5.5.10.1 Archaeological Resources of the YCP

The north coast of Suriname further inland from the fluid shoreline is archaeologically important. Archaeological resources in coastal areas include remnants and indications of the presence of ancient Indigenous cultures (Amerindians and Indians, Suriname's first inhabitants who lived in the YCP or the savannahs of the interior). These resources include pottery, stone, charcoal, bones, soil discolorations, and soil displacements such as mounds and raised fields (Versteeg 2003). Virtually all archaeological finds in the YCP are located near existing roads, and not in the vicinity of the shoreline. Mounds (local name '*terp*') are found in the extensive clay swamps of NW Suriname. These were raised to build settlements.

Elsewhere in the YCP, settlements were mostly established on sand and shell ridges. Graves have been found near settlements on shell ridges. Raised fields for agricultural purposes (surrounded by ditches) have been identified near many former settlements in the western and eastern YCP, as well as the area between the Suriname and Coppename Rivers (including at the coastal swamp areas at the mouths of these rivers; see Figure 5-171 below).

The only archaeological find along the coastline has been made at Matapica (see Figure 5-171 below), where in 1965, a small frog ornament of nephrite of Amazonian origin was found. This was probably a stray find, as since then no other finds have been reported for the wider area. Being inland, none of these archaeological resources within the YCP will be affected by Nearshore drilling activity (Noordam 2018a).

5.5.10.2 Historical Resources of the YCP

Historically, the establishment and gradual expansion of plantations came with the settlement of Suriname by the English, Jewish and Dutch, along with the need to protect them, since they typically occurred near rivers. The Forts Sommelsdijk and Nieuw Amsterdam (see Figure 5-171 below) were developed as security measures and remain as historical sites to date. An example of these on the eastern YCP include the plantation associated with Fort Sommelsdijk and the establishment of Fort Nieuw Amsterdam (see Figure 5-171 below) was also meant to protect this and other upstream plantations. Development of plantations along the Saramacca River and in the (current) Coronie and Nickerie Districts also took place. Except for Matapica and Coronie, where cotton was grown, no plantations were developed along the sea coast (see Figure 5-171 below). These, in particular, have been subjected to erosion and land loss.

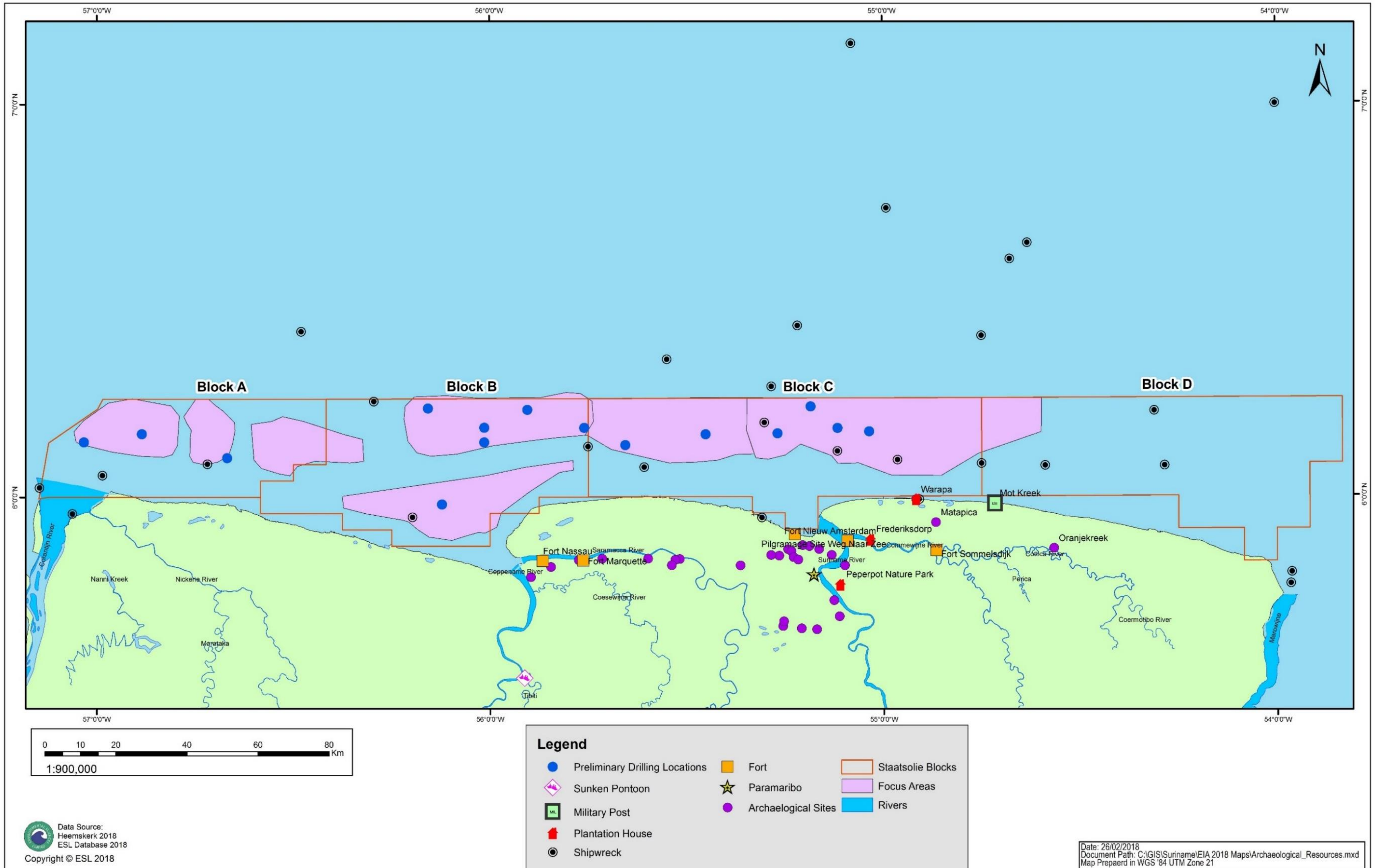
Some plantation houses still serve as historical sites, including at Frederiksdorp and Peperpot (see Figure 5-171 below) and in other places, structures associated with plantation economies can be found throughout the YCP, such as defence fortifications, dams, canals and sluices, plantation houses, and production facilities and equipment. One site such as this is at Warapa Creek, Commewijne. Historical records also indicate that a military post was present at the mouth of the Motkreek, Commewijne, but no remains have been found.

Within the Saramacca District, there are 2 forts of historical importance: Fort Nassau and Fort Marquette. There is also a pilgrimage site built by a private organisation, which has religious significance, and is located at the end of the Henry Fernandesweg at Weg naar Zee near Paramaribo (see Figure 5-171 below). There are no religious and sacred places or burial sites in or near the study area.

Also of historical importance is the inner city of Paramaribo, which was designated a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO) based on the following criteria:

- Paramaribo is an exceptional example of the gradual fusion of European architecture and construction techniques with indigenous South America materials and crafts to create a new architectural idiom
- Paramaribo is a unique example of the contact between the European culture of the Netherlands and the indigenous cultures and environment of South America in the years of intensive colonisation of this region in the 16th and 17th Centuries (UNESCO; n.d.).

Given that Project activities will be confined to Nearshore and on land at ports, with transportation along main roads, it is not likely that these sites will be affected by Project activities (Noordam 2018a).



Sources: ESL Database 2018; Versteeg 2003; Noordam 2018a; and MAS 2017 in Heemskerk & Djuives 2018 (see Appendix D.23)

Figure 5-171: Archaeological & Historical Resources of the YCP and Nearshore and Offshore Areas of Suriname

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5.5.10.3 Offshore Archaeological Resources

The National Register of Cultural Heritage Sites indicates that there are no cultural heritage sites located in the Nearshore area of Suriname, but it is possible that these have not yet been discovered, since (i) a full search of the area has never been done and (ii) shipwrecks have been discovered in the past, indicating the potential for other such sites to exist. Examples include the shipwreck of the Goslar, a WW2 ship in the Suriname River mouth, and that of the Leusden, an 18th Century slave ship in the Marowijne River mouth. Figure 5-171 above illustrates the shipwrecks known to occur in the offshore area of Suriname (Heemskerk and Duijves 2018; Appendix D.23), and also shows the location of a sunken loaded pontoon in the Coppename River as of December 2017 (see Appendix D.23).

Several shipwrecks are located within Blocks A to D, but only a few within the focus areas (Blocks A, B and C). None of the preliminary drilling locations occur in the immediate vicinity of the shipwrecks (see Figure 5-171 above), but the locations of these will have to be taken into account in the selection of the final drilling locations and in planning and execution of the drilling programme.

Other than shipwrecks, no other submerged cultural resources such as ancient (flooded) structures and artefacts have been detected in the Nearshore and marine areas of Suriname to date (Noordam 2018a).

5.5.11 Ports & Marine Transportation

The main ports in Suriname are Havenbeheer or Nieuwe Haven (Paramaribo), Paranam, Moengo, Integra Marine at Smalkalden, Nieuw Nickerie and Wageningen (Figure 5-172 below), of which Paramaribo is the most important, with the greatest frequency of ship movements in the spring time. The SDSM, VABI and Kuldipsingh ports in Paramaribo are also utilised (see Figure 5-172 below).

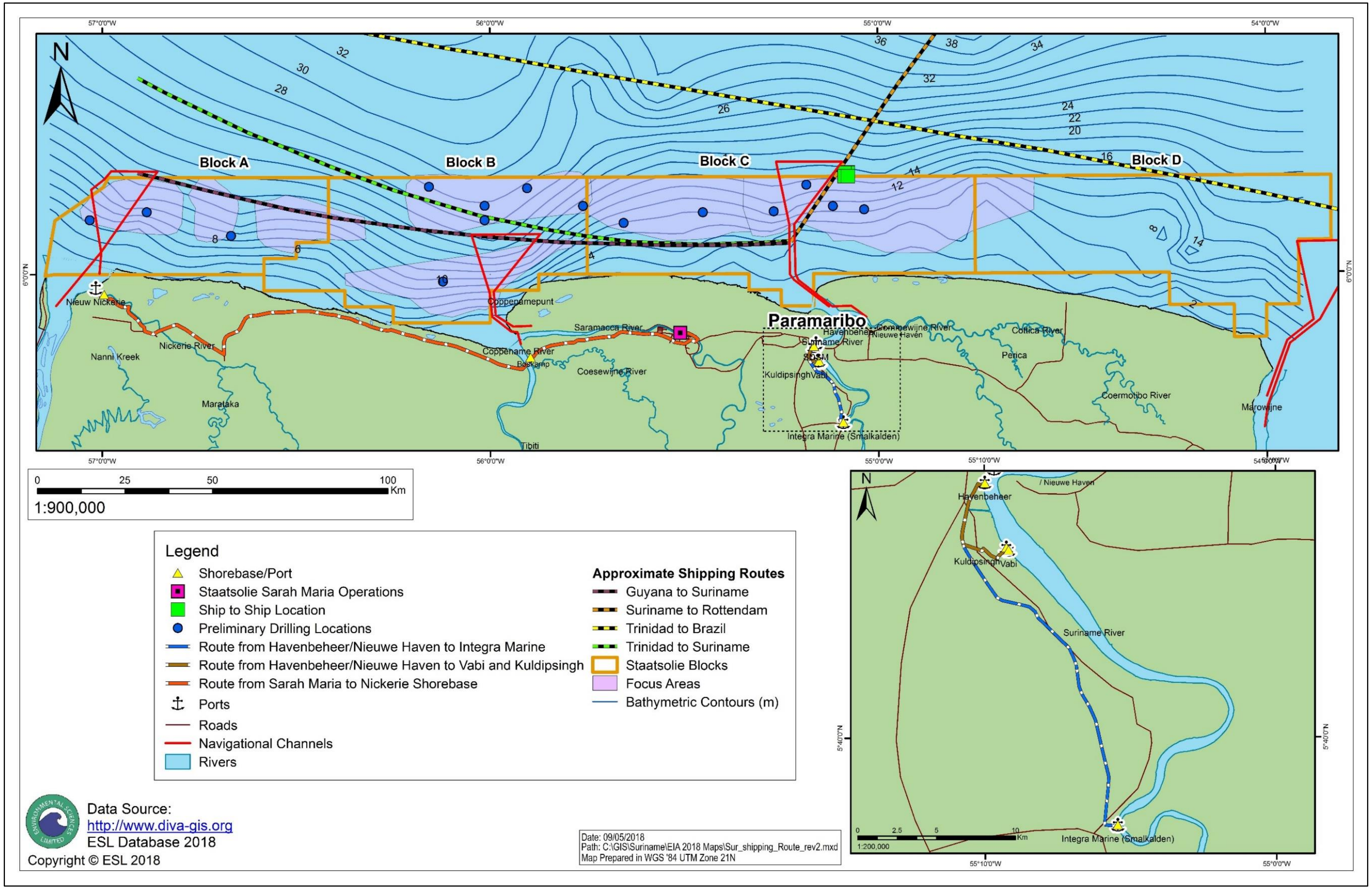
Traffic in the Nearshore and marine area comprises patrol vessels (Coast Guard and MAS), fishing vessels (artisanal and industrial) and freight traffic. Patrol vessels traverse the area intermittently, during transit of larger vessels to and from ports; during the execution of activities in the Nearshore and offshore areas (e.g. exploration drilling). Fishing activities are described in Section 5.5.7 above.

Freight traffic occurs in the Nearshore area; freight vessels use the area beyond 6 nautical miles (11.1 km; see Figure 5-172 below) from shore and includes primarily freight carriers (imports and exports) which utilise the main navigation routes shown on Figure 5-172 below. These include routes: between Suriname and Trinidad & Tobago; from Guyana to Suriname; Suriname to Rotterdam (Netherlands); and from Trinidad & Tobago to Brazil. In the navigation routes between Trinidad and Brazil and Guyana and Suriname, vessels sail near the 20 m depth contour. To enable large ships to enter and leave Suriname, 4 navigation channels are located along the coast at the entrance of the main rivers. These intersect with the focus areas and with the preliminary drilling locations, as shown in Figure 5-172 below.

In addition to the navigation routes, there is a “ship to ship” location, where bulk freight (e.g. gravel) is loaded from smaller boats onto larger ships. The ship to ship location is in close proximity to the navigation channel for the Suriname River (Block C; see Figure 5-172 below). Careful consideration will therefore have to be given in determining the final drilling locations, taking the channels and ship to ship location into account. MAS has requested, during the execution of past projects, that no drilling activities are performed in the navigation channels or the ship to ship location (Heemskerk & Duijves 2018; see Appendix D.23).

For this Project, chemicals to be used in drilling will be imported through Havenbeheer / Nieuwe Haven port. There will be an onshore shorebase at Nieuwe Haven, in close proximity to the port facility. Vabi, Kuldipsingh and Integra Marine ports (Smalkalden) will also be used for this Project, and there will be an onshore shorebase located within 0.5 km of each of these ports. These 3 ports/shorebases will facilitate storage and loading of materials for transport to the drilling locations within Blocks B and C. Drilling locations within Block A will be serviced by the port and oshore storage area at Nieuw Nickerie (where chemicals to be used in drilling will be transported from Staatsolie’s Sarah Maria operations in Saramacca, via lorry on an overland transportation route 203 km in length). There will also be a shorebase located at Boskamp, from which crew transfers will be made for the duration of the Project. These facilities and the overland transportation routes to be used for this Project are presented in Figure 5-172 below.

All of the ports/shorebases selected for this Project are ideally situated for transportation requirements, and they are equipped to provide supplies such as food provisions, potable water, fuel, oil and diesel.



Source: MAS 2017 in Heemskerk & Djuives 2018 (see Appendix D.23)

Figure 5-172: Ports of Suriname & Nearshore and Offshore Marine Transport Routes, along with Land Transport Routes to be Utilised for this Project

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5.6 Stakeholder Consultation

This Section summarises the proceedings of stakeholder consultations as relates to: (i) requirements of the ESIA study to be included in the Draft Scoping Report (or Draft TOR) for this Project; and (ii) the Public Consultation to present the findings of the draft ESIA report submitted to NIMOS for approval.

5.6.1 Consultations on the Draft Scoping Report

The following is a summary of the details of the meetings held to ascertain any concerns which stakeholders may have in relation to the requirements of the ESIA study for inclusion in the Draft Scoping Report (subject to NIMOS' approval). Two strategies were employed to gauge concerns:

1. Meetings with various stakeholders; and
2. An Introductory Public Consultation Meeting.

Details are presented in the relevant sub-sections below.

5.6.1.1 Stakeholder Meetings

Face to face meetings were held between the local Sub-Contractor for Social Assessment, Social Solutions (SS), and a range of Governmental and Non-Governmental entities, during the period June 2^{nd} – 6^{th}, 2017 (see Appendix G.1 for the list of interviewees). The details of these meetings, including the comments provided by the meeting participants are presented in Appendix G.1 below.

At each meeting, SS briefly introduced the Project via a Project Description Brief (see Appendix G.2). The Draft Scoping Report (TOR) was also provided as a handout. Concerns were then recorded (see Appendix G.1 below).

The main concerns highlighted / advice provided were in relation to the following:

- The need to consult with fishers on a more personal basis, or one-on-one, such as conducting meetings with small groups of fishers at the landing sites. This is based on the view that Fishers Collective do not fully represent all fishers in all areas, and because individual fishers tend to avoid larger meetings such as public meetings. It was also advised that meetings be conducted in English and Sranantongo;
- Provision of contact information for the relevant Fishers Collectives by the Ministry of LVV Field Operations Coordinator;
- Lack of information on the status of indigenous fishers;
- The need to inform fishers via the Collectives of the restrictions to fishing as a result of the Project at least 3 months in advance;

- The use of nets for fishing which drift for 2 km, up to 6 hours after deployment; this may be an issue during Project execution;
- Questions on the potential impacts of drilling on fish, particularly from the stirring up of sediment, and from vibrations during drilling;
- Whether compensation would be provided in the case of reduced catch as a result of the Project;
- The need for an adequate system of warning fishers of activities;
- Information on the movement of vessels across Blocks A to D, as well as in the Nearshore and further offshore;
- Method of distribution of information on the Project across the various Districts;
- Different types of coastal land use, such as large-scale agriculture in some areas of Commewijne;
- The need for Staatsolie to provide follow-up on the Project (during execution and after completion);
- The potential impact of the Project on the Bigi Pan area/MUMA; and
- Continuation of good working relationship and good communication with Staatsolie.

5.6.1.2 Introductory Public Consultation

This meeting was conducted on June 9th, 2017 at the IGSR Building, University Complex, Paramaribo, and lasted from 8:30 am to 10:30 am. The meeting was facilitated by Staatsolie, whose representatives provided an overview of the Project. The ESIA Contractor, ESL, provided detailed information on the ESIA process and the requirements of the TOR, related to the Project Description, Description of the Baseline Environment and Impact Assessment Methodology. The local ESIA Sub-Contractors, Dirk Noordam and Marieke Heemskerk of SS, were also present at the meeting to lend support to ESL.

The summary of concerns raised at the meeting by the various stakeholders is presented in Appendix G.3. Appendix G.4 presents the attendance register, whilst Appendix G.5 is a list of the targeted invitees. Appendix G.6 consists of the PowerPoint Presentation made to guests; and Appendix G.7 presents the Staatsolie HSE Policy & Community Relations Policy (provided as handouts to attendees). The Draft Scoping Report (TOR) was also presented as a handout.

The main concerns raised and a summary of Staatsolie's/ESL's responses are presented in Table 5-53 below; the more detailed responses are provided in Appendix G.3. The required action for the ESIA report is also included, with an indication of the status of these actions.

Table 5-53: Main Concerns raised by Stakeholders at the Introductory Public Consultation Meeting (June 9th, 2017), with Staatsolie/ESL Responses & Action Status

Concern		Response (Staatsolie/ESL)	Action Required & Status
Project Description Details	Details on the possible location of wells within the focus areas; the intensity of drilling activity across the Blocks; and the condition in which the seafloor will be left (drilling holes)	The indicated focus areas are the areas where the chances of finding oil are highest, but the precise location of the drilling wells is not yet known, nor is it known how the well-sites will be distributed across the focus areas (Staatsolie) Each Block (A-D) is about 10,000 m^2. The direct impacted area of the drilling platform will be about 500 m^2 radius per well-site (ESL) A maximum of 10 wells will be drilled; each drilling hole (about 10-20 cm in diameter) will be worked for about 3-4 weeks, and will be closed after drilling. The seabed will be restored to its original state (Staatsolie)	Where possible, these details were included in the ESIA report (see Chapter 3, which provides the Description of the Project).
	Methods of treatment and disposal of wastes generated from drilling, such as drilling wastes	Treatment and disposal of wastes from drilling will be addressed in the Waste Management Plan for this Project. No waste will be left in the Project area. The WMP will also address strategies for different kinds of waste (ESL). More information on the WMP will be provided at the 2nd Public Consultation (ESL)	The Waste Management Plan will be developed prior to Project start-up (see Section 7.3.1 below). Additional details will be presented at the 2nd Public Consultation Meeting, the details of which

Concern		Response (Staatsolie/ESL)	Action Required & Status
			will be provided in the Final ESIA report.
Potential Impacts from drilling	Drilling wastes on fish	Response: This is dependent on the type of drilling muds used. Release of muds will take place infrequently and intermittently, and impacts are expected in only on immediate surroundings around drilling rig (ESL).	This was taken into account in the impact assessment for the ESIA (see Section 6.4.5)
	Noise from drilling operations on fish	The impact of noise from drilling on fish is expected to be minimal and not lasting. The fish are acclimatised to vessel noise, and drilling will not generate as much noise as seismic (ESL)	This was taken into account in the impact assessment for the ESIA (see Section 6.4.3 and Section 6.4.4)
	Air pollution associated the Project on human health	The ESIA will contain an assessment of air pollution as relates to this Project; and any impacts identified will be mitigated. There will be no impact on human health from air pollution at coastal communities, or on the fishers. Possible impacts may be on people working on the drilling platform (ESL) ESL will also consider the impact of the Project on climate change but these impacts are expected to be low (ESL)	This was taken into account in the impact assessment for the ESIA (see Section 6.4.11)

Concern		Response (Staatsolie/ESL)	Action Required & Status
Management Actions & Plans	Management actions and plans in the event of an oil spill, if developed as a worst-case scenario; the size of the areas which may be affected; and the availability of oil spill clean-up resources, along with the timeliness of clean-up efforts, should this be required	The worst-case scenario, such as an oil spill, will be modelled, taking into account the potential maximum amount of oil that may be released. In the event of an oil spill, Management will rely on a Project-specific oil spill contingency plan, which will address containment and clean-up (ESL) Existing structures and agreements will also be taken into account during response, such as liaising with the NCCR; the National Oil Spill Contingency Plan (NOSCP) will also provide the required framework and guidance (Staatsolie). In the case of an accidental oil spill, the Drilling Contractor is responsible for the first, immediate response, and has the appropriate equipment in place to deal with small spills. In the case of large spills, Oil Spill Response Limited (OSRL) from Trinidad is available for assistance; they would be on stand-by to undertake action if such would turn out to be necessary (Staatsolie).	The results of modelling studies were incorporated in the impact assessment exercise for this ESIA (see Section 6.4.10). The Project-specific Oil Spill Response Plan (OSRP) is presented in Appendix F.2. This report will be updated to include the Coastal Environmental Sensitivity Maps and a revised draft will be generated (with stakeholder consultation) prior to Project start-up.
	Arrangements for marine traffic management during the Project	A marine traffic management plan will be in place for the Project equipment as well as for other marine traffic users (ESL).	A Project-specific Traffic Management Plan will be developed prior to Project start-up (see Section 7.3.1 below).

Concern		Response (Staatsolie/ESL)	Action Required & Status
Management Actions & Plans	Consideration of the option of possibly relocating bird nesting colonies along the shoreline as a safeguard against potential impacts to these from potential oil spills, and collaboration with the Nature Conservation Department in respect of this	Bird nesting colonies will be included in the impact assessment. To reduce impacts, we might suggest mitigation measures such as drilling in another time period so that the potential impact to birds is addressed in this way, rather than to move the colonies (ESL).	Avifauna data was included in the description of the environment (see Section 5.4.7) and in the impact assessment exercise (see Section 6.4.4 and Section 6.4.10, among others).
	Consideration of the ferry channel which dissects Block C during sampling and Project execution and which must be open and accessible at all times	There will be a marine traffic management plan in place to manage any of these potential impacts (ESL). Staatsolie will take the location of the ferry channel into account in the planning (and MAS will also be consulted) (Staatsolie).	A Project-specific Traffic Management Plan will be developed prior to Project start-up (see Section 7.3.1 below).
The ESIA Report	Availability of the findings of the ESIA after completion of the Draft ESIA Report	Yes, there will be another public consultation meeting after completion and submittal of the first draft ESIA to NIMOS. At this meeting the ESIA results, more details on the Project Description and impact assessment will be presented (ESL).	Additional details will be presented at the 2nd Public Consultation Meeting, the details of which will be provided in the Final ESIA report.

Source: ESL and Social Solutions (June 2017)

5.6.2 Consultations on the Draft ESIA

The following is a summary of the details of the meetings held to ascertain any concerns which stakeholders may have in relation to the execution of this Project and the ESIA study, which takes into account the Final Scoping Report (approved by NIMOS; see Appendix A.1).

Stakeholders were consulted during the ESIA process to ascertain comments and concerns related to the execution of the Project and the ESIA study, and the outcome of these meetings are summarised in Section 5.6.2.1 below.

Following the completion of the Draft ESIA Report, a second Public Consultation Meeting will be held on May 23rd, 2018, to inform stakeholders, including the general public, on the Project, the environment in which it occurs, and the findings of the impact assessment exercise.

5.6.2.1 Stakeholder Meetings

Face to face meetings were held between SS and a range of Governmental and Non-Governmental entities, during the period November 20th, 2017 – February 19th, 2018. The details of these meetings, including the list of meeting participants and their comments are presented in Appendix D.23.

At each meeting, SS briefly introduced the Project (see Appendix D.23), and concerns were then recorded. The main concerns highlighted / advice provided are summarised below.

5.6.2.1.1 Governmental Stakeholders

Governmental stakeholders consulted included: Fisheries Department (Ministry of LVV); Fishery Centres; District Government (Ministry of Regional Development); MAS; Nature Conservation Division (NB; Suriname Forest Service); Nature Conservation Division (NB) of the Suriname Forest Service; LBB) and Coast Guard. These stakeholders indicated concern about the following potential impacts and the mitigation measures that would be put in place to reduce/eliminate:

- The impact of an oil spill on fish and shrimp populations and the Coppename Monding Nature Reserve (CMNR), its bird feeding area, and the feeding and spawning areas of other marine life. Concern was also expressed about the potential impact from drilling on the status and reputation of the CMNR as a RAMSAR and WHSRN site (and on Suriname on the whole);
- The impact of noise from drilling on fish;
- The impact of drilling muds and cuttings on aquatic life; and
- The impact of the Project on mangroves along the shoreline

Other concerns included the efficiency of any oil spill plan generated for this Project, and it was recommended that Coast Guard and NB be included in discussions related to the development of the OSRP for this Project. MAS and Coast Guard also indicated that safety at sea must be ensured during the execution of the Project, for all users, and that effective and timely communication is crucial to successful implementation of the Project, within the limitations which currently exist. These include that not all fishers respond to meeting requests, and that some SK boats are not equipped with communication systems. These stakeholders therefore recommend informing the various stakeholders with precise coordinates of drilling and dates of work per location, well in advance of the Project start-up (including the use of Mariner's Notices). It was also recommended that there be no activities in the navigation channels and ship to ship location, and that Staatsolie ensure the compliance of the drilling rig (registration, certification, lighting, through the use of a nautical agent). NB also recommended that representatives from its department be placed on the rig when nearest to shore, with Staatsolie providing support for regular monitoring trips to monitor the possible impacts of the presence of the oil rig on bird populations. Lastly, NB also recommended the use of MMO's to monitor the impacts of drilling on marine life in the Nearshore area.

5.6.2.1.2 Fishers

The main concern of artisanal fishers (SK and BV boats, including fishers' collectives) is the loss of income and livelihood from reduced or no catch (fish/shrimp) due to the impacts on these from drilling noise and an oil spill. Fishers also expressed uncertainty about impacts given that the actual drilling locations are unknown. As a result, fishers requested additional information related to impacts related to drilling and relevant mitigation measures (including oil spill), as well as the GPS locations of the actual drilling locations and exclusion zones. They requested that this information should be submitted to all fishers in a timely manner in advance of Project start-up and during Project activities (schedule of work). Compensation in case of an oil spill and social responsibility projects in affected areas were also requested.

5.6.2.1.3 NGOs & Associations

The NGOs consulted included World Wildlife Fund (WWF), Green Heritage Fund Suriname (GHFS), Conservation International (CI) and the Association for Sports Hunters & Fishers was also interviewed. Several attempts were made to interview the Suriname Hospitality & Tourism Association (SHATA), but this was unsuccessful (see Annex 2 of Appendix D.23).

These groups cited a major concern in relation to the lack of baseline data to be able to monitor the impacts associated with drilling activities in the Neashore area. Another concern raised was the potential impacts of drilling on mangroves and marine life, including whales, sea turtles, dolphins and birds, from: an oil spill; discharge of drilling muds and cuttings; noise from drilling; the physical presence of the rig; and movement of rig and supply vessels from Trinidad and within the Nearshore area.

The NGOs recommended that the drilling activities be aligned with the turtle nesting season, and that no activities be conducted in Blocks C and D during the 'high season' (January/February to June), and that drilling utilise a bubble curtain[29] to reduce effect of noise on marine life. They also indicated that Environmental Sensitivity Index Mapping should be conducted, and suggested that the WWF guidelines (which aligns with the vision of CI) for the Suriname oil and gas sector (still being developed) be included as part of mitigation in order to minimise the potential impacts of the Project. CI also indicated that the execution of drilling activities should be in compliance with all national and international regulations. Lastly, as the NB suggested, the NGOs recommended having MMOs on-board of vessels during transportation phases of the Project to monitor marine wildlife (including turtles), and to collect the following information:

- Daily census counts of seabird, sharks, rays and *Sargassum* (seaweed);
- Positions/type/registration number of industrial fishing vessels; and
- Data related to depth, salinity, currents and sea surface temperature.

Several measures were suggested towards the protection of turtles, including: the prohibition of boat-based activity in front of a nesting beach during the nesting season; reduction of travelling speed to reduce risks of vessel collisions with turtles (<3-5 knots); the use of turtle guards on tail buoys; limiting operations at night in areas of high sensitivity; the use of propeller guards to reduce the risk of accidentally injuring surfacing animals; exercising caution when *Sargassum* is sighted, and no boating over these areas; halting operations during animal sightings; and reduce waste (solid and liquid) associated with boat operations, exploration drilling and production, with a view to ensuring that no waste is dumped at sea.

The Association for Sports Hunters & Fishers also recommended the execution of a biological study including an assessment of the possible effect of disruptions in coastal protection exercises as a result of oil spills from the Project.

[29] *A bubble curtain is a system that produces bubbles in a deliberate arrangement in water. Perforated pipe is laid along the sea or riverbed and air pumped through continuously. The upwelling of tiny bubbles acts as a barrier to fine sediments and sound waves. The curtain traps suspended sediment on the turbid side of the curtain it also stops the propagation of waves or the spreading of particles and other contaminants (Bray 2008).*

5.6.2.2 Public Consultation Meeting

This meeting will be conducted on May 23rd, 2018, and the proceedings will be provided as an addendum thereafter.

6 IMPACTS & RISK ASSESSMENT

The potential environmental impacts and risks associated with the proposed Staatsolie Nearshore Drilling Project 2019 within Blocks A, B, C & D are identified and evaluated in this Chapter. The evaluation is based on a systematic analysis of likely environmental effects on physical, biological and socio-cultural resources.

The likely impacts (beneficial, adverse, direct, indirect, permanent, temporary and cumulative) associated with all phases of this Project are assessed using a methodical approach based on internationally recognised protocols.

The potential impacts of this Project were evaluated under the following categories or phases:

- Exploration Well Development:
  - Pre drilling;
  - Drilling; and
  - Post drilling (Well Abandonment & Rig Demobilisation).
- Unplanned Events[30];
- Positive Impacts; and
- Cumulative Impacts.

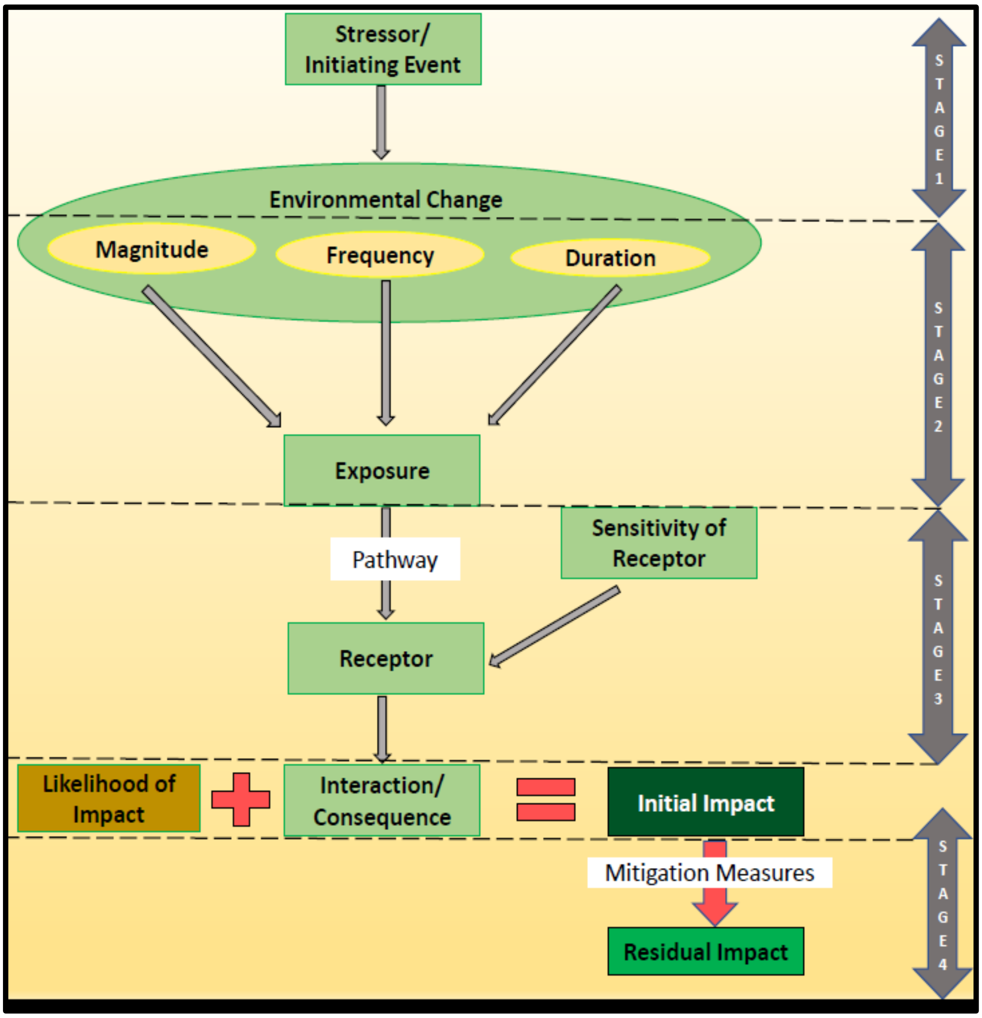
6.1 Impact Assessment Methodology

A conceptual model was used to assess the impacts of the proposed activities on the receiving environment as illustrated Figure 6-1 below. Here, the term '*source*' or '*initiating event*' describes the origin of the impact (e.g. the disposal of drilling muds from the rig) and the term '*pathway*' as the means by which the impact reaches the receiving environment (e.g. deposition via the water column to the seabed). The '*receptor*' is the organism or habitat which is sensitive to the impact (e.g. the smothering of an organism by muds can lead to anoxia and ultimately death). To assess all possible pathways and potential receptors, the ecosystem approach was utilised, which involves a consideration of all the physical, chemical and biological variables within an ecosystem, taking account of their complex interactions and connections.

The general framework used to assess impacts was intentionally designed not to be overly prescriptive. It also used the best available information derived from a wide range of data and information sources. These included client and stakeholder consultation, literature review, surveys, modeling, baseline

[30] *A Project-specific Risk Register will be conducted for this Project, prior to Project start-up, which will identify all unplanned events.*

environmental results, informed scientific interpretation and judgment based on past experience. The framework comprised of the following 4 stages (the most important considerations are highlighted in red).



Stage 1
Identification of change resulting from the proposed activities on the features of interest (i.e. physical, biological, socio-economic, cultural and health) that could be affected

↓

Stage 2
Understanding of the nature of change in terms of ***exposure to the impact, natural variability and the sensitivity*** (where appropriate) of the features of interest

↓

Stage 3
Evaluation of the ***vulnerability*** of the features as a basis for assessing the nature of the impact and its ***significance***

↓

Stage 4
Identification of ***impact reduction measures*** (or mitigation measures) to manage any impacts that are found to be significant

Source: ESL Database 2018

Figure 6-1: Conceptual Model Used to Assess the Impacts

6.1.1 Identification of Change (Stage 1)

To identify potential changes to the receiving environment, the potential impacts of this Project were evaluated under the categories mentioned above, i.e. the pre drilling, drilling and post drilling phases.

6.1.2 Exposure, Natural Variability & Sensitivity (Stage 2)

Estimations of changes represent the potential exposure to a receiving environment. Whether the receiving environment can be exposed to a change depends on there being a route or pathway (e.g. through air, water, ingestion, etc.). The magnitude of the exposure and its ability to impact on a receptor also depends on a range of factors, such as its duration, frequency and spatial extent.

Duration: The duration of an exposure can be over the short term (temporary) or long term (permanent). '*Temporary'* or short term has been considered as occurring during the pre drilling and drilling phases, as well as the during well abandonment and rig demobilization activity of the post drilling phase. Conversely, '*Permanent*' exposure is more appropriate for any activities in the long term. There are no long-term or permanent activities associated with this Project. Thus, in its entirety, this Project is considered a short-term one.

It should also be noted here that the availability of the drilling rig is the major influencing factor in determining the sequence of drilling of the wells. For this Project, the 10 wells will be drilled consecutively over the period April 1st to December 31st, 2019 (see Section 3.5 and Table 3-3 above). The duration of the various phases under consideration within this impact assessment is also presented in Table 6-1 below.

Table 6-1: Duration of the Phases of the Proposed Project

Phase	Activity	Duration (days)	Total Duration	Total Duration of Phase
Pre drilling	Transportation of the Jack-up rig from the Customs Clearance point (Nearshore) to the first drilling location	2	2	**38.5**
	Movement of the rig to each well-site	2 (per well, for 9 wells)	18	
	Positioning of the Jack-up Rig for drilling at the well-site	0.25 (per well)	2.5	

Phase	Activity	Duration (days)	Total Duration	Total Duration of Phase
	Rig crew and materials transfer	16	16	
			% of Overall Project Timeline	***14%***
Drilling	Placement of the conductor pipe, drilling and casing placement at 7 of 10 well-sites	18 (per well)	126	**207**
	Placement of the conductor pipe, drilling and casing placement at 3 of 10 well-sites	27 (per well)	81	
			% of Overall Project Timeline	***75.27%***
Post Drilling	Well abandonment at each well (cement plugs)	1 (per well)	10	**29.5**
	Rig removal at each well-site	0.25 (per well)	2.5	
	Rig crew and materials transfer	15	15	
	Final demobilisation of the rig from the 10th well-site to the Customs Clearance Point (Nearshore)	2	2	
			Total for Post Drilling Phase	**10.72%**
	Total Duration Across All Phases (April 1st – December 31st, 2019)		**275**	**100%**

Spatial Extent: The spatial extent of a change has been referred to using terms such as '*Localised*' (impacts are restricted to the Project area and wider study area) and '*Regional*' (impacts extend to other South American countries, the Caribbean Basin and beyond). For the purposes of this impact assessment exercise, the '*Immediate Project Footprint*' is the area surrounding each well-site, marine transit corridors and ports/shorebases, whilst the wider study area is considered to be the surrounding coastal Nearshore and marine offshore waters of the north coast of Suriname, and the terrestrial (coastal) zone within 2 km of the coastline of Suriname (see Section 5.2 and Figure 5-1 above).

Frequency: Frequency is the ability for a change to be repeated and as such can be described as being Infrequent, Frequent or Continuous.

Many different methods may be used to determine the extent of changes, and in some cases, it will be desirable to take account of uncertainty e.g. where there is insufficient information to make an accurate assessment of the impact. The precautionary principle is employed such that consideration will be given to any potential harmful or negative impact even in the absence of scientific certainty.

Natural variability in the environment is difficult to evaluate given that changes over time can extend to decades rather than annually (i.e. seasonal or inter-annual variability). However, for the purpose of this report, seasonal or inter-annual variability has been accounted for quantitatively in the numerical modelling of spill scenarios and transportation of offshore drilling wastes. Known natural variability has been evaluated in the context of baseline data collected and described in Section 5.3.9, Section 5.3.10, Section 5.4.1 and Section 5.4.2 of this report.

An impact can only occur if the receiving environmental component is exposed to a change to which it is sensitive. Hence, it is necessary to understand the sensitivity of receiving environmental components. Sensitivity can be described as the intolerance of a habitat, community or individual species to a given change. In this assessment, sensitivity was considered as the inability of the receiving environmental component to tolerate the levels of predicted changes to which they were exposed.

The assessment of sensitivity considers the adaptability of habitats, communities and species to change or their ability to return to a former status once Project activities cease. Therefore, sensitivity incorporates both the ability to cope with and recover from change.

This stage essentially provides a benchmark against which the changes and level of exposure can be compared. In some cases, it may be applicable to compare the anticipated change or exposure against either baseline conditions or other relevant thresholds such as quality criteria.

6.1.3 Vulnerability & Significance (Stage 3)

The vulnerability of a receiving environment is essentially the comparison of the anticipated exposure with the specific sensitivity or response characteristics. Where the exposure and sensitivity characteristics overlap, then vulnerability exists and an effect may materialise. Where an exposure or change occurs for which the receptor is not sensitive, no direct impact can occur. Vulnerability is an expression of the risk associated with an impact. Whether this vulnerability state or risk is ‘significant’, or ‘not significant’, is described below.

Estimating and categorising the significance of an impact is the stage that probably incorporates the greatest degree of subjectivity. A receiving environment may have a high or low vulnerability, but whether this potential impact is ‘*significant*’ may depend on other factors, such as its potential recoverability (temporary or permanent impact) and its relative ‘importance’ (either to the ecosystem or in terms of statutory designations). Potential impacts were classified in terms of significance based on Table 6-2 below.

Table 6-2: Impact Classification

Significance	Examples of Indicative Criteria
Negligible (not significant)	• Unlikely occurrence of effects, and if it does occur, there is little or no detectable impact – i.e. effects are within the range of normal natural variations in the biological, chemical or physical systems or from pre-existing anthropogenic activities within the study area • No mitigation is required
Low (not significant)	• Short time scale of the activity or event (e.g. <5% of the regeneration time of the resource of concern, or <5% of a critical sensitive period such as breeding season etc.), or event occurs <5% of total Project duration • Area over which the activity or event may occur is <5 % of the area occupied by the resource of concern • Affects a specific group of localised individuals within a population over a short time period (one generation or less, in reference to plant and animal species), but does not affect other trophic levels or the population itself • Does not affect users of natural resources, or affects <5% of local users of natural resources • There is no cumulative impact with other impacts from different sources • Activity does not exceed statutory limits for any parameter • Organisms (group of localised individuals) affected are able to regenerate within a month of the removal of the stressor • No mitigation is required
Medium/ Moderate (may be significant)	• Time scale of the activity or event is 5-10% of the regeneration time of the resource of concern or a critical sensitive period or event occurs 5-10% of total Project duration • Area over which the activity or event may occur is 5-10% of the area occupied by the resource of concern • Affects a portion of a population and impact may bring about a change in abundance and / or distribution over one or more generations, but does not threaten the integrity of that population or any population dependent on it • Organisms (group of localised individuals) affected are able to regenerate within a few months of the removal of the stressor

Significance	Examples of Indicative Criteria
	• Affects users of natural resources, but only in the short term, or resources used by a minority of local people (<10%) • Effect is cumulative but does not contribute >10% of the total impact • Activity may exceed statutory limits for more than one but less than five parameters or for one parameter by between 5-10% on some occasions • Some mitigation may be necessary to minimise impacts.
High (significant)	• Time scale of the activity or event is >10% but less than 50% of the regeneration time of the resource of concern or a critical sensitive period or event occurs between 10 and 50% of the total Project duration • Area over which the activity or event may occur is >10% but less than 50% of the area occupied by the resource of concern • Causes a decline in abundance/distribution of an entire population or species, beyond which natural recruitment would not return that population or species, or any population or species dependent upon it, to its former level within several generations • Users of natural subsistence or commercial resources (on which 10% of local people depend) are affected to the degree that their well-being is affected over a long term. • Effect is cumulative and contributes >10% but <50% of the total impact • Activity may exceed statutory limits for more than five parameters or for one parameter by between 10 and 50% on several occasions • Mitigation is required – Project cannot proceed without it.
Critical (significant)	• Time scale of the activity or event is >50% of the regeneration time of the resource of concern or a critical sensitive period or event occurs more than 50% of the total Project duration • Area over which the activity or event may occur is >50% of the area occupied by the resource of concern • Affects an entire population or species to cause a decline in abundance and/or change in distribution beyond which natural recruitment would not return that population or species, or any population or species dependent upon it, to its former level

Significance	Examples of Indicative Criteria
	• May affect a subsistence or commercial resource (on which more than 10% of local people depend) use to the degree that the activity is no longer viable • Effect is cumulative and contributes more than 50% of the total impact • Activity regularly exceeds statutory/regulatory limits for any parameter • Event or activity is not amenable to mitigation • Changes to Project design will be required to allow mitigation or Project may need to be abandoned.
Positive	• Event or activity is considered to have a positive benefit on the environment either through an improvement in the resource base or by increasing the resource base. Positive benefits should be offset against negative impacts
Unknown	• Not enough data to assess the extent and nature of the impact in any meaningful way. Recommended course of action would be to monitor unless the resource is of a critical nature (habitat or species) in which case additional studies would be required

Source: ESL 2018

The Interaction Matrices in Section 6.3 below provide an overview of the identified potential impacts. Potential impacts were identified as significant (medium, high or critical) or not significant (negligible or low). Negligible impacts were determined to require no mitigation action.

In this Chapter, potential impacts identified as significant are discussed. A significance statement is determined for each stressor considered. The significance statement provides a summation of the evaluation process in terms of adverse impacts. It would be inappropriate to apply a rigid framework for the actual categorisation of the significance level as this will tend to be a judgement-based decision. However, adverse impacts will be those impacts that are judged to be undesirable. The concern they raise will increase from Low, which has been assessed as tolerable, through to Moderate, High and Critical, which may require some form of impact reduction measure or mitigation. Beneficial (positive) impacts are those impacts that are judged to provide some environmental or social gain whilst, cumulative impacts were evaluated as those that have the potential to cause accumulation of environmental effects within a particular location and timeframe.

6.1.4 Impact Reduction Measures (Stage 4)

A range of standard best practice procedures and impact reduction measures (or mitigation measures) are considered in order to minimise the potential impact on different receiving environments. These impact reduction measures (hereafter referred to as '*inherent mitigation*') have been incorporated into the design of the drilling Project and so, are included in the relevant sections within Chapter 3 of this report. These inherent mitigation measures are also summarised within the discussion of the various stressor-receptor relationships in Section 6.4 below. Other mitigation measures proposed are recommendations arising from the impact assessment process, and are referred to hereafter as '*additional mitigation*'. These impact reduction measures (additional mitigation) and associated monitoring procedures are described in Chapter 7.

6.2 Numerical Modelling

TETRA TECH's Oil Spill Contingency and Response (OSCAR) model was used to simulate oil and diesel spill scenarios within the study areas; similarly, the Offshore Operators Committee Mud and Produced Water Discharge (OOC) model was used to simulate the dispersion of drill cuttings and mud discharges within the study area (Tetra Tech 2018a). The complete report is presented in Appendix E.

Potential crude oil blowout, diesel fuel spills from a vessel collision and drill cuttings/mud discharges simulations were conducted at 5 modelling points, representative of the spatial variability of dynamical conditions in the Blocks' area, during two seasonal periods. These are referred to within Appendix E and the impact analysis as the 'short season', which pertains to the short wet and short dry seasons of Suriname (early December to late April); and the 'long season', which pertains to the long wet and long dry seasons (late April to early December; see Section 5.3.6.1 above).

Proposed well-site locations are in the process of being defined based on geology for high probability of oil in that area, and the modelling sites were chosen to be representative of the focus areas where drilling can occur. The five modelling points (see Figure 6-2 below) represent different oceanic dynamics throughout the Blocks' area:

- Site 1 is the westernmost point (closest to Guyana) within Block A;
- Site 2 is located within the shallower waters of Block B, representing the portion of the study area in which the tidal influence is expected to be the greatest
- Site 3 within Block B, which is representative of greater variability in the current pattern, owing to changes in depth;
- Site 4 within Block C, which was selected to ensure the best coverage of Block C; and

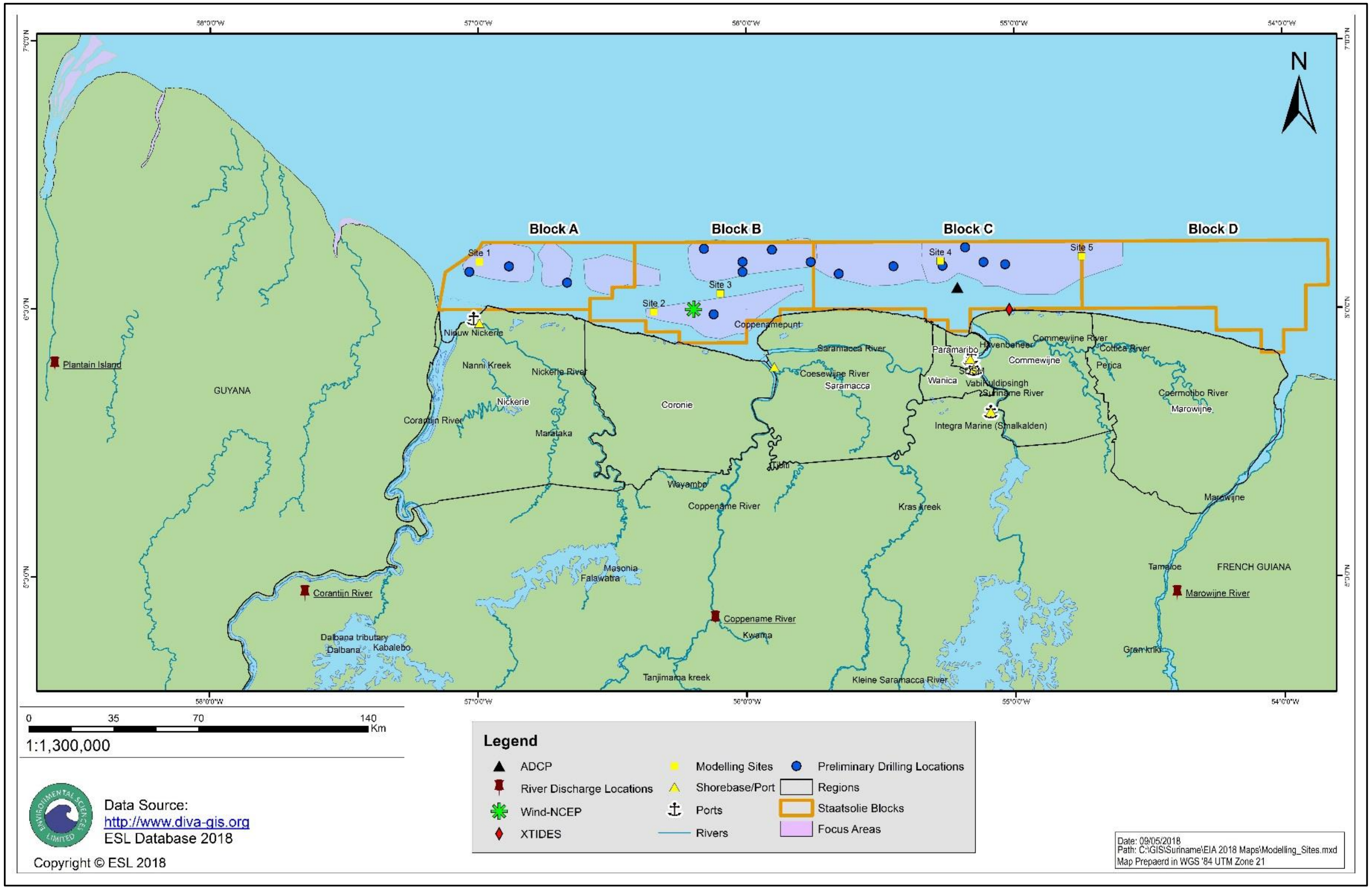
- Site 5 was placed as the easternmost location, in order to provide coverage of the eastern portions of the study area.

Modelling sites were placed within Blocks A, B and C, as Staatsolie has indicated that no drilling is expected within Block D (see Section 1.1 above).

The three-dimensional hydrodynamic model used in this study was Delft3D hydrodynamic model (Deltares 2013; see Appendix A of Appendix E). Meteorological and oceanographic data that were utilised in the modelling process (validation and/or forcing) include:

- XTIDES Station, within Block C;
- Wind data from National Centre for Environmental Prediction (NCEP) and National Data Climate Centre (NDCC);
- Current dataset obtained using an ADCP deployed by ESL during the period October 18th – December 13th, 2017;
- Wave data from NCEP, north of Block C; and
- Mean monthly river discharge from the Coppename, Corantijn River, Marowijne and Essequibo Rivers, from the Centre for Sustainability and the Global Environment (SAGE).

Simulations were conducted for the whole year, allowing Delft3D to represent the seasonal oscillations in currents. The model also captured the variation of ITCZ and trade winds within the simulated periods.



Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-2: Location of Sites from which Oil, Diesel & Discharge of Drilling Muds and Cuttings were Modelled

6.2.1 Sediment Fate and Transport Analysis

The Offshore Operators Committee Mud and Produced Water Discharge Model (OOC Model), developed by EPR[31] was applied to simulate the dispersion of the drill cuttings and mud discharge scenarios. A more detailed OOC's description is presented at Appendix E.

The OOC is a deterministic model and does not have a stochastics mode. Each scenario represents a different drilling section, covering a period time and duration. However, TETRA TECH has applied the following methodology to generate stochastic results.

After performing the deterministic simulations in the OOC model (2 simulations per day), its thickness results are analysed and post processed to make it possible to present stochastic and worst-case results; this assessment is presented in Section 6.4.5 below.

A drilling program of up to 4 different hole sections in the well-bore was assumed. Each hole section represents an area of a specific hole diameter. As the drilling program progresses, the hole diameter gets progressively narrower as illustrated in Table 6-3 below. The tables also provide scenario specifications for the drill cuttings and mud modelling based on the expected drilling program. The tables contain the discharge location, the amount of the discharges, the mud type and the duration for the 4 sections to be drilled for the 5 modelling sites.

Table 6-3: Specifications for the Discharges of Drill Cuttings and Mud at 5 modelling sites

Hole Section diameter (inches)	Length (ft)	Drilling Duration (days)	Discharge Depth (m)	Volume Released (bbl.)		Mud Type
				Cuttings	Mud	
20''	300	1.5	Surface of water	16	116	Water Based Mud
16"	1,700	3.0	Surface of water	477	498	
12¼"	4,000	5.0	Surface of water	560	875	
8½''	2,500	6.0	Surface of water	157	597	

Source: Tetra Tech 2018a (see Appendix E)

Note: Water depth discharge: surface of water column (0 m)

[31] *Exxon Production Research Company.*

The model used, focused on the initial dispersion of the particulates over wide areas that may expose important components of the receiving environment to brief episodes of high drilling particle concentrations. All results from the transport modeling (predicted water column concentration of discharged material and seafloor thickness depositions) represent conditions at the end of the drilling operation. For the purpose of this study, the numerical model outputs are discussed in the relevant Sections below.

6.2.2 Spill Modelling for the Proposed Drillling Operation

As indicated above, the OSCAR model (see Appendix B of Appendix E), developed by SINTEF was used to carry out the crude oil and diesel spills modelling. The approach used for the oil releases in this study was to first generate a stochastic simulation. The stochastic model computed probable surface trajectories of oil and effectively sampled the variability in the wind and current records; i.e., the stochastic model delineated the maximum predicted footprint of the spill from a location and time. Predicted weathering of the oil included both evaporation and water column entrainment in the stochastic simulations. Appendix E lists the various numerical parameters used as input for each scenario of the oil and diesel spill modelling; each simulation corresponded to a single scenario. The summary of the spill scenarios is presented below:

- Crude oil, representing loss during drilling of the exploration well, at a rate of 400 bbl/day at the surface of the water column, over a 7-day period, without mitigation controls applied, at each of the modelling Sites 1 to 5, during both the short and long seasons; and

- Diesel fuel oil, representing unplanned spill due to a vessel collision, instantaneous release of 100 bbl at the surface of the water column, without mitigation controls applied, with simulation durations of 6 hours, 12 hours and 7 days, at each of the modelling Sites 1 to 5, during both the short and long seasons.

The stochastic predictions for each scenario was based on a large number of individual simulations, and provided different types of information such as:

1. Sea surface areas that might be affected and the associated probability
2. The shortest time required for the pollutant to reach any point in the areas predicted to be affected
3. Shore probability, and
4. Maximum mass on shore.

The plots generated do not imply that the entire coloured surface presented would be affected by a single spill, but rather define all areas (based on the ensemble of independent trajectories) in which the pollutant may be expected.

The analysis of the stochastic simulations results of crude oil and diesel spills allowed the identification of the critical or 'worst case' scenarios. For these simulations, the scenarios which presented the shortest time for the oil to reach the coast have been considered as the most critical. Once the worst case shortest time to shore) simulation was identified, the trajectory and fates model predicted the weathered state of the oil (types of weathering for the trajectory and fates model include evaporation, water column entrainment, and shoreline interactions). The trajectory and fates simulation used the same wind and current forcing as the "worst case" stochastic simulation.

6.3 Identification of Impacts

A summary of the activities associated with the pre drilling, drilling, and post drilling phases of the proposed Project that are considered to have some degree of negative impact are presented in the tables below. These tables address the activities and environmental interactions between the stressors and receptors in the various phases:

- Table 6-4: Pre Drilling Phase;
- Table 6-5: Drilling Phase; and
- Table 6-6: Post Drilling Phase.

The following is a list of all stressors identified and associated with each respective phase of the proposed Project:

- PRE DRILLING PHASE – STRESSORS
  - Transport and Installation of Rig:
    - Vessel Movement;
    - Improper Solid Waste Disposal;
    - Operational Discharge;
    - Hydrocarbon & Chemical Spillage;
    - Positioning of Jack-up Rig;
    - Anchoring;
    - Discharge of Sanitary & Organic Waste;
    - Rig & Vessel Illumination; and
    - Vehicular Movement (Onshore).

- DRILLING PHASE – STRESSORS
  - Drilling
    - Discharge of Water Based Drilling Muds & Cuttings;
    - Vessel Movement;
    - Anchoring;
    - Improper Solid Waste Disposal;
    - Operational Discharge;
    - Hydrocarbon & Chemical Spillage;
    - Discharge of Sanitary & Organic Waste;
    - Disposal of Excess Cement/Water Mixture;

    - Rig and Vessel Illumination;
    - Conductor Pipe, Drilling & Casing Placement; and
    - Vehicular Movement (Onshore).

- POST DRILLING PHASE – STRESSORS
  - Well Abandonment, Demobilisation & Transport of Rig:
    - Vessel Movement;
    - Improper Solid Waste Disposal;
    - Operational Discharge;
    - Hydrocarbon and Chemical Spillage;
    - Discharge of Sanitary and Organic Waste;
    - Disposal of Excess Cement/Water Mixture;
    - Rig & Vessel Illumination;
    - Anchoring;
    - Jack-up Rig Removal; and
    - Vehicular Movement (Onshore).

Table 6-4: An Interaction Matrix between the Proposed Pre Drilling Activities and the Receiving Environment (Potential Significant Impacts – Shaded Cells)

RECEIVING ENVIRONMENT		PRE DRILLING PHASE – Transport & Installation of Rig								
		Vessel Movement (Physical movement, Gas Emissions & Noise)	Solid Waste Disposal*	Operational Discharge	Hydrocarbon & Chemical Spillage	Positioning of Jack-up Rig	Anchoring (Rig & all support vessels)	Discharge of Sanitary & Organic Waste	Rig &Vessel Illumination	Vehicular Movement –Onshore (Gas Emissions & Noise)
Physical Environment	Seabed (Physical Nature)		N			L	L			
	Mudflats		U		N					
	Freshwater Quality									
	Marine Water Quality		L	N	M	L	L	L		
	Marine Sediment Quality				L			L		
	Air Quality	L			L					L
	Sound Quality (Above water)	N								L
	Sound Quality (Below water)	N				L	L			
	Soil Quality (Onshore)									
Biological Environment	Offshore Soft-Bottom Macrobenthos		L		N	L	L	L		
	Soft Coral Taxa (Isolated)		L		N					
	Benthic Fish and Shellfish	N	L		M	L	L	L		
	Marine Mammals	M	L	N	M	N	N	L		
	Sea Turtles	M	L	N	M	N	N	L		
	Pelagic Fish & Plankton	N	L	N	M	N	N	L	N	
	Marine & Coastal Avifauna	N	L	N	M			L	N	
	Terrestrial Fauna				N					
	Protected Areas (NRs & MUMAs)	N	U		N			N		
	Other Sensitive Ecosystems (Mudflats, Mangroves, Lagoons & Swamps)		U		N			N		
Socio-cultural Environment	Resource Users	L	L	N	M			L		
	Employment, Income & Labour Market				N					
	Fisheries	L	L	N	M			L	N	
	Recreation & Tourism	N	U		L					
	Archaeological & Historical Resources				N					
	Marine Ports & Traffic	N	L		L					
	Road Infrastructure & Traffic									L
	Human Health	L		N	M			L		L
	Emergency Resources				M					L

**Impacts associated with this stressor were discussed as cumulative for the duration of the project*

Impact Classification	Symbol	Impact Classification	Symbol
Low	L	Unknown	U
Medium	M	Negligible	N
High	H	Cumulative	
Significant impact			

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Table 6-5: An Interaction Matrix between the Proposed Drilling Activities and the Receiving Environment (Potential Significant Impacts – Shaded Cells)

RECEIVING ENVIRONMENT		DRILLING PHASE: Discharge of Water Based Drilling Muds & Cuttings	Vessel Movement (Physical movement, Gas Emissions & Noise)	Solid Waste Disposal*	Operational Discharge	Hydrocarbon & Chemical Spillage	Discharge of Sanitary & Organic Waste	Disposal of Excess Cement/Water Mixture	Rig & Vessel Illumination	Conductor Pipe, Drilling & Casing Placement (Physical Placement, Gas Emissions & Noise)	Vehicular Movement-Onshore (Gas Emissions & Noise)	Anchoring (PSVs & Crew/Chase Boat)
Physical Environment	Seabed (Physical Nature)	N		N						L		L
	Mudflats			U		H						
	Freshwater Quality											
	Marine Water Quality	L		L	L	H	L	L		N		L
	Marine Sediment Quality	L				L	L			N		
	Air Quality		L			L				L	L	
	Sound Quality (Above water)		N							M	L	
	Sound Quality (Below water)		L							M		L
	Soil Quality (Onshore)											
Biological Environment	Offshore Soft-Bottom Macrobenthos	L		L		M	L			U		L
	Soft Coral Taxa (Isolated)			L		N						
	Benthic Fish and Shellfish	L	N	L	L	H	L			M		L
	Marine Mammals	L	M	L	L	H	L	L		M		L
	Sea Turtles	L	M	L	L	H	L	L		M		L
	Pelagic Fish & Plankton	L	N	L	L	H	L	L	N	M		L
	Marine & Coastal Avifauna		N	L	L	H	L		N	L		
	Terrestrial Fauna					H						
	Protected Areas (NRs & MUMAs		N	U		H	N			N		
	Other Sensitive Ecosystems (Mudflats, Mangroves, Lagoons & Swamps)			U		H	N					
Socio-cultural Environment	Resources Users	L	M	L	L	H	L			L		
	Employment, Income & Labour Market					M						
	Fisheries	L	M	L	L	H	L		N	L		
	Recreation & Tourism		N	U		L				N		
	Archaeological & Historical Resources					L						
	Marine Ports & Traffic		L	L		H						
	Road Infrastructure &Traffic										L	
	Human Health		L		L	H	L			L	L	
	Emergency Resources					H					L	

Note: In the printed table, cells are coloured orange (significant impact) or purple (cumulative), as the legend below explains; the colours are not shown here.

**Impacts associated with this stressor was discussed as cumulative for the duration of the project*

Impact Classification	Symbol	Impact Classification	Symbol
Low	L	Unknown	U
Medium	M	Negligible	N
High	H	Cumulative	(purple shading)
Significant impact	(orange shading)		

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Table 6-6: An Interaction Matrix between the Proposed Post Drilling Project Activities and the Receiving Environment (Potential Significant Impacts – Shaded Blocks)

RECEIVING ENVIRONMENT		POST DRILLING PHASE – Well Abandonment, Demobilisation & Transport of Rig									
		Vessel Movement (Physical movement, Gas Emissions & Noise)	Solid Waste Disposal*	Operational Discharge	Hydrocarbon & Chemical Spillage	Discharge of Sanitary & Organic Waste	Disposal of Excess Cement/Water Mixture	Rig & Vessel Illumination	Rig Removal	Vehicular Movement-Onshore (Gas Emissions & Noise)	Anchoring (All support vessels)
Physical Environment	Seabed (Physical Nature)		N								L
	Mudflats		U		H						
	Freshwater Quality										
	Marine Water Quality		L	L	H	L	L		L		L
	Marine Sediment Quality				L	L					
	Air Quality	L			L					L	
	Sound Quality (Above water)	N								L	
	Sound Quality (Below water)	N									L
	Soil Quality (Onshore)										
Biological Environment	Offshore Soft-Bottom Macrobenthos		L		M	L					L
	Soft Coral Taxa (Isolated)		L		N						
	Benthic Fish and Shellfish	N	L		H	L			L		L
	Marine Mammals	M	L	L	H	L	L		L		N
	Sea Turtles	M	L	L	H	L	L		L		N
	Pelagic Fish & Plankton	N	L	L	H	L	L	N	N		N
	Marine & Coastal Avifauna	N	L	L	H	L		N			
	Terrestrial Fauna				H						
	Protected Areas (NRs & MUMAs)	N	U		H	N					
	Other Sensitive Ecosystems (Mudflats, Mangroves, Lagoons & Swamps)		U		H	N					
Socio-cultural Environment	Resource Users	L	L	L	H	L					
	Employment, Income & Labour Market				M						
	Fisheries	L	L	L	H	L		N			
	Recreation & Tourism	N	U		L						
	Archaeological & Historical Resources				L						
	Marine Ports & Traffic	N	L		H						
	Road Infrastructure & Traffic									L	
	Human Health	L		L	H	L				L	
	Emergency Resources				H					L	

**Impacts associated with this stressor was discussed as cumulative for the duration of the project*

Impact Classification	Symbol	Impact Classification	Symbol
Low	L	Unknown	U
Medium	M	Negligible	N
High	H	Cumulative	
Significant impact			

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6.4 Well Exploration Impact Assessment

An evaluation of the impacts associated with the Staatsolie Nearshore Exploration Drilling Project 2019 is described in the following sections. Only those environmental receptors considered impacted to a significant degree are discussed in detail, based on their relationships with the following stressors, as a result of the execution of this Project:

- Positioning of the Jack-up Rig;
- Anchoring;
- Vessel Movement;
- Conductor Pipe, Drilling and Casing Placement;
- Discharge of Water Based Drilling Muds and Cuttings;
- Improper Solid Waste Disposal;
- Discharge of Sanitary and Organic Waste;
- Vehicular Movement (Onshore);
- Operational Discharge;
- Hydrocarbon and Chemical Spills; and
- Gas Emissions.

The following sections include both quantitative and qualitative assessments, taking into account the impact assessment criteria presented in Table 6-2 above. Where the relevant Project details were available, the quantitative assessment was supported by numerical calculations, which took the maximum of 10 wells into account. For the qualitative assessment, spatial extent included the location of all 15 preliminary drilling locations as well as the focus areas.

6.4.1 Positioning of Jack-up Rig

During the pre drilling phase of the Project, 3 tug boats will be used to tow the drilling rig to the 1st proposed drilling location in Block C from the customs clearance point at sea and subsequently to the other 9 locations within the nearshore Blocks A – C. Prior to this, Staatsolie will conduct geophysical and geotechnical surveys to determine the presence/absence of seabed structures and substrate type at the potential drilling locations. Additionally, preload and stability checks will be performed to ensure that the substrate will be able to support the drilling rig. Lastly, a site-specific approach will be employed during the movement of the rig to each of the 10 locations before rig positioning. These mitigation measures will be used on every occasion to ensure that the optimum location is chosen each with time with the least impact to the seafloor.

On arrival at the drilling site locations, the rig’s 3 legs (supported by a mat) will be lowered to the seafloor into the required position. While this process will have an impact with the physical nature of the seabed via scarring (mostly clay dominated soils; Section 5.3.9.3 above). Other receptors that may be impacted by this stressor include the marine water quality, sound quality (below water), soft-bottom macrobenthos and benthic fish and shellfish.

The positioning of the rig's mat will result in an impact on the seabed; the area of which is dependent on many variables, one of which is seafloor conditions at the final positions. The rig's mat will then remain in place for the duration of the drilling at each drill site which creates impacts to the physical nature of the seabed. It is expected that the impact produced per drill site will be equivalent to the area of the rig's mat. It is estimated that the area of impact at one drill site location would be 12,744 ft^2 (0.001184 km^2)[32]. This area will be exposed to oceanic environmental conditions after the final positioning of the Jack-up rig, and so may become silted over, and benthic communities may regenerate within a short time frame.

The area which would be lost over the medium term (duration of the Project) as a result of the positioning of the Jack-up would be unavailable for re-colonisation. Thus, the total area of the seabed which would be affected by the positioning of the Jack-up rig (per well-site) based on the specifications of the Well Services Rig 53 is estimated to be 127,440 ft^2 (0.012 km^2)[33]. It should be noted for the above calculations that, specification from the Well Services Rig 53 were used to estimate the impacts to the seafloor.

The positioning of the Jack-up drilling rig is expected to displace sediment and can crush benthic fish and shellfish, and benthic soft-bottom macrofauna on the seabed. The displaced sediment can also bury and smother benthic macrofauna and benthic fish and shellfish at the periphery and down-current of the indentation on the seafloor. However, this impact will only be limited to a small area, which is less than 0.00012% of the total acreage of Nearshore Block A-D[34] and less than 0.00027% of the focus areas[35]. It will also affect a specific group of localised individuals in a population over the short to medium term. These benthic populations will have a fast regeneration time. As a result, the impact of the positioning of the Jack-up rig mat will have a **negative**, **direct** and **low** impact to soft- bottom macrobenthos. Additionally, the impact to the physical nature of the seabed is also classified as **negative**, **direct** and **low**.

Decreased water quality due to increased turbidity may also result from sediment displacement as a result of the positioning of the rig. This impact was also identified as **negative**, **direct** and **low** due to the fact that the plume is expected to cover a small area, and dissipate over a short period of time in water that is already turbid (Artigas *et al.* 2003; Froidefond *et al.* 2002; Lowe-McConnell 1962; and Eisma 1967).

Additionally, the lowering of the rig's mat at each of the 10 locations will generate an impact to the seafloor and consequently underwater noise. Given that marine biota, namely, marine mammals, cetaceans, pelagic fishes and sea

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[32] *The impact area is determined by multiplying the length (118 ft) of the mat by its width (108 ft). This gives an impact area of 12,744 ft^2 or 0.001184 km^2 per location.*
[33] *Total area of impact by the rig's mat on the seafloor is determined by multiplying the impact at one drill site by 10 drill sites. This gives a total impact area of 127,440 ft^2 or 0.012 km^2.*
[34] *The acreage of the Nearshore Blocks A-D is approximately 11,133.22 km^2.*
[35] *The acreage of the focus areas within Blocks A-D is 4,405.60 km^2*

turtles are sensitive to noise and changes to its frequency, the jack-down of the rig mat may have negative impacts to these animals. However, as all these animals are mobile, they may easily escape the areas where noise levels may be a nuisance to them. Based on the above, impacts to sound quality (below water) for the pre drilling phase, has been ranked as **negative**, **direct** and **low**, whilst the impacts to the marine mammals, sea turtles, pelagic fish & plankton will be **negative**, **indirect** and **negligible.**

Overall, the impact of positioning of Jack-up rig during the pre drilling phase on the physical nature of the seabed, water quality, sound quality (below water), benthic fish and shellfish and offshore soft-bottom dwelling and feeding macrofauna is considered to be short to medium term and over a small area, thereby contributing to a **low** impact.

6.4.2 Anchoring

During the pre-drilling phase of the Project; 3 tug boats will be used to tow the drilling rig to the first well-site from the customs clearance point in Suriname waters. Prior to this, a chase vessel will be deployed to scan and survey the rig move route and set the location buoy for the 1st drill site. This procedure will be repeated at the other 9 proposed drilling locations before rig jack-down and rig jack-up. On arrival at each of the 10 drill site locations, the rig will be positioned and the legs on the mat base jack-downed. The rig may be affixed to the seabed via anchors or remain in position through dynamically positioned thrusters. If anchoring occurs, four 5-tonne Flipper Delta Anchors will be used for the rig stabilization process in the absence of a “back down” anchor during the pre-drilling phase of the Project. Additionally, anchors will be used by the Anchor Handling Tug and Support Vessel (AHSTV), Platform Supply Vessel (PSVs) and Crew Boat for the duration of the project. This stressor was hence, assessed based on the nature of the impact, i.e. modification of the seabed, smothering and crushing of benthos.

The receptors which may be affected by anchoring are: physical nature of the seabed; marine water quality; sound quality (below water); benthic fish and shellfish and soft-bottom macrobenthos. This process can have an impact with the physical nature of the seabed (muddy) through scarring. In addition, it is expected to displace sediment and can crush benthic fish and shellfish, and benthic soft-bottom macrofauna on the seabed. The displaced sediment can also bury and smother benthic macrofauna and benthic fish and shellfish at the periphery and down-current of the scar.

The impact of the anchors on the seafloor will result in a scar on the seabed; which is influenced by many factors including the final location of the anchor. The anchors associated with the rig will then remain in place for the duration of the drilling of each well-site which can range from 18 – 27 days, whilst those of the vessels will be for a shorter time frame, but at a greater frequency. This area will be exposed to oceanic environmental conditions after the final positioning of the anchors, and so may become silted over, and benthic communities may regenerate within a short time frame.

It is expected that the scar produced per anchor will be equivalent to the size of the anchor's surface area. Thus, it is estimated that the area of impact of one Flipper Delta anchor would be 4.8 x 10^{-6} km^2)[36] giving an overall total of 1.92 x 10^{-4} km^2 for the entire project duration, considering the rig will be using 4 anchors at a time.

Each of the support vessels (AHTSV and PSVs) will be fitted with 2 anchors each, whilst the crew boat/chase vessel will use one anchor for positioning. The area of impact will consider similar factors mentioned above in Section 6.4.1 above, in addition to the number of vessels and the frequency of anchor drops by each vessel. Assuming that the anchors on all the vessels are similar to that of the PSV, the impact area from one anchor is estimated to be 5.57 x 10^{-6} km ^{2}. This is an overestimation as the area above was calculated using length and width of the anchor[37]. Based on the above, a total impact area of 5.34 x 10^{-3} km^2 was due to the rig and vessel anchors. When the entire project area was considered, it was found that impacts to the seafloor was <0.0001% of Blocks A-D, whilst it was <0.001% of the focus areas.

This impact will only be limited to a small area which will affect a specific group of localised individuals in a population over a short period of time with a high regeneration time (r-strategist), thereby contributing to a **negative**, **direct** and **low** impact for all phases of the project until the removal of anchors.

Decreased water quality due to increased turbidity may also result from sediment displacement. This impact was also identified as **negative**, **direct** and **low** due to the fact that the plume is expected to cover a small area and dissipate over a short period of time.

Although anchoring is expected at 10 distinct locations, the cumulative impacts from the drilling of all 10 wells described above were still considered to be **negative**, **direct** and **low** because the wells would be drilled one at a time and the impacts described above will only occur at one point in time (i.e. during the drilling of each well). Additionally, the difference in the lag time between drilling would be sufficient for benthic regeneration to occur.

In addition, sound quality (below water) may be altered by the impact of anchors to the sea floor from the combined activities of the rig and support vessels. Given that the frequency of the vessel movement will be greater during the drilling phase, the impacts for this phase will be greatly influenced by the vessel anchors. Similar to that of the positioning of the rig mat, marine biota, namely,

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[36] *The area of impact per Flipper Delta Anchors on the rig is determined by dividing the product of the base (1.74 m) and height (2.78 m) by 2. This gives an impact area of 4.8 m^2 or 4.8 x 10^{-6} km^2.*

[37] *Area of impact from one anchor drop is determined by multiplying the length (10 ft) by the width (6 ft). This given an area of 60 ft^2 or 5.57 x 10^{-6} km^2.*

marine mammals, cetaceans, pelagic fishes and sea turtles may be impacted by changes to noise and its frequency below water. Since most these animals can move away from the source of the noise, impacts to them will be minimal. As such, impacts to sound quality (below water) for the drilling phase, has been ranked as **negative**, **direct** and **low**, whilst the impacts to the marine biota will be **negative**, **indirect** and **low.** As both pre and post drilling phases are considerable shorter, impacts to sound quality (below water) has been ranked as **negative**, **direct** and **low**, whilst the impacts to the marine biota will be **negative**, **indirect** and **negligible.**

6.4.3 Vessel Movement

For this Project, vessel movement will occur during all phases of the Project. Vessels will include 3 anchor handling tugs which operate during the pre and post drilling phase to transport the Jack-up rig between the first and last well-sites to and from the Customs Clearance point, and to move the rig from well-site to well-site over the duration of the Project. During all phases, 3 supply vessels will also be used for the supply of materials over the life of the Project, and there will be a chase vessel in operation to navigate the 500 m exclusion zone surrounding Project activities. A crew boat will also be employed to transport workers to and from the rig.

The supply vessels will originate from one of 5 proposed ports/shorebases: at Vabi, Kuldipsingh, Nieuwe Haven or Integra Marine for the 8 proposed well-sites within Blocks B and C; and at Nickerie for the 2 well-sites located within Block A (see Section 5.5.11 and Figure 5-172 above). There is a 6th port/shorebase at Boskamp; crew transfers only (and not supply runs) will be made from this location for the duration of the Project.

For this Project, a total of 724 return trips was estimated, across all phases, based on the assumption that vessels will operate daily (the frequency depending on the vessel type), and that vessel operation would be continuous over the life of the Project (the only exception being the anchor handling tugs, which will operate with less frequency over a shorter duration during rig movement (see Table 6-1 above). When all vessels were considered together, it was noted that 75% of return trips were scheduled for the drilling phase, which is expected since this will be the most work-intensive phase of the Project. The corresponding values for the pre and post drilling phases are 15% and 10%, respectively. Additionally, the chase vessel will make the most trips / operate most intensively during 24-hour operations of these vessels (taking rotation of vessels into account).

Vessel movement may impact the receptors of the study area in 3 ways: (i) from physical movement; (ii) from noise generated from vessel operations; and (iii) via gas emissions from engine operations. For all phases, vessel movement has been identified as having potential interactions with the following receptors: air quality; sound quality (above and below water); marine mammals; sea turtles; benthic and pelagic fish; marine and coastal avifauna; protected areas;

resource users (fishers and tourists); fisheries; recreation and tourism; marine ports and traffic; and human health. The impacts to air quality and human health from the vessel-associated gaseous emissions are presented in Section 6.4.11 below.

The inherent mitigation measures related to vessel movement which were considered for the initial assessment of the potential impact of this stressor included:

- The enforcement (by chase vessel) of a voluntary exclusion zone 500 m in radius, surrounding each drilling location (rig);
- The enforcement of an exclusion zone along the established routes for Project related vessels as they transit between the port/shorebases and the rig location;
- Formal (published) communications between Staatsolie (via MAS) and the relevant users of the marine areas (fishers) through the issuance of Mariner's Notices and via the media; and
- Fish representatives will be on-board the support vessels to have direct communications, where possible, with fishers or representatives of fishers' organisations.

Fisheries may be affected by vessel movements through short-term, temporary loss of fishing grounds during the pre and post drilling phases, since fishermen (SK, SKL and SKB fishers as well as Seabob trawlers and industrial fishers; see Section 5.5.7 and Figure 5-169 above) will not be able to fully occupy vessel routes during vessel movements for this Project. However, throughout the duration of this Project, fishermen will still be able to fish along vessel routes when vessel movements are not occurring. Additionally, the wells will be drilled consecutively, so that restrictions will only apply to one well-site at a time.

Fishermen may also be impacted by these vessel movements which can result in damage to their fishing gear (such as destruction of driftnets, especially if nets are not appropriately identified). Still, a **negative**, **indirect** and **low** impact is expected from this because vessel movement during pre and post drilling would be only marginally higher than if the Project was not being executed, particularly given the relatively shorter duration of these phases. However, the impact of vessel movement on fisheries and resource users (fishers) during the drilling phase has been classified as **negative**, **indirect** and **moderate** overall, given the longer duration of this phase and more frequent vessel movements during this phase. This impact is not considered to be cumulative, given that the wells will be drilled sequentially, and, as indicated above, restrictions will only apply to one well-site at a time.

Similarly, the movement of individual parts of the vessels, in particular the propeller blades, can function similar to a knife or any other sharp tool. These moving parts can be sharp enough to penetrate the tough skins of marine mammals or sea turtles and either cause severe bodily harm or loss of life. There is also the potential for vessel collision with organisms. Collision between the operational vessels and marine mammals or sea turtles can cause considerable injury.

Marine mammals may occur throughout the study area during Project execution (April – December 2019), since they can be found within the Southern Caribbean during January to May, and were noted as being present in deeper waters of Suriname during June – August by de Boer 2015. Their presence (whales and dolphins) was also noted in CSA 2015c (the most recent available marine protected species survey) during June to November 2014, within the Nearshore area of Blocks A to D. However, the likelihood of finding larger marine mammals within the shallower Nearshore area is low, as whales tend to prefer deeper waters (Ward *et al.* 2001). Conversely, dolphin taxa, which show varying levels of site fidelity (Zanardo *et al.* 2016; Zolman 2002 and Balmer *et al.* 2008) and tend to enter or occupy shallower waters, often because of a preference for brackish water (Santos and Rosso 2008), may occur within the Project area throughout the year (see Section 5.4.3.2 above). Thus, the likelihood of vessels potentially impacting upon dolphins is higher than for whales. Studies suggest that dolphins have varying levels of susceptibility to boat strike. Wells and Scott 2006 indicate that dolphins may be less susceptible to boat strike as they are physiologically smaller mammals and are faster swimmers (in comparison to some whales), but other sources indicate that the increase in vessel traffic within an area where these species occur may increase the risk of propeller-related injuries to these taxa (Fahy 2016 and New Zealand Department of Conservation; n.d).

Sea turtles are also expected within the Nearshore area, since the drilling period coincides with the nesting period (generally from February to August for the 5 taxa, peaking during May – June; see Section 5.4.4.2 above). Fahy 2016 and Krall; n.d indicate that sea turtles are also susceptible to injuries from boat strikes. Strikes may result in death or injury which makes turtles (as well as whales and dolphins) more susceptible to attack by predators. Injuries could also affect their foraging and migration abilities, which can also lead to death.

Based on the foregoing, the potential impact of vessel movement from all phases on marine mammals (whales and dolphins) and sea turtles was evaluated to be **negative** and **direct** and **moderate** (for all phases). Even though vessel movement (physical damage) during this Project will only affect a specific group of localised individuals (whales, dolphins and sea turtles) within a population over a short time period (one generation or less), and the potential impacts inflicted to these individuals will not be significant enough to affect any other trophic levels or the populations themselves, the rank of moderate has been assigned taking into account the vulnerability of these protected taxa (where several of these taxa are classified as threatened on the IUCN Red List; see Section 5.4.3 and Section 5.4.4 above). Additional mitigation should therefore be applied to take all precautions to safeguard these taxa for the duration of the Project.

Noise disturbances (which affect above-water and underwater sound quality) from rotation of propellers, the use of positioning thrusters, and vessel engines can have a negative impact on marine mammals, benthic and pelagic fish and, to a lesser extent, marine and coastal avifauna. Vessel noise will be loudest while using thrusters and propulsion for dynamic positioning at full power, though significantly lower levels will be present for the vast majority of the time, particularly in good weather conditions. An underwater noise modelling report prepared for the Guayaguayare Block, offshore the east coast of Trinidad (ESL 2012d) indicated that it is unlikely on the basis of the current evidence that fish will be affected by the sound emissions from drilling operations inclusive of vessel movements even during periods of maximum source noise. Thus, the overall impact will be **negligible** (i.e. little or no detectible effects) for all phases. Furthermore, the sound generation will be continuous and so there will be no 'startle' effect to marine mammals or pelagic fish which can be caused by sudden sound generation underwater.

The reaction of toothed whales to vessels is reviewed in Richardson *et al.* 1995 and the overall conclusion is that there is a good deal of variation in response, with many odontocetes showing considerable tolerance of vessel traffic. The Bottlenose dolphin (*Tursiops truncatus*), a species recorded in Suriname, commonly approaches boats. Thus, given that a portion of the study area (Block C) has some level of vessel movement as a result of the proximity of the Paramaribo Port (see Section 5.5.11 above), as well as the occurrence of fishing vessels throughout the study area (see Section 5.5.7 above), marine mammal fauna may already be acclimatised to vessel movement in the area, thus having no significant impact to them.

An underwater noise assessment conducted in the Brighton and Guapo Blocks (west coast of Trinidad; NCE 2011) indicated the estimated maximum noise levels associated with drilling activities and vessels with the spectra 10 – 2,000 Hz is approximately 120 dB re 1µPa for the typical condition and 130 dB re 1µPa for the maximum condition (vessels at full power) at a distance 1 km away from the rig. As expected, the levels of drilling noise quoted above are also higher than the third octave band spectrum levels of 90 – 100 dBA at most frequencies which characterise the baseline level of underwater sound within Block IV (western portion of Block C) in September 2010, as described in ESL 2012a (see Section 5.3.14 above).

The US National Marine Fisheries Service (NMFS) indicates that marine mammals in general are affected adversely by noise greater than 160 dB re 1µPa, whereas injuries may occur with exposure greater than 180 dB re 1µPa (ASRC 2008). The noise generated underwater by the drilling rig and support vessels to be used for the Drilling Project will therefore be lower than these levels. As a consequence, the impact on marine mammals as a result of the project will be **negligible**. Additionally, marine mammals are mobile organisms and as such have the ability to temporarily avoid areas with elevated noise levels. Effects are, therefore, not expected to be significant (Lawson *et al*.

2001). The same can be said for marine and coastal avifauna, and so the impacts to this receptor are also considered to be **negligible** for all phases.

The limited information available suggests that there is unlikely to be an impact on the marine turtle population, as these animals are not believed to rely upon sound to any significant degree for communication or food location. This impact has therefore been classified as **negligible**, for all phases.

As a result of the foregoing discussion, the overall impact of vessel movement on underwater sound quality has also been evaluated as **negligible**, for all phases. However, above water noise (from vessel operations) may affect sound quality above water, and may impact upon marine and coastal avifauna. These birds may typically move across the study area during feeding and migration, while occupying mangroves and mudflats along the shoreline, the majority of which occur within areas protected as bird habitat (see Section 5.5.8 and Figure 5-170 above). Though the numbers of bird migrants are high (see Section 5.4.7 above), and the proposed drilling period (April – December 2019) coincides with migration (southbound: July – November; and northbound: February to May) and breeding (generally from March – September, peaking in May – June), the wells will be drilled consecutively, so that noise from vessel movements be restricted to one well-site at a time, and birds may also actively avoid noisier areas. Thus, the overall impact to marine and coastal avifauna occupying the offshore area during feeding is thus classified as **negligible**. Given that the wells are located a minimum of 17 km and a maximum of 87 km from shore, then it is anticipated that noise will be attenuated over this distance in the Nearshore area, and will have a **negligible** impact upon birds feeding, nesting and breeding along the shoreline within the protected areas, and that there will also be a **negligible** impact to recreation and tourism (bird watching) and resource users (local and international tourists) given the limited disturbance of bird colonies.

Lastly, the potential impacts of vessel movement on marine ports and traffic was evaluated as **negligible**, given that vessel movement during pre and post drilling would be only marginally higher than if the Project were not being executed, particularly given the relatively shorter duration of these phases. However, during the drilling phase, the impact was evaluated as **negative**, **direct** and **low**, due to the increase in vessel movement and the longer duration of the phase.

6.4.4 Conductor Pipe, Drilling and Casing Placement

The receptors which may potentially be affected by the placement of conductor pipes via piling, drilling and placement of the casings during the drilling phase are: seabed (physical nature); marine water quality; marine sediment quality; sound quality (above water and underwater); benthic fish and shellfish; offshore soft-bottom macrobenthos; marine mammals; sea turtles; pelagic fish; marine and coastal avifauna; protected areas; resource users (fishers, other Nearshore users and tourists); fisheries; recreation and tourism; and human health. These impacts will be assessed in tandem with the impacts of air and noise from drilling and casing placement during the drilling phase. In this case, the receptors of concern are: air quality, sound quality, resource users and human health. A discussion on the impacts to air quality and human health associated with this activity is presented in Section 6.4.11 below).

The most important impact from conductor pipe placement is the generation of underwater sound, from impact piling. In descending order of severity, the impacts on all receivers thus far identified will be: piling>vessel noise>drilling, based on OSPAR 2009; see Table 6-7 below).

Table 6-7: SPL and Frequency Distributions for Main Underwater Sound Producing Activities

Sound	Source level (dB re 1 µPa-m)	Bandwidth (Hz)	Major Amplitude (Hz)	Duration (ms)
Pile Driving	228 peak	20 - >20,000	100 - 500	50
Drilling	145 - 190	10 - 10,000	<100	continuous
Small boats & supply vessels	160 - 180	20 - 10,000	>1,000	continuous
Large vessels	180 - 190	6 - 30,000	>200	continuous

Source: OSPAR 2009

There has been a lot of research conducted in the last 10 years on the impact of piling on underwater sound and on associated sensitive receivers, specifically cetaceans and a number of fish species. The majority of these studies have been conducted in European waters as a direct result of the rapid expansion of the offshore energy industry. OSPAR 2009 contained a review of underwater noise profiles and associated impacts of marine construction and industrial activities, including piling. Source levels vary depending on the diameter of the pipe and the method of pile driving (impact or vibropiling). The frequency spectrum ranges from less than 20 Hz to more than 20 KHz (see Table 6-7 above), with most energy around 100 – 200 Hz. The reported exposure levels from a number of research studies vary between 170 dB re 1µPa rms at 250 m from the source with an unknown diameter pipe to 257 dB re 1µPa peak to peak at 1 m from the source using a 4.7 m diameter pipe. The pipe diameter proposed for the Staatsolie Nearshore Drilling Project 2019 (20" or 0.508 m; see Nearshore well-bore designs in Figure 3-3 and Figure 3-4 in Section 3.5.3 above) will be less than 1 m and so the sound generated is likely to be at the lower end of the produced sound range in the region of 230 dB re 1µPa. OSPAR 2009 gives an SPL (sound pressure level) peak of 228 dB re 1 µPa with a bandwidth of 20 - 20,000 Hz and a major amplitude between 100-500 Hz for piling activities based on sound at the source (see Table 6-7 above).

Modelling studies conducted by Thomsen *et al*. 2006 and Madsen *et al*. 2006 indicated that the signals from pile driving in conditions typical for the North Sea and the Baltic (semi-enclosed sea) might be audible to porpoises over at least 80 km and perhaps over several hundreds of kilometres underwater. Thomsen *et al.* 2006 focused its study on waters up to 50 m deep, and Madsen *et al.* 2006, between 20 – 100 m. Thus, these results are applicable, based on water depths within the study area.

De Jong & Ainslie (2008) looked in detail on the potential impact of piling noise on the harbour porpoise (*Phocoena phocoena*) from piling activities associated with wind farms in the North Sea. These porpoises fall into the functional hearing group of 'high frequency cetaceans' (Southall *et al*. 2007) and are a reasonable surrogate for the delphinids that may be found periodically in the Project area. The harbour porpoise's hearing threshold at 500 Hz is about 90 dB re 1µPa, while its hearing threshold, 50 kHz, is in the order of 35 dB re 1µPa. This would mean that a sound with an SPL of 100 dB re 1µPa and at a frequency of 500 Hz would hardly be audible to the porpoise, however the same SPL at a frequency of 50 kHz would be perceived as relatively loud. So for this species, the sound levels required to produce discomfort are between 87 - 101 dB re 1µPa SPL in the frequency range 10 - 14 kHz. Levels of severe discomfort are experienced at 125 dB re 1µPa; for Temporary Threshold Shift (TTS) at 127 dB re 1µPa and for Permanent Threshold Shift (PTS) at 180 dB re 1µPa. These authors demonstrated that the received SPL is well above the discomfort threshold for porpoises within a radius of 5.6 km (furthest distance measured). At distances closer than about 1.5 km to the source, the levels are above the 'severe discomfort' criterion and at distances closer than about 500 m, the levels are higher than the TTS criterion.

There are only a very limited number of investigations on the effects of marine construction sound on fish and many relate to pile driving. Hastings & Popper (2005 *loq. cit.* OSPAR 2009) compiled findings from 5 experiments carried out in the US and UK using caged fish. Results varied between species and reported both behaviour changes (e.g. avoidance) and damage, as well as variety of physical injuries. In another study, no physical injuries were detected in caged trout 400 m away from the piling source, with an estimated sound level of 194 dB re 1µPa (Nedwell *et al.* 2003). There are also reports in the grey literature which suggest that there is a zone of direct mortality about 10 – 12 m from the piling source and a zone of delayed mortality extending between 150 m to 1,000 m from the piling; the OSPAR 2009 report goes on to suggest that the results from the grey literature are far from equivocal and that further research is necessary.

Other marine life that is sensitive to underwater sound include invertebrates such as decapod crustaceans which produce sounds and are sensitive to frequencies below 3 kHz and sea turtles which have hearing capabilities in the lower frequency band (OSPAR 2009).

Given the high levels of noise generated by piling activities and the presence of sensitive receivers (marine mammals, sea turtles, benthic fish and shellfish (crustacea) and pelagic fish) in the vicinity of the Project activities, the impact has been classified as **negative**, **direct** and **moderate**. This is because noise generated from piling affects a portion of these populations and impact may bring about a change in the abundance and/or distribution over one or more generations, but does not threaten the integrity of that population or any population dependent on it.

For soft-bottom macrobenthos, the impact of noise from piling of the conductor pipe has been evaluated as **unknown**, given the lack of scientific information on the impacts of noise and vibration on these species, though it is anticipated that organisms affected would be able to regenerate within a few months of the removal of the stressor.

Based on the afore-mentioned impact to pelagic fish, the potential impact of noise from the placement of conductor pipes and casings on fisheries and resource users (fishers) was initially considered to be negative, indirect and moderate. However, this impact was classified as **negative**, **indirect** and **low**, given that fish may display avoidance behaviour upon exposure to noise (see above) and fishers can fish anywhere within the Nearshore area which do not coincide with the location of drilling operations. Additionally, only one well will be drilled at a time, restricting this potential impact to a small area relative to the Project area. The impact of the exclusion zone has been evaluated as **negative**, **direct** and **low** for the pre and post drilling phases, given their short duration relative to drilling (see Table 6-1 above).

As a result of the foregoing discussion on the impacts of noise from piling, the impact of these activities on sound quality (underwater) has been classified as **negative**, **direct** and **moderate**.

The placement of conductor pipes is expected to affect the seabed through vertical displacement of sediment. For this Project, either a 20” or 30” conductor pipe will be used, and this has been identified as having a **negative**, **direct** and **low** impact with the physical nature of the seabed, because the area impacted will be very small (0.456 m^2 per well-site; i.e. surface area of the 30” conductor, to be conservative or estimate the higher potential impact, giving a total of 4.56 m^2 for all 10 well-sites).

Placement of the conductor pipe can also crush benthic fish and shellfish, and benthic soft-bottom macrofauna on the seabed. The mitigation inherent within the planned Project execution and design, which was considered in order to assess the initial rank of the impact of the stressor conductor pipe placement on benthic fish and shellfish, and benthic soft-bottom macrofauna included that the vertical displacement of seabed sediment and seabed scarring from the piling activities during placement of the conductor pipes will be minimised to a surface area that is as small as practicable. This, this crushing impact will be limited to a very small area, which will affect a limited number of localised individuals over a short time period, thereby contributing to **negative**, **direct** and **low** impacts.

Decreased water quality due to increased turbidity may also result from sediment displacement. This potential interaction however was classified as **negligible**, given that any turbidity plumes generated will extend over a localised area and would dissipate over a short period of time in water that, as part of the Brown water zone (see Section 5.3.10.1 above), is already deemed turbid (Artigas *et al.* 2003; Froidefond *et al*. 2002; Lowe-McConnell 1962; and Eisma 1967). Suspended sediments may also settle within the areas surrounding the rig mat, and temporarily affect sediment quality (chemical composition) but this potential impact has also been assessed as **negligible**, since these changes will be over a small scale with no lasting impact upon the prevailing sediment quality.

In addition, the above-water noise from the piling activities may be heard by resource users (fishers) and other users of the Nearshore area (such as shipping vessels, among others) but may not be heard by other resource users of the shoreline (such as coastal inhabitants, recreational users and tourists), given that Project activities will occur a minimum of 17 km from the shore. Above-water noise may cause fishers to relocate based upon their perception that fish will move away from the underwater noise source (i.e. exhibit avoidance behaviour). Fishers may also relocate to areas in which they are not accustomed to fishing (and which may be more costly to them e.g. additional expenses related to fuel). Given that the underwater noise source (piling) will be short-term and intermittent (10 hours per well) and that fishers may relocate to other nearby fishing areas, the impact of above-water noise from piling on resources users (fishers) has been classified as **negative**, **indirect** and **low** for the drilling phase.

The impact of piling noise (above-water) on other resource users (other marine users, such as shipping vessels and sea defence) of the Nearshore area (disturbance and human health) has been classified as **negative**, **direct** and **low**, since it is expected that above water noise will be attenuated given the meteorological (windy) conditions in the Nearshore environment.

Noise from piling may disturb coastal and marine avifauna, in which they may temporarily leave the area; however, once the noise has ceased, they may return to the area. Additionally, birds occupying the shoreline within protected areas may not be affected by these noise emissions, as noise attenuation will occur over the minimum 17 km distance to shore, from Project activities. Thus, it is anticipated that recreation and tourism (bird watching) and resource users (tourists) will also be unaffected, since colonies will remain undisturbed. Thus, the impact of this stressor on marine and coastal avifauna has been classified as **negative**, **direct** and **low**, while the potential impacts to protected areas, recreation and tourism and resource users (tourists) has been classified as **negligible**.

In terms of the drilling activity itself (i.e. apart from the placement of the conductors and casings), the principal issue is sound generated in the underwater environment. An underwater noise modelling report prepared for the Guayaguayare Block, along the east coast of Trinidad (ESL 2012d) indicated that sounds emitted during drilling are frequently masked by the sounds emitted by support vessels, especially when the vessels are operating at full power. OSPAR 2009 provides a review of the impacts associated with sound generated by drilling activities. Richardson *et al*.'s 1995 account of studies relating to behavioural effects of drilling in toothed whales is very equivocal. This study shows both avoidance, by bowhead and grey whales at received levels of 115 – 120 dB re 1µPa, and neutral responses to playback sounds in captive Beluga whales. Given the infrequent occurrence of baleen and toothed whales in the area (these preferring deeper waters), the continuous nature of the sound generation and the relatively short nature of the impact, the overall effect is considered **negligible**, and since marine mammals are considered more sensitive, the impacts to turtles and fish can also be assessed as **negligible**.

There may be potential impacts to fisheries and resource users (fishers) as a result of the imposition of a voluntary 500 m exclusion zone around each well-site, and fishers will be unable to operate within an area of 0.785 km^2 around each well-site, and a total of 7.85 km^2 over the Project area. This amounts to 0.07% of the acreage of Blocks A to D (11,133 km^2), combined, and 0.18% of the acreage of the focus areas combined (4,406 km^2).

However, this impact was considered **negative**, **direct** and **low**, given that fishers can fish anywhere within the Nearshore area which do not coincide with the location of drilling operations. As indicated above, wells will be drilled consecutively, therefore, the exclusion zone will remain 0.785 km^2 at any given point during Project activities. The impact of the exclusion zone has been evaluated as **negative**, **direct** and **low** for the pre and post drilling phases, given their short duration relative to drilling (see Table 6-1 above).

6.4.5 Discharge of Water Based Drilling Muds & Cuttings

Drilling mud is fluid used to control subsurface pressures, lubricate the drill bit, stabilise the well-bore, and carry the material excavated by the drill bit (drill cuttings) to the surface. Inherent mitigation inclusive of treatment of drill cuttings and testing of the drilling muds and cuttings prior to disposal will be done during the drilling phase. The treatment of drill cuttings entails its movement over a mud shaker system which separates the drill cuttings from the drilling mud, the latter of which goes to the mud tank where it is reused in the well, whilst the drill cuttings are washed to remove excess drilling mud, and then discharged to the seafloor. The discharged cuttings consist of small rock particles (gravel size). Given that spent drilling mud and drill cuttings will be among the most significant waste streams generated during drilling activities in the drilling phase of the Project, no free oil (<50%) will be the final criteria for disposal overboard. This involves a sheen test done in accordance with USEPA GOM Effluent Limits (2007) using a sample of the drill cuttings after each hole section to ensure that drilling muds and cuttings are not contaminated prior to disposal. In the event that the sheen test fails, no discharge will occur. It should also be noted that drill one of the potential drilling location in Block C, intersects with a protected area. As such, no discharge of drilling muds and cuttings will occur at this location either. Instead, contaminated cuttings and muds will be collected, stored in cutting boxes and transported onshore for proper treatment and disposal. Given that only WBM will be used in this drilling project, as well as the inherent mitigations measures described above, potential impacts to the receiving environment will be reduced.

The discharge of drilling muds and cuttings from the Jack-up drilling rig can affect the physical nature of the seabed; marine water and sediment quality; benthic fish and shellfish; soft-bottom dwelling benthic organisms (macrobenthos and benthic fish and shellfish); marine mammals; sea turtles; pelagic fish and plankton; resource users and fisheries.

Water based mud (WBM) will be used for this drilling programme. This type of drilling muds can give rise to barite plumes within the water column; however, the view that barite (barium sulphate) has "no observed effects" at concentrations of less than 2 mg/l in standard chronic tests is supported (Wills 2000). Also, Bakke *et al*. 2013, states that exposure for 6-70 days to concentrations between 0.5 and 10 mg/L of used WBM in suspension had a negative effect on somatic and/or reproductive tissue growth in scallops. As such the impacts to receptors that occur in or utilise the water medium such as marine mammals, sea turtles, pelagic fish and plankton and marine and coastal and avifauna are expected to be minimal, if any.

During discharge of cuttings with entrained WBM from an offshore platform, dispersion of WBM occurs rapidly, and concentrations are quickly diluted to near ambient conditions (2 mg/l). As cuttings and clay particles settle to the sea floor, they may cause a local decrease in the abundance levels of immobile bottom-dwelling, benthic organisms due to physical burial. This however is expected to have little effect on diversity. In high energy environments, small amounts of WBM accumulate on the sea floor and adverse effects of the discharges cannot be detected (Neff 2005).

With the discharge of drill cuttings and mud, due to their geotechnical characteristics, seabed depositions are mainly formed by cuttings, as this fraction presents greater settling velocities. The results of the sediment transport simulations (Appendix E) show, for the mud/cuttings cumulative discharge, that the main seabed deposition patterns extended in a westward direction during both short and long season at all 5 sites (Figure 6-3 below). However, Site 2 (site closest to shore), it was possible to visualize deposition in all directions, due to tidal influence. As such the physical nature of the seabed will be altered with the greatest thickness closest to the each of the drill sites and then tapered to the seafloor forming a mound like structure. Given that the areas for the short and long seasons area very small, impacts to the physical nature of the seabed was classified as **negative**, **direct**, **short term** and **negligible**.

Other components of drilling muds of major environmental concern are petroleum hydrocarbons and heavy metals. The main concern is whether they can accumulate in tissues to concentrations high enough to be toxic to the animals themselves and/or to higher trophic levels. However, the majority of petroleum hydrocarbons in drilling muds will be adsorbed to the clay fraction and will be dispersed in the water column with the slow-settling fraction. Most of the hydrocarbons may eventually desorb from the clay and evaporate to the atmosphere, be degraded by bacteria, or be deposited with the clay on the bottom (ODCE 2012).

Hydrocarbons in solution are generally much more bioavailable to marine organisms than those which are adsorbed in bottom sediments. As with petroleum hydrocarbons, the bioavailability of sediment-adsorbed metals is generally low. The critical determinants of the impacts of discharged drilling muds and cuttings on water column biota are the rate and extent of the dispersion and dilution processes. The effects of drilling mud on water column organisms will depend not only on its inherent toxicity, but also on actual exposure concentrations and durations. Offshore field studies have shown that drilling muds discharged to open ocean waters generally are diluted to low concentrations at which they are not expected to produce adverse effects in water column organisms (ODCE 2012).

Field investigations have shown that, in all but deep or high-energy environments, drilling muds and cuttings initially will settle very rapidly from the discharge plume to the bottom. The severity of impact of deposition on the benthos is directly related to the amount of material accumulating on the substrate, which in turn is related to the amount and physical characteristics of the material discharged, and to the environmental conditions, such as current speed and water depth, at the time and site of discharge. In low energy and depositional environments, more material accumulates, and there may be a reduction in the abundance of some benthic species (ODCE 2012). However, the offshore, coast environment of Suriname is considered to be complex due to the influences of the Guiana current, NBC retroflection and local and regional estuarine outflows.

The model assumed discharge of the drill cuttings from the surface of the water column via a 4” shunt line after the drilling of all four hole sections during the short and long season at each of the 5 sites. The maximum cumulative sediment depositions were 24 mm and 17 mm for the short and long seasons, respectively with corresponding areas of the thickness >1 mm of 223 m and 209 m. Cutting deposits of more than 5 cm (50 mm) thick in the vicinity of the well may result in the smothering of benthic organisms mainly of sessile species (IMECS 2011). Given that the maximum thicknesses above (24 mm and 17 mm) were below the threshold value (50 mm), immobile benthic organisms around the drill sites may be still affected due to smothering. This is corroborated by Henrik *et al.* (2006), which states that the limit of PNEC (Predicted No Effect Concentration or Predicted No Effect Change) expresses the lower limit where effects on the marine biota in the sediment may be encountered. Given that burial in operations discharge of cuttings and drilling mud limit is 6.5 mm, the discharge of cuttings and drilling mud 1 mm would be very conservative. As such, marine biota which coincides with the sediment deposition extent may experience minimal impacts (Table 6-8 below).

Table 6-8: Results of Predicted Bulk Material Seabed Deposition

PARAMETERS	WELL									
	Site 1		Site 2		Site 3		Site 4		Site 5	
	short	long	short	long	short	long	short	long	short	long
Maximum Distance (meters) until 1 mm	210.0	209.0	172.0	179.0	210.0	209.0	162.0	172.0	223.0	198.0
Maximum Thickness (mm)	20.0	17.0	20.0	14.0	20.0	17.0	24.0	15.0	22.0	17.0

Different fauna groups are tolerant to different degrees of smothering; for example, burrowing organisms are more tolerant compared to bottom feeders living on the surface of the seabed. Based on the results of this model, the majority of deposition will occur closer to the rig discharge site and so the effects to benthic fish and shell fish, soft-bottom macrofauna and marine sediment, are considered **negative**, **direct** and **low** for WBM. The impact will not be of sufficient magnitude or duration to threaten any population itself but single species or groups of localised individuals. All the drill cuttings however, will be tested and monitored for the presence of any base fluids retained in order to comply with Staatsolie’s standards before discharge overboard.

The result of the model is very conservative and over-estimated the height of the cuttings pile and area, because biogeochemical processes were not considered between cuttings release, but the release of the total volume was modelled. The drill cuttings will be discharged in smaller volumes at multiple events and dispersion through current processes between discharge events (for each hole section and between the drilling of the wells at the platform) will create lower cuttings piles and smaller area of spread. Therefore, the model gives an over-estimation of the areas that will be affected, and this represents a conservative estimate for a worst case situation. According to studies done along the east coast of Trinidad (ESL 2015a, b, c), it was found that the impact of the drilling muds is confined to the well-site, for a relatively short period of time. In all 3 studies, post drilling monitoring showed no evidence of cuttings piles within one year of the completion of drilling.

While the areas of affected seabed are much smaller where only water-based muds have been used (Grant 2000 and Olsgard and Gray 1995), ecological effects can still occur because WBM drilling wastes may contain dissolved aromatic hydrocarbons, heavy metals and radionucleides (minerals such as barite and bentonite). Thus, WBM and cuttings can adversely affect water column biota (marine mammals, sea turtles and pelagic fish and plankton) life as well as smother it with artificial sediments or suffocate it with plumes of superfine suspended particles.

Additionally, heavy metals and other toxic chemicals associated with drilling muds and cuttings can be toxic to marine mammals, pelagic fish including commercial fish species and sea turtles. Very fine material suspended in water column can also affect the respiration of small marine animals and fish. Also, elevated levels of drilling muds into the water column will increase water turbidity which in turn will reduce light penetration and hence photosynthetic activity by plankton. However, given that the study area is already turbid in nature, the impacts will be minimal. Based on the above discussion, the impacts to marine mammals, sea turtles and pelagic fish and plankton were classified as **negative**, **direct** and **low**.

The resulting impacts on fisheries and resource users (nets) are expected to be relatively localised and short-term. In a low energy environment (April to December), the seabed deposition of drilling muds and cuttings will contact the seafloor and can create anoxic conditions in the vicinity of the discharge. Therefore, the fish species that have a greater potential to be affected will be the demersal or bottom feeding fish. However, due to the water depths and the currents, impacts to fisheries will be minimised because of the rapid mixing of the plume in the water column and the small area around the drilling rig where deposition of the cuttings would occur. Impacts to the pelagic fish resource as a result of hydrocarbon and chemical spills have been presented in Section 6.4.10. The impacts from the discharge of drilling muds and cuttings to fisheries and resource users was **negative, direct** and **low** as the closest site (Site 2) was more than 1.5 km away from the coastal fishing areas, whilst the other 4 sites were much further away from similar fishing areas.

The water column concentrations of discharged material are a function of the discharge amount and ambient current strength/direction. The highest concentration expected in the water column is the concentration of the solids present in mud while the discharge occurs. The predicted water column concentration from the discharge of drilling muds at the 5 sites (Tetra Tech 2018a; Appendix E) revealed that the resultant plumes ranged from 1 – 1,000,000 mg/l concentration with the maximum at the point of discharge. However, it was also stated that the plume will quickly dissipate within a few hours after discharge (Tetra Tech 2018a; Appendix E). The modelling report showed that the ambient concentration of the water column (2 mg/l) was re-established within a vertical distance from the discharge point of 9.46 – 21.24 m with a horizontal spread of 0.15 – 0.37 m for the short season and a vertical distance of 8.54 – 18.47 m and a horizontal spread of 0.44 - 0.51 m wide for the long season. This distance was considerably less than the sediment deposition extent of 209 m and 223 m for the long and short seasons, respectively. Thus, impacts to the receptors such as marine mammals, sea turtles, pelagic fish, plankton and others and marine and coastal and avifauna from the drilling muds in the water column are expected to be **negligible**.

Therefore, based on the above discussion, the overall impact of discharge of drilling muds and drill cuttings on the physical nature of the seabed was **negligible**, whilst impacts to marine water and sediment quality; benthic fish and shellfish; soft-bottom macrobenthos; marine mammals; sea turtles; pelagic fish and plankton; fisheries and resource users are **negative**, **direct, cumulative** and **low** during the drilling phase.

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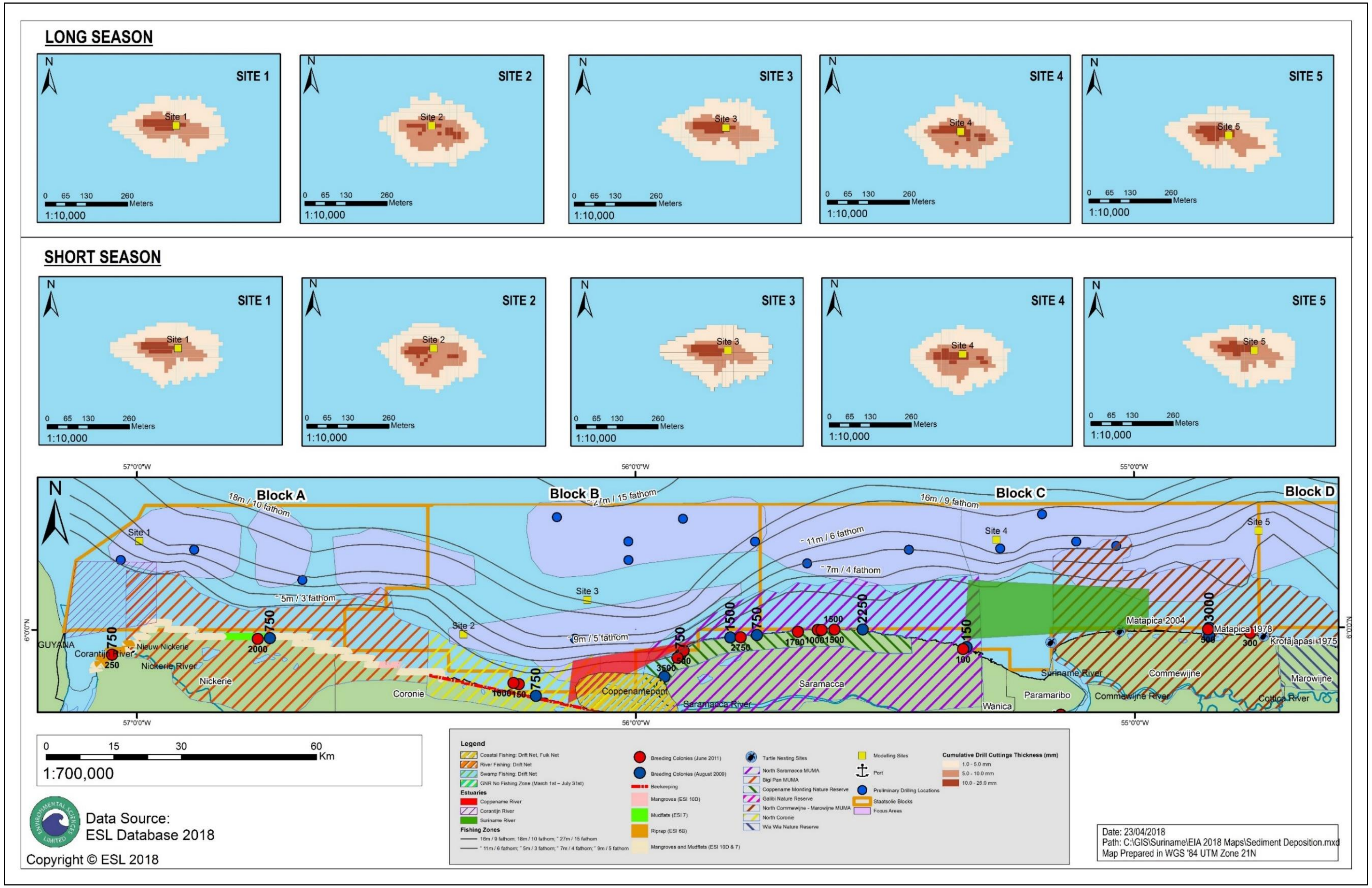

Source: ESL Database & Tetra Tech 2018a (Appendix E)

Figure 6-3: Cumulative Sediment Deposition Thickness for the Short and Long Seasons at 5 Modelling Locations, Offshore Suriname

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6.4.6 Improper Solid Waste Discharge

Solid waste is described as refuse, debris and other discarded materials. It includes inorganic materials such as paper, glass, bottles, cans, metals and plastics, as well as hazardous waste such as oily rags, oil-saturated filters and sorbent materials. For the purposes of this assessment, solid hazardous waste excludes drilling muds and cuttings, which are assessed under Section 6.4.4 above. It should be noted here that the overboard disposal of oily rags, oil-saturated filters and sorbent materials (in the case of the initial impact assessment, where mitigation is applied) would lead to the contamination of the water column with oil and lubricants, which are assessed under Section 6.4.9 below.

Solid waste will be produced throughout the pre drilling, drilling and post drilling phases of the project duration. The inherent mitigation measures associated with this stressor include the collection, sorting and transportation of the generated solid waste material to an onshore disposal site for proper treatment or disposal for the duration of the drilling project (see Table 3-10 above). However, improper and accidental disposal of waste material may occur overboard in unplanned events, for which the impacts will be minimal. Improper disposal of waste material may occur from AHSTV, support vessels (supply vessels, chase vessels and crew boats), drilling rig and the platform crew which can affect various components of the receiving environment.

Principal receptors identified in the Project area that may be affected by this stressor are: the seabed (physical nature); mudflats; marine water quality; benthic fish and shellfish; soft-bottom macrobenthos; soft coral taxa; marine mammals; sea turtles; pelagic fish; marine and coastal avifauna; protected areas, sensitive ecosystems (mudflats, lagoons and mangroves); resource users, fisheries; recreation and tourism; and marine ports and traffic.

The volumes of solid waste generated will vary across the wells due to differences in types of activities, phases and length of each phase. According to American Society of Civil Engineers 2010, the estimated daily rate of garbage in general is 1.5 – 1.7 kg/person/day. Thus, an average of 152.30 kg of solid waste will be generated per drilling day. Where the maximum capacity of the drilling rig is 70 persons; solid waste estimates for the drilling phase for the 10 wells is a total of 31,526.50 kg (Table 6-9) below. As such, the impacts of the drilling phase will be greater than that of pre drilling and post drilling.

Table 6-9 below shows the equivalent % contribution of the drilling phase (10 wells; 207 days) of the estimated total for all phases (35,491.75 kg). The volumes presented are very conservative and over-estimated the amount of solid waste since calculations were made with the assumption of maximum capacity at all phases, therefore the actual volume may be smaller. Additionally, the impacts of this stressor consider that only a small fraction of the generated solid waste from each phase will be improperly disposed of overboard. The impacts of this stressor on the receptors identified above are discussed below cumulatively for the duration of the Project.

Table 6-9: Summary of Volumes of Solid Wastes generated for the Duration of the Nearshore Drilling Program 2019

Proposed Project Phases	Estimated Volume of Solid Waste Generated (kg)	% Contribution to Overall Drilling Period (275 days)
Pre drilling	1,729.75	4.87
Drilling	31,526.50	88.83
Post drilling	2,235.50	6.30
TOTAL	**35,491.75 kg**	

Accidental disposal of solid waste at sea can end up on the seafloor depending on the weight of the material. There will be no detectable impact on the physical nature of the seabed due to the deposition of these materials; however, the greater impact will be to benthic fish and shellfish and soft bottom macrobenthos.

Mudflats dominate the coastline of Suriname (almost 50%) and may extend as far as 58 km long and 1,000 m wide. Mudflats are intricate ecosystems that support a rich benthic community (worms, small crustaceans and foraminifera; see Section 5.4.6.3), as well as provide feeding grounds for a number of other animal taxa. Improper disposal of solid waste during the project may result in the transportation of the material westward along the coastline and unto the mudflats. This can potentially result in the entanglement of animals (crabs, birds etc.), accidental ingestion of plastics by the feeding population, as well as, alteration of the environmental conditions of the mudflats. It should be noted that improper disposal may be intermittent and that the final fate of discharged solid waste material will depend on prevailing winds, currents and tides. Given that only accidental disposal of small volumes of solid waste is considered and that dispersion of the material is unpredictable due to the complex metocean conditions in the Project area, the impacts of solid waste to mudflats has been ranked as **unknown** for all phases of the project.

The disposal of larger, heavier solid waste (e.g. full, closed barrels and pieces of equipment) can have a negative impact on benthic fish and shellfish, soft-bottom macrobenthos and soft coral taxa. This is due to the fact that they are at risk of being buried, crushed and smothered by such debris which can lead to death. In addition, the presence of such items on the seabed may result in the destruction of localised ecosystem components (such as soft-bottom macrobenthos colonies) and/or obstruction of niches. The soft coral taxa are south of Block C and approximately 8 km SW of one of the potential drilling location. As such, impacts may occur from the eastern most drill sites but may be reduced as prevailing currents and dominant riverine outflow will move debris and solid wastes westwards. Thus, impacts to this receptor was classified as **negative, direct, cumulative** and **low** for all phases of the drilling project.

The impact of small volumes of solid waste on benthic fauna was found to be **negative**, **direct**, **cumulative** and **low** for all phases of the drilling project. This stressor can affect a portion of the population and the impact may bring about a change in abundance and or distribution over one or more generations but does not threaten the integrity of that population or any population dependent on it. It should also be noted that, if accidentally disposed, heavier solid waste, will settle on the seafloor and may provide surface areas for the development of new colonies of benthic macrofauna.

Improperly disposed solid waste can degrade water quality as a result of entrainment of plastic bags, bottles, cans and the like, thereby increasing pollution levels along the coast. More importantly, degraded water quality is the pathway via which biological and socio-economic receptors are affected by this stressor, and the potential impacts to the identified receptors are discussed in detail below.

Suriname’s coast is home to a number of locally sensitive cetacean taxa (particularly dolphins, which prefer shallower waters), as well as sea turtles (as evidenced by the turtle nesting sites along the eastern most portion on the coast). Pelagic fish are also abundant and commercially important, and marine and coastal avifaunal taxa are also present, including migratory taxa.

Entrained solid waste articles may be mistaken for food and ingested by marine mammals, sea turtles, pelagic fish and avifauna. These organisms may either mistake plastics for food or they may accidentally consume these while foraging. Such ingestion can be detrimental to these marine organisms as it can damage the alimentary canal, block or impair digestion of food and remain within the stomach of the organism. Translucent plastic material is often mistaken for gelatinous prey such as jelly-fish and siphonophores. When large quantities of these are consumed over time by a single organism (particularly foamed plastics), the animal’s buoyancy is affected, thereby impairing their ability to dive (Fisheries and Oceans Canada 2010).

Ingested plastic material can cause turtles, such as Loggerhead and Leatherback turtles, to become more buoyant making them more susceptible to collisions with vessels which can result in injury and death. Additionally, sea turtles, marine mammals, and sea birds may become entangled and trapped by debris. As a result, physical harm or debilitation can occur such as reduced limb mobility which can lead to drowning. In birds, entanglement with discarded debris can also result in prevention or hindrance in their ability to fly.

The impact of this stressor is considered cumulative for each phase of the project. Improper disposal of solid waste may occur occasionally during the drilling program and may spread over a large portion of the wider study area.

Consequently, the waste material may affect a portion of these populations of marine mammals, sea turtle, pelagic fish and marine and coastal avifauna found along Suriname's coast and the impact may bring about a change in abundance and or distribution over one or more generations but does not threaten the integrity of the populations or any population dependent on them. Therefore, the impact of this stressor on these receptors has been classified as **negative**, **direct**, **cumulative** and **low** for all phases of the project. This is due to that fact that there will be mitigation and no intentional disposal of solid waste overboard, however the accidental discharge still exists and hence was considered in this impact assessment.

The fish stocks along Suriname's coast are the basis of active, commercially viable fisheries utilised by a number of fishermen (local and regional) who mobilise from landing sites in the vicinity of Paramaribo. There is the potential for accidental disposal of solid waste materials to impact this receptor. Solid waste articles may become entangled in fishing nets and lines, and efforts by fishermen to retrieve their lines and nets can result in gear damage, thus hindering fishing activities. Floating solid waste can also hamper movement of small fishing vessels, further impacting fishing activities, which can in turn affect livelihood. Also, the socio-economic importance of fishing along the coast as a means of livelihood, impacts may affect a minority (<10%) of local users of natural resources in the short term. However, considering that mitigation measures will be implemented to ensure no disposal, and only accidental disposal was considered, impacts to resources users will be reduced. As such, the impact of improper solid waste on resource users (fishers) and fisheries was classified as **negative**, **indirect**, **cumulative** and **low** for the all the phases of the drilling project.

As with fisheries, floating solid waste can also hamper movement of vessels and cause delays to fishermen while actively fishing and other vessel operators, leading to a **negative**, **indirect**, **cumulative** and **low** impact of this stressor on marine ports and traffic. It should be noted that this assessment considered solid waste mitigation, with the possible occurrence of accidental solid waste for the project duration which may affect a minority (<10%) of local users of natural resources in the short term.

Local and national residents utilise the beach resources along the coast. The aesthetic value of beaches may be decreased due to the accidental discharge of solid waste into the marine environment. A large proportion of improperly disposed solid waste comprises floatable material, and this may be transported large distances from offshore to onshore (depending on oceanographic conditions), and thus become visually unappealing. This decreased aesthetic value can then impact on tourism and recreation activities, as a littered beach and its vegetation becomes less attractive to its users and bathers, who may decrease visits to these beaches. The actual beaches that may be affected by such waste however is not known as the floatable material will be carried along the prevailing currents at the time disposal.

Additionally, solid waste may reach the protected areas and sensitive ecosystems (mudflats, mangroves, lagoons) identified along the coast, which are considered to be vulnerable or sensitive on account of the high number of avifaunal taxa which inhabit them, as well as the numerous functions they provide. Mangroves also act as nurseries for juvenile fish and shellfish (particularly where they maintain connectivity to the sea or connectivity to larger wetland areas), and harbour fauna which are hunted for local sale and/or consumption. Exposure of this habitat type to pollutants may reduce the viability of juvenile populations (which tend to be more susceptible than adult populations) and hence, may have an impact on adult population levels via increased morbidity and mortality. Birds may mistake waste material such as plastic for food items and ingest them casing gastrointestinal damage, discomfort or even death. Additionally, the presence of solid waste may also interfere with feeding patterns of coastal avifauna encountered along the mangrove areas of the coast, of which a large proportion are migratory bird species. For example, if one area is found to be polluted, it may disrupt birds from seeing prey within water, or alternatively, they may seek other, cleaner areas to feed, thereby delaying feeding. Like beaches, protected areas that may be affected are not easily identifiable as the disposed waste will be carried by the currents at the time of disposal and remain in the water column before it becomes stranded onshore.

Given that there is a limited understanding of how far solid waste will travel before onshore deposition along beaches, mudflats and mangrove areas, and the consequent lack of knowledge as to these areas will be affected and to what degree, the impact of improper solid waste disposal on recreational use of beach areas and sensitive ecosystems has been classified as **unknown** for all the phases of the Project.

This impact is considered **cumulative** for the duration of the project given that small volumes of solid waste discharged accidentally during the duration of the drilling program will persist in the marine environment. Based on the foregoing discussion and the evaluation of the impacts of the stressor of improperly disposed solid waste on the biological (benthic fish and shellfish, soft-bottom macrobenthos, marine mammals, sea turtles, pelagic fish, coastal and marine avifauna) and socio-economic (resource users (fishers and other vessel operators) fisheries and marine ports and traffic) receptors, the impact of solid waste on marine water quality (which has been identified as the valued ecosystem component (VEC) given that degraded water quality is the pathway through which these receptors are affected) has been evaluated as **negative**, **direct** and **indirect**, **cumulative** and **low** for all phases of the project.

6.4.7 Discharge of Sanitary & Organic Waste

Biodegradable (organic) liquid waste (or sanitary waste) originating solely from humans and human activities, such as grey water (waste collected from kitchen washing, showering and laundry activities) and black water (toilet waste or sewage) will be produced throughout all phases of the drilling program. Noteworthy, is that an Omnipure^{TM} 12MC Unit on-board the rig will be used to treat sanitary waste with chlorination (a minimum of 1 mg/l of residual chlorine). As such, it is assumed that the nutrient load of treated sewage will remain high, however the microbial load will reduce. Additionally, discharge of treated sanitary waste will only occur at locations more than 5.6 km from the shoreline, in accordance with MARPOL 73/78 (Annex IV) requirements. As such, absolutely no discharge of sanitary waste will occur at the potential drilling location in Block C that intersects with a protected area or any other focus areas that intersects with a protected area, if changes to the well locations occur (see Figure 5-121 above).

Estimates of black and grey water for each well will vary due to the number of phases and the length of each phase. Given that the drilling phase of each well has the longest durations, the estimated overall, total cumulative volumes of black water and grey water which may be discharged are 160.22 m^3 and 29,711.25 m^3, respectively, with a total black and grey water discharge volume of 29,871.47 m^3 (see Table 6-10 below). However, discharge will be well site-specific and hence will occur over the Project area. The volumes presented are an over-estimation of the amount of sanitary and organic waste since calculations were made with the assumption of maximum capacity (of the rig and support vessels) at all phases, therefore the volume may actually be smaller. Additionally, discharge may not be continuous over the Project, but may be intermittent, i.e. smaller quantities of the total volumes given above may be discharged every 1-3 days, for each well. Thus, this impact assessment of sanitary waste to the receiving environment and its receptors considered all the inherent mitigation measures described above.

Table 6-10: Summary of Sanitary and Organic Waste generated for the Duration of the Staatsolie Nearshore Drilling Project 2019

Phase	Vol. of Sewage (Black & Grey Water) Generated (m^3) for 10 wells	% Contribution to Overall Project Discharge
Pre drilling	1,204.39	4.03
Drilling	26,834.86	89.83
Post drilling	1,832.22	6.13
TOTAL	**29,871.47 m^3**	

Disposal of treated sanitary waste from the rig and vessels can affect various components of the receiving environment, including: marine water quality; marine sediment quality; benthic fish and shellfish; soft-bottom macrobenthos; marine mammals; sea turtles; pelagic fish & plankton; marine and coastal avifauna; protected areas; other sensitive ecosystems; fisheries; resource users and human health.

Treated sanitary and organic waste contains minerals, grease, faeces and urine. Given that chlorination occurs during the treatment of sanitary waste, levels of pathogens and intestinal parasites will be greatly reduced and incapacitated, if not totally destroyed. As such, the impact of discharged treated sanitary and organic waste will be due to the nutrient load as opposed to the microbial content. This discharge of treated sanitary waste will result in an increase in the nutrient content of the water surrounding the rig. The elevated nutrient supply can result in eutrophication, which is the degradation of water quality due to enrichment by nutrients. This results in excessive plant (mainly algae and phytoplankton) growth and decay. The subsequent decay of the organic material from dead algae and the increase in decomposers feeding on organic matter causes a depletion in oxygen as the decomposers rapidly use a great deal of oxygen in the decomposition process and mostly affects the bottom of the water column.

Marine sediment quality may be indirectly affected by the discharge of treated sanitary and organic waste, as a result of the settling out of suspended solids from grey and black water and contamination of sediment interstitial water; decomposing matter which settles at the bottom of the seafloor may temporarily increase organic sediment parameters which would be utilised by organisms in the benthos, in addition to the uptake of interstitial water. As such impacts to the sediment quality has been classified as **negative**, **indirect** and **low**.

Thurow 1997 in Courtney *et al*. n.d also concluded after some research, that nutrient loading was responsible for an increase in fish biomass. Noteworthy, is that marine systems are very complex and function with threshold levels. Caddy 2000 in Courtney *et al* .n.d, stated the a positive correlation between fisheries and nutrient load will occur to a point, after which it declines. This was corroborated by Oczkowski and Nixon 2008 which showed that fish landings increased at a threshold concentration of 100 µM of dissolved inorganic nitrogen. Breitberg 2002 also indicated that high productivity of finfish in nutrient-enriched systems were greater than losses due to oxygen depletion.

Particulate organic matter (POM) in effluent can act as food subsidies for some species of fish and hence may also have a positive effect on fish biomass and fisheries. Parnell 1992 noted that effluent of POM, 3 orders of magnitude above normal, dissipated and reached ambient levels within 10 minutes from it point source. This was also found to be true for dissolved nutrients such as NH_4^+, PO_4^{3-}, NO_3^-, NO_2 and Si and total coliform (Parnell 1992). Additionally, Grigg 1994 stated that primary or secondary treated effluent had no negative impact on corals, algae and invertebrates.

Operations at the rig will be 24 hours for a total duration of 275 days, which will span across 10 potential drill site locations. It is assumed that treated effluent will be discharged daily into the marine environment. However, no discharge will occur at potential drilling locations less than 5.6 km from the coastline (MARPOL 1973/1978) or which occur in a focus area that intersects with a protected area. Based on the fact that dissipation occurs within a short time frame and fish biomass can increase but within a threshold, impacts of treated sanitary and organic waste may occur such that it affects a specific group of localised individuals within a population over a short time period, but does not affect other trophic levels or the population itself. Hence, treated sanitary and organic waste impacts to pelagic fish and plankton has been classified as **negative, direct** and **low** for the drilling phase.

Disease-causing bacteria, viruses and protozoa such as *Salmonella* sp., *Vibrio cholerae*, Hepatitis A virus and Cryptosporidium in the water is another impact from the discharge of raw sewage. Viruses can survive from anywhere between a few days to weeks in sea water. Filter-feeding shellfish are very good at concentrating pathogens such as *Salmonella* sp., *Vibrio cholerae* and Hepatitis A virus present in sewage (Miget 2010). Vibrio species in particular (which pose significant health hazards to humans) are known to accumulate in shrimp tissue and fluids (Jayasinghe *et al*.; 2010). Microbial pathogens can therefore bio-accumulate in filter-feeding organisms to levels that can be harmful and pose potential health problems to humans and other consumers (e.g. birds). Such bio-accumulation can also have a negative impact on marine and coastal avifauna (which feed on pelagic fish), resource users (fishers) and fisheries (via a reduction in catch) and human health (biomagnification) via shellfish, such as the commercially important Atlantic Seabob, Penaeus and large sea shrimp species caught along the coast.

Pathogens also pose health risks to marine mammals, sea turtles, pelagic fish, benthic fish and shellfish via infections (e.g. in mucosal linings, or open wounds), leading to stress within the organism and reduced fitness, which in turn may increase the morbidity (incidence of ill health) and mortality (incidence of death) of the organism. In the case of sea turtles, both the leatherback turtle *(Dermochelys coriacea)* and the Green turtle *(Chelonia mydas)* nest in Suriname, with almost 40% of the world's leatherback turtles noted in Suriname (Kenney 2010). Given that they are listed as vulnerable and endangered species, respectively by the IUCN and protected under the Ministerial ordination designed for the North Commewijne/Marowijne MUMA (see Section 2.4.3.6 above), impacts to these species will be of concern. However, given that the sanitary waste will be treated and chlorinated prior to disposal, impacts to sea turtles are expected to be minimal. Also, given the metocean conditions within the project area, any discharge of treated sewage will be further diluted and minimal contaminants entrained in the marine waters will travel generally in a NW and westerly direction away from turtle nesting sites located SE of the project area (see Figure 5-121 above). Thus, impacts to sea turtles has been classified as **negative**, **direct** and **low**.

In theory, almost any plant or animal is at risk from microbial pathogens, albeit that most attention has focused on the causes of fish kills and illnesses of marine mammals. However, monitoring of shellfish populations means that more information probably exists about this group of organisms than any other collective group of marine fauna. In marine waters, species of bacteria from the *Aeromonas*, *Alteromonas* / *Pseudomonas* and *Vibrio* groups have been detected in elevated numbers during fish kills associated with *Karenia* (formerly *Ptychodiscus brevis* red tides (Buck and Pierce 1989). Though *K. brevis* is not known to occur along the coast of Suriname (Mote Marine Laboratory; n.d.), the interaction above highlights the potential effects; the presence of these disease-causing microorganisms may reduce dissolved oxygen levels to those which initiate fish kills. Microbial pathogens are also regarded as a potential threat to the tucuxi dolphins (which may be found along the coast from Brazil to Nicaragua) by Alexandre *et al*. 2008.

Several studies suggest that marine mammals may be susceptible to infection via human or livestock pathogens transferred via sewage or agricultural effluents. Although limited research has been conducted on cetacean contamination by sewage-borne pathogens, studies indicate that high rates of skin disease exhibited by tucuxi dolphins may be linked to pathogens in the water (Alexandre *et al*. 2008). Given that pathogens and microbes will be virtually absent in treated sewage (minimum of 1 mg/l residual chlorine), exposure of marine mammals to such will be low. Also, treated sewage will follow strict conditions for discharge, and as such, the impact of treated sanitary and organic waste to marine mammals has been classified as **negative**, **direct** and **low**.

The discharge of sanitary and organic waste could also result in BOD_5 levels exceeding the limit of 100 mg/L, as stated in the Trinidad & Tobago Water Pollution Rules, 2001 (as amended). However, the impacts will not be of sufficient magnitude or duration to threaten the overall integrity of any marine populations but single species or groups of species could be exposed to short-term effects through localised deterioration of water quality.

The coastline of Suriname is populated with a number of protected areas (MUMAs) and Nature Reserves (NR). Whilst sustainable activities are allowed within the MUMAs, the NRs are fully protected and off limits to the general public. All but one of the 10 potential drilling locations at which treated sanitary and organic wastes will be intermittently discharged were found to occur outside the boundaries of the protected areas. As such, discharge of treated sanitary and organic waste stream into a dynamic marine environment allows for dissipation of the possible contaminants and hence lowers the likelihood of an impact on these areas. Given that treated sanitary waste will only be discharged at locations further than the prescribed 5.6 km from the shoreline (MARPOL 1973/1978) and / or does not intersect with a protected area, the impact of treated sanitary waste on protected areas was classified as **negative, direct** and **negligible**.

Based on the foregoing discussion and on the conservative volumes of treated black and grey water to be discharged (89.93% of the total volume over the entire Project life i.e. 10 wells combined) during the drilling phase, the impact of the discharge of treated sanitary and organic waste on the receptors: protected areas and other sensitive areas have been classified as **negative, direct** and **negligible.** Additionally, marine water quality (the VEC and pathway via which all other receptors are affected) and receptors affected by high nutrient load such as pelagic fish, benthic fish and shellfish and soft-bottom macrobenthos have been classified as **negative**, **direct** and **low**, whilst those more affected by microbial content such as marine mammals and sea turtles have been classified as **negative**, **direct** and **low.**

For the receptors, resource users (fishers) and fisheries, the impact has also been classified (during drilling) as **negative** and **low**, but these will be affected **indirectly**, given that these are at a higher trophic level. Additionally, marine and coastal avifauna and human health has been classified (during drilling) as **negative, indirect** and **low.** For the impact of this stressor on fisheries, in particular, a **low** significance level applies, given the potential impact of treated sanitary and organic waste on the supply of fish consumed as food to local populations. In the case of human health and resources users (fishers), the discharge of treated sanitary and organic waste may affect fishers' livelihood and fish consumers but only in the short-term or may affect fish consumed by a minority (<10%) of the local population. Thus, impacts to resource users (fishers) and human health has been classified as **negative**, **indirect** and **low**.

The impacts of treated sanitary and organic waste discharge on the 13 receptors mentioned directly above are considered to be **negative**, **direct**, **indirect** and **low** for the pre drilling and post drilling (as well as marine sediment quality for all phases). This is because of the fact that relatively lower volumes of treated black and grey water that may be discharged over these phases in comparison to the drilling phase. Pre drilling estimates of black and grey water are 4.03 % of the total volume of the waste streams and the corresponding number for post drilling is 6.13%, as compared to 89.83 % for the drilling phase, over the life of the drilling program (all 10 wells combined). Classification of the impact of this stressor on the receptors identified also takes into account that discharge is not continuous but occurs intermittently over the life of the Project (where each well will be drilled over an average of 20 days over a Drilling Program duration of 9 months (April to December 2019).

6.4.8 Vehicular Movement (Onshore)

Vehicular movement will occur during all phases of this Project. Prior to the commencement of the proposed Project, imported materials (drilling muds and additives) will be transported to the onshore shorebases (Nieuwe Haven, Vabi, Kuldipsingh or Integra Marine) by truck from Havenbeheer (Nieuwe Haven) port. During pre drilling, trucks will be required to mobilise fuel and other stockpiled materials (e.g. strings, sack materials such as bulk cement and bulk bentonite/barite; see Section 3.5.5 above). Trucks will load materials at either of 5 onshore storage areas (Nieuwe Haven, Vabi, Kuldipsingh, Integra Marine and Nickerie) for short trips (0.5 km) to the port loading area nearby at each of these shorebases. From there, these materials will be loaded onto vessels for transport to the drilling rig. This activity will also be required during the drilling phase, when fuel and materials on the rig need replenishing. During post drilling, vehicular movement will be limited to the transfer of excess amounts of materials from vessels to the port/shorebase via trucks (see Figure 5-172 above). The onshore port/shorebase loading area at Nieuw Nickerie located approximately 203 km from Staatsolie's Sarah Maria operations, from which chemicals (imported) for use in the drilling mud will be brought, for the drilling of the 2 wells located within Block A. Finally, movement will take place between the onshore storage areas and port loading areas on a daily basis over the life of the Project, with only a few trips between Sarah Maria and Nieuw Nickerie.

Based on the foregoing, vehicular movement may affect various components of the receiving environment, via engine operations (gas emissions and noise); transfer of fuel and materials (accidental spills and noise); and movement on the road surface (dust from traction processes). Principal receptors identified in the Project area that may be affected by this stressor are: air quality sound quality (above water); road infrastructure and traffic; human health; and emergency resources. Of these, air quality and human health are discussed under Section 6.4.11 below.

Engine operation during vehicular movement can affect sound quality within the immediate area by increasing noise levels; levels may also be increased from the transfer of materials from vehicle to vessel and vice versa. The former noise source may produce continuous sound, whereas the latter may only produce instantaneous loud noises; both are considered to be sources of transient noise. Given this, and the fact that the activity will be ongoing within the shorebases and port, the impact of vehicular movement on sound quality is considered to be **negative**, **direct** and **low** for all phases of this Project. The impact of noise from vehicular movement on human health has also been classified as **negative**, **direct** and **low** for all phases of the Project as the activity will be of a short time scale; and is not expected to exceed statutory limits (hence mitigation is not required).

As indicated above, vehicular movement within and between the relevant areas will be continuous during all phases; pre and post drilling are of a shorter duration, in comparison to the drilling phase. Overall, vehicular movement during drilling comprises 75.27% of total expected movement, and this is expected, given that drilling is the most work-intensive phase of the Project. The corresponding values for the per drilling and drilling phases are 14% and 10.72%, respectively (see Table 6-1 above).

Vehicular movement over the duration of the Project may compromise the integrity of roads used to transit between the port and shorebases at Vabi, Kuldipsingh and Integra Marine, as well as the transit between Sarah Maria and Nickerie, creating potentially unsafe road conditions as well as traffic congestion. In the case of the former, the distance is short (0.5 km apart) and will be confined to an area which already is exposed to heavy machinery (port atmosphere). In the case of the latter, road conditions may not be compromised to any great extent, given that the transit between Sarah Maria and Nieuw Nickerie will be infrequent and over a short period of time (since this route is meant to service the drilling of 2 wells in Block A). Based on the foregoing, the impact of vehicular movement on road infrastructure and traffic is considered **negative**, **direct** and **low** for all phases of the Project.

Emergency resources may be required at the shorebases and at the port, unrelated to the Project. Increased vehicular movement as a result of the Project may hamper emergency response, particularly since the area is a high traffic one. The impact of Project-related vehicular movement on emergency resources has been evaluated as **negative**, **direct** and **low** for all phases of the Project, given that most vehicular activity will be restricted to a 0.5 km distance between the shorebases at Nieuwe Haven, Vabi, Kuldipsingh and Integra Marine and the port.

6.4.9 Operational Discharge

For this Project, operational discharge will occur in only the drilling and post drilling (well abandonment) phase. It can include:

- Bilge water (water that accumulates in the bilge or the lowest compartment at the bottom of a ship) from support vessels, which is estimated at a total volume of 24 bbls (1,000 gallons) over the life of this Project, assuming discharge only once, during the drilling phase;
- Deck drainage and wash-down water (rainwater that falls on the rig floor, in chemical storage areas or areas where equipment is exposed). The per day estimate for this parameter is 10 bbl, and for the life of this Project, has been calculated as 2,170 bbl (assuming the deck drainage will occur during both the drilling phase as well as during well abandonment in the post drilling phase. The per well estimate of deck drainage ranges from 190 – 280 bbl;
- Service water (seawater used as cooling water and fire control system; and
- Miscellaneous minor discharges, including minor amounts of: BOP fluid; test fluids; light fraction oils (liquid oil products used in internal

combustion engines); uncontaminated fresh water; and support vessel discharges.

Inherent mitigation measures related to operational discharge considered for the initial assessment of the potential impact of this stressor on the various receptors included:

- All hydrocarbon-contaminated runoff (deck drainage) on the rig will be routed to an oil/water separator, where it will be monitored prior to discharge (see Section 7.2.2 below);
- The effluent stream from the oil/water separator will not be released into the marine environment if:
    - The effluent stream, prior to discharge does not comply with the limits specified in Section 7.2.2 below;
    - the effluent stream contains free oil, as determined by a sheen test conducted prior to discharge (as per USEPA GOM Effluent Limits 2007);
    - the drilling location (rig) occurs within 5.6 km of the shoreline (as per MARPOL 73/78);
    - the drilling location occurs within a protected area; and
- The discharge of bilge water will be prohibited within 5.6 km of the shoreline, in accordance with MARPOL 73/78 requirements and, where discharged, will display no free oil as per USEPA GOM Effluent Limits (2007).

For the purposes of this assessment, the impacts of this stressor on the receiving environment will be similar to those for solid hazardous waste contaminated with oily matter (such as oily rags, sorbent materials etc.), as oil from these materials would contaminate the water column. Impacts from the solid waste component of this stream are discussed under Section 6.4.6 above.

Principal receptors or receivers identified in the Project area that may be affected by operational discharge are: marine water quality; marine mammals; sea turtles; benthic and pelagic fish; marine and coastal avifauna; fisheries; resource users (fishers); and human health.

The operational discharge component of primary concern is hydrocarbons which may contain toxic inorganic compounds and which degrade marine water quality. This receptor (marine water quality) has been identified as a VEC and the main medium via which the majority of the identified biological and socio-economic receptors will be affected. Azetsu-Scott *et al.* 2007 indicates that toxic inorganic compounds may associate with oil droplets when operational discharges are dispersed at sea, after which these droplets, which are lighter than seawater, rise to the surface, with some level of evaporation taking place. This pathway of oil association / evaporation is the one through which the marine biota receptors identified above may be affected by hydrocarbons contained in operational discharge.

Through this pathway, marine biota can be exposed to these droplets while moving through the water column and can also be exposed to a sheen at the surface prior to and during evaporation. This film may affect sea turtles and mammals, which break the surface of the water to breathe, and seabirds which dive through the water to feed.

The oil itself, if ingested, may be responsible for a wide range of sub-lethal, indirect impacts on wildlife, such as:

- Interference with breeding either by making the animal too ill to breed, by interfering with breeding behaviour or by reduction in avifauna fecundity
- Damage to a marine mammal's or turtle's eyes can cause ulcers, conjunctivitis and/or blindness, making it difficult for them to find food, and resulting in starvation
- Irritation or ulceration of skin, mouth or nasal cavities
- Damage to and suppression of a marine mammal's immune system, sometimes causing secondary bacterial or fungal infections
- Damage to red blood cells
- Organ damage and failure such as a bird or marine mammal’s liver
- Damage to a bird's adrenal tissue which interferes with a bird's ability to maintain blood pressure, and concentration of fluid in its body decrease in the thickness of egg shells
- Stress and
- Poisoning of young through the mother, as a dolphin calf can absorb oil through its mother's milk (Australian Maritime Safety Authority 2010)

Inhalation of oil can cause damage to the airways and lungs of marine mammals and turtles, congestion, pneumonia, emphysema and even death by breathing in droplets of oil, or oil fumes or gas.

The film formed on the surface of the water by hydrocarbons can also decrease light penetration thereby reducing algal photosynthesis and productivity but this is a very short term impact as the lighter oil fractions will quickly break down on the water surface. Also, the film is moved around by wind and surface currents, breaking it up, and so would not be in one place for long enough to create a significant impact through shading.

Hydrocarbons introduced into the water column by operational discharge in the marine environment can also affect pelagic fish by direct contact, clogging of gills, which may lead to asphyxiation or ingestion which can lead to the accumulation of hydrocarbons in tissues or body fluids. The introduction of even low concentrations of hydrocarbons can also affect the proportions of fish eggs which hatch and on the growth rates and development of fish larvae but only if there is exposure.

It should also be noted that refined petroleum (non-sticky) products are more commonly encountered in operational discharges, as opposed to sticky oils such as crude oil and bunker fuels; the former typically does not last as long in the marine environment as the latter. They are not likely to coat birds, marine mammals, turtles or fish, but they are much more poisonous than crude oil or bunker fuel. Toxic components of these oils may include, in trace amounts: dissolved organic compounds of toxic hydrocarbons (phenols, acids, BTEX, benzenes, poly-aromatic hydrocarbon (PAHs)); traces of heavy metals; and inorganic salts (Yang 2006; Walsh 2015).

These chemicals are considered major toxicants (AMAP 2010; Neff *et al.* 2011), but there is limited research on the possible long term ecological impacts of these chemicals on marine biota, though studies conducted have indicated that they can impact negatively on marine biota through a range of mechanisms, generally through endocrine and reproductive effects and non-endocrine effects (Bakke *et al.* 2013).

For example, PAHs are known to be potent carcinogens and can affect several chemical, biochemical and genetic biomarkers (or naturally occurring molecules, genes, or characteristics by which a particular pathological or physiological process, disease, etc. can be identified; Bakke *et al.* 2013). Studies indicate that PAHs can adversely affect marine organisms through DNA damage, oxidative stress, cardiac function defects, embryotoxicity or by affecting fish growth (Aas *et al.* 2000, Sturve *et al*. 2006, Incardona *et al.* 2004, Carls *et al.* 2008 and Carls *et al.* 2005 in Bakke *et al.* 2013).

Studies also indicate that exposure of marine organisms to BTEX may cause subtle but chronic biological effects during long-term exposure, despite the fact that they evaporate rapidly from seawater (Neff, 2002; Neff *et al.* 2011; Terrens and Tait 1996 in Bakke *et al.* 2013). These effects are an important consideration for organisms which come into contact with discharges containing these chemicals before these biogeochemical processes take place.

Alkyl phenols (AP) have also been demonstrated to have hormone-disrupting effects (Bakke *et al.* 2013). These compounds, along with phenols are both hazardous and toxic and can cause a range of biological effects (Priatna *et al.* 1994).

Azetsu-Scott *et al.* 2007 also indicated that inorganic elements may also potentially affect marine biota via oxidation and precipitation to insoluble inorganic compounds that would sink to the sea floor. Here, it is likely that insoluble organic compounds may become deposited on surficial sediment near the rig, thereby potentially decreasing the sediment quality, and also impact upon the benthic epifauna and infauna that occupy this space. It can be reasonably expected that these chemicals may impact on benthic fauna in much the same way explained above, though the question of bioavailability of these compounds would need to be considered further (i.e. taking into account any biogeochemical processes which may occur at this interface). Bioaccumulation effects may then also be seen at higher trophic levels.

Despite the severity of the potential impact of the chemical components of operational discharge described above, it is useful to note that for this Project: (i) the overall volume of operational discharge (2,194 bbl) is a very small quantity; (ii) the discharge will not occur all at once; rather 190 – 280 bbl will be discharged at each well-site, so the effect will be reduced; and (iii) this discharge stream will be quickly dispersed within the Nearshore environment, given the prevailing met-ocean conditions, and this will dilute the chemicals contained therein and serve to increase the rate of evaporation at the surface.

Based on the foregoing, the potential impacts of this stressor on water column biota will not be of sufficient magnitude or duration to threaten either the integrity of any marine populations, or single localised individuals which could be exposed to short-term effects through a localised deterioration of water quality. Therefore, the potential impacts of operational discharge during drilling and post drilling (well abandonment) phases of the Project on marine mammals; sea turtles, pelagic and benthic fish and marine and coastal avifauna are considered to be **negative**, **direct and low.** It should be kept in mind that this impact is **cumulative** in nature, given that the discharge occurs intermittently over the life of the Project, despite its rapid dispersion throughout the water column.

Given that the impact of this stressor on pelagic fish is **low** for the drilling phase, the impact of this stressor on fisheries and other resource users (fishers) as well as human health is also expected to be **low** for the drilling and post drilling (well abandonment) phases of the Project, as trophic level impacts are not anticipated.

As indicated above, the receptor, marine water quality, has been identified as a VEC as it is the main pathway via which all identified biological and socio-economic receptors will be affected. As a result of the foregoing discussion, the impact of operational discharge on marine water quality has been evaluated as **negative**, **direct** and **low**, for the drilling and post drilling (well abandonment) phases of the Project.

6.4.10 Hydrocarbon & Chemical Spills

Hydrocarbon and chemical spillage can potentially occur in all 3 phases (pre drilling, drilling and post drilling) of the Project, during upset conditions. Spills may include oil, diesel or any other chemical in use throughout the varying phases of the Project, and could be of varying volumes. The different potential spills and discharge sources covered under this assessment include:

a. A major heavy crude oil spill during drilling or well abandonment, accidental in nature, as a result of a blowout (modelled scenario; see Section 6.2.2 above);
b. A diesel spill (instantaneous release) during drilling phase, accidental in nature, as a result of a vessel collision (vessel/vessel at drilling location, or vessel/rig at drilling location (modelled scenario; see Section 6.2.2 above);
c. Minor accidental spills of diesel (all phases) during the bunkering process (onshore at the shorebases and offshore at the point of transfer of fuel to the drilling rig fuel tanks); and
d. Light fraction oils (liquid oil products used in internal combustion engines).

Inherent mitigation measures related to hydrocarbon and chemical spills were considered for the initial assessment of the potential impact of this stressor on the various receptors, and included:

- Spills will be managed by Staatsolie's Project-specific Emergency Response Plan or ERP (which will be developed prior to Project execution; see Section 7.3.1 below) and Oil Spill Response Plan or OSRP (see Section 7.3.1.2 below and Appendix F.2), which will be updated with the Coastal Environmental Sensitivity Maps in Appendix D.22, prior to Project execution;
- Staatsolie shall gather feedback from the relevant stakeholders (Governmental (NB, NCCR, MAS, Coast Guard); local and international conservation community; fishers (including sport fishers); other marine users (e.g. ports); coastal populations (including farmers), and tourism interest groups on the OSRP, and incorporate, where applicable, any recommendations made;
- Spill response will include, but not be limited to the use of absorbent pads, booms and dispersants which are known to be effective in reducing spill envelop and oil concentration, and these shall be kept on-board the Jack-up drilling rig and support vessels;
- Staatsolie personnel and sub-contractors will be trained in emergency spill response outlined in Staatsolie's ERP and OSRP;
- A BOP stack (ensuring multiple levels of blowout protection via rams and annular preventers) shall be used on each well, and will be tested regularly according to manufacturer's instructions;
- Diesel fuel used for generators and engines will be stored in approved tanks on the rig;

- Diesel will be transported to the rig in approved, covered containers via boat. These containers will be separated and secured to minimise the possibility of spills during fuel dispensing;
- Fuels and chemical storage areas will have secondary containment so that any material that is discharged or leaked from the primary containment will be prevented from reaching outside the system. The utilisation of secondary containment will also aid in the detection and recovery of the discharged material; and
- Accidental spillage during loading will be immediately cleaned up as per Staatsolie's Project-specific OSRP.

The following paragraphs describe the results for the modelled scenarios as listed in Bullets a – d above, outlined in Section 6.2.2 above and described in detail within the Oil Spill and Drill Cuttings Discharge Modelling Report (Appendix E), taking all inherent mitigation into account, as far as practicable The impacts described subsequently relate to all spills and discharge sources listed in Bullets a – d above.

The stochastic simulations presented in Appendix E showed that the predominant transport directions are westward as a result of the prevailing winds and currents in the area (where the latter component showed oscillation according to the movement of the flood and ebb tides).

A comprehensive review of the stochastic analyses revealed that the crude oil simulations reached Suriname coast in both short and long seasons for all 5 spill sites. The minimum time to reach the coast was 23 hours for the short season and 30 hours for the long season, both from Site 2 (the closest one from the shore).

The diesel fuel simulations reached Suriname coast in both short and long seasons for Sites 1, 2 and 3, considering 7-day simulation. The minimum time to reach the coast was 28 hours for the short season and 29 hours for the long season, both from Site 2 (the closest one from the shore).

For both oil and diesel, it is important to consider 2 aspects of the results of the modelling report: those that pertain to the area of spread of oil at the surface of the water and associated behaviours with exposure to environmental conditions, which would potentially impact upon important biological (water column biota and receptors on the seabed) and socio-economic and cultural receptors (marine traffic, fisheries etc), occurring in the Nearshore area; and those that relate to the potential for oil and diesel to come ashore, thereby potentially affecting onshore biological (birds and mangroves) and socio-cultural (protected areas etc) receptors. Based on this, the following parameters presented within the modelling report were considered:

- Contours of probability of an oil or diesel slick on water surface from an oil or diesel spill occurring at the relevant spill site, during the short and

long seasons, after 7 days (to assess receptors occurring in the Nearshore area); and
- Shoreline probabilities for an oil or diesel spill occurring at the relevant spill site during the short and long seasons, 7 days after an instantaneous spill (to assess receptors along the shoreline).

In tandem with the above, ESL sought to identify 2 sites of the 5 which would be representative of the eastern and western areas of the study area. Site 2 was chosen (from among Sites 1, 2 and 3) as representative of the western portion of the study area, based on the following:

- Site 2 is the shallowest of all 5 sites, located closest to the shore, and was found to be the location at which tidal influence is expected to be the greatest, thereby resulting in the highest probability of oil and diesel coming ashore during all simulations, during the short and long seasons; and
- Site 2 scenarios for oil and diesel during the short season were classified as worst case on the basis of the shortest time to shore and the largest volume of oil and diesel coming ashore after 7 days.

Sites 4 and 5 were considered in order to determine a representative well-site for the eastern portion of the study area, and Site 4 was selected on the basis of the following:

- Site 4 presented a larger area of spread of oil in the Nearshore area, in comparison to Site 5;
- Site 4 presented greater lengths of oiled shorelines, with higher probabilities of oil coming ashore in comparison to Site 5; and
- The areas of oiled shoreline for Site 4 covered all of the areas of oiled shoreline for Site 5.

Further consideration was given to the stochastic analyses for Sites 2 and 4 (both seasons), and it was determined that Site 2 (short season) and Site 4 (long season) presented the greatest impacts to the water surface/column and to the shoreline. As a result of the foregoing, the potential impacts of oil and diesel spills are assessed in relation to the receptors affected, based on the results of contours of probability of oil/diesel slick on water surface and shoreline probabilities for an oil/diesel spill for Site 2 (short season) and Site 4 (long season) only. Modelled results and the relevant receptor data are presented in Figure 6-4 to Figure 6-12 below. Finally, it is important to note that the modelling Sites 1 to 5 do not coincide with preliminary drilling locations (see Figure 6-2 above). Thus, during the execution of the Project, a potential spill may occur not from the modelling site but from the preliminary drilling location. The impact assessment described hereunder however applies to the study area based on the trajectories modelled from the spill site, and the trajectories from the preliminary drilling location may differ in time and space, and so may potentially affect receptors differently from what is described below.

Figure 6-4a, Figure 6-5a and Figure 6-6a present the contours of probability of an oil slick on the water surface from an accidental oil spill at Site 2 during the short season (after 7 days). These figures show that the full range of contours of probability (1 – 100%) are expected within the majority of Block A and the western Nearshore portion of Block B. The potential spill may also affect the majority of the westernmost focus area of Block A, and smaller portions of the other 2 as well as the western tip of the Nearshore focus area of Block B.

Figure 6-4b, Figure 6-5b and Figure 6-6b present the contours of probability of an oil slick on the water surface from an accidental oil spill at Site 4 during the long season (after 7 days). These figures show that the full range of contours of probability (1 – 100%) are expected within all of Block A, more than 90% of Block B and the western portion of Block C. The potential spill may also affect all of the focus areas within Blocks A and B, as well as the within the westernmost focus area of Block C, to the west of Site 2 (1 – 100%). Thus, an accidental oil spill from Site 4 (eastern portion of the study area) could potentially affect a larger area of the water surface (and by extension, enter the water column and/or sink to the seafloor), as compared to Site 2 (western portion of the study area).

Figure 6-7a, Figure 6-8a and Figure 6-9a present the contours of probability of a diesel slick on the water surface from an accidental spill of diesel at Site 2 during the short season (after 7 days). These figures show that the full range of contours of probability (1 – 100%) are expected within the majority of Block A and the western Nearshore portion of Block B. The potential spill may also affect all of the westernmost focus area of Block A, and the majority of the other 2 focus areas within Block A, as well as the western tip of the Nearshore focus area of Block B.

Figure 6-7b, Figure 6-8b and Figure 6-9b present the contours of probability of a diesel slick on the water surface from an accidental spill of diesel at Site 4 during the long season (after 7 days). These figures show that the full range of contours of probability (1 – 100%) are expected within the majority of Block A, more than 90% of Block B and the western portion of Block C. The potential spill may also affect the majority of the focus areas within Blocks A and B, as well as the within the westernmost focus area of Block C, to the west of Site 2 (1 – 100%). Thus, an accidental diesel spill from Site 4 could potentially affect a larger area of the water surface, where a large fraction of this is expected to evaporate from the surface of the water. Additionally, the zones of highest probability occurred closest to the spill sites, with decreasing probabilities with distance from the well-site, for both crude oil and diesel. Therefore, the highest probabilities of oil/diesel slick on the water column occur within Blocks A and B for spill Site 2 (western portion of the study area), and within Blocks B and C for spill Site 4 (eastern portion of the study area).

Figure 6-10a and Figure 6-11a present the contours of probability of an oil slick coming ashore from an accidental oil spill from Site 2 during the short season (after 7 days). These figures show that, for oil, the full range of contours of probability (0 – 100%) are expected along the shoreline from the western portion of District Coronie and the whole of the shoreline of District Nickerie, with the highest probability of oiling along the shoreline (90-100%) occurring along the majority of the latter (see Figure 6-10a).

Figure 6-10b and Figure 6-11b present the contours of probability of an oil slick coming ashore from an accidental oil spill from Site 4 during the long season (after 7 days). These figures show that the full range of contours of probability (1 – 10%) are expected along the shoreline of the majority of District Nickerie. Thus, the potential impact of an oil spill coming ashore is greater from spill Site 2 (short season) as opposed to spill Site 4 (long season), as it will affect a longer portion of the coastline, and at higher probabilities.

Figure 6-12a and Figure 6-12b present the contours of probability of a diesel slick coming ashore from an accidental spill of diesel from Site 2 during the short season (after 7 days). This figure shows that diesel is expected to come ashore (1 – 90%) along the shoreline from the western portion of District Coronie and the whole of the shoreline of District Nickerie, with the highest probability of oiling along the shoreline (90-100%) occurring at a single location within District Nickerie (see Figure 6-12a). Diesel does not come ashore from an accidental spill of diesel from Site 4 during the long season (after 7 days). Thus, as for oil, the potential impact from a diesel spill at Site 2 (short season) is greater than that expected from Site 4 (long season).

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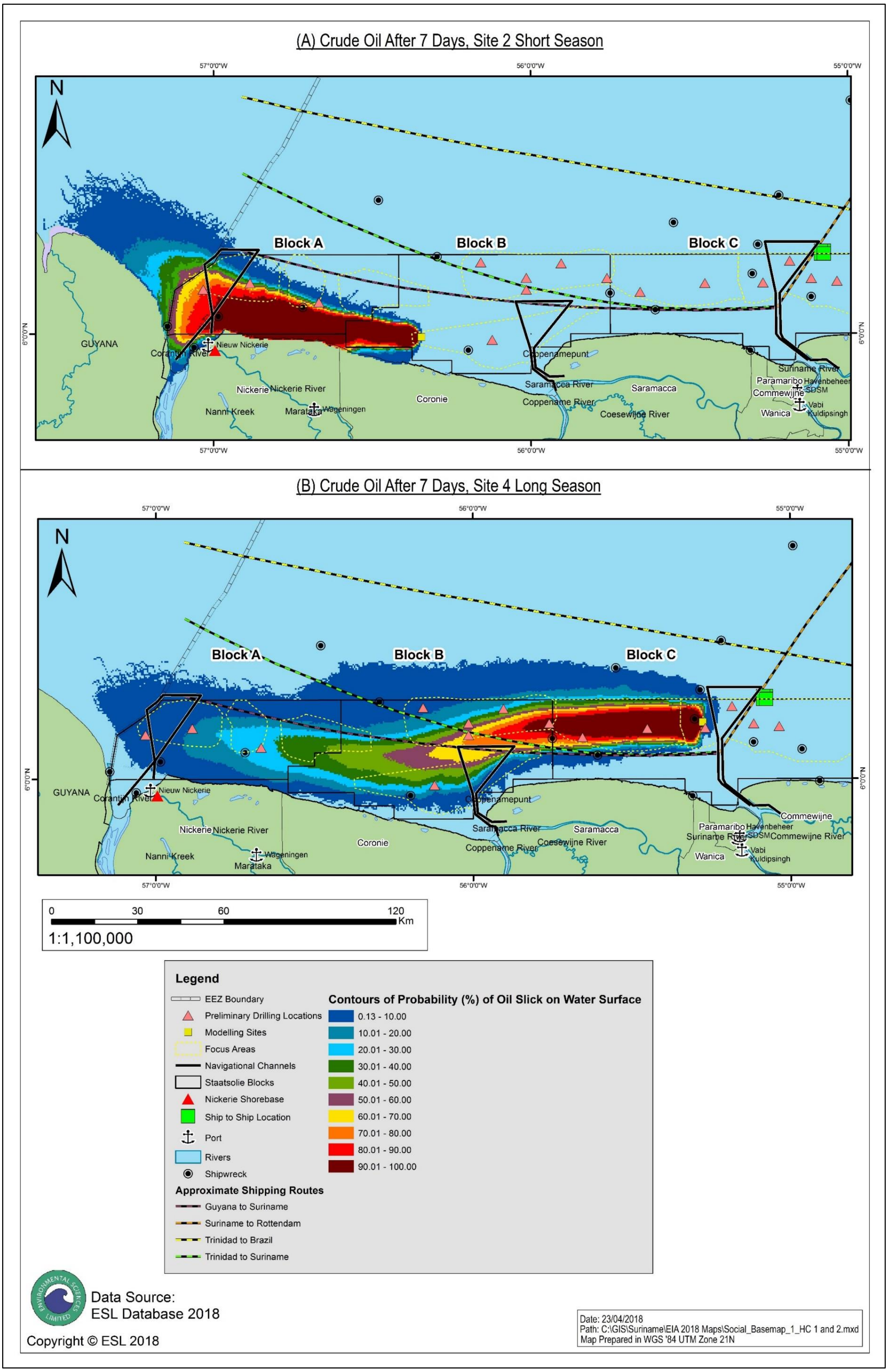
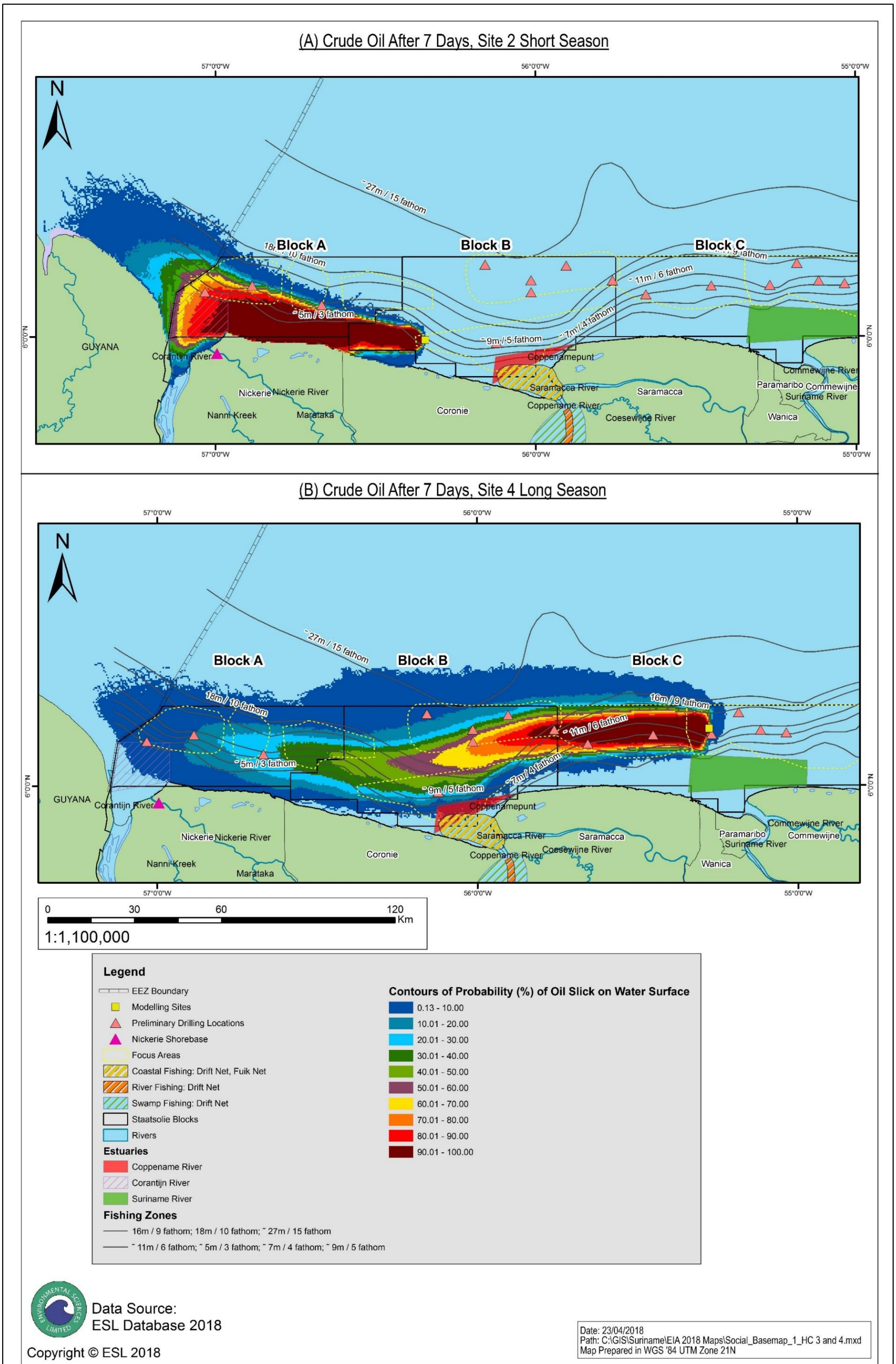


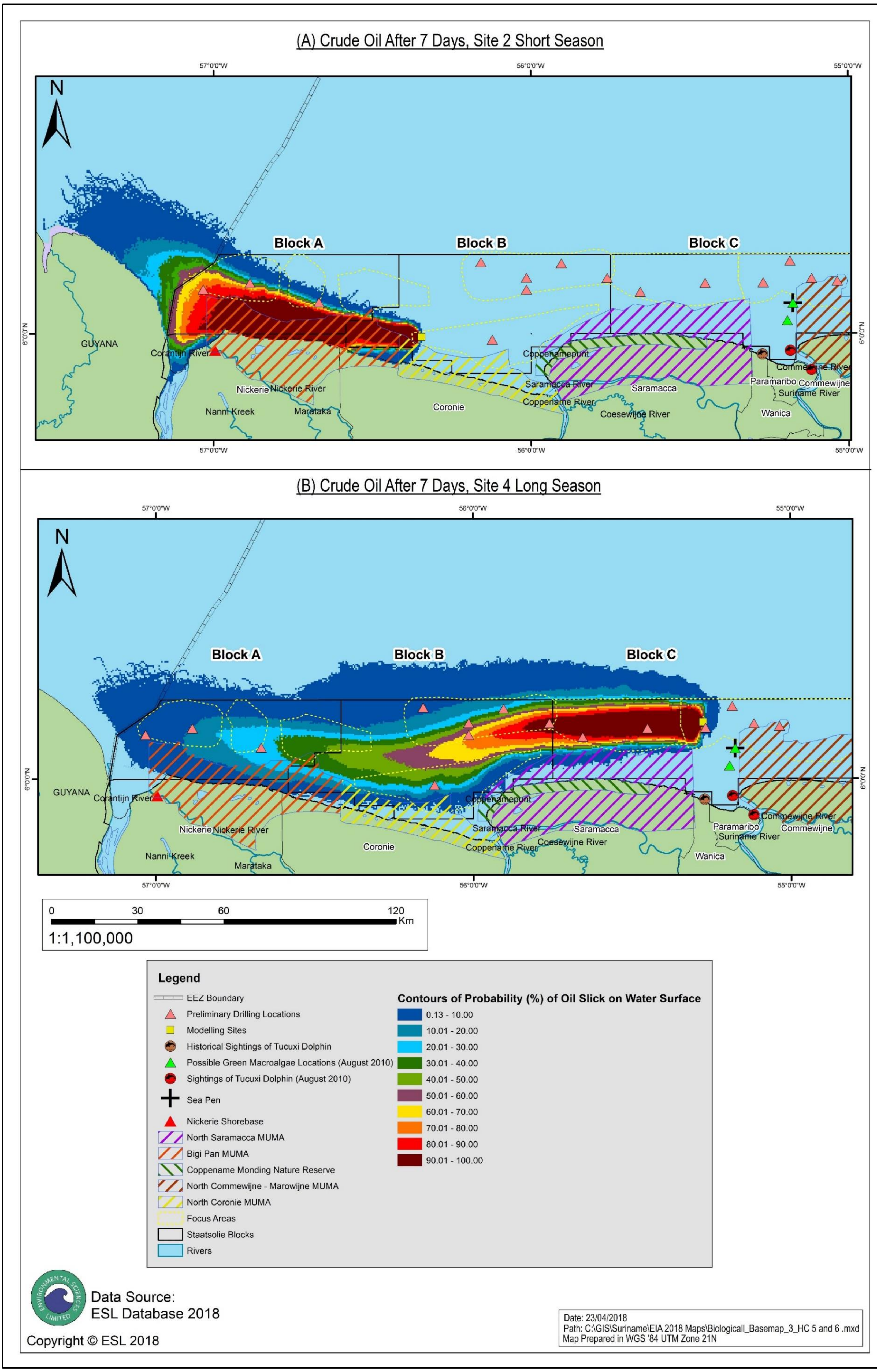
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-4: Contours of Probability of an Oil Slick occurring on the Water Surface from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Marine Ports & Traffic and Offshore Archaeological Resources



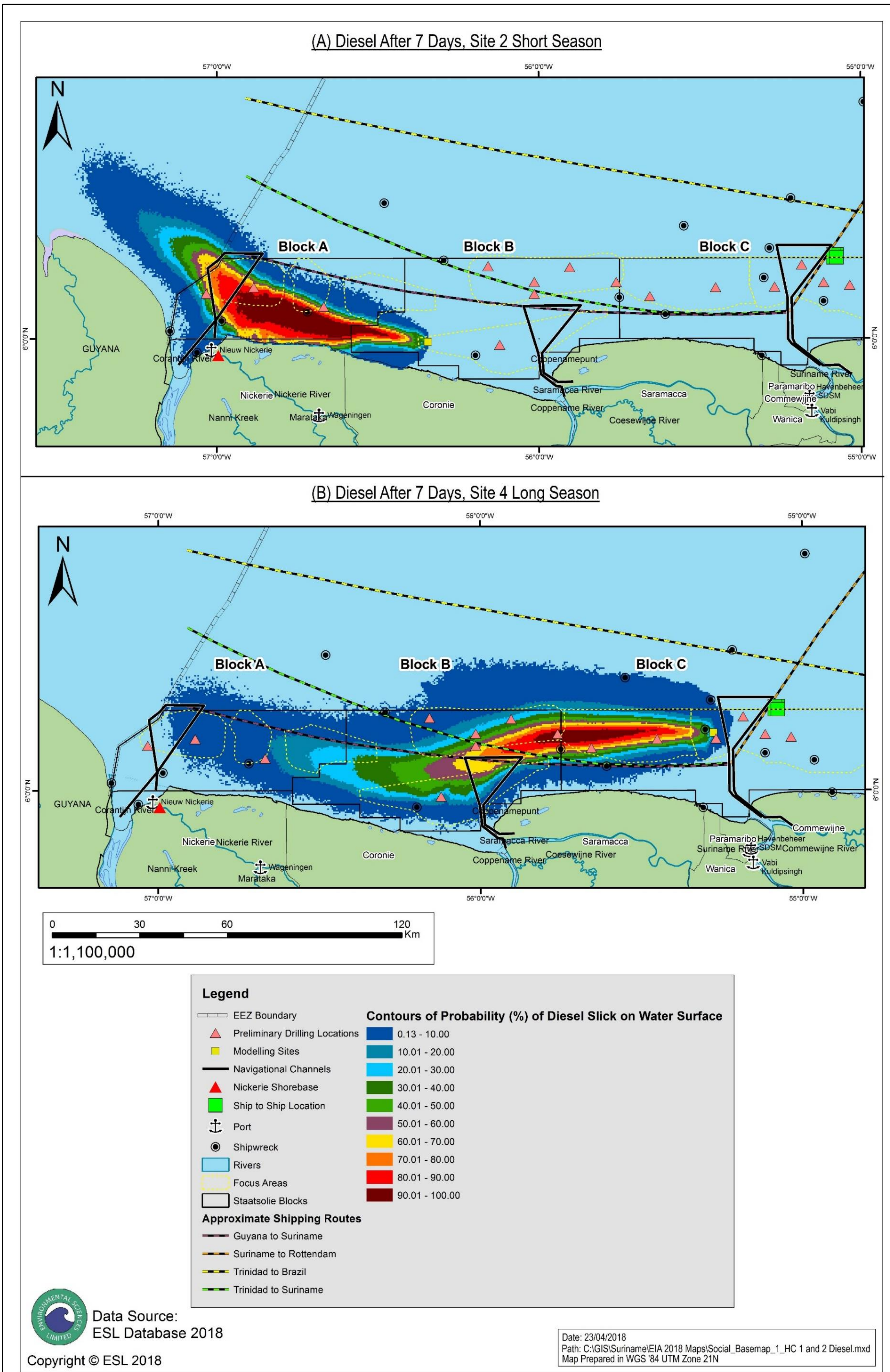
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-5 Contours of Probability of an Oil Slick occurring on the Water Surface from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Fishing (Fathom Lines for Nearshore Fishing Zones; Areas of Coastal Fishing and Location of Estuaries)



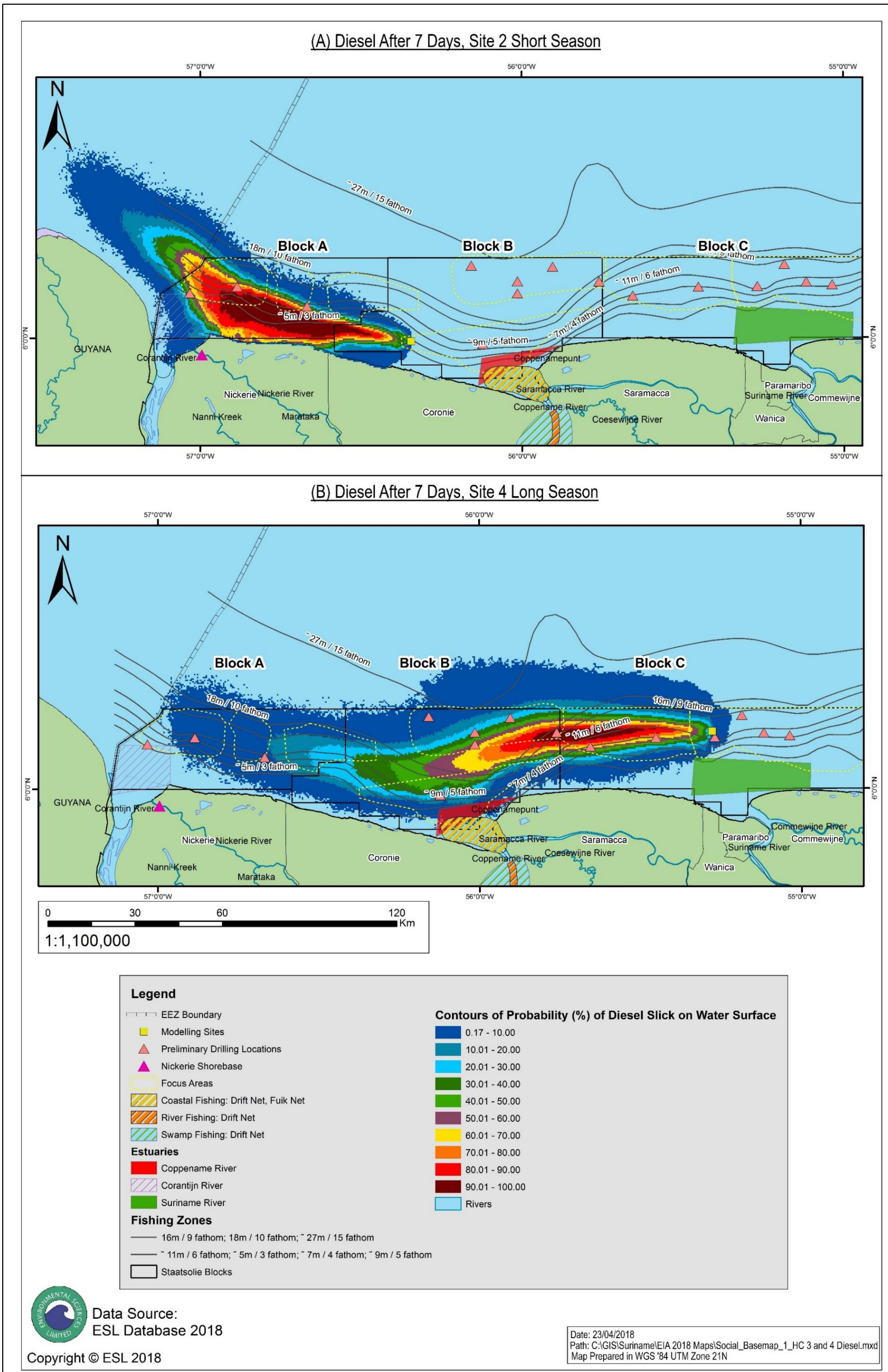
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-6: Contours of Probability of an Oil Slick occurring on the Water Surface from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Protected Areas and Offshore Ecological Components



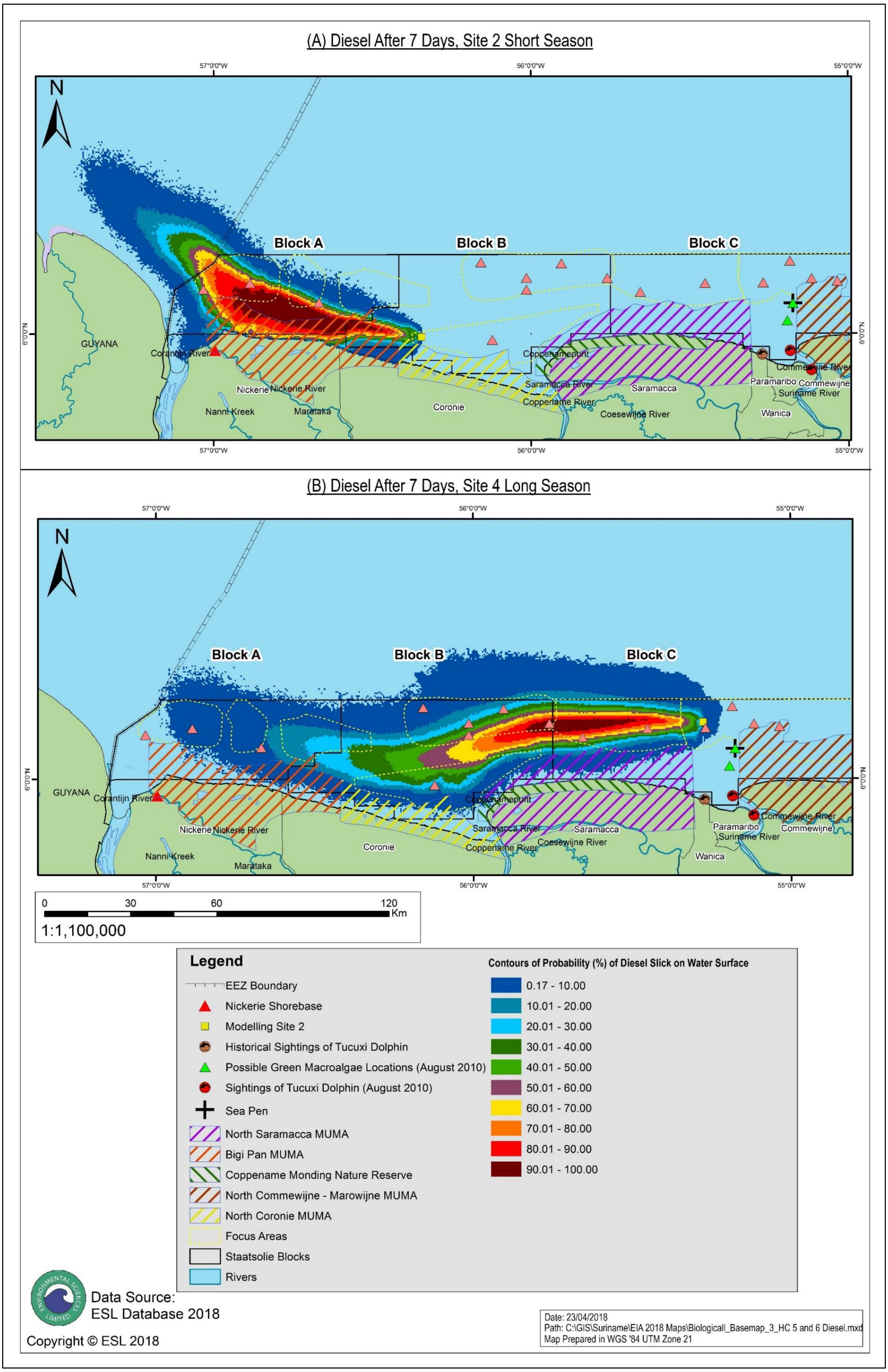
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-7: Contours of Probability of a Diesel Slick occurring on the Water Surface from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Marine Ports & Traffic and Offshore Archaeological Resources



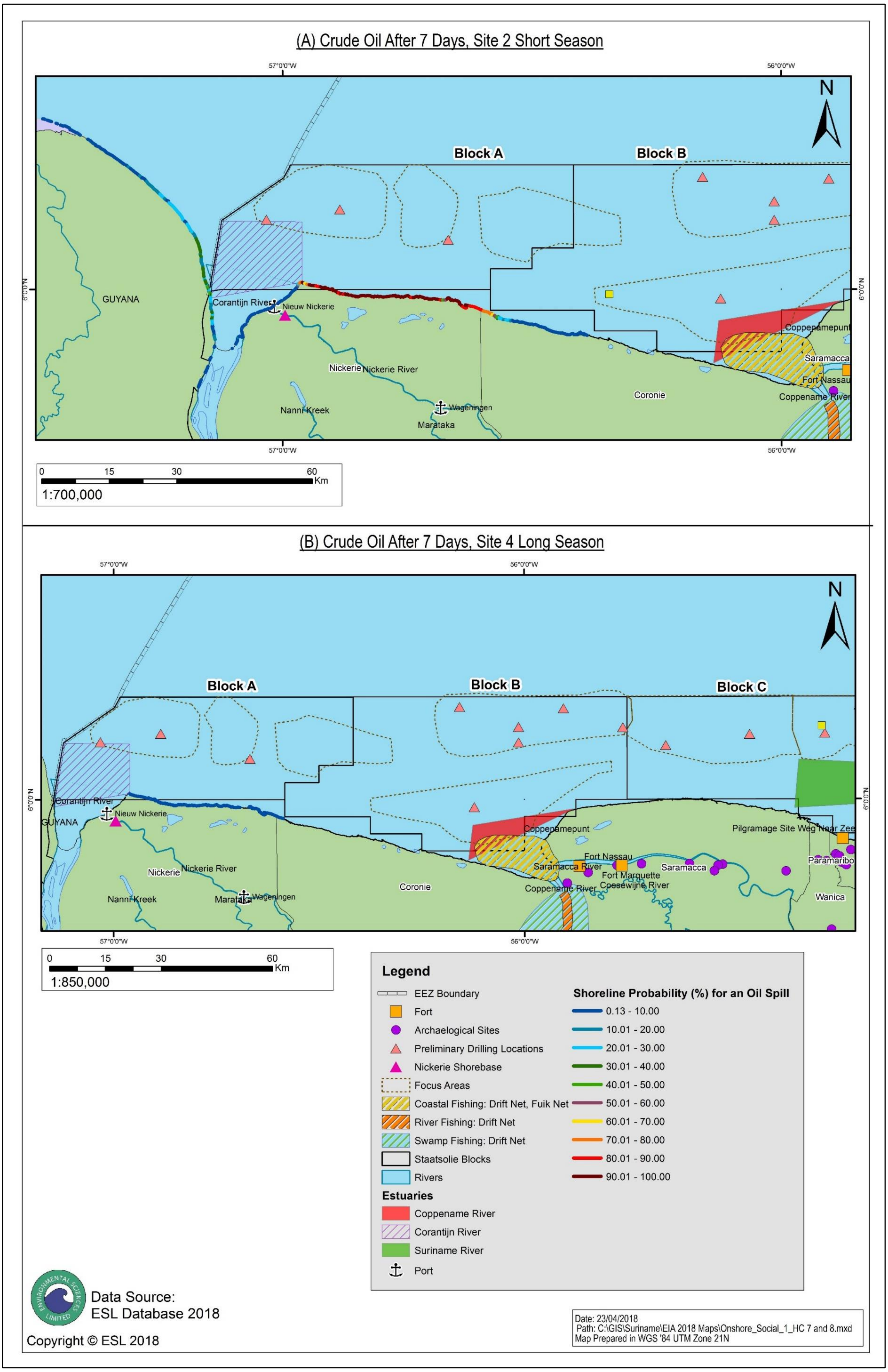
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-8: Contours of Probability of a Diesel Slick occurring on the Water Surface from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Fishing (Fathom Lines for Nearshore Fishing Zones; Areas of Coastal Fishing and Location of Estuaries)



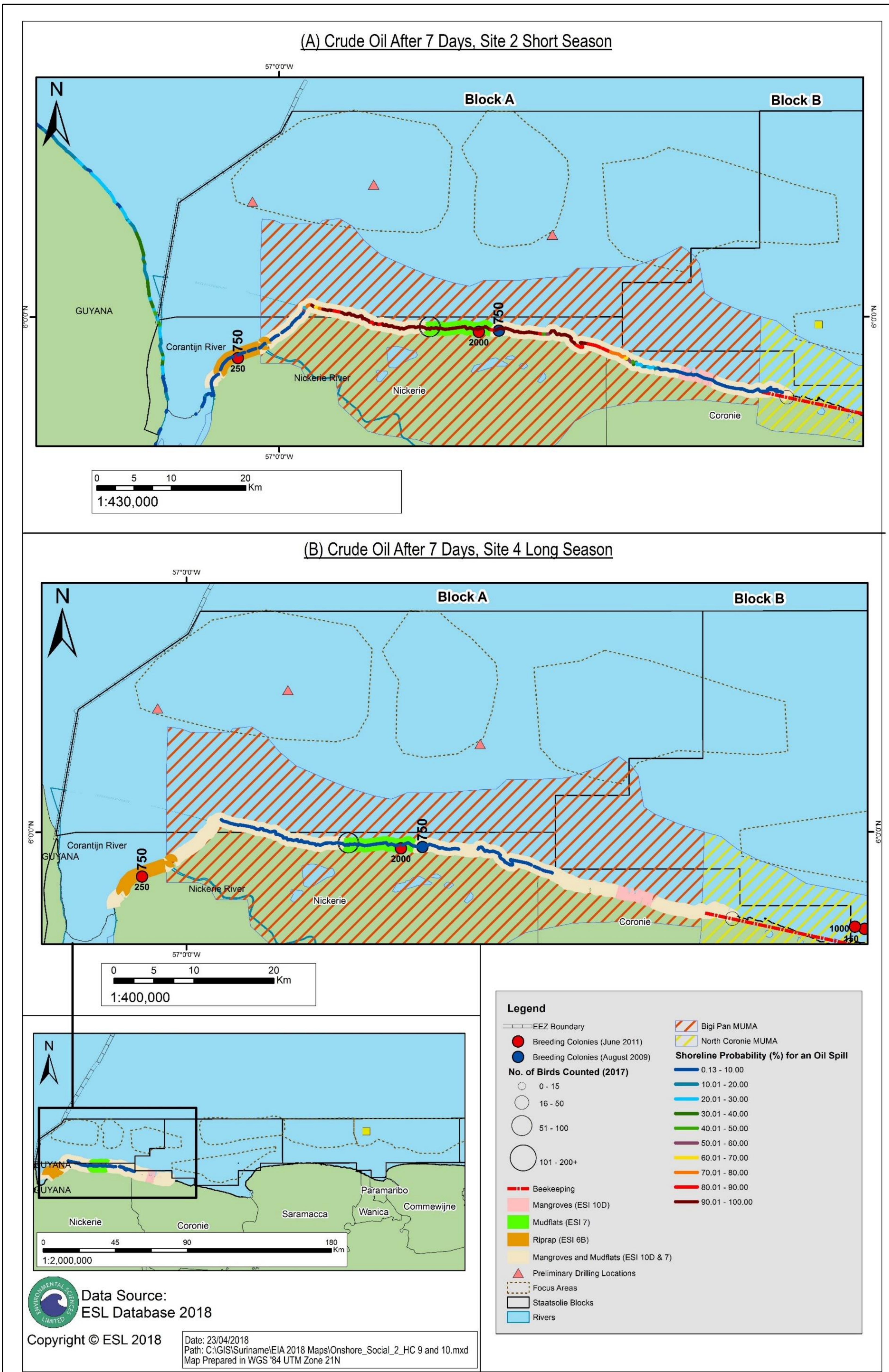
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-9: Contours of Probability of a Diesel Slick occurring on the Water Surface from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Protected Areas and Offshore Ecological Components



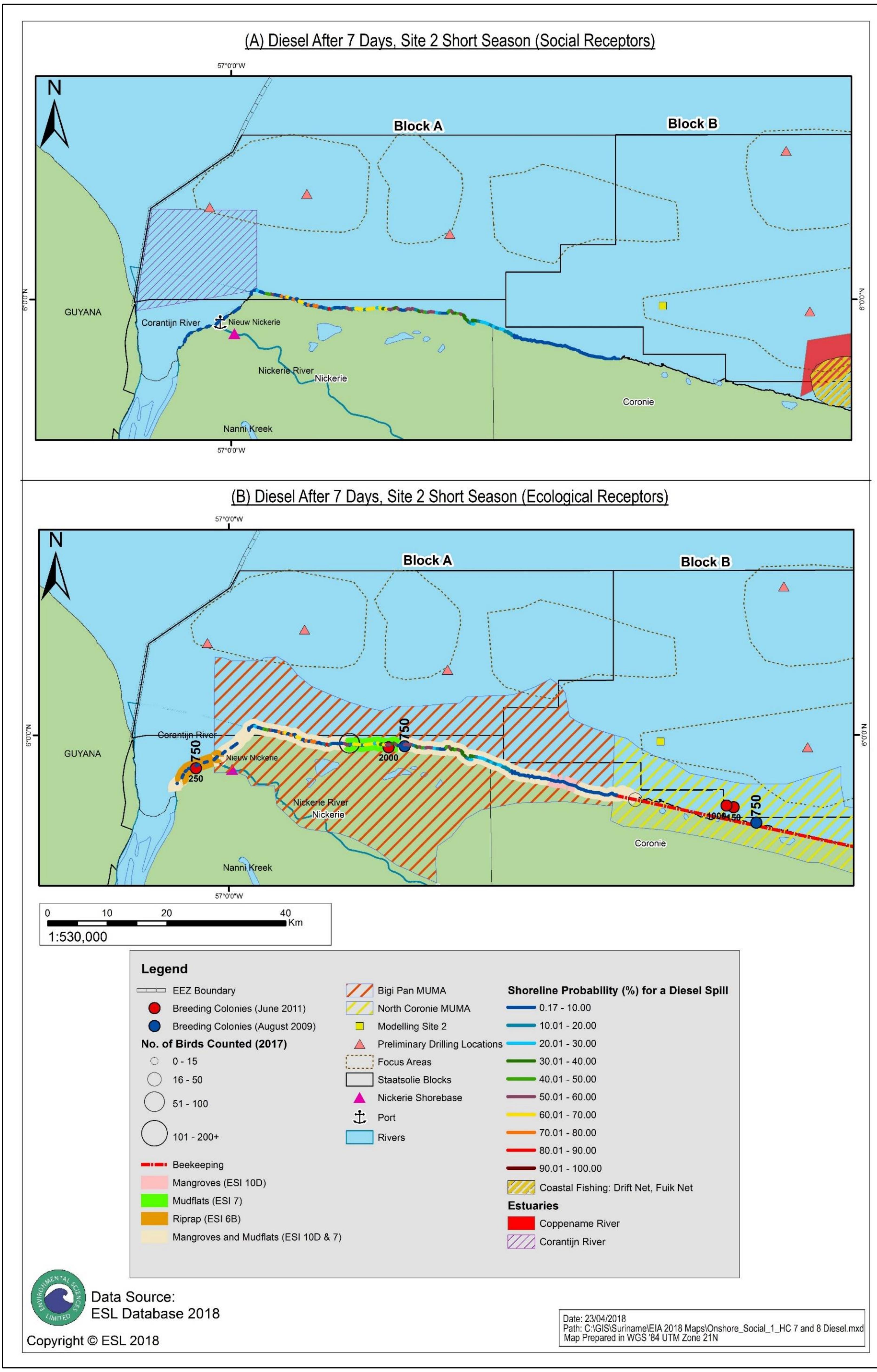
Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-10: Contours of Probability of an Oil Slick occurring along the Shoreline from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Fisheries (Areas of Coastal Fishing and Location of Estuaries) and Onshore Archaeological Resources



Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-11: Contours of Probability of an Oil Slick occurring along the Shoreline from an Accidental Spill of Oil from (a) Spill Site 2, during the Short Season (Early December – Late April) and (b) Spill Site 4 during the Long Season (Late April – Early December), showing Receptors related to Protected Areas, Bird Breeding Colonies, Areas of Beekeeping and the Location of Mangroves and Mudflats along the Shoreline



Source: ESL Database 2018 & Tetra Tech 2018a (Appendix E)

Figure 6-12: Contours of Probability of a Diesel Slick occurring along the Shoreline from an Accidental Spill of Oil from Spill Site 2, during the Short Season (Early December – Late April) Spill Site 4 during the Long Season (Late April – Early December), showing (a) Receptors related to Fisheries (Areas of Coastal Fishing and Location of Estuaries) and Onshore Archaeological Resources and (b) Receptors related to Protected Areas, Bird Breeding Colonies, Areas of Beekeeping and the Location of Mangroves and Mudflats along the Shoreline

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The receptors which may potentially be affected by the stressor hydrocarbon and chemical spills (whether from an oil or diesel slick on the surface of the water column or from an oil or diesel slick coming ashore) include: mudflats; marine water quality; marine sediment quality; air quality; benthic macrofauna; soft coral taxa; benthic fish and shellfish; marine mammals; sea turtles; pelagic fish and plankton; marine and coastal avifauna; terrestrial fauna; protected areas; other sensitive ecosystems (mangrove and mudflats); resource users (fishers, other users of the marine and coastal areas (e.g. shipping and sea defence) and tourists (local and international); employment, income and labour market; fisheries; recreation and tourism (sport fishing, bird watching, nature tours); archaeological resources; marine ports and traffic; human health; and emergency resources.

Components of hydrocarbon and chemical spills can include gases, drilling muds, hydrocarbons and other chemicals, the latter 3 of which may contain heavy metals. As a result, hydrocarbon and chemical spillages can degrade marine water quality, which in turn affects various components of the receiving environment. These impacts, excluding those associated with drilling muds which have been discussed in Section 6.4.5 are highlighted and discussed below.

Heavy metals, hydrocarbons and other toxic chemicals which may be used during the drilling process may be toxic to the nervous and reproductive systems as well as major organs, and are potentially carcinogenic to water column biota such as marine mammals, sea turtles, pelagic fish, benthic fish and shellfish, as well as marine and coastal avifauna. These chemicals act as irritants to the skin, and the lungs. Some may be soluble in water, whilst others are immiscible; oil and less dense hydrocarbons such as diesel tend to remain on the water’s surface, whilst heavier fractions of oil may sink to the seafloor.

Heavier fractions of spilled crude oil which have coagulated and sunk to the seafloor may affect marine sediment quality. The presence of heavy metals, hydrocarbons and other toxic chemicals on the seafloor may bring about negative impacts to benthic fish and shellfish and soft-bottom macrobenthos. These organisms may die as a result of coming into contact with oil and toxic chemical constituents, or feeding mechanisms may be hindered, leading to starvation. Given the depth of the Project area (water depth within the Block is 0-30 m), it is likely that spilled oil may reach the seafloor. Current speeds may cause these coagulated molecules to disperse in the water column, and it is likely that a small fraction will reach the seafloor for Site 2 for the short season and Site 4 for the long season, given that heavy crude oil was modeled and the spill sites are relatively shallow (see Appendix E).

Diesel is a lighter fraction than oil and there is a lower likelihood that spilled diesel will enter the water column and sink to the seafloor. Based on this, the impact of hydrocarbon and chemical spills on marine sediment quality has been classified as **negative**, **direct** and **low** for the pre drilling phase, as the impact of this stressor on benthic fish and shellfish and soft-bottom macrobenthos. This is because only minor accidental spills of diesel during the bunkering process and the release of light fraction oils was considered for this phase (see further above).

For the drilling and post drilling phases, the impact of this stressor on marine sediment quality has been evaluated as **negative, direct** and **moderate**, as a result of the potential for the occurrence of a larger spill (i.e. 400 bbls for 7 days; which is the duration expected to control the well). A spill of this magnitude may result from a blowout during installation of the BOP in the drilling phase or its failure during well abandonment.

Based on the effects described above, a small amount of oil is expected to reach the seafloor during drilling. The receptors, benthic fish and shellfish, soft-bottom macrobenthos, soft coral taxa and archaeological resources (shipwrecks) may be affected by oil sinking to the sea floor during drilling. Of these, crude oil and diesel contours of probability do not intersect the isolated location of soft coral taxa (see Sea pen in Figure 6-6a and b and Figure 6-6a and b), and so the impact of this stressor on this receptor is **negligible** during all phases i.e. unlikely occurrence of effects; see Table 6-1 above).

For the receptor, archaeological resources (shipwrecks), Figure 6-4a shows that, for an oil spill from Site 2 during the short season, contours of probability of 1 – 100% intersect 4 shipwrecks within Block A and within the mouth of the Corantijn River. For an oil spill from Site 4 during the long season, contours of probability of 1 – 100% intersects 9 shipwrecks within Blocks A to C (Figure 6-4b). Given that sinking oil will foul these shipwrecks, but the volume reaching the sea floor will be low, and the oil will be weathered and removed over time, the potential impact of this stressor on archaeological resources (shipwrecks) has been classified as **negative, direct** and l**ow** for the drilling and post drilling phases and negligible for the pre drilling phase. Negligible impacts to this receptor will occur owing to a diesel spill, since diesel will not sink to the seafloor.

For the receptors, benthic fish and shellfish and benthic macrofauna, the impact of oil on the sea floor during drilling and post drilling has been classified as **negative**, **direct** and **moderate**. Such events (should they occur) may affect a portion of the population and impact may bring about a change in abundance and /or distribution over one or more generations, but may not threaten the integrity of that population or any population dependent on it. The benthic organisms and demersal fish potentially affected are generally r-selected[38] species and are able to regenerate quickly; within 4-9 months of disruption (Gesteira *et al.* 2003). There may be few exceptions, for instance, benthic fish

[38] *r-selection occurs when a population is far below the carrying capacity of an unstable environment: tends to favour individuals that reproduce early, quickly, and in large numbers so as to make use of ephemeral resources and ensure that at least some offspring survive (Beeby and Brennan 1997). Characteristics of these populations include: rapid development; high reproductive rate; early reproductive age; small body size; one reproductive cycle; and short lifespan, among others (Hartstock; n.d.).*

taxa which are listed as vulnerable under the IUCN Red List of Threatened Species (version 2017.3), such as the Jarabaku (catfish), Lane and Vermillion snappers, Tarpons, Bluefishes, and the Jewfish (see Section 5.4.5 above). The impact of this stressor during pre drilling has been assessed as **negligible**, given that these may be from minor spills, which may not reach the sea floor.

Degraded marine water quality as a result of hydrocarbon and chemical spills may negatively affect marine mammals, sea turtles, benthic and pelagic fish, plankton, and coastal and marine avifauna through various pathways – direct contact; inhalation; ingestion; irritation; inflammation and impairment of feeding. The impacts of spills can differ between various life stages of fishes. Hydrocarbon spills or spills containing toxic chemicals can affect adult fishes by direct contact with gills or in the gut after swallowing the toxic mixture, which can lead to death or illness. Table 6-11 below presents the minimum, average and maximum % of oil and diesel which will be dispersed after a spill of oil and diesel from Sites 2 and 4 during the short and long seasons, respectively (see Appendix E). These data are based on the mass balance calculations generated from the modelling exercise, and showed that at least 45% of the oil or diesel which enters the water column is dispersed throughout the water column within the maximum area defined by the contours of probability presented in Figure 6-4 to Figure 6-12 above. This represents a significant proportion of the spilled volume after 7 days. Smaller proportions are found at the surface during all scenarios (see Appendix E).

Table 6-11: Minimum, Average and Maximum % of Oil and Diesel Dispersed 7 days after a Spill of Oil and Diesel from Sites 2 and 4, during the Short and Long Seasons, respectively

Modelled Scenario	% Oil or Diesel Dispersed throughout the Water Column		
	Minimum	Average	Maximum
Oil, Site 2, Short Season, after 7 days	6.14	25.86	45.38
Oil, Site 4, Long Season, after 7 days	1.14	20.37	56.99
Diesel, Site 2, Short Season, after 7 days	25.75	43.27	62.99
Diesel, Site 4, Long Season, after 7 days	18.75	36.01	58.11

Marine mammals, sea turtles and benthic,pelagic fish (and the marine fauna which feed on pelagic fish) and plankton will occur throughout the study area. Marine mammals typically occupy the offshore areas from January to May, with studies by de Boer 2015 indicating their presence during June – August (see Section 5.4.3.2 above). Dolphins, which display high curiosity and high site fidelity may also be found within the Nearshore area, particularly near River mouths. Sea turtles will also occupy the marine area related to the Project during the turtle nesting season (February to August) but nesting turtles are generally restricted to beaches on the eastern side of Suriname, the most westerly of which is at Matapica (based on 2004 data), located to the east of the Suriname River mouth (see Figure 5-121 above and Section 5.4.4.2 above). Given that the Project is carded for April – December 2019, it is therefore expected that marine mammals and sea turtles can potentially be found within the Project Area.

Pelagic and benthic fish will occur throughout the area and at all times of the year. Figure 6-5a shows that the contours of probability of an oil slick on the water surface of 50 - 100% intersect the Corantijn River estuary (from a spill of oil from Site 2 during the short season). Figure 6-5b (Site 4, long season) showed that contours of probability of an oil slick on the water surface of 1 - 10% intersect the Coppename River estuary and coastal fishing ground within the Coppename River; the northwestern tip of the Suriname River estuary may also be affected by a potential oil spill (1 – 10% contours of probability).

Contours of probability of a diesel slick on the water surface from (a spill of diesel from Site 2 during the short season) of 1-90% intersect the Corantijn River estuary (see Figure 6-8a), whereas, for Site 4 (long season), the probability of a diesel slick on the water surface of 1 - 10% intersect the Coppename River estuary and coastal fishing ground within the Coppename River; the northwester tip of the Suriname River estuary may also be affected by a potential oil spill (1 – 10% contours of probability; see Figure 6-8b). These areas are important nursery and feeding areas for pelagic and benthic fish and shellfish, and for sustainable livelihoods of coastal fishers. Sub-lethal effects such as reduced egg hatchings and larval survival can also occur, which in turn, can negatively affect the commercially viable and very important fisheries, via reduced catches. Bio-concentration of toxic substances in fish can also occur through absorption of chemicals through gills and skin. Fish can therefore be contaminated which can result in negative human health effects after consumption of these fish. Bio-magnification of chemical constituents of hydrocarbons may also occur in coastal and marine avifauna that consumes pelagic fish.

In an oil spill, a sheen or thicker layer may cover the surface of water (thinner sheen for diesel). Ingestion of these hydrocarbons by birds and pelagic fish as well as inhalation by organisms that break the surface of the water to breathe such as marine mammals and turtles can occur. Ingestion and contact with hydrocarbons and other chemicals can cause irritation as well as toxic effects in these organisms and lead to death. The sheen may also disrupt oxygen mixing at the surface of the water column and may lead to reduced DO levels, causing physiological stress to organisms in the water column, and even death.

Diesel may also affect marine and coastal birds known to occur along the coast, such as Seagulls and Terns (e.g. *Sterna hirundo* or Common Tern), Pelicans (e.g. *Pelecanus occidentalis* or Brown Pelican) frigatebirds (e.g. *Fregata magnificens* or Magnificent Frigatebird) Semipalmated Sandpiper (*Calidris pusilla*) and Scarlet Ibis (*Eudocimus ruber*; see Section 5.4.7 above). The marine species dive for food, and oil present on the water's surface may coat feathers, disrupting their interlocking structure. As a result, the waterproof external feathers are destroyed, and the downy, insulating layer is soaked, destroying the properties of plumage (Oiledwildlife 2007). Ingestion or inhalation of hydrocarbons can also occur on the shorebirds that feed on the tidal flats. Ingestion may also occur when birds try to clean oil or diesel from their feathers by preening or as they feed upon a contaminated food source, and could result in internal effects. Such ingestion can be sub-lethal or acute. Direct toxic effects on the gastrointestinal tract, pancreas and liver have all been documented. Damage to the gastrointestinal tract prevents the animal's digestive system from utilising food or water, causing the animal to become progressively weaker in a very short time.

A similar irritation of other mucosal surfaces can lead to ulceration of eye surfaces, and the moist surfaces inside the mouth. As the affected bird becomes more debilitated, its immune system is compromised and the bird becomes susceptible to secondary bacterial and fungal infections. The oil/diesel may also have an effect on the bird's ability to reproduce; the number of eggs laid; the fertility of the eggs; the shell thickness; and the breeding and incubating behaviour.

The baseline assessment of the water quality within Block C in 2017 showed an increase in the levels of phenols but a decrease in the levels of TPH, hexavalent chromium and the total metals, copper, lead, iron, and aluminium, as compared to 2013 (within Block IV, the western portion of Block C; see Section 5.3.10.3 above). The levels of these and other chemicals may be increased in the water column as a result of potential spills from the Project, as well as from those associated with current/future oil and gas activities occurring in Suriname. When taken in, these metals can have toxic effects in marine fauna (fish, turtles and marine mammals, all of which are found within the offshore study area). Local fisheries can be affected if commercial species are contaminated and poisoned by these metals in the water. Bio-concentration of these toxins in the tissue of marine animals can then occur which can negatively impact human health after consumption of fish harvested in the area. Bio-magnification can also affect avifauna, sea turtles and marine mammals feeding on these contaminated fish.

As a result of the forgoing discussion, the potential impact of hydrocarbon, chemical spills on the receptors, marine mammals, sea turtles, benthic and pelagic fish, plankton and marine and coastal avifauna have been deemed **negative**, **direct** and **high** for the drilling and post drilling phases, given the high % of oil and diesel expected to be dispersed throughout the water column, and that the spill may potentially intersect critical nursery areas, expose threatened taxa (some fish taxa and sea turtles) to chemicals, and that drilling may occur during time-sensitive periods for some of these taxa (sea turtles). Thus, the impact of this stressor on the above receptors may cause a decline in abundance/distribution of an entire population or species, beyond which natural recruitment may not return that population or species, or any population or species dependent upon it, to its former level within several generations (see Table 6-1 above). This stressor has been assessed as **negative**, **direct** and **moderate** for the pre drilling phase, given that in this short phase, there will be only minor spills, and so this stressor may cause a decline in abundance/distribution of an entire population or species, beyond which natural recruitment would not return that population or species, or any population or species dependent upon it, to its former level within several generations (see Table 6-1 above).

Given that water quality is the valued ecosystem component (VEC) which affects the ecological receptors indicated above, the overall impact of the stressor hydrocarbon and chemical spills has been assessed as **negative**, **direct** and **high** for the drilling and post drilling phases, and **negative**, **direct** and **moderate** for the pre drilling phase.

In the case of fisheries, resource users (fishers and consumers of fish and fish products) and human health, hydrocarbon and chemical spills have been classified as **negative**, **indirect** and **moderate**, for pre drilling phase. This is because: (i) spills which occur during this phase is minor; (ii) spills may affect users of natural resources (in this case fishers) but only in the short-term (given that only one well will be drilled at a time) and (iii) fishers can operate in areas outside the minor spills.

For the drilling and post drilling phases, the impact of this stressor on fisheries, resource users (fishers and consumers of fish and fish products) and human health was classified as **negative, indirect** and **high**. This is because the contours of probability of an oil or diesel spill from Site 2 in the short season and Site 4 in the long season (after 7 days; see Figure 6-5 and Figure 6-8) covers a large portion of the study area, the whole of which may be fished at any given time, based on fathom line classification, by both artisanal and industrial fishers (see Figure 5-169 and Table 5-52 of Section 5.5.7 above). The occurrence of a spill (and subsequent clean up) may limit or restrict fishing activities and cause potential losses to local livelihoods and to the fishing industry, given its high commercial value (see Section 5.5.7 above). Another negative, indirect consequence may be reduced consumption of sea food (as a result of consumers' fear of health effects of consuming tainted fish), leading to further reduction in livelihood over an unspecified period of time, until consumers' return to normal purchasing habits. Thus, the impact of this stressor on employment, income and labour market has been assessed as **negative**, **indirect** and **moderate** for the drilling and post drilling phases, and **negligible** for the pre drilling phase.

Hydrocarbon and chemical spills may affect recreation and tourism (sport fishing) and also have impacts on resource users (sport fishers). Figure 6-5 and Figure 6-8 show that contours of probability (1 – 100%) will affect the Nearshore and offshore areas within the study area beyond the 5 fathom line, (> 13 km from shore), where sport fishers normally operate. Given that sport fishing is not as well established within the offshore area, and that sport fishers can migrate to areas further offshore, the impact of this stressor on recreation and tourism and resource users (sport fishers) has been assessed as **negative**, **indirect** and **low** for all phases of the Project.

Hydrocarbon and chemical spills may also affect protected areas. The contours of probability of an oil and diesel slick on the water surface from Site 2 during the short season intersect the Bigi Pan MUMA (0 – 100%; offshore portion), which overlaps the southern portions of Blocks A and B, as well as the westernmost tip of the North Coronie MUMA (see Figure 6-6a and Figure 6-9a). For Site 4 (long season), contours of probability of oil slick on the water surface which intersect the Bigi Pan MUMA is reduced to 1-40%; a reduction is also observed for the westernmost tip of the North Coronie MUMA (1-30%). However, the diesel slick associated with Site 4 in the long season intersects the Coppename Monding Nature Reserve and North Saramacca MUMA (1-60%) (see Figure 6-6b). For diesel (Site 4, long season, Bigi Pan (1-30%), North Coronie MUMA (1-10%), and Coppename Monding Nature Reserve and North Saramacca MUMA (1-30%) are all affected (see Figure 6-9b).

These areas are protected on the basis of high avifaunal density (nesting, feeding, migration and breeding (see Section 5.4.7 and Section 5.5.8 above). The impacts to these (in relation to the birds which inhabit them) are discussed under shoreline impacts further below.

The occurrence of hydrocarbon and chemical spills can adversely impact marine ports and traffic and resource users (other marine users such as shipping vessels and sea defence). Figure 6-4a and Figure 6-7a show that contours of probability of oil and diesel slicks on the water surface (1-100%) from a spill at Site 2 (short season) could potentially affect the navigational channel of the Corantijn River. Additionally, contours of probability of 1 – 10% intersect the marine shipping route from Guyana to Suriname, as well as the Nieuw Nickerie shorebase and port to be used for this Project. The impact may be greater for a spill from Site 4 long season, as contours of probability of oil and diesel slicks on the water surface could potentially affect the navigational channels of the Corantijn, Coppename and Suriname Rivers. Also, contours of probability (1 – 70% for oil and 1 – 90% for diesel) intersect the marine shipping routes from Guyana to Suriname and Trinidad to Suriname but not the Nieuw Nickerie shorebase and port (Figure 6-4b and Figure 6-7b).

As a result of the foregoing, the impact of this stressor on marine ports and traffic and resource users (other marine users such as shipping vessels and sea defence) has been classified as **negative**, **direct** and **high**, for the drilling and post drilling phases, given the high use and importance of the study area to marine traffic. For the pre drilling phase, the impact of this stressor has been classified as **negative, direct** and **low,** given that spills within this phase will be minor.

Spills in the offshore area will also require extensive clean-up. Given the aerial extent of potential oil and diesel spills from both Sites 2 and 4 in the short and long seasons, respectively, and the relatively large distances over which the response operations will occur, the impact of this stressor on emergency resources has been classified as **negative**, **direct** and **high** for the drilling and post drilling phases, and **negative**, **direct** and **moderate** for the pre drilling phase.

Oil and diesel spills which remain at the surface of the water may affect air quality (and human health of workers such as clean-up crews). These impacts may arise from the inhalation of gases as they evaporate to the atmosphere. Though the aerial extent of the oil and diesel spills are extensive, and a considerable fraction of each will remain at the surface of the water column after 7 days (see Appendix E), met-ocean conditions will help to dissipate the fumes generated. As a result, the impact of this stressor on air quality and human health has been classified as **negative**, **direct** and **low** for all phases on the Project, when also taking into account that workers will be equipped with the requisite and appropriate PPE for clean-up activities.

Spills of oil and/or diesel during the various phases may reach the shoreline, and thus may have impacts on marine and coastal avifauna, protected areas, sensitive ecosystems (mudflats, mangroves, estuaries and associated nursery areas and fishing grounds), terrestrial fauna (mammals and herpetofauna), archaeological resources; recreation and tourism (bird watching tours); resource users (tourists and beekeepers); and marine ports and traffic. Physiological impacts to beach macrofauna and shore birds observed along the coast, as well as to larval and juvenile populations of fish and shellfish found in mangroves will be similar to those discussed for birds and benthic and pelagic fish above.

Figure 6-10a shows that, from a spill of oil from Site 2 during the short season, the eastern boundary of the Corantijn River estuary intersects the shoreline and at this location, there is a 90-100% probability of oil coming ashore. Oil does not come ashore at the shoreline boundaries of the Coppename River estuary, nor the fishing grounds associated with this river. These oiled shoreline areas also intersect with the shoreline boundary of the Bigi Pan MUMA, as well as a small portion of the shoreline aligned with the North Coronie MUMA (see Figure 6-11a). These MUMAs coincide with the occurrence of mangroves and/or mudflats along the shoreline in the potentially affected area (see ESI ranks ESI 7 for mudflat locations and ES1 10D for mangroves in Figure 6-11a). Figure 6-11a also shows that the majority of the oiled shoreline (including the areas of highest probability) coincide with the occurrence of mangroves and/or mudflats, which are crucial for birds along the Suriname coast. The occurrence of these birds within the sensitive ecosystems above have been verified by the results of the breeding colony counts for 2009, 2011 and 2017, which also intersect the areas of highest shoreline probability (90-100%). Figure 6-11a indicates that 100 – 2,000 birds were observed over the time period (where the number of birds was combined for all 3 years in which the surveys were conducted; see Section 5.4.7 above). Terrestrial fauna (such as terrestrial mammals and herpetofauna; see Section 5.4.8 and Section 5.4.9 above) may potentially be affected by oil coming ashore in these areas.

The probability of diesel from a spill at Site 2 during the short season is lower at the shoreline of the Corantijn River estuary (20-30%) as compared to oil, and like oil, diesel does not come ashore at the shoreline boundaries of the Coppename River estuary, nor the fishing grounds associated with this river (see Figure 6-12a). Diesel coming ashore from Site 2 also affects Bigi Pan MUMA and North Coronie MUMA (see Figure 6-12b). Figure 6-12b also shows lower probability of oiling of sensitive ecosystems (mudflats and mangroves); lower shoreline probabilities (1-70%, compared to oil) occur at the 2009 – 2017 bird colonies.

As for a spill of oil from Site 4 (long season; diesel does not come ashore in this scenario), the eastern boundary of the Corantijn River estuary intersects the shoreline at only a 1-10% probability, and as with oil and diesel for Site 2 (short season), oil does not come ashore at the shoreline boundaries of the Coppename River estuary, nor the fishing grounds associated with this river (see Figure 6-10b). Oiled areas from Site 4 also intersect with a significant portion of the shoreline boundary of the Bigi Pan MUMA, but at the lowest probability (1-10%; see Figure 6-11b). Thus, the potential impact of oil coming ashore from an oil spill from Site 4 (long season) is lower for marine and coastal avifauna, protected areas, sensitive ecosystems (mudflats and mangroves) and terrestrial fauna.

Based on the foregoing, and given that the greatest potential impacts to these receptors may come from a spill of oil after 7 days from Site 2 during the short season, the impacts of the stressor hydrocarbon and chemical spills on the receptors, mudflats, marine and coastal avifauna, protected areas, sensitive ecosystems (mudflats, mangroves, estuaries and associated nursery and coastal fishing areas, and terrestrial fauna has been assessed as **negative**, **direct** and **high**, for the drilling and post drilling phases, given the extensive portions of the shoreline which may be oiled, and the remoteness of the locations at which remedial actions may be required. For the pre drilling phase, it is not anticipated that spills of oil or diesel will reach the shoreline, and so the impact of this stressor on these receptors has been classified as **negligible**.

For an oil and diesel spill from Site 2 (short season), oil and diesel come ashore (1-10%) at the westernmost point along the District Coronie shoreline in which beekeeping is practised (see Figure 6-11a and Figure 6-12b above), but it does not come ashore at this location (neither oil nor diesel) from a spill at Site 4 (see Figure 6-11b above). Oiled shorelines may hamper beekeepers from harvesting honey (and so, potentially impact livelihoods), owing to restricted access from oiled mangroves and clean-up activities. Tourists (and tour operators) who intend to visit Bigi Pan MUMA may also be hampered by these factors, but these tours are usually more common in the Coppename Monding Nature Reserve. The impact of this stressor on resource users (beekeepers, tourists and tour guides) has been assessed as **negative**, **indirect** and **low** for the drilling and post drilling phases, and negligible for the pre drilling phase of the Project.

No archaeological resources occur along the stretches of potentially oiled shorelines from a spill of oil or diesel from Site 2 (short season) nor from a spill of oil from Site 4 (long season Figure 6-10a and Figure 6-12a above). Thus, the impact of this stressor on archaeological resources is **negligible**, for all phases of this Project.

Figure 6-10a and Figure 6-12a show that there is a 1-10% probability of oil and diesel coming ashore at the Nickerie port/shorebase, from a spill at Site 2 (short season (but no such effects occur from Site 4, long season). This could potentially impact upon Project execution, and so, the impact of this stressor on marine ports has been classified as **negative**, **direct** and **moderate**, for the drilling and post drilling phases, and negligible for the pre drilling phase.

6.4.11 Gas Emissions

This section addresses impacts to air quality from all potential sources of gas emissions associated with this Project (onshore and offshore; daily planned operations and unplanned events, such as an accidental spill of oil or diesel). Air quality may be impacted during this Project through gaseous emissions from the rig (movement); drilling operations at the well-sites; marine support vessels (tugs, supply vessels, chase vessel and crew boat); and vehicles operating at the ports/shorebases. Thus, pollutants emitted will be mainly from internal combustion sources such as diesel engines. The quantities generated are primarily dependent on the condition and maintenance of the engines, vessel and vehicle operating mode (moving, stationary), speed of operation and load weight. Emissions from the rig, vessels and vehicles can occur during all phases of the Project.

Engines operating during the drilling Project will combust diesel, and exhaust from this process will be emitted constantly once ignition is engaged. Diesel exhaust contains: diesel particulate matter (DPM), which includes diesel soot and aerosols such as ash particulates, metallic abrasion particles, sulphates, and silicates; nitrogen oxides; sulphur oxides, carbon monoxide (when running on full load); a range of VOCs; and other chemical compounds, including metal compounds, phenol and BTEX.

The emission of these chemicals into the atmosphere can result in an increased concentration of air pollutants, thereby degrading air quality, and the emission of greenhouse gases (nitrous oxides and CO_2) pose the threat of contributing to and increasing global warming (see Section 6.6.2 below). Dust from traction processes (vehicles moving on unpaved surfaces) may also degrade air quality. As such, the impact to air quality from onshore vessel and vehicular movement was assessed as **negative**, **direct** and **low** for all phases.

Directly related to the release of emissions is the potentially negative, indirect impact to human health. Inhaling degraded air as a result of diesel exhaust emissions by workers in the immediately impacted area may lead to acute and chronic respiratory ailments, as some of the gases can act as irritants to the respiratory system and may cause wheezing, chest tightness and shortness of breath. Air pollutants may also lead to diseases such as cancer, given that many of the chemical compounds found in diesel exhaust are known to be carcinogenic.

Air quality may also be degraded as a result of spills of hydrocarbons and other chemicals. Gases and vapours may be emitted and through inhalation, can act as an irritant to the respiratory system, thereby affecting human health. Given the moderately high wind speeds experienced offshore the east coast (at its highest and ranging from 9 – 10 m/s during the long wet season, and which conforms to a fresh breeze on the Beaufort Scale; NOAA; nd), it is expected that rapid dispersion of emissions will occur. Thus, the impact of hydrocarbon and chemical spills on air quality was classified as **negative**, **direct** and **low** for all phases of the Project. Mitigation measures are proposed in Chapter 7 to eliminate the impact altogether which are typically adopted as best practice and often form part of the standard operating practices (SOPs) on-board sea-going vessels.

The total CO_2 emissions generated over the life of the Project is presented in Table 6-12 below. It should be noted that the emissions from vehicles operating onshore could not be calculated as the fuel consumption rates were unknown.

Table 6-12: Volume of CO_2 Emissions over the Life of the Project (Offshore)

Vessel Type	Volume (mt CO_2)
Rig	4,140
Tugs, Supply Vessels, Chase Vessel & Crew Boat	13,502
Total (Project)	17,642
% of Total CO_2 Emissions for Suriname*	0.74

**Source: NationMaster 2018*

Overall, the impact of gas emissions on air quality has been classified as **negative**, **cumulative**, **direct** and **low**. This is because emissions are continuous over the life of the Project but only contributes less than 1% of the total CO_2 emissions for Suriname. Dissipation upon release into the environment, owing to wind speeds of 9 – 10 m/s within the Project area, combined with a localised area of impact would also mean that the impact of this stressor on human health can be classified as **negative**, **direct**, and **low**.

6.5 Positive Impacts

Positive impacts were identified utilising the Impact Assessment Methodology outlined in Section 6.1 above. The area (geographic, economic, environmental and social) around the Project footprint (i.e. the wider study area) that influences and is influenced by the proposed Project, were taken into consideration when ascertaining the potential positive impacts.

There are 2 significant positive impacts from the proposed Project. The first positive impact is the provision of additional energy resources to users and the employment of oil and gas industry services providers, both of which should deliver economic growth. Preference will be given to the local residents within the study area when seeking skilled workers, once they are adequately qualified. The second positive (but indirect) impact should result from the investment of the revenues generated from the sale of oil in public services such as education, environment, health and economic sectors.

6.6 Cumulative Impacts

Cumulative impacts can be considered in 2 ways. The first relates to the impacts of multiple stressors on a single receptor, as a result of the execution of this Project (and so, not considering the effects of other new or additional Projects within the Nearshore area. The second relates to the cumulative impacts as a result of the execution of this proposed Project simultaneously with other new or additional Projects within the area.

6.6.1 Cumulative Impacts to Individual Receptors from Multiple Stressors

For this Project, cumulative impacts on fisheries can result from increased marine traffic (support vessel operations), increased air emissions, solid and sanitary and organic waste discharges and operational discharges, as well as from an accidental spill of oil and/or diesel. There will also be in place an exclusion zone of 500 m surrounding each well-site. Given that the 10 wells will be drilled sequentially, there will be only one exclusion zone enforced at a given time, fishing can still occur throughout the Blocks, in the areas outside of the 500 m exclusion zone (though this does not apply to the exclusion zone along the support vessel routes i.e., the areas of operation of the support vessels during transit to and from the ports, during this proposed Project). For this Project, the stressor which could potentially have the highest negative impact on fisheries (barring mitigation), is hydrocarbon and chemical spills (**negative**, **indirect** and **high** for the drilling phase).

Similarly, water column biota such as marine mammals, sea turtles, benthic and pelagic fish, and marine and coastal avifauna may be impacted by reduced water quality from stressors the various discharge streams, as well as from noise generated from vessel operations and drilling. For this Project, the stressor which could potentially have the highest negative impact on these receptors (barring mitigation), is hydrocarbon and chemical spills (**negative**, **indirect** and **high** for the drilling phase).

6.6.2 Cumulative Impacts from Simultaneous Projects

There are no additional projects scheduled to occur within or around the Blocks during the proposed drilling event. As a result, there are – at the time of issue of this report – no cumulative impacts with this Project and other projects. However, it is recommended that, should new Projects come on stream, Staatsolie continue to engage both Project proponents and, by extension, stakeholders, in order to ensure that cumulative impacts between Projects are identified and addressed, as per Staatsolie's Community Relations plan and policy. Potential impacts which may be cumulative in nature which may arise during the execution of multiple similar Projects within the area may include:

- Impacts to fisheries – increases in frequency of vessel movements and larger exclusion zones may hamper fishers' abilities to fish, thereby affecting local and foreign demand for Suriname's fish products, and reduction in fishers' earnings, impacting livelihood;

- Impacts to water quality – waste discharges may be cumulative, and may include: operational discharges; hydrocarbon and chemical spills; discharge of solid waste and sanitary and organic wastes into the sea; and discharge of drilling muds (if the new/additional Project is drilling-related). These can have impacts on water column biota as well as sensitive receptors along the shoreline;

- Impacts to marine traffic and port operations – this may be as a result of increase vessel operations within the Project area and at the ports;

- Impacts of noise – cumulative operations at sea have the potential to increase the sound pressure levels above and below water, which can have impacts on water column biota and birds. These may primarily arise from increased frequency of vessel movements, and if the new/additional Project is drilling-related, from the placement of conductor pipes and casings, as well as the activity of drilling itself; and

- Impacts on air quality – New/additional Projects will increase the emission of CO_2 into the atmosphere, increasing the overall contribution to climate change, as a result of the execution of multiple Projects.

6.6.3 Contribution to Climate Change

The Staatsolie Nearshore Drilling Project 2019 has the potential to negatively impact the environment via greenhouse gases from combustion during fuel consumption by machinery such as engines, generators and compressors. The combustion of fuel results in the generation of greenhouse gases such as CO_2. These gases trap the energy of the sun and results in the greenhouse effect i.e. a rise in the Earth's temperature.

CO_2 emissions from fuel consumption for the Staatsolie Nearshore Drilling Project 2019 were estimated at 17,642 metric tonnes, over a 275-day period (all phases). This volume of CO_2 emissions represents approximately 0.74%, of Suriname's total CO_2 emissions, based on a total CO_2 value of 2,383,550 metric tonnes (2010 estimate; NationMaster 2018).

Emission volumes do not include Green House Gas (GHG) contributions from other potential sources of fugitive emissions. Climate change predictions by the Intergovernmental Panel on Climate Change (IPCC) include a rise in sea-level, an increase in average temperatures, an increase in the frequency of temperature extremes, an increase in the intensity and severity of storms and an increase in the frequency of rainfall extremes (floods and droughts). Precautionary concerns warrant "future proofing" of the potential impact from predicted climate change.

7 MITIGATION, MONITORING & MANAGEMENT PLAN

This Chapter presents Staatsolie's strategies to monitor and manage the potential impacts on the receiving environments from its drilling activities at the well-sites within Nearshore Blocks A to D. Staatsolie is committed to maintaining the highest environmental standards practicable. The monitoring and management procedures that Staatsolie intends to implement will be consistent with national regulations, internationally accepted industry standards and guidelines recommended by the World Bank for offshore oil and gas exploration. Moreover, these procedures will be defensible, practicable and cost-effective.

It is also important to note that the monitoring and management measures identified in this Chapter will form part of Staatsolie's Environmental & Social Management Plan (ESMP). In accordance with World Bank Standards, the ESMP will utilise municipal and industrial management strategies to achieve long-term sustainable development. This will involve the establishment of environmental policies and goal setting, decentralisation policies, promotion of improved performance and management rather than relying solely on pollution control measures, the adoption of best available technology and cost-effective strategies. These must be economically and environmentally feasible. The ESMP will, therefore consist of monitoring and organisational measures that will eliminate and offset environmental and social impacts.

For the purpose of this study, the mitigation, monitoring and management measures and procedures will be described under the following categories:

- Mitigation Measures;
- Monitoring Plan; and
- Management Actions and Plans.

7.1 Mitigation Measures

All anticipated significant adverse environmental impacts identified in Chapter 6 were described in terms of the environmental receptors' response to the potential impact activity with some level of mitigation (hereafter referred to as inherent mitigation), as outlined in the impact assessment for each stressor presented in Chapter 6. Additional or further mitigation is then applied to reduce or eliminate the initial potential impact. Mitigation measures will be employed in order to reduce the initial impacts' significance to as low as reasonably practicable (thereby providing the residual impact rank). Residual impacts are those that remain following the application of mitigation measures, and are reduced in magnitude as a result of the mitigation measure implemented.

The following Sections describe the mitigation measures for each impact including the type of impact to which it relates and the conditions under which it is required. Table 7-1, Table 7-2 and Table 7-3 below show the impact significance matrices for the pre drilling, drilling and post drilling phases of the Project, respectively. These tables reflect the initial (I) impact significance ascertained considering, where applicable, the mitigation inherent in the Project planning and design phase, and the residual (R) impact significance after additional mitigation measures have been implemented. In addition, reference to all statutory requirements, where applicable, will be made for planned events; occupational health and safety matters related to this Project will be the subject of a Health, Safety and Environment (HSE) Plan developed specifically for this Project, prior to Project start-up.

7.1.1 Planned Events

Mitigation measures outlined in this Section will be evaluated from a receptor-based approach (e.g. impacts to water quality, benthic habitats and fauna and air quality, among others). The advantage of this approach is that all appropriate mitigation measures are captured at one time for a single receiving environment, and it avoids duplication of stated mitigation measures within the Chapter.

7.1.1.1 Seabed Physical Nature Mitigation

Potential interactions on the physical nature of the seabed from conductor pipe, drilling and casing placement, installation of the mat-type Jack-up drilling rig and anchoring were identified based on seabed scarring and scouring associated with these activities. Additional potential impacts to the seabed were identified from the deposition of drill cuttings.

The mitigation inherent within the planned Project execution and design, which was considered in order to assess the initial rank of the impact for the stressor positioning of the Jack-up rig (see Section 6.4.1 above), and which resulted in an initial classification of negative and low impact on the seabed, included the following:

- The seabed affected from the installation of the Jack-up drilling rig (sliding of rig supports) will be minimised to a surface area that is as small as practicable. This will be achieved through the adoption of “best practices” with regards to braking technology and system selection as well as taking into consideration environmental variables such as wind and current speeds and directions during the rig installation process. The main concerns for siting a Jack-up drilling rig are the structural adequacy of the rig and the capacity of the soil foundation. The following procedures are recommended to ensure that the rig is safely positioned on-site to minimise impact to it and the surrounding environment; and to mitigate against unplanned events. These procedures are considered to be the ‘best practices’ for siting a Jack-up drilling rig, and include:

- Conducting a site-specific assessment for the rig approach – this includes the evaluation of met-ocean data, including wind, wave and currents to ensure that these parameters are within the design capacity of the rig;
- Conducting geophysical surveys to evaluate the seabed (including bathymetry) to identify obstructions and seabed features; and
- Conducting geotechnical surveys to reveal the general near surface geological features (including shallow hazards) and changes in soil characteristics and stratigraphy (see Section 3.5.2 above).

These assessments will be undertaken to mitigate against rig installation problems such as:

- Punch through;
- Settlement under storm loading or bearing failure;
- Sliding failure;
- Scour;
- Geo-hazards, e.g. sub-surface gas pockets/shallow gas; faults;
- Localised holes; and
- The presence of reefs or archaeological phenomenon, e.g. ship wrecks.

Likewise, the initial potential impact of anchoring during the Project was assessed as negative and low for all phases of the Project. It is important to note that the potential impact of seabed scouring and scarring from the positioning of the mat-type Jack up rig cannot be avoided. The zone of impact may be further reduced if an alternative type of rig is used (e.g. a Jack-up not supported by a mat). However, this may prove infeasible for this Project given the geophysical conditions of the sea floor.

The additional mitigation which will be applied during the execution of this project to further reduce the impact of anchoring to the seabed will include using vessels equipped with dynamic positioning (DP) in preference to anchoring or mooring, where possible. DP systems automatically maintain vessel position through the use of propellers and thrusters and render the use of anchors unnecessary, thereby reducing the potential impact on seabed. However, other impacts from increased air emissions may result.

The mitigation inherent within the planned Project execution and design, which was considered in order to assess the initial rank of the impact of the stressor conductor pipe placement (see Section 6.4.4 above), and which resulted in an initial classification of negative and low impact on the seabed, included that the vertical displacement of seabed sediment and seabed scarring from the piling activities during placement of the conductor pipes will be minimised to a surface area that is as small as practicable. As such, no additional mitigation for this stressor is required.

7.1.1.2 Water Quality Mitigation

Water quality may decrease due to impacts arising from the pre drilling, drilling and post drilling phases of the Project. The release of sanitary and organic waste, solid waste, operational discharge, discharge of drilling muds and cuttings into the marine environment could have an adverse impact on overall water quality. Accidental hydrocarbon and chemical spills were also considered to have a potential adverse significant impact on water quality. Water quality may also be adversely affected by sediment displacement during conductor pipe placement, positioning of the Jack-up rig, anchoring and disposal of excess cement/water mixture (from plugging during well abandonment). Potential impacts on the receiving environment may include increased concentration of suspended solids, increased turbidity, elevated nutrient content, increased BOD_5, hydrocarbon and chemical levels. Possible mitigation methods are discussed below according to only those activities most likely to have an impact on water quality.

7.1.1.2.1 Sanitary and Organic Waste Discharge

The mitigation inherent within the planned Project execution and design, which was considered in order to assess the initial rank of the impact of the stressor disposal of sanitary and organic waste (see Section 6.4.7 above), and which resulted in an initial classification of negative and low on water quality (drilling phase), considered that sanitary and organic waste will be treated by a fully functional and certified Omnipure 12MC unit (see Section 3.5.6.3 above) and will be disposed of in the marine area more than 5.6 km from the shoreline, in accordance with MARPOL 73/78 (Annex IV) requirements. However, Figure 5-170 above in Section 5.5.8 shows that there is the potential for drilling to occur within the protected area of North Commewijne-Marowijne MUMA (Block C). Additionally, Staatsolie has indicated that drilling may potentially occur anywhere within the focus areas, and the focus areas of Blocks B and C do occur within 5 km of the shoreline. As a result of the foregoing, the additional mitigation to keep a low residual impact for this stressor on water quality, is to prohibit discharge of treated sanitary waste at any drilling locations which occur within 5.6 km of the shoreline and within the marine components of protected areas. This waste from these sites only shall instead be collected and transported onshore for disposal at an approved facility, since it is impractical to collect and bring to shore all sanitary and organic waste generated during the Project.

Sanitary and organic waste has been identified as a waste stream to be managed by Staatsolie's Project-specific Waste Management Plan, which is still to be developed for this Project (see Section 7.3.1 below). As such, additional mitigation to maintain a low residual impact will include monitoring of the sanitary effluent stream generated by the Ominpure unit (see Section 7.2.2 below) and the disposal of said stream. This shall be done by a designated representative of Staatsolie, who shall be present on-site for the duration of the Project. Monitoring (prior to discharge, at least once during the drilling phase of the Project, at all drilling locations) and disposal shall therefore be in line with waste management requirements outlined in Staatsolie's Project-specific Waste Management Plan, which will take into account all pertinent local, international and company standards.

7.1.1.2.2 Improper Solid Waste Disposal

Inherent mitigation measures related to the disposal of solid waste were considered for initial assessment of the potential impact of this stressor on the various receptors, inclusive of water quality included:

- During the Project, hazardous and non-hazardous solid waste management (collection, storage and disposal) will occur as per Staatsolie's Project-specific Waste Management Plan to be developed prior to Project execution (see Section 7.3.1 below), and in accordance with '*GFI 611 Solid Waste Handling and Disposal*' (Rev 0; 2002; see Appendix F.1);
- There will be the provision of on-board solid waste storage; and solid hazardous and non-hazardous waste will be stored separately;
- Non-hazardous wastes will be collected in bins located at strategic locations on the rig, which will then be transported to an approved disposal site, as per Staatsolie's Project-specific Waste Management Plan;
- Hazardous waste will be collected in waste storage units and transferred onshore for proper treatment or disposal at an approved landfill as per Staatsolie's Project-specific Waste Management Plan;
- Hazardous waste will be managed via the use of bulk storage by supply contractors;
- No solid waste will be disposed overboard. In the event of accidental overboard disposal of solid waste (such as plastics and metal scraps), it will be immediately recovered, as practicable and within the requirements of health and safety; and
- Food waste shall be macerated and shall display no floating solids prior to discharge (USEPA GOM 2007).

The initial impact assessment therefore considered the improper disposal of solid waste (specifically overboard disposal contrary to that stated in the Waste Management Plan). Thus, the initial classification of the potential impact of improper solid waste and disposal on water quality was cumulative, adverse and low.

Based on this, the additional mitigation to keep this residual impact low will be to have a designated representative of Staatsolie on-board the rig at all times, for the duration of the Project. This representative shall be responsible for ensuring compliance with the requirements of the waste management (collection, storage and disposal) strategies detailed within Staatsolie's Project-specific Waste Management Plan. This Plan must take into account the requirements of Staatsolie's '*GFI 611 Solid Waste Handling and Disposal*' (see

Appendix F.1 and Section 7.3.1.2 below), as well as all pertinent local, international and Staatsolie's HSE standards.

7.1.1.2.3 Operational Discharge

Inherent mitigation measures related to operational discharge were considered for the initial assessment of the potential impact of this stressor on the various receptors, inclusive of water quality, and included:

- All hydrocarbon-contaminated runoff (deck drainage) on the rig will be routed to an oil/water separator, where it will be monitored prior to discharge (see Section 7.2.2 below);
- The effluent stream from the oil/water separator will not be released into the marine environment if:
    - The effluent stream, prior to discharge does not comply with the limits specified in Section 7.2.2 below;
    - the effluent stream contains free oil, as determined by a sheen test conducted prior to discharge (as per USEPA GOM Effluent Limits 2007);
    - the drilling location (rig) occurs within 5.6 km of the shoreline (as per MARPOL 73/78);
    - the drilling location occurs within a protected area; and
- The discharge of bilge water will be prohibited within 5.6 km of the shoreline, in accordance with MARPOL 73/78 requirements and, where discharged, will display no free oil as per USEPA GOM Effluent Limits (2007).

When taking the above into account, the initial potential impact of the stressor operational discharge on water quality was assessed as adverse and low. The additional mitigation required to keep this residual impact low will be to monitor (prior to discharge) the effluent stream from the oil/water separator as per the requirements outlined in Section 7.2.2 below. In order to achieve this, Staatsolie shall have a designated representative on-board the rig who shall be responsible for ensuring compliance with monitoring plan requirements, to be executed by the Drilling Contractor. Operational discharge will not be released into the marine environment in the event of non-compliance.

7.1.1.2.4 Hydrocarbon and Chemical Spills

Inherent mitigation measures related to hydrocarbon and chemical spills were considered for the initial assessment of the potential impact of this stressor on the various receptors, inclusive of water quality, and included:

- Spills will be managed by Staatsolie's Project-specific Emergency Response Plan or ERP (which will be developed prior to Project execution; see Section 7.3.1 below) and Oil Spill Response Plan or OSRP (see Section 7.3.1.2 below and Appendix F.2), which will be updated with the Coastal Environmental Sensitivity Maps in Appendix D.22, prior to Project execution;
- Staatsolie shall gather feedback from the relevant stakeholders (Governmental (NB, NCCR, MAS, Coast Guard); local and international conservation community; fishers (including sport fishers); other marine users (e.g. ports); coastal populations (including farmers), and tourism interest groups on the OSRP, and incorporate, where applicable, any recommendations made;
- Spill response will include, but not be limited to the use of absorbent pads, booms and dispersants which are known to be effective in reducing spill envelop and oil concentration, and these shall be kept on-board the Jack-up drilling rig and support vessels;
- Staatsolie personnel and sub-contractors will be trained in emergency spill response outlined in Staatsolie's ERP and OSRP;
- A BOP stack (ensuring multiple levels of blowout protection via rams and annular preventers) shall be used on each well, and will be tested regularly according to manufacturer's instructions;
- Diesel fuel used for generators and engines will be stored in approved tanks on the rig;
- Diesel will be transported to the rig in approved, covered containers via boat. These containers will be separated and secured to minimise the possibility of spills during fuel dispensing;
- Fuels and chemical storage areas will have secondary containment so that any material that is discharged or leaked from the primary containment will be prevented from reaching outside the system. The utilisation of secondary containment will also aid in the detection and recovery of the discharged material; and
- Accidental spillage during loading will be immediately cleaned up as per Staatsolie's Project-specific OSRP.

When taking the above measures into account, the initial potential impact of the stressor hydrocarbon and chemical spills (upset conditions, i.e. from a well blowout owing to BOP failure or from a spill of diesel from a collision (vessel/vessel or vessel/rig) on water quality was assessed as adverse and high, for the drilling and post drilling phases.

The additional mitigation required to reduce this impact to a residual level of low will include the following:

- Staatsolie shall ensure that a Project-specific Traffic Management Plan is developed and implemented, which shall address the coordination of the movement of Project-related vessels (the rig, project supply vessels, anchor handling tugs, chase boat and crew boat), taking into account vessels belonging to other users of the marine environment, such as fishing and shipping vessels, and vessels related to sea defence);
- Staatsolie shall ensure that monitoring of met-ocean conditions takes place on a daily basis to determine safe working conditions for vessels at sea;
- Bunkering of fuel shall only by done during calm seas;
- Staatsolie shall sub-contract experienced drillers in order to reduce the likelihood of a well blowout;
- Staatsolie shall have in place prior to and throughout Project execution, an oil spill response and support team (OSRL, recently merged with Clean Caribbean & Americas) with an in-country presence (at the relevant shore base), inclusive of a stockpile of materials and equipment as deemed necessary for oil spill response and clean-up;
- This in-country oil spill and response team shall be responsible for a quick spill response time, to potentially reduce the aerial extent of marine waters and shoreline oiled, as per Section 6.4.10 above.

7.1.1.2.5 Drilling Muds and Drill Cuttings Discharge

Inherent mitigation measures related to drilling muds and cuttings discharge were considered for the initial assessment of the potential impact of this stressor on the various receptors, inclusive of water quality, and included:

- No Synthetic Oil Based Mud (SOBM) will be used during drilling, and all WBM drilling fluids/muds will be sourced from a pre-approved list;
- Drill cuttings generated during the drilling process will be brought to the surface by the drilling mud. This will be passed over the mud shaker system where the drill cuttings will be separated from the drilling mud. The drilling mud will then go to the mud tank where it will be reused in the well. The drill cuttings will be washed to remove excess drilling mud, and then discharged to the seafloor; The discharged cuttings consist of small rock particles (gravel size). The drilling mud will also be recycled for subsequent wells;
- There will only be a single discharge of drill muds into the marine environment; after the drilling of the maximum of 10 wells for this Project;
- Drill cuttings will be tested and monitored prior to discharge, for toxicity and the presence of any oil as described in Section 7.2.2 below;
- Treatment of drill cuttings and oily waste generated will be in accordance with USEPA GOM Effluent Limits 2007 guidelines;
- Rig preparation for using WBM will involve the following:
    - Efficient deck drainage whereby oil/mud present will be diverted to a separate holding tank or pit;

- Use of a rig vacuum on-board for cleaning up spills and maintaining rig cleanliness;
- Mud saver subs and buckets would be used to reduce mud loss on the rig floor;
- Drill pipe wipers would be encouraged to reduce mud spilled on the drill floor;
- Pressure washing equipment will be used to speed up the clean-up of spills and reduce the amount of surfactant used to clean the rig; and
- Rubber valves, liners and hoses would be checked to ensure compatibility with base oil and replaced if necessary to prevent mud loss or contamination.

When taking the above measures into account, the initial potential impact of the stressor discharge of drilling muds and cuttings on water quality was assessed as adverse and low.

The additional mitigation required to keep this residual impact low will be to monitor (prior to discharge) drilling muds for LC_{50}-96hr suspended sediment phase (SPP) toxicity and formation oil. For drill cuttings, free oil will also be monitored via a sheen test. Should the limits of these tests be exceeded (as specified in Section 7.2.2 below), there shall be no overboard discharge. Instead, drilling muds collected in holding tanks shall be transported to shore for treatment and disposal by the supplier (re-export) or at an approved onshore facility in Suriname. Drill cuttings shall be stored in approved cuttings boxes and transported to shore for treatment and disposal at an approved onshore facility.

7.1.1.3 Air Quality Mitigation

Air quality impacts will result from a number of Project-related activities which include:

- Emissions generated from internal combustion engines (e.g. generators) on the rig in use during all phases of the Project;
- Emissions from vessel movement to and from the Project site;
- Accidental spills of hydrocarbons in the marine environment; and
- Emissions from vehicular movement onshore, at the various ports/shorebases.

The impact on air quality has been evaluated as adverse and low from all sources identified above, considering no inherent mitigation in the initial impact assessment because rapid dispersion of emissions given met-ocean conditions will occur and the overall contribution of this Project to CO_2 emissions for Suriname was calculated as 0.74% (see Section 6.4.11 and Section 6.6.2 above). Notwithstanding, the following mitigation measures will be implemented to ensure the emission of air pollutants from the Project remains at a low significance:

- Internal combustion engines (rig, vessel and vehicle) will be regularly maintained in accordance with manufacturer's specifications to reduce combustion emissions which include: NO_x, CO, CO_2, SO_2 and particulate matter; and
- Support vessels will originate from the closest port/shorebase to minimise transit time, thereby minimising overall emissions from vessels.

7.1.1.4 Mitigation of Impacts on Benthic Habitats & Fauna

Seabed habitats and associated fauna (benthic macrofaunal, isolated soft coral taxa and benthic fish and shellfish) within the study area will be affected by various activities. This includes: anchoring; installation of the mat-type Jack-up drilling rig; piling for the placement of the conductor pipe; discharge of drilling muds and cuttings; discharge of sanitary and organic waste, improper solid waste disposal; and hydrocarbon and chemical spills.

Removal, crushing and smothering of benthic habitats and fauna can occur during the positioning of the mat-type Jack-up drilling rig, anchoring, conductor pipe placement and drill cuttings deposition on the seafloor, as well as through the improper disposal of larger, heavier components of solid waste which may reach the sea floor. These receptors may also be exposed to biological and chemical impacts as a result of exposure to pathogens from sanitary waste and increased toxicity from hydrocarbons and chemicals, respectively.

Specifically, the physical impacts on benthic fauna from positioning of the mat-type Jack-up rig and anchoring were initially evaluated as adverse and low, taking into account the inherent mitigation measures mentioned in Section 7.1.1.1 above. Crushing and smothering impacts which arise from rig positioning and anchoring cannot be mitigated, and as a result, the only manner in which to further reduce these impacts as a result of anchoring is to use DP vessels instead (see Section 7.1.1.1 above).

The initial physical impacts on benthic fauna from the placement of the conductor pipe was assessed as adverse and low. Given that Project execution already has taken into account the need to minimise the surface area impacted by conductor piling (i.e. inherent mitigation) and the conduct of geophysical surveys to identify sea floor features, no additional mitigation can be recommended, as this impact is unavoidable.

Benthic fauna (benthic fish and shellfish) may also be adversely affected by underwater noise generated during conductor pipe placement, drilling and casing placement (adverse and moderate). See Section 7.1.1.5 below for a discussion of the mitigation measures which would also serve to reduce this initial potential impact from moderate to a low residual impact.
The initial physical impact on benthic fauna from solid waste disposal was evaluated as adverse and low. As indicated in Section 7.1.1.1 above, the additional mitigation to keep this residual impact low will be to ensure that proper monitoring of the disposal of solid waste occurs on-board the rig and

associated vessels at all times, by a designated representative of Staatsolie, who shall be present on-site for the duration of the Project. Monitoring shall be in line with waste management requirements outlined in Staatsolie's Project-specific Waste Management Plan to be developed prior to Project execution (see Section 7.3.1 below), and in accordance with '*GFI 611 Solid Waste Handling and Disposal*' (see Appendix F.1 and Section 7.3.2.1 below). Further mitigation measures against improper solid waste disposal are discussed in Section 7.1.1.2 above.

Benthic fauna may adversely be impacted by discharge of drilling muds and cuttings in 2 ways: from the physical impact of smothering at the discharge point and from changes in water quality (initially adverse and low). The impact of smothering of benthic macrofauna may only be avoided if drill cuttings are not discharged. However, this may prove infeasible, particularly if this waste stream meets the criteria for discharge (no free oil; USEPA GOM Effluent limits 2007). As a result, this smothering impact cannot be mitigated. However, if the discharge criteria of drilling muds and cuttings are met (and taking into account the application of all inherent mitigation for water quality impacts as described in Section 7.1.1.2 above), the bio-chemical/ecological impacts may be alleviated to keep the residual rank of this stressor on benthic habitats and fauna as low.

The initial potential impacts on benthic fauna from the discharge of sanitary and organic waste and hydrocarbon and chemical spills were assessed as adverse, moderate and high, respectively. The primary pathway of effects will be via water quality. The application of additional mitigation described for these stressors in Section 7.1.1.2 will also serve to reduce these impacts to a residual rank of low.

7.1.1.5 Mitigation of Impacts on Marine Mammals, Sea Turtles, Pelagic Fish & Marine and Coastal Avifauna

Occurrences such as hydrocarbon and chemical spills could have potentially adverse impacts on fish, plankton, marine mammals, marine and coastal avifauna and sea turtles during the drilling and post drilling phases, and these were assessed as adverse, direct and high. Additionally, improper discharge of solid waste and sanitary and organic waste discharge were assessed as having an adverse impact of low and moderate significance, respectively. The discharge of drilling muds and untreated drill cuttings as well as operational discharge could also potentially result in negative impacts of low significance to fish, marine mammals, marine and sea turtles. The primary pathway through which these receptors may be affected relates to the valued ecosystem component of water quality. Section 7.1.1.2 above addresses the inherent mitigation considered for the initial impact from these stressors on water quality, and describes additional mitigation measures to be implemented, including various components of monitoring to be executed prior to discharge, where discharge is prohibited if the effluent does not meet the discharge criteria. As a result of the foregoing, the additional mitigation measures recommended for the various waste streams affecting water quality in Section 7.1.1.2 above will also serve to bring the residual impact ranks to these receptors to low.

Noise disturbance from piling activities for the placement of the conductor pipe in the drilling phase was identified as adverse and moderate, particularly with respect to fish and marine mammals (considering no inherent mitigation in the initial impact assessment for this stressor). In order to reduce the impact, ramp up or soft start procedures should be used at all times. The piling will be conducted over a 10-hour period for each well. The soft start procedure, which involves a gradual increase in sound pressure to full operational levels, should be implemented each time there is a break in operations which generate the sound. Prior to implementing the soft start procedure, a 500 m zone around the rig should be surveyed visually by Marine Mammal Observers (MMOs, whose sole function during the execution of the Project is to observe the marine area for signs of marine mammals and sea turtles), ideally for a period of 30 minutes prior to start up (BOEM 2016). In the event that there may be any marine mammals sighted, the start-up procedure should be postponed until the marine mammals have cleared the 500 m zone. It is not necessary to stop the piling operation if it is already underway and marine mammals come within 500 m. Underwater noise monitoring will also be conducted during drilling as outlined in Section 7.2.2.4 below.

Other methods of mitigation are available to reduce underwater sound from piling and they including the drilling of the conductor pipe and cementing the conductor in place, pending feasibility, based on the results of the geophysical and geotechnical surveys to be executed prior to Project-start up; enclosing the ramming pile with acoustically isolated material (e.g. plastic); installation of air bubble curtains around the pile; a combination of both methods; or extending the duration of the impact during pile driving (OSPAR 2009). However, all these methods have costs as well as benefits and the short duration of the piling coupled with the long interval in between drilling the 10 wells does not warrant more complex or costly mitigation measures. With mitigation in place, the impact will be reduced to low.

Noise levels from vessel movements and the drilling activity itself are not considered to be significant and so no mitigation is required. Additionally, noise levels from the impact of the anchor on the seafloor was initially found to be adverse and low on the receptors, marine mammals, sea turtles and pelagic fish during the drilling phase (and low for the pre drilling and post drilling phases). This impact can only be mitigated through the use of DP vessels (see Section 7.1.1.1 above).

Marine mammals and sea turtles may also be adversely impacted by vessel movement within the offshore area, these impacts relating to physical damage as a result of collisions with moving vessels (adverse and moderate, considering no inherent mitigation in the initial impact assessment for this stressor). To mitigate this impact so that it is reduced to a residual rank of low for these receptors (based on ESL's experience and best judgement, in conjunction with Staatsolie), it is recommended that MMOs should be placed on-board the various Project-related vessels to continually survey the area surrounding the drilling operations at each well-site. Alternatively, a crew member of each vessel may be designated as a lookout for marine mammals and sea turtles. Should any be sighted, vessels shall either stop to allow the passage of the animal(s), or slow down and move out of the way. These measures will be implemented to ensure that the likelihood of collisions is reduced.

7.1.1.6 Mitigation of Impacts on Fisheries & Fishers

Fisheries and fishers may be adversely affected by increased vessel movement within the zones demarcated for fishing within the Nearshore and offshore areas, through restrictions in the areas in which fishers may operate, or through damage of set fishing nets which have drifted into restricted areas. The inherent mitigation measures related to vessel movement which were considered for the initial assessment of the potential impact of this stressor on fishing and resource users (fishers) included:

- The enforcement (by chase vessel) of a voluntary exclusion zone 500 m in radius, surrounding each drilling location (rig);
- The enforcement of an exclusion zone along the established routes for Project related vessels as they transit between the ports/shorebases and the rig location; and
- Formal (published) communications between Staatsolie (via MAS) and the relevant users of the marine areas (fishers) through the issuance of Mariner’s Notices and via the media; and
- Fish representatives will be on-board the support vessels to have direct communications, where possible, with fishers or representatives of fishers’ organisations.

When taking the above measures into account, the initial potential impact of the stressor vessel movement on fisheries and fishers was assessed as adverse, indirect and moderate. The additional mitigation measures required to reduce this impact to residual level of low significance include the development and implementation of a Project-specificTraffic Management Plan, which, in part, shall specifically address the coordination of the movement of Project-related vessels (the rig, project supply vessels, anchor handling tugs, chase boat and crew boat) and fishing vessels. Staatsolie has compensation guidelines that apply in cases where it can be proven that stakeholders will lose income or property as a result of Staatsolie’s activities.

Fisheries and fishers may also be adversely affected by discharge of sanitary and organic waste (adverse and moderate), operational discharge (adverse and low), improper solid waste disposal on fisheries (adverse and low), discharge of drilling muds and cuttings (initially adverse and low) and hydrocarbon and chemical spills (initially adverse and high). These impacts will be indirect (with the exception of hydrocarbon and chemical spills, which has an additional direct impact discussed further below), since the stressors will affect pelagic and benthic fish and shellfish, which are the fishers' source of income and livelihood. The main pathway through which these waste streams will impact fish (and so fisheries and resource users) will be water quality. As a result, the additional mitigation recommended in Section 7.1.1.2 above will serve to reduce/keep the residual impact to low.

Hydrocarbon and chemical spills may directly impact upon fishers through the oiling of nets or indirectly through restrictions in areas which can be fished owing to oily waters. These can result in reduced income. Spills may also result in the need for emergency resources which have knock-on effects to fishers and other users of the marine area. In addition to the mitigation measures for this stressor listed in Section 7.1.1.2 above, this impact (adverse, high) may further be reduced (low), through the development and implementation of a Project-specific Traffic Management Plan (as described above). Additional mitigation will also include:

- A clear strategy and methodology for communications between Staatsolie and stakeholders will be developed within a Project-specific Community Relations Plan or CRP (see Section 7.3.1 below) to be developed prior to Project implementation;
- In order to ensure the safety of fisher folk and minimise disturbance to fishing activity, good communication and open dialogue will be established and maintained between Staatsolie and the fisher folk for the entire duration of the Project. This will be facilitated via a Community Liaison Officer employed by Staatsolie;
- Staatsolie's Community Liaison Officer will provide notification to the fishers within 14 days prior to the commencement of the activity, including the GPS locations of proposed activities;
- Staatsolie will continue to work with and engage all stakeholders, in particular the ones who engage in activities near the Project area, throughout the Project;
- Project activities will take place over the shortest time period required;
- If possible, Project activities will take place in a manner which will minimise conflict between Staatsolie and fisher folk (particularly conflicts related to vessel movements). Open communication will be maintained via the Community Liaison Officer, who shall communicate with the fishing communities in matters relating to claims and compensation (one of the major losses to fishermen include the destruction of driftnets as a result of vessel movement in the area), and noting the concerns of the fishermen; and
- Staatsolie shall liaise with MAS and Coast Guard on periodic monitoring of activities in the Nearshore area during the execution of the Project.

Fisheries and fishers may also be indirectly adversely affected by potential negative impacts to benthic and pelagic fish from noise associated with piling. Mitigation measures against these effects are outlined in Section 7.1.1.4 and Section 7.1.1.5 above.

7.1.1.7 Mitigation of Impacts on Protected Areas, Sensitive Ecosystems, Terrestrial Fauna, Recreation and Tourism & Resource Users

Initial impacts to protected areas, sensitive ecosystems, terrestrial fauna were identified as adverse and high for the drilling and post drilling phases, and adverse and low for recreational and tourism (bird watching), and resource users (tourists and beekeepers), as a result of hydrocarbon and chemical spills. In addition, the impact of improper disposal of solid waste and discharge of sanitary and organic waste on protected areas and sensitive ecosystems was evaluated as adverse and low. This initial assessment took into account the inherent mitigation measures relevant to the various stressors as described in Section 7.1.1.2 above. Thus, the additional mitigation measures described in Section 7.1.1.2 will also serve to reduce the impact of this stressor on these receptors to a residual impact rank of low.

7.1.1.8 Mitigation of Impacts on Emergency Resources, Marine Ports and Traffic and Other Resource Users

Impacts to emergency resources, marine ports and traffic and other resource users (other marine users such as shipping vessels and sea defence) have been identified as negative and high as a result of hydrocarbon and chemical spills during the drilling and post drilling phase of the Project, where marine ports and traffic and other resource users would be affected by increased vessel traffic within the Project area (such that they may not be able to operate or they may become oiled). This initial impact assessment considered the inherent mitigation measures presented in relation to hydrocarbon and chemical spills as presented in Section 7.1.1.2 above. As a result, the additional mitigation measures related to this stressor, as stated in Section 7.1.1.2 above will also serve to reduce the residual rank for this receptor to low. Additional mitigation measures which will also be applied towards this same end will include the following:

- Staatsolie shall ensure that a Project-specific Traffic Management Plan is developed and implemented, which shall address the coordination of the movement of Project-related vessels (the rig, project supply vessels, anchor handling tugs, chase boat and crew boat), taking into account vessels belonging to other users of the marine environment, such as fishing and shipping vessels, and vessels related to sea defence); and
- The mitigation measures listed in Section 7.1.1.6 above with respect to community relations as a result of the impact of hydrocarbon and chemical spills on fishers operating in the marine area.

Marine ports and traffic and other resource users may also be adversely affected by improper discharge of solid waste (low). The impacts of this activity on these receptors will be mitigated by the additional mitigation measures outlined in Section 7.1.1.2 above.

7.1.1.9 Mitigation of Impacts on Archaeological Resources (Shipwrecks)

Impacts to shipwrecks on the sea floor within the study area have been identified as negative and low as a result of hydrocarbon and chemical spills during the drilling and post drilling phase of the Project (considering that geophysical surveys will be conducted and preliminary drilling locations will not be sited in close proximity to a shipwreck). Nonetheless, in order to ensure the significance of this impact remains low, the following mitigation measures will be put in place:

- Establish the locations of shipwrecks within a 5 km buffer surrounding each preliminary drilling location, and set a buffer around identified shipwrecks, within which no drilling will occur; and
- Liaise with the Ministry of Education, Science and Culture as a key stakeholder in determining actions going forward in the event that a potential drilling location is in the vicinity of a shipwreck, with a view to establishing a plan to manage the impacts of a potential spill of hydrocarbons on shipwrecks from the nearby drilling location.

7.1.1.10 Mitigation of Impacts on Human Health

Adverse impacts to human health may arise from hydrocarbon and chemical spills (high), discharge of sanitary and organic waste (moderate) and from vessel movement, operational discharge, and conductor pipe, drilling and casing placement (noise; low). Reduced air quality may also impact human health emissions from spills and vessel, vehicle and machinery operations during the Project. The initial impact assessment took into account the relevant inherent mitigation measures for these stressors as listed in Section 7.1.1.2 (water quality), Section 7.1.1.5 (noise from piling) and Section 7.1.1.6 (vessel movement) above. As such, the additional mitigation measures listed under these sections also serve to reduce the initial impact to a residual level of low. Additional measures to mitigate the impacts on human health from noise from piling and drilling include the provision of requisite and appropriate PPE for avoidance of hearing damage. Measures to mitigate the impact on human health by degraded air quality from exhaust for vessel and vehicular movement are described in Section 7.1.1.3 above.

Table 7-1: An Impact Significance Matrix between the Proposed Pre Drilling Project Activities and the Receiving Environment

RECEIVING ENVIRONMENT		PRE DRILLING PHASE – Transport & Installation of Rig																	
		Vessel Movement (Physical movement, Gas Emissions & Noise)		Solid Waste Disposal*		Operational Discharge		Hydrocarbon & Chemical Spillage		Positioning of Jack-up Rig		Anchoring (Rig & all support vessels)		Discharge of Sanitary & Organic Waste		Rig &Vessel Illumination		Vehicular Movement – Onshore (Gas Emissions & Noise)	
		I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R
Physical Environment	Seabed (Physical Nature)			N						L		L							
	Mudflats			U				N											
	Freshwater Quality																		
	Marine Water Quality			L		N		M	L	L		L		L					
	Marine Sediment Quality							L						L					
	Air Quality	L						L										L	
	Sound Quality (Above water)	N																L	
	Sound Quality (Below water)	N								L		L							
	Soil Quality (Onshore)																		
Biological Environment	Offshore Soft-Bottom Macrobenthos			L				N		L		L		L					
	Soft Coral Taxa (Isolated)			L				N											
	Benthic Fish and Shellfish	N		L				M	L	L		L		L					
	Marine Mammals	M		L		N		M	L	N		N		L					
	Sea Turtles	M		L		N		M	L	N		N		L					
	Pelagic Fish & Plankton	N		L		N		M	L	N		N		L		N			
	Marine & Coastal Avifauna	N		L		N		M	L					L		N			
	Terrestrial Fauna							N											
	Protected Areas (NRs & MUMAs)	N		U				N						N					
	Other Sensitive Ecosystems (Mudflats, Mangroves, Lagoons & Swamps)			U				N						N					
Socio-cultural Environment	Resource Users	L		L		N		M	L					L					
	Employment, Income & Labour Market							N											
	Fisheries	L		L		N		M	L					L		N			
	Recreation & Tourism	N		U				L											
	Archaeological & Historical Resources							N											
	Marine Ports & Traffic	N		L				L											
	Road Infrastructure & Traffic																	L	
	Human Health	L				N		M	L					L				L	
	Emergency Resources							M	L									L	

**Impacts associated with this stressor was discussed as cumulative*

Impact Classification	Symbol
Low/Minor	L
Moderate/Medium	M
High	H
Negligible	N
Unknown	U

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Table 7-2: An Impact Significance Matrix between the Proposed Drilling Project Activities and the Receiving Environment

	RECEIVING ENVIRONMENT	DRILLING PHASE																					
		Discharge of Water Based Drilling Muds & Cuttings		Vessel Movement (Physical movement, Gas Emissions & Noise)		Solid Waste Disposal*		Operational Discharge		Hydrocarbon & Chemical Spillage		Discharge of Sanitary & Organic Waste		Disposal of Excess Cement/Water Mixture		Rig & Vessel Illumination		Conductor Pipe, Drilling & Casing Placement (Physical Placement, Gas Emissions & Noise)		Vehicular Movement-Onshore (Gas Emissions & Noise)		Anchoring (PSVs & Crew/Chase Boat)	
		I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R
Physical Environment	Seabed (Physical Nature)	N				N												L				L	
	Mudflats					U				H	L												
	Freshwater Quality																						
	Marine Water Quality	L				L		L		H	L	L		L				N				L	
	Marine Sediment Quality	L								L		L						N					
	Air Quality			L						L								L		L			
	Sound Quality (Above water)			N														M	L	L			
	Sound Quality (Below water)			L														M	L			L	
	Soil Quality (Onshore)																						
Biological Environment	Offshore Soft-Bottom Macrobenthos	L				L				M	L	L						U	U			L	
	Soft Coral Taxa (Isolated)					L				N													
	Benthic Fish and Shellfish	L		N		L		L		H	L	L						M				L	
	Marine Mammals	L		M	L	L		L		H	L	L		L				M	L			L	
	Sea Turtles	L		M	L	L		L		H	L	L		L				M	L			L	
	Pelagic Fish & Plankton	L		N		L		L		H	L	L		L		N		M	L			L	
	Marine & Coastal Avifauna			N		L		L		H	L	L				N		L					
	Terrestrial Fauna									H	L												
	Protected Areas (NRs & MUMAs			N		U				H	L	N						N					
	Other Sensitive Ecosystems (Mudflats, Mangroves, Lagoons & Swamps)					U				H	L	N											
Socio-cultural Environment	Resources Users	L		M	L	L		L		H	L	L						L					
	Employment, Income & Labour Market									M	L												
	Fisheries	L		M	L	L		L		H	L	L				N		L					
	Recreation & Tourism			N		U				L								N					
	Archaeological & Historical Resources									L													
	Marine Ports & Traffic			L		L				H	L												
	Road Infrastructure &Traffic																			L			
	Human Health			L				L		H	L	L						L		L			
	Emergency Resources									H	L									L			

**Impacts associated with this stressor was discussed as cumulative*

Impact Classification	Symbol
Low/Minor	L
Moderate/Medium	M
High	H
Negligible	N
Unknown	U

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Table 7-3: An Impact Significance Matrix between the Proposed Post Drilling Project Activities and the Receiving Environment

		POST DRILLING PHASE – Well Abandonment, Demobilisation & Transport of Rig																					
		Vessel Movement (Physical movement, Gas Emissions & Noise)		Solid Waste Disposal*		Operational Discharge		Hydrocarbon & Chemical Spillage		Discharge of Sanitary & Organic Waste		Disposal of Excess Cement/Water Mixture		Rig & Vessel Illumination		Rig Removal		Vehicular Movement-Onshore (Gas Emissions & Noise)		Anchoring (All support vessels)	
		I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R	I	R
Physical Environment	Seabed (Physical Nature)			N																L	
	Mudflats			U				H	L												
	Freshwater Quality																				
	Marine Water Quality			L		L		H	L	L		L				L				L	
	Marine Sediment Quality							L		L											
	Air Quality	L						L										L			
	Sound Quality (Above water)	N																L			
	Sound Quality (Below water)	N																		L	
	Soil Quality (Onshore)																				
Biological Environment	Offshore Soft-Bottom Macrobenthos			L				M	L	L										L	
	Soft Coral Taxa (Isolated)			L				N													
	Benthic Fish and Shellfish	N		L				H	L	L						L				L	
	Marine Mammals	M	L	L		L		H	L	L		L				L				N	
	Sea Turtles	M	L	L		L		H	L	L		L				L				N	
	Pelagic Fish & Plankton	N		L		L		H	L	L		L		N		N				N	
	Marine & Coastal Avifauna	N		L		L		H	L	L				N							
	Terrestrial Fauna							H	L												
	Protected Areas (NRs & MUMAs)	N		U				H	L	N											
	Other Sensitive Ecosystems (Mudflats, Mangroves, Lagoons & Swamps)			U				H	L	N											
Socio-cultural Environment	Resource Users	L		L		L		H	L	L											
	Employment, Income & Labour Market							M	L												
	Fisheries	L		L		L		H	L	L				N							
	Recreation & Tourism	N		U				L													
	Archaeological & Historical Resources							L													
	Marine Ports & Traffic	N		L				H	L												
	Road Infrastructure & Traffic																	L			
	Human Health	L				L		H	L	L								L			
	Emergency Resources							H	L									L			

**Impacts associated with this stressor was discussed as cumulative*

Impact Classification	Symbol
Low/Minor	L
Moderate/Medium	M
High	H
Negligible	N
Unknown	U

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7.2 Monitoring Plan

Staatsolie is committed to the implementation and completion of the Nearshore Exploration Drilling Project 2019 in accordance with the highest environmental standards. Their goal is to maintain this throughout the duration of the Project by implementing an environmental monitoring programme. This Section summarises the proposed monitoring plan for the Project. The objectives of the monitoring plan are as follows:

- To assess the actual coastal Nearshore and offshore impacts of the proposed Project;
- To evaluate the effectiveness of the inherent and additional mitigation measures that have been proposed to minimise the environmental impact of the Project;
- To ensure environmental compliance with relevant local, international and company requirements; and
- To provide feedback to Staatsolie on learnings for other future projects.

To achieve these objectives, Staatsolie will undertake the following:

- Post drilling environmental monitoring: sampling of water, sediment and benthic organisms will be conducted to determine and evaluate change in the environment. Results of post drilling monitoring will be compared to the results of the baseline assessment conducted in 2017 (i.e. the 2017 baseline dataset will serve as the pre drilling dataset); and
- Environmental monitoring during the drilling process: sampling of effluents entering the water column and seabed sediments will be collected and quantitatively analysed to ensure compliance with applicable local and international standards.

These surveys are described in more detail below.

7.2.1 Post Drilling Environmental Monitoring

To determine and evaluate the change in the environment, it is proposed that marine surveys should be conducted 6 weeks after drilling has been completed (post drilling). Data collected from post drilling (6 weeks after drilling) will be compared to the 2017baseline (pre drilling) data. A single sampling event will take place for post drilling. Further monitoring of the study area will only occur if indicated as necessary by initial monitoring findings.

The results of the water quality assessment (see Section 5.3.10.3 above) indicated that stations at which the highest parameter levels occurred within Block C, proximally to the drilling locations therein, as well as at the westernmost drilling location within Block B (further offshore) and the one closest to shore. Additionally, comparisons made between 2017 and 2013 data revealed that nitrites and phenols in water were higher in 2017 as compared to 2013, within the western portion of Block C.

Likewise, within sediment, relatively higher levels of the total metals, chromium, lead, zinc and mercury coincided with preliminary drilling locations within Block C during the long wet season, and these parameters also exceeded their respective USEPA Benchmarks during this season. Along with aluminium, these 4 metal parameters were recorded at higher levels in 2017 as compared to 2013 (see Section 5.3.9.3 above). As a result of the foregoing, these sediment parameters will be monitored (at a minimum) during the post drilling environmental monitoring programme. Overall, the parameters listed below will be evaluated. As specified above, post drilling results will be compared to 2017 baseline (pre drilling) results. The results of the sediment quality analyses (post drilling) will also be compared to the USEPA 2006 Mid-Atlantic Risk Assessment Marine Sediment Screening Benchmarks for total metals (see Table 7-4 below).

- Water:
    - Aluminium[39]
    - Ammoniacal Nitrogen
    - Arsenic
    - Barium
    - Cadmium
    - Chemical Oxygen Demand
    - Chromium
    - Specific Conductivity
    - Copper
    - Dissolved Oxygen
    - Iron
    - Lead
    - Nickel
    - Nitrate
    - Nitrite
    - pH
    - Salinity
    - Temperature
    - Chlorophyll
    - Total Oil and Grease
    - Total Residual Chlorine
    - Total Phenolic Compounds
    - Total Phosphorus
    - TPH
- Sediment:
    - Cadmium
    - Chromium
    - Hexavalent Chromium
    - Lead
    - BTEX
    - Sediment Grain Size
    - TPH
    - Zinc
    - Mercury
    - Barium
    - Aluminium

[39] *The total and bioavailable forms of all metals in water and sediment shall be tested.*

    - TSS
    - Zinc
    - Hexavalent chromium
    - Mercury
- Benthic macrofauna; and
- Plankton.

Six sampling stations will be strategically placed with respect to each proposed drilling location and in relation to the prevailing current and wind axis. The proposed sampling design for each well-site is illustrated in Figure 7-1 below.

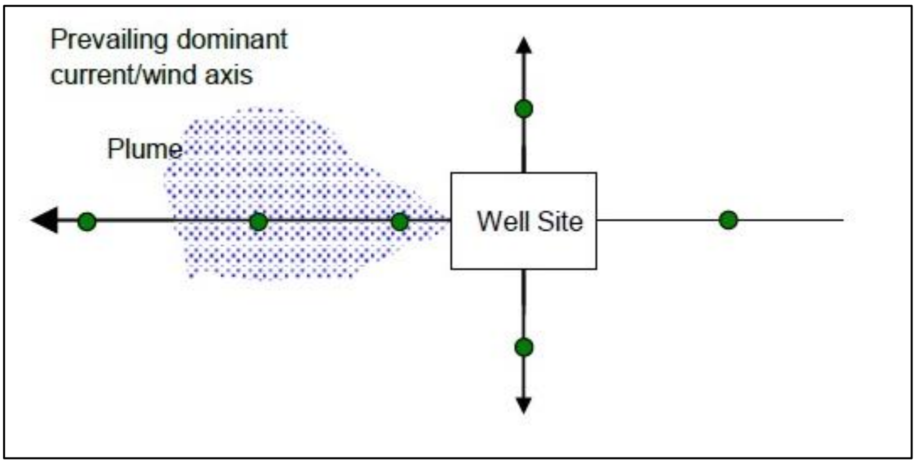

Figure 7-1: Diagram of a Proposed Sampling Design for Proposed Drilling Location within Blocks A to D, for Pre and Post Drill Environmental Monitoring

Table 7-4: Sediment Quality Parameters and Their Respective USEPA 2006 Sediment Screening Benchmarks

Parameter	USEPA Benchmark (mg/kg)
Arsenic	7.24
Cadmium	0.68
Chromium	52.30
Copper	18.70
Lead	30.20
Mercury	0.13
Nickel	15.90
Zinc	124.0

7.2.2 Environmental Monitoring During Drilling

This section focuses on monitoring the sewage (rig and support vessels), hydrocarbon and operational discharges and drilling muds and drill cuttings discharged into the environment during the drilling phase of the Project. The proposed parameters to be monitored and the standards with which to compare results are identified in the relevant sub-sections below. Sampling will take place at least once during the drilling phase of the Project, at all drilling locations, unless specified differently in the relevant sections below.

7.2.2.1 Hydrocarbon, Chemical Spills and Operational Discharges

Notwithstanding the fact that the impact of operational discharge on the various receptors has been evaluated as low during the initial impact assessment exercise for all phases of the Project, the potential adverse impacts as a result of an accidental spill of oil and or diesel was found to be high. As a result, the following additional monitoring requirements will be essential for the Project to ensure the inherent mitigation is sufficient:

- The effluent stream of the oil/water separator shall be monitored (at the discharge point) prior to discharge for TPH at least twice during the drilling phase of the activity; once at the start and once at the end of drilling;
- The level of TPH contained within the sampled effluent shall not exceed 15 mg/l (as per MARPOL 73/78 requirements);
- The effluent stream of the oil\water separator shall be subjected to a sheen test;
- The sheen test will be deemed to have failed if there is free oil (as per USEPA GOM Effluent Limits 2007) contained in the sample (>50% sheen over the surface area of the sample within the sample container);
- The effluent stream shall not be discharged if the level of TPH in the sample exceeds 15 mg/l or if the sheen test has failed;
- Chemical and oil storage areas located on the drilling rig will be inspected on a daily basis in order to ensure that secondary containment is structurally sound and free from defects; and
- Internal environmental audits will be carried out in accordance with Staatsolie’s requirements.

7.2.2.2 Drilling Mud and Cuttings Discharge

Drilling mud samples (taken from holding tanks prior to discharge) will be subject to toxicity testing as well as to determine formation oil content. LC_{50}-96hr toxicity tests shall be carried out on the suspended particulate phase of drilling muds, from a sample obtained at the end of the life of the drilling mud (assumed to be after the completion of the drilling of all 10 wells for this Project). Water based muds shall not be released if the result of this LC_{50}-96hr SPP toxicity test exceeds 30,000 ppm (USEPA GOM 2007). The drilling mud sample shall also be tested to ensure that there is ≤ 1% formation oil (using a sheen test) prior to discharge (USEPA GOM 2007).

For the drill cuttings, a sheen test shall be carried out on a sample obtained after the completion of every hole section of each well drilled. There shall be no free oil upon discharge of drill cuttings (as per USEPA GOM Effluent Limits 2007).

7.2.2.3 Sewage Discharge

The monitoring of sewage effluent from the rig and support vessels is required to ensure that the residual impact of this stressor is kept low for this Project. Therefore, prior to discharge, sewage effluent from the rig's Omnipure unit and the vessel's holding tanks will be tested at the point of discharge for the parameters, pH, temperature, BOD_5, TSS, faecal coliforms and total residual chlorine. Sewage effluent shall not be discharged from the rig or support vessels to the marine area if these parameters do not meet the limits specified in Table 7-5 below (based on the 2^{nd} Schedule of the Trinidad & Tobago Water Pollution Rules (TTWPR), 2001 (as amended) and the USEPA Gulf of Mexico (GOM) Effluent Limits, 2007).

Additional monitoring requirements are outlined below:

- Testing for the level of total residual chlorine will occur as required (i.e. prior to discharge;
- Discharge of sewage effluent will not occur if total residual chlorine is > 2 mg/l (TTWPR 2001; but see Table 7-5 below) and if floating solids or foam is visible (USEPA GOM Effluent Limits, 2007);
- To ensure compliance of the Jack-up drilling rig and support vessels with statutory requirements, as well as the efficient functioning of the Omnipure unit, effluent samples will be collected and tested twice during the drilling phase of the Project: once at the start and once at the end of drilling.

In addition to the foregoing, Staatsolie shall have a designated representative on-board the rig to ensure that discharge of sanitary effluent only occurs more than 5.6 km from the shoreline, as per MARPOL 73/78 Annex IV requirements. This representative shall also ensure that no discharge occurs within a protected area.

Table 7-5: Maximum Permissible Limits (IMO, TTWPR 2001 & USEPA GOM 2007) for the Monitoring of Sewage Effluent from the Point of Discharge of the Rig (Omnipure Unit) and Support Vessels

Parameter	Sanitary & Organic Waste Discharge Standards		
	IMO Annex A of Resolution MEPC 2(6) 1976	TTWPR 2001, 2nd Schedule (as amended) Marine Offshore (> 5km from HWM)	USEPA (2007) Effluent Limit in GOM
COD (mg/l)		250	
pH		6 – 9	
Ammoniacal Nitrogen (mg/l)		10	
Total phosphorus (mg/l)		5	
BOD_5 (mg/l)	50*	100	
TSS (mg/l)	100*	200	
Total Residual Chlorine (mg/l)	As low as practicable	2*	1
Faecal Coliforms (counts per 100 ml)	250*	400	
Solids			No floating solids

**This standard takes precedence where multiple standards are available*

7.2.2.4 Underwater Noise Monitoring

The monitoring of underwater noise is required to ensure that the levels of noise from drilling to which the receptors, marine mammals and sea turtles are exposed does not cause undue harm during the execution of this Project. A single underwater noise monitoring study shall be conducted during drilling (piling and drilling) at a single well location (to be recommended by the Contractor selected to conduct said study). This study shall assess the levels of underwater noise during active drilling within the band width and frequency levels (recommended by the Contractor) so as to ascertain a comparison to the underwater acoustic thresholds for onset of Permanent and Temporary Threshold Shifts (PTS and TTS) recommended by the National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS 2016; and NMFS; n.d.).

7.3 Management Actions & Plans

This Section describes the Management Actions and Plans which are proposed for the Staatsolie Nearshore Exploration Drilling Project 2019, and provides a summary of available supporting action and planning documentation which will supplement Project-specific plans listed below.

7.3.1 Project-Specific Plans

For this Project, the following plans will be generated prior to the execution of the Project and will address the strategy for dealing with potentially adverse impacts identified in Chapter 6 and mitigated as proposed in Section 7.1 above. These will include:

- Environmental and Social Management Plan (ESMP);
- Oil Spill Response Plan (OSRP);
- Emergency Response Plan (ERP);
- Waste Management Plan (WMP);
- Traffic Management Plan (TMP); and
- Community Relations Plan (CRP).

The ESMP and OSRP are further described in the sub-sections below; the ERP, WMP, TMP and CRP will be provided to NIMOS subsequent to the approval of the ESIA but prior to Project execution.

7.3.1.1 ESMP

The ESMP is a framework management plan for the drilling Project, which seeks to identify and manage existing health, safety, environmental and social impacts resulting from the Project and the mitigation measures implemented to eliminate or reduce these potential impacts (see Appendix F.3).

This ESMP includes the following:

- The aims and objectives for which the ESMP is designed;
- The roles and responsibilities of each individual;
- The location of Blocks A to D in relation to the wider study area, and short descriptions of the Project and the environmental setting (baseline conditions);
- The potential impacts of the drilling Project;
- The mitigation measures that will be implemented to eliminate or reduce these potential impacts;
- The waste management strategies relating to the treatment and disposal of residuals from the drilling operations;
- Loss prevention and hazard control analysis;
- Emergency Response Planning; and
- Environmental monitoring requirements after Project execution.

As part of this drilling activity, Staatsolie intends to adopt and fully implement Best Available Technologies (BAT) and Best Practicable Environmental Options (BPEO) to avoid, mitigate or remedy all potential impacts arising from the drilling Project to ensure that the safety of all persons and the protection of the environment are maintained.

Staatsolie, as part of its implementation plan for managing and mitigating potential environmental and social impacts associated with the drilling Project, will adhere to all national regulations, internationally accepted industry standards and practices and World Bank Guidelines for drilling activity that are considered to be feasible as well as cost-effective.

This ESMP will strive to control, mitigate and monitor potential environmental and social impacts, hazards and risks and will incorporate the following:

- Providing the necessary resources to ensure that the health and safety of all persons and stakeholders involved in the drilling operations are upheld and maintained;
- Guiding the principle that the health, safety and the environment takes precedence over all operational matters at all times;
- Promoting a "Zero Tolerance" culture with respect to degradation of the marine and near coastal environment;
- Providing adequate information, training, supervision and instruction necessary to all parties involved to enable them to carry out their tasks competently and safely, and to the best of their ability;
- Providing engineering controls to minimise the risk associated with mechanical and physical hazards, in strict accordance with applicable Industry Standards;
- Inspecting and evaluating worksites to ensure that there is adequate protection of the environment, property and the public; and
- Ensuring that personnel, inclusive of stakeholders and contractors, are aware of the impacts associated with the drilling operation and the procedures to follow during an emergency.

7.3.1.2 OSRP

Staatsolie has contracted Oil Spill Response Limited (OSRL) to develop an OSRP specific to the operational activities for the Nearshore Exploration Drilling Project 2019 (see Appendix F.2), inclusive of the coastal environmental sensitivity maps developed for this Project (see Appendix D.22). The OSRP will cover the following exploration drilling operations:

- Drilling: oil spills arising from exploration drilling activities for Blocks A to C;
- Ports and harbours: oil spills arising from activities associated with ports and harbours;

- Oil storage: oil spills arising from the storage of oil (i.e. marine diesel, lubrication and hydraulic oils stored at the shore base, on vessels and on the drilling rig); and
- Field support: oil spills arising from activities involving field support vessels (i.e. vessels involved in supporting the rig during the drilling operation).

The OSRP will utilise the Incident Command System (ICS) under a tiered response concept to contain, recover and clean up oil spills. The OSRP will outline the following steps:

- Assess the spill;
- Mobilisation and initiation;
- Establish organisation;
- Reporting and notification;
- Assess situation, decide on response technique and implement response;
- Monitor and review effectiveness of response; and
- Deactivate and debrief.

These steps will be used together by the members of the Drilling Contractor Emergency Response Team and Staatsolie's Incident Management Team (IMT) to produce an effective response operation.

7.3.2 Available Supporting Documentation

This Section provides short summaries on the following documentation which is meant to supplement the plans identified in Section 7.3.1 above:

- GFI 611 Rev 0 Solid Waste Handling and Disposal;
- GFI 210 Rev 1 Handling of Hazardous Chemicals;
- GFI 105 Rev 1 Routine Safety Talks;
- GFI 106 Rev 3 HSE and Security Induction for New Arrivals; and
- GFI 110C Incident Reporting and Investigation;

7.3.2.1 GFI 611 Rev 0 Solid Waste Handling and Disposal

Staatsolie is dedicated to continuously applying responsible and effective waste management to minimise the risk of health, safety and environmental incidents and liabilities that may be caused by waste. To this end, Staatsolie has developed general field instructions (GFI) on solid waste handling and disposal. The objective of this GFI is to reduce the creation of waste to a minimum and to process the waste that nevertheless originates in a safe and environmentally friendly manner. Through the use of this GFI, Staatsolie expects that all employees will contribute to reducing waste.

This GFI provides guidance for solid waste handling and disposal requirements for specific categories of waste. For this Project, some of these applicable streams include: oil spill clean-up materials, oily sorbents, paper and paper products; plastic and glass containers and drilling cuttings (see Appendix F.1). The Health, Safety and Environmental (HSE) Division will provide detailed guidance for the handling and disposal of other waste at the request of the waste generator. It is expected that all waste generators exercise “due care” in handling and disposing of waste.
The management system for solid waste management includes the following:

- Definition of terms;
- Waste management methods;
    - Source Reduction;
    - Reuse;
    - Recycling/Recovery;
    - Disposal;
    - Open dumping;
    - Open burning;
    - Burial;
    - Storage; and
    - Land spreading;
- Waste handling;
    - Preparation for removal;
    - Removal; and
    - Handling of waste for reuse.

7.3.2.2 GFI 210 Rev 1 Handling of Hazardous Chemicals

Many chemicals that are used in the industry can be hazardous to personnel and the environment if they are not handled and controlled properly. To this end, Staatsolie has developed a GFI on the handling of hazardous chemicals (see Appendix F.4). The GFI describes the management system for the selection, approval, handling and disposal of all such hazardous chemicals used by Staatsolie, which includes:

- Definition of terms;
- Selection and approval of hazardous chemicals;
    - Approval process;
    - Request;
    - Review;
    - Approval; and
    - Records;
- Availability of information;
    - Safety Data Sheet (SDS);
    - Hazardous chemical handling and usage notice;
    - Handler’s information card; and
    - Labeling;
- Transport and storage of hazardous chemicals;

- Personal protection;
- Cross mixing and applying;
- Personal Hygiene;
- Emergency Response;
  - Injury/Illness;
  - Spills; and
  - Fire;
- Training; and
- Disposal.

7.3.2.3 GFI 105 Rev 1 Routine Safety Talks

The safe performance of jobs is dependent on the dissemination of information to develop skill, maintain a high level of motivation and initiate safety awareness among all concerned. This GFI formalises the dissemination of information through regular meetings (approximately 10 minutes in duration), commonly referred to as “Toolbox Meetings” or “Safety Talks” (see Appendix F.5). This GFI covers the following aspects of safety talks:

- Topics of talks;
- Presenters;
- Reporting of safety talks;
- Recording of safety talks;
- Frequency of safety talks; and
- Timing (fixed schedule).

7.3.2.4 GFI 106 Rev 3 HSE and Security Induction for New Arrivals

Every new arrival, whether a Staatsolie employee or not, must be made familiar with the company’s health, safety, environmental and security requirements as they relate to the activity that they are about to undertake (see Appendix F.6). They must attend an induction course delivered by appropriate personnel. New arrivals fall into 3 categories: (i) Staatsolie employees; (ii) contractors’ employees; and (iii) visitors. The management system for this aspect of operations includes:

- Definition of terms;
- Preparation for the induction;
- Content of the induction;
- Presenters;
- Reporting and Recording; and
- Identification and issuance of induction cards.

7.3.2.5 GFI 110C Incident Reporting & Investigation

The purpose of Incident Reporting and Investigation is to make certain that incidents are investigated according to the injury, or injury potential of an event, in accordance with Staatsolie's policy and legislation. This will help to control further losses of human and material resources by identifying and correcting unsafe acts and conditions that can lead to an incident (see Appendix F.7).

This policy applies to any and all work-related incidents that affect Staatsolie's employees and sub-contractors and the environment. Anyone working with Staatsolie is required to report all incidents. Incidents are reported and recorded for the following purposes: mitigating of consequences, preventing recurrence, monitoring performance, satisfying statutory requirements and for insurance claims.

This reporting system includes the following:

- Definition of terms;
- Incident Reporting Process;
    - Additional reporting for injuries; and
    - Additional reporting for vehicle incidents;
- Routing of information;
- Investigation of incidents;
- Case status follow-up; and
- Recommendations follow-up.

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