The Shell Petroleum Development Company of Nigeria Limited

ENVIRONMENTAL IMPACT ASSESSMENT REPORT

FOR

OML 77 AND 74 3D SEISMIC RESHOOT DATA ACQUISITION PROJECT IN AKUKU-TORU, DEGEMA LOCAL AND BRASS LOCAL GOVERNMENT AREAS OF RIVERS AND BAYELSA STATES

FINAL REPORT

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Originator: THE SHELL PETROLEUM DEVELOPMENT COMPANY OF NIGERIA LIMITED (SPDC), PORT HARCOURT, RIVERS STATE

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Abbreviations And Acronyms

AHC	Active Heave Compensator
ALARP	As Low As Reasonable Practicable
BCOT	Bonny Crude Oil Terminal
CITES	Convention on International Trade in Endangered Species of Flora and Fauna
CMS	Convention on Migratory Species
DAU	Data Acquisition Unit
DPR	Department of Petroleum Resources of Nigeria
E	East
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
FEPA	Federal Environmental Protection Agency (Defunct)
FMENV	Federal Ministry of Environment
HUB	Hydrocarbon Utilizing Bacteria
HUF	Hydrocarbon Utilizing Fungi
IMO	International Maritime Organization
ISO	International Standards Organization
IUCN	International Union of Conservation of Nature
MGSVA	Mariano Global Surface velocity Analysis
NAOC	Nigerian Agip Oil Company
NECC	North Equatorial Counter current
NESREA	National Environmental Safety Regulations and Enforcement Agency
NGDC	National Geophysical Data Centre
NLNG	Nigerian Liquefied Natural Gas
NNPC	Nigerian National Petroleum Corporation
NOAA	National Oceanic and Atmospheric Administration
OBC	Ocean Bottom Cable
OBN	Ocean Bottom Node
OBS	Ocean Bottom Seismic
^oC	Degree Centigrade
OGGS	Offshore Gas Gathering System
OML	Oil Mineral Lease
OOZI	Out-Of-Zone-Injection
pH	Hydrogen Ion Concentration
ROV	Remote Operated Vehicle
SBM	Single Buoy Mooring
SE	South East
SPDC	Shell Petroleum Development Corporation
SU	Sensor Unit
SW	South West
TDS	Total Dissolved Solids
TED	Turtle Exclusion Device
THB	Total Heterotrophic Bacteria

THC	Total Hydrocarbons
THF	Total Heterotrophic Fungi
TOC	Total Organic Carbon
TPH	Total Petroleum Hydrocarbon
TSS	Total Suspended Solids

EIA Preparers

S/N	Name	Qualification	Designation
1	Williams Bella	BSc, Biochemistry	Project Coordinator
2	Nwonye Kingsley	HND, Electrical Engineering	Field Supervisor & Air Sampler
3	Kordah Eric	BSc, Industry Chemistry	HSE & Water Sampler
4	Obua Uche	BSc, Geology	Sediment /Water Sampler
5	Rafiu Shelle	PhD, Hydrobiology and Fisheries	Fisheries & Hydrobiologist
6	Wokoma Thanks	BSc, Oil and Gas Engineering	*In situ* measurements & documentations
7	Joseph Obigwai	PhD, Botany	Biodiversity
8	Olabode Oladun	BSc, Industrial Chemistry	Sediment /Water Sampler
9	Itoro-Ubong Victor	BSc, Surveying and eomatics	Survey Engineer
10	Ngah Barika	HND, Surveying and Geoinformatics	Online Surveyor

SPDC Reviewers

S/N	Name	Designation
1	Ojikutu, Mukaila O	Environment Manager
2	Stanley Amam	Environment studies Lead
3	Chikere, Blaise	Environment studies Specialist
4	Ilamina Ebinum	Environment studies Specialist
5	Richard Michael	Project Environmental Adviser & Activity Co-ordinator
6	Isah Suleiman	Head Seismic Acquisition
7	Adesola Ojesanmi	Environmental Inspector

Executive Summary

ES 1.0: Background Information

The Shell Petroleum Development Company Nigeria Limited (SPDC), operator of the NNPC/Shell/TEPNG/Agip Joint venture on behalf of its Joint Venture partners, has conducted the Environmental Impact Assessment for the OML 77/74 3D Seismic Reshoot Data Acquisition Project. The 3D seismic reshoot will cover HA, HB, HD, ABC, BLKG and JK fields. Various 2D streamer seismic data have been acquired over OML 77 and 74 and also 3D streamer seismic data as well as an Ocean Bottom Cable (OBC) 3D seismic data acquisition from 1990 – 1998 with different levels of data quality. The new seismic dataset is planned to address both the imaging in the shallow reservoirs and the deeper exploration opportunities. Some of the prospects in the planned project area have been explored and the fields are producing. However, both the shallow and the deeper exploration opportunities have not been fully explored and properly evaluated. This EIA study has identified the key potential impacts of the project activities on Biophysical, Social and Health components within the project area and proffered mitigation measures for Environmental Management. The findings are hereby incorporated in this report.

ES 2.0: EIA Objectives

The objectives of the EIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions of the host communities;
- Use the baseline data to describe and characterize the study area;
- Identify the environmental sensitivities of the project area;
- Determine and evaluate the potential impacts of the proposed project activities on the identified environmental sensitivities and the interactions between the sensitivities;
- Recommend appropriate mitigation measures; and
- Develop an Environmental Management Plan (EMP).

ES 3.0: Project Location

The planned OML 77 and 74 Shallow Water Offshore 3D seismic data acquisition reshoot activity will be carried out off the coast of Niger Delta in water depths of about 7m and close to the shoreline to above about 70 m away from the shoreline. The planned surface coverage area for this seismic survey is about 2,218 sqkms and span from Akuku-Toru LGA in Rivers State to Brass LGA in Bayelsa state. The 32’’ RPA – Bonny Terminal OGGS Gasline and Brass Forcados Nitel Fibre cables transverses through the oil concession (OML 77/74).

ES 4.0: Project Proponent

The Shell Petroleum Development Company of Nigeria Limited (SPDC) is the largest Shell company in Nigeria and produced the country’s first commercial oil exports in 1958. SPDC is the operator of a joint venture (the SPDC JV) between the government-owned Nigerian National Petroleum Corporation – NNPC (55% share), SPDC (30%), Total E&P Nigeria Ltd (10%) and the ENI subsidiary Agip Oil Company Limited (5%). It is focused on onshore and shallow water oil and gas production in the Niger Delta. SCiN make a major contribution to developing the country's human capital and contracting capacity. SCiN pursue a variety of social investment projects, with a particular focus on community and enterprise development, education and health.

ES 5.0: Legal and Administrative Framework

Legislations, guidelines and international treaties which govern the assessment of environmental impacts of development projects in the oil and gas industry in Nigeria includes but not limited to the following:

- World Bank Guidelines on Environmental Assessment, 1991
- International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, 2001
- Convention on Biological Diversity, 1992
- Environmental Impact Assessment Act CAP E12 LFN 2004
- Endangered Species Act CAP E9 LFN 2004
- Nigerian Oil and Gas Industry Content Development Act 2010
- Bayelsa State Pollution Compensation Tax Law 1998;
- Rivers State Noise Pollution Control Law of 1984

ES 6.0: Need for Project

The execution of the project shall ensure the following:

- Significant contribution to actualizing Federal Government's plan to increase its hydrocarbon production capacity.
- Increased revenue to the government of Nigeria emanating from the project activities and sales of the hydrocarbon products.
- Transfer of Oil exploration and Production technology to indigenous Nigerian personnel in the various fields of oil exploration and production operations.
- The seismic activity and the eventual operation shall lead to the provision of employment for both skilled and unskilled Nigerians.

ES 7.0: Benefit of the Project

The proposed project will provide a better understanding of the geological heterogeneity of the lease and this will:

- help SPDC to identify/ confirm the presence of hydrocarbon reserves within the block and hence delineate appropriate prospects for exploitation;
- provide necessary data for decision makers as relates to oil and gas exploration/ exploitation in Nigeria;
- improve development of resources as well as reduce drilling wastes due to more effective well placement;
- reduce the overall drilling costs thereby substantially improving project economics;
- cut exploration time relative to successful production which would also reduce cost;
- add to Nigeria's total hydrocarbon reserve, increased production capacity and ultimately, enhancement of the overall export earnings of the nation;

- support SPDC business growth plan; and
- provide direct and indirect employment opportunities for Nigerians during the various phases of activities.

ES 8.0: Envisaged Sustainability of the Proposed Project

Economic and Commercial Sustainability

Data from the planned survey will be interpreted and results used to determine the presence of hydrocarbon bearing structures/reserves within the blocks. Consequently, exploratory drilling campaigns may be undertaken to further confirm the nature and size of such reserves. All these will establish the economic and commercial sustainability of the project.

Technical Sustainability

The proposed project is technically viable because it will rely on existing and well-established technologies, with proven oil field experience and strong HSE awareness. The design and operation of the proposed 3D seismic survey would be carried out in line with national and international codes and standards of practice. Also, SPDC and its contractors shall develop operating manuals and procedures relating to the proper operation of the project activity. These materials will be used as the basis for providing facility-specific training to relevant personnel prior to start-up. In addition, personnel with experience in similar operations will be involved in the transition and early operations.

Environmental Sustainability

The findings and recommendations of this EIA would be integrated into all phases of the proposed project. Recommendations on the project process, waste management (handling, treatment and disposal) which were developed in line with the environmental regulations, guidelines and standards of the FMEnv and the DPR as well as international best practices would ensure the environmental sustainability of the proposed project. Specific international practices relating to aquatic animal protection would also be employed. In addition, SPDC shall conduct the proposed 3D seismic campaign in line with the company's HSE policy to ensure negative impacts are reduced to levels as low as reasonably practicable (ALARP). Specifically, the acoustic energy for this 3D seismic data acquisition shall be by means of air guns; this is the most environmentally friendly for marine operations, compared to the other acoustic energy sources.

ES 9.0: Project Options and Analysis of Alternatives

No Project Option

The no project option implies that the 3D seismic data acquisition projects will not be executed. The implications of this option are:

- Paucity of information to resolve uncertainties in the fields which will lead to sub-optimal well placement/ reservoir deliverability and enhance performance management of existing development in the field.
- The loss of economic benefits that would have accrued to the Nation by actualising Federal Government’s plan to increase hydrocarbon production capacity.

- No contribution/support for the NLNG and domestic gas growth requirements.
- Loss of revenue to Joint Venture (JV).
- Loss of the employment opportunities that would have arisen from the project/loss of new technology learning to Nigerians.

Delayed Project Option

This option implies postponing the planned 3D seismic acquisition activities to a much later date. Such option is usually taken when prevailing conditions (such as economic, political, etc.) are unfavourable for a project implementation. Thus, delaying the proposed 3D seismic acquisition will result in the following.

- Putting on hold all processes that have been put in place for the project design, implementation schedule, etc. and consequent impact on the FOD plans of the various fields within the Shallow Water Offshore environment.
- Loss of opportunity and project value from the current Low Oil Price that would reduce the seismic data acquisition cost to the Federal Government of Nigeria and the Joint Venture Partners.
- Erosion of the Value Of Information (VOI).
- Loss of favourable weather acquisition windows.

Remarks: Recommended

Carry out the Project

This option implies going ahead with the project using the most suitable and Available Technology.

Ocean Bottom Cables (OBC) seismic data acquisition technique

Advantage

Cheaper to execute than Ocean Bottom Node (OBN) seismic data acquisition technique

Disadvantages

- Can be affected by swell noise (surf zone) hence high downtime.
- Cables always by passes obstacles which results in a poor receiver to sea bed contact/cable sagging.
- Limitation where there are access problems/obstructions (E&P facilities) hence gap exist in the data
- Processing challenges in using Ocean Bottom Cables as a baseline for future advanced technology acquisition.
- Increase in environmental footprint

Ocean Bottom Node (OBN) seismic data acquisition technique

Advantages

- Works well even in the shallow water depths

- Works optimally in areas with E&P facility obstructions and related operational HSE challenges including obstruction of and entanglement with third party fishing facilities
- Provides optimal data quality that could be acquired
- Better seismic imaging issues, good imaging without chaotic reflections around the faults over the complex collapsed crestal structures characteristic of the project area
- High bandwidth, Low noise, wide offsets and associated good data resolution for optimum interpretation/maturation efforts.
- Better and wide-azimuthal coverage and long offset seismic data for better imaging of both shallow (new image data will help to further improve shallower levels for development activities) and deep depths (new image data will help to support mapping the exploration opportunities),
- Forms 4D baseline data, benefit from the current state of the art processing workflows and also relevant for future advancement in processing technologies.
- Nodes are highly reliable and can achieve uptimes of 98% or higher.

Disadvantages

- Costly to execute than Ocean Bottom Cable (OBC) seismic data acquisition technique
- OBN surveys usually require a shooting vessel and a node laying vessel or node on a rope laying vessel with dynamic positioning systems

ES 10.0: Project description

Sound signals will be generated from arrays of towed energy sources called Airguns. These energy sources store compressed air (generated on the vessel), which is released on command from the towing vessel. The released air forms a bubble, which expands and contracts in a predictable fashion, emitting sound waves as it does so. The pressure variation in the water as a function of time caused by the high-pressure bubble is called the airgun signature. Individual energy sources are configured into arrays. These arrays have an output, which are more desirable than that of a single bubble and serve to focus the sound output primarily in the downward direction, which is useful for the seismic method. This array effect also minimizes the sound emitted in the horizontal direction. The downward propagating sound travels to the seafloor and into the geologic strata below the seafloor. Changes in the acoustic properties between the various rock layers result in a portion of sound being reflected towards the surface of each layer. The nodes which are laid on the sea floor receive this reflected energy.

Use and operations of the airguns shall be tuned to the depth of investigation and balanced with environmental considerations to the lowest practicable output and power levels to achieve objectives. Local regulatory requirements and best practices shall be applied to mitigate the impact of acoustic sound generated by airguns on marine mammals. Offshore seismic data acquisition activities are guided by both National and International Environmental regulatory standards. Furthermore, marine mammal observers and passive acoustic monitoring shall be deployed in the operations. Also, soft start of air guns shall be adopted to ensure marine mammals move away from the shooting area operation in addition to all other SPDC and industry best practices.

In addition to the technical justifications, the impact of the project on the environment will be significantly minimized by using this seismic acquisition technique. This is because the Ocean Bottom Node technology is being deployed internationally, adopting the best industry practice, is of short duration utilization of best available weather window and only experience contractors are known to carry out these activities.

Project Objectives

The objective of this project is to acquire new 3D seismic data with increased multiplicity, longer offset and state of the art technology that will:

- Significantly improve the structural imaging of the fields.
- Help in optimizing well locations through the improved imaging.
- Be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, longer offset and recording higher fold). These will maximize economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping the facilities full and grow Nigeria's / SPDC reserve base.
- Data will also aid future production decision-making and the field development. Additional hydrocarbon resources in the Shallow Water Offshore will be developed to support NLNG and domestic gas growth requirements.

Project Scope

The OML 77 & 74 3D seismic data acquisition operations include the following:

- Node deployment vessels with crew.
- Energy Sources – Air Compressors on board vessels.
- Towed seismic airgun lying just beneath the sea surface.
- Detectors – Housed within the deployed Ocean Bottom Nodes at the bottom of the ocean.
- Chase boats to monitor activities in and around the operational areas.
- Guard boats to monitor activities
- Fast Rescue Boats in mother vessels: In emergency situation to convey personnel to a safe /evacuation point.

Project Activities

The specific project activities to be carried out include:

- **Pre-Mobilization**
    - ✓ Regulatory approvals
    - ✓ Stakeholder engagements
- **Mobilization**
    - ✓ Personnel
    - ✓ Audit of vessels & equipment

- ✓ Vessels (and equipment) deployment to project sites
- **Execution**
  - ✓ Seismic energy source and seismic data recording
- **Demobilization**
  - ✓ Personnel, Vessels & Equipment from project sites
  - ✓ Stakeholder engagements

Waste Management

Wastes sources during the seismic acquisition shall be from the operation of the survey vessel, personnel on board, and wastes associated with normal seismic data acquisition activities. The waste shall include sump oil discharge, ballast water discharge, grey water discharge, sewage discharge, solid waste discharge, faecal waste and waste from human activities such as biodegradable food remains. Wastes strategies include: incineration for air filters, medical wastes and Thermal Desorption Unit (TDU) for oily sludge. Details are contained in the Waste Management guidelines for the project in Chapter 3, section 3.6.

ES 11.0: Proposed Project Schedule

The project is planned to commence in Q2/2019 and be completed in Q2/2020

ES 12.0: Description of Existing Environment

The current environmental status of the study area for the proposed 3d Reshoot Seismic Data Acquisition Project has been described in this chapter of the EIA report. One-season field data gathering conducted from 26th of November 2018 to 7th December 2018. The environmental components evaluated comprised ecological parameters interacting with ecological sensitivities within the project area and include: Air quality and noise, Surface water qualitSediment quality and Hydrobiology and fisheries. Sea water, Sediment and Air quality samples were sampled using 3000 m x 3000 m sampling grid spread over the spatial boundary of the OML 77 and 74 acreage in the direction of he persistent bottom current. In locations where there are existing facilities (wreckage, pipelines), samples were located at least 150m from these facilities. The Control locations were sampled outside the seismic spatial reshoot boundaries on the north, east and west to take cognizance of the dominant coastal hydrodynamics (tidal and longshore currents).

Climate and Meteorology

The study area is in the Gulf of Guinea and it is influenced by the tropical wet and semi-hot equatorial climate with high solar radiation. The climatic conditions of the proposed study area were obtained from the Nigeria Institute of Meteorology (NIMET) Port Harcourt climatic synoptic station; closest meteorological station to location. Ten years (1990 – 2010) meteorological data on Port Harcourt were obtained from the Nigerian Meteorological Agency (The two main seasons are the wet season (April - October) and a shorter Dry season (November - March). Rainfall in the area is generally high and is experienced almost all year round with highest value of 355mm recorded in the month of July. Peak periods are generally experienced from June to September while least values were recorded from December to February. The total annual rainfall in the area is more than 2,203mm. The highest relative humidity value recorded in the area is 87.0% at 10.00hrs, although higher values of up to 99% have been recorded within the climatic synoptic area in the rainy seasons. The recorded lowest value is 60.0% at 16.0hrs. Generally, relative humidity is higher during the morning hours and decreases gradually as the sun sets. The predominant wind direction in the synoptic area is South –Westerly for a period of about eight months. Data from NIMET showed that April (1.79m/s) recorded the highest wind speed while the lowest was recorded in December (1.06m/s).

Air Quality and Noise

SOx, NOx COx and H_2S were not detected in any of the sampling locations both in the Field operations area and at the control station they were taken to be within DPR set limits per Hr. This implies that SOx, NOx and COx were within their respective (350, 400 and 30µg/m^3) DPR hourly limits. SO_2 was below detection limit of 0.1µg/m^3 limit per hour, COx below detection limit of 8.7µg/m^3 limit and H_2S was below detection limit of 1.1 µg/m3 limit. NOx at AQ CTL3 was 7.1µg/m^3 and within DPR Limit of 400µg/m^3. The suspended particulate matter (SPM) was detected in all the sampling locations including the Control Stations. It was measured to have minimum of 8µg/m^3 at AQ12 and maximum of 44 at AQ2 and it also within DPR limits of 60-90. However, the maximum level was recorded at AQ8 with 78.2 and the minimum is 73.4 dBA at AQ CTL3 but still within DPR limits of 80-100db(A).

Surface Water quality

Average water temperature ranged from 28.55oC at the top to 28.00oC at mid and bottom compared to control 28.67oC higher than the top of sample station but have equivalent measurement with the mid and bottom at the samples. pH ranged from 8.50 at the top, which is higher than mid and bottom with 8.00 compared to control with 8.53, 9.00 and 9.00 (top, mid, and bottom). The pH is lower at the sample point than the control and this variation was not significance ($P<0.05$). Dissolved oxygen compared well at top and mid between the study are and control station. However, significant variation was observed between DO levels from bottom samples, where higher concentration was recorded at the study area (4mg/l) and Concentration at the control was (3mg/l). Average levels of BOD ranged from 0.72mg/l at the top, 1.00 at the mid to 0.00mg/l at bottom compared to control of 0.67mg/l at top, 0.00mg/l at mid and 0.00mg/l at the bottom. There is significant variation in the level of BOD between sample locations and control. Average levels of COD ranged from 180.49mg/l at top, 179.00mg/l at the mid to 160.00mg/l at bottom compared to control with 188.00mg/l at the top, 182.00mg/l at mid to 189.00mg/l at the bottom. There is a decrease of COD at it approach the bottom but when compare to control, there is significant increase as it approaches the bottom, but generally, it not significant ($P<0.05$). Vanadium and barium were not detected in water at the sample points and control. Average cadmium ranges from 0.02mg/l at the top to bottom compared to control of 0.01mg/l and 0.01mg/l at the mid and 0.06 bottom. Cadmium was significantly higher at the top of sample point than the control. Average zinc ranged from 0.04mg/l at the top, 0.04mg/l at the mid to 0.06mg/l at the bottom. These shows increase in the level of Zn as it moves down. Same occur at the control point.

Also, the top, the level of Zn is higher at sample points compare to control and, but the bottom is significance at ($p<0.05$). Average iron ranged from 1.16mg/l at the top, 0.15 at mid to 0.16 at bottom compared to control with same 0.16mg/l and 0.03mg/l at the mid and 0.04mg/l at the bottom. Iron is higher at mid and bottom than control and both the mid and bottom are significance at $p<0.05$. Chromium ranged from 0.03mg/l at top and mid to 0.06 at bottom compared to control of 0.17mg/l top, 0.04mg/l at mid and 0.06mg/l at the bottom. Nickel ranges from 0.21 at the top compare with 0.62 at the control top point. The mid is 0.34mg/l and bottom has 0.15mg/l at sample point compare to control with 0.62mg/l top, 0.57mg/l mid and 0.75mg/l at the bottom. Oil and Grease, Total Petroleum Hydrocarbons were not detected in the water samples. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. The THB and TF were in the order of 102 cfu/ml with mean counts of 2.18 x 10^2cfu/ml, 3.33 x 10^2cfu/l and 2.10 x 10^2cfu/ml, 1.12 x 10^2cfu/ml in the study area and control respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the surface water. Similarly, the hydrocarbonoclastis were not identified in the seawater including the control stations. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified in the seawater samples across the study area and control and indicates the unlikelihood of biogenic souring during the operation phase of the project.

Sediment quality

Sediment temperature ranged from 20.43oC at sampled points compared to 20.80oC at the control. pH ranged from 7.28 at sample compared to 7.36 at the control. The pH of the sediments is related to that of the overlying waters. Redox potentials were negative ranging from -22.69mV at sampled points compare to control with -24.50mV. Total Organic Carbon (TOC) ranged from 1.39% at sampled points compared to control of 1.37%. There was significant difference between study locations and control. TOC levels varied widely but were relatively higher at the study location compared to control. Nitrate ranged from 0.63mg/kg at sampled points compared to 0.70mg/kg at the control station. Phosphate ranged from 0.35mg/kg at sampled points compared to levels at the control of 0.21mg/kg. Total Petroleum Hydrocarbons mean concentration at the sample stations was 0.05mg/kg and 0.01mg/kg at the control stations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. The heavy metal concentrations in the sediment were within optimal ranges of shallow water bodies in the Niger delta. The mean concentration of Ni ($p=0.42$), Fe ($p=0.32$), Pb ($p=0.20$), Cu ($p=0.18$), Zn ($p=0.55$), Cd ($p=0.18$), Ba ($p=0.62$) and Co ($p=0.40$) were not significantly across the receptor locations and control stations. Similarly, Ag and V were not detected in the sediments across the sampling locations. In order of increasing concentration, the heavy metals were: : Ag/V << Cu << Cd << Ba << Cr << Zn << Pb << Fe. The THB and TF were in the order of 102 and 101cfu/g with average mean counts of 2.11x102 and 7.23x101 with the proposed project area and 2.20x102cfu/g, 7.80x101cfu/g in the control locations. The heterotrophic bacteria counts is suggestive of the availability of utilizable organic substrates in the sediment. Results of the TOC across the receptor distances lend credence to this finding. Similarly, the hydrocarbonoclastis were not identified in the sediments including the control location and suggestive of the low hydrocarbon burden of the proposed project location. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified in the sediment samples and indicate unlikelihood of biogenic souring during the operation phase of the project.

Hydrobiology and Fisheries

Benthic Fauna

The species composition showed a total of 16 species of benthic fauna belonging to 10 families, 6 orders and 2 Classes. The 2 Classes, the Gastropods recorded 11 species, and the Bivalves recorded 5 species. Though, the Bivalves recorded the lowest number of species in both the control and sample points, they were the dominant Class as they recorded the highest number of organism/species (92.52%) occurrence than the Gastropod which recorded low (7.48%) species occurrence.

Phytoplanktons

The Phytoplankton composition revealed a high composition with a total of 28 species belonging to 24 families, 19 orders and 5 Classes. The 5 classes are the Bacillariophyceae, Dinophyceae, Fragilariophyceae, Dictyochophyceae, and the Haptophyceae. The Bacillariophyceae were the dominant class with 17 species, followed by Dinophyceae with 8 species and the rest 3, Fragillariophyceae, Dictyochlorophyceae, and Haptophyceae were the least, with 1 species each. However, the control points were devoid of the Dictyochlorophyceae, and thus had 4 Classes and 27species.

Zooplankton

The zooplankton comprised a high composition of 21 species belonging to 18 families, 21 orders and 7 classes. The 7 classes in descending order of dominance are Hexanauplia with 12 species, followed by Oligotrichea with 3 species, Malacostraca (2 species), and classes Polycheata, Branchiopoda, Calanoida and Stenolaemata (all having 1 species each). However, the control points only have 3 classes of Zooplanktons namely; Hexanauplia with 7 species, Oligotrichea (3 species), and Stenolaemata (1 species).

Fisheries Study

Artisanal fishers operate largely in rivers creeks and creeklets that empty directly or indirectly into the Atlantic Ocean adjacent to the project area. These rivers, creeks and creeklets include Akwamobugo creek and Brass River, into which the former empties, Akassa creek, Ekole Creek, Nembe Creek and St. Nicholas River. Information from the baseline study further reported that fishers operate in dug-out wooden canoes which may or may not be motorized. In the Akuku-Toru axis where the Sombrero river and its network of creeks traverses (Ibim and Bongilli, 2017,2018; Ibim and Douglas, 2016) the project area, the fishers are also predominantly artisanal fishers depending on planked wooden boats that may or may not be motorized. The fishing gears used were ghost shrimp traps, castnets, gillnets, setnets, long line, Stownet, scoopnet and circular liftnets. The gillnets and setnets measure 6-12 m in length and 2-4 meters in width. Nets are manually operated using paddles and poles. They are set and allowed to stay for up to one hour before they are retrieved with the catch. The fishermen in this area go fishing with more than one net units. These Fish stocks were: croakers (Pseudotolithus), threadfins (Galeoides, Pentanemus and Polydactylus), soles (Cynoglossidae), marine catfish (Arius), brackish water catfish (Chrysichthys), snapper (Lutjanus), grunts (Pomadasyidae), groupers (Epinephelus), and the estuarine white shrimp (Palaemon). Bonga dominates the pelagic fishery but there are modest catches of shad (Ilisha), sardine (Sardinella), various jacks (Caranx spp.) and Atlantic bumper (Chloroscombrus chrysurus).

Biodiversity

Reptilian Diversity

A total of five reptilian species were inventoried in the study. Two of the species (*Chelonia mydas, Dermochelys coriacea)* were sighted while the other three species (Crocodylus *niloticus, Caretta caretta, Lepidochelys olivacea)* were inventoried through indirect evidences. A total of 21 individuals of *Chelonia mydas* and 3 individuals of *Dermochelys coriacea* were sighted during the survey. About 77% of the sighted reptiles were females with 23% males. Individuals of *Chelonia mydas* were censored across diurnal and nocturnal hours while individuals of *Dermochelys coriacea* were censored during diurnal hours only. Individuals were sighted within the upper column of the sea at depths lesser than 5 m. All observed individuals sighted swam vertically down (to greater depths) during flooding regimes and swims diagonally upward during ebbing episodes. Individuals were sighted both offshore and on-shore exhibiting solitary and social interactions. Their foods were reviewed to include small invertebrates, sea serpents, mosses, and seas hare eggs. Both species are poached locally for their meat and eggs and in tradition medicine application. Result on the conservation statuses of each of the species showed that *Dermochelys coriarea* and *Caretta caretta* are categorized as Vulnerable (VU), *Chelonia mydas* is Endangered (EN) while *Crocodylus niloticus* is categorized as Least Concern (LC) according to the International Union for Conservation of Nature (IUCN) 2018 version 2 Red list of Threatened species.

Nesting sites

A total of eleven established and four potential nesting sites were studied and their physico-chemical parameters analyzed. The study establishes novel turtle nesting baseline for physico-chemical parameters for the analyzed parameters, probably, the first in Nigeria. The values for moisture content, temperature, grain size distribution, and pH obtained for all nesting sites were compared with values reported in reviewed reports outside the country. These physico-chemical parameters were reviewed to perhaps affect the sex of hatchings, success rate of hatching,, size and morphology of hatching and nesting site choice. Statistical significant difference at $P<0.05$ was observed between established and potential nesting sites for electrical conductivity, total Nitrogen content, Exchangeable sulphate, Magnesium, Potassium, Sodium, calcium, Iron, lead, Molybdenum, and Zinc. This amounts to about 31% of the total analyzed parameters.

Mammalian Diversity

A total of four mammalian species were inventoried in the study. Three of the species (*Orcinus orca, Trichechus senegalensis, Stenella longirostris)* were sighted while only one species (*Stenella frontalis)* was inventoried through indirect evidences. A total of 7 individuals of *Stenella longirostris* and 5 individuals each of *orcinus orca* and *Trichechus senegalensis* were sighted. This comprised of about 72% and 28% males. Individuals of the three sighted species were all censored during the day and within the niretic zone (10 m -35 m) of the sea. *Orcinus orca* was reviewed to breed all year round while *Trichechus senegalensis, Stenella longirostris* were reviewed to breed from March to November and February to August respectively. All individuals were sighted foraging, travelling, resting, diving, self cleaning or socializing. *Orcinus orca* was reviewed to prey on octopuses, seals, sea lions, smaller whales and dolphins, fish, sharks, squid, octopi, sea turtles, sea birds, sea otters and river otters, *Trichechus senegalensisI* feeds on vegetation (mangrove species) while *Stenella longirostris* feeds on mesopelagic fishes. Result on the conservation statuses of each of the species showed that *Orcinus orca, Stenella longirostris,* and *Stenella frontalis* are categorized as Data Deficient (DD) while *Trichechus senegalensis* is categorized as Vulnerable (VU) according to the International Union for Conservation of Nature (IUCN) Red list of Threatened species. The species are sources of meat, oil, and ingredients of traditional medicine as revealed during interviews with the locals.

Avian Diversity

A total of twenty six (26) sighted avian species were censored. Some of the sighted species include *Nycticorax nycticorax, Casmerodius albus*, *Phalaropus fulicarius*. Result on individual abundance revealed that 77 individuals were censored across the counting stations. *Nycticorax nycticorax*, *Casmerodius albus, and Phalaropus fulicarius* accounted for about 40% the total counts. This species inventoried were sighted either feeding, resting or at flight. The birds were observed flying in three main directions. Ten individuals were observed flying in the NE direction as against one flying in the North westerly direction. Seven individuals were observed flying in the south westerly direction. With regards to the gender of the individuals sighted, seven were females and eight were males. No defined flocking pattern was observed for all the species during study. Only one individual was flying within 0-50m altitude. Significantly, A total of 19 individuals were observed to be flying within the 50-75m range while 2 individuals were seen flying above 75m. A total of 13 of the censored species are full migrants while 5 species are raptors. None of the sighted species censored in the study area were of conservation interest as all were categorised as Least Concern (LC).

Social Profile

The study was conducted in Brass and Akuku-Toru Local Government Areas of Bayelsa and Rivers States respectively. There are forteen (14) neighbouring communities to the proposed OML 77 and 74 3D Shoot Seismic Data Acquisition Project areas. These communities host some Shell Petroleum Development Companies (SPDC) and Liquified Natural Gas (LNG) and other company's oil and gas facilities. The total population of the surveyed communities ranged between 315 to 7613persons. It is expected that by 2020 the population will increase to between 1314 -16,959 persons at a growth rate of 3.2%. Furthermore, findings reveal that, on average over 70% of the sampled population in the study area are married. Similar trend was observed across all the communities. Beletieama, Ewoama, Ibidi, Okunbiri-Belau and Obioku communities had the highest number of married households in the study area.

Marital status

Respondents with single status is estimated at 20% while those with separated and divorced status is 10% respectively. This result reveals that, most families living along the shoreline communities of the proposal OML 77 and 74 3D Re-shoot seismic data requisition project are predominantly married married with children and other dependent relatives. Over 40% of the males across the project communities are within the bracket 35-45years. Males in Twon-Brass, Beletieama, Ibidi and Okumbiri- Belau were more with 21-40 years. However, 20% of the male population is above 65 years of age while the females were found more in the age bracket of 41-50 years. In Liama, Obioku, Dieama and Sangana communities both males and females are within the age bracket of 20-30 years.

Education

Over 50% attended and completed primary school. Respondents who attended secondary, vocational/technical, tertiary education represents 25% and 15% respectively. Quite negligible proportion of the population (5%) had non-formal education and learning through experience respectively. This trend is observed in virtually across all the project communities. The literary level (those who can read and write) in the project area could be described as being sufficiently high judging by the level of educational attainment (formal training), exposure, knowledge and understanding of issues discussed during the Focus Group Discussions

Governance structure

The governance structure shows the Amanayabo as the Paramount Chief or King of the Ijaw kingdom supported by the Council of chiefs or elders. They are known as the community executives.

Religious traditions

Majority (over 80%) of community members are Christians while traditional religious elements are still making the rounds. As Ijaw ancestral stock, it is crucial to hold in reverence the reminiscence of ancestors and religious traditions. One of the most prominent idols is one of the water spirits called *Owuamapu*. Most of the members believes that, water spirits are just like humans, they have their accomplishments and imperfections.

Health Profile

Over the years, a substantial increase in births has been recorded in both the Rivers and the Bayelsa communities. However, due to the prevailing weakness in the health care system, characterized by the preponderance of deliveries by traditional birth attendants (TBAs) and poor record keeping, it was impossible to accurately estimate the crude birth rate.

Crude Death Rate (CDR)

An approximated total of 9.2 deaths per 1,000 population occurred in the Bayelsa communities and 7.8 per 1,000 population in the Rivers State communities in one year. These figures might have been grossly underestimated.

Under-Five Mortality Rate (U-5MR)

The U-5 mortality rate in the Bayelsa axis is 95 per 1,000, and that of the Rivers axis is 58 per 1,000.

Maternal Mortality Rate (MMR)

Information from women in the communities during focus discussions (FGDs) pointed out that maternal mortality is common in both the Bayelsa and Rivers communities under reference but could not quantify it. The discussants attributed the problem to the paucity of good quality health care facilities in the areas and the cultural practice of delivery by elderly women, who are said to be traditional birth attendants. Unfortunately, however, neither the weak health care system, nor these TBAs are able to manage the direct causes of maternal deaths during delivery, which include; severe bleeding, infection, high blood pressure.

Quality of health care facilities/health seeking behaviours of community members

Among the hospitals existing in the Bayelsa axis, the Sangana Cottage hospital was built by the Texaco Company and has one medical doctor in attendance. The hospital at Twon Brass has two doctors and three nurses in attendance, while the hospital at Okpoma also has a doctor in attendance. Most of the health centres are staffed by nurses and community health care officers. Nevertheless, there is a general shortage of qualified health workforce in these health care facilities. Many of the health workers reside in the state capital, Yenagoa and only visit the communities on specific days of the week. The Rivers State axis has five primary health care centres, in each of the communities, and a good number of patent medicine vendors and traditional birth attendants. Like the Bayelsa axis, these health centres are located within the communities, such that physical access does not constitute any problems to the people. However, one common feature of these health facilities is the non-availability of relevant drugs, equipment, and other supplies in sufficient variety and quantity.

Medical emergencies and severe illnesses are usually referred out to the nearest general hospitals closest to the area. For communities in the Rivers State axis, the Degema General hospital or Abonnema General Hospital and sometimes, the University of Port Harcourt Teaching Hospital in Port Harcourt, or the Braithwaite Memorial Specialist Hospital (BMSH), both in Port Harcourt serve as referral centres. For communities in the Bayelsa State axis, medical evacuations are referred to the Nembe General Hospital or the Federal Medical Centre at Yenagoa.

Morbidity Pattern

Common diseases in the area based on the health facility records of the Ministries of Health are infectious/communicable and non-communicable diseases. The common diseases found predominantly among the adult population include hypertension, stroke, diabetes mellitus, arthritis, pregnancy and birth-related complications in women, chronic liver disease, and chronic respiratory tract infections, inguinoscrotal hernia, peptic ulcer, injuries, and burns.

Social and Lifestyle Issues Affecting Health

Several social and lifestyle issues significantly impact on the human health. Some of these include excessive use of alcohol intake, tobacco and illicit drug use (Figure 4.50). Others are sexual promiscuity and unprotected sexual encounters with non-regular partners. Young persons and adolescents are especially vulnerable because they are at a critical period of life transition and are largely without access to appropriate information regarding age-appropriate sexual and reproductive health information and services.

ES 13.0: Potential and Associated Impacts

Qualitative and quantitative analyses of the negative, associated and potential impacts of the proposed project were carried out using a robust process, which involved assessment of impact severity based on give key criteria: magnitude, areal extent, frequency, impact duration and sensitivity of resource. Some potential and associated impacts identified include but not limited to the following:

- Disturbance to marine fauna (spawning sites and migratory routes of fishes)
- Possible death of marine fauna from seismic air guns
- Increase in noise and vibration from seismic air guns
- Impairment of water quality from effluent discharges
- Injuries and accident from vessel collision
- Interference with fishing activity
- Piracy and kidnapping

ES 14.0: Mitigation measures

Disturbance to marine fauna (spawning sites and migratory routes of fishes)

SPDC shall ensure:

- Marine audit / inspection of seismic vessel shall be carried out to ensure compliance with international specified standards.
- Soft start procedures for seismic source shall be followed.
- Marine Mammal Observers (MMO) shall be part of the seismic crew to ensure minimum interference with marine mammals.
- Appropriate technology to minimize the impact of noise and vibration
- Soft start protocols are adopted for shooting airguns (Noise emissions shall begin at low power, increasing gradually until full power is reached).
- Acoustic Mitigation devices (PAM) shall be used to drive away marine mammals.

Possible death of marine fauna from seismic air guns

SPDC shall ensure:

- ensure the presence of Marine Mammal Observer (MMOs) on board the vessel
- a gradual increase of signal intensity at the beginning of the procedure (‘soft-start’ or ‘ramp-up’);

- implementation of wildlife exclusion zones (EZs) within which air guns can be shut down or their use delayed if any marine mammal is detected
- ensure restriction of night time seismic survey activity;
- sensitive ecosystems (turtle nesting sites) are avoided during seismic data acquisition.
- Vessels use Passive Acoustic Monitoring to verify the presence of near-surface fish shoals within the mitigation zone.

Impairment of water quality from effluent discharges

- SPDC shall ensure compliance with MARPOL regulations.

Injuries and accident from vessel collision

SPDC shall ensure

- Adequate radio communication between merchant ships and standby vessels
- Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective
- Regular drills on abandon ship procedures shall be enforced
- Activate Emergency response plan inline with SOLAS
- Use of appropriate PFDs by the survey team

Interference with fishing activity

SPDC shall ensure that:

- All project vessels shall have high-rise beacons to fore warn other fishing vessels in the project location.
- Marine notices shall be put in strategic locations,
- Radio monitoring of the area shall be continuously conducted.
- Notify Fishing Communities on time

Piracy and kidnapping

SPDC shall:

- Ensure all countermeasures to mitigate identified threats are in place
- Ensure project non productive time are reduced to the barest minimum.
- Regular drills are conducted.
- Movement shall be under a GSA armed escort.

ES 15.0: Environmental Management Plan

A specific Environmental Management Plan (EMP) has been designed to articulate overarching and specific strategies including plans to assure environmental and social acceptability of the proposed project. It provides the guiding principles, management structure, roles and responsibilities communication strategy and other commitments to achieve the project's HSE goals including regulatory compliance. For each potentially severe impact (high or moderate severity), the EMP identifies and describes monitoring requirements. Specific mitigation and monitoring requirements that are peculiar to the project will be incorporated into the existing HSE-MS and associated plans as appropriate. It is noted also that the cost of implementing the EMP is fully covered in the overall budget for project implementation.

Acknowledgment

The Shell Petroleum Development Company Limited wishes to express her sincere gratitude to the Federal Ministry of Environment, Bayelsa State and Rivers States Ministry of Environments for the support and invaluable assistance in the preparation of this document. The support of community chiefs, Community Development Committees, Youth groups, Women Groups and Non-governmental organizations in Rivers and Bayelsa states is also acknowledged.

CHAPTER ONE
INTRODUCTION

1.1: Background Information

The Shell Petroleum Development Company Nigeria Limited (SPDC), operator of the NNPC/Shell/TEPNG/Agip Joint venture on behalf of its Joint Venture partners, has conducted the Environmental Impact Assessment for the OML 77/74 3D Seismic Reshoot Data Acquisition Project. The planned acquisition is in the Shallow Offshore Water environment off the coast of the Niger Delta. The 3D seismic reshoot will cover HA, HB, HD, ABC, BLKG and JK fields. Various 2D streamer seismic data have been acquired over OML 77 and 74 and also 3D streamer seismic data as well as an Ocean Bottom Cable (OBC) 3D seismic data acquisition from 1990 – 1998 with different levels of data quality. The acquired new 3D seismic data with increased multiplicity, longer offset and state of the art technology will:

- Significantly improve the structural imaging of the producing intervals,
- Help in optimising infill well locations through the improved imaging,
- Be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, using longer recording spreads and recording higher fold) which will maximize economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping facilities full and grow the nation's reserve base.

The new seismic dataset is planned to address both the imaging in the shallow reservoirs and the deeper exploration opportunities. Some of the prospects in the planned project area have been explored and the fields are producing. However, both the shallow and the deeper exploration opportunities have not been fully explored and properly evaluated.

Following the potentials for several interactions of the project activity with sensitive biological resources within the project area, SPDC subjected this project to the FMEnv EIA process in line with the Environmental Impact Assessment Act CAP E12 LFN 2004. The initial conceptual stages of the EIA has been completed with active participation of relevant stakeholders across Bayelsa and Rivers state and regulators (Appendix 6). Due to the dynamic business environment and the need to meet the Federal Government of Nigeria's export gas aspirations, SPDC approached the FMEnv to accelerate the EIA process with the view to secure environmental permits in time for the seismic data acquisition in June, 2019. The FMEnv agreed to support SPDC in realizing her business growth plan (Appendix 7). This EIA study has identified the key potential impacts of the project activities on Biophysical, Social and Health components within the project area and proffered mitigation measures for Environmental Management. The findings are hereby incorporated in this report.

1.2: EIA Objectives

The objectives of the EIA are to:

- Acquire baseline data of the environment as well as the socio-economic and health conditions of the host communities;

- Use the baseline data to describe and characterize the study area;
- Identify the environmental sensitivities of the project area;
- Determine and evaluate the potential impacts of the proposed project activities on the identified environmental sensitivities and the interactions between the sensitivities;
- Recommend appropriate mitigation measures; and
- Develop an Environmental Management Plan (EMP).

1.3: Project Location

The planned OML 77 and 74 Shallow Water Offshore 3D seismic data acquisition reshoot activity will be carried out off the coast of Niger Delta in water depths of about 7m and close to the shoreline to above about 70 m away from the shoreline (Fig. 1.1). The planned surface coverage area for this seismic survey is about 2,218 sqkms (Fig. 1.2) and span from Akuku-Toru LGA in Rivers State to Brass LGA in Bayelsa state. Coordinates of the

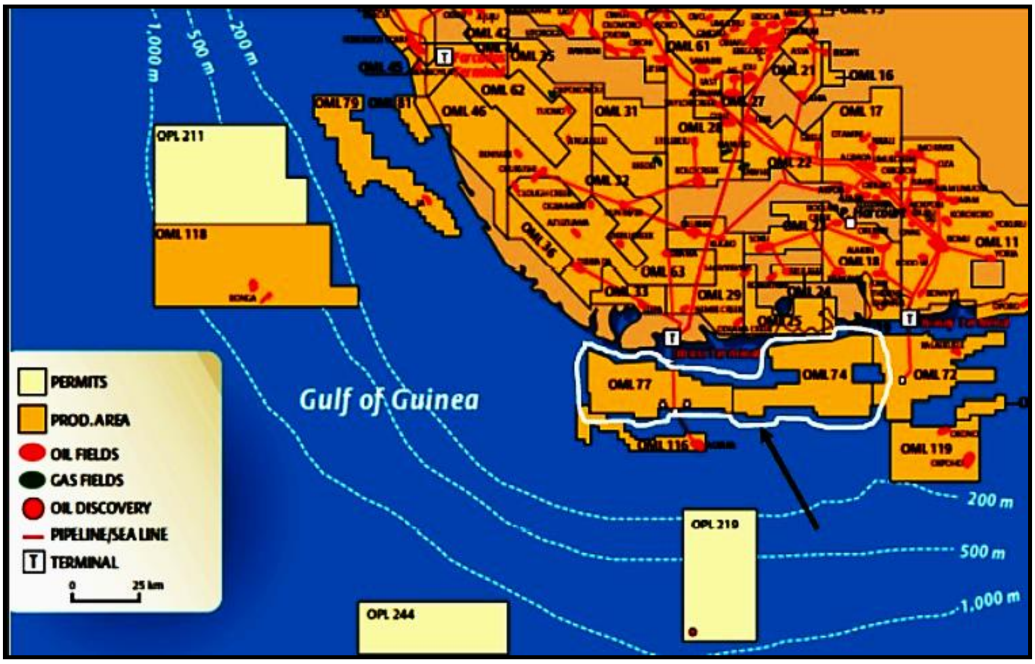


Figure 1.1: Map of the OML 77 and 74 in a polygon

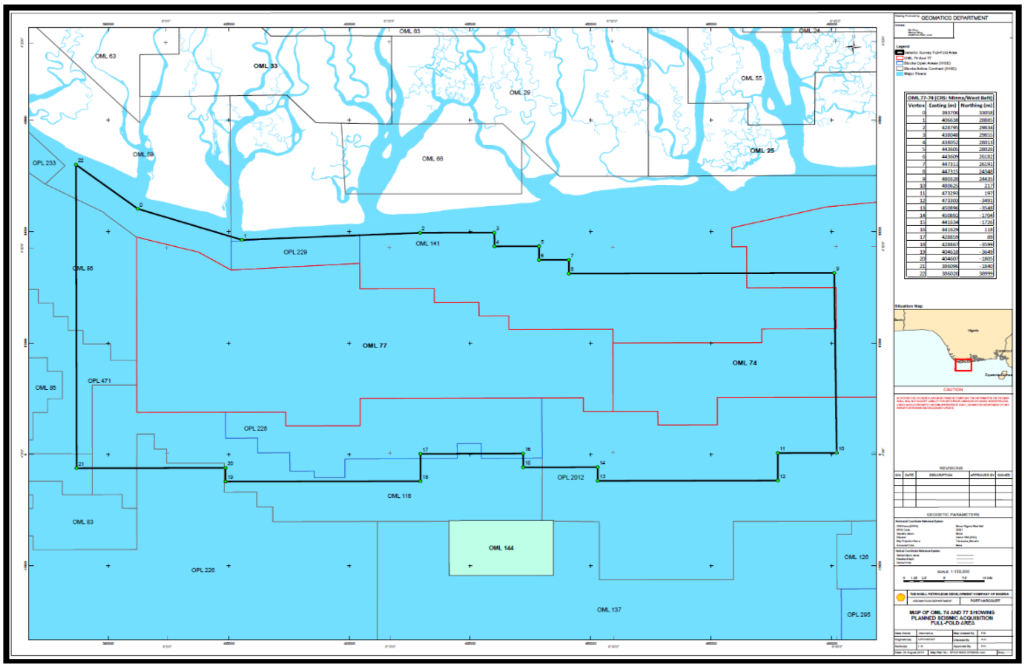


Figure 1.2: Map of the Area of Interest for OML 77 &74 3D Seismic Data Acquisition Reshoot

1.4: Project Proponent

The Shell Petroleum Development Company of Nigeria Limited (SPDC) is the largest Shell company in Nigeria and produced the country's first commercial oil exports in 1958. SPDC is the operator of a joint venture (the SPDC JV) between the government-owned Nigerian National Petroleum Corporation – NNPC (55% share), SPDC (30%), Total E&P Nigeria Ltd (10%) and the ENI subsidiary Agip Oil Company Limited (5%). It is focused on onshore and shallow water oil and gas production in the Niger Delta. SCiN make a major contribution to developing the country's human capital and contracting capacity. SCiN pursue a variety of social investment projects, with a particular focus on community and enterprise development, education and health.

1.5: EIA Terms of Reference

The Terms of Reference (ToR) for EIA of OML 77 and 74 3D Reshoot Seismic Data Acquisition Project was developed and submitted for regulatory approval (Appendix 1.1) the ToR defined the scope of work, objectives, baseline data requirements, assessment tools and methods for the EIA. It also outlined the regulatory framework within which the EIA should be conducted and highlighted some key issues / activities of environmental concern in the proposed project planning and implementation.

EIA Workscope

The scope of work for this EIA as contained in the approved ToR includes:

- one season field data collection for characterization of project area environment
- surface water sampling at thirty-seven (37) within the study area and three (3) points at control locations

- sediment sampling at sixty-three (63) points within the study area and three (3) points at control locations
- Physico-chemical, microbiological analysis of all collected sediment and surface water samples
- Hydrobiology sampling at surface water sampling points
- Macro benthic sampling at sediment sampling point
- Predict impacts and proffer mitigation measures of identified impacts;
- Develop an environmental management plan (EMP) for the proposed project;
- Prepare and submit draft EIA reports
- Produce final EIA report after addressing comments and inputs from panel/technical review

1.6: EIA Methodology

The methods/approach used to ensure that an effective EIA was carried out includes; submission of proposal/ ToR, planning and review of field pre-mobilisation activities, field data gathering campaign, laboratory analyses, interpretation, reporting, etc. These items are presented in the flowchart in Figure 1.3 and discussed further.

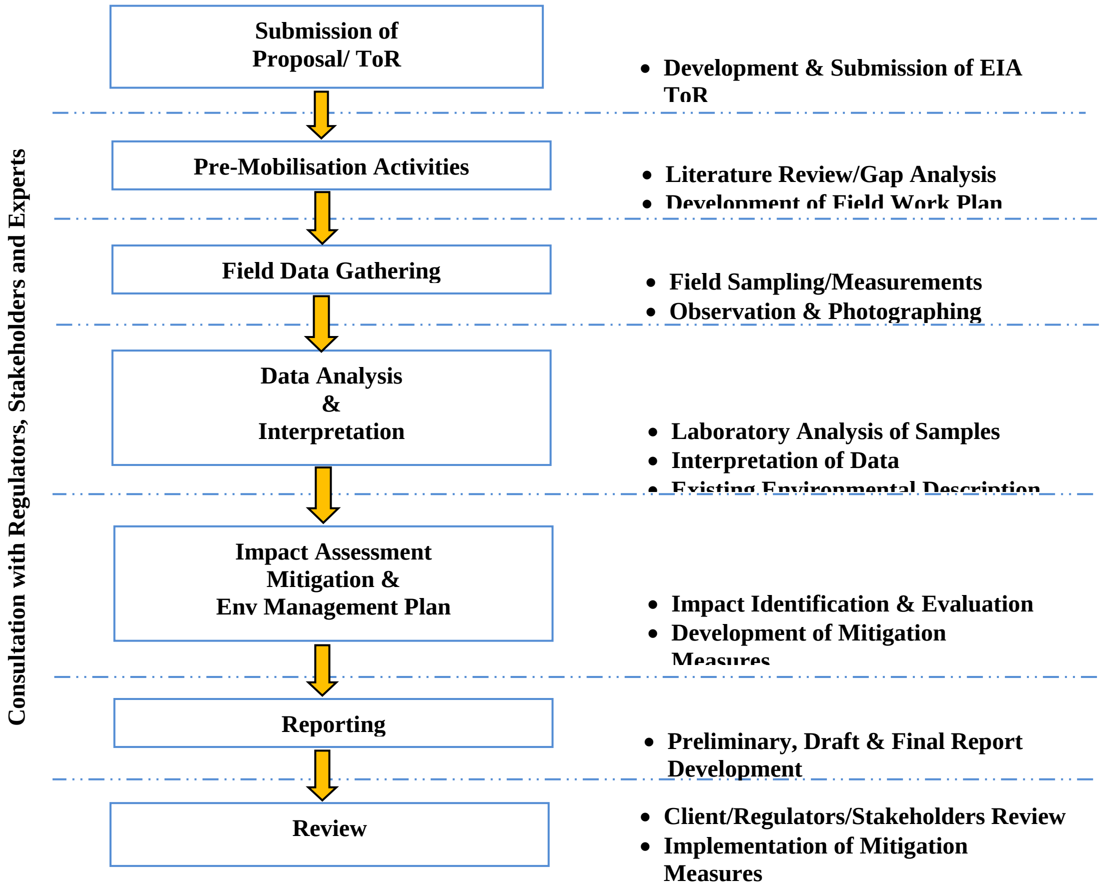


Figure 1.3: EIA Methodology Flowchart

Submission of Proposal and Term of Reference

The first step in the EIA study was the development and submission of the project proposal/ EIA terms of reference (ToR). The ToR contained synopsis of the proposed seismic acquisition project, scope of the EIA study, the regulatory framework for conducting the study, objectives, baseline data requirements and assessment tools/methods for the EIA. Further, it highlighted some key issues/activities of environmental concerns in the proposed project planning and implementation.

Pre-Mobilisation Activities

Pre-mobilisation activities involved literature review and design of field data gathering approach. Literature review and research involving consulting relevant articles, research publications, maps, past reports and the internet to obtain relevant background information on the biophysical and social environment of the study area and to identify gaps required to be filled during the field study. Further research was conducted at the end of the field data gathering exercise to compare literature information with generated field data and fill gaps identified.

The sample station co-ordinates and maps obtained from SPDC were used to design and plan the best strategy towards obtaining the samples from the study area.

Field Data Gathering

Field data gathering exercise covered the biophysical and social environment of the study area which includes ambient air, surface water, sediment, soil, fisheries and socio-economic characteristics. In-situ measurements were carried out on certain parameters with short holding time (pH, salinity, DO, temperature, electrical conductivity) and information obtained was recorded. Consultations with neighbouring communities were also carried out during the field study.

Data Analysis and Interpretation

Field samples obtained during the field data gathering were subsequently taken to the laboratory for analyses. Results obtained were interpreted and used to describe the existing baseline of the study area as documented in chapters four of this report.

Impact Assessment, Mitigation and Environmental Management Plan

The potential/associated adverse and beneficial impacts of the proposed seismic and drilling activities on the existing environment were identified at this stage of the EIA. The EIA Sectoral Guidelines for Oil and Gas Industry projects (FEPA, 1995) and the World Bank Environmental Assessment Source Book (1991) among other references were used in the identification process. Evaluation of the identified impacts were carried and compared using criteria such as legal/regulatory requirements in respect of the planned activities, magnitude of impact, risk posed by impact, public perception and importance of affected environmental component. The results of identification and evaluation of the seismic data acquisition activities are presented in chapter five of this report.

Mitigation measures designed to prevent, reduce or control the adverse impacts of the environmental aspects of the proposed project to as low as reasonably practicable were considered and documented in chapter six of this report. Finally, an Environmental Management Plan (EMP) was developed (chapter seven), which would be an environmental management tool to ensure that all mitigation measures are implemented and adhered to during the duration of the project operation. The EMP shall also enable a rapid rescue/response if an unforeseen environmental impact occurs.

Reporting

The findings of the proposed seismic acquisition and exploratory well drilling EIA were documented as contained in this draft report. The final version of this report shall be issued at the end of the regulators/stakeholders' review meetings. The report shall incorporate all pertinent issues and comments arising from the review meetings as will be directed by FMEnv/ DPR.

Consultation with Regulators, Stakeholders and Experts

Consultation was an essential aspect of the EIA implementation and will continue throughout the life span of the project. Consultation involved information dissemination and interaction/dialogue with various stakeholders concerned with the proposed project including professionals/experts in relevant fields of engineering, science, health and environment. Information obtained from consultation activities were also used during the impact prediction, assessment, evaluation and mitigation of the proposed project.

1.7: Legal and Administrative Framework

There are legislations, guidelines and standards that govern the assessment of environmental impacts of development projects in the oil and gas industry in Nigeria. These regulations can be classified as follows:

1.7.1: International Laws and Regulations

Nigeria is signatory to several laws, treaties and regulations that govern the environment. Among these are:

(i) World Bank Guidelines on Environmental Assessment {EA} (1991)
(ii) International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines
(iii) Convention on the Migratory Species of Wild Animals (Bonn Convention)
(iv) Convention of Biological Diversity
(v) Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention)
(vi) Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and.
(vii) United Nations Framework Convention on Climate Change (1992)

World Bank Guidelines on Environmental Assessment {EA} (1991)

The World Bank requires the execution of an EIA on a proposed industrial activity by a borrower as a pre-requisite for granting any financial assistance in form of loans. Details of World Bank's EIA procedures and guidelines are published in the Bank's EA Source Book vols. I - III of 1991. Potential issues considered for EA in the upstream oil and gas industry include the following:

- Biological Diversity
- Coastal and Marine Resources Management
- Cultural Properties
- Hazardous and Toxic Materials and
- International waterways.

International Union for Conservation of Nature and Natural Resources (IUCN) Guidelines, 2001

The IUCN in conjunction with the Oil Industry International Exploration and production Forum presented a set of guidelines for oil and gas exploration and production in mangrove areas. These guidelines are aimed at conservation of mangroves and enhancing the protection of marine ecosystems during E & P activities. The document also discusses the policy and principles for environmental management in mangrove areas as well as EIA procedures, Environmental Audit and Monitoring.

Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention), 1979

The Bonn Convention concerns the promotion of measures for the conservation and management of migratory species.

Convention on Biological Diversity, 1992

The objectives of the Convention include the conservation of biological diversity, the sustainable use of its components, and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.

Convention Concerning the Protection of the World Cultural and Natural Heritage Sites (or World Heritage Convention), 1972

The convention sets aside areas of cultural and natural heritage for protection. The latter is defined as areas with outstanding universal value from the aesthetic, scientific and conservation points of view.

Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal, 1989

The convention focuses attention on the hazards of the generation and disposal of hazardous wastes. The convention defines the wastes to be regulated and control their trans-boundary movement to protect human and environmental health against their adverse effects.

United Nations Framework Convention on Climate Change (1992)

In order to achieve sustainable social and economic development, energy consumption for developing countries needs to grow taking into account the possibilities for achieving greater energy efficiency and for controlling greenhouse gas emissions in general. This also includes the application of new technologies on terms which make such an application economically and socially beneficial, determined to protect the climate system for present and future generations.

1.7.2: Legislations guiding Environmental management in Nigeria

The Mineral Oil (Safety) Act CAP 350 LFN 1990

Sections 37 and 40 of the Mineral Oil (Safety) Act CAP 350 LFN 1990 require provision of Personal Protective Equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

Federal Environmental Protection Agency (Now FMEnv) Act No. 58, 1988

This Act, which was issued in 1988 and amended by Act No. 59 of 1992, provides the setting up of the Federal Environmental Protection Agency, as the apex organization for the overall protection of the Environment and Conservation of Natural Resources. The act also makes environmental impact assessment (EIA) mandatory for all new major projects. In compliance with its mandate, FEPA issued the procedure, guidelines and standards for the execution of EIA with emphasis on the significance associated with current and potential impacts of such projects. The procedure also indicates the steps to be followed (in the EIA process) from project conception to commissioning in order to ensure that the project is executed with adequate consideration for the environment.

EIA Sectoral Guidelines for Oil and Gas Industry Projects, 1995

In compliance with its mandate, FEPA issued the EIA Sectoral Guidelines for Oil and Gas Industry Projects, 1995. Contained in the Procedural Guidelines (pg. 8) are Category I projects (mandatory study activities) and listed under item 15, sub-item (a) on page 10) (Petroleum) is Oil and Gas Fields Development, making an EIA mandatory for the proposed project. The Procedural Guidelines also indicate the steps to be followed (in the EIA process) from project conception to commissioning in order to ensure that the project is executed with adequate consideration for the environment. Annex C contains the EIA writing format as required by FMEnv. The guidelines are intended to assist in the proper and detailed execution of EIA studies of projects in consonance with the EIA Act.

S.I. 15 - National Environmental Protection Management of Solid and Hazardous Wastes Regulation (1991) (FMEnv)

This provides that the objective of solid and hazardous waste management shall be to:

- Identify solid, toxic and extremely hazardous wastes dangerous to public health and environment,
- Provide for surveillance and monitoring of dangerous and extremely hazardous wastes and substances until they are detoxified and safely disposed,

- Provide guidelines necessary to establish a system of proper record keeping, sampling and labelling of dangerous and extremely hazardous wastes,
- Establish suitable and provide necessary requirements to facilitate the disposal of hazardous wastes;
- Research into possible re-use and recycling of hazardous wastes.

Environmental Impact Assessment Act CAP E12 LFN 2004

The Act sets out general principles, procedures and methods to enable the prior consideration of Environmental Impact Assessment on certain public or private projects. The objectives of the Act is to promote the implementation of appropriate policies consistent with all the laws and decision making processes through which the goal and objectives maybe realized. The Act also encourages the development of procedures for information exchange, notification and consultation between the organs and persons when proposed projects or activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages.

FEPA (Now FMEnv) Nigeria's National Agenda 21 (1999)

Nigeria's National Agenda 21 was developed to:

- Integrate environment into development planning at all levels of government and the private sector,
- Intensify the transition to sustainable development,
- Address sectoral priorities, plans, policies and strategies for the major sectors of the economy and,
- Simultaneously foster regional and global partnerships.

FEPA (Now FMEnv) National Policy on the Environment (1989)

This gave the policy goals, conceptual framework and strategies for implementation.

Land Use Act CAP 202 LFN 1990

The land-use Act of 1978 states that "… it is also in the public interest that the rights of all Nigerians to use and enjoy land in Nigeria in sufficient quality to enable them to provide for the sustenance of themselves and their families should be assured, protected and preserved".

National Inland Waterways Authority Act No 13 of 1997

This Act established the National Inland Waterways Authority with a view to improving and developing inland waterways for navigation, providing an alternative mode of transportation for the evacuation of economic goods and persons, executing the objectives of the national transport policy as they concern inland waterways. The Act also prescribes regulations and sanctions on the use and exploitation of resources of inland waterways such as dredging, sand or gravel, mining and erection of permanent structures within the right-of-way or diversion of water from a declared waterway.

Endangered Species Act CAP E9 LFN 2004

This Act prohibits hunting, capture and trade of some *endangered species* like crocodile, alligator, turtles, Parrot, etc. The Endangered (Control of International Trade and Traffic) Decree (No. 11 of 1985) has been enacted by the Federal Republic of Nigeria specifically to implement CITES. It is broader than CITES in that it also covers domestic taking of listed species. Two schedules are included: Schedule I (Endangered Species – Animals in relation to which International Trade is absolutely Prohibited), and Schedule 2 (Animals in Relation to which International Trade may only be conducted under License). The decree prohibits taking of Schedule 1 species and requires that taking of Schedule 2 species be in accordance with a license issued under the decree.

Petroleum Act CAP 350 LFN 1990

An Act to provide for the exploration of petroleum from the territorial waters and the continental shelf of Nigeria and to vest the ownership of, and all on-shore and off-shore revenue from petroleum resources derivable therefrom in the Federal Government and for all other matters incidental thereto.

Territorial Waters Act CAP 428 LFN 1990

The territorial waters of Nigeria shall for all purpose include every part of the open sea within twelve nautical miles of the coast of Nigeria (measured from low water mark) or of the seaward limits of inland waters. Any act or omission which-

(a) is committed within the territorial waters in Nigeria, whether by a citizen of Nigeria or a foreigner; and

(b) would, if committed in any part of Nigeria, constitute an offence under the law in force in that part, shall be an offence under that law and the person who committed it may, subject to section 3 of this Act, be arrested, tried and punished for it as if he had committed it in that part of Nigeria

Water Resources Act CAP W2 LFN 2004

The Water Resources Act vests the right to the use and control of all surface and groundwater and of all water together with the bed and banks in any watercourse affecting more than one state in the Government of the Federation. However, the Act essentially preserves existing rights, including customary rights, provided they are for domestic use, watering of livestock and personal irrigation schemes. A proviso to section 1(1) states that the subsection shall not be deemed to infringe or to constitute a compulsory right over or interest in property. Apparently, the idea is to separate rights over water resources from other rights in property.

Nigerian Oil and Gas Industry Content Development Act 2010

The Act provides for the development of Nigerian Content in the Nigerian Oil and Gas Industry, Nigerian Content Plan, Supervision, Coordination, Monitoring and Implementation of Nigerian content and for related matters. All regulatory authorities, operators, contractors, subcontractors, alliance partners and other entities involved in any project, operation, activity or transaction in the Nigerian oil and gas industry shall consider Nigerian content as an important element of their overall project development and management philosophy for project execution.

Employee's Compensation Act No. 13, 2010

The objectives of the Act are to— (a) provide for an open and fair system of guaranteed and adequate compensation for all employees or their dependants for any death, injury, disease or disability arising out of or in the course of employment ; (b) provide rehabilitation to employees with work-related disabilities as provided in this Act ; (c) establish and maintain a solvent compensation fund managed in the interest of employees and employers ; (d) provide for fair and adequate assessments for employers ; (e) provide an appeal procedure that is simple, fair and accessible, with minimal delays ; and (f)combine efforts and resources of relevant stakeholders for the prevention of workplace disabilities, including the enforcement of occupational safety and health standards.

National Inland Waterways Authority Act No. 13, 1997

This Act established the National Inland Waterways Authority with a view to improving and developing inland waterways for navigation, providing an alternative mode of transportation for the evacuation of economic goods and persons, executing the objectives of the national transport policy as they concern inland waterways. The Act also prescribes regulations and sanctions on the use and exploitation of resources of inland waterways such as dredging, sand or gravel, mining and erection of permanent structures within the right-of-way or diversion of water from a declared waterway.

1.7.3: Legislations guiding Environmental management in Bayelsa State

The Bayelsa state regulations guiding Environmental management includes but not limited to the following:

- Bayelsa State Environmental and Development Planning Authority Law 1998;
- Bayelsa State Pollution Compensation Tax Law 1998;

1.7.4: Legislations guiding Environmental management in Rivers State

The Rivers state regulations guiding Environmental management includes but not limited to the following:

- Public Health Law – CAP 103 of the Laws of Eastern Nigeria 1963;
- Rivers State Environmental Protection Agency Law No. 2 of 1994
- Rivers State Private Health and Allied Establishments Authority Law, 2001
- Rivers State Public Health Law, 1999
- Rivers State Noise Pollution Control Law of 1984

1.7.5: SPDC Policies and Principles

Shell Petroleum Development Company (SPDC) operates under the Shell Group guidelines and complies strictly with them. Where national standards and regulations are more stringent than Shell guidelines, SPDC's policy is to comply with the existing national legislation.

(a) Business Principles

Shell companies have a systematic approach to health, safety, security and environmental management in other to achieve continuous performance improvement. To this end, Shell companies manage these matters as critical business activities, set standards and targets for improvement, and measure, appraise and report performance internally and externally.

(b) Governing Policies

The SPDC 1998 Corporate Policies emerged with five Business Governing policies. Of interest to this document is the section on HSE referred to as 'Health, Safety and Environment Policy'. This policy addresses the health, safety, and environmental risks to the business and the potential impacts on staff, personnel, and the host communities. The policy reflects good practice and is mandatory.

(c) HSE Policy

It is SPDC's Policy that all activities shall be planned and executed in a manner that,

- Preserves the health, safety and security of all Company and contractor personnel and members of the public;
- Preserves the integrity and security of Company assets;
- Minimizes the impact of operations on the environment; and
- Is sensitive to the needs and concerns of the Host Communities.

The implications of implementing this policy are that,

- All activities shall be analyzed to systematically identify related hazards, risks and sensitivities;
- Arrangements shall be put in place to control the hazards, risks and sensitivities and to deal with consequences should they arise;
- Any activity which is unhealthy, unsafe, environmentally unsound or may adversely impact relations with the community, shall be suspended until an acceptable solution is found;
- All personnel, including those of contractors, shall be trained and made fully aware of the hazards, risks, sensitivities and controls in place; and
- Plans and procedures shall be in place to respond to any emergency or loss of control.

Every employee and contractor employee must plan and perform his work in accordance with this policy. Each employee is required to report, and where necessary, suspend any activity considered to be in contravention of this policy.

(d) SCiN Biodiversity Policy

''In Shell, we recognize the importance of biodiversity. Therefore, we are committed to:

- Work with others to maintain Ecosystems
- Respect the basic concept of Protected Areas
- Partner with others to make positive contributions towards the conservation of biodiversity in our areas of operations

- Conduct Environmental Assessments with increased focus on impacts on biodiversity
- Engage and collaborate with other stakeholders to manage biodiversity responsibly especially in sensitive environments

(e) Waste Management Policy

It is the policy of SPDC to:

- Take all practical and reasonable measures to minimize the generation of solid and liquid wastes, as well as emissions from construction equipment and otherwise;
- Manage and dispose wastes in an environmentally responsible manner;
- Track and maintain records of waste streams and provide an auditable trail as to their management and disposal.

(f) Emergency Response Policy

This states that the response to any emergency within SPDC will be directed towards

- Saving life
- Care for the injured
- Protection of the environment
- Limitation of damage to assets
- Defense of SPDC's good corporate image

SPDC shall provide appropriate organization, facilities, procedures and training so that immediate coordinated action can be taken to manage the situation in line with the above

- Maintenance of emergency equipment shall receive high priority. Close liaison will be maintained with appropriate Government and industry organization and communities
- Regular exercises will be carried out to confirm effectiveness, and any necessary improvements made promptly to maintain our readiness at all times.

1.8: EIA Report Presentation

This EIA report is presented in eight (8) chapters as follows:

- Chapter one: presents the proponent, objectives, scope, EIA methodology, regulatory and administrative framework of the EIA.
- Chapter two: presents the project justification, need/value, envisaged sustainability and the project options.
- Chapter three: describes the proposed project design, project implementation schedule as well as decommissioning / abandonment activities.
- Chapter four: describes the existing environment of the project. It also presents the socio-economic and health profile of the coastal communities proximal to the project site.
- Chapter five: presents the identified potential and associated impacts of the project activities.
- Chapter six: presents the mitigation measures proffered for envisaged significant and non-significant impacts.

- Chapter seven: presents the Environmental Management Plan (EMP) recommended for sustainability.
- Chapter eight: presents the conclusion of assessment conducted

CHAPTER TWO
PROJECT JUSTIFICATION

2.1: General

The proposed OML 77 and 74 3D Reshoot seismic acquisition is aimed at obtaining data on the field reservoir to enhance the subsurface reservoir knowledge and aid future production decision-making and the field development. The 3D seismic reshoot technique is well established as an industry 'best practice' for sound reservoir management - to monitor flood front movement, to identify by-passed oil and to track the effectiveness of a water injection scheme.

2.2: Need for Project

The execution of the project shall ensure the following:

- Significant contribution to actualizing Federal Government's plan to increase its hydrocarbon production capacity.
- Increased revenue to the government of Nigeria emanating from the project activities and sales of the hydrocarbon products.
- Transfer of Oil exploration and Production technology to indigenous Nigerian personnel in the various fields of oil exploration and production operations.
- The seismic activity and the eventual operation shall lead to the provision of employment for both skilled and unskilled Nigerians.

2.3: Benefit of the Project

The proposed project will provide a better understanding of the geological heterogeneity of the lease and this will:

- help SPDC to identify/ confirm the presence of hydrocarbon reserves within the block and hence delineate appropriate prospects for exploitation;
- provide necessary data for decision makers as relates to oil and gas exploration/ exploitation in Nigeria;
- improve development of resources as well as reduce drilling wastes due to more effective well placement;
- reduce the overall drilling costs thereby substantially improving project economics;
- cut exploration time relative to successful production which would also reduce cost;
- add to Nigeria's total hydrocarbon reserve, increased production capacity and ultimately, enhancement of the overall export earnings of the nation;
- support SPDC business growth plan; and
- provide direct and indirect employment opportunities for Nigerians during the various phases of activities.

2.4: Envisaged Sustainability of the Proposed Project

Economic and Commercial Sustainability

Data from the planned survey will be interpreted and results used to determine the presence of hydrocarbon bearing structures/reserves within the blocks. Consequently, exploratory drilling campaigns may be undertaken to further confirm the nature and size of such reserves. All these will establish the economic and commercial sustainability of the project.

Technical Sustainability

The proposed project is technically viable because it will rely on existing and well-established technologies, with proven oil field experience and strong HSE awareness. The design and operation of the proposed 3D seismic survey would be carried out in line with national and international codes and standards of practice. Also, SPDC and its contractors shall develop operating manuals and procedures relating to the proper operation of the project activity. These materials will be used as the basis for providing facility-specific training to relevant personnel prior to start-up. In addition, personnel with experience in similar operations will be involved in the transition and early operations.

Environmental Sustainability

The findings and recommendations of this EIA would be integrated into all phases of the proposed project. Recommendations on the project process, waste management (handling, treatment and disposal) which were developed in line with the environmental regulations, guidelines and standards of the FMEnv and the DPR as well as international best practices would ensure the environmental sustainability of the proposed project. Specific international practices relating to aquatic animal protection would also be employed.

In addition, SPDC shall conduct the proposed 3D seismic campaign in line with the company's HSE policy to ensure negative impacts are reduced to levels as low as reasonably practicable (ALARP). Specifically, the acoustic energy for this 3D seismic data acquisition shall be by means of air guns; this is the most environmentally friendly for marine operations, compared to the other acoustic energy sources.

2.5: Project Options and Analysis of Alternatives

For any project, there are several option scenarios that must be considered. The options considered for this Seismic project are no-project option, delayed project, and the selected alternative.

2.5.1: No Project Option

The no project option implies that the 3D seismic data acquisition projects will not be executed. The implications of this option are:

- Paucity of information to resolve uncertainties in the fields which will lead to sub-optimal well placement/ reservoir deliverability and enhance performance management of existing development in the field.
- The loss of economic benefits that would have accrued to the Nation by actualising Federal Government’s plan to increase hydrocarbon production capacity.
- No contribution/support for the NLNG and domestic gas growth requirements.
- Loss of revenue to Joint Venture (JV).

- Loss of the employment opportunities that would have arisen from the project/loss of new technology learning to Nigerians.

2.5.2: Delayed Project Option

This option implies postponing the planned 3D seismic acquisition activities to a much later date. Such option is usually taken when prevailing conditions (such as economic, political, etc.) are unfavourable for a project implementation. Thus, delaying the proposed 3D seismic acquisition will result in the following.

- Putting on hold all processes that have been put in place for the project design, implementation schedule, etc. and consequent impact on the FOD plans of the various fields within the Shallow Water Offshore environment.
- Loss of opportunity and project value from the current Low Oil Price that would reduce the seismic data acquisition cost to the Federal Government of Nigeria and the Joint Venture Partners.
- Erosion of the Value of Information (VOI).
- Loss of favourable weather acquisition windows.

Consequently, the delayed option is not the chosen option.

2.5.3: Carry out the Project

This option implies going ahead with the project using the most suitable and Available Technology. Details of the options selection are summarized in Table 2.1

Table 2.1: Project Options

S/N	Options	Advantages	Disadvantages	Remarks
1.	No project option	• No Capital Expenditure. • No pressure on existing social-economic activities. • No impact on the environment.	• Paucity of information to resolve uncertainties in the fields which will lead to sub-optimal well placement/ reservoir deliverability and enhance performance management of existing development in the field. • The loss of economic benefits that would have accrued to the Nation by actualizing Federal Government's plan to increase hydrocarbon production capacity. • No contribution/support for the NLNG and domestic gas growth requirements. • Loss of revenue to Joint Venture (JV). • Loss of the employment opportunities that would have arisen from the project/loss of new technology learning to Nigerians.	Not recommended
2.	Delayed Ocean Bottom Nodes (OBN) 3D seismic	• No Capital Expenditure. • No pressure on existing social-economic activities • No impact on the environment.	• Lost opportunity to impact the targeting of the Field Development Plans. • Loss of increased Hydrocarbon production capacity. • Loss of opportunity to reduce number of potentially dry wells and well placement optimization for (development) wells proposed in existing discovered resource volumes. • Delaying the proposed 3D seismic acquisition re-shoot will result in putting on hold all processes that have been put in place for the project design, implementation schedule, etc. and consequent impact on the FOD plans of the various fields within the Shallow Water Offshore environment. • Loss of opportunity and project value from the current Low Oil Price that would reduce the seismic data acquisition cost to the Federal Government of Nigeria and the Joint Venture Partners. • Erosion of the Value Of Information (VOI). • Loss of favourable weather acquisition windows.	Not recommended
3.	Ocean Bottom Cables (OBC) seismic data acquisition technique	Cheaper to execute than Ocean Bottom Node (OBN) seismic data acquisition technique	• Can be affected by swell noise (surf zone) hence high downtime. • Cables always by passes obstacles which results in a poor receiver to sea bed contact/cable sagging. • Limitation where there are access problems/obstructions (E&P facilities) hence gap exist in the data • Processing challenges in using Ocean Bottom Cables as a baseline for future advanced technology acquisition. • Increase in environmental footprint	Not recommended

S/N	Options	Advantages	Disadvantages	Remarks
4.	Ocean Bottom Node (OBN) seismic data acquisition technique	• Works well even in the shallow water depths • Works optimally in areas with E&P facility obstructions and related operational HSE challenges including obstruction of and entanglement with third party fishing facilities • Provides optimal data quality that could be acquired • Better seismic imaging issues, good imaging without chaotic reflections around the faults over the complex collapsed crestal structures characteristic of the project area • High bandwidth, Low noise, wide offsets and associated good data resolution for optimum interpretation/maturation efforts. • Better and wide-azimuthal coverage and long offset seismic data for better imaging of both shallow (new image data will help to further improve shallower levels for development activities) and deep depths (new image data will help to support mapping the exploration opportunities), • Forms 4D baseline data, benefit from the current state of the art processing workflows and also relevant for future advancement in processing technologies. • Nodes are highly reliable and can achieve uptimes of 98 percent or higher.	• Costly to execute than Ocean Bottom Cable (OBC) seismic data acquisition technique • OBN surveys usually require a shooting vessel and a node laying vessel or node on a rope laying vessel with dynamic positioning systems	Recommended

2.5.4: Seismic Data Acquisition Alternatives

Seismic surveys started as far back as the 1930s. The basic objective of seismic reflection recording is normally to measure the time for a seismic wave to travel from a known source point to one or more buried discontinuities and back to a known receiver point to infer the subsurface structures.

2D Seismic Technique

In 2D Seismic Technique, the recording devices (receivers) and the sources are placed along the same, generally straight line of measurement. It is generally used for reconnaissance and to resolve simple structures at depth.

Remark: Not recommended

3D Seismic Technique

The 3D seismic technique can be laid out in a variety of geometries. Seismic geometry is the areal configuration of the shots and receivers on the surface. Complicated structures causing out-of-plane reflections (sideswipe) can only be imaged properly using 3D reflection technique in which a 3D volume (x,y,z) of crust is sampled and monitored using a planar, rather than a linear array of shots and receivers. In practice, this is accomplished by laying/towing out thousands of receivers along parallel lines of receiver groups and then shooting into the entire array (receivers) from each shot point along a series of orthogonal/parallel shot lines. Generally, a 3D seismic survey is acquired after a preliminary 2D seismic survey.

Remark: Not recommended

Streamer Seismic Technique

In Streamer technique the source and receivers are towed along in a vessel with the streamers trailing the sources. The receivers are contained in cables which are separated by some fixed distances.

Ocean Bottom Cable (OBC) Technique

In OBC, data acquisition is achieved by laying receiver cables on the seabed to record reflections from the subsurface.

Remark: Not recommended

Ocean Botton Node (OBN) Technique

OBN technique involves planting individual receiver nodes on the seabed. These nodes are battery powered and record signals from the subsurface for as long as they are programmed to. Once the acquisition is complete, the nodes are retrieved and the information in them recovered. The nodes are usually positioned on the seabed using Remotely Operated Vehicles (ROVs) that have pre-programmed coordinates for the receiver positions.

Remark: Not recommended

4D Seismic Technique

4D seismic data is a timelapse seismic data. It is a repeat exercise of a survey acquired at different time over the same area to assess changes in a producing hydrocarbon reservoir with time. This change will aid future production decision-making and well placement in the development of the field.

Selected Option - 3D Ocean Bottom Nodes (OBN) Seismic Data Acquisition

The shallow water depths, the E&P facility obstructions with some sticking out of the sea bed and related operational HSE challenges, coupled with the sub-optimal data quality that could be acquired technically limit the appropriateness of streamer/cable technology deployment in the planned project areas. Also, the quality of the existing legacy streamer seismic data from current evaluations over the 3 blocks clearly identified seismic imaging issues, such as poor imaging with chaotic reflections around the faults over the complex collapsed crestal structures, multiples, low bandwidth, high frequency noise, short offsets and associated poor data resolution impacting negatively interpretation/maturation efforts.

The advancement in technology favours the requirement of an ocean bottom nodes seismic technology over the project areas. The ocean bottom nodes technology deployment will give a better and wide-azimuthal coverage and long offset seismic data for better imaging of both shallow (new image data will help to further improve shallower levels for development activities) and deep depths (new image data will help to support mapping the exploration opportunities), it will also form 4D baseline data, benefit from the current state of the art processing workflows and also relevant for future advancement in processing technologies. Therefore, this technique is selected.

The current concepts for achieving marine seismic surveys include the Streamer and the Ocean Bottom Seismic techniques (comprising the Ocean Bottom Cable and Ocean Bottom Nodes) techniques. Analysis of the different concepts is based on differences with respect to HSE, E&P Obstructions, Technology, (Imaging/Resolution), as well as cost among others. Details for the concept selection are shown in Table 2.2. The selection of the most viable acquisition option is obtained using a matrix scoring process which utilizes:

- Environmental and Safety considerations
- E&P Obstructions
- Technology Considerations (Imaging/Resolution)
- Cost

The impact of each criterion is ranked by assigning scores between 5 (Very high positive performance) and 1 (Very poor performance) as follows:

1 = Very poor performance
2 = Moderate Performance
3 = Average Performance
4 = High Performance

5 = Very High Performance

Based on these criteria (Environmental, Safety, Technical, Cost) the selected concept for the Seismic Data Acquisition is the 3D Ocean Bottom Node Technology. The OML 77&74 3D seismic data acquisition operations will include the following:

- A node deployment vessel with crew
- Energy Sources – Air Compressors on board vessel
- Towed seismic airgun lying just beneath the sea surface
- Detectors – Housed within the deployed Ocean Bottom Nodes at the bottom of the ocean.
- Chase boats to monitor activities in and around the operational areas
- Guard boats to monitor activities
- Fast Rescue Boats in mother vessels: In emergency to convey personnel to a safe /evacuation point.

Table 2.2: Concept Selection criteria for Seismic Acquisition

PARAMETERS	STREAMER	OBC	OBN
HSE Issues	• HSE related challenges where there are access problems/obstructions (E&P facilities) due to the towed streamers coming close to facilities. • Water depths is a limiting factor in streamer deployment - HSE related challenges due to the water depths and vessel availability that can tow the streamers in shallow depths • HSE issues related to seismic recording cables coming close to fishing boats/gears due to the lengths being towed	• HSE related challenges where there are access problems/obstructions (E&P facilities) due to the laying of cables close to facilities. • Can be deployed in shallow water.	• Acquisition where there are obstructions (E&P facilities) because individual Nodes located close to obstructions • The individual nodes are usually positioned on the seabed using Remotely Operated Vehicles (ROVs) that have pre-programmed coordinates for the receiver positions though nodes on a rope technology is also used and most especially in shallow areas. • Can be deployed even in ecologically sensitive areas. • Can be deployed both in shallow and deep water.
Score	1	3	5
Technology (Imaging/Resolution)	• Limitation due to access problems/ obstructions (E&P facilities) hence gap exist in the data. • Easily affected by swell noise, hence susceptible to high noise, high downtime, meandering and more infill shots may be required • Narrow azimuth and also limited cross line offsets • Towed streamer data cannot successfully image channels. Channels may attenuate primary energy and produce strong multiples • Hydrophone component only • Streamer acquisition do not provide high resolution & Imaging in such structurally complex areas like our planned project areas • Processing challenges in using streamer as a baseline for future advanced technology acquisition. • Poor repeatability. • Not able to provide Shear waves which are useful for lithology and fracture characterization and for differentiation between fluid replacement and pressure effects in reservoir monitoring. • Images from streamer survey would suffer from multiples significantly more than images from seabed receivers.	• Limitation due to access problems/obstructions (E&P facilities) hence gap exist in the data. • Can be affected by swell noise (surf zone), hence high downtime. • Cables always by passes obstacles which results in a poor receiver to sea bed contact/cable sagging. • Processing challenges in using Ocean Bottom Cables as a baseline for future advanced technology acquisition. • Repeatability challenges. • Data domain - 4C Sensors (3 component geophone + 1 hydrophone) • Seabed receivers enable separation of up and down going waves. • Full azimuth acquisition • Unlimited offsets (long offsets).	• Nodal acquisition provides high resolution & Imaging in complex collapsed crestal structures with chaotic reflections behind the faults as in our project areas. • Future 4D pre-requisite for better reservoir monitoring and evaluation • Data domain - 4C Sensors (3 component geophone + 1 hydrophone) • Full azimuth acquisition • Unlimited offsets (long offsets). • Nodes are battery powered and record signals from the subsurface for as long as they are programmed to. • Minimal reported Nodes failure. • Seabed receivers enable separation of up and down going waves.
Score	1	4	5

PARAMETERS	STREAMER	OBC	OBN
Cost	• Streamers are generally less expensive to deploy than seafloor systems. • Streamers technology utilizes a single vessel for both towing the streamers and airguns.	• Ocean bottom cable (OBC) systems come with less reliable terminations, connectors, power distribution, and data transmission, making them also prone to technical downtime, driving up costs • OBC surveys usually require a shooting vessel and a cable laying vessel with dynamic positioning systems.	• Ocean-bottom nodes (OBN) contain no cables or wires. It is a, self-contained receivers and eliminate the need to troubleshoot for streamer/cable problems coupled with low nodal failure hence less technical downtime, that could drive costs . • OBN surveys usually require a shooting vessel and a node laying vessel or node on a rope laying vessel with dynamic positioning systems,
Score	3	3	5
Quality Control	• During a streamer seismic survey, acquired data QC can be carried out real-time.	• During an OBC seismic survey, acquired data QC can be carried out real-time.	• The recorded data are stored internally in the nodes and downloaded when the nodes are retrieved to the surface. • A good and comprehensive pre-deployment QC procedure in place. QC checks begin with the modem test where the node is interrogated for its ID. This ensures that good communication exists between the node and the modem and the node can be interrogated at all times from deployment to recovery. • Nodes are highly reliable and can achieve uptimes of 98 percent or higher.
Score	3	3	4
Total Score	8	13	19

CHAPTER THREE
PROJECT DESCRIPTION

3.1: General

Seismic surveys are, the only feasible technology available to accurately image the subsurface before a single well is drilled. It is the least intrusive and most cost-effective means to demonstrate the likely occurrence of recoverable hydrocarbons. It increases the likelihood that exploratory wells will successfully tap hydrocarbons and thus reduces associated safety and environmental risks and the overall footprint for exploration. Various 2D streamer seismic data have been acquired over OML 77 & 74 and 3D streamer seismic data as well as an Ocean Bottom Cable (OBC) 3D seismic data acquisition from 1990 – 1998 with different levels of data quality. However, both the shallow and the deeper exploration opportunities have not been fully explored and properly evaluated. The new 3D seismic reshoot dataset with high multiplicity, long offsets and state of the art technology is being planned to address both the imaging in the shallow reservoirs and the deeper exploration opportunities.

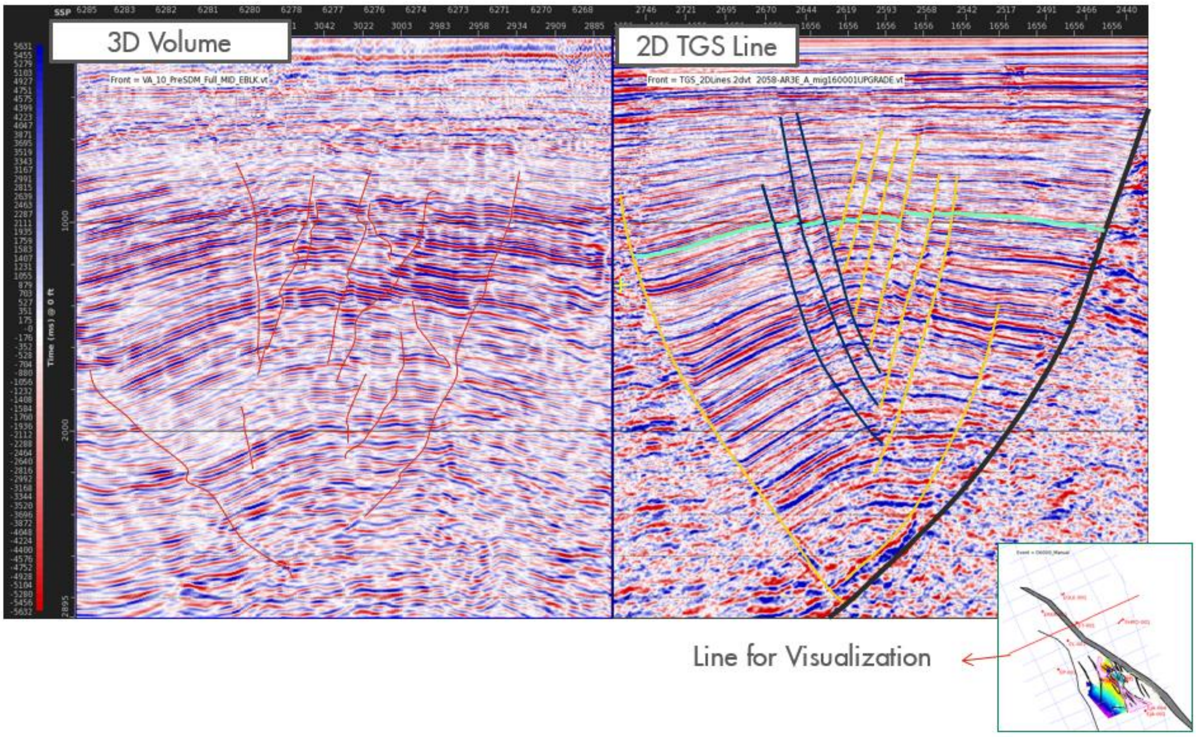


Plate 3.1: 3D and 2D Legacy seismic data showing sub-surface information of the project area.

3.2: Project Objectives

The objective of this project is to acquire new 3D seismic data with increased multiplicity, longer offset and state of the art technology that will:

- Significantly improve the structural imaging of the fields.
- Help in optimizing well locations through the improved imaging.
- Be beneficial in identifying deep exploration opportunities (by leveraging on the existing technology, longer offset and recording higher fold). These will maximize

economic recovery of hydrocarbons, increase production, maximize economic use of existing facilities by keeping the facilities full and grow Nigeria's / SPDC reserve base.

- Data will also aid future production decision-making and the field development. Additional hydrocarbon resources in the Shallow Water Offshore will be developed to support NLNG and domestic gas growth requirements.

3.3: Project Scope

The OML 77 & 74 3D seismic data acquisition operations include the following:

- Node deployment vessels with crew.
- Energy Sources – Air Compressors on board vessels.
- Towed seismic airgun lying just beneath the sea surface.
- Detectors – Housed within the deployed Ocean Bottom Nodes at the bottom of the ocean.
- Chase boats to monitor activities in and around the operational areas.
- Guard boats to monitor activities
- Fast Rescue Boats in mother vessels: In emergency situation to convey personnel to a safe /evacuation point.

Both the shallow and the deeper exploration opportunities have not been fully and properly evaluated. The new seismic dataset with high multiplicity, long offsets and state of the art technology is being planned to address both imaging in the shallow reservoirs and the deeper exploration opportunities.

In marine seismic surveying, sound waves are mechanically generated and sent into the earth. Some of this energy is reflected to the recording sensors (measuring devices) that accurately record the strength of this energy and the time it has taken for this energy to travel through the various layers in the earth's subsurface and back to the locations of the sensors. The seismic techniques planned for the proposed project is Ocean Bottom Node (OBN) Technique (see figure 3.1 below). The sound signal will be generated from arrays of towed energy sources called Airguns. An airgun is a device that releases a high-pressure bubble of air underwater as a source of energy to generate the acoustic/pressure waves that are used in seismic surveys.

The Ocean Bottom Node seismic data acquisition technique have the receivers (nodes) laid at the bottom of the sea-floor (on seabed) to record the reflections from the sub-surface which provides graphic images of seafloor and sub-seafloor. A seismic system consists of sources and detectors, the positions of which must always be accurately measured. The Nodes are retrieved after the seismic data acquisition recording of the patch/area they were laid. The seismic signals are recorded on magnetic tapes via the recording instruments. Using specialized seismic data processing equipment and techniques, these recorded signals are transformed into visual images of the subsurface of the earth in the seismic survey area.

Plate 3.2: Typical Node deployment vessel with On-Board Equipment

Plate 3.3: Typical Source (Air Gun Shooting) Vessel

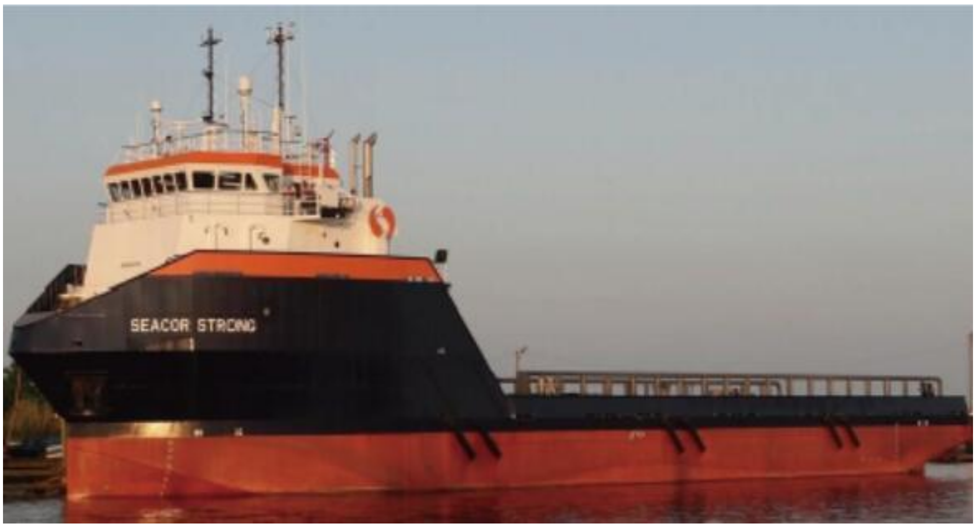


Plate 3.4: Typical Support (Supply) Vessel

Plate 3.5: Typical Support (Chase) Vessel

Plate 3.6: Typical Support (Security Guard) Vessel

3.4: Project Activities

A reputable Geophysical Acquisition Contractor would be contracted by SPDC to carry out the 3D seismic data acquisition over the OML 77 & 74) fields. Company Site Representatives (CSRs) and SPDC staff would closely supervise the seismic re-shoot data acquisition activities. The seismic survey shall include the following activities:

The specific project activities to be carried out include:

- **Pre-Mobilization**
  - ✓ Regulatory approvals
  - ✓ Stakeholder engagements
- **Mobilization**
  - ✓ Personnel
  - ✓ Audit of vessels & equipment
  - ✓ Vessels (and equipment) deployment to project sites
- **Execution**
  - ✓ Seismic energy source and seismic data recording
- **Demobilization**
  - ✓ Personnel, Vessels & Equipment from project sites
  - ✓ Stakeholder engagements

3.4.1: Permitting / Stakeholder Engagement – Freedom To Operate (FTO)

Permitting is the process of obtaining consent from the neighbouring community and relevant government bodies to enable uninhibited access for the seismic operations. The neighbouring communities would be informed on seismic operations during permitting/FTO discussions and other subsequent fora where applicable e.g. people's parliament, Project Advisory Committee meeting/Cluster Development Boards meetings, etc. Their consent would be obtained during permitting/FTO discussions before carrying out the seismic activities. The contractor's community affairs staff and SPDC staff would engage neighbouring communities, relevant government bodies and other stakeholders at an agreed date to explain the processes involved in seismic operations and possible associated hazards. After the meeting, a permit form/FTO that would serve as agreement would be presented for signatures to ensure that peace and harmony prevail during and after the seismic operations. Cluster Development Boards (CDB) shall be used to manage issues related to the project where such bodies exist. Where such boards or any existing SPDC stakeholder relations committee arrangement have not been firmed up, an appropriate arrangement e.g. Project Advisory Committee (PAC) which will serve as a stakeholder relations committee comprising government representatives, community leaders/elders, youths and women representatives shall be set up prior to commencement of the seismic operations. The stakeholder relations committee's duty is to manage issues that may arise with the communities or relevant government bodies in the areas of operation.

Periodic meetings will be held with the stakeholder relations committee members during the seismic survey operation. During such meetings, issues such as contractor's company's policy, community's interest as it relates to the seismic activities in the area and demands shall be discussed. Community elders, chiefs, youths and women leaders would be invited to attend such meetings. Information on the seismic activities would also be disseminated to Government agencies. Some employment opportunities where possible shall be extended to the communities by the contractor with due regards to the required skills and the availability of such skills within the community members. The contractor's Community Affairs Department would interview the selected people. Successful candidates shall be medically certified fit and possess all the mandatory offshore requirements before they can commence work.

The lists of communities so far identified that would be impacted by the proposed Project are shown on **Table 3.1**.

Table 3.1: Concept Selection criteria for Seismic Acquisition

Communities	**Local Government**	**State**
1. Okunbiri (Opu-Okunbiri)	Brass	Bayelsa
2. Sangana	Brass	Bayelsa
3. Ewoama	Brass	Bayelsa
4. Ibidi	Brass	Bayelsa
5. Obioku	Brass	Bayelsa
6. Oginibiri	Brass	Bayelsa
7. Okumbiribeleu	Brass	Bayelsa
8. Liama	Brass	Bayelsa
9. Beletiama	Brass	Bayelsa
10. Twon Brass	Brass	Bayelsa
11. Egwema	Brass	Bayelsa
12. Okpoama	Brass	Bayelsa
13. Odioma	Nembe	Bayelsa
14. Diema	Brass	Bayelsa
15. Kula Town	Akuku-Toru	Rivers
16. Sanga Kiri	Akuku-Toru	Rivers
17. Oye Kiri	Akuku-Toru	Rivers
18. Elija Kiri	Akuku-Toru	Rivers
29. Eliza Kiri	Akuku-Toru	Rivers
20. Idegeba Kiri	Akuku-Toru	Rivers
21. Maclean Kiri	Akuku-Toru	Rivers
22. Klinson Kiri	Akuku-Toru	Rivers
23. Ibieye Kiri	Akuku-Toru	Rivers
24. Elem Tombia	Degema	Rivers
25. Ngeribar Ama	Akuku-Toru	Rivers
26. Boko kiri	Akuku-Toru	Rivers
27. Elem Oproama	Degema	Rivers
28. Iboro Kiri	Akuku-Toru	Rivers
29. Bulobulo kiri	Akuku-Toru	Rivers

Communities	Local Government	State
30. Owukori Kiri	Akuku-Toru	Rivers
31. Ekine Kiri	Asari-Toru	Rivers
32. Macfini Kiri	Asari-Toru	Rivers
33. Filokoma Kiri	Akuku-Toru	Rivers
34. Elegbe Kiri	Akuku-Toru	Rivers
35. Philama	Akuku-Toru	Rivers
36. Ineama	Akuku-Toru	Rivers
37. Gold Coast	Akuku-Toru	Rivers
38. Okolo-Ogono	Akuku-Toru	Rivers
39. Opolobiama	Akuku-Toru	Rivers
40. Lucky Land	Akuku-Toru	Rivers
41. Chris Island	Akuku-Toru	Rivers
42. Obudu Kiri	Degema	Rivers
43. Ke Town	Degema	Rivers
44. Elem Ifoko	Degema	Rivers
45. Abisa	Degema	Rivers
46. Elem Okpo	Degema	Rivers
47. Biobele Kiri	Degema	Rivers
48. Okomaso Island	Akuku-Toru	Rivers
49. Ekelema	Akuku-Toru	Rivers

3.4.2: Pre-Mobilization

Prior to mobilization, SPDC shall carry out pre-mobilization inspection of all items and personnel to be mobilized to site. In this regard, all equipment and personnel shall be certified fit for purpose and approved by SPDC before deployment to site. The contractor shall only mobilize all necessary personnel, materials and equipment to site after obtaining necessary approvals.

Equipment Calibration

All equipment would be calibrated, tested and maintained from mobilisation phase to project completion to meet set tolerances. Prior to mobilization, SPDC shall carry out pre-mobilization inspection of all items and personnel after which pre-mobilisation certificate would be issued. All equipment and personnel that would be involved in the seismic data acquisition activities shall be certified fit for the purpose and approved by SPDC before deployment to site.

3.4.3: Mobilization of Personnel and Equipment

Seismic data acquisition survey activities last for relatively short period of time and do not involve the establishment or use of long-term facilities and structures. The contractor shall mobilize all necessary personnel, materials and equipment to site after obtaining FTO consent. Mobilization involves movement of personnel and equipment (vessels) to site. Project personnel (TBOSIET Certified) shall be moved to site by helicopters and/or marine craft in line with approved Security and Journey Management Plans. A general analysis of the area and operating conditions are being undertaken before the commencement of the seismic data acquisition operations.

The proposed project area is a Shallow Water Offshore Environment. Materials, equipment and personnel will be mobilized to site after regulatory approvals. The marine vessels shall accommodate the project supervisors and equipped with standard living and office accommodations, messing area, recreational facilities, maintenance workshop, clinic, and telecommunication systems. All seismic data acquisition operations and other support staff will be on board the vessels during the acquisition campaign.

3.4.4: Shooting and Data Recording

Seismic data acquisition surveys are of relatively short duration by their nature. Safe shooting distances (based on EGASPIN standards) shall be maintained to avoid any damage to infrastructures and other facilities. The sound signal will be generated from arrays of towed energy sources called Airguns. An airgun is a device that releases a high-pressure bubble of air underwater as a source of energy to generate the acoustic/pressure waves that are used in seismic surveys.

These energy sources store compressed air (generated on the vessel), which is released on command from the towing vessel. The released air forms a bubble, which expands and contracts in a predictable fashion, emitting sound waves as it does so. The pressure variation in the water as a function of time caused by the high-pressure bubble is called the airgun signature. Individual energy sources are configured into arrays. These arrays have an output, which are more desirable than that of a single bubble and serve to focus the sound output primarily in the downward direction, which is useful for the seismic method. This array effect also minimizes the sound emitted in the horizontal direction.

The downward propagating sound travels to the seafloor and into the geologic strata below the seafloor. Changes in the acoustic properties between the various rock layers result in a portion of sound being reflected towards the surface of each layer. The nodes which are laid on the sea floor receive this reflected energy.

Use and operations of the airguns shall be tuned to the depth of investigation and balanced with environmental considerations to the lowest practicable output and power levels to achieve objectives. Local regulatory requirements and best practices shall be applied to mitigate the impact of acoustic sound generated by airguns on marine mammals. Offshore seismic data acquisition activities are guided by both National and International Environmental regulatory standards.

Furthermore, marine mammal observers and passive acoustic monitoring shall be deployed in the operations. Also, soft start of air guns shall be adopted to ensure marine mammals move away from the shooting area operation in addition to all other SPDC and industry best practices.

In addition to the technical justifications, the impact of the project on the environment will be significantly minimized by using this seismic acquisition technique. This is because the Ocean Bottom Node technology is being deployed internationally, adopting the best industry practice, is of short duration utilization of best available weather window and only experience contractors are known to carry out these activities.

3.4.5: Demobilization

After completion of each phase of the activity, the Seismic Contractor will ensure the complete retrieval of the Ocean Bottom Nodes from the bottom of the ocean (sea-floor) and the seismic airguns from the water onto the seismic shooting vessel and sail back to base. Personnel shall be moved by water/landing crafts and/or helicopter as necessary. During the acquisition process, the area will constantly be inspected to ensure that no hazardous substance is spilled or left behind at the end of the project.

3.5: Survey Programme

The survey programme will comprise a dual source, multiple streamer 3D survey or OBS Seismic survey system. The total data acquisition period is expected to cover approximately six months (dependent on weather conditions). The field programme will consist of the following main components:

- Premobilization (Regulatory Approvals and Stakeholder Engagements)
- Mobilisation (Audit of vessel, personnel, and deployment including seismic vessel and support vessel(s) to project site);
- Data acquisition (shooting and data recording), comprising the bulk of the programme (NB. Vessels may be kept on standby due to adverse weather conditions, equipment repair etc); and
- Demobilization (retrieval of equipment and demobilisation from the area).

During data acquisition, the seismic vessel is expected to follow the pre-determined sail lines. However, this is subject to prevailing current and wind conditions. When the vessel is planning to return to port all in-water equipment will need to be retrieved. A seismic system consists of sources and detectors, the positions of which must always be accurately measured. The sound signal comes from arrays of towed energy sources. These energy sources store compressed air, which is released on command from the towing vessel. The released air forms a bubble, which expands and contracts in a predictable fashion, emitting sound waves as it does so; individual energy sources are configured into arrays. These arrays have an output, which are more desirable than that of a single bubble and serve to focus the sound output primarily in the downward direction, which is useful for the seismic method. This array effect also minimizes the sound emitted in the horizontal direction. The downward propagating sound travels to the seafloor and into the geologic strata below the seafloor. Changes in the acoustic properties between the various rock layers result in a portion of sound being reflected towards the surface of each layer. The detectors called hydrophones, housed within submerged streamer cables and, are towed behind the seismic vessel (Streamer Technique) or deployed on the ocean bottom (OBS Technique) receive this reflected energy.

A typical node system consists of Data Acquisition Unit (DAU); Sensor Unit (SU); Acoustic Modem; Battery Units; Plastic Shell and Aluminium frame. A typical Data Acquisition Unit (DAU) carries out most of the control and communication tasks in the system. It stores digitized sensor data and status data onto files, contains the reference clock, and the system power supply. The Sensor Unit (SU) contains the primary seismic sensors (three geophones and a hydrophone). It also contains a hydrophone pre-amplifier with programmable gain. A dual-axis inclinometer measures the SU verticality with great accuracy. Nodes are placed in a basket which is then deployed overboard. A remotely operated vehicle (ROV) removes nodes individually from the basket and is guided to location using a combination of positioning system and navigation software. When in the intended position on the seabed, the sensor unit is removed from the node and planted in the seabed. At each deployment station video and still images are captured, and details of the planting quality are recorded. A fix of the node is taken to ensure installation positioning accuracy when compared to preplot and for repeatability and recovery. Figure 3.6 below depicts a typical OBN vessel and ROV Node deployment respectively.

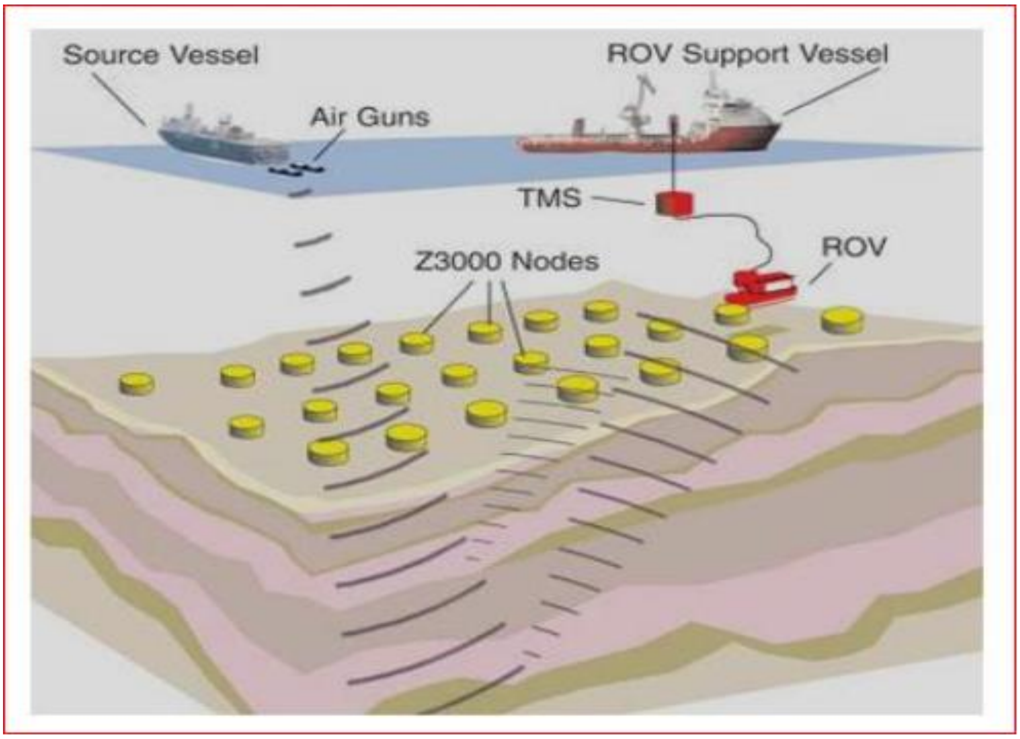


Figure 3.6: Typical ocean bottom node (OBN) deployed using an ROV (Remotely Operated Vehicle) system

3.6: Waste Management

Waste Sources and Types

Wastes sources during the seismic acquisition shall be from the operation of the survey vessel, personnel on board, and wastes associated with normal seismic data acquisition activities. The waste shall include sump oil discharge, ballast water discharge, grey water discharge, sewage discharge, solid waste discharge, faecal waste and waste from human activities such as biodegradable food remains (Table 3.2).

Waste Management procedures

The management (collection handling, treatment, re-use and disposal) of waste from the project activity shall follow SPDC Waste Management Guidelines, all applicable national and international regulations relating to waste management and discharges of materials into the marine environment. As part of premobilization checks, the survey vessels should have equipment, systems and written out procedures for prevention of pollution by oil, sewage and garbage in accordance with national and international environmental regulatory standards. Where the decision is reached to manage the waste on-board, the survey vessel shall have waste treatment facilities. Where the decision is reached to evacuate the waste from survey vessel for subsequent treatment, an accredited waste management outfit shall be contracted to handle and manage the hazardous waste that shall be generated throughout the period of the project execution. There shall be a waste management plan written out for the seismic operations. Waste will be delivered to an approved waste management company ashore via supply vessel for proper disposal.

Table 3.2: Estimated Waste Generation for Vessels mobilized for the Seismic data acquisition project

Waste General Category	Project Phase	Specific Classification		Estimated Volume per day in m^3			
				Ocean Europe	Ocean Sea	Ocean Pearl	REM Aquarius
Non- Hazardous Waste	- Mobilization - Acquisition - Demobilization	Food Waste		0.14	0.14	0.2	0.24
	- Mobilization - Acquisition - Demobilization	Plastic		0.15	0.3	0.2	0.01
	- Mobilization - Acquisition - Demobilization	Domestic waste	Paper	0.2	0.2	0.2	0.01
	- Mobilization - Acquisition - Demobilization		Glass	0.001	0.002	0.002	0.005
	- Mobilization - Acquisition - Demobilization		Aluminium cans	0.01	0.05	0.05	0.005
	- Mobilization - Acquisition - Demobilization		Wood	0.01	0.02	0.02	0.01
	- Mobilization - Acquisition - Demobilization	Incinerator Ashes		0.01	NIL	0.01	NIL
	- Mobilization - Acquisition - Demobilization	Cooking oil		0.001	0.001	0.001	0.001
Hazardous Waste	- Mobilization - Acquisition - Demobilization	Operation waste	Oily waste (Rags/filters)	0.057	0.11	0.1	0.01
	- Mobilization - Acquisition - Demobilization		Fluorescent tubes	0.0029	0.003	0.003	0.001

<table>
<tr><th rowspan="2">Waste General Category</th><th rowspan="2">Project Phase</th><th rowspan="2" colspan="2">Specific Classification</th><th colspan="4">Estimated Volume per day in m^3</th></tr>
<tr><th>Ocean Europe</th><th>Ocean Sea</th><th>Ocean Pearl</th><th>REM Aquarius</th></tr>
<tr><td rowspan="5"></td><td>- Mobilization
- Acquisition
- Demobilization</td><td rowspan="4"></td><td>Medical waste</td><td>0.0001</td><td>NIL</td><td>Nil</td><td>NIL</td></tr>
<tr><td>- Mobilization
- Acquisition
- Demobilization</td><td>Aerosol Cans</td><td>0.0001</td><td>0.002</td><td>0.0015</td><td>0.001</td></tr>
<tr><td>- Mobilization
- Acquisition
- Demobilization</td><td>Hazardous waste (Oily waste, etc.)</td><td>0.001</td><td>0.002</td><td>0.0015</td><td>0.001</td></tr>
<tr><td>- Mobilization
- Acquisition
- Demobilization</td><td>Waste oil/ Sludge</td><td>0.004</td><td>0.008</td><td>0.005</td><td>0.01</td></tr>
<tr><td>- Mobilization
- Acquisition
- Demobilization</td><td colspan="2">E-Waste</td><td>0.001</td><td>0.002</td><td>0.002</td><td>0.001</td></tr>
</table>

Table 3.3: Waste Management Plan

S/N	Waste Name	Category	Major Source	Approved Disposal Options: Recycle				Treatment							Disposal		
				Reuse/recycle	Use as fuel	Composting	Return to Supplier	Incineration	Chemical Conversion	Maceration	Waste Water System	Land treatment	Solidification/Stabilisation	Thermal Destruction Unit (TDU)	Inject to subsurface	Discharge to surface	Land fill
1	Absorbents (include Contaminated Polyethylene & Jute Sacs)	Hazardous	Oil spill response, production/ maintenance	🟢	🟠			🟢									
2	Air Filters	Non- Hazardous	Maintenance/Workshop	🟢				🟠									🟠
3	Batteries (dry & wet)	Hazardous	Maintenance/workshop; transportation	🟢													
4	Cables	Non- Hazardous	Electrical/telecoms Maintenance	🟢													
5	Cans and Tins	Non- Hazardous	Catering services	🟢													
12	Furniture Waste	Non- Hazardous	Accommodation/Infrastructure maintenance	🟢				🟠									
13	Glass Waste	Non- Hazardous	Catering	🟢													🟢
14	Spent Grit (Blasting)	Non- Hazardous	Surface/Tank Maintenance/Rehabilitation of FPSO										🟢				🟠
15	Medical Waste	Hazardous	Bonga Medic/Sick bay					🟢									
16	Oil & Fuel Filters	Hazardous	Maintenance/Turbines/ Generators/Pumps/workshop	🟢				🟠									
17	Oily Rags	Hazardous	Maintenance/workshop					🟢									
18	Oily Sludge/Tank Bottoms	Hazardous	Production operations, Tanks, IGFU, Hydrocyclones									🟠		🟢			

3.7: Safety Considerations

Prior to the proposed 3D seismic survey, SPDC shall design a detailed pre-survey programme, focused primarily at achieving personnel safety, minimising environmental and sea-related disturbances and ensure efficient waste management.

The essential considerations in pre-survey activities are:

- Survey transects shall be chosen to ensure maximum coverage of the area is achieved with minimum number of sweeps. Allowance shall be made in the schedule for bad weather contingency and equipment down time;

- All information regarding the survey/ ancillary vessel to be used and that of the workforce shall be collated prior to mobilisation to identify any areas where further equipment and crew training may be necessary;
- Log of daily activities shall be maintained including any incidents, which occur relating to safety of personnel and environmental effects;
- The provision of a support vessel with security 'look outs' onboard shall be considered. The 'look outs' shall provide early warning of security threat to seismic crew; at which the seismic vessel will enter a 'lock down' mode until safe to continue operations;
- Management guidelines for storing and disposal of wastes shall be made available. All personnel shall be briefed on waste disposal and minimisation methods;
- An inventory of waste materials stored on the vessel shall be established and maintained. Materials would be stored in suitable containers and labelled accordingly;
- Systematic timing of operation to reduce the likelihood of encounters with marine mammals and fishes; and
- Trained personnel shall be designated with the responsibility of maintaining health, safety, security and environmental issues on-board the vessel.

Guidance before and during Seismic Activity

All marine observations would be carried out from the source vessel (where the airguns are being deployed from). The marine mammal observer (MMO) would be positioned on a high platform with a clear unobstructed view of the horizon, and communication channels between the MMO and the crew would be in place before commencement of the pre-shooting search.

Pre-Shooting Search

Pre-shooting search would be conducted over a period of 60 minutes before the use of airguns. The MMO available on the vessel would make a visual assessment to determine if any marine mammals are within 500 meters of the centre of the airgun array.

Delay if Marine Mammals is within 500 Meters
In line with JNCC regulation, SPDC would delay the soft-start of the seismic sources if marine mammals are seen within 500 meters of the centre of the airgun array during the pre-shooting search, or if the transit of the vessel, results in the marine mammals being more that 500 meters from the source. In both cases, there would be a 20 minute delay from the time of the last sighting within 500 meters to the commencement of the soft-start to determine if the animals have left the area.

If PAM is used, it is the responsibility of the PAM operatives to assess any acoustic detection and determine if there are likely to be marine mammals within 500 meters of the source. If the PAM operatives consider marine mammals are present within that range, then the start of the operation would be delayed as outlined above.

Soft Start
Soft-start is defined as the time that airguns commence shooting till the time that full operational power is obtained. Power should be built up slowly from a low energy start-up (e.g. starting with the smallest airgun in the array and gradually adding in others) over at least 20 minutes to give adequate time for marine mammals to leave the area. This build-up of power should occur in uniform stages to provide a constant increase in output. There should be a soft-start every time the airguns are used.

The duration of the pre-shooting search (at least 30 minutes) and the soft-start procedure (at least 20 minutes) would be factored into the survey design. SPDC would also observe the following JNCC guideline recommendations during soft start activation:

- commence soft-start not longer than 20 minutes to minimise additional noise in the marine environment;
- start survey line immediately the soft-start has been performed;
- if, for any reason, firing of the airguns has stopped and not restarted for at least 10 minutes, then SPDC would commence a pre-shooting search and 20 minute soft-start;
- if a marine mammal is detected whilst the airguns are not firing, the MMO would advise SPDC to delay commencement, as per the pre-shooting search, if none are present then they can advise to commence firing the airguns;

3.8: Proposed Project Schedule
The project is planned to commence in Q3/2019 and be completed in Q1/2020 as shown in Table 3.7. All normal pre-mobilization processes shall be carried out before work commencement.

Table 3.7: Project Delivery Schedule

	2017		2018				2019				2020			
Activities/Period	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Feasibility Studies														
EIA Scoping workshop - OML 77/74														
Regulatory Approval (DPR / FMEnv)														
Stakeholder Engagement														
Mobilisation														
Data Acquisition														
Demobilization														

CHAPTER FOUR
DESCRIPTION OF EXISTING ENVIRONMENT

4.1: Introduction

The current environmental status of the study area for the proposed 3d Reshoot Seismic Data Acquisition Project has been described in this chapter of the EIA report. One-season field data gathering (Dry season) conducted from 26th of November 2018 to 7th December 2018. An integral and important part of an EIA study is the establishment of a comprehensive environmental baseline condition of the proposed project area. Such environmental baseline data provide information on the characteristics and features of the proposed project environment. It also provides the background/scientific basis for predicting, evaluating and mitigating the impacts of the planned project activities on the environment, monitoring environmental changes in the area, as well as support the decision making in future project design, operation and management.

The environmental components evaluated comprised ecological parameters interacting with ecological sensitivities within the project area. In addition, the statuses of the various ecological components of the project area were assessed from data obtained in 2018. Environmental sensitivities likely to be affected and investigated include:

- Air quality and noise.
- Surface water quality.
- Sediment quality.
- Hydrobiology and fisheries.

Statistical tools such as analyses of variance (ANOVA), Dunnett's test were employed to determine spatial variations between the control stations and sampling stations as well as their sources.

Sampling rationale

In line with international best practices and regulatory guidelines on sea bed sampling, environmental matrices were sampled using grid sampling techniques in the direction of persistent bottom current. All samples were analysed in a FMEnv accredited laboratory (International Energy Services Limited, Old Aba Road, Port Harcourt). Details of sampling rationale and quantity are presented in Table 4.1a.

Table 4.1a: Quantities of samples to be obtained during the field data gathering

S/N	Environmental component	No. of sampling points	Control Points	Description of sampling points
1	Ambient Air quality and noise	12	3	Grid sampling (3000m x 3000m) technique was adopted over the entire acreage. Control samples were collected outside the acreage.
2	Surface water quality	37	3	Grid sampling (3000m x 3000m) technique were adopted over the entire acreage along the persistent bottom currents. Additional sampling were collected around existing facilities (pipelines and wreckages). Control samples were collected outside the acreage
3	Sediment quality	63	3	Grid sampling (3000m x 3000m) technique were adopted over the entire acreage along the persistent bottom currents. Additional sampling were collected around existing facilities (pipelines and wreckages). Control samples were collected outside the acreage
4	Social Profile	14	-	Coastal communities along the acreage predominantly fisher folks
5	Health Profile	14	-	Coastal communities along the acreage predominantly fisher folks

Sampling methodology

Table 4.1b gives a summary of the methods/instruments used for sampling various environmental spheres as approved in the Terms of Reference (ToR). The details of the methodology of data acquisition for each of the environmental components are presented in Appendix 2.

Table 4.1b: Summary of sample type and method of collection

Environmental Aspect	Method of Samples collection/Field Data Generation
Air Quality and Noise	Aeroqual analyser was used to measure NO_2, SO_2, NH_3, and H_2S. Met One Aerosol Mass Monitor was used to capture suspended particulate matter (SPM), Jenway Model Noise meter was used to measure ambient noise level.
Meteorology	Literature Review, Micro-climatic data were captured with Wind meter and Sky master handheld instruments
Surface Water	Water Samplers
Sediment	Sediment Eckman Grab sampler
Hydrobiology/Fisheries/ benthos	Collection with, Collection with Plankton Net and sieves, observance of fish landings, interview with fisher folks
Socio-economics/ Health	Interviews, questionnaires, focus group discussions, review of secondary data, direct observations, walk through survey.

Quality Assurance and Quality control

The following QA/QC was observed in sample collection and *in situ* analysis carried out in the field. Samples were collected in bottles that have been thoroughly washed with detergent (nutrient free) and rinsed thoroughly. Prior to sample collection, each container was rinsed with the water to be sampled before finally collecting the representative sample for laboratory analysis.

- All sampling equipment were properly protected and maintained in accordance with manufacturers' manuals.
- Sampling bottles were adequately labeled with masking tapes and indelible markers to avoid mistaken identity.
- Only analytical reagents (Analar grade) and chemicals were used.
- Automated equipment were calibrated prior to field sampling
- The same stock solutions and standards of H_2SO_4, HNO_3, $Na_2S_2SO_3$ Winkler's (A and B), and Starch Indicator were used for all the batches of samples to ensure comparability and reliability of results.

4.2: Climate and Meteorology

The study area is in the Gulf of Guinea and it is influenced by the tropical wet and semi-hot equatorial climate with high solar radiation. Heavy precipitation, light winds, and low atmospheric pressure are the major climatic characteristics of the study area. The climatic conditions of the proposed study area were obtained from the Nigeria Institute of

Meteorology (NIMET) Port Harcourt climatic synoptic station; closest meteorological station to location. Ten years (1990 – 2010) meteorological data on Port Harcourt were obtained from the Nigerian Meteorological Agency (The two main seasons are the wet season (April - October) and a shorter Dry season (November - March). The major climatic/meteorological elements examined are rainfall, relative humidity temperature, wind pattern, tides and sunshine hours. The mean monthly climatic data from Port Harcourt synoptic station is presented in **Table 4.1c**.

Table 4.1c: Characteristics of Climatic Elements in the Project Area

Month	Rainfall (mm)	Mean RH (%) (16:00 Hrs)	Mean RH (%) (10:00 Hrs)	Mean Daily Temp (ºC)	Mean Daily Max Temp (ºC)	Mean Daily Min Temp (ºC)	Mean Atm Pres. (hpa)	Mean Sunshine (Hrs)	Mean Wind Speed (m/s)
January	25.4	60.0	86.5	26.29	31.35	21.18	1182.0	14.06	1.45
February	76.2	60.0	85.0	27.11	31.96	21.84	1166.0	15.17	1.55
March	152.4	68.5	82.0	27.73	31.96	22.50	974.0	14.14	1.70
April	177.8	71.0	83.5	27.73	31.79	22.66	1099.0	14.36	1.79
May	228.6	74.5	81.5	26.84	31.41	22.55	1226.0	13.99	1.60
June	279.4	79.5	83.5	25.63	29.21	22.22	1375.0	11.93	1.53
July	355.6	82.0	84.5	24.75	27.83	21.73	1424.0	9.98	1.45
August	254.0	79.5	85.5	24.86	27.83	21.78	1480.0	9.76	1.65
Sept	297.2	83.0	86.5	25.19	28.44	22.0	1384.0	10.93	1.67
October	254.0	78.0	84.0	25.85	29.98	21.95	1300.0	12.44	1.43
Nov	77.2	72.0	83.5	26.57	31.08	22.0	194.0	13.9	1.13
Dec	25.4	66.5	87.0	26.13	31.41	23.65	1197.0	14.48	1.06
Mean	180.3	72.9	84.4	26.13	30.36	22.17	1250.0	12.93	1.51
Max	355.6	83.0	87.0	27.23	31.96	23.65	1424.0	15.17	1.79
Min	25.4	60.0	81.5	24.75	27.83	21.18	974.0	9.76	1.06

Source: NIMET; Synoptic Station Port Harcourt; RH= Relative Humidity

Rainfall

Rainfall is the quantity of rain that falls in a location over a period. The **Figure 4.1** indicates that rainfall in the area is generally high and is experienced almost all year round with highest value of 355mm recorded in the month of July. Peak periods are generally experienced from June to September while least values were recorded from December to February. The total annual rainfall in the area is more than 2,203mm.

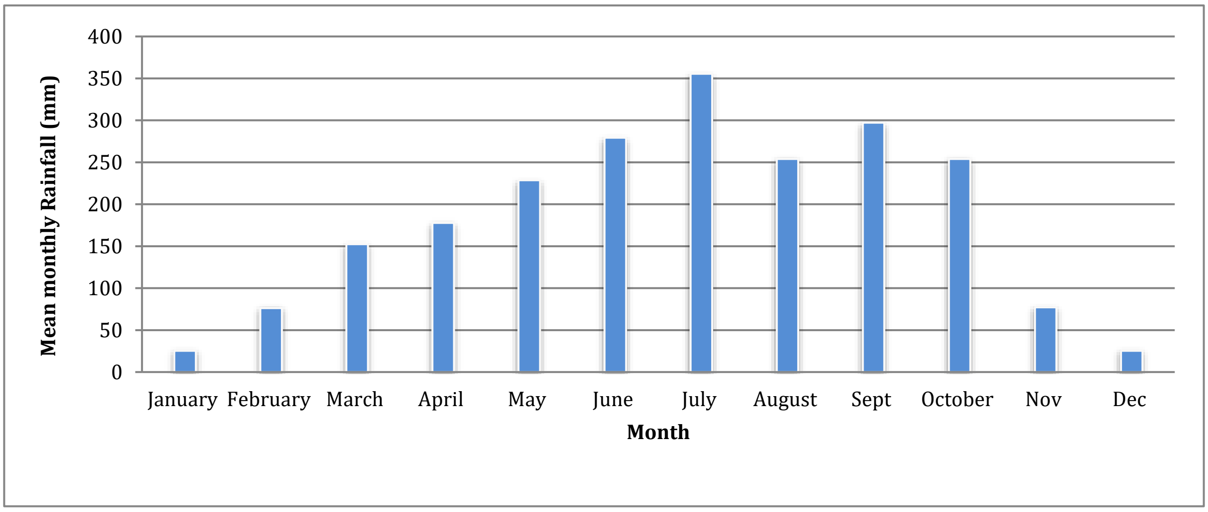


Figure 4.1: Mean Monthly Rainfall Distribution

Relative Humidity

Relative humidity is the ratio of the amount of water vapour in the air at a given temperature as compared to the maximum amount air can hold at the same temperature, expressed as a percentage. The highest relative humidity value recorded in the area is 87.0% at 10.00hrs, although higher values of up to 99% have been recorded within the climatic synoptic area in the rainy seasons. The recorded lowest value is 60.0% at 16.0hrs. Generally, relative humidity is higher during the morning hours and decreases gradually as the sun sets. Relative humidity as low as 21% during the drier periods of the harmattan winds in the months of November and December have also been recorded in the area (Oguntoyibo, 1992). Relative humidity is high all the year round within the project area (**Fig. 4.2**).

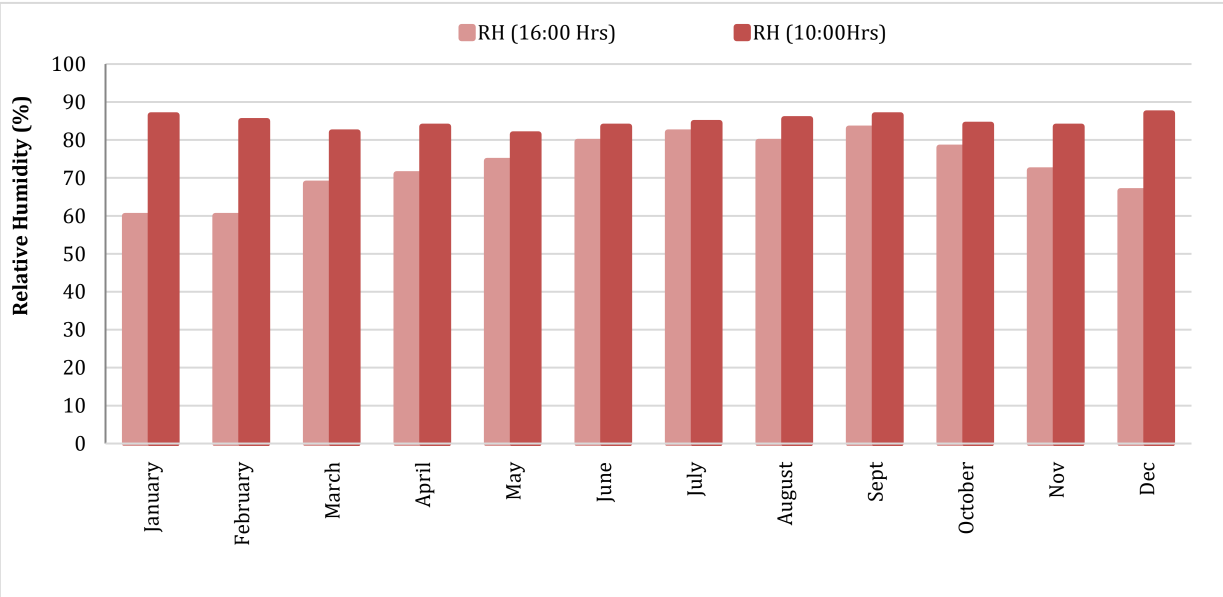


Figure 4.2: Mean Monthly Relative Humidity Distribution

Air Temperature

Air Temperature is the degree of hotness or coldness of the air in given area or location. The synoptic area experiences moderately high incidence of solar radiation and long periods of sunshine. Climatic data from NIMET (Table 4.1) showed that both maximum and minimum temperature values are moderately high with the lowest values occurring during the between June to October. The maximum mean temperature values (31.350C - 31.960C) in the area are experienced in the months of January to May. Incident of sun light in the area also follows this pattern (Figure. 4.3).

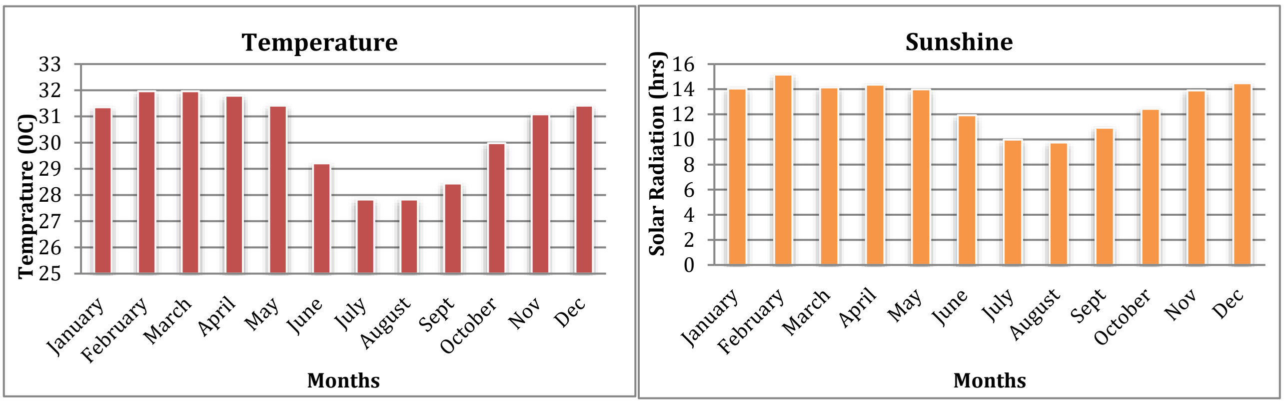


Figure 4.3: Mean Monthly Temperature and Solar Radiation Distribution in the Study Area

Wind Pattern

Wind is referred as air moving through the atmosphere at an appreciable and noticeable speed. The predominant wind direction in the synoptic area is South –Westerly for a period of about eight months. Data from NIMET showed that April (1.79m/s) recorded the highest wind speed while the lowest was recorded in December (1.06m/s) (**Fig. 4.4**). Oguntoyibo and Hayward (1987) reported that wind speeds in the study area are generally below 2.5 m/s and hardly get to 3 m/s, with the highest values recorded at the onset of the rainy seasons in late March or early April.

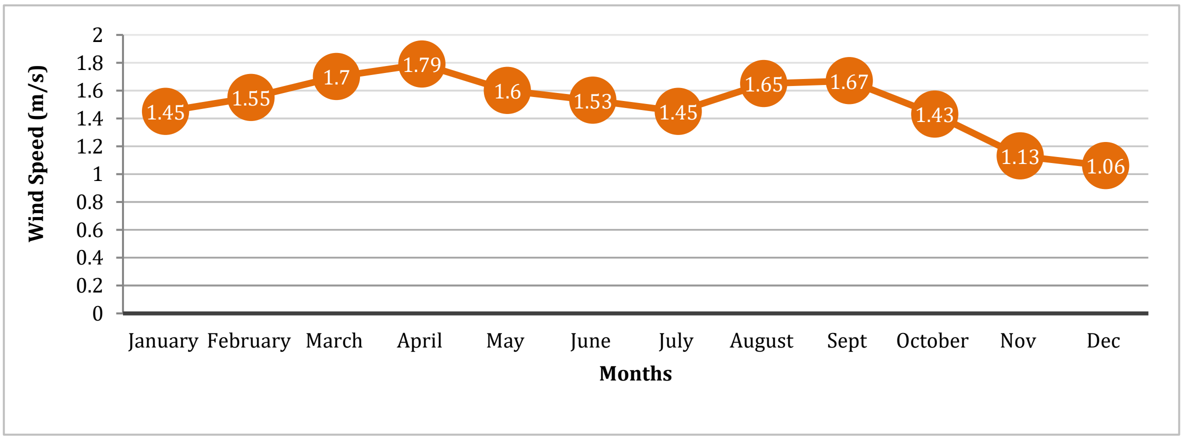


Figure 4.4: Mean Monthly Wind Speed Distribution in the Area

Oceanography

The dominant oceanographic forcing within the project area consist of waves, currents and tides. The project area lies within the shallow continental shelf with water depths ranging between 6.8 m near shore to about 46.6 m offshore.

Waves

Wave heights ranged from 0.5 to over 2 m with periods ranging between 6 – 10 s along Brass beach. Wave conditions in the offshore waters gave highest wave heights (Hs) of 2.5 m in water depths of about 30 m. Waves are dominant from the southerly sectors. The months of April – June represent a period where waves over 2 m were measured. In August a significant fraction of waves exceeds 2 m in height. The wet season (May to October), on average, experiences larger waves in comparison to the dry season, with offshore wave height (Hs) generally greater than in the dry season (May and October).

Tides

The tide levels in project area ranged between 0.15 m and 1.57 m. The tides at the estuaries, proximal to the project area have a south-westerly component and are semi diurnal with two inequalities. The spring tidal range at Brass is about 1.6 m and significant surges are infrequent. The littoral (coastal) circulation system offshore the Brass estuary coastline is under the control of the prevailing wind systems, tides, waves and coastline orientation. The South-westerly tides produce ebb and flood tidal currents, which are in phase with the tidal cycle. Ebb currents due to their higher velocity and tidal time could result in the higher flushing of ocean waters from the tidal basin

Ocean Currents

The Guinea current is the major oceanic current affecting the project area. The Guinea Current flows east at approximately 3°N along the western coast of Africa. Depending on the season, the primary source waters for the Guinea Current is either the Canary Current or the N. Equatorial Counter Current (NECC). For example, during the winter, the NECC is very weak, while in the summer, the NECC is at its strongest. Within the Gulf of Guinea, it can reach velocities close to 100 cm/s near 5°W. Reversals occur in the Guinea current direction which is mostly prevalent during the wet season. Offshore Brass, maximum measured depth averaged currents were 0.7-0.8 m/s in the 75-105° sector. Maximum measured currents were observed at the surface, with magnitude of 1.1 m/s. Deeper offshore (~150 m depth), the currents are generally in the opposite direction.

Longshore Current

Longshore currents affecting the project area follow a west - east current direction. Longshore currents attain speeds averaging 0.2 m/s. The coastline east of Akassa point trends almost west-east with the result that the south-westerly waves break obliquely with the open side to the east. The waves arriving along the east - west trending coastline is obliquely incident to the coast and hence produce a west-east longshore current. The major near-shore drift cells affecting the area consist of a west-east littoral cell of the eastern Niger delta. Sediment supply to the littoral drift is essentially by the Niger delta tributaries.

Seismicity

Seismicity in the Niger Delta is not well known, due to the lack of historical records and of modern seismic networks. Seismicity in mid Atlantic ridge area is well documented. Seismicity within the Mid-Atlantic ridge could be transmitted through the deep seated faults resulting in displacement of either side of the faulted blocks and could result in earthquakes. The tectonic evolution of the plates leads to the formation of fracture zones parallel to the direction of plate motion. The Benue Trough of Nigeria is bound by two offshore transform faults (the Chain and the Charcot Fracture Zones). However, no record of any seismicity is available within the Chain and Charcort fracture zones of the Gulf of Guinea, which could result in earthquakes in the project area.

Wind Pattern

In the study area, surface wind is characterized by small diurnal variation influenced by sea breezes resulting from the warming of the sea. It reaches maximum level during the night due to radiation cooling leading to instability in the surface layer. The wind speed is usually a gentle breeze (0.4 - 1.4 m/sec) followed by light breeze (1.6 - 3.3 m/sec), and moderate breeze (5.5 - 7.9 m/sec). Winds above 10 m/sec occur but only during thunderstorms. During this study, the wind speed ranged between 2.8 and 4.9 m/s with an average of 3.8 m/s in the northeast but 2.5 – 5.3 m/s with 3.9 m/s in the southwest, which all fall within the climatic wind data for the area **(Fig 4.5).**

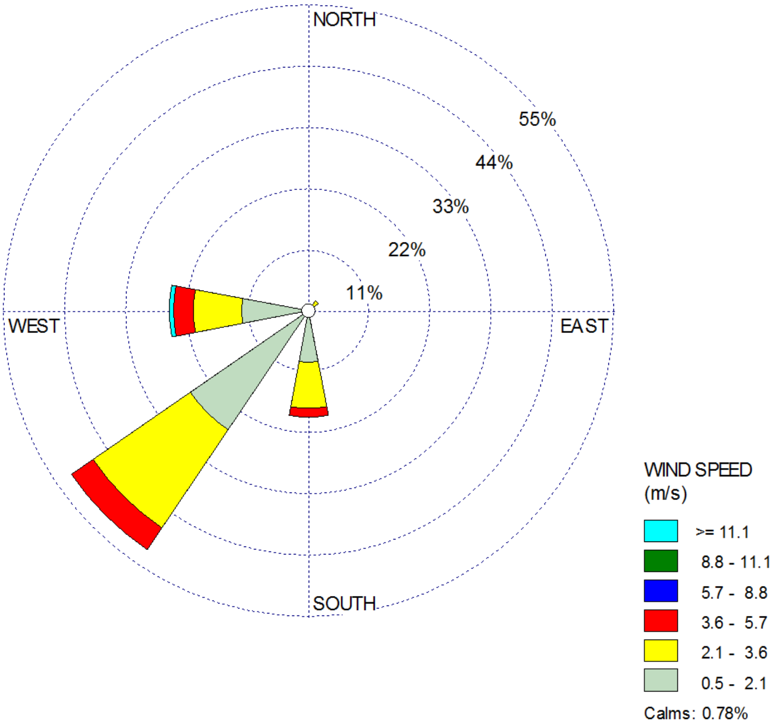


Figure 4.5: Wind Speed and Prevailing Direction in the Study Area

4.3: Air Quality and Noise

Twelve air quality parameters including NO_x, SO_x, CO, N_2H, CxHY, smoke density, wind direction, wind speed, ambient temperature, relative humidity, atmospheric temperature and SPM were monitored during the study. Data for air quality parameters for the different platforms are summarized in **Tables 4.2**

Table 4.2: Meteorological /Gaseous Emission Field Measurement

Stations Identity	Date	Parameter											
		Concentrations											
		SO_X	**NO_X**	**CO_X**	**H_2S**	**C_XH_Y**	**Smoke Density**	**Wind direction**	**Wind speed**	**Amb. Temperature**	**Relative Humidity**	**Atm. Pressure**	**SPM**
AQ1	11/26/2012	<0.1	5.7	<8.7	<1.1	<1.0	N/A	SW	2.5	32.3	70.7	1008	26
AQ2	11/27/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	3.5	30.1	98.1	1006	44
AQ3	11/28/2012	<0.1	4.3	<8.7	<1.1	<1.0	N/A	SW	3	34.5	64.1	1003	24
AQ4	11/29/2012	<0.1	1.42	<8.7	<1.1	<1.0	N/A	SW	1.7	33.1	66.2	1004	17
AQ5	11/30/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	2.4	29	81.5	1004	42
AQ6	12/1/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	2	30.6	74.4	1009	36
AQ7	12/1/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	4.6	29.6	78.7	1006	26
AQ8	11/30/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	3.8	28.1	83.7	1005	38
AQ9	11/30/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	3.1	29.3	84	1007	18
AQ10	11/28/2012	<0.1	4.3	<8.7	<1.1	<1.0	N/A	SW	2.6	32.6	68.2	1005	21
AQ11	11/30/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	2.1	29.9	77.5	1007	12
AQ12	11/30/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	5.6	26.8	83.8	1007	8
AQ CTL1	11/27/2012	<0.1	2.8	<8.7	<1.1	<1.0	N/A	SW	3	30.5	75.3	1005	32
AQ CTL2	11/28/2012	<0.1	<1.42	<8.7	<1.1	<1.0	N/A	N	2.5	32	69.5	1006	30
AQ CTL3	11/29/2012	<0.1	7.1	<8.7	<1.1	<1.0	N/A	SW	0.8	32.6	68.3	1007	32
DPR Limit		350	400	30			2	N/A	N/A	N/A	N/A	N/A	60-90
FMEnv limit		26	75 - 113	22.8		160							250
WHO limit (2005)		20	200										50
Unit		µg/m3	µg/m3	µg/m3	µg/m3	ppm	Ringlemann	N/A	m/s	OC	%	Pa	µg/m3

Source: Field Survey 2019

Table 4.2 above presents the meteorological/ gaseous emission field measurement. SOx, NOx COx and H_2S were not detected in any of the sampling locations both in the Field operations area and at the control station they were taken to be within DPR set limits per Hr. This implies that SOx, NOx and COx were within their respective (350, 400 and 30µg/m^3) DPR hourly limits. SO_2 was below detection limit of 0.1µg/m^3 limit per hour, COx below detection limit of 8.7µg/m^3 limit and H_2S was below detection limit of 1.1 µg/m3 limit. NOx at AQ CTL3 was 7.1µg/m^3 and within DPR Limit of 400µg/m^3.

The suspended particulate matter (SPM) was detected in all the sampling locations including the Control Stations. It was measured to have minimum of 8µg/m^3 at AQ12 and maximum of 44 at AQ2 and it also within DPR limits of 60-90.

When present at elevated level in the atmosphere, SO_2 could have some health impact on man that may include nose, throats an airways irritation which may lead to coughing, wheezing and shortness of breath. Its reaction with water also in the atmosphere can result in formation of secondary pollutants including sulphuric acid, sulphurous acid and sulphate particulates which are harmful to the environment.

It has been identified that the binding of carbon monoxide with haemoglobin to form carboxyhaemoglobin (COHb) reduces the oxygen-carrying capacity of the blood and impairs the release of oxygen from haemoglobin to extravascular tissues which are the main causes of tissue hypoxia produced by carbon monoxide at low exposure levels. CO level was below detection limit at all the sampling stations. Its absence in the airshed during the field work could indicate that the SPDC field operations were not impacting the airshed negatively with COx.

Exposure of man to oxides of nitrogen (NOx) can cause a plethora effects in the lung and other internal organs problems (EPA, 1981). Their non-detection during the field data gathering could indicate their absence in the airshed of the study area. Ammonia emission has little or no direct link with production activities at the SPDC field but could be from metabolic processes of sea life. Its impacts are like that of NOx. Its absence during the study could indicate that the present operations on the field are not impacting air quality of the environment with H2S.

Noise

Noise is an environmental stimulus that disturbs sleeps (Sinha and Sridharan, 1999). The sleep disturbances may lead to other effects (WHO, 2004). Hearing impairment which can be caused due to its exposure (Berglund et al, 1999) can lead to tinnitus (buzzing in the ear). In all the sampling locations during the study, sources of noise were production activities and the sampling points. This may mean that those identified noise sources were properly maintained.

Table 4.3: below indicates that the noise level is within DPR limits. However, the maximum level was recorded at AQ8 with 78.2 and the minimum is 73.4 dBA at AQ CTL3 but still within DPR limits of 80-100.

Table 4.3: Measured Ambient Noise Level in Study Area

S/N	Sampled Points ID	DPR Limits	FMEnv limit	Unit	Noise Level
1	AQ1	80-100	90	dBA	77.4
2	AQ2	80-100	90	dBA	76.3
3	AQ3	80-100	90	dBA	76.6
4	AQ4	80-100	90	dBA	76.4
5	AQ5	80-100	90	dBA	76.5
6	AQ6	80-100	90	dBA	75.6
7	AQ7	80-100	90	dBA	74.5
8	AQ8	80-100	90	dBA	78.2
9	AQ9	80-100	90	dBA	76
10	AQ10	80-100	90	dBA	76.8
11	AQ11	80-100	90	dBA	75.7
12	AQ12	80-100	90	dBA	76.9
13	AQ CTL 1	80-100	90	dBA	77.9
14	AQ CTL 2	80-100	90	dBA	75.3
15	AQ CTL 3	80-100	90	dBA	73.4

Source: Field Survey 2019

4.4: Surface Water quality

Table 4.3 shows the Summary results of physicochemical measurements in surface water at sample stations compared with control.

Table 4.4: Summary of surface water qulity

Parameter	Sample ID			Control station		ANOVA	Significance
		mean	SD	Mean	SD		
Temperature ℃	Top	28.55	0.49	28.67	0.40	0.98	Not significant
	Mid	28.00	0.39	28.00	0.38	0.83	Not significant
	Bottom	28.00	0.44	28.00	0.42	0.87	Not significant
pH	Top	8.50	0.05	8.53	0.03	0.71	Not significant
	Mid	8.00	0.05	9.00	0.06	0.67	Not significant
	Bottom	8.00	0.44	9.00	0.06	0.47	Not significant
Conductivity µS/cm	Top	39581.08	1844.79	40766.67	2138.54	0.55	Not significant
	Mid	41900.00	2188.23	42200.00	2951.27	0.41	Not significant
	Bottom	43177.00	1830.83	42867.00	3200.52	0.17	Not significant
Turbidity NTU	Top	0.04	0.25	0.00	0.00		Not significant
	Mid	1.00	2.22	0.00	0.00		Not significant
	Bottom	2.00	7.21	0.00	0.00		Not significant
Dissolved Oxygen mg/l	Top	5.91	0.09	6.00	0.00		Not significant
	Mid	4.00	0.28	4.00	0.35	0.50	Not significant
	Bottom	4.00	0.14	3.00	0.21	0.30	Not significant
TDS mg/l	Top	27711.65	1288.27	28537.67	1495.24	0.55	Not significant
	Mid	29330.00	1531.51	29541.00	2065.86	0.41	Not significant
	Bottom	30226.00	1280.17	30007.00	2240.36	0.17	Not significant
Chloride mg/l	Top	14620.22	806.53	14721.67	772.18	0.82	Not significant
	Mid	15246.00	930.98	15119.00	1091.62	0.58	Not significant
	Bottom	16189.00	1202.54	15480.00	1155.80	0.85	Not significant
Alkalinity mg/l	Top	13.03	2.29	12.00	4.00	0.12	Not significant
	Mid	11.00	2.50	9.00	2.31	0.90	Not significant
	Bottom	11.00	3.52	14.00	0.00		Not significant
COL mg/l	Top	0.01	0.01	0.01	0.00		Not significant
	Mid	0.007	0.01	0.00	0.01	0.58	Not significant
	Bottom	0.004	0.01	0.00	0.00		Not significant
TSS mg/l	Top	22.11	3.30	21.33	1.15	0.23	Not significant
	Mid	22.00	3.78	27.00	3.06	0.92	Not significant
	Bottom	24.00	5.28	24.00	4.00	0.84	Not significant
COD mg/l	Top	180.49	14.25	188.00	10.15	0.79	Not significant
	Mid	179.00	12.62	182.00	10.02	0.90	Not significant

Parameter	**Sample ID**			**Control station**		**ANOVA**	**Significance**
		mean	**SD**	**Mean**	**SD**		
	Bottom	160.00	11.46	189.00	2.65	0.10	Not significant
BOD mg/l	Top	0.72	0.31	0.67	0.21	0.72	Not significant
	Mid	1.00	0.21	0.00	0.21	0.83	Not significant
	Bottom	0.00	0.14	0.00	0.12	0.97	Not significant
NO_3 mg/l	Top	1.23	0.31	1.00	0.17	0.55	Not significant
	Mid	1.00	0.31	1.00	0.46	0.30	Not significant
	Bottom	1.00	0.24	1.00	0.69	0.01	Significance
NO_2 mg/l	Top	4.04	1.01	3.29	0.57	0.54	Not significant
	Mid	4.00	1.01	4.00	1.51	0.30	Not significant
	Bottom	4.00	0.79	5.00	2.27	0.01	Significance
SO_4 mg/l	Top	801.62	112.13	730.00	52.85	0.40	Not significant
	Mid	826.00	113.75	724.00	34.50	0.17	Not significant
	Bottom	784.00	102.24	741.00	56.32	0.51	Not significant
PO_4 mg/l	Top	0.30	0.10	0.42	0.01	0.01	Significance
	Mid	0.00	0.09	0.00	0.02	0.08	Not significant
	Bottom	0.00	0.11	1.00	0.02	0.05	Significance
NH_4 mg/l	Top	0.58	0.14	0.47	0.08	0.50	Not significant
	Mid	1.00	0.15	1.00	0.03	0.25	Not significant
	Bottom	1.00	0.27	1.00	0.32	0.56	Not significant
O/G mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		
	Bottom	<0.001	<0.001	<0.001	<0.001		
THC mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		
	Bottom	<0.001	<0.001	<0.001	<0.001		
TPH mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		
	Bottom	<0.001	<0.001	<0.001	<0.001		
PAH mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		
	Bottom	<0.001	<0.001	<0.001	<0.001		
BTEX mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		

Parameter	Sample ID			Control station		ANOVA	Significance
		mean	SD	Mean	SD		
	Bottom	<0.001	<0.001	<0.001	<0.001		
Ni mg/l	Top	0.21	0.29	0.62	0.44	0.22	Not significant
	Mid	0.00	0.36	1.00	0.27	0.81	Not significant
	Bottom	0.00	0.10	1.00	0.35	0.00	Significance
Fe mg/l	Top	0.16	0.32	0.16	0.24	0.84	Not significant
	Mid	0.15	0.36	0.00	0.02	0.01	Significance
	Bottom	0.16	0.31	0.00	0.02	0.01	Significance
Pb mg/l	Top	0.10	0.21	0.19	0.14	0.96	Not significant
	Mid	0.05	0.06	0.00	0.40	0.00	Significance
	Bottom	0.07	0.06	0.00	0.42	0.00	Significance
Mn mg/l	Top	0.07	0.05	0.08	0.04	0.69	Not significant
	Mid	0.07	0.05	0.00	0.03	0.92	Not significant
	Bottom	0.11	0.05	0.00	0.06	0.56	Not significant
Cr mg/l	Top	0.03	0.03	0.17	0.00	0.23	Not significant
	Mid	0.03	0.03	0.00	0.04	0.40	Not significant
	Bottom	0.06	0.05	0.00	0.08	0.22	Not significant
Zn mg/l	Top	0.04	0.02	0.02	0.02	0.75	Not significant
	Mid	0.04	0.03	0.00	0.03	0.80	Not significant
	Bottom	0.06	0.03	0.00	0.00	0.02	Significance
Cd mg/l	Top	0.02	0.03	0.01	0.01	0.39	Not significant
	Mid	0.02	0.02	0.00			
	Bottom	0.02	0.02	0.00			
Ba mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		
	Bottom	<0.001	<0.001	<0.001	<0.001		
Co mg/l	Top	N/A	N/A	N/A	N/A		
	Mid	N/A	N/A	N/A	N/A		
	Bottom	N/A	N/A	N/A	N/A		
Hg mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		
	Bottom	<0.001	<0.001	<0.001	<0.001		
V mg/l	Top	<0.001	<0.001	<0.001	<0.001		
	Mid	<0.001	<0.001	<0.001	<0.001		

Parameter	Sample ID			Control station		ANOVA	Significance
		mean	SD	Mean	SD		
	Bottom	<0.001	<0.001	<0.001	<0.001		
K mg/l	Top	381.13	5.93	382.30	7.21	0.48	Not significant
	Mid	383.00	5.35	378.00	6.63	0.51	Not significant
	Bottom	385.00	6.13	378.00	5.54	0.93	Not significant
Na mg/l	Top	9824.92	196.84	9791.33	202.26	0.72	Not significant
	Mid	9845.00	106.69	9844.00	99.93	0.88	Not significant
	Bottom	16799	24765.34	10056.00	151.84	0.00	Significance
Mg mg/l	Top	1246.92	46.21	1170.67	63.52	0.33	Not significant
	Mid	1253.00	27.95	855.00	638.48	0.00	Significance
	Bottom	1261.00	25.60	1168.00	180.60	0.00	Significance
Ca mg/l	Top	403.84	3.03	404.67	4.16	0.33	Not significant
	Mid	406.00	2.60	406.00	4.36	0.20	Not significant
	Bottom	408.00	2.79	408.00	4.36	0.26	Not significant

**The mean difference is significant at the 0.05 level. Means highlighted are significantly different from the Control (Dunnett's test)*

Source: Field Survey 2019

Table 4.3 shows the Summary results of physicochemical measurements in surface water at sample stations compared with control station; the detailed results from field measurements and laboratory analysis of all collected samples are presented in Appendix 4.1.

Physicochemistry

Average water temperature ranged from 28.55oC at the top to 28.00oC at mid and bottom compared to control 28.67oC higher than the top of sample station but have equivalent measurement with the mid and bottom at the samples. pH ranged from 8.50 at the top, which is higher than mid and bottom with 8.00 compared to control with 8.53, 9.00 and 9.00 (top, mid, and bottom). The pH is lower at the sample point than the control and this variation was not significance (P<0.05) as shown in Figure 4. Conductivity is 39581µS/cm at the top and it was lower than that of mid and bottom samples which recorded 41900µS/cm, 43177µS/cm. when compared with the conductivity of the control station, significant variation was observed for concentration at the bottom samples due to the high conductivity obtained at the study area.

Dissolved oxygen compared well at top and mid between the study are and control station. However, significant variation was observed between DO levels from bottom samples, where higher concentration was recorded at the study area (4mg/l) and Concentration at the control was (3mg/l). This indicates oxygen enrichment range brought about water current and wave action; enabling transfer of dissolved oxygen from surface to lower depth. Observed variations in pH and DO are attributed to natural variations associated with mixing, phytoplankton productivity, atmospheric inputs and other biochemical processes. Dissolved oxygen levels are considered harmful to marine biota if they fall below 2mg/l (U.S. Environmental Protection Agency 2008). All measurements were considered normal for tropical marine waters.

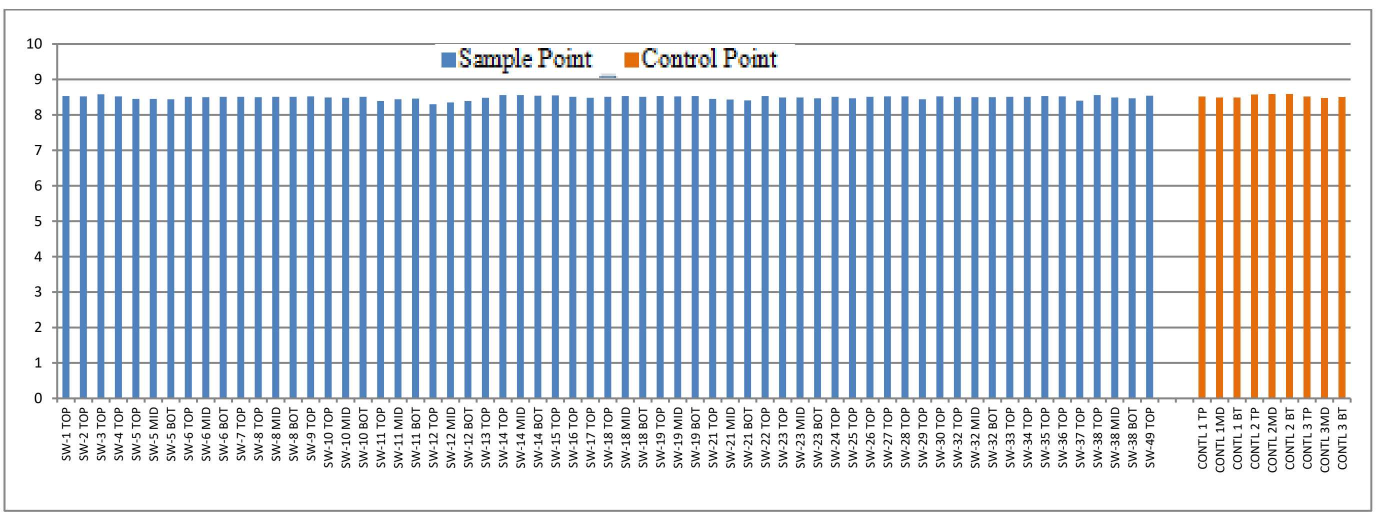


Figure. 4.6: Spatial Variation in Concentration of pH Compared to Control Locations

Average levels of alkalinity ranged from 13.03mg/l at the top, 11.00mg/l at mid to 11.00mg/l at bottom compared to control of 12.00mg/l at the top, 9.00mg/l to 14.mg/l. Concentration at top and mid is significantly higher than at the control but all levels are normal for tropical marine waters. The coincidence of the highest alkalinity with the lowest DO is an indicator that the variation in DO is mainly due to differences in phytoplankton productivity. Average turbidity ranged from 0.04 at the top to 1.00 at mid and 2.00 at the bottom compared to control of 0.00, 0.00 and 0.00 at top, mid and bottom. Turbidities at top, mid and bottom are significantly higher than that of the control, but all levels were low and normal for ocean waters. Variations are associated with sediment re-suspension and hydrodynamics within the system.

Organic Load

Biochemical Oxygen Demand and Chemical Oxygen Demand are routinely used as indicators of organic load in surface waters. Average levels of BOD ranged from 0.72mg/l at the top, 1.00 at the mid to 0.00mg/l at bottom compared to control of 0.67mg/l at top, 0.00mg/l at mid and 0.00mg/l at the bottom. There is significant variation in the level of BOD between sample locations and control. But the result indicates that reduction of BOD as it moves to the bottom. However, the top and mid were significantly higher than the top and mid of the control points.

Average levels of COD ranged from 180.49mg/l at top, 179.00mg/l at the mid to 160.00mg/l at bottom compared to control with 188.00mg/l at the top, 182.00mg/l at mid to 189.00mg/l at the bottom. There is a decrease of COD at it approach the bottom but when compare to control, there is significant increase as it approaches the bottom, but generally, it not significanT at ($P<0.05$). High levels of COD at the control may be associated with land-based and related input of materials from coastal rivers. All measurements including the control were high compared to those expected in unpolluted surface waters and are indicative of moderate levels of organic pollution. Unpolluted waters typically have BOD of 2 mg/l or less, whereas water in contact with waste water may have values up to 10 to 15 mg/l (Chapman and Kimstach, 1992).

Nutrients

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Spatial variations in levels of both parameters at the study location are shown in fig. 4.2b. Average levels of nitrate ranges from 1.23mg/l at the top, 1.22mg/l at the mid to 1.83mg/l at bottom compared to control of 1.00 mg/l at the top, 1.13mg/l at mid to 1.40 at the bottom. But the nitrate is higher at the top, mid and bottom compare to control. And the bottom is significance at ($p< 0.05$). There is a reduction in the level of Phosphate as it move from top to bottom with 0.30mg/l at the top, 0.28mg/l at the mid and 0.29mg/l at the bottom compared to levels at the control of 0.42mg/l at the top, 0.47mg/l at the mid and 0.42mg/l at the bottom. The top and bottom is significant at ($p<0.05$). Nitrate concentrations in excess of 20 mg/l usually indicate pollution by human or animal waste, or fertilizer runoff (Chapman and Kimstach, 1992). Present values are therefore normal for the study area. Most natural waters have phosphate levels ranging from 0.01 to 0.05 mg/l (Mills, 2013). Phosphate values above 0.02 mg/l are known to accelerate eutrophication in waters (Vollenweider and Kerekes, 1982). Present values of phosphate are high and indicative of contribution from diverse sources such as sediment release, land-based inputs as well as input form vessels and crude oil operations. NO2 ranges from 4.04mg/l at the top, 4.00 at both mid and bottom. The NO2 is higher at the top when compare to control, but the bottom is significance at $p<0.05$. SO4 has higher concentration at the mid with 826.00mg/l. The top has 801.61mg/l while bottom is 784.00mg/l. But SO4 is lower at the control point with 730.00mg/l top, 724.00mg/l mid and 741.00mg/l at the bottom. NH4 ranges from 0.58mg/l at the top, 0.57mg/l at the mid and 0.63mg/l at the bottom. Compare to control with 0.47mg/l at the top, 0. 55mg.l at the mid and 0.65mg/l at the bottom. The concentration of NH4 increases as it moves to the bottom. The top and mid of sample point are higher than the control but are not significance at $p<0.05$.

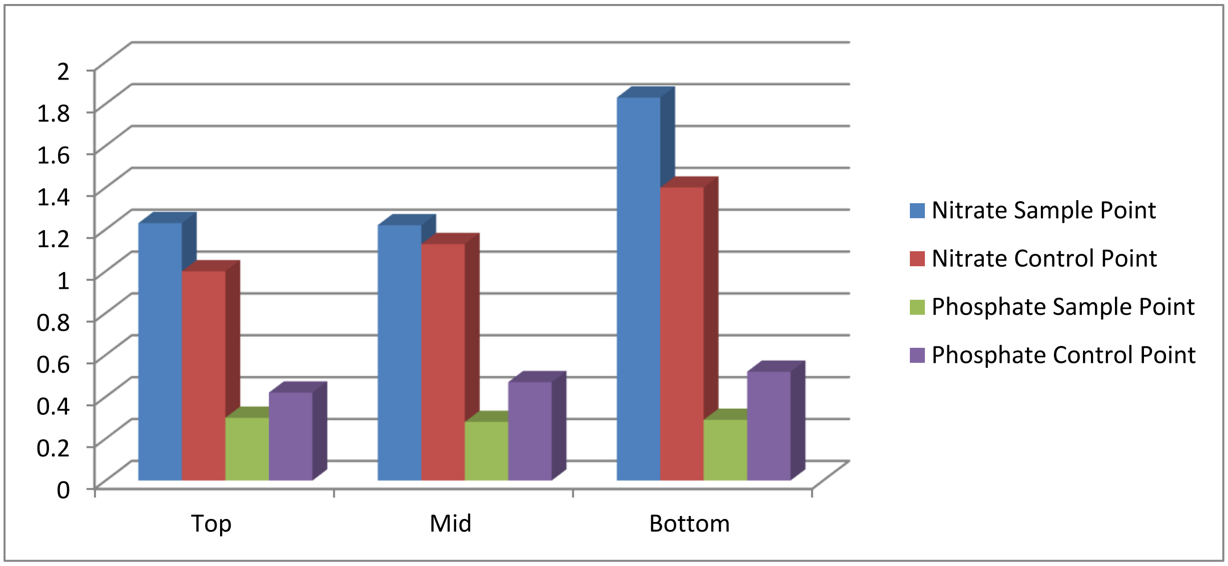


Figure 4.7: Spatial variation in Concentration of Nitrate and Phosphate

Heavy metals

Vanadium and barium were not detected in water at the sample points and control. Average cadmium ranges from 0.02mg/l at the top to bottom compared to control of 0.01mg/l and 0.01mg/l at the mid and 0.06 bottom. Cadmium was significantly higher at the top of sample point than the control. Average zinc ranged from 0.04mg/l at the top, 0.04mg/l at the mid to 0.06mg/l at the bottom. These shows increase in the level of Zn as it moves down. Same occur at the control point. Also, the top, the level of Zn is higher at sample points compare to control and, but the bottom is significance at ($p<0.05$). Average iron ranged from 1.16mg/l at the top, 0.15 at mid to 0.16 at bottom compared to control with same 0.16mg/l and 0.03mg/l at the mid and 0.04mg/l at the bottom. Iron is higher at mid and bottom than control and both the mid and bottom are significance at $p<0.05$. Chromium ranged from 0.03mg/l at top and mid to 0.06 at bottom compared to control of 0.17mg/l top, 0.04mg/l at mid and 0.06mg/l at the bottom. Nickel ranges from 0.21 at the top compare with 0.62 at the control top point. The mid is 0.34mg/l and bottom has 0.15mg/l at sample point compare to control with 0.62mg/l top, 0.57mg/l mid and 0.75mg/l at the bottom. Cobalt is not application in both sample and control. Higher levels of magnesium were also found at the study locations compared to control (Fig. 4.2c).

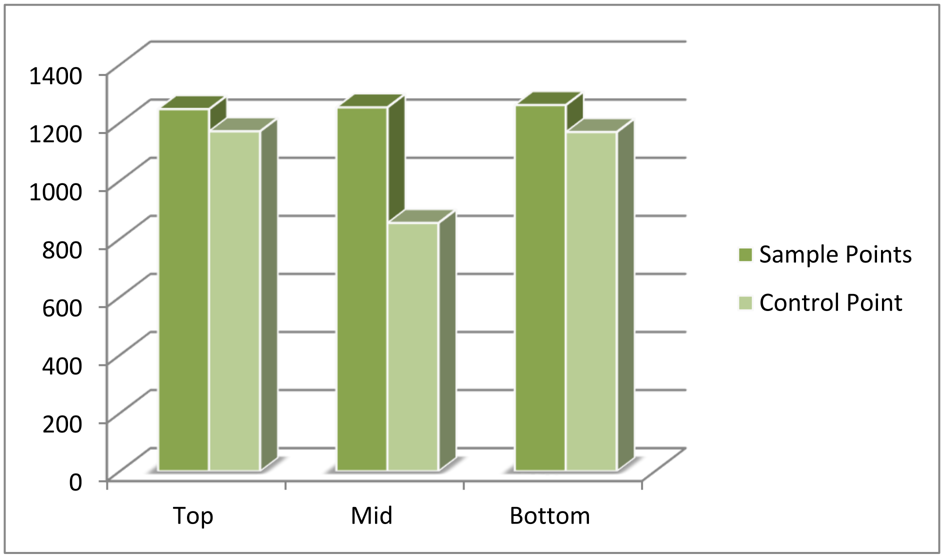


Fig. 4.8: Spatial variation in Concentration of Magnesium

Hydrocarbons

Oil and Grease, Total Petroleum Hydrocarbons were not detected in the water samples. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area.

4.5: Sediment Quality

The Summary results of sediment samples physicochemical measurements are presented in Table 4.5 below. Detailed analytical results are presented in Appendix 4.1.

Table 4.5: Summary Sediments Physicochemical Composition

Parameter	Sample ID		Control station		ANOVA	Significance
	Mean	SD	Mean	SD		
pH	7.28	0.17	7.36	0.04	0.10	Not Significance
Redox potential (mV)	-22.69	10.41	-24.50	5.36	0.46	Not Significance
Temperature ℃	20.43	1.42	20.80	0.70	0.43	Not Significance
Colour	Grey	Grey				-
Cl mg/kg	8843.73	349.16	9316.67	425.54	0.47	Not Significance

Parameter		Sample ID		Control station		ANOVA	Significance
		Mean	SD	Mean	SD		
TOC (%)		1.39	0.69	1.37	0.42	0.61	Not Significance
NO_3 mg/kg		0.63	0.30	0.70	0.20	0.70	Not Significance
PO_4 mg/kg		0.35	0.16	0.21	0.07	0.34	Not Significance
NH_4 mg/kg		0.29	0.14	0.33	0.10	0.72	Not Significance
PARTICLE SIZE ASTM P 2487-92	Sand	Nil	Nil	Nil	Nil	Nil	-
	Silt	42.27	6.46	37.83	28.73	0.00	Significance
	clay	57.52	6.50	62.14	28.75	0.00	Significance
THC ASTM mg/kg		14.80	7.45	10.00	6.07	0.96	Not Significance
TPH mg/kg		0.05	0.02	0.01	0.02	0.28	Not Significance
PAH ASTM (ma/ka)		<0.001	<0.001	<0.001	<0.001		-
BTEX mg/kg		<0.001	<0.001	<0.001	<0.001		-
Ni mg/kg		25.15	9.81	24.88	4.80	0.42	Not Significance
Fe mg/kg		7851.09	760.21	7079.00	316.32	0.32	Not Significance
Pb mg/kg		22.04	7.47	23.43	2.42	0.20	Not Significance
Cu mg/kg		2.67	2.39	1.20	0.73	0.18	Not Significance
Cr mg/kg		16.17	6.78	<0.001	<0.001		-
Zn mg/kg		16.87	6.81	16.22	7.82	0.55	Not Significance
Cd mg/kg		2.78	4.09	0.73	1.26	0.18	Not Significance
Ba mg/kg		8.63	2.79	13.67	3.06	0.62	Not Significance
Co mg/kg		16.95	4.52	18.57	2.14	0.40	Not Significance
Ag mg/kg		<0.001	<0.001	<0.001	<0.001		-
V mg/kg		<0.001	<0.001	<0.001	<0.001		-
K mg/kg		735.36	60.71	649.17	27.78	0.38	Not Significance
Na mg/kg		10438.17	201.62	10526.67	285.72	0.29	Not Significance
Mg mg/kg		2185.01	309.80	2691.17	52.49	0.06	Not Significance
Ca mg/kg		633.00	21.48	614.67	6.03	0.15	Not Significance

*The mean difference is significant at the 0.05 level. Means highlighted are significantly different from the Control (Dunnett's test)

Source: Field Survey 2019

Physicochemistry

Sediment temperature ranged from 20.43°C at sampled points compared to 20.80°C at the control. pH ranged from 7.28 at sample compared to 7.36 at the control. The pH of the sediments is related to that of the overlying waters. According to Zobel (1946) typical pH values for recent sediments range from 6.4 to 9.5. These sediments were generally muddy, consisting mainly of silt (42.27%) and clay (57.52%) with grey colour. Redox potentials were negative ranging from -22.69mV at sampled points compare to control with -24.50mV. Typical redox potentials for recent sediments range from +350 to -500 mV (Zobel, 1946) and indicative of anaerobic conditions. There were no significant differences in the levels of physicochemical parameters compared to control. The levels of physiochemical measurements are within limits expected in natural environments within the region.

Organic Load

Total Organic Carbon (TOC) ranged from 1.39% at sampled points compared to control of 1.37%. There was significant difference between study locations and control. TOC levels varied widely but were relatively higher at the study location compared to control. USEPA (2002) recommended the following assessment categories for TOC (or organic pollution) in sediments: Low: ≤ 1%, Intermediate: 1 to 3%, High: >3%. TOC values encountered were lower than 1% indicating that organic pollution is low in the sediments. Low organic carbon levels are usual in the Gulf of Guinea (UNEP, 1984). The low TOC levels may be attributed to the nature of sediments.

Nutrients

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. Nitrate ranged from 0.63mg/kg at sampled points compared to 0.70mg/kg at the control station. Phosphate ranged from 0.35mg/kg at sampled points compared to levels at the control of 0.21mg/kg. There was no significant difference in concentrations between study location and control. According to Singh et al. (2014) availability of inorganic nutrients, particularly nitrogen and phosphorous, is often a primary control on crude oil hydrocarbon degradation in marine systems. The low levels of nutrients recorded may be explained by prevailing negative redox conditions of the sediments. According to Marsden (1989) and Holz and Hoagland (1999) Oxidation-Reduction (Redox) processes at sediment-water interface can lead to significant releases of nitrates and phosphates into the water column under negative redox conditions.

Hydrocarbons

Total Petroleum Hydrocarbons mean concentration at the sample stations was 0.05mg/kg and 0.01mg/kg at the control stations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area.

Generally, the levels of petroleum hydrocarbons were low compared to the DPR target limit of 50mg/kg for TPH indicating absence of any significant oil pollution in the area.

Heavy metals

The heavy metal concentrations in the sediment were within optimal ranges of shallow water bodies in the Niger delta. The mean concentration of Ni (p=0.42), Fe (p=0.32), Pb (p=0.20), Cu (p=0.18), Zn (p=0.55), Cd (p=0.18), Ba (p=0.62) and Co (p=0.40) were not significantly across the receptor locations and control stations. Similarly, Ag and V were not detected in the sediments across the sampling locations. In order of increasing concentration, the heavy metals were: : Ag/V << Cu << Cd << Ba << Cr << Zn << Pb << Fe.

4.6: Microbiology

Surface Water

Table 4.6 below shows the summary of the microbiological characteristics of the sediments in the proposed seismic data acquisition project area. The THB and TF were in the order of 10^2 cfu/ml with mean counts of 2.18 x 10^2cfu/ml, 3.33 x 10^2cfu/l and 2.10 x 10^2cfu/ml, 1.12 x 10^2cfu/ml in the study area and control respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the surface water. Similarly, the hydrocarbonoclastis were not identified in the seawater including the control stations. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified in the seawater samples across the study area and control and indicates the unlikelihood of biogenic souring during the operation phase of the project.

Table 4.6: Microbiology Results for surface water quality

Parameter	Sample		Control		ANOVA	Significant
	Mean	StD	Mean	StD		
HUF (cfu/ml)	Nil	Nil	Nil	Nil	Nil	
HUB (cfu/ml)	Nil	Nil	Nil	Nil	Nil	
THB (cfu/ml) x102	2.18	0.20	2.10	0.19	0.97	
THF (cfu/ml) x10^2	3.33	3.35	1.12	0.07	0.00	Significant
Faecal Coliform (cfu/ml)	0.18	0.47	0.22	0.67	0.12	
SRB	Nil	Nil	Nil	Nil	Nil	

*The mean difference is significant at the 0.05 level. Means highlighted are significantly different from the Control (Dunnett's test)

Source: Field Survey 2019

Sediment microbiology

The summary of the microbial load of the sediment is presented in Table 4.7. The THB and TF were in the order of 10^2 and 10^1cfu/g with average mean counts of $2.11x10^2$ and $7.23x10^1$ with the proposed project area and 2.20x102cfu/g, 7.80x101cfu/g in the control locations. The heterotrophic bacteria counts is suggestive of the availability of utilizable organic substrates in the sediment. Results of the TOC across the receptor distances lend credence to this finding. Similarly, the hydrocarbonoclastis were not identified in the sediments including the control location and suggestive of the low hydrocarbon burden of the proposed project location. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified in the sediment samples and indicate unlikelihood of biogenic souring during the operation phase of the project.

Table 4.7: Sediment Microbiology Result

Parameter	**Sample points**		**Control point**		**ANOVA**	**Significant**
	Mean	**StD**	**Mean**	**StD**		
HUF APHA 9215B (cfu/ml) $X10^1$	-	-	-	-		
HUB APHA 9610C (cfu/ml) $X10^1$	-	-	-	-		
THB APHA 9215C (cfu/ml) $X10^2$	2.21	0.14	2.20	0.07	047	
THF APHA 9610C (cfu/ml X101	7.23	2.31	7.80	1.57	0.74	
SRB $X10^1$	Nil	Nil	Nil	Nil	Nil	

*The mean difference is significant at the 0.05 level. Means highlighted are significantly different from the Control (Dunnett's test)

Source: Field Survey 2019

4.7: Hydrobiology and Fisheries

4.7.1 The Benthic Fauna

Composition

The Composition of the benthic fauna recorded at the control and sample points are as shown in Table 4.7 and Appendix 4.2 below. The species composition showed a total of 16 species of benthic fauna belonging to 10 families, 6 orders and 2 Classes. The 2 Classes, the Gastropods recorded 11 species, and the Bivalves recorded 5 species. Though, the Bivalves recorded the lowest number of species in both the control and sample points, they were the dominant Class as they recorded the highest number of organism/species (92.52%) occurrence than the Gastropod which recorded low (7.48%) species occurrence.

Also, the composition in Appendix 1 revealed that both the control and sample points recorded a varied but mostly low Benthic fauna population with many station (SD3, 19, 31, etc.) and a control (Ctrl 3) recording between 1 and 0 species occurrence. However, a few sample stations

(SD63) and controls (Ctrl 1 and 2) recorded high population density. Finally, the sample points generally recorded between 0 – 10 organisms, whereas the control points recorded between1 – 11 organisms (Ctrl 1 and 2, with 9 and 11 species respectively). The composition of the organisms in the control and the sample points were similar. This also indicate similarity in environmental factors which directly influence biota distribution. Macrobenthos in estuarine ecosystem provides significant support to the aquatic food web. They contribute to ecosystem stability through the sustenance of fishery resources including birds. The composition, abundance and distribution pattern of macrobenthos can act as an ecosystem index by indicating trophic structure, quality of water and the eutrophication level of the aquatic ecosystem (Mehdi *et al*., 2005). Physicochemical parameters of the environment may influence macro-benthic organisms either positively or negatively depending on their sources. Excessive input of nutrients and changes of soil parameters can cause long or short-term shifts in benthic species composition, abundance and richness (Aura *et al*., 2011).

The number of benthos in each station was low when compared to the OML 77 & 74 3D Seismic Baseline study (2018), and with literature reports of other systems in Nigeria (Victor and Ogbeibu, 1985, Olomukoro and Ezemonye, 2007; Emere and Nasiru 2008). This low population density is probably related to several factors such as food availability for organisms, increased prey presence in the dry season, or even species competition. It may also be because of over-exploitation of seafoods, in the advent of the dry season when fishers and fishing activities have increased (Abowei, 2000; Ibim and Douglas, 2016; Ibim and Bongilli, 2018). Therefore, the results of this study showed that the facility has not significantly impacted the environment negatively.

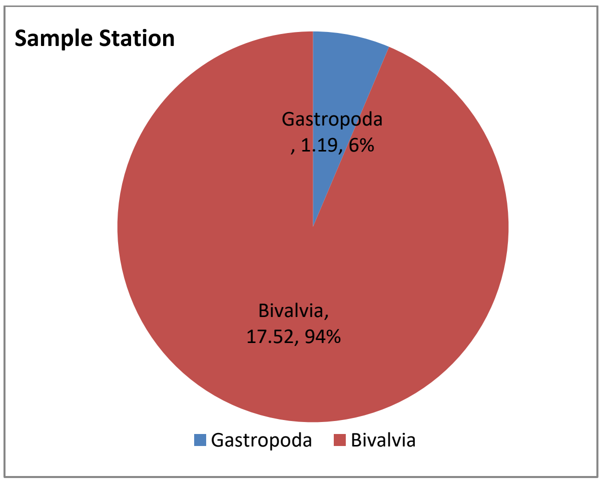
Table 4.8: Composition of the Benthic fauna of the Study Area

S/N	Species	Family	Order	Class
1	*Bela atlantidae*	*Mangeliidae*	*Neogastropoda*	Gastropoda
2	*Conus marmoreus*	*Conidae*	*Caenogastropoda*	Gastropoda
3	*Eucithara dubiosa*	*Mangeliidae*	*Caenogastropoda*	Gastropoda
4	*Eucithara abbreviate*	*Mangeliidae*	*Caenogastropoda*	Gastropoda
5	*Eucithara amabilis*	*Mangeliidae*	*Caenogastropoda*	Gastropoda
6	*Glyphoturris rugirima*	*Mangeliidae*	*Neogastropoda*	Gastropoda
7	*Heterocithara sp.*	*Mangeliidae*	*Caenogastropoda*	Gastropoda
8	*Stigmaulax elenae*	*Naticidae*	*Littorinimorpha*	Gastropoda
9	*Ophrodermella inermis*	*Borsoniidae*	*Neogastropoda*	Gastropoda
10	*Ptychosyrinx chilensis*	*Turridae*	*Neogastropoda*	Gastropoda
11	*Vokesimurex elenensis*	*Muricidae*	*Neogastropoda*	Gastropoda
12	*Mercenaria mercenaria*	*Veneridae*	*Veneroida*	Bivalvia
13	*Mya arenaria*	*Myidae*	*Myoida*	Bivalvia
14	*Cerastoderma glaucum*	*Cardiidae*	*Veneroida*	Bivalvia
15	*Chlamys opercularis*	*Pectinidae*	*Ostreoida*	Bivalvia
16	*Aequipecten opercularis*	*Pectinidae*	*Ostreoida*	Bivalvia

Source: Field Survey 2019

Mean Composition/Density

The mean density of the Benthic fauna (Figures 4.9) revealed that, the sample points recorded bivalves (17.52) and (1.19) Gastropods whereas the control recorded 18.0 Bivalves and 9.5 Gastropods. This showed that the control recorded similar density of Bivalves but a significantly higher density of Gastropods in the control than the sample points. Analysis of composition between control station and sample stations showed no significant variation in the benthic community composition as at the time of field data gathering. This reflects the fact that most sampling points were devoid of or low in Gastropods. The reason for this is not known but it could be attributed to the presence of a distressing impact in the area, or prey preponderance, or even over-exploitation of the fisheries; as this area is shallow and can serve as a point for sea food fishery carried out by the women, using baskets to pick at low tide.



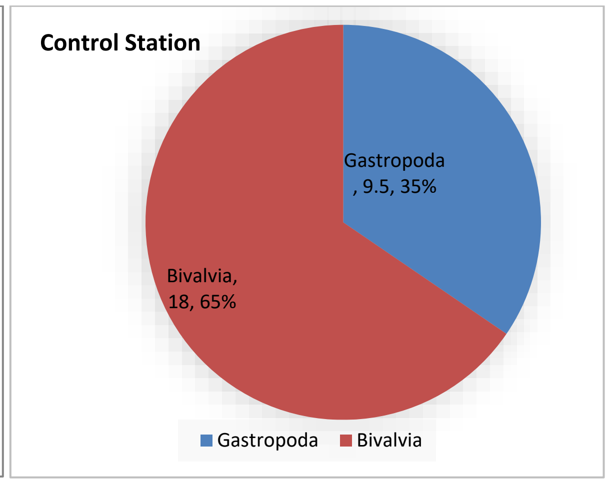


Figure 4.9 : Mean Composition/Density of Benthos

Benthic species Abundance

The relative abundance of Benthic fauna (Figure 4.10) revealed that, the abundance of the Gastropod and Bivalve species of the control points varied significantly among themselves, and so also, the abundance of the Gastropod and Bivalve species of the control points varied significantly among themselves. However, the mean abundance revealed that the sample points recorded 8.10% Gastropods and 91.33% Bivalves, whereas the Control points recorded 17.92% Gastropods and 82.50% Bivalves. This reveals that the Control points recorded higher mean abundance (Figures 3 and 4) than the Sample points. The reason for this higher abundance is not known but it could be because of over grazing by predator species which increase in waters in the dry season, or as the volume of water in the environment reduces.

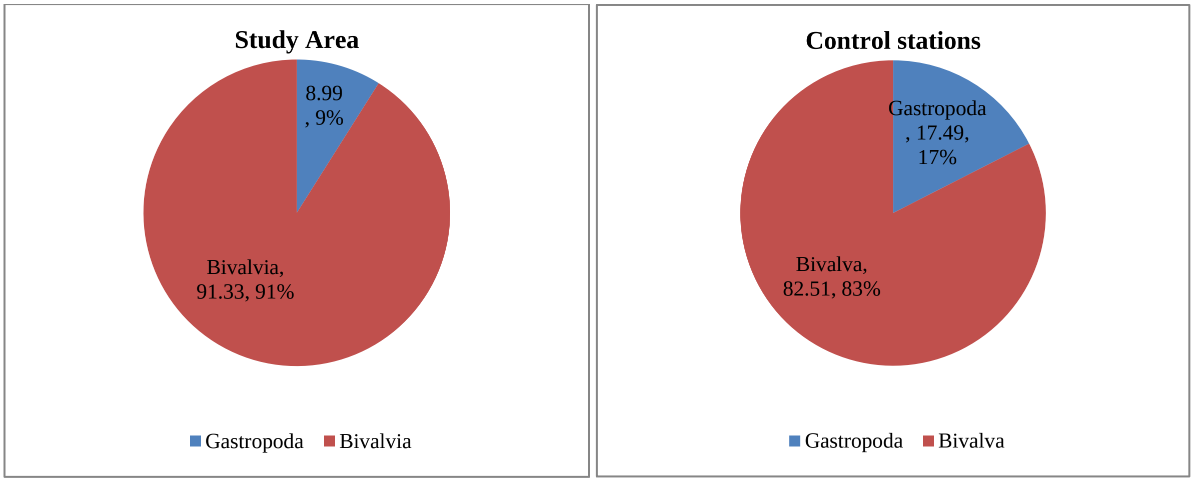


Figure 4.10: Mean Relative Abundance of Benthos

Benthic species Diversity

Generally, the diversity revealed that among the 2 Classes, Gastropods were the most diverse with 11 species out of 16 Benthic species, while the Bivalves were less diverse with 5 species. Benthos species diversity (Table 4.9) was analysed and it was observed that there was no significant difference for Richness, Shannon_Entropy, Simpson_Dominance, Gini_Simpson_Index and Berger_Parker_Index_max between sample sites and control sites.

Table 4.9: Test of Significance for Benthic Diversity Indices

Diversity Index	Area	Mean
Richness	Sample Sites	8.00±3.00
	Control Sites	8.00±3.00
Shannon_Entropy	Sample Sites	1.62±0.43
	Control Sites	1.41±0.04
Simpson_Dominance	Sample Sites	25.40±10.50
	Control Sites	34.25±0.15
Gini_Simpson_Index	Sample Sites	74.60±10.50
	Control Sites	70.75±4.85
Berger_Parker_Index_max	Sample Sites	38.25±13.25
	Control Sites	16.70±11.10

Source: Field Survey 2019

4.7.2: Phytoplanktons

Composition

The total Phytoplankton composition recorded in both the control and sample points are as shown in Table 4.10 and Appendix 4.2 below. The Phytoplankton composition revealed a high composition with a total of 28 species belonging to 24 families, 19 orders and 5 Classes. The 5 classes are the Bacillariophyceae, Dinophyceae, Fragilariophyceae, Dictyochophyceae, and the Haptophyceae. The Bacillariophyceae were the dominant class with 17 species, followed by Dinophyceae with 8 species and the rest 3, Fragillariophyceae, Dictyochlorophyceae, and Haptophyceae were the least, with 1 species each. However, the control points were devoid of the Dictyochlorophyceae, and thus had 4 Classes and 27species. Both the control and sampling points recorded a varied occurrence of species.

Table 4.10: Observed Phytoplankton Composition for OML 77 & 74 Fields

S/N	Species	Family	Order	Class
1	*Ditylum sp.*	*Lithodesmiaceae*	*Lithodesmiales*	Bacillariophyceae
2	*Entomoneis sp.*	*Entomoneidaceae*	*Surirellales*	Bacillariophyceae
3	*Fragilariopsis sp.*	*Bacillariaceae*	*Bacillariales*	Bacillariophyceae
4	*Leptocylindrus sp.*	*Leptocylindraceae*	*Leptocylindrales*	Bacillariophyceae
5	*Licmophora sp.*	*Licmophoraceae*	*Licmophorales*	Bacillariophyceae
6	*Melosira sp.*	*Melosiraceae*	*Melosirales*	Bacillariophyceae
7	*Navicula sp.*	*Naviculaceae*	*Naviculales*	Bacillariophyceae
8	*Nitzschia sp*	*Bacillariaceae*	*Bacillariales*	Bacillariophyceae
9	*Chaetoceros spp*	*Chaetocerotaceae*	*Chaetocerotanae incertae sedis*	Bacillariophyceae
10	*Coscinodiscus sp.*	*Coscinodiscaceae*	*Coscinodiscales*	Bacillariophyceae
11	*Rhizosolenia sp.*	*Rhizosoleniaceae*	*Rhizosoleniales*	Bacillariophyceae
12	*Skeletonema sp.*	*Skeletonemaceae*	*Thalassiosirales*	Bacillariophyceae
13	*Stephanopyxis sp.*	*Stephanopyxidaceae*	*Melosirales*	Bacillariophyceae
14	*Pleurosigma sp*	*Pleurosigmataceae*	*Naviculales*	Bacillariophyceae
15	*Pseudo-nitzschia sp.*	*Bacillariaceae*	*Bacillariales*	Bacillariophyceae
16	*Thalassionema sp.*	*Thalassionemataceae*	*Thalassionematales*	Bacillariophyceae
17	*Thalassiosira sp.*	*Thalassiosiraceae*	*Thalassiosirales*	Bacillariophyceae
18	*Alexandrium sp.*	*Ostreopsidaceae*	*Gonyaulacales*	Dinophyceae
19	*Dinophysis sp.*	*Dinophysiaceae*	*Dinophysiales*	Dinophyceae
20	*Ceratium furca*	*Ceratiaceae*	*Gonyaulacales*	Dinophyceae
21	*Ceratium fusus*	*Ceratiaceae*	*Gonyaulacales*	Dinophyceae
22	*Tripos longipes*	*Ceratiaceae*	*Gonyaulacales*	Dinophyceae
23	*Noctiluca scintillans*	*Noctilucaceae*	*Noctilucales*	Dinophyceae
24	*Protoperidinium sp.*	*Protoperidiniaceae*	*Peridiniales*	Dinophyceae

S/N	Species	Family	Order	Class
25	Scrippsiella sp.	*Peridiniaceae*	*Peridiniales*	Dinophyceae
26	Asterionella sp.	*Fragilariaceae*	*Araphidineae*	Fragilariophyceae
27	Coccolithophora sp.	*Coccolithophoridae*	*Prymnesiophyceae*	Haptophyceae
28	Dictyocha sp.	*Dictyochaceae*	*Dictyochales*	Dictyochophyceae

Source: Field Survey 2019

Mean Composition/Density

The mean numerical composition/Density (Figure 4.11) revealed that the Bacillariophyceae (29.38) recorded the highest density followed in descending order by the Dinophyceae (18.32), Fragillariophyceae(3.03),Haptophyceae (2.38), and the Dictyochlorophyceae(0.76), However, the Dictyochlorophyceae were absent in most of the sample points. However, in the control points, the density revealed that, the Baillariophyceae (14.67) was the dominant class, closely followed by the Dinophyceae (14.0), and then the Fragillariophyceae(5.67) and Haptophyceae (1.67), but the Dictyoclorophyceae was completely absent. This difference between the control and sample points reveal that the sample points were better than the control points. Additionally, there was a general good status of the sample points as the number of classes of Phytoplankton (5) in the current study sample stations, were higher than the 4 Classes of Phytoplankton reported in the project area in the Baseline study (2018) by 1 class, whereas the control points of this study recorded the same 4 Classes of Phytoplankton as the Baseline study (2018). Thus, it could be said that the facility did not impact the Phtoplankton community of the project environment.

The 5 classes of phytoplankton in descending order of occurrence, in this study is as follows; the Bacillariophyceae, Dinophyceae, Fragilariophyceae, Dictyochophyceae, and the Haptophyceae, while in the Baseline studies (2018), the 4 Phytoplankton composition in the project area in descending order of occurrence: Baccilariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae and Euglenophyceae. There was therefore similarity in the dominant class and Classes available between the Baseline study and the present study. However, the variation in the occurrence of classes between both studies may not be unrelated to the period of the study (wet/dry season), increase in grazing species as the water level reduces in the dry season, increased environmental perturbation, among other variables.

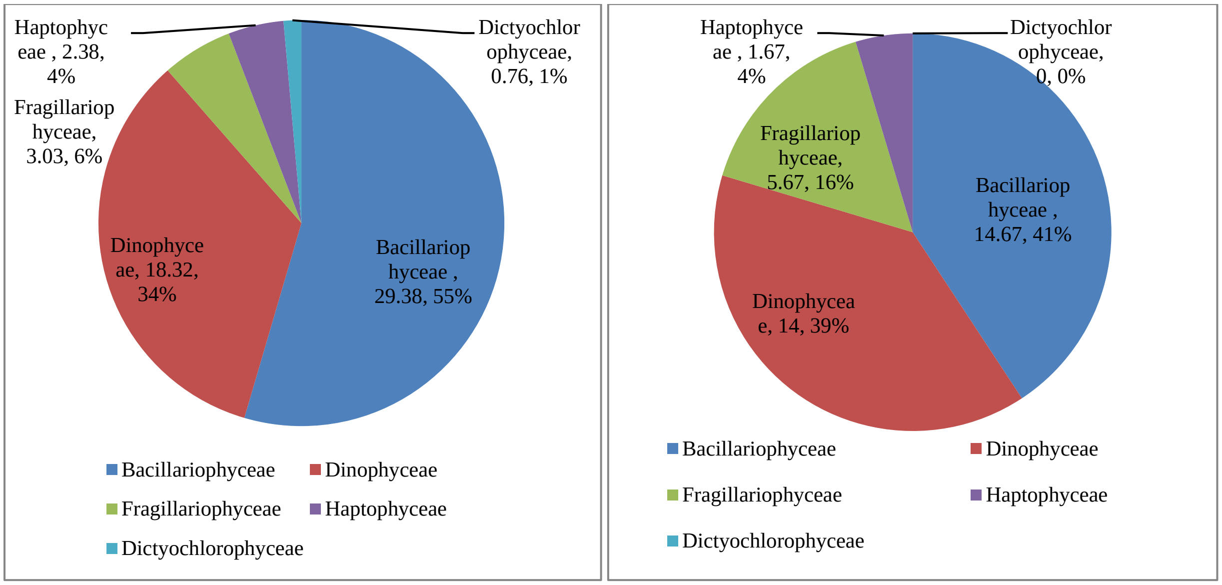


Figure 4.11: Mean Numerical Composition / Density of Phytoplanktons

Abundance

The mean relative abundance (Figure 4.12) of Phytoplankton classes showed that, within the samples Bacillariophyceae was dominant (54.08%), followed in descending order by Dinophyceae (34.46%), Fragillariophyceae (6.19%), Haptophyceae(4.45%), and Dictyochlorophyceae (0.082%). It was observed that the Dictyochlorophyceae were absent in most of the sampling points and where it was available (SW 18, 19, 25 and 26), it recorded very low abundance. This trend was similar in the Control points, where the Bacillariophyceae was the dominant class and recorded the highest mean relative abundance (41.27%), followed also by Dinophyceae(37.60%), Fragillariophyceae (16.30%), Haptophyceae(4.83%),. However, the Dictyochlorophyceae was completely absent (0%) in the control points. Though Bacillariophyceae was lower in the control points, the control points recorded recorded higher mean percentage of Dinophyceae, Fragillariophyceae and Haptophyceae but recorded no (0%) Dicthyochlorophyceae. Thus, the control was poorer by 1 class when compared to the sample points. Also, the mean percent abundance of the sample and control Fragillariophyceae were significantly different. Thus, there was a significant difference between the sample and control points.

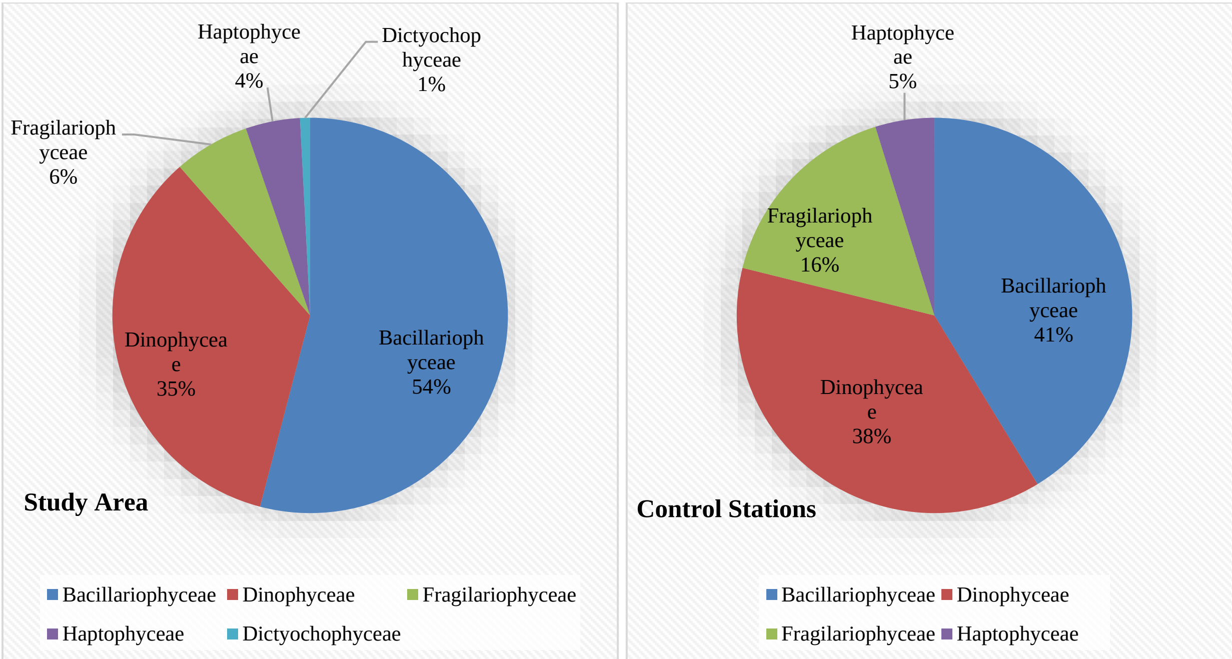


Figure 4.12: Mean Relative Abundance of Phytoplamkton Species

Diversity

Highest species diversity occurred in the sample points as they recorded 5 classes while the control recorded 4 classes. Species richness was analysed and the diversity (Table 4.11) was represented by Shannon_Entropy, Simpson_Dominance, Gini_Simpson_Index and Berger_Parker_Index_max. This showed that there was no significant difference for Richness, Shannon_Entropy, Simpson_Dominance, Gini_Simpson_Index and Berger_Parker_Index_max between sample sites and control sites.

Table 4.11: Test of Significance for Phytoplankton Diversity Indices

Diversity Index	Area	Mean
Richness	Sample Sites	5.60±3.16
	Control Sites	3.00±1.38
Shannon_Entropy	Sample Sites	.92±0.57
	Control Sites	.59±0.36
Simpson_Dominance	Sample Sites	64.84±21.57
	Control Sites	70.64±18.09
Gini_Simpson_Index	Sample Sites	35.16±21.57
	Control Sites	29.36±18.09
Berger_Parker_Index_max	Sample Sites	67.66±19.84
	Control Sites	75.26±15.45

Source: Field Survey 2019

4.7.3: Zooplankton

Composition

The total Zooplankton Composition of the OML 77 and 74 Fields recorded in both the control and sample points are as shown in Appendix 4.2 and Table 4.12 below, consisting of a high composition of 21 species belonging to 18 families, 21 orders and 7 classes. The 7 classes in descending order of dominance are Hexanauplia with 12 species, followed by Oligotrichea with 3 species, Malacostraca (2 species), and classes Polycheata, Branchiopoda, Calanoida and Stenolaemata (all having 1 species each). However, the control points only have 3 classes of Zooplanktons namely; Hexanauplia with 7 species, Oligotrichea (3 species), and Stenolaemata (1 species).

Table 4.12: Observed Zooplankton Composition for OML 77 and 74 Fields

S/N	Species	Family	Order	Class
1	*Aegisthus mucronatus*	*Aegisthidae*	Harpacticoida	Hexanauplia
2	*Acartia tonsa*	*Acartiidae*	Calanoida	Hexanauplia
3	*Acrocalanus longicornis*	*Paracalanidae*	Calanoida	Hexanauplia
4	*Elminius modestus (Nauplius)*	*Austrobalanidae*	Sessilia	Hexanauplia
5	*Bestiolina Arabica*	*Paracalanidae*	Calanoida	Hexanauplia
6	*Semibalanus balanoides (larvae)*	*Archaeobalanidae*	Sessilia	Hexanauplia
7	*Canthocalanus pauper*	*Calanidae*	Calanoida	Hexanauplia
8	*Calanopia elliptica*	*Pontellidae*	Calanoida	Hexanauplia
9	*Euchaeta concinna*	*Euchaetidae*	Calanoida	Hexanauplia
10	*Ambunguipes spp.*	*Hamondiidae*	Harpacticoida	Hexanauplia
11	*Oithona nana*	*Oithonidae*	Cyclopoida	Hexanauplia
12	*Oithona setigera*	*Oithonidae*	Cyclopoida	Hexanauplia
13	*Calanoides spp.*	*Calanidae*	Calanoida	Hexanauplia
14	*Strobilidium sp*	*Strobilidiidae*	Choreotrichida	Oligotrichea
15	*Euphausia recurve*	*Euphausiidae*	Euphausiacea	Malacostraca
16	*Alpheus Fabricius*	*Alpheidae*	Decapoda	Malacostraca
17	*Tintinnus sp*	*Tintinnidae*	Choreotrichida	Oligotrichea
18	*Tintinnopsis sp.*	*Codonellidae*	Choreotrichida	Oligotrichea
19	*Tomopteris spp.*	*Tomopteridae*	Phyllodocida	Polychaeta
20	*Actinopora sp.*	*Actinoporidae*	Cyclostomatida	Stenolaemata
21	*Daphnia sp.*	*Daphniidae*	Anomopoda	Branchiopoda

Source: Field Survey 2019

This varied occurrence of Zooplankton between the sample and control points revealed that the sample points recorded more Zooplankton than the control points.

Zooplankton Composition/Density

The numerical composition/density revealed that the both control and sample points recorded the highest numbers of Hexanauplia species but very low to zero of other Classes of species. Furthermore, the control points recorded zero species number in the Classes Malacostraca, Branchiopoda, Calanoida and Polycheata. The mean density (Figure 4.13) showed that the classes of organisms in the sample points recorded in descending order Hexanauplia (26.65), Malacostraca (3.22), Oligotrichea(2.84), Stenolaemata(2,57Calanoida(1.70), Branchiopoda(1.24), and Polycheata(0.30). The control points however recorded mean densities (fig. 17) zooplanktons: Hexanauplia(20.67), Oligotrichea (5.67) and Stenolaemata (3.33). This further confirms that the sample points recorded more Zooplankton class/species than the control points, although the Oligotrichea and Stenolaemata were higher in the control. It is therefore clear that the studied area has a potentially strong influence in the development of fisheries since the zooplankton interaction of the river is healthy enough to support fish production. The river can serve as a dependable resource pool for fisheries development. High zooplankton biomass and productivity may be related to the input of energy and organic matter from mangrove forests, which is one of the most frequent coastal vegetation in the project area (Lugo and Snedaker, 1974). Mangrove forests are periodically inundated by the tides and form a virtually inseparable part of the aquatic biome. However, zooplankton is an important intermediate component in estuarine food webs, acting as a trophic link between small particles (e.g., detritus and microalgae) and planktivorous fishes. These ecosystems have an outstanding direct socio-economic importance for many tropical coastal regions (Aksornkoae et al., 1993; Uthoff, 1996).

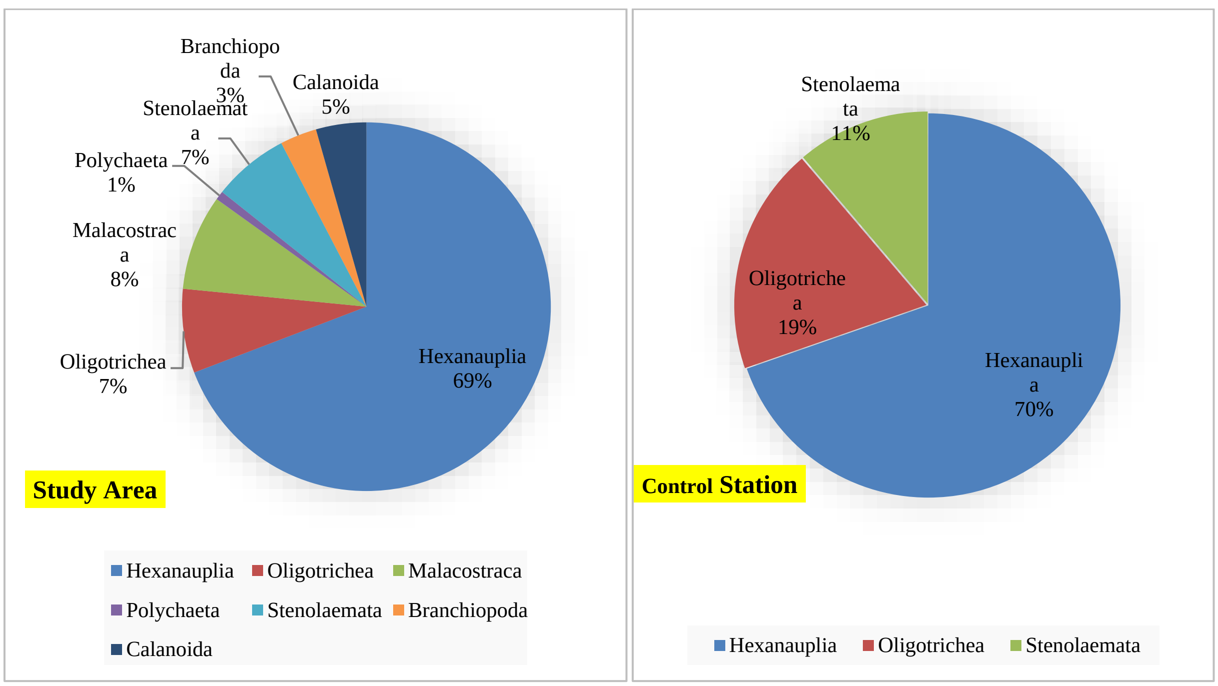
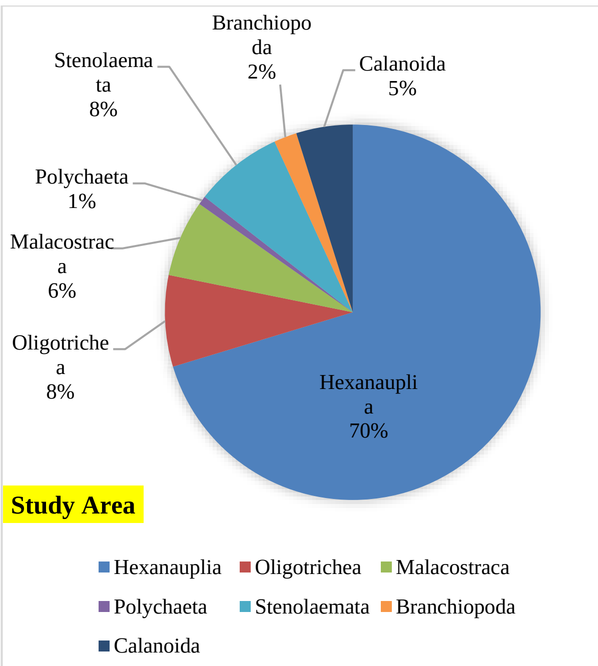


Figure 4.13: Mean Composition/Density of Zooplankton Species

Source: Field Survey 2019

Relative Abundance of Zooplankton

The mean relative abundance of the Zooplanktons between the Sample and Control points (Figure 4.14) shows that the Hexanauplia was the dominant class with both areas recording similar mean percent abundance (69.59% for control and 70. 88% for sample points). The Oligotrichea was the next abundant with 15.55% for the Sample points and 7.93% for control; followed in descending order by Stenolaemata (14.87 for control and 7.68 for sample points), revealing higher means for the control points. After these, the sample points recorded mean percent abundance for Malacostraca (6.66%), Calanoida(4.40%), Branchiopoda(1.99%) and Polycheata (0.76%). However, the control points lacked the Malacostraca, Calanoida, Branchiopoda and the Polycheata.



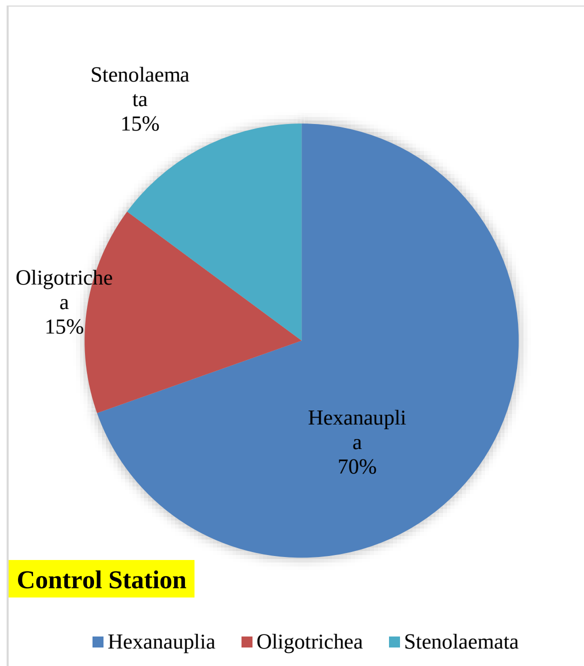


Figure 4.14: Mean Relative Abundance of Zooplankton Species

Source: Field Survey 2019

Thus, in both control and sample points (figures: 11 and 12) even though the Hexanauplia were similarly dominant and very abundant, the Oligotrchea and Stenolaemata recorded higher mean relative abundance in the control points than the sample points. However, in the Control points, Malacostraca, Branchiopoda, Polycheata, and Calnoida recorded 0% mean relative abundance as they were absent, whereas they recorded very low percent relative abundance ranging from 0.76% to 7.68% in the sample points. This difference between the control and sample points showed that the sample points and control recorded advantages over each other; however, the ANOVA showed that this difference was not significant.

Species Diversity of Zooplankton

Zooplankton species in the sample points were far more diverse with & classes than the 3 classes in the control points. The ANOVA (Table 4.13) showed that there is significant difference between the Simpson_Dominance/Berger_Parker_Index_max for the Sample sites and Simpson_Dominance/Berger_Parker_Index_max for control. The Species Richness, Shannon_Entropy and Gini_Simpson_Index; no significant difference between the sample site and control site was observed.

Table 4.13: Test of Significance for Zooplankton Diversity Indices

Diversity Index	Area	Mean
Richness	Sample Sites	3.00±1.53
	Control Sites	2.29±1.67
Shannon_Entropy	Sample Sites	0.58±0.33
	Control Sites	0.38±0.25
Simpson_Dominance	Sample Sites	71.79±14.22
	Control Sites	22.19±13.93
Gini_Simpson_Index	Sample Sites	28.21±14.22
	Control Sites	20.67±13.41
Berger_Parker_Index_max	Sample Sites	75.55±12.75
	Control Sites	23.55±14.00

Source: Field Survey 2019

4.7.4: Fisheries Study

Fishing Activities

The fisheries information obtained from the OML 77& 74 baseline (2018) studies citing Troadec and Garcia, 1980; Chindah and Osuamkpe, 2008 and Ekeke *et. al*. 2008, reported that artisanal fishers or small-scale fishers dominate the fishery along the coastline adjacent to the project area. Artisanal fishers operate largely in rivers creeks and creeklets that empty directly or indirectly into the Atlantic Ocean adjacent to the project area. These rivers, creeks and creeklets include Akwamobugo creek and Brass River, into which the former empties, Akassa creek, Ekole Creek, Nembe Creek and St. Nicholas River. Information from the baseline study further reported that fishers operate in dug-out wooden canoes which may or may not be motorized. In the Akuku-Toru axis where the Sombrero river and its network of creeks traverses (Ibim and Bongilli, 2017,2018; Ibim and Douglas, 2016) the project area, the fishers are also predominantly artisanal fishers depending on planked wooden boats that may or may not be motorized (Plate 4.1).

Plate 4.1: Small fishing activity around the project area (a &b)

Fishing Gears

Fishing in in the project area is a multi – fishing gears operation. The fishing gears used were ghost shrimp traps, castnets, gillnets, setnets, long line, Stownet, scoopnet and circular liftnets. The gillnets and setnets measure 6-12 m in length and 2-4 meters in width. Nets are manually operated using paddles and poles. They are set and allowed to stay for up to one hour before they are retrieved with the catch. The fishermen in this area go fishing with more than one net units. When the net is set and before it is removed another net is also set. Other fishing gears used especially by the female fishers in the fin or shell fishery are traps, mainly the basket traps and the non-return valve traps. The non-return valves are set in shallow areas of the rivers on stakes and in creeks where they catch fishes swimming with the tide or seeking for food set as traps in the traps. Also, the women fishers pick the shell fishes with baskets.

Life Expectancy of Fishing Gears

Monofilament nets are considered very effective when in use because they are thin, but their durability is short. Fishermen engaged in catching juveniles prefer to use them. The nets often snap whenever fish is being extracted and only floats, sinkers, and the ropes are recoverable for possible recycling. They last for only 3 to 12 months depending on intensity of fishing and the fishing ground. Stownet can last between 6 months and 2 years depending on the mending ability of the fisherfolk. The traps used in the area last between 1 to 2 years depending on the use intensity and maintenance.

Fishing Intensity

The fishing operation depends on the fishing weather (calmness and roughness) and the number of crew also is dependent on the system and species targeted. For small operations between 1 – 3 crew (comprising man, wife and son or man and son or two women) are involved. In some fishing settlements the crew pool to share facilities such as boat and engine, with individual fishermen bringing in their own net. Although this is not common among the fishers in the project area. The boat owner can carry more than one net. The outboard engine owner also enjoys the same status as the boat owner. All fishermen own a combination of gears to be able to fish all the year round and they take advantage of the proximity of the sea. The fishing days vary between 5 and 7 days a week.

Fish Catch

The catch rates were previously reported to be dependent on seasons (Emmanuel, 2009). The fishers catch more in the dry season than in the wet season. This was attributed to ease of fishing, low water volume and concentration of fishes in smaller areas in the dry season (Ibim and Njoku, 2018). Fish catches from these rivers are sold in settlement such as Kulama, Sangana, Brass, Nembe, Odiama, Degema, Abonnema and Yenagoa. Fish sales vary from N1000.00 to N100,000.00 daily depending on the season and the catch. However, the demand outstrips the supply.

Fish Composition

The fish composition of the area was reported based on literature. Information was obtained from the work of Troadec and Garcia (1980) on the fish species that inhabit the coastal waters of Nigeria. They reported several species fished by off-shore trawlers such as Lutjanidae, Sparidae, Serranidae Cynoglossidae Ariidae Pomadasyidae, Haemulidae, Polynemidae, and Rajidae. Also, the Baseline studies (2018) reported some fishes targeted by artisanal fishers in the area. These Fish stocks were: croakers (*Pseudotolithus*), threadfins (*Galeoides*, *Pentanemus* and *Polydactylus*), soles (Cynoglossidae), marine catfish (*Arius*), brackish water catfish (*Chrysichthys*), snapper (*Lutjanus*), grunts (Pomadasyidae), groupers (*Epinephelus*), and the estuarine white shrimp (*Palaemon*). Bonga dominates the pelagic fishery but there are modest catches of shad (*Ilisha*), sardine (*Sardinella*), various jacks (*Caranx spp*.) and Atlantic bumper (*Chloroscombrus chrysurus*).

Furthermore, Fish fauna of the area was reported by Ibim and Bongilli (2018) from a total catch of 40,509 fish specimens in 24 weeks of study of the Sombrero River. They reported a total 31 species belonging to 26 genera, 20 families and 10 orders. The Carangidae was the highest with four species (*Trachinotus teraia*, *Carangoides malabaricus*, *Alectis indica*, *Caranx hippos*) in four (4) genera and 13 out of the 31species, the Scombridae (*Scomberomorous tritor*), Belonidae (*Tylosurus acus acus*), Cynoglossiidae (*Cynoglosus senegalensis*), Paralichthyidae (*Syacium guineensis),* Dasyatidae *(Dasyatis margarita),* Elopidae *(Elops lacerta),* Synodontidae *(Saurida caribbaea*), Clupeidae (*Sardinella maderensis*), Pristigasteridae (*Ilisha africana*), lophidae *(Lophius vaitlanti),* Drepaneidae *(Drepane longimana),* Monodactylidae *(Monodactylus sebae),* Sphyraenidae *(Sphyraena guachandro*), all had a single species from one genera. A combination of fishes reported by these in this area is shown in Table: 4.14.

Table 4.14: Study Area Common Fish Species of Commercial Importance

S/N	Family	Scientific name	Common name
1	Lutjanidae	*Lutjanus agennes* *Lutjanus gorensis*	African red snapper Gorean snapper
2	Rajidae	*Raja miraletus*	Skates
3	Dasyatidae	*Dasyatis pastinaca*	Stingray
4	Pristigasteridae	*Ilisha africana*	West African Ilisha
5	Lophidae	*Lophius vaitlanti*	Shortspine African angler
6	Sciaenidae	*Pseudotolithus (F.) elongatus* *Pseudotolithus (Pinnacorvina) epipercus* *Pseudolithus senegalensis* *Pseudolithus (P.) typus* *Pteroscion peli*	Bobo croaker Guinea croaker Cassava croaker Longneck croaker Boe drum
7	Elopidae	*Elops lacerta*	Ten pounder

S/ N	Family	Scientific name	Common name
8	Belonidae	*Tylosurus acus acus*	Needle fish
9	Cichlidae	*Sarotherodon melanotheron* *Oreochromis mossambicus* *Coptodon zillii*	Tilapia
10	Monodactylidae	*Monodactylus sebae*	Moon fish
11	Drepaneidae	*Drepane longimana*	Concertina fish
12	Scombridae	*Scomberomorous tritor*	Scomberomorous
13	Mugilidae	*Liza falcipinnis* *Mugil cephalus*	Sickle-fin mullet Flathead grey mullet
14	Ariidae	*Arius heudeloti* *Arius latiscutatus*	Sea catfish
15	Bagridae.	*Chrysichthys nigrodigitatus*	Bagrid catfish.
16	Pomadasyidae	*Brachydeuterus auritus* *Parapristipoma octolineatum* *Pomadasys jubelini*	Bigeye grunt African striped grunt Sompat grunt
17	Polynemidae	*Galoides decadactylus* *Pentanemus quinquarius* *Polydactylus quadrifilis*	Smaller African threadfin Royal threadfin Giant African threadfin
18	Carangidae	*Caranx spp.* *Trachurus trachurus* *Chloroscombrus chrysurus*	Jacks Atlantic horse mackerel Atlantic bumper
19	Clupeidae	*Ethmalosa fimbriata* *Sardinella maderensis*	Bonga shad Madeiran sardine
20	Cynoglossidae	*Cynoglossus browni* *Cynoglossus canarensis* *Cynoglossus monodi* *Cynoglossus senegalensis*	Nigerian tonguesole Canary tongue Guinea tonguesole Senegalese tonguesole
21	Serranidae	*Epinephelus aeneus* *Epinephelus alexandrinus* *Epinephelus caninus* *Epinephelus guaza (= E. gigas)*	White grouper Golden grouper Dogtooth grouper Dusky grouper
22	Sparidae	*Boops boops* *Dentex angolensis* *Pagellus bellottii (= P. coupei) Sparus pagrus pagrus*	Bogue seabream Angola seabream Red pandora Common seabream

(Source: Troadec and Garcia, 1980; Ibim and Bongilli, 2018)

Fish Species Landed and Fishermen Involvement

The species composition of the fishermen catches in the area is shown in Table 4.15. The analysis of catches in this study reveals that *Caranx spp* constituted the most dominant fish species landed by the fishermen (Plates 4.2, 4.3 & 4.4). This was followed by *Dentex angolensis and Epinephelus aeneus* of the fishermen catches. *Sepia officinalis* was among the least common fish species hauled by the fishermen. Comparing the number of fishermen hauling particular fish species and the amount of fish landed, the *Caranx spp* was found to be the most hauled fish species by the majority of fishermen.

In addition, the commercial abundance of the species may also have impacted on its value making it an affordable source of protein. This may be associated with the upwelling seasons which result in food abundance for the species (*Caranx spp)* resulting in its abundance. Some fish species such as *Thunnus sp* and *D. margarita* were hauled in low quantities by few fishermen giving the indication of either dwindled stocks or these species are not actively targeted by the fishermen. However, *Dentex* spp. are targeted by relatively high number of fishermen even though the percentage catches are not very high.

Table 4.15: Fish species composition of fishermen catches in the area

S/N	Family/ Species	Common Name	Local conservation status
1	**Balistidae** *Balistes puntactus*	bluespotted triggerfish	C
2	**Carangidae** *Caranx hippos*	crevalle jack	A
3	*Caranx crysos*	blue runner	R
4	*Alectis alexandrinus*	African threadfish	C
5	*Chloroscombrus chrysurus*	Atlantic bumper	A
6	**Clupeidae** *Sardinella aurita*	Round sardinella	A
7	**Pomadasysidae** *Pomadasys jubelini*	Sompat grunt	C
8	**Sparidae** *Dentex canariensis*	Canary dentex	A
9	*Dentex sp*		A
10	**Sphyreanidae** *Sphyreana barracuda*	Barracuda	C
11	**Drepanidae** *Drepane africana*	African sickle fish	C
12	**Cynoglossidae** *Cynoglossus senegalensis*	sole	R
13	**Elopiidae** *Elops lacerta*	West African ladyfish	C

S/N	Family/ Species	Common Name	Local conservation status
14	**Ephippididae** *Chaetodipterus goorensis*	African spadefish	C
15	**Scieanidae** *Pseudotolithus elongatus*	Bobo croaker	C
16	*Pseudotolithus senegalensis*	Cassava croaker	C
17	*Umbrina canariensis*	Canary drum	C
18	**Scombridae** *Scomberomorus tritor*	West African Spanish mackerel	C
19	*Thunnus sp*	Tuna	R
20	**Serranidae** *Epinephelus aeneus*	White grouper	C
21	**Sepiidae** *Sepia officinalis*	Common cuttlefish	R
22	**Portunidae** *Portunus validus*	Smooth crab	C

NB: A =abundance, C = common, R =Rare

Plate 4.2: species composition of catches from small-scale fishery in the project area

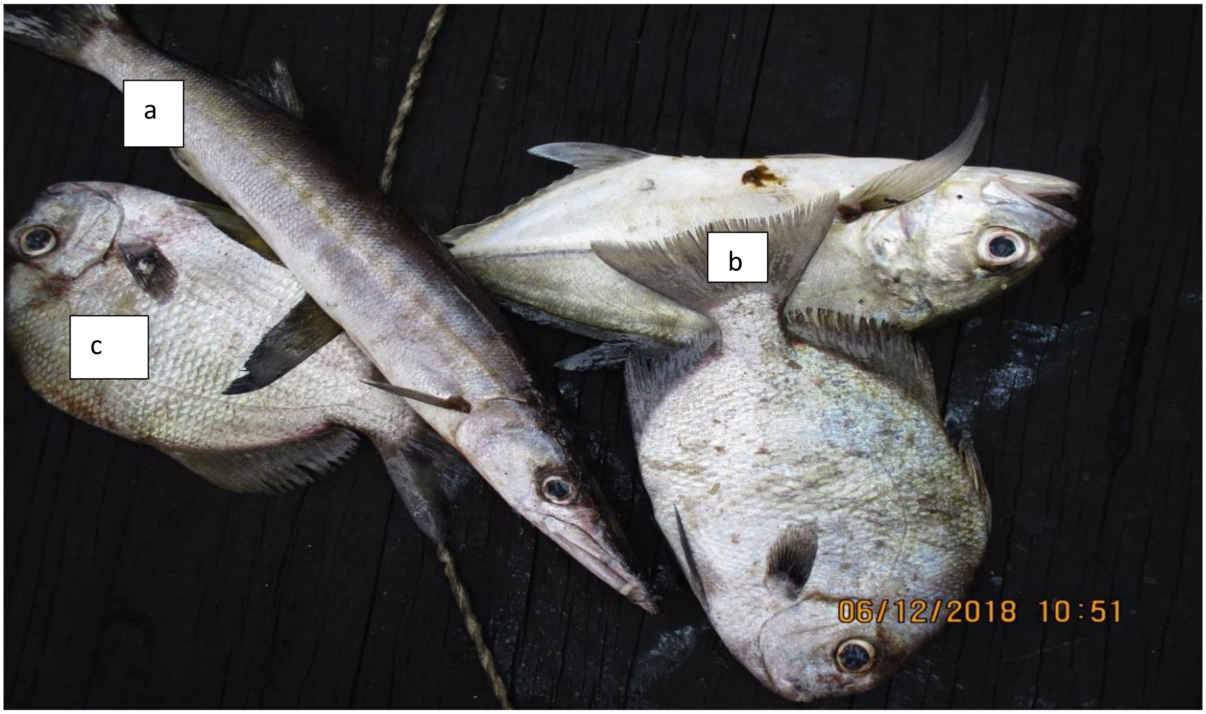


Plate4.3: *Sphyreana barracuda* (a), *Caranx* sp (b)and *Chaetodipterus goreensis* **(c)** caught around the project area

Plate 4.4: Some of the fishes caught by the small-scale fishermen around the project area

Apart from the small-scale fisheries solely depend upon by the local for food and profit, industrial fishing also occurs in the project area (Plate 4.5). The trawlers operate day and night but recently they have to operate with caution due to pirate attacks. The Fishing Trawlers Owners Association of Nigeria listed some of the challenges facing the industry to include inconsistent government policies, and the porosity of Nigerian waterways. The biggest challenge facing the fish trawling industry in Nigeria is pirate activities and armed robbery at sea. Piracy has become a menace on Nigerian waterways posing a major challenge for every maritime related business in the country. It is sad that whilst maritime business in the country is experiencing a decline, piracy and armed robbery are gaining more grounds. What is now obvious is the inability of the current security strategy to protect Nigerian investors that conduct business on the sea. This calls for an urgent review of our waterways security strategy in the interest of the nation. The local benefit from this sector by buying mixed fishes and bycatch from the for sale and their local markets.

The industrial fishery also causes problems to the small-scale fisheries by destroying their nets, this has caused some conflict among them (Small scale and industrial). Legally, the “Sea Fisheries (Fishing) Regulations and the “Sea Fisheries (Licensing) Regulations” are the two laws that seek to regulate the fishing and trawling business in Nigeria. The Sea Fisheries (Licensing) Regulations forbids any unlicensed vessel from trawling on Nigerian waters. However, contrary to the dictates of this law, observers have suggested that some strange, foreign, and unlicensed ships come into the country’s waters to trawl without any form of questioning from relevant authorities, which presupposes a connivance of some sort at the expense of local operators. The current situation demands intervention of the government. The private sector in any industry cannot deliver to its fullest without an enabling environment, which is the responsibility of the government.

Plate 4.5: Fishing trawler operating around the project area

Fish preservation in marine fisheries

The small-scale fishery in the area has adopted a technique to preserve their fishes from deteriorating for two to three days by using improvised cold room constructed from plywood and stainless steel filled with iceblocks (Plate 4.6). This has prolonged the shelf life of their catches for two to three days.

Plate 4.6: Fishes preserved in an improvised cold room by fishers around the project area

The fishes in the area were said to have increased over the years compared to like 20 years ago in terms of number. This may be as a result of the length of nets used now and the distance the fishermen covered. Despite this, some species of fish have been identified as scare or not available. These are *Lutjanus goorensis*, guitar ray, ray fish, giant *Tarpon atlanticus*, sea tortoise, *Pristis sp* (sawfish) and *Torpedo torpedo*. The scarcity of these species may be as a result of the pressure on the fishes and increased number of fishermen.

Fish Migration

Migratory fish require different environments for the main phases of their life cycle which are reproduction, production of juveniles, growth and sexual maturation. The life cycle of diadromous species takes place partly in fresh water and partly in sea water: the reproduction of anadromous species takes place in freshwater, whereas catadromous species migrate to the sea for breeding purposes and back to freshwater for trophic purposes. The migration of potamodromous species, whose entire life cycle is completed within the inland waters of a river system. Fish migration is a phenomenon associated with reproduction, or food availability. Some of the exploited fish species, e.g., bonga, croakers, sardinella, snappers, threadfins, pink shrimp and barracuda, make seasonal migrations from the sea into the creeks and back to sea (OML 77 & 74 Baseline Study, 2018), mainly for reproduction. Such migrations are likely to influence movement of fishing units along the coast. The migration of these species can influence migration of fisher folks in the they may be more concentrated in a at a particular time of the year than the other area which will affect the catches. Besides, the onshore/offshore and lateral migrations mean that several stocks are harvested by both artisanal and industrial fleets. However, by the nature of the project, fish migration is not affected by the project because the diversity recorded has not been seriously affected. Although, fisher folks in the area noted that fishes in the area have drastically reduced due to interest and pollution that has rampage the area in recent times. In addition to these people also assumed that they are not secured fishing in the area due to security tension in the area this has limited fishing activities to the open waters where they can still be sure of safe operation.

Fish Breeding

Fish breeding in the entire area is very likely as varying sizes of fishes are caught by fishers in this area and the shore line is not in any way tampered or affected by the project. Adult fish that are ready for breeding are known to swim to shore areas or shallow parts of the river where they can lay their eggs and care for their young. These areas are also expected to be rich with enough micro food organisms for their young and fewer predators as well as disturbance. Such areas are mainly creeks and rivulets.

4.8: Marine Biodiversity

Aquatic biodiversity contributes a wide range of ecosystem services. However, they are the most vulnerable to pollution because of anthropogenic activities and infrastructure development that are further challenged by climate change impacts. The proposed project is one of the mega off shore oil developmental projects in the area in recent times, which is planned for geophysical data acquisition in 2019. This report provides a baseline assessment of mammalian, avian and reptilian taxa survey for the project. Fishery report is covered elsewhere in the report. However, results of the scoping workshop conducted on November 2019 in Akassa revealed predicted impacts on marine lives, making baseline study of aquatic biodiversity imperative.

Results presented for each species include species sighted/indirectly censored, species abundance, coordinates where sighted, depth where sighted, behavioural activity when sighted, time/tidal regime when sighted, species indigenous uses, and the analysed water physicochemical parameters at the sighted depth. The result for the sighted turtle species also included delineation and conditions of nesting sites and nesting sites oil physicochemical parameters. Parameters reviewed for each species are IUCN status, national protected status and reserve location, breeding seasons, feeding patterns, type of predator threats, migrant/non-migrant classification and raptors (avian fauna only). The report on each species also presented interviews with the locals and Akassa Development Foundation (ADF) on the local names of directly/indirectly censored species, regularity of species/egg catch/sighting and species poaching/consumption. Also, soil samples for physico chemical analyses were collected on established and potential turtle nesting sites.

Three mammalian, two reptilian and 23 avifauna species were sighted during this study. On the other hand, two mammalian and three reptilian Taxon were censored via indirect evidences.

4.8.1: Reptilia Species Study

The species sighted were *Chelonia mydas* (Green turtle) and *Dermochelys coriacea* (Leatherback sea turtle) both in the order Testudines. On the other hand, *Crocodylus niloticus* (Nile crocodile) *Caretta caretta* (Loggerhead sea turtle) were censored via various indirect evidences and are in the reptilian orders Croccodylia (*Crocodylus niloticus) and* Testudines *(Lepidochelys olivacea* and Caretta *caretta*).

4.8.1.1 *Chelonia mydas* (Green Turtle)

Species Frequency of *Chelonia mydas*

This species was sighted in four locations (4.337895/5.982486; 4.341395/ 5.944029; 4.297461/6.021926 and 4.288614/6.055960). These sites are located about 45.3m, 47m, 80m and 30m nautical miles from Sangana, Fishtown, Okumbiri and Okumbiribeleu communities respectively. Figure 4.15 is a geo-reference map of the location sites of this species.

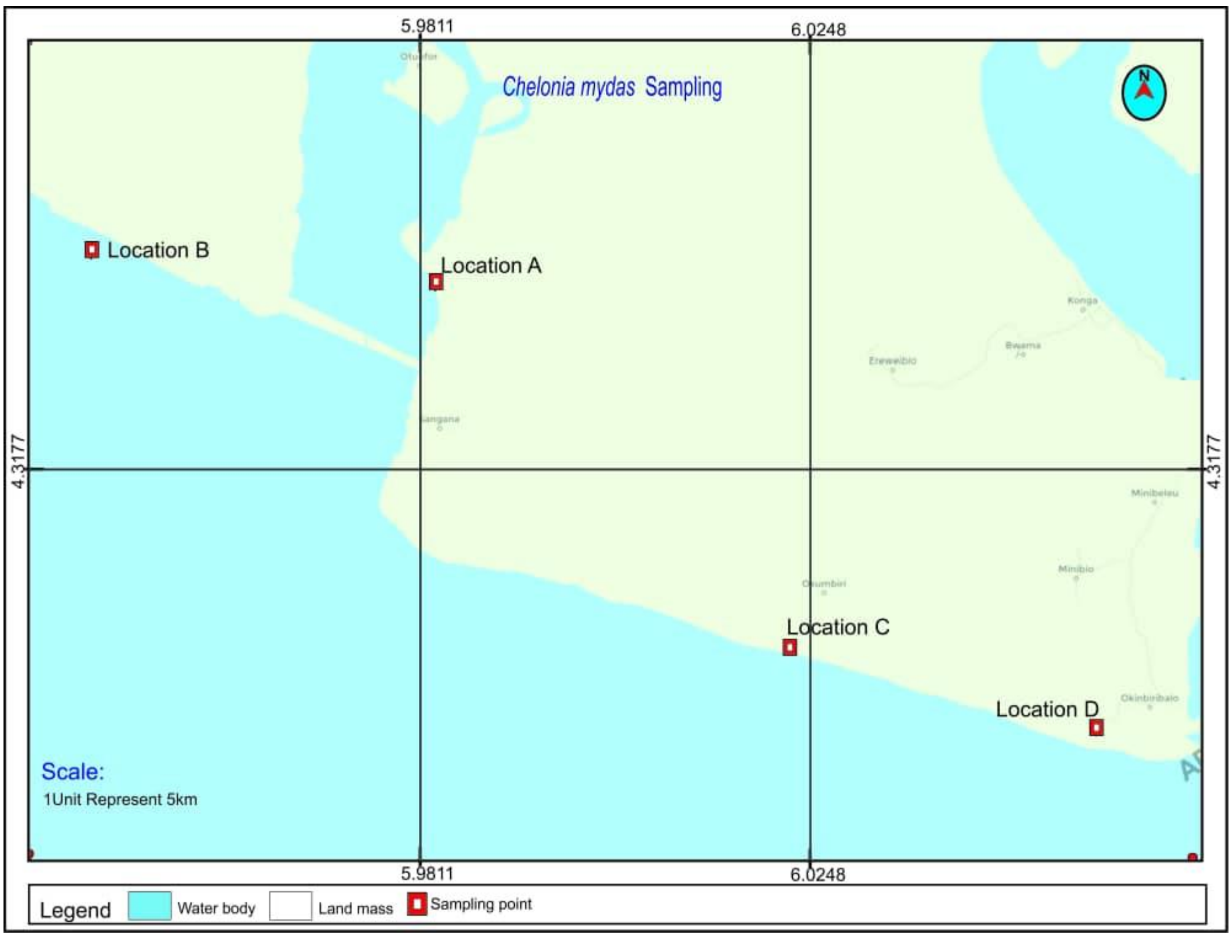


Figure 4.15: Locations of sighted *Chelonia mydas*

The occurrence of these species has severally been reported as shown by Abayomi, (2017), Oyeronke (2013), Akani and Luiselli (2009) and AGIP (2014).

Species Abundance of Chelonia mydas

A total of 21 individuals of this species were sighted, five were captured and returned into the wild while 2 injured was administered with first aid treatment before been returned to the wild. Carcasses of seven individuals consumed by the people were also observed and documented during field activities. The location of the sighted individuals revealed that seven individuals were sighted in location C, five each were sighted in locations A and D, while four individuals were sighted in location B. Plate 4.7 shows some of the sighted sea turtles.

a. C. mydas retrieved from fishermen by the study team in Sangana

b. Caught individual in Fish Town been returned to the Wild

Plate 4.7: Imagery of *Chelonia mydas* (a & b)

Sex of Chelonia mydas

A clear gender distinction was observed in this species. Four sexual dimorphic characters were used either in isolation or in combination for gender identification among the adult populations of C. *mydas*. These are lengths of carapace, claw, tail and position of cloacal opening (Kaska *et al.*, 1998; Broderick *et al*.,2000). Sexual dimorphism is non-existent among juveniles of this species. However, the occurrence of black- greenish back among the species was used as juvenile identification as described by Bull (1980) and Gomuttapong *et al*. (2013). There were four males, seven females, three juveniles among the sighted populations. The gender of seven individuals could not be determined due to the sizes and other environmental factors like temperature. In most species, gender is determined during fertilization. However, the sex of most turtles, is determined after fertilization. The temperature of the developing eggs is what decides whether the offspring will be male or female. This is called temperature-dependent sex determination, or TSD. Research shows that if a turtle's eggs incubate below 81.86 Fahrenheit, the turtle hatchlings will be male. If the eggs incubate above 87.8° Fahrenheit, however, the hatchlings will be female. Temperatures that fluctuate between the two extremes will produce a mix of male and female baby turtles (NOAA, 2018). Researchers have also noted that the warmer the sand, the higher the ratio of female turtles. As the Earth experiences climate change, increased temperatures could result in skewed and even lethal incubation conditions, which would impact turtle species and other reptiles (NOAA, 2018). The gender of the five individuals caught showed that four were adult females and one was male. The gender of the two injured individuals, found on the shorelines of Fishtown and Sangana were females (Plate 4.8).

Plate 4.8: Freshly Killed *Chelonia mydas* at Fish town (January 20, 2019)

It was observed that the four caught female individuals were found on the shorelines as against the only male that was found along the shallow waters. The purpose of the caught female could be for nesting since no male as observed among those caught on the shoreline while that of the male on shallow waters could be for feeding or escort of the female. The injury could be as a result of predator attack (Spotila 2004) and trawlers movement (Nel, *et al.*, 2013). Personal communication and observation during the field study revealed debris comprising left over and pieces of fishing gears and fallen vegetal matter at the shorelines are potential sources/causes of injury (Plate 4.9 & 4.10).

Plate 4.9: Debris at shorelines

Plate 4.10: a. Interview with the indigenes at Okunbiri b. the consultant and one of the fishermen at Okunbiri

Time/Tidal regime of Sea turtles

All the sighted sea turtles of this species were censored across diurnal and nocturnal hours and across ebbing and flooding regimes. However, the caught and injured individuals were captured at dawn or late in the night and during ebbing episodes. This finding implied that the species often migrate to shallow epilimnion part of the water when anthropogenic influences are at minimal (most likely during night time) and return back to deeper waters and locations further from the continental shelf during day and peak periods of disturbance episodes.

Sighted Depth of Sea turtles

The sea turtles were all sighted at the surface, 1.2m, 3.7m and 4.4m water depth. They were also observed not more than 700 m away from the shorelines. Similar depth range was reported by (Reisser, et al., 2013). This preferred depth range exposes them to human threats and vessel injuries.

Movement Direction of Sea turtles

Movement direction of the sighted individuals was equally evaluated this gave insight on movement pattern of the sea turtles in the area. Interestingly, it was observed that all individuals sighted swims vertically down (to greater depths) during flooding regimes and swims diagonally upward during ebbing episodes. The most plausible suggestions could be avoidance of clastic materials from terrestrial environments during flooding or the feeding gains of upwelling effects and avoidance of predator elements during ebbing regimes since it was observed that marine mammals inventoried in this study operate in opposite fashion to that of these species during each of the tidal sequence of ebbing and flooding.

Behavioral Activity of Sea turtles

Behavioural activities during sighting events were grouped into two, Solitary and social. The solitary events evaluated for are swimming (this includes in the water column and near the sea surface as well as patrolling by males), foraging (mining for bivalves) and cleaning (This includes both self cleaning and symbionts cleaning). When self cleaning, they repetitively rubbed their heads and flippers and carapace (include this part for turtle) against submerged rocks or anchors) and surface basking (Surface- basking were observed up to 1 m beneath the sea surface with the head and flippers lowered) as a resting behaviour. All these behavioural activities including resting at sea surface could not be evaluated due to the 40m depth limitation of the hydroscopic instrument deployed as against the above 40m depth of the water body. Antagonistic interactions (This included female–female and male–male interactions) and reproductive activities (This includes courtship and copulation with and without male attendants) were the two social behaviours evaluated.

The result over five sighting events revealed female-female contest at those sighted off Odioma. Three sighted off Brass town were engaged in swimming, cleaning and foraging respectively. Expression of these behavioural activities is indicative of conducive habitat. although swimming could be suggestive of predator avoidance or presence of unfavourable physico chemical conditions.

Food Habits of Sea turtles

The reviewed food sources of this species are turtles begin their lives as omnivores and food comprises flesh and vegetal diets (Arthur, et al., 2008; Russell, et al., 2011). Juveniles of this species were reviewed as having different diet type from adult populations. Their food include small marine invertebrates and sea serpents moss, Bryozoa, and sea hare eggs (Arthur, et al., 2008; Russell, et al., 2011; Seminoff, 2004; Spotila, 2004). Wetland plants found on salt marshes have been documented as part of their food regimes. Series of published reported several alga species, Caloglossa (red moss), lobster horns, sea lettuce, green seaweed, and crinkle grass. Because they are highly mobile throughout their lives, their food choices are often opportunistic.

(Seminoff, 2004; Spotila, 2004). These food sources have been reported in this water bodies and adjoining ones (Forbes, 1996; Higgins, 2002; Seminoff, 2004; Spotila, 2004; Kadiri, 2006; Tiseer, *et al.*, 2008, Arthur, et al., 2008; Russell, et al., 2011).

Indigenous Uses of Species

In the project area, the species is poached for eggs and as meat. Locals claim the species form a palatable combination with beans soap. This species is also used in tradition medicine and its shell is used to adorn some traditional masquerades. Plate 4.11 showed shell carcasses of consumed populations. The local name for this species is Obo

Plate 4.11: Carcasses of Consumed populations

Predation of the Sea turtles

Green turtle hatchlings are at a higher risk of predation than adult green sea turtles. Eggs are preyed upon by multiple land mammals, reptiles, and crustaceans (Kennedy, 2019). Young green sea turtles also are consumed by crabs (Brachyura) which can attack them both on land and in the water. The huge nesting sites around the ox bow lake (Plate 4.12) typed water bodies is perhaps an adaptive protective mechanism. However, the hatchlings face other predatory threats in the water. Large mammals, reptiles and humans are the main threat in the water bodies. Attacks from trawlers and oil exploration vessels have also been documented (Kennedy, 2017; Gardner, 1998). Green turtles are also hunted by humans for meat.

4.2702824/6.0870248

4.2737164/6.0848165

Plate 4.12: Nesting site similar to Ox Bow Lake

Conservation Status

Green turtles are categorized as Endangered (EN) species according to the IUCN Red List. The Convention on International Trade in Endangered Species classifies green sea turtles under I which include species that are most endangered and most at risk of extinction. This specifically explains that trade of this species is prohibited unless the species is being used for research. Exceptions to this prohibition are only valid under approval of import and export permits (IUCN, 2015). In Nigeria, this species is categorized as Endangered. In Akassa, the ADF actions have helped in its conservation, although absence of well-trained personnel, funding and referral centers to treat injured populations are impediments.

Ecosystem Roles

Juvenile green turtles are predators of sea serpents (Hydrozoa), moss animals (Bryozoa), sea hare eggs (Aplysia) and small jellyfish (Medusoza). Mature green turtles are mostly herbivorous and consume large quantities of sea grass and algae. Green turtles play a role in their ecosystem by facilitating nutrient turnover and sea grass regrowth (Aguirre, *et al.* 1998). As the turtles graze on sea grass, they provide nitrogen-rich fertilizer in the form of faecal matter. Green sea turtles suffer from parasitic trematode eggs known as flukes (Aragones, et al., 2006). These trematodes cause inflamed cardiovascular tissue that infect turtles and commonly result in death (Raidal *et al.*, 1998). Species of flukes that are found in green turtles include: *Learedius leardei, Carettacola hawaiiensis, Hapalotrema dorsopora,* and *Hapalotrema postorchis* (Raidal *et al.*, 1998).

4.8.1.2: *Dermochelys coriacea* (Leatherback Sea Turtle)

Sighted Location

This species was sighted in two locations with coordinate 4.329314, 5.980700 and 4.2808182, 6.084047 also about 35 m and 25 m from Sangana and Oginibiri communities respectively. Figure 4.16 is a geo referenced map providing sighting details.

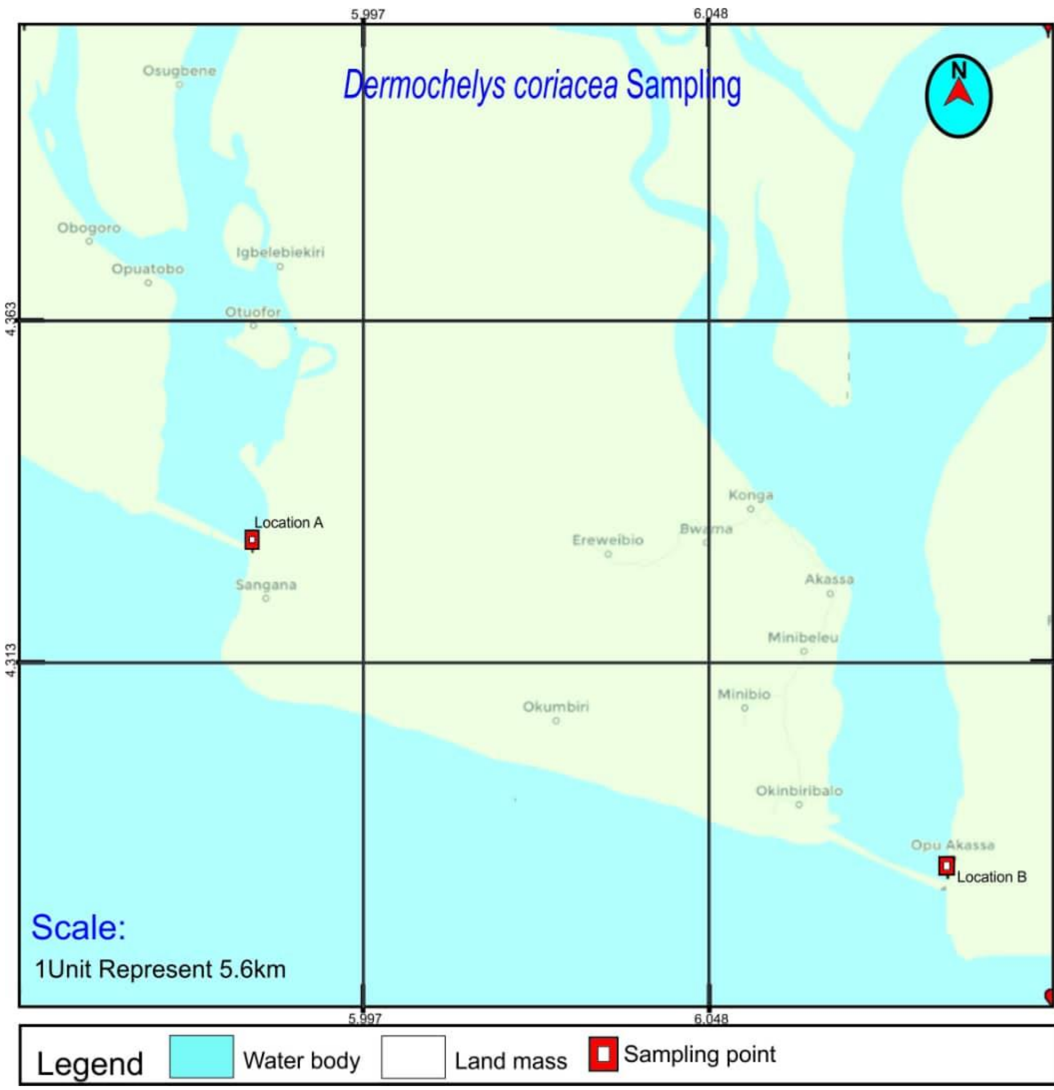


Figure 4.16: Location of sighted *Dermochelys coriacea*

Species Abundance

A total of 3 individuals of this species were sighted during field activities. Two individuals were sighted in location B while one individual was sighted in location A. The individuals were inventoried at location B were sighted swimming will that in location A was found on the shores. All three individuals inventoried were adults. The presence of this species was reported by Abayomi (2017), Oyeronke (2013), and Akani and Luiselli (2009). Plate 4.13 a and b are pictorial illustrations of the sighted individuals.

a

b

Plate 4.13: a) Swimming individual at 2.3m b) ADF Marked and recaptured individual

Sex:

A clear gender distinction was observed within individual of these species, especially in adults. The two individuals sighted swimming in location B were of both sexes while the one observed basking in location B was a male. The species exhibited similar sexual dimorphism as that of *Chelonia mydas*.

Time/Tidal regime

All the sighted populations of this species were censored only during diurnal hours across ebbing and flooding regimes. They were specifically inventoried between the hours of 02.00PM - 4.00PM. Two Individuals of this species were inventoried around 2.3m and 7.9m deep (could not be photographed due to depth). Though leatherback turtles are pelagic species, the individuals sighted may have come to the surface for hunt food or for nesting. The proposed project would impact negatively on the species habitat preference of deep offshore.

Movement Direction

Movement direction of the sighted individuals was equally evaluated. Interestingly, it was observed that all individuals sighted swims vertically down (to greater depths) during flooding regimes and swims diagonally upward during flooding episodes. The explanation provided in Chelonia also pertains.

Food Habits

Gelatinous invertebrates, crustaceans and fish, cephalopods, sea urchins, snails and salps are their main food sources (Caut *et al.*, 2006). They compensate for their light sharp-edged jaws for biting soft-bodied prey (Houghton *et al.*, 2006).

Indigenous Uses of Species

The indigenous uses of the species are like that reported for *Chelonian mydas*.

Predation

Humans have been reviewed to be the primary predator of this species, gathering eggs and killing adults (Chiang, 2003). Information from locals revealed that monitor lizards (Varanus) and Killer whales (*Orcinus orca*) also prey upon this species. Many mammals including genets (Genetta), mongooses (Herpestidae) and pigs (Suidae) excavate nests as well (Caut *et al*., 2006). Hatchings of this species are also preyed upon by raptors (Falconiformes) as they try getting to the sea (Ernst *et al.*, 1994).

Conservation Status

The species is categorized as Vulnerable (VU) to the IUCN 2018 version 2 Red List. In Nigeria, it is not listed in the Endangered Species Act 2016. The primary threat to the species is commercial fishing. Turtles are accidentally trapped and drowned in nets and trawls or hooked or tangled by long lines and trap lines (Evans, 2004). Harvesting of eggs is a significant problem as well. Also, leatherbacks apparently sometimes eat plastic debris they find in the water, probably mistaking it for jellyfish (Ernst et al, 1994). This plastic debris is indigestible, and an increasing number of turtles are found dead with blocked digestive tracts.

Ecosystem Roles

This species is a predator of mainly jellyfish and other soft-bodied marine animals (Myers and Hays, 2006). Their effect on prey population densities is unknown but might have been substantial before their populations were reduced by harvesting. Their eggs and hatchlings may be a significant food source for egg predator populations near their nesting beaches (Ernst *et al*., 1994). Leatherbacks are the host of *Conchoderma virgatum,* a commensal species of barnacle (Eckert and Eckert, 1987; Spotila, 2004).

Proposed Management Plan

Delineation and access restriction to identified nesting sites, construction of egg chambers and capacity training for ADF members. The establishment of medicare centres would aid treatment of injured individuals before re introduction to the wild. It should be a component part of the enlarged Aquatic Species Management Plan proposed to be developed prior to seismic operation.

Indirectly Censored Species

The following reptilian species were censored indirectly through various indirect evidences. Locals reported its presence in the area, but no individual of this species was inventoried during the study.

4.8.1.3: *Caretta caretta* (Loggerhead sea turtle)

Parameters reviewed for the species are discussed herein.

Food Habit

They are primarily carnivorous, but will also eat algae - Ascophyllum, Ulothrix, Urospora, Sargassum - and vascular plants - *Cymodocea, Thalassia, Zostera* - making them omnivorous. Their huge heads and massive, powerful jaws make them well-adapted to eating hard-shelled prey, such as horseshoe crabs (Limulus polyphemus), bivalves, barnacles, whelks, and conchs. However, *Caretta caretta* is a dietary generalist and also eats many other invertebrates, such as sponges, jellyfish, cephalopods, shrimp, insects, sea urchins, and fish and fish eggs, including Brecoortia species, Ceratoscopelus species, and Diodon species. There are slight variations in the diet of each life stage, but loggerhead sea turtles are generalists throughout life. ("MarineBio", 2006; Ernst, et al., 1994; Spotila, 2004)

Predation

The main predators of these species are sharks and humans. Hatchlings and eggs have many predators and few defenses. Their major predators include genets (*Genetta*), mongooses (Herpestidae) and pigs (Suidae)

Ecosystem Roles

Caretta caretta is a "keystone species" because of its ecological impact. It feeds on large numbers of invertebrates, affecting their populations and allowing their broken shells to be used as a calcium source for other species. Also, a substantial portion of the eggs laid become food for predators. Finally, over 100 species from 13 phyla may live on the carapace of loggerheads, making it somewhat of a mobile reef. (Spotila, 2004)

Economic Importance for Humans:

Caretta caretta is beneficial to humans in many ways. They are an attraction for ecotourism and popular with people wanting to snorkel or dive with these animals, as well as for those wanting to watch the nesting process. Locally, these species and their eggs are exploited for food. ("MarineBio", 2006; "NOAA Fisheries", 2006; Ernst *et al*., 1994; Spotila, 2004)

Conservation Status

This species is categorized as Vulnerable (VU) according to the IUCN Red List. The greatest causes of decline world-wide is probably incidental capture in fishing gear such as long lines, gill nets, shrimp trawls, and direct exploitation of adult turtles and eggs for human food.

Other important causes of decline include beachfront development, human disturbance of nesting females, pesticides, petroleum products (oil spills), and other ocean pollutants, human-influenced increases in nest predators such as raccoons, collisions with watercraft, and offshore and channel dredging.

4.8.1.4: *Crocodylus niloticus* (Nile crocodile)

Food Habits

This species are opportunistic apex predators; a very aggressive species of crocodile, capable of taking almost any animal within their range (Erkert *et al*, 2005). Their diet was reviewed to consist mostly of mud crabs, turtles, snakes, birds, buffalo, wild boar, and monkeys (Cout *et al*, 2006). They are ambush predators and can wait for hours, days, and even weeks for the suitable moment to attack (Kyalo, 2013).

Indigenous Uses of Species:

In the project area, the species is used in tradition medicine, especially as an antidote for poisons or as an aphrodisiac. Its skin and teeth are also used as ornaments. It is called Opain locally.

Predation

Humans are the only known predators of the species in the project area. However, their eggs are vulnerable to attacks by the Nile monitor (*Veranus niloticus*).

Economic Importance for Humans

The hide of this species is considered very valuable. It is also used locally for traditional medicine.

Conservation Status

The species is categorized as Least Concern (LC) according to the IUCN Red List. It is listed as Absolute Prohibited by the Endangered Species Act of 2016.

Ecosystem Roles

This species is considered a keystone species in several ecological systems. As primary predators, they help maintain ecosystem structure and function as they impact on lower trophic levels and recycle nutrients (Ross 1998).

4.8.1.5: Reptilian Species Habitat Water Physico Chemical Composition

Physico-chemical analysis of the water samples obtained at depths where the reptilian species were sighted was carried out. The result is presented in Table 4.16

Table 4.16: Habitat Water Physico-chemical Characteristics

Parameters	**SW 1**	**SW 2**	**SW 3**	**SW 4**	**Mean of *Chelonia mydas***	**SW 5**	**SW 6**	**Mean of *D. coriarea***	**Brown, 2016**	**WHO Regulatory limit for Aquatic lives (EPA 2001)**
	Chelonia mydas					***D. coriarea***				
pH @ 28.2°C	7.51	7.56	7.62	7.66	7.59	7.67	7.78	7.725	7.4 – 7.8	6.0-9.0
Temperature (0C)	27.2	26.8	24.9	24.5	25.85	25.6	21.9	23.75		>25
Conductivity (mS/cm)	125.6	120.3	100.2.	92.6	112.83	109.5	51.2	80.35		1000
Turbidity (NTU)	13.4	11.8	8.1	6.8	10.03	9.2	4.8	7		5
COD	43.6	39.5	34.5	30.5	37.03	38.5	26.9	32.7		40
BOD	12.8	11.7	8.1	7.9	10.13	8.3	8	8.15		5
DO	3.5	3.9	4.6	5.02	4.26	4.3	6.7	5.5		4
TDS (g/l)	75.2	72.1	60	54.4	65.43	65.6	30.7	48.15	20 -40	
THC (mg/l)	4.03	3.89	3.11	2.98	3.50	3.21	0.7	1.955		5
Nitrate (mg/l)	98.6	81.4	73.2	69.5	80.68	78.3	49.3	63.8		50
Sulphate (mg/l)	245.8	222.1	186.7	174.8	207.35	191.2	89.2	140.2		200
Phosphate (mg/l)	23.6	19.2	18.1	16.2	19.28	18.6	10.8	14.7		0.5
Ammonia (mg/l)	0.69	0.61	0.5	0.5	0.58	0.54	0.2	0.37		0.2
Chromium mg/l)	0.1	0.09	0.08	0.08	0.09	0.08	0.05	0.065		0.05
Manganese (mg/l)	0.09	0.09	0.07	0.08	0.08	0.08	0.02	0.05		0.05
Lead (mg/l)	1.5	1.2	0.91	0.86	1.12	0.93	0.03	0.48		0.05
Zinc (mg/l)	3.39	3.32	3.16	2.76	3.16	3.2	1.52	2.36		3
Copper (mg/)	0.12	0.12	0.1	0.05	0.10	0.11	0.01	0.06		0.05
Total Iron (mg/l)	2.63	2.69	2.48	2.49	2.57	2.5	0.22	1.36		0.2
Nickel (mg/l)	0.036	0.004	ND	0.02	0.02	0.02	0.02	0.02		-
Mercury (mg/l)	0.002	0.002	ND	ND	0.00	0.001	0.001	0.001		0.001
Cadmium (mg/l)	0.01	ND	0.009	0.008	0.01	ND	0.007	0.007		0.005
Arsenic (mg/l)	0.15	0.14	ND	ND	0.15	ND	0.06	0.06		0.05
Aluminium (mg/l)	3.15	3.19	3.08	3.14	3.14	3.13	0. 25	3.13		-
Selenium (mg/l)	0.28	0.23	0.2	ND	0.24	0.21	ND	0.21		0.01
E-coli (cfu/100ml)	3.24×10^4	2.15×10^3	1.45×10^3	1.12×10^3	9.28 x 103	1.62×10^3	0.15×10^3	8.85 x 102		0

Source: Field Survey 2019

Most parameters analyzed in water samples where *Chelonia mydas* were sighted were above regulatory limits. The results obtained from nutrient analyses, turbidity and total dissolved solids were indicative of heavily polluted water bodies. This in turn may have promoted algal and bacterial bloom (Kadiri, 2006, Ezekiel *et al*, 2011) that places huge BOD and COD stress beyond the regulatory limits as reflected in the results, ultimately depleting the dissolved oxygen to near an anoxic condition as shown by the concentration. Aquatic lives are put on stress when DO falls below 4 mg/L (Arimoro *et al* 2014). The slight increase in pH levels of waters also indicative of the presence of significant algal population which might not favour the existence of large aquatic fauna. Similar scenario was reported by (NOSE, 2017). This is because CO_2, a major component of photosynthesis becomes carbonic acid when it dissolves in water, the removal of CO_2 results in a higher pH, and the water becomes more alkaline, or basic.

The turbidity levels recorded were above WHO limits for aquatic lives indicative of massive inputs of organic waste load from the terrestrial environment. The water at these depths also had elevated levels of nutrients (nitrates and phosphates). Turtles have been reported to thriving at highly polluted environments. *(Wyneken et al, 2001)*. The algal metabolic process possibly releases H^+ which could account partly for the moderately alkaline nature of the water bodies. Some of the heavy metals as shown were above regulatory limits. Increase and bioaccumulation of these metals in turtles have been reported to result in low sperm counts, infertile eggs and other health problems in these reptiles *(Davis and Burghardt, 2007)*. The presence of coliform bacteria in these water samples is a confirmation of fecal inputs into the water body.

4.8.1.6: Nesting Sites

A total of eleven established and four potential nesting sites were studied. Table 4.17 below provides details of the coordinates, while Plates 4.14 shows the physical imagery of the delineated sites.

Table 4.17: Delineated Nesting Sites

Name of Community	Coordinates	Elevation (Ft)	Length (m) of shoreline to nesting site
Oginibiri	4.27028/6.08702	5	18.6
Oginibiri	4.27371/6.08481	8	13.6
Oginibiri	4.28019/6.08408	10	23.6
Oginibiri	4.28081/6.08404	8	9.7
Okunbiri	4.28801/6.06388	6	11.6
Okunbiri	4.28819/6.06169	9	17.5
Sangana	4.32932/5.98132	10	14.9
Oginibiri	4.27156/6.10409	9	21.7
Oginibiri	4.27125/6.09466	7	14.8
Near Sangana	4.31038/5.98215	10	18.6
Fish Town	4.34536/5.96445	-4	22.6

Source: Field Survey 2019

Plate 4.14: Pictorial imagery of some nesting sites (a - h)

Some characteristic features of the identified sites include areas relatively devoid of debris and reduced anthropogenic influences such as fishing, movements and motor cycling riding. In areas with these attributes, interviews with ADF team members and field observation also showed a direct relationship of nesting sites to recently exposed soil surface. The PSD of the analysed soils obtained from all the nesting sites ranged between 87% to 96% sandy, (discussion of soil physicochemical sections) giving further credence to nesting in only recently exposed soil surface assertion. Other potential nesting sites candidates were also evaluated and discussed in subsequent section. Soil profiling conducted on the identified nesting sites revealed same elevation with the water bodies or one with slowly increasing elevations.

All identified sites were observed to greater that 10ft above mean sea levels. The relative distance of the shoreline to the farthest identified nesting site is in Diema sea side which was about 22.6m. The area corresponds to only site below mean see levels, absence of debris and higher water energy environment (personal observation). Geo morphological features of an area also influence choice of nesting sites. An area with pockets of water and soil in between similar to ox-bow lake was observed in five locations, two of which were confirmed as nesting sites.

The site shown in Plate 4.8 is reported by the locals to be the most active nesting site. This may not be unconnected with the ease of the hatchlings to be carried into the water bodies. This assertion finds support in Hirth (1971, Carr and Ogren 1960).

4.8.1.7: Nesting Site Soil Physico-chemical

All species of sea turtles exhibit an oviparous reproductive strategy that requires gravid females to return to their natal beaches to lay eggs. While eggs remain buried in the ground during the 45–65-day incubation period, they are exposed to an array of environmental variables that influence the development of eggs and hatchlings (Standora and Spotila (1985), Booth 2006, Burgess et al, 2006). All turtle species censored during the study were either listed vulnerable or endangered on the IUCN Red List of threatened species prompting the conservation and management of suitable nesting sites for these species. Nesting sand physico-chemical parameters were conducted to establish baseline for future management plan. Soil samples collected between 0-60cm (maximum depth of nesting holes) on exposure of surface during ebbing sequence was subjected to physico chemical analysis. The soil profile of yellowish brown was uniform all through. The average physico-chemical parameters obtained for the confirmed and potential nesting sites are as presented in Table 4.18 for comparative evaluation. While detailed physicochemical results is presented in Appendix 4.3.

Table 4.18: Physico-Chemical Properties of Nesting Sites

Parameters	**Mean of Established Nesting Site**	**Mean of Potential Nesting Sites**	**Statistical Difference (P-value at P<0.05)**	**Reviewed Range for Turtle nests**
pH (H_2O) @ 24.8°C	4.74±0.31	4.70±0.04	0.935	5-8*
Temperature (^{0}C)	31.8	30.7	0.16	30-32
Elect. Cond. (mS/cm)	1.78±0.08	1.28±0.05	0.001*	0.3-1.0*
Organic Carbon (g/kg)	3.75±0.20	3.41±0.14	0.066	
Moisture Content (%)	15.6	15.3	0.84	15-18*
Sand	89.29±5.20	90.12±4.01	0.837	≥85%
Silt	6.90±0.27	5.75±0.06	0.014*	≤10%
Clay	3.81±0.05	4.13±0.13	0.039	≤5
TPH (C_8-C_{40})mg/kg))	<0.05	<0.05	-	
THC (mg/kg)	<10.00	<10.00	-	
Total Nitrogen (mg/kg)	2.09±0.18	0.57±0.03	0.004*	
Chloride (mg/kg)	18.89±0.02	15.65±1.56	0.069	3.75-5.46
Extractable Nitrate (mg/kg)	0.48±0.08	0.35±0.07	0.104	
Ext. Sulphate (mg/kg)	1.76±0.04	0.05±0.02	0.000*	
Ext. Phosphate (mg/kg)	13.31±0.61	13.33±0.48	0.972	
Magnesium (mg/kg)	978.00±15.77	522.00±84.15	0.009*	205-363
Potassium (mg/kg)	10,562.00±71.36	9,404.00±451.44	0.044*	
Sodium (mg/kg)	5,738.00±228.48	4,294.00±356.40	0.007*	55-145
Calcium (mg/kg)	3,541.00±93.25	2,690.00±105.67	0.001*	148-353
Total Chromium (mg/kg)	2732.95±434.76	<0.10	-	
Total Iron (mg/kg)	16,950.00±653.83	11,487.00±623.74	0.000*	
Copper (mg/kg)	55.50±5.05	<0.50	-	0.19-0.52
Lead (mg/kg)	4.75±0.19	3.10±0.11	0.001*	1.05-2.34
Nickel (mg/kg)	21.20±1.59	20.15±1.86	0.496	
Arsenic (mg/kg)	7.28±0.34	<0.50	-	
Selenium (mg/kg)	<0.10	<0.10	-	
Molybdenum (mg/kg)	1.25±0.02	0.10±0.00	0.000*	
Zinc (mg/kg)	16.61±0.54	6.75±1.06	0.001*	0.38-0.84
Cadmium (mg/kg)	<0.10	<0.10	-	0.25-0.52
Mercury (mg/kg)	<0.10	<0.10	-	
Barium (mg/kg)	<2.00	<2.00	-	
Aluminum (mg/kg)	37,999.002978.67	33,330.00±1712.66	0.095	
Vanadium (mg/kg)	13.62±0.10	2.86±0.06	0.000	
Manganese (mg/kg)	267.97	262.75±39.63	0.859	

Source: Field Survey 2019

This study establishes novel turtle nesting baseline for physico-chemical parameters in Nigeria. The pHs of all the nesting soils were acidic. This may not be unconnected with the general leaching effect in Niger Delta (Abii and Nwosu, 2009) that renders most soil acidic. The pH values obtained for both nesting grounds conformed with those obtained by Sükran Yalçın-Özdilek 2005, Bouchard 2000 and Canbolat 2004. Also, no statically significant difference was observed for pH values obtained between the established nesting sites and potential nesting sites.
The temperature values obtained from the established and potential nesting sites compared well with results obtained by Drake 2002, Sükran Yalçın-Özdilek 2005, Girondot 2015 and Zoey, 2017. No statistically significant difference was observed for mean temperature values obtained in the established nesting grounds and potential nesting sites.

Temperature have been reported to be the principal temperature that produces both sexes is called the transitional range (TR) and typically only spans 1–4°C (Wibbels, 2003). In ***Dermochelys coriacea***, the TR is 1°C or less (Binckley et al, 1998 Chevalier et al, 1999). Temperature during incubation also influences hatching success (Harley *et al*., 2006). In ***Lepidochelys olivacea***, incubation temperature greater than 35°C result in the death of developing embryos and failure to produce any hatchlings (Valverde et al, 2010).

The moisture content values obtained from the established and potential nesting sites compared well with results obtained by Mcgehee (1990), Ralph *et al,* (2005), and Matsuzawa *et al*., (2002). No statistically significant difference was observed for mean moisture content values obtained in the established nesting grounds (15.6%) and potential nesting sites (15.3%). Moisture content also interacts with temperature to influence hatchling morphology in turtles including the hatching sizes (McGehee 1990) and may also influence the hatchling sex (reviewed by Carthy *et al.* 2003, Wibbels 2003). Godfrey *et al*. (1996) found increased production of male hatchlings in green turtle (*Chelonia mydas*) and leatherback turtle (*Dermochelys coriacea*) nests during April and May, months with the most rainfall in Suriname. High moisture content decreases gas diffusion throughout the nest (Miller *et al*., 2003), which can cause egg death if extreme.

Result obtained for moisture content compared favorably with those reported by Brook, (1989), Crain *et al*., (1995), and Foote, and Sprinkel (1995). Over 90% of the soils in the nesting sites contain sand particles with grain sizes of above 2mm. Salleh et al., (2012) reported that green turtles tend to abort nesting at sites with sands of particle sizes < 1mm. However, large particulate sizes may be preferable in terms of gas exchange between nests and surrounding sand (Mazaris *et al.,* 2008). However, Mortimer (1990) linked the inhibition of green turtle digging and reduction in hatching success to large sand particle sizes. The negative effects large of sand particle size may be caused by high compactness of sand (Chen *et al*, 2017).

Statistically significant difference at P<0.05 was observed between established and potential nesting sites for Electrical conductivity, total Nitrogen content, Exchangeable sulphate, Magnesium, Potassium, Sodium, calcium, Iron, lead, Molybdenum, and Zinc. This amounts to about 31% of the total analyzed parameters. These differences could be due to the variation in topography and parent material of the soil. Other parameters showed no statistically significant difference at P>0.05.

4.8.2: Avifauna Species Study

Species richness

Species richness is the number of different species represented in an ecological community. A total of twenty-five (25) sighted avian species were censored, as evident in Table 4.18. Some of the sighted species include *Nycticorax nycticorax, Casmerodius albus, Phalaropus fulicarius* etc. Plate 4.15 is a representative picture of the avian taxa and Table 4.19 is a summarized avian check list.


a. *Nycticorax nycticorax*


b. *Casmerodius albus*


c. *Phalaropus fulicarius*

Plate 4.15: Representative avian taxa censored

Table 4.19: Summarized check list Bird species and Characters

	Species	Frequency	Abundance	Behaviour	Sex	Flight direction	Altitude
1.	***Botaurus stellaris***	1	1	F		NE	0-50
2.	***Ardea cinerea***	1	1	F		NE	50-75
3.	***Dendrocygna viduata***	2	3	R,F,F	M,F	NE	50-75.50-75,50-75
4.	***Tachybaptus ruficollis***	1	5	F,F,FL,F	F	NE,NE. NE	0-50,50-75. 0-50
5.	***Lissotis melanogaster***	1	2	FL		SE	0-50,50-75
6.	***Ardea goliath***	1	4	R.F,F,FL. F,F	F,F	NE,NW. NE	0-5-,50-75,50-75. 50-75,50-75
7.	***Ardea***	2	2	F.F,F	M	NE. SW	0-50. 50-

	Species	Frequency	Abundance	Behaviour	Sex	Flight direction	Altitude
	cinerea						75,50-75
8.	***Porphyrio porphyria***	1	1	R, R,R	F	SW. NE	50-75. 50-75,50-75
9.	***Podica senegalensis***	1	1	F,FL		SW	50-75,50-75
10.	***Rostratula benghalensis***	1	1	FL		SW	75&ABOVE
11.	***Actophilornis africanus***	1	1	FL		SW	75 & ABOVE
12.	***Microparra capensis***	1	6	F,R. F.F	F,M, M	NE. NE. NE	0-50,0-50. 50-75. O-50
13.	***Anastomus lamelligerus*** •	2	1	F. FL. F,F		NE. SW	0-50. 50-75. 0-5-,0-5-
14.	***Scopus umbretta***	2	6	R. F		NE. SW	0-50. 0-50
15.	***Anas crecca***	1	4	FL. FL. R		NE. SW	50-75. 50-75
16. s	*Nycticorax nycticorax*	3	2	F. R. R		NE, NE	0-50. 50-75, 50-75
17.	*Bubulcus ibis*	2	3	FL. R		SW. NE	50-75. 0-50
18.	*Casmerodius albus*	3	3	R,R,F,FL. FL.FL. FL	M,M	NE,NE. NE	0-50,0-50,50-75. 0-50
19.	*Calidris alba*	1	2	R,R		SW	50-75,50-75
20.	*Sterna caspia*	2	7	R,FL. RF. FL,R	M	NE.NE NE,NE	0-50,50-75,50-75. 0-50. 50-75,0-50
21.	*Ardenna grisea*	1	3	F,F,FL. F,F,F		NE. SW	0-50,50-75. 0-50. 0-50,0-50
22.	*Hydrobates leucorhous*	1	6	R,R	M	NE,SW. SW,NE	50-75,50-75
23.	*Phalaropus fulicarius*	2	4	R. R,R,FL		NE. NE	0-50,50-75. 50-75,50-75
24.	*Stercorarius longicaudus*	1	4	FL. FL. FL	F	NE. NE	50-75. 50-75,50-75
25.	*Stercorarius pomarinus*	1	4	F. F		NE	50-75

Source: Field Survey 2019

Species Abundance of Birds

A total of 77 individuals were censored across the counting and observation stations. The findings revealed that *Nycticorax nycticorax, Casmerodius albus, and Phalaropus fulicarius* accounted for about 40% the total counts.

Species Frequency of Birds

Bird species frequency was also evaluated. *Nycticorax nycticorax, Casmerodius albus, Dendrocygna viduata, Ardea cinerea, Anastomus lamelligerus, Scopus umbretta, Bubulcus ibis, Hydroprogne caspia, Phalaropus fulicarius* were more frequent. Noteworthy is the presence of these species in at least two different habitats making them highly adaptable to wider food source as food availability in habitat varies. Those observed in only one habitat are highly specific and enjoy territorial dominance. However, they encounter declining population and range when their habitat is challenged with threats such as climate change and other weather-related issues. Climate has played a key role in shaping the life histories of species (Parmesan 2006). Rapid human-induced climate changes, such as those experienced today, and the effects this will have on the evolution and ecology of wildlife species are not well understood (Parmesan 2006, Dawson *et al.* 2011). Migratory animals, for example, are highly mobile, which could make them more resilient to climate change if they are able to shift their ranges or their phenology to track suitable climate. In fact, long-distance migration may have evolved in response to prehistoric climate change (Louchart 2008). On the other hand, migrants may be more vulnerable because their annual climatic and ecological requirements are complex and span vast distances. They are exposed to a wide range of climatic conditions, and climate changes at migratory, winter, or summer locations could influence survival, reproductive success, or ecological cues used to optimize migratory timing (Studds and Marra 2007, Gienapp *et al.* 2012, Cohen *et al.* 2015).

Bird Behaviour

Three behavioural tendencies were evaluated at the time of censoring. They were feeding, resting and flight. A total of twenty individuals were observed in flight while 23 were observed resting. Thirty-two individuals were observed feeding. In terms of habitats, nine individuals each were observed during feeding and on flight as against 11 resting. *Botaurus stellaris, Ardea cinerea and Stercorarius pomarinus* were always observed feeding, *Porphyrio porphyria, Calidris alba and Hydrobates leucorhous* were observed always resting. *Lissotis melanogaster, Rostratula benghalensis and Actophilornis africanus* on the other hand was always on flight. De bushing would adversely impact these species observed as resting always.

Flight direction

Flight direction was equally observed and evaluated. The birds were observed flying in three main directions. Ten individuals were observed flying in the NE direction as against one flying in the North westerly direction. Seven individuals were observed flying in the south westerly direction for which all three individuals of *Podica senegalensis, Rostratula benghalensis* and *Actophilornis africanus* were remarkably seen flying in the south westerly direction only. Nevertheless, there was no observable peculiarity in flight direction among other bird species.

Sex evaluation

The bright colouration of the male was used as discriminatory character. A total of 15 individuals were identified as belonging to any of male or female. Seven were female and eight were male. No defined flocking pattern was observed either among the individuals or among the specific sexes in anyone habitats.

Altitude

Flight altitude was also evaluated. The findings showed that one individual was flying within 0-50m altitude. Significantly, 19 individuals were observed within the 50-75m range. On the other hand, 2 were seen flying above 75m. Other species observed in the 50-75 and above the 75m active while in flight. Conversely, there was no species observed exclusively within the 0-50m range. Species within this altitudinal range seems attracted to feeding and resting. Since species in this range were also observed in the 50-75m range, it is most likely that the height of the trees in the habitat is determining factors. They perch on the trees after long flight duration to rest or when they needed food. A strong correlation coefficient of 0.79 was obtained between altitude and bird behaviour in this study.

Species migration

Some avian species are known to migrate. Avian migration is either regular or irregular (Nomadic interruption or invasions) seasonal movement between north and south. Avian migration is usually driven by food, habitat and changes in weather conditions. These movements are usually between breeding and wintering grounds (veen *et al.*, 2014). In Nigeria as in other countries in the Northern hemisphere, migratory birds commence this movement between February, March and April to warmer areas and return between August, September and October to winter grounds. Migratory movement often results in high mortality and predation. Details are shown below in Table 4.20 and Plate 4.16 are pictures some of the censored migratory species.

Table 4.20: Details of Migratory Species

Species	Local Name	Nesting Grounds	Breeding season	Major threats	Conservation actions (IUCN/Local)
Ardea cinerea		Tree tops and branches	Mid-February –end of May	Habitat loss.	Colony protection
Nycticorax nycticorax		Trees or ground (reed beds)	March - September	Habitat loss	Colony protection
Casmerodius albus	Pinabo	Marshes, ponds, shores, mud flats, trees or shrubs near water	Mid-December - January	Habitat degradation and loss	Colony protection/ control of disturbance and vegetation management
Botaurus stellaris		reedbed edge	March -June	habitat alteration	
Dendrocygna viduata		Round, reed over water,trees	According to location & rainy season	Susceptible to avian botulism, influenza. Human disturbance	Invasive species control or prevention, Subject to ex-situ conservation, In-Place Education Subject to recent education and awareness programmes, Included in international legislation, Subject to any international management/trade controls.
Tachybaptus ruficollis		Shallow water	March -July	transformation of wetlands by destruction, pollution or recreation	Monitoring and protection should be introduced to ensure the destruction of wetland habitats is mitigated and where possible prevented.
Ardea goliath		reeds, bushes, trees or even on rocks or large tree stumps	Rainy season		Action Recovery Plan, Systematic monitoring scheme, Conservation sites identified, occurs in at least one protected area, Invasive species control or prevention,

Species	Local Name	Nesting Grounds	Breeding season	Major threats	Conservation actions (IUCN/Local)
					successfully reintroduced or introduced benignly, Subject to ex-situ conservation, Subject to recent education and awareness programmes, included in international legislation, Subject to any international management / trade controls
Ardea cinerea		Trees, reed-bed, cliffs, bushes	Mid-February _ end of May	habitat alteration, hunting, and predation at nesting colonies, Timber harvesting	Colony protection
Anastomus lamelligerus		Nests are typically built in sedge meadows, grasslands, brush thickets, or in woods near a pond.	Rainy season	The species is threatened by habitat loss, entanglement in fishing lines and environmental pollution, it also suffers from hunting, poaching and the destruction of breeding colonies by villagers	Action Recovery Plan, Systematic monitoring scheme, Invasive species control or prevention, ex-situ conservation, Subject to recent education and awareness programmes, Included in international legislation, Subject to any international management / trade controls
Anas crecca		Nests are typically built in sedge meadows, grasslands, brush thickets, or in woods near a pond.	late-February onwards (peaking March-April)	lowland habitat loss and degradation, upland habitat loss due to afforestation and other land-use changes, disturbance from human recreational activities	Action Recovery Plan, Systematic monitoring scheme, Conservation sites identified Conservation sites identified, Invasive species control or prevention etc.

Species	Local Name	Nesting Grounds	Breeding season	Major threats	Conservation actions (IUCN/Local)
Calidris alba		sandy beaches of inland lakes, prairie potholes, and saline or alkaline flats	mid-July to mid-August	species is threatened by the degradation and loss of wetland habitats through environmental pollution, reduced river flows and human disturbance	Action Recovery Plan, Systematic monitoring scheme, Conservation sites identified Conservation sites identified, Invasive species control or prevention etc.
Sterna caspia		sandy, muddy, or pebbly shores or areas with little vegetation on islands	late May and early June	Biological resource a, intrusions & disturbance	Invasive species control or prevention
Ardenna grisea		Underground	September to November	By-catch in drift nets and gillnets Breeding habitat alteration/degradation (due to human activities or introduced herbivores); Introduced predators in breeding habitat; Mutton birding – hunting of nesting birds, for human consumption.	The species is monitored at some sites and has been extensively studied in parts of its range. Some breeding grounds are protected and have benefited from the eradication of introduced predators.

**IUCN Status of the censored migratory species revealed all as Least Concern (LC)*

a. Ardea cinerea

b. *Anas crecca*

c. *Ardenna grisea*

Plate 4.16: Migratory Species of the study area (a - c)

4.8.2.1: Raptors

A diurnal predatory bird that hunts and feed on rodents, insects and small animals exerts strong biodiversity in fluencies on the ecosystem. In such environments, they act as key stone species by regulating their prey population. Some are known as 'Earth Cleaners; for their role in eating up dead carcasses. Raptors are members of Accipitridae, Pandionidae, Sagittaridae, Falconidae and Cathartidae of Acciptriformes, Apodidae and Falconiformes orders (Fowler *etal*., 2009). In this study, a total of 5 raptor species, belonging to Ardeidae , Podicipedidae , Scolopacidae and Ciconiidae families were sighted. Table 4.21 shows details of raptors sighted in the study area.

Table 4.21: Raptors of the Study Area

S/N	Species	Common Name	Prey
1	***Ardea cinerea***	**Grey herons**	, small fish, amphibians, lizards and insects, frogs
2	*Ardea herodias*	Great blue heron	shrimp, crabs, aquatic insects, rodents, mammals, amphibians, reptiles, and birds
3	*Nycticorax nycticorax*	Night heron	**fish**, crustaceans, frogs, aquatic insects, and small mammals
4	*Casmerodius albus*	Great egret	Fish, amphibians, reptiles, mice, and other small animals.
5	*Botaurus stellaris*	Great Bittern	fish, eels, small snakes, salamanders, insects, frogs, crayfish, and small mammals
6	*Tachybaptus ruficollis*	little grebe	insects, larvae, **fish**, frogs, tadpoles, crustaceans, and molluscs.
7	***Ardea goliath***	**Goliath** heron	frogs, prawns, mammals, lizards, snakes, insects and carrion
8	*Ardea cinerea*	Grey Herons	fish, reptiles, amphibians, crustaceans, molluscs, and aquatic insects.
9	*Anastomus lamelligerus*	African open bill	terrestrial snail, frogs, crabs, fish, worms, and large insects
10	*Calidris alba*	sanderling	Crabs, amphipods, isopods, insects, marine worms, small molluscs; also, may eat some carrion.

Source: Field Survey 2019

Species of Conservation Interest

Analysis for the conservation status of the species censored in the project area was conducted using the IUCN 2018-2 Red List of Threatened species. None of the sighted species censored in the study area were of conservation interest as all were categorised as Least Concern (LC).

4.8.3: Mammals

A total of four mammalian species were inventoried in the study. Three of the species (*Orcinus orca*, *Trichechus senegalensis*, *Stenella longirostris)* were sighted while only one species (*Stenella frontalis)* was inventoried through indirect evidences. *Orcinus orca Stenella longirostris and Stenella frontalis* are in the order Artiodactyla while *Trichechus senegalensis* is in the order Sirenia

***Orcinus orca* (Killer whale)**

Species Frequency

This species was sighted in two locations. The coordinates are N4.318125, E6.236511 and 4.336290/6.427398. The areas are about 521 m and 613 m North East of Brass town and Odioma/Diema town respectively. The location of this species is graphically shown in Figure 4.17. They were observed in flocking in groups.

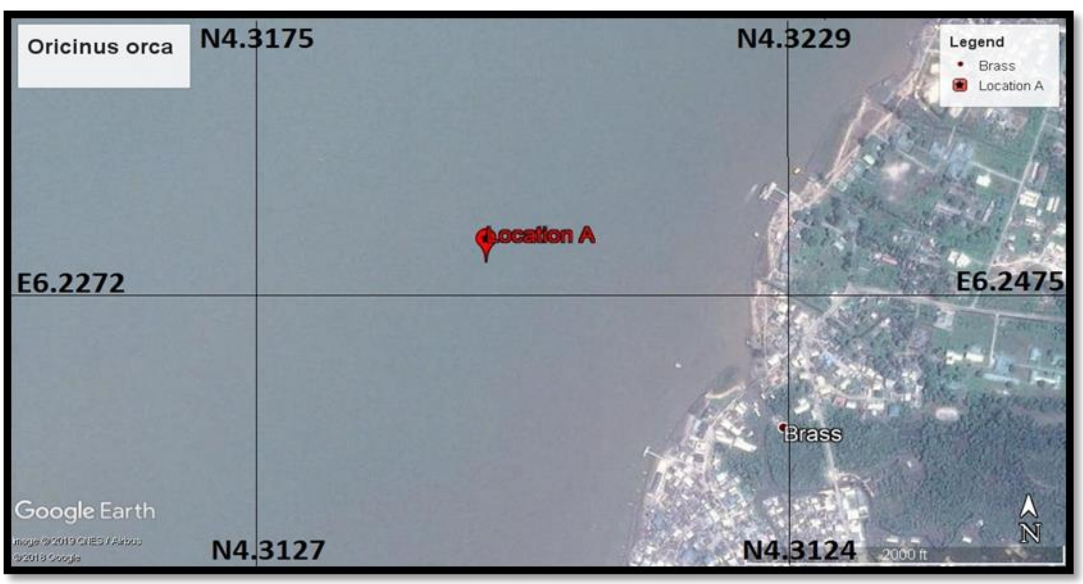


Figure 4.17a: Graphical location of sampling points of *Orcinus orca*

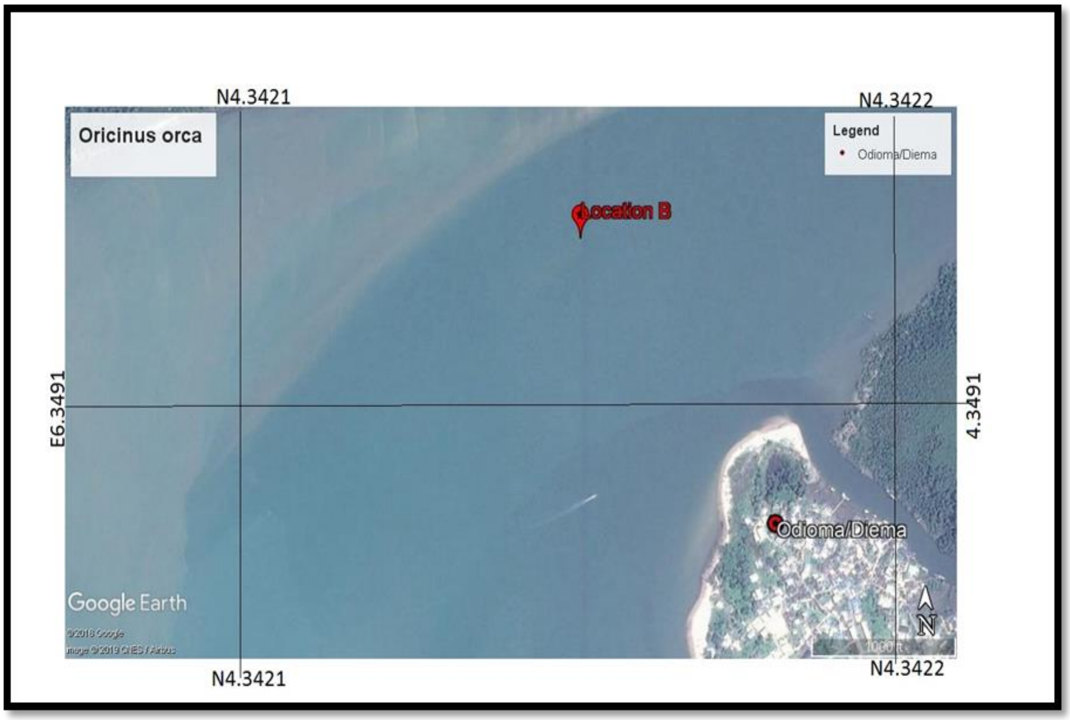


Figure 4.17b: Graphical location of sampling points of *Orcinus orca*

(Wole and Myade, 2014) reported the existence of this species in Akwa Ibom (Weir, 2010) reported the existence of this species in other Nigerian water bodies

Species Abundance

A total of five individuals were sighted with three flocking on N4.336290, E6.427398 and two on 4.318125, 6.236511. Plate 4.17 is a pictorial illustration of photographed sighted individual.

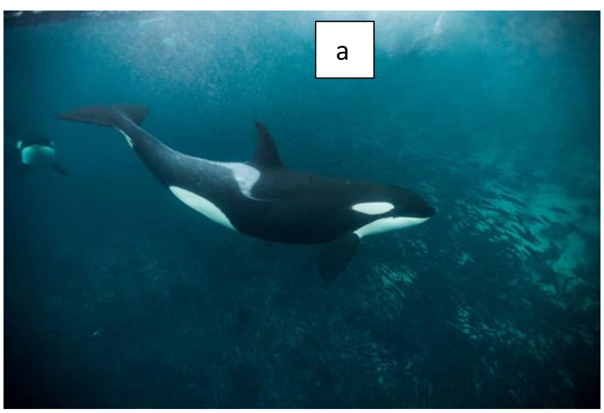


Plate 4.17: Orcinus orca (a &b)

Sighted Depth

The two of killer whale species shown in Plate 3.11 were sighted in same location (about 2 meters apart) around 2.5m water depth at location near Brass and while the three that could not be photographed were sighted at around 28.8m water depth on location near Odioma/Diema.

Sex

The size of the dorsal fins was the sexual dimorphic feature employed to differentiate the genders of the five sighted individuals. The three sighted off Odioma had dorsal fins lengths of approximately 3.7ft, 2.1ft and 1.4 ft respectively, implying same sex most probably female. The two sighted individuals off Brass town had dorsal fins of approximately 2.7ft and 2.4ft respectively. The sizes of the species strongly suggest a male, female and perhaps a juvenile (identified by a grey saddle spot) whose gender could not be determined. Since this species is polygamous in nature (Mann, *et al* 2000), coupled with the relative size of the calf which suggest an independent age, mating could be a plausible reason for the flocking observed.

Time/tidal regime when sighted

The sighted species at 2.5m water depth was observed at around 5.45pm while that observed at about 28.8m water depth was observed at around 11.25 am. Depth preference seems to correlate strongly with light intensity. It is probable that the species visit the epilimnion water layers when light intensity is at minimum and dives to greater and colder depth during higher light intensity. Depth preference also seems to correlate with tidal influences. All individuals of this species were sighted at low tidal regimes. These findings suggest a species preference for calmer and less turbulence water regimes.

Behavioral Activity

Four behavioural activities were evaluated, foraging, travelling, resting and socializing. Killer whales frequently engage in surface behaviour such as breaching (jumping completely out of the water) and tail-slapping. These activities may have a variety of purposes, such as courtship, communication, dislodging parasites, or play. However, all the sighted species were seen travelling which may be in search of mating partners or moving away from unfavourable conditions (Carwardine 2001).

Species indigenous uses

The species is consumed locally as meat and as a source of oil. The species is not hunted in the region.

Food Habits

The reviewed food sources place the species in the top of the food chain haunted only by humans. The species food source comprises of the following octopuses, seals, sea lions, smaller whales and dolphins, fish, sharks, squid, octopi, sea turtles, sea birds, sea otters, river otters, and other animals. Orcas use many different techniques to catch prey. Sometimes they beach themselves to catch seals on land, meaning they jump from the water onto land. Orcas will also work together to catch larger prey or groups of prey such as schools of fish (Bradford, 2014)

Predators

Killer whales have no natural predators, although young killer whales may be attacked by other killer whales or large sharks. They are at the top of the marine food chain. This species is not hunted by locally. However, some fishermen gathered that juveniles of this species have inadvertently been caught occasionally by their fishing gears. A disease that affects killer whales and is often studied is toxoplasmosis (*Toxoplasma gondii*). While this parasite is often benign, it can have serious and fatal effects (Chadwick, 2001; Murata, *et al.*, 2004; Estes, *et al.*, 1998; Heyning and Dahlheim, 1988; Mann, *et al*., 2000)

Migration Pattern

Killer whales are full migrants. Migrations are purposed for food sources and search for breeding grounds (NMFS, 2015). Thus, occur all year round in the proposed project area.

Breeding Season

Killer whales are known to breed all year round. The average fecundity rate per breeding time is one offspring and females are known to breed every 3-10 years.

Conservation Status

The species is categorized as Data Deficient (DD) according to the IUCN Red List of threatened species and hence need be treated as a Threatened taxon In Nigeria; they are not listed in the Endangered Species Act 2016. Review showed that they are numerically abundant (at least tens of thousands of mature individuals) and very widely distributed. Killer whales inhabit all oceans of the world. Next to humans and perhaps the brown rat (***Rattus norvegicus***), killer whales are the most widely distributed mammal (Kachar *et al*., 2018).

Proposed Management Plan

Their preferred deep offshore habitat and day time preference for colder areas interferes with that of the proposed project. A high level standalone *Orcinus orca* management Plan need be developed as a component part of the wider Aquatic Mammal Management Plan before commencement of seismic operations.

***Trichechus senegalensis* (West African Manatee)**

Method of Inventory

This species was sighted in two locations. The coordinates are 4.324991/6.245043 (A) and 4.397702/6.548134 (B). These coordinates are referred to as Brass and kula. This area is about

75 m and 68 m nautical miles North East of Brass and North West of Kula community. The location of this species is graphically shown in Figure 4.18.

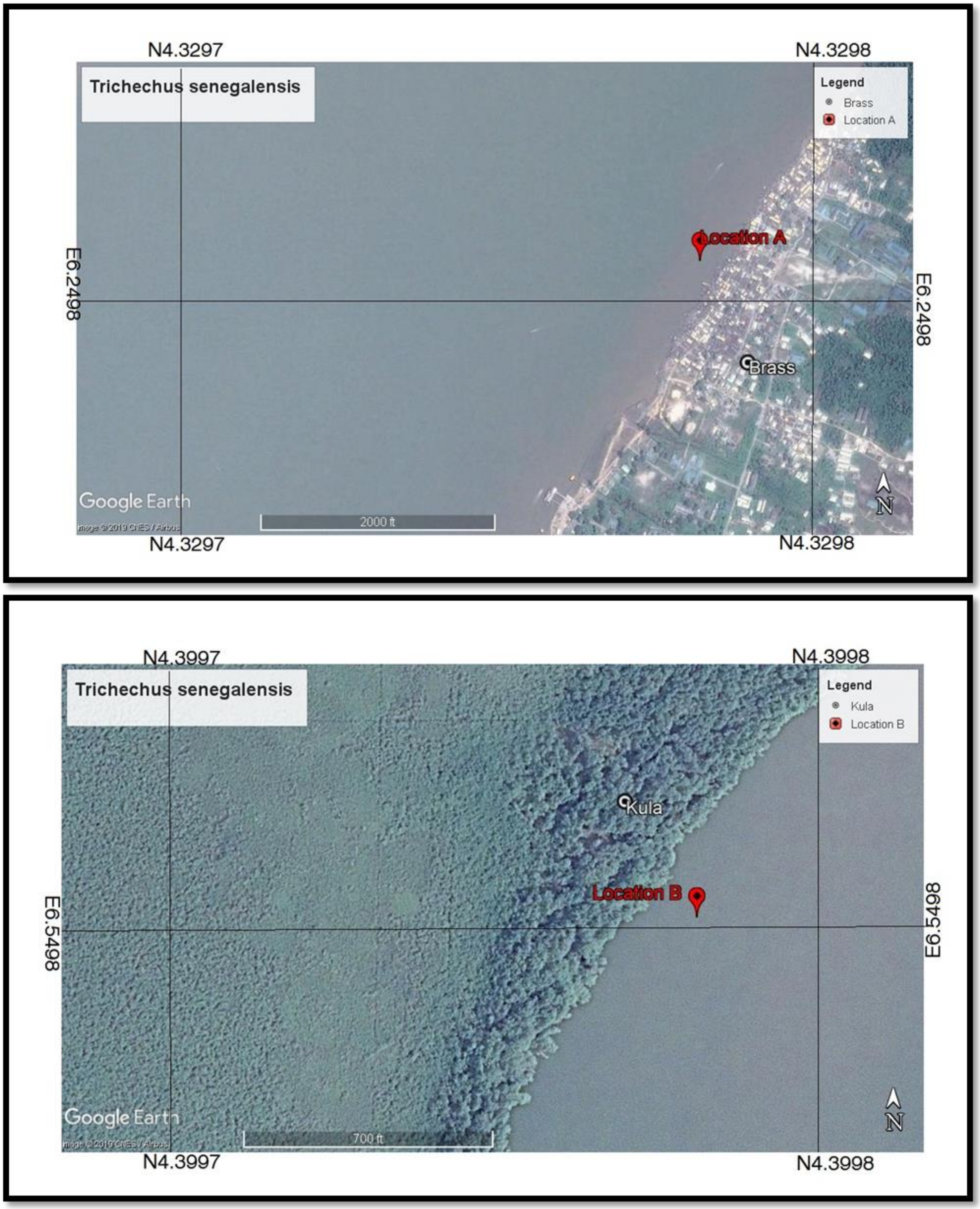


Figure 4.18: Graphical location of Observation Points for *Trichechus senegalensis*

Species Abundance

A total of five individuals were sighted with three found in coordinates A and one in coordinates B.

Depth where sighted

All five individuals of this species were sighted either foraging or swimming near the surface of the ocean. The three individuals sighted in Location A were observed foraging at depths of above 5 m while the individuals sighted swimming in location B was observed in depth of around 8.9m.

Sex

The sexes of these individuals could not be determined during study. This was primarily because all five individuals of the species were observed at about 6.20pm. Also, except for body size which maybe sometimes ambiguous in this case due to the slight differences observed, no distinct sexual dimorphic character was observed. Male West African Manatees are usually slightly smaller than their female counterparts (Nowak 1991). Very little is reported about this species. The West African Manatee is one of the least understood marine mammals in the world, and has recently been shown to be the least studied large mammal in Africa (Trimble and Van Aarde 2010)

Behavioural activity when sighted

The three individuals sighted in location 1 were observed foraging on aquatic vegetations and two self-cleaning. The two individuals sighted in location 2 was observed swimming. The foraging materials were vegetal matters; preferably sea grass and mangrove leaves that were observed close by. (Nico and Taphorn 1994; Buck and Sazima 1995; Yossa and Araujo-Lima 1998; Delariva and Agostinho 2001 and Violante-Huerta, 2017**)** reported algae, invertebrates and other small fishes as symbionts of Manatee. Since the presence of these symbionts has been reported in water bodies around this area, the self-cleaning behaviour may be the removal of these symbionts.

Time/tidal regime when

All five individuals of these species were sighted between 6.-6.20pm. This coincided with peak flooding sequence. Their non-sighting during day time may suggest preference for upper water surface at night and deeper sub surface at day time. Them not been sighted during any of the ebbing sequence could also indicate great distance away from shorelines. This assertion finds support in Littles et *al*., 2018 and Runge *et al*., 2016.

Species indigenous uses

This species is consumed by a few locals as meat. Most of the population complained about its taste, rendering it unpalatable. The species is also used locally as ingredients in traditional medicinal.

Food Habits

The food resources of this species were reviewed. They feed primarily on aquatic vegetation, and adults have been reported to consume up to 8000kg per year (Rathbun 1990). They may also feed on overhanging bank growth (Domning, 1982). This corroborated onsite study of three individuals feeding on vegetal matter.

Breeding Season

This species breeds from March to November producing a calf each breeding season. Shallow lagoons and near shore lines have been reported as birth places (Liadre, 2008) where the young stays for a further five years. The shoreline habitat of the project area is faced with fishing, poaching and other human threats including boat berthing threats.

Conservation Status

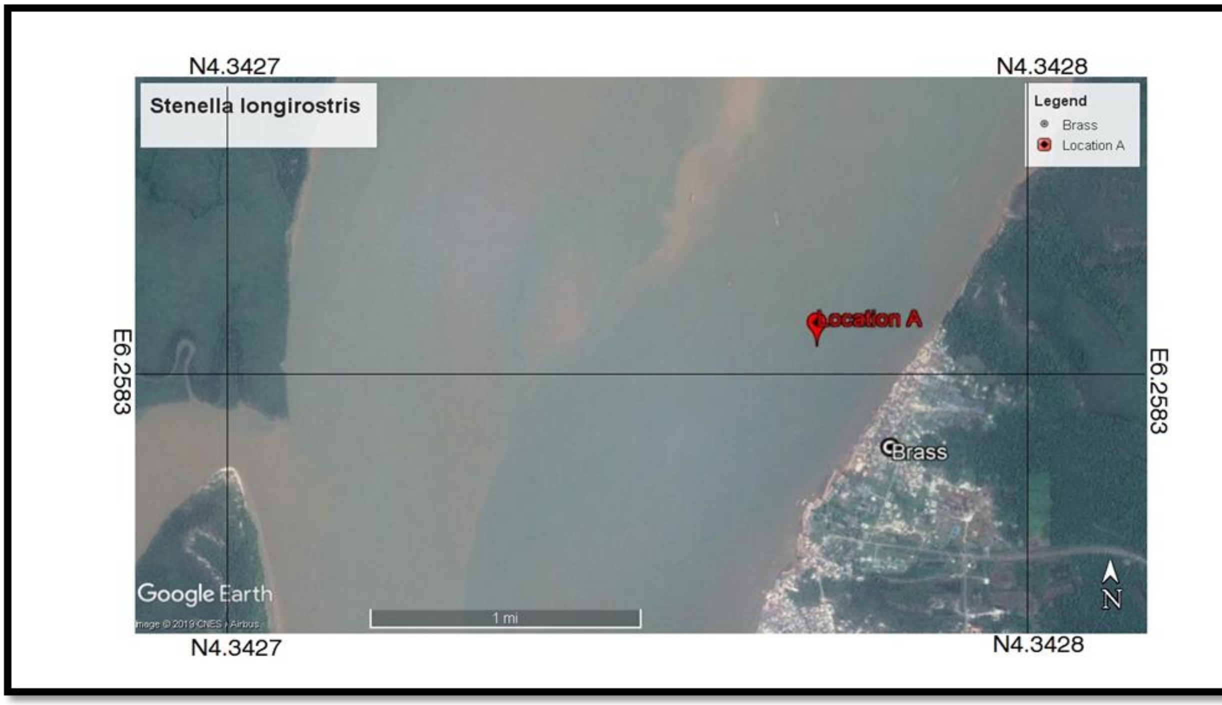
The species is categorized as Vulnerable (VU) according to the IUCN Red List of threatened species. It is listed as Absolute Prohibited in the Endangered Species Act 2016. The Manatee is believed to be depleted throughout Nigeria due to hunting and incidental capture during fishing operations, including the use of explosives in rivers (Powell 1996, Oboto 2002, E. Eniang pers.comm.). It is hunted for its meat, oil and for organs used in traditional medicine (Oboto 2002, Awobamise 2008). A fisherman of Sapele district reported that Manatees of different ages and sizes were found dead and floating after the Jesse petroleum pipeline fire incident (Oboto 2002).

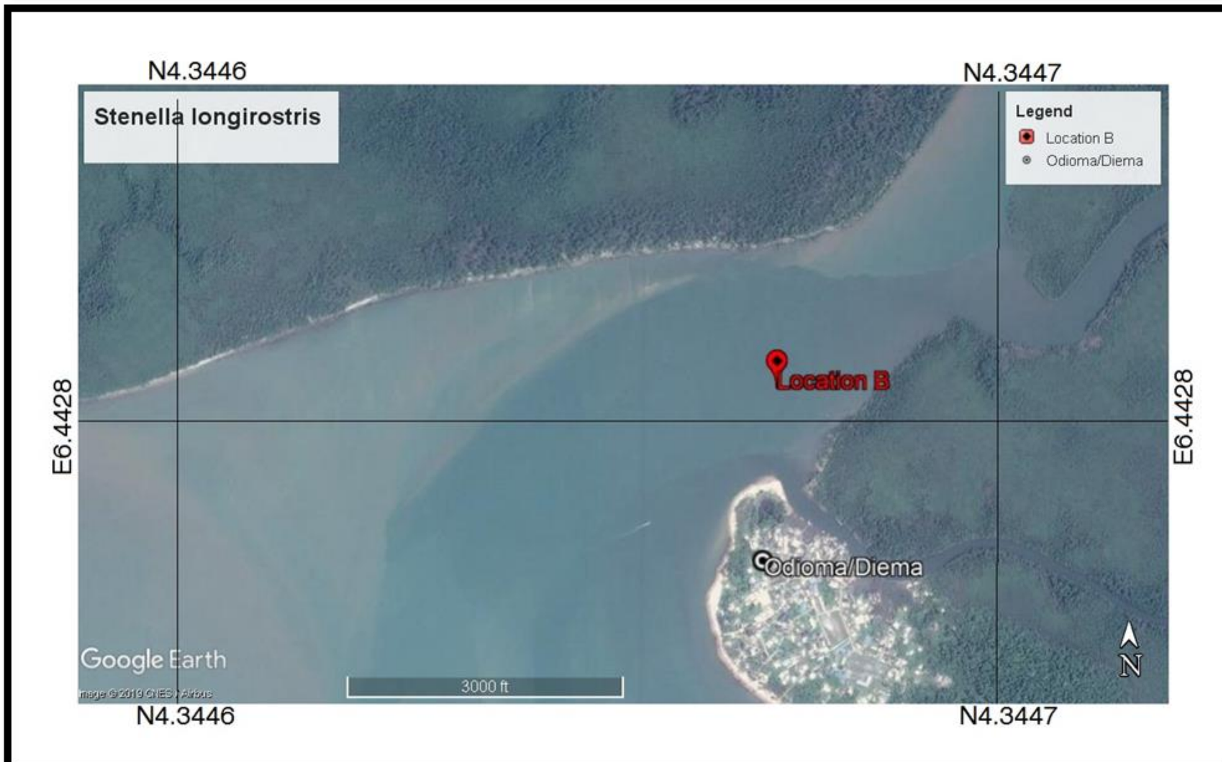
Proposed Management Plan

Restricted movements along the shorelines provided by the coordinates and enlarging the scope of the ADF to include monitoring and advocacy of this species as well. Seismic data acquisition of the proposed SPDC project and subsequent operations to avoid the delineated sensitive areas. Data acquisition during ebbing sequence during day time if possible to be deferred in preference to day time flooding times.

***Stenella longirostris* (Spinner Dolphin)**

This specie was sighted in three locations. The coordinates are 4.328044/6.242177, 4.335723/6.431543 and 4.495707/6.495127. These coordinates are referred to as Brass, Odioma/Diema and Ikensi. This area is about 500m nautical miles North East of Brass community, 230 m North East of Odioma/Diema and 673 m North West of Ikensi Community respectively. The location of this species is graphically shown in Figure 4.19.


N4.3427
N4.3428
Stenella longirostris
Legend
Brass
Location A
E6.2583
E6.2583
Location A
Brass
Google Earth
1 mi
N
N4.3427
N4.3428


N4.3446
N4.3447
Stenella longirostris
Legend
Location B
Odioma/Diema
E6.4428
E6.4428
Location B
Odioma/Diema
Google Earth
3000 ft
N
N4.3446
N4.3447

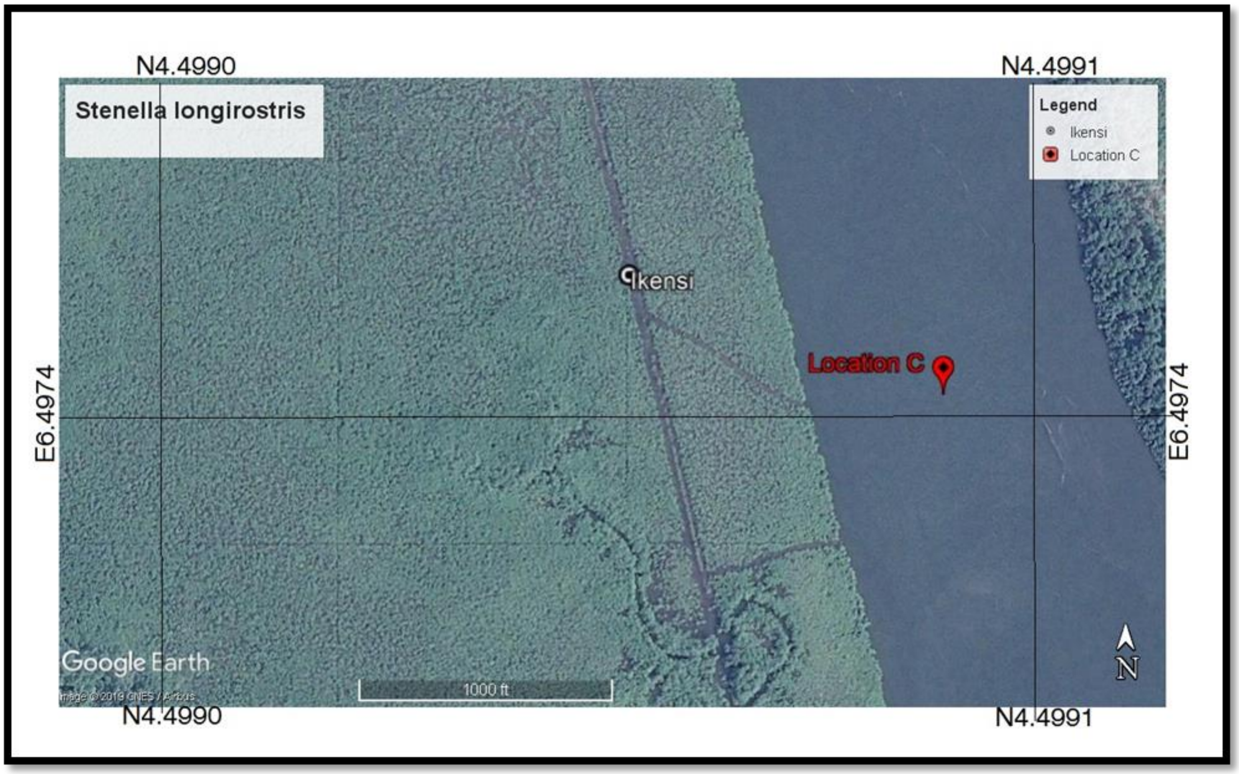


Figure 4.19: Graphical location of Observation points for *Stenella longirostris*

(Uwagbae and Waerebeek, 2010) reported the existence of this species in Brass and Imbikiri

Species Abundance

A total of seven individuals were sighted with three found in coordinates N4.324867, E6.245719, two in c-ordinate N4.334033, E6.433246 and two also in coordinates E4.500011, N6.514792. The individuals were observed to be either swimming or diving.

Depth where sighted

The 4 individuals sighted swimming in Location 1 were observed within 24 m, those observed in location 2 (15m) while those sighted diving in location 3 were observed within depth of about 35 m. These depths are suggestive of preference of shallow water columns with intense sunlight illumination. This shallow water preference at day time would expose the boat passengers to navigational threats. It would also expose the species to injuries from large moving vessels. Sooner this species may be observed on sea surface.

Behavioural activity when sighted

All seven individuals of this species were either sighted swimming or diving (spins, leaps, tail-over-head leaps, backslaps, headslaps, noseouts). These behaviours are good predictors of daily activity patterns, can reveal the activity state of a school, and play, an essential role in communication (Norris and Dohl, 1980; Norris, *et al*., 1994). All 5 individuals censored in

Location A and B were swimming while the two individuals observed in Location C were seen exhibiting diving to deeper depth. None of the individuals were seen foraging. This may not be unconnected by their nocturnal feeding habits (Norris, *et al.*, 1994)

Sex

A clear distinction between both sexes of the species was observed during study. Females have their posterior bodies significantly longer than those of their male counterparts "Spinner Dolphin", (Norris *et al*., 1994; Perrin *et al*., 2007; Perrin, 2009; "Arkive", 2003; Yusuf *et al.*, 2010). Five of the seven individuals sighted were females while 2 were males. The three individuals sighted in location A were all females while those sighted in location B and C had representatives of both sexes.

Time/tidal regime when sighted

All seven individuals of this species were sighted during the day within the periods of 1pm – 03:05 pm. This coincided with flooding regimes. No individual of this species was observed at night just as none was observed during ebbing sequences. This is probably because this species peculiarly visits deeper depth at night in search of food (Norris, *et al*., 1994), thus reducing the possibility of being inventoried during this period. Scott *et al*., 2009 reported the movement of this species to deeper depths periodically, perhaps conforming to ebbing regimes.

Food Habit

This species is reported feeding primarily on a wide variety of mesopelagic fish, which are abundant in the project area (Pauly *et al*., 1995). They also eat squids and some migrating crustaceans to the surface in search of their food (Manuel *et al*., 1997). It has been reported that Spinner dolphins go as deep as 400 m in search of prey. (Dolar *et al*., 2003).

Predation

Sharks are the major predators of this species. The characteristics wound, and scar are indicators of predatory attack by small squaloid shark and other larger sharks (Everet, 1971). They are also threatened by the chase and capture techniques used by commercial fishermen (Edwards, 2007; Norris and Dohl, 1980)

Species indigenous uses

This species is consumed locally as meat. Fishermen have also reported their use as bait in fisheries (Norris, et al., 1994).

Breeding Season

This species breeds once every three years usually from February to August.

Conservation Status

The species is categorized as Data Deficient (DD) by IUCN 2018 version 2. This implied that this species should be treated as Threatened. The species is one of the most abundant cetaceans globally (Perrin 2018). In Nigeria, the species is listed as Absolute prohibition by Endangered Species Act 2016.

Ecosystem Roles

Yellowfin tuna follow this species in search of food. This relationship is probably mutualistic. There are some known parasites associated with this species. These parasitic organisms include *Strobilocephalus triangularis, Phyllobothrium delphini, Tetrabothrius forsteri, Sarcocystis sp., Anisakis simplex, Halocercus lagenorhynchi, Crassicauda sp., Monorygma grimaldii* and *Oschmarinella rochebruni*. (Dailey and Stroud, 1978; Edwards, 2007; Gibson, et al., 1998; Norris and Dohl, 1980).

Indirectly Censored Species

The following mammalian species were censored indirectly through various indirect evidences. Locals reported its presence in the area, but no individual of this species was inventoried during the study.

***Stenella frontalis* (Spotted Dolphin)**

Species indigenous uses

Besides being used for food, certain parts of its body were reported by the people as serving medicinal purposes. Specifically, the oil from the liver is used by locals ulcer treatments.

Food Habits

This species is carnivorous, consuming a variety of invertebrates, as well as small eels and herring (Lopes, et al 2012). They have even been known to follow trawlers to consume discarded fish (Lopes, et al 2012). Other feeding habits include feeding at or near the surface and "tracking" schools of small fish. (Ridgway, 1994).

Economic Importance for Humans

In the past dolphin flesh was considered a delicacy. Besides being used for food, certain parts of its body were used for medicinal purposes. Of late, salvage operations and involvement in military operations have awaken the scientific community on the intelligence quotient of this species (Stephen, 1973). Coordinated studies are required to confirm its presence.

Conservation Status

The species is categorized as Data Deficient (DD) according to the IUCN Red List of threatened species and hence need be treated as Threatened. It is listed as Absolute Prohibition by the Endangered Species Act 2016.

Mammalian Species Habitat Water Physico-Chemical Characteristics

Physico-chemical analysis of the water samples obtained at depths where the mammalian species were sighted was carried out. The result is presented in Table 4.22

Table 4.22: Physico-chemical Parameters of Mammalian Species Habitat

Parameters	**SW 7**	**SW 8**	**Mean for *O. orca***	**SW 9**	**SW10**	**Mean *T. senegalensis***	**SW 11**	**SW 12**	**SW 13**	**Mean of *S. longirostris***	**WHO LIMIT**
	Orcinus orca			***Trichechus senegalensis***			***Stenella longirostris***				
pH @ 28.2^oC	7.89	7.86	7.875	7.68	7.71	7.695	7.84	7.8	7.98	7.87333	6.0-9.0
Temperature (0C)	18.7	22.4	20.55	20.8	19.5	20.15	19.1	21.3	18.1	19.5	>25
Conductivity (mS/cm)	44.6	99.7	72.15	87.6	51.2	69.4	47.9	49.7	40.7	46.1	1000
Turbidity (NTU)	3.4	11.1	7.25	6.8	4.8	5.8	3.8	4.5	2.3	3.53333	5
COD	13.25	28.7	20.975	21.9	19.3	20.6	14.7	21.3	10.5	15.5	40
BOD	5.3	9.6	7.45	8.4	7.2	7.8	5.8	7.9	4.4	6.03333	5
DO	7.7	4.8	6.25	5	7.02	6.01	7.1	6.5	8.1	7.23333	4
TDS (g/l)	21	69.7	45.35	52.1	30.66	41.38	29.03	29.79	24.37	27.73	
THC (mg/l)	ND	3.43	3.43	2.01	1.3	1.655	1.5	0.6	ND	1.05	5
Nitrate (mg/l)	36.9	71.2	54.05	63.1	52.8	57.95	42.9	46.5	28.4	39.2667	50
Sulphate (mg/l)	65.7	210.3	138	156.1	127.6	141.85	81.4	86.1	32.6	66.7	200
Phosphate (mg/l)	5.12	20.4	12.76	17.6	14.5	16.05	9.9	10.4	3.07	7.79	0.5
Ammonia (mg/l)	0.18	0.65	0.415	0.49	0.27	0.38	0.19	0.2	0.01	0.13333	0.2
Chromium mg/l)	0.03	0.09	0.06	0.06	0.04	0.05	0.04	0.04	0.01	0.03	0.05
Manganese (mg/l)	0.01	0.08	0.045	0.05	0.04	0.045	0.02	0.02	0.01	0.01667	0.05
Lead (mg/l)	0.01	1.4	0.705	0.89	0.02	0.455	0.02	0.03	0.01	0.02	0.05
Zinc (mg/l)	1.27	3.29	2.28	2.99	1.68	2.335	1.42	1.51	0.24	1.05667	3
Copper (mg/)	0.02	0.1	0.06	0.07	0.04	0.055	0.02	0.02	0.01	0.01667	0.05
Total Iron (mg/l)	0.14	2.58	1.36	2.31	2.18	2.245	0.18	0.2	0.1	0.16	0.2
Nickel (mg/l)	0.01	0.031	0.0205	0.02	0.01	0.015	0.03	0.03	ND	0.03	-
Mercury (mg/l)	ND	ND		0.001	ND	0.001	ND	ND	ND		0.001
Cadmium (mg/l)	ND	0.008	0.008	ND	ND	-	0.007	0.008	ND	0.0075	0.005
Arsenic (mg/l)	0.06	0.12	0.09	ND	ND	-	0.07	0.07	0.03	0.05667	0.05
Aluminium (mg/l)	0.2	3.09	1.645	3.01	2.14	2.575	0.19	0. 23	0.17	0.18	
Selenium (mg/l)	ND	0.23	0.23	ND	ND		0.19	ND	ND	0.19	0.01

Parameters	**SW 7**	**SW 8**	**Mean for *O. orca***	**SW 9**	**SW10**	**Mean *T. senegalensis***	**SW 11**	**SW 12**	**SW 13**	**Mean of *S. longirostris***	**WHO LIMIT**
	Orcinus orca			***Trichechus senegalensis***			***Stenella longirostris***				
E-coli (cfu/100ml)	0.10 X 10^2	1.24 X 10^3	6.25 x 10^2	1.39 X 10^3	0.23 X 10^3	0.8 x 10^3	0.22 X 10^3	0.12 X 10^3	0	0.13 x 10^3	0

Source: Field Survey 2019

The recorded concentrations of physicochemical parameters for *Orcinus orca* seems directly related to depth of sighting. Parameters analysed for samples where individuals were sighted at shallower depth is suggestive that their presence may be connected to search for foods at avoidance of predator elements. *Carrington* (2013) reported that most whale migrations are largely due tend to increase in acidity of seas and search of food. Concentrations of turbidity, nutrients, BOD, DO, COD and TDS are al suggestive of heavily polluted environment. At deeper depth, the analysed parameters suggest a water body that is only mildly polluted as most parameters were within regulatory limits. Concentrations of parameters obtained at deeper depth seem to be the optimum conditions for this species. The low nutrient concentrations recorded at greater depth could be due to the restricted human access made possible by the relative distance of the sample point offshore and increased depth. In all, *Orcinus orca* seems to be eurycious species as they can tolerate wide variations in environmental conditions. Similar sighting environments for *Trichechus senegalensis* offers same explanation.

However, the ecology of *Stenella longirostris* seems different as they occupied deeper depths (range?). The analysed physico-chemical parameters suggest that they preferred a more alkaline environment, colder waters, less turbid, less nutrient load and reduce anthropogenic influences**.** This much was further confirmed *the* most of parameters analysed for samples where this species was sighted were within regulatory limits. The relatively concentrations of faecal Coliforms is indicative of a mildly polluted environment.

4.9: Social Profile

The study was conducted in Brass and Akuku-Toru Local Government Areas of Bayelsa and Rivers States respectively. There are fourteen (14) communities along the proposed OML 77 and 74 3D Shoot Seismic Data Acquisition Project. These communities host some Shell Petroleum Development Companies (SPDC) and Liquified Natural Gas (LNG) and other company's oil and gas facilities. Relevant stakeholders and gatekeepers (traditional rulers, youth and community development committees (CDC), women, children and the physically challenged persons were consulted.

The Social Impact Assessment (SIA) component of this study focuses on establishing adequate and comprehensive baseline situation data subsequent upon implementation of the proposed project which comprises of listing of all stakeholder communities, settlement history, religion, customs belief systems, political structure and governance, land ownership and land use, population and socio-demographic information, livelihood and micro-economy, infrastructural facilities and quality of life, housing and house types as well as perception, needs, interests, concerns and expectations by the communities from proposed project area.

Table 4.23: Stakeholders Communities in the Study Area

Stakeholders communities	LGAs	State	Clan	Major Language
1. Okunbiri (Opu-Okunbiri)	Brass	Bayelsa	Ijaw	Mein and Kalabari
2. Sangana	Brass	Bayelsa	Ijaw	
3. Ewoama	Brass	Bayelsa	Ijaw	
4. Ibidi	Brass	Bayelsa	Ijaw	
5. Obioku	Brass	Bayelsa	Ijaw	
6. Oginibiri	Brass	Bayelsa	Ijaw	
7. Okumbiribeleu	Brass	Bayelsa	Ijaw	
8. Liama	Brass	Bayelsa	Ijaw	
9. Beletiama	Brass	Bayelsa	Ijaw	
10. Twon Brass	Brass	Bayelsa	Ijaw	
11. Egwema	Brass	Bayelsa	Ijaw	
12. Okpoama	Brass	Bayelsa	Ijaw	
13. Odioma	Brass	Bayelsa	Ijaw	
14. Diema	Brass	Bayelsa	Ijaw	

Source: ***NPC, 1991 and www.bayelsastategov.org***

Objectives of the Study

- Identify and obtain all relevant data from secondary sources such as Government agencies (National Population Commission, National Bureau of Statistics, National Archives, The Nigerian Police and other security Agencies etc.), Regulators and SPDC Reports, Journals, etc.
- Establish baseline data on the people, history, culture, tradition, governance structures, natural resource management, socio-economic conditions, demographic trends, geographical area, social infrastructure, archaeological and religious artefacts, traffic analysis and potential impacts of the projects.
- Identify all stakeholders including National and International Authorities, Non-governmental Organizations (NGOs), Community–based Organizations (CBOs), Local/State government, regulators, community leaders, and groups that could be involved in the project and state the basis of their involvement.

4.9.1: Consultation with Relevant Stakeholders

Consultation approach to social enquire was used for the survey. It is a major feature of the Social impact assessment` (SIA) component of any environmental impact assessment (EIA), because it helps, in gathering the concerns and views of the generality of stakeholders (Plates 4.18a and b), it ensure the several acceptability of survey results in order to ensure minimal dissensions and conflict, it enhances smooth and crisis-free project implementation and guarantees economic and social sustainability of the proposed project in the study area. In each of the community visited, the first point of call was the Palace of the Village/Community leader and his council assisted by the Community Relation Officer (CRO), youth president/leader, women leader, Chairman of community development committee (CDC), the children as well as the physically challenged persons. The aim of this exercise was to gain their support and blessings for a smooth and crisis free study during project implementation.

Plate 4.18: Consultation with Communities and Secretary to Brass LGA, Bayelsa (a &b)

4.9.2: Sampling Rationale

Sampling Procedure and Size

The communities were purposively selected for this study. The rationale for using this sampling procedure is based on the premise that the project location and scope of data generation is already known, and that certain desirable parameters and variables are clearly stated and known. This is in line with the DPRs EGASPIN requirement on sea bed sampling which demands that social economic study should be conducted in coastal communities along the acreage that predominantly occupied by fisher folks. The study deployed relevant social scientific methodologies having collected, analysed and discussed/documented baseline socioeconomic conditions of the proposed project communities. The challenge of obtaining actual population figures in all the communities was overcome by adoption of technique of non-proportional to size sampling. Fifty-one (51) respondents were randomly selected from the fourteen selected (14) communities spanning the project area. This sum up to seven hundred and fourteen (714) respondents. Every community was given equal sampling opportunity without bias especially in selection of respondents for the study.

Field Data Collection, Techniques and Analysis

Primary and secondary sources of data gathering approaches was used to collect baseline socio-economic data from the OML 77/74 shoreline communities. The study deployed Social Science approach of quantitative and qualitative data collection. Primary data were predominantly collected from households using questionnaire, focus group discussion (FGD), Key informant interviews (KII) and in-depth interview, personal observation and snowballing techniques was used to obtain salient information (data) related to community history and culture from the landlord and other satellite communities. A total of four (4) FGD sessions (with the youth, men, women, and children), in each community was conducted with maximum of 5-10 discussants per FGD session. Two (2) key informants (1 adult male and 1 adult female) were interviewed in each of the project communities (Plate 4.19).

Plates 4.19: Key Informant Interview with the Youth (a) and Woman Leader (b)

Quantitative data collected were analysed using descriptive statistics and results are presented in tables, charts, figures and photo plates. This study is supported with focused photographs/discussion and interview sessions and social infrastructures. Secondary data were collected from official publications of National Population Commission (NPC), National Bureau of Statistics (NBS), United Nations Development Programme (UNDP) and publications of Niger Delta Commission (NDDC) and related reports of SPDC (various years) among others.

Analytical Procedures

Data collected for this study were analysed using statistical software packages such as SPSS, gretl and Minitab 17. Population figures were estimated using the linear geometric and exponential growth rates as stated in equations 1, 2 and 3. It assumes that growth is a continuous process rather than an annual increase.

$$\mathbf{r} = \left(\frac{P_n - P_0}{P_0}\right)\frac{1}{n} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(1)}$$

$$\mathbf{r} = \left(\frac{P_n}{P_0}\right)^{1/n} - 1 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \textbf{(2)}$$

$$1/n\ (\log_{10} P_n - \log_{10} P_o)\ \ldots\ldots\ldots\ldots \textbf{(3)}$$

Barceley (1970) and Poland *et al* (1981), pointed out that the exponential growth rate is appropriate and realistic way of representing the effect of human population growth. The geometric and exponential models arrive at almost the same result when deployed in population forecast.

4.9.3: Population Dynamics and Socio-Demographic Information

Settlement History of Shoreline Communities in the Proposed Project Locations

The first migration out of Otu-Ife (or Ile-Ife as it was later to be known) was led by Prince Ijo (alias ***Idekoseroake***, The Etekuro, The Kala-Suo) mentioned in the ancestral tradition as being the first son of King Adumu. Between 650 –700 AD. Prince Ijo led his migration out of Ife to the Benin region, where he encamped and established a settlement (***Uzama!***) At this time other ***ORU*** people, as well as the ***EFA*** people were settling in the Benin region.

Ijaw World Studies (2011) has shown that, the Ijaws originated ancestrally from the Aborigins ORU people (H) ORU or Horus people, the Aborigin Kwa People, the Aborigin Bantu and Semi-Bantu people, and numerous other unnamed Aborigins e.g. the TWA PIG between 500-700AD, the various ancient aborigines lived in autonomous and semi-autonomous communities arranged in form of confederacy, which are now kingdom refer to as Borgh (Bussa), Beni (Nupe), Ife (Yoba), Beni (Ado) and Ijo (Ijaw). King Adumu VIII instructed his son Prince Ijo to move and settle in the coastal region in view of defending the territory. Prince Ijo proceeded to the Central Niger Delta with his follows and came across isolated ancient communities of ORU people in remote settlements of the Central Delta (The TOBY or ANCIENT PEOPLES). This is the birth or genesis of the Ijo (Ijaw) people. The KUMONI-ORU who settled the Niger Delta with the most ancient inhabitants known as the ORU (TOBU OTU) who gave birth to the IJOS (Table 4.24).

Table 4.24: Chronological Summary of the Formation of the IJO (IJAW): BCE-BC and 2000 BCE – 600 CE (AD)

Date	Niger Delta Region: The Ijaws
100-600	Proto-Ijo(Oru) ancestors Nupe settled in Benin and Delta fringe
620 – 650	Proto – Ijaw (Oru) Settled in the Niger Delta Northern Fringes
650 – 690	-do-
690 – 750	Prince Ijo (Idekoseroake) leaves Ife to Benin kingdom and western Niger Delta King Adamu died , Ogu Senior army commander Succeeded him
800 - 1000	Prince Ijo sent expeditions to settle in the central delta Nun River, were towns such as Kula, Gbaran, Oporoma, Agadasba-bou, Apoi, Ijos ke, Oproza, Arogbo from Warife
1190 – 1200	Foundation of the Nembe Settlements (obioku) Dispersals from other ancient centres such as Agadagba-bou, Isoma-bou, Obiama, Apoi
1400 – 1500	More ijo ancestors left Benin region for the central Detla. Migrations within the delta. Kala-Ekule becomes the first crowned king of Nemba. Marked the arrival of European along the coast. The ancestors of the Kumbo Kabo and Gbaran leave Oproza town because of the activities (scare trade) of the Portuguese in the area. Mein and a large number of Ijo followers leave Benin for Aboh then to the central Delta area of Igbedi Creek. They establish Ogobiri which lead to major migrations from Igbedi creek to the Western and Eastern Delta.
1500-1600	Awomekalaso establishes herself at Kalabari. Pereziagha retakes Ikoro (an old ancestral settlement of the Ijos) and establishes Olodiama-Ibe, in the western delta fringe. The Arogbos establish an army camp at Kurama (Lagos) in response to the Benin invasion of Lagos region.
1700-1900	Atlantic slavery, trade in captives, raiding and kidnapping, in full swing in the West African subregion. This leads to migration within the delta.
1900-	British colonial acquisition of the Niger Delta and southern Nigeria
1914-	The amalgamation of Southern and Northern Nigeria
1960 - present	Nigeria granted so called independence. The creation of states. The Ijo (Ijaw) administratively partitioned into several regions, later into several states.

Source: Ijaw World Studies, 2016 and SPDC, 2018

According to SPDC (2018) the settlement history of the communities was documented with specific reference to H-Block micro influence area, as contained in the Colonial Intelligence Report of the 1920s that the people of Obioku, Odioma, Ibidi, Twon Brass, Okpoama, Beletiama, Egweama, and Iwoama are said to have migrated from Ogbolomabiri (Nembe) on account of a civil war. On the other hand, the people of Sangana Opu-Okumbiri, Oginibiri, Okumbiri Beleu, Liama, and environs are of the Akassa Clan. Among the Ibanis of Bonny LGA, historical accounts have it that the people migrated from present-day Bayelsa State and settled in the present area by the eleventh century. Unlike many other communities, Ikaba (The progenitor of Dieama Community) came from a place called Iselema – present day Itshekiri. He migrated to Oruamabiri to serve the King Deity of Nembe called OGIDIGA. History has it that Ogidiga also came from Iselema – present day Itshekiri. When the deity migrated to Oruamabiri, a young virgin maiden was brought with the deity to serve him as it was stipulated that only a virgin maiden that has not started seeing her monthly circle, is allowed to serve him. Her name was Inai. She was at Oruamabiri serving the deity called Ogidiga. Much later, Ikaba also came to dwell in Oruamabiri by the influence of Ogidiga. Inai later grew up to an adult and got married to Ikoli and gave birth to Warikubu. Ikaba became very prominent and influential and was like the Second in Command in Oruamabiri. Ikaba was a typical fisherman popularly known for his fishing escapades.

He could spend months in his fishing adventure and return home. Ikaba later got married to Warikubu – daughter of Inai and Ikoli and together, they started their fishing adventure. In one of their adventures, they settled at a place called Owu-Pogu close to present day Dieama community. At this place, they mysteriously lost one of their children. They became uncomfortable staying at Owu-Pogu as a result of the mysterious disappearance of their child. In search for better and safer place, Warikubu – Ikaba's wife, went further into the canal and saw a place that seems suitable for habitation. On her arrival back home, she related her latest discovery to her husband – Ikaba. They both went together and saw that it was suitable for habitation. While taking a walk around the place, they saw a deity in the form of Clay-Pot. Ikaba said to the deity to leave the place before his final settlement if the deity was a bad one, otherwise, the deity could stay. When they went back for final settlement, the deity was still there, they assumed that it was a good deity. So, IKABA named the deity as Suo-Yai – Idele (The king deity of Dieama Town).

Population Size, Growth and Distribution

There are several factors that could influence the population dynamics of an area. These factors are environmental dynamics, changes in economic and social activities, emerging public policies, conflicts, migration, discovery of natural resources such as crude petroleum and gas deposits, fertile agricultural land etc., among others. The population of the communities is presented in Table 4.25 above based on official publication by National Population Commission (NPC) as well as projected values based on 3.2% annual growth rate using exponential growth model as stated in the study methodology. The study adopted NBS (2019) NPC (2019), SPDC 2011 and Akpan, 2017 assess the population size, growth and distribution in the shoreline communities as presented in Tables 4.26 and 4.27.

Table 4.25: Population Figures of the Local Government Areas- State

S/N	LGAs	Senatorial District	Land size	Male	Female	Both sexes
1	Brass	A	1,410,764	94,359	89,768	184,127
2	Ekeremor	C	1,820,232	137,753	131,835	269,588
3	Kolokuma/opokuma	B	363,334	39,952	39,314	79,266
4	Nembe	A	763,877	66,768	64,198	179,606
5	Ogbia	A	699,013	92,015	87,591	186,869
6	Sagbama	C	951,650	95,667	91,202	186,869
7	Southern Ijaw	B	2,695,862	165,329	156,479	321,808
8	Yenegoa	B	711,024	182,240	170,045	352,285
9	Beyelsa State		9,415.752	874,083	830,432	1,704.515

Source: Authors. A = Bayelsa East, B = Bayelsa Central, C = Bayelsa West

Table 4.26: Baseline Population of Stakeholder - Communities

S/N	Communities	Population Census, 1991			Census, 1996
		Males	**Females**	**Both Sexes**	
1.	Li – ama 1 & II B	3,088	3,523	4,611	7824
2.	Oginibiri	655	768	1,433	1696
3.	Okunbiri	660	711	1,372	1,624
4.	Okunbiri-Beleu	1,535	1,053	2,588	3,063
5.	Ibidi	1,630	1,316	2,946	3,486
6.	Obioku	1,107	1,467	2,574	3,046
7.	Beletie-ama	2,120	2,315	4,435	5,249
8.	Egweama	4,116	3,989	8,105	9,592
.	Twon Brass	8,025	6,460	14,425	17,072
10.	Ewoama	2,307	1,892	4,199	4,969
11.	Okpuama	7,613	7,349	14,962	17,707
12.	Diematown	628	651	1,279	1,514
13.	Odioma	2,961	2,765	5,726	6,777
14.	Sangana	2,212	2,846	4,058	4,808

Source: Authors Computation, 2019

Table 4.27: Baseline Population of stakeholder community 1991± 30 years

S/N	Communities /Status	1991			1996	2006	2010	2015	2018	2020
		Male	**Female**	**Both sex**						
1	Liama I & II	1088	3523	6611	7924	10460	11474	12742	13503	14010
2	Oginibiri	665	768	1433	743	981	1076	1195	1267	1314
3	Okunbiri	315	395	710	843	1113	1221	1356	1437	1490
4	Okumbiri – Belou	1535	1053	2588	3063	4043	4436	4925	5220	5416
5	Ibidi	1630	1316	2946	3486	4602	5048	5606	5940	6164
6	Obioku	1107	1467	2574	3046	4021	4411	4898	5191	5386
6	Beletieama	2120	2315	4435	5249	6929	7601	8441	8945	9281
7	Egweama	4116	3989	8105	9592	12661	13890	15424	16345	16959
8	Twon –Brass	8025	6400	14425	17072	22535	24721	27452	29091	30184
9	Ewoama	2307	1892	4199	4969	6560	7196	7991	846	8786

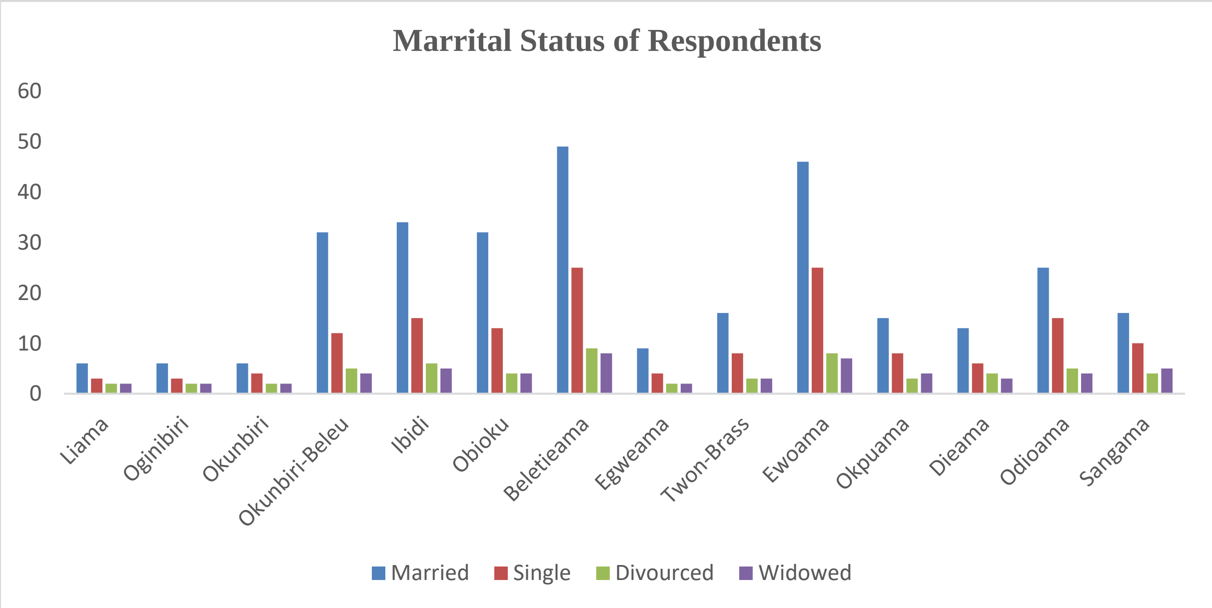
S/N	Communities /Status	1991			1996	2006	2010	2015	2018	2020
		Male	Female	Both sex						
									8	
10	Okpuama	7613	7349	14962	17707	23373	25640	28473	30173	31306
11	Dieama	623	651	1279	1514	1999	2193	2435	2580	2677
12	Odioama	2961	2765	5726	6777	8946	9814	10898	11549	11982
13	Sangama	2212	1846	4058	4803	6340	6955	7723	8185	8492

Source: Computed by the Author, 2019

Using the 1991 and 1996 Census figures as benchmark. In 1991, the total population of the surveyed communities ranges between 315 to 7613persons. It is expected that by 2020 the population will increase to between 1314 -16,959 persons at a growth rate of 3.2%. This analysis is consistent with the current population density for Rivers and Bayelsa States which stands at 260.45 and 109.59 persons per km^2, a figure that rose to 387.4 and 161.97 persons per km^2 in 2005 (RVSG, 2006; BYSG, 2018). The benchmark population density being applied here is a maximum of 75 persons per hectare (pph) which is categorized as low density (Obateru, 2000). This is in line with the terms of reference that presents three different scenarios for population density in the H-Block Project micro-influence areas, assuming normal growth rates (3.0%); slight population change in growth rate (3.5%) and high population change in growth rate (5.0%).

Findings reveals a marginal increase (3%) in population across the fourteen (14) communities in the study area. Therefore, the study deduces that, increase population in these communities may likely be exert pressure on existing resources and facilities over time in the study area thereby causing uncontrolled social and economic tensions. This prediction is in tandem with the *a priori* expectations of population growth rate. On the other hand, increase population may likely lead to productivity and enhances innovative drive on effective and efficient management of resource and sustainable environment. The analysis and outcome are based on thirty (30) years population projection using 1991 base year as shown in Table 4.26 above. This finding is consistent with SPDC and Akpan (2017), which concluded that, population growth may impact negatively on the living standards, resources use and the environment which may cause changes in the communities' landscape for a very long period of time if nothing is done to checkmate the rapid growth.

Several studies have linked stability of societies to stability of families. Findings reveals that, on average over 70% of the sampled population in the study area are married. Similar trend was observed across all the communities. Beletieama, Ewoama, Ibidi, Okunbiri-Belau and Obioku communities had the highest number of married households in the study area (see figure 4.20). Respondents with single status is estimated at 20% while those with separated and divorced status is 10% respectively. This result reveals that, most families living along the shoreline communities of the proposal OML 77 and 74 3D Re-shoot seismic data requisition project are predominantly married married with children and other dependent relatives. This result is consistent with Ojile (2008), Umoh 2017 and Akpan, (2018). However, SPDC (2014) reported much lower figures as obtained from this study.



Source: Field survey, 2019

Figure 4.20: Distribution of Marital Status

The National Bureau of Statistics (NBS) and United Nations Development Programme (UNDP) standards was used as the basis for determination of household size. Figure 4.21 above present the household size in the study area. Result shows that, household size of 7-9 persons and 4-6 persons and above is 45% and 30% respectively. Households with 1-3 persons and 10 persons and above is presented by 12% and 9% respectively. The average household size across the project communities is 7 persons. This value is in line with the size of 6 persons established for communities in Niger Delta (NDDC, 2006). This result is consistent with study by Ojide (2011) that there are average of 8 persons with other relatives per household. Large households were prevalent in the project communities especially in Twon-Brass). Review also shows that, the average household size in the region is 6 persons with considerable variations among the individual states and Local Government Areas. Generally, household sizes are larger in the rural communities (with an average of 8 persons).

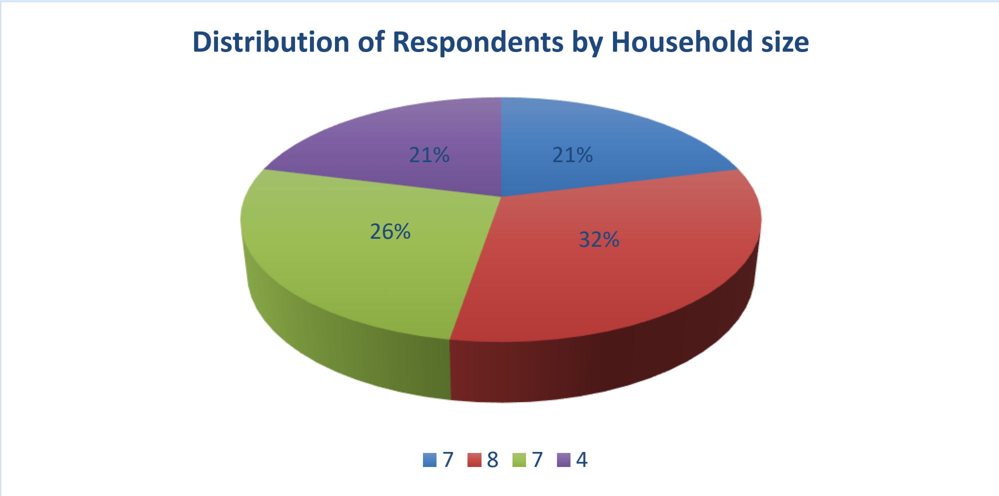


Figure 4.21: Household Size and Headship Distribution in the Study Area
Source: Field Survey, 2019

Figure 4.22 presents household headship in the study area. It reveals that, across the communities, over 58% are male headed households while 42% of the households are female headed households in the study area. Focus group discussion (FGD) session with the discussants reveals that, in the past 10-15 years, most men lost their lives as a result of engagement in militancy activities, as well as communal conflicts. The result shows a slight difference (increase) in female headed households compared with Niger Delta Report (NDR) baseline report shows that 93% male headed households against 7% of female headed households in the Niger Delta region. This result is in tandem with Ojide, 2011, SPDC and Akpan, (2018).

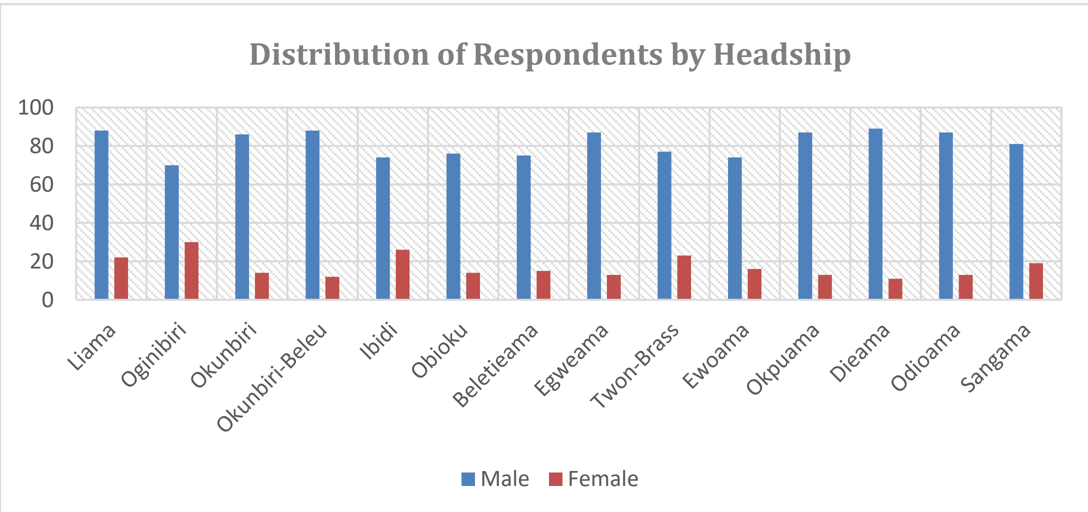


Figure 4.22: Distribution of Household Headship in the Study Area
Source: Field Survey, 2018

Age – sex structure

The age-sex composition of the communities is presented in Figures 4.23 and 4.24. Over 40% of the males across the project communities are within the bracket 35-45years. Males in Twon-Brass, Beletieama, Ibidi and Okumbiri- Belau were more with 21-40 years. However, 20% of the male population is above 65 years of age while the females were found more in the age bracket of 41-50 years. In Liama, Obioku, Dieama and Samgama committees both males and females are within the age bracket of 20-30 years. This is consistent with Akpan (2018). The age-sex structure in the proposed project communities deduced that, there is a strong patriarchal headship structure. Like in many other communities in the Niger Delta, men traditionally are the head of households. The women in turn support the men especially in raising the children and in carrying out households' chores. It was observed that, there are three different types of male headed household namely; the English tradition (monogamy), the African Polygamy and the single male/female status. Men are recognized and known as the decision makers except in few instances where women are bread winners they then direct and take key decision in the family.

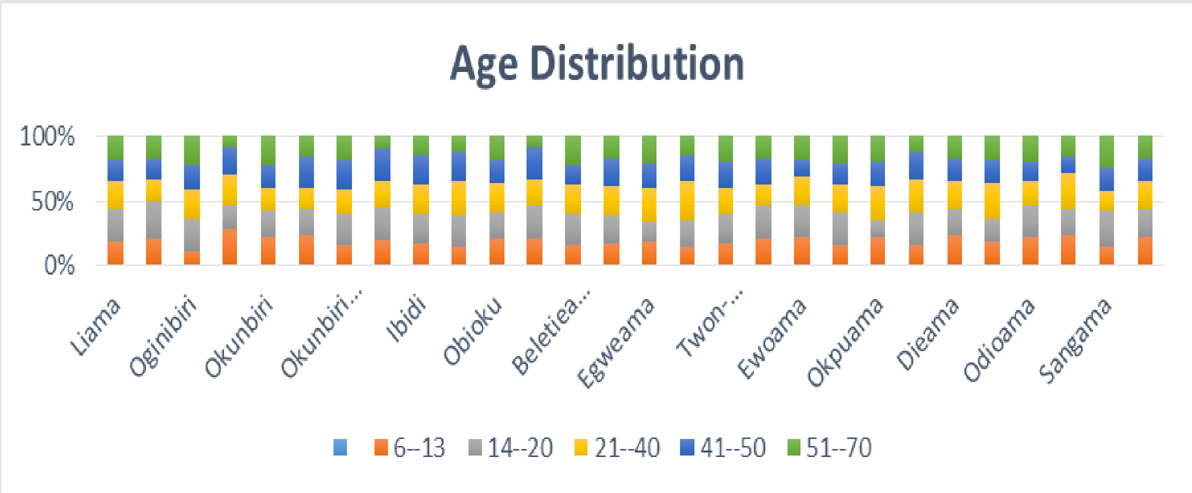


Figure 4.23: Age and Gender Distribution in the Study Area

Source: Field survey, 2019

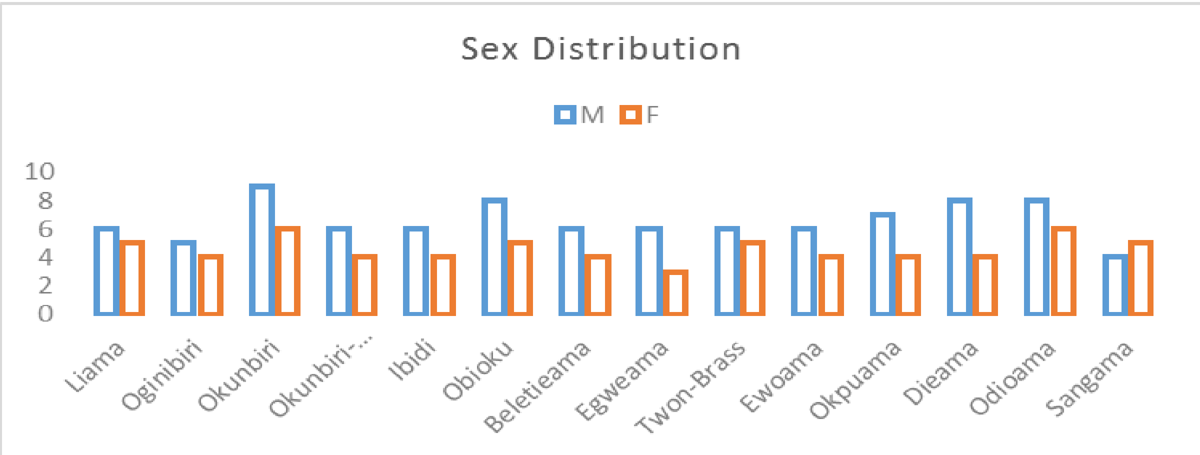


Figure 4.24: Sex Distribution of Respondents

Source: Field Survey, 2019

Findings on educational attainment is presented in Figure 4.25. It shows that in all the communities, the modal educational attainment is secondary education. Over 50% attended and completed primary school. Respondents who attended secondary, vocational/technical, tertiary education represents 25% and 15% respectively. Quite negligible proportion of the population (5%) had non-formal education and learning through experience respectively. This trend is observed in virtually across all the project communities. The findings is consistent with SPDC and Ojide (2011) which stated that, approximately 95% of the total population in most communities in the Niger Delta has some form of education, with more than half (51%) having attempted and completed secondary education, 21.1% on avenue completed primary and tertiary education respectively while approximately 5% of the inhabitants have no formal education. SPDC 2008 reported that there is an *appreciable* proportion of residents in the Niger Delta some formal educational training indicating a satisfactory literate society. The literary level (those who can read and write) in the project area could be described as being sufficiently high judging by the level of educational attainment (formal training), exposure, knowledge and understanding of issues discussed during the Focus Group Discussions (Figure 4.26).

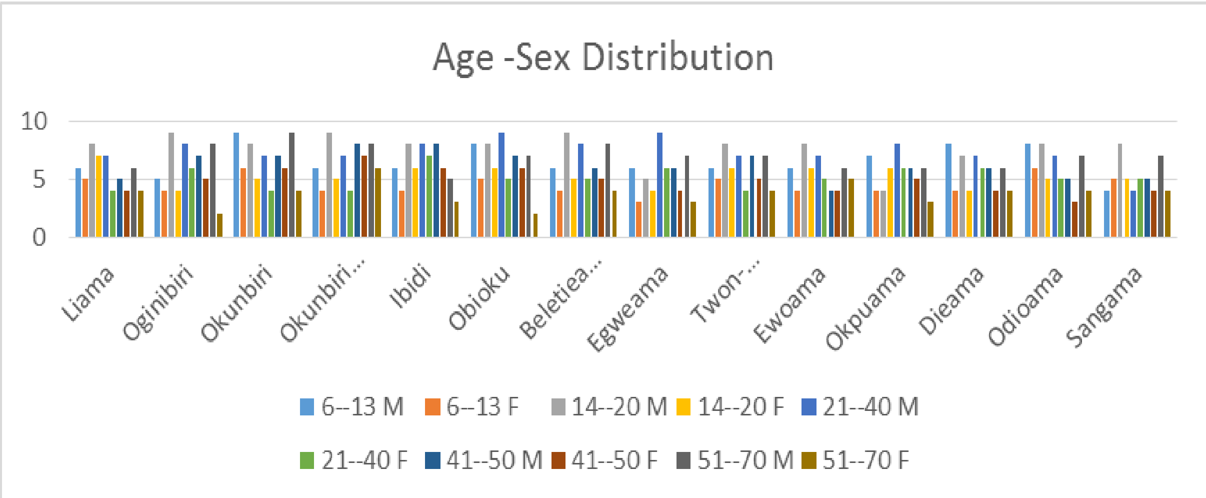


Figure 4.25: Age-Sex Distribution of Respondents

Source: Field survey, 2019

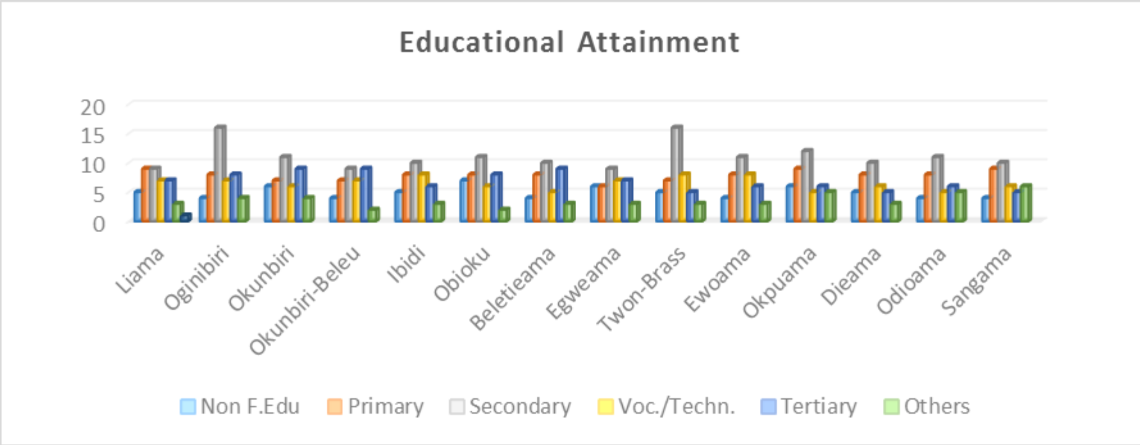


Figure 4.26: Education Attainment in the study Area
Source: Field Survey, 2019

Judging by the level of educational attainment (formal training), exposure, understanding and participation on issues discussed during focus group discussion and interview sessions in the communities. Figure 4.27 buttressed the adult literacy situation in the study area. Findings reveal that over 85% of the population are functionally literate while 15% has no formal education. Similarly, desk review in the schools visited reveals low teacher pupil ratio of 1.46 compared with the national average of 1:36. The low teacher – pupil ratio affects class control, effective teaching and learning as well as pressure on educational facilities in the study area.

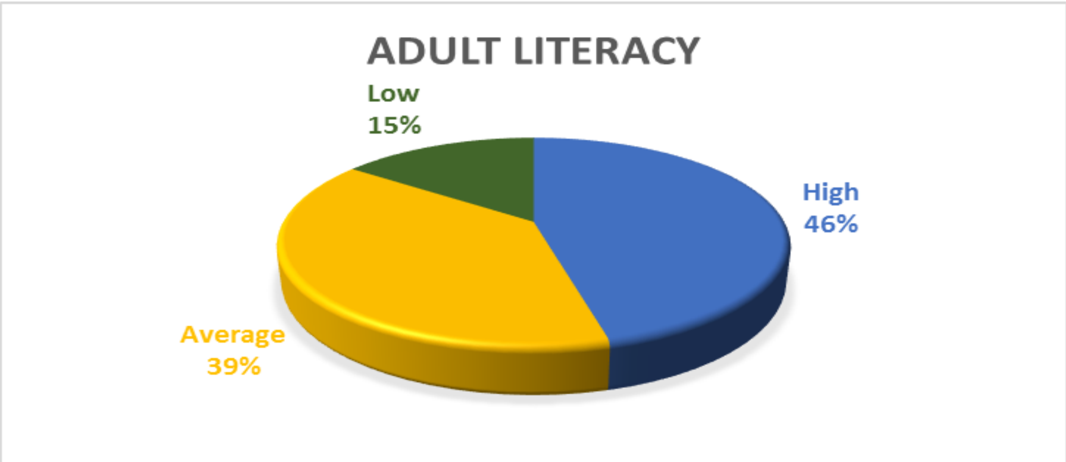


Figure 4.27: Adult Literacy
Source: Field Survey 2019

Table 4.28 reveals the levels of educational attainment in the Niger Delta region where the study will be conducted. Adult literacy is over 70% across the states while attainment of primary education is less than 50 % except Akwa Ibom State. Secondary and tertiary education attainment is less than 505 across the states. Statistical estimates in the project communities shows the proportion of children attending primary school in the Niger Delta region at 80% which compares favourably with the estimated national average of 54%

(UNDP, 2006). The improvement in education attainment recorded so far may be attributed to several factors including availability of social and physical infrastructure such as potable water, electricity good roads, security, as well massive support in school blocks construction by the multinationals (Shell Petroleum Company Development (SPDC), State Government, donor agencies and private sector investment in education.

Table 4.28: Levels of Educational Attainment in the Niger Delta States

State	Adult Literacy(%)	Attainment of pri. Sch. (%)	Attainment of sec.sch (%)	Attainment of Post sec. Sch.(%)	No. of Jobs in Sector (2000)
Abia	84.1	39.6	43.6	16.8	9.276
Akwa Ibom	76.3	54.4	44.4	8.3	13.683
Bayelsa	78.7	38.8	49.3	11.9	3,525
Cross River	82.2	44.6	42.8	12.6	11,425
Delta	77.4	37.9	43.6	18.5	15,720
Edo	69.7	49.3	38.8	11.9	10,959
Imo	79.3	46.1	42.7	11.2	14,145
Ondo	78.8	45.0	44.2	10.8	12.342
Rivers	79.9	33.4	49.5	17.1	4.011
The Region	78.7	43.3	43.2	13.5	95,076

Source: Niger Delta Regional Development and SPDC (2017)

The dependency ratio describes how much pressure an economy faces in supporting its non-productive population. The higher the ratio, the greater the burden carried by working age persons. The dependency ratio for the proposed project communities was computed using derived equation. The dependency ratio computed in the study area is 72.7% compared with the national dependency ratio of 88.2%. The implication is that, for every working-class youth (person) there are about 7 to 8 person dependants. The working population are likely subjected to increase tax to in order to compensate for the larger dependent population. This result reveals that, social security and safety net is lacking across the communities and requires intervention probably from donor agencies government and other multinationals. This is consistent with national average of total dependency ratio of 87.2 ratio implying a change of 0.28%. This finding reveals a high dependency ratio meaning that those of working age and the overall micro-economy in the proposed project communities may face a greater burden in supporting the aging population. The youth dependency ratio focuses on those over 61. The project when implemented is expected to reduce the economic burden of the active labour force in the community through employment and engagement in dominant economic activity.

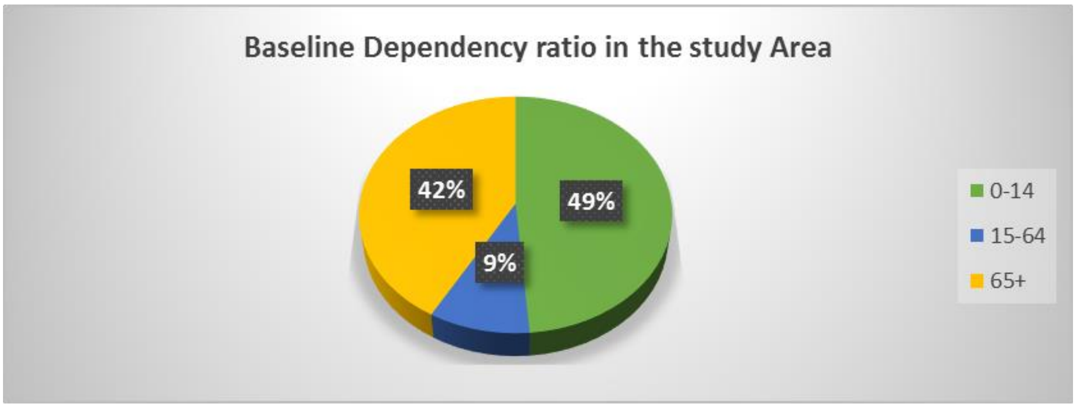


Figure 4.28: Assessment of Dependency Ratio
Source: Field survey, 2018

4.9.4: Political Structure and Governance

Traditional Governance System, Power Structure and Social Organization

The project communities' shares similar governance system. Two major types of governance system were identified during field visit, (the formal and informal system). The formal system is the presence and subjection to local, state and federal governance structure. Primarily, the informal governance system was practice before the colonial administration. Considering the ancestral stock of the people of Benin kingdom who migrated to the coastal area known today as the Niger Delta Region, because of fishing or fear of the activities of the Portuguese some centuries ago. The governance structure as presented in figures 8a and b below, shows the Amanayabo as the Paramount Chief or King of the Ijaw kingdom supported by the Council of chiefs or elders. They are known as the community executives. Previous studies (Akpan, 2018, SPDC 2009, Umoh, 2017 etc.) reported that, Brass is one of the few most permanent settlements along the shoreline communities. However, it has given birth to several satellite towns and villages (constituents' villages under its jurisdiction. They include among Liama, Oginibiri, Okunbiri, Okunbiri-Belou, Ibidi, Eletieama, Dieama, Odioama and Sangama all in Bayelsa State, while Obioku community is in Rivers State (Figure 4.29). These communities and other satellite settlements belong to the Ijaw tribe and Kalabari under the formal jurisdiction of Brass and Nembe Local Government Areas of Bayelsa State. During consultation with the community leaders (adult men, women and the youths), it reveals that there are strong community development committees in all the project communities. They are known according to the prevalent resources; oil and gas committee construction committees, village project committee, security and surveillance committee among others.

The committees work in synergy with the community structures to promote peace, project initiation and implementation, provide security to community and public facilities and enforces law and order in the project communities. Interestingly, identified was the harmonies relationship between SPDC and other donor agencies through the signing of memorandum of understanding (MOU) between host communities and the operating company(s) including SPDC. The women groups equally are very vibrant and active across all the project communities. The women leaders oversee family affairs contribute immensely to community development. All the governance organs identified in the study area work in harmony with other committees. The existence of community and faith-based organization was also assessed in the proposed project communities. Community based organizations (CBOs) such as community Development Committees etc, and active faith-based organizations (FBOs) such as Churches, healing centres etc. were also identified and classified. These organizations though broad based are created to promote social affection between families and kindred's as well as inter and intra community co-existence.

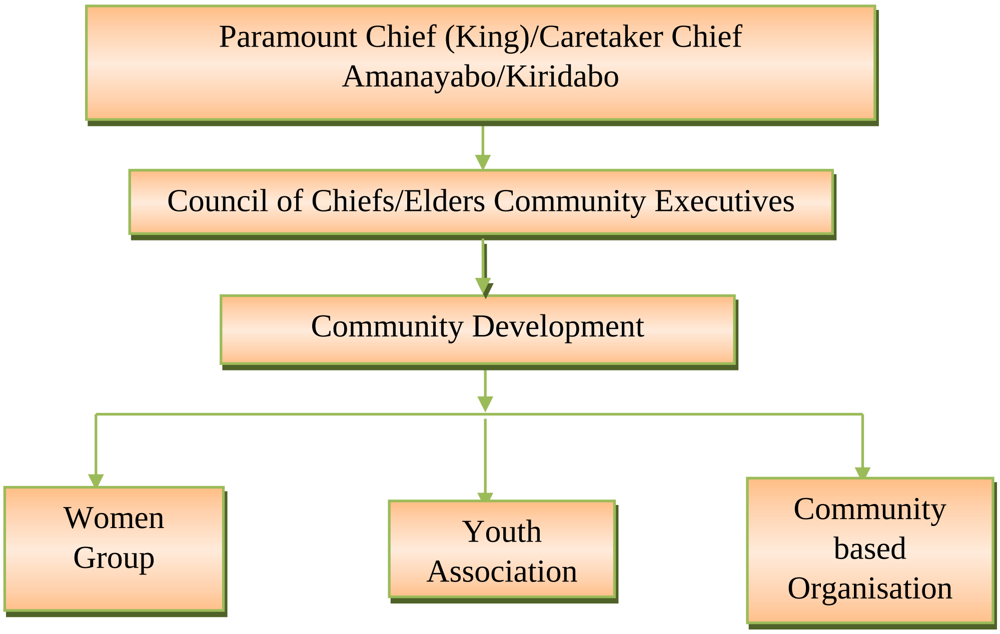


Figure 4.29: Traditional Governance System in the Project Communities

Political Structure and Governance

The study reveals that similar traditional governance system peculiar to the Ijaws of the Niger Delta are practiced in all the 14 committees. At the apex of community political structure is the village Head. Umoh (2017) and Akpan (2018) reported that, each community has its village council with Chairman that works hand in hand with the village head. In the hierarchy of political structure, family heads preside over the affairs of their families. The traditional leadership and system in Brass and Nembe Kingdoms to which the fourteen(14) communities belong is structured into hierarchies with about five (5) functional organs namely: the Paramount chief/king (the clean head), the traditional council, Youth Executive Council and women leader), Development Organisation (e.g. Liama Development organization, Oginibiri Development Organsiation and so on, a representative council, advisory council, project and development committee, youth and women associations.

There is a 15-18-man council of chiefs from each of the project communities, headed by a Paramount Ruler (Chief). The Paramount Ruler and the Council of Chiefs Wield much power and influence in the traditional governance of the communities (Brass – Kingdom) and must be properly consulted for any before any projected is imitated or implemented in the area. Evidences have shown that, traditional institutions in the Niger Delta are very strong and have remain stable over time. These institutions are subject to the Amananyabo kingdom and Brass and Nembe traditional ruler council. Figures 4.30 below shows the hierarchy of influence as well as line of authority across the fourteen (14) communities in the project area. It reveals that the higher the position in the ladder of influence, the higher the influence/power vested on the individual or group as in the case of village council.

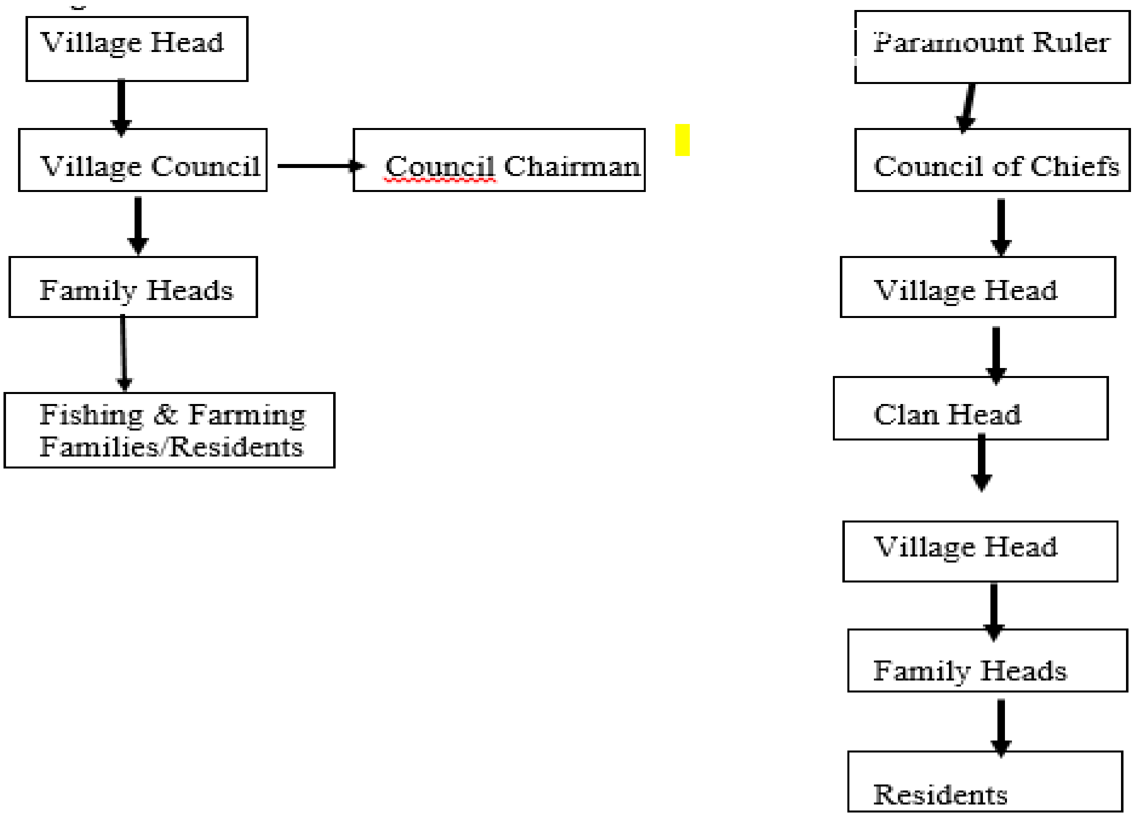


Figure 4.30: Traditional/Political Governance Structure

Succession Issues

Most African traditional communities especially in the Niger Delta upholds that, the tenure of traditional rulers (Paramount Rulers, Clan/District Heads and village Heads) is for life (Plate 4.20). They are succeeded only when they pass through transition. According to Umoh (2017) and SPDC (2017) and Akpan (2018) the tenure of village heads and paramount ruler is for life. In the case of a Paramount ruler, special rites are usually undertaken during the selection and the candidate that finally emerges is always from the ruling or Royal family. In communities, where the proposed OML 77 and 74 projects will be implemented, it was gathered that, at the demise of the Village Head, it is the responsibility of the Village Council to choose (among their kindred's) the candidate to succeed the demise chief. There are changing dynamics in the positions of the village chairmen and community executive councils. For instance, the tenure of the community executive council is three (3) years while the youths and women leaders are two years term respectively. Also, there is a condition guarding their operations and activities. However, if any executive member of the council or associations errs or violates the principles guiding the association as provided in the constitution he/she could be remove from office and may face sanctions by the members.

Plate 4.20: Symbol of Legend in Ijaw Kingdom

In most cases, if the succession process is not properly managed it could lead to serious tension and conflicts. It was gathered that, women association in these communities played an important role in community development especially in areas of commerce, fishing, sanitation, value re-orientation and education. For instance, Mrs. Charity Inemo a 46 year old trader from Ibidi community says in pigin English **"** *See ma, women de try well well for our community, every two weeks, we gada to sweep the community, support our husbands by paying schools fees for our children and save money in our association, we do plenty thing O".*

Prevailing Situation/Relationship between the Traditional Leadership and Modern Governance Institutions –Federal, State and Local governments administration.

An in-depth interaction with the community stakeholders the physically challenged persons reveals that, there is strong relationship existing between traditional (informal) leadership and the modern (formal) governance institutions. In Niger Delta region and in other regions in Nigeria, the governance structure is the three (3) levels of government namely local, state and federal, national government. The closest government to rural populace especially the project communities is the local government. Some studies have shown that, traditional leadership has a stronger link to local governance institution than the state or federal (National) government. As applicable to other states in the study area, village and Clan Heads obtain their certificates of recognition and staff of office from the state government after due facilitation by the Ministry in charge of Chieftaincy affairs of the state. This framework enhances effective administration in the project communities, the local and state governance institutions. This relationship has brought about peace as well as busting criminal elements in the communities. Similarly, the relationship has been strengthened by oil exploration activities in the study area which necessitated frequent meetings between the communities, local and state government and the community Relation Officers (CLOS) to mitigate conflict and stem youth restiveness. The local and state government rely on the traditional leadership to enforce civil laws and maintain order in the communities. This is achievable through regular interface between the traditional institutions and the local as well as state government (Figure 4.32).

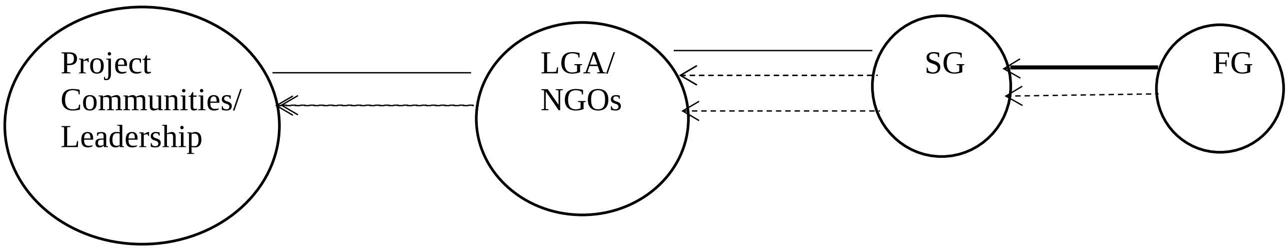


Figure 4.32: Relationship between the Traditional Institutions and modern Governance

Emerging Power Brokers in The Communities

In addition to the constituted traditional governance structure in the project communities, the study identifies emerging groups that seemingly wielding enormous power in the area. During group discussion and consultation meetings between the study team and the communities, it was clearly observed that, community executives/village councils, youths and women association executives have seen coming up very forcefully in community issues and decision making. According to George Ayibatoye a 36 year old Youth President of Sangama community, during the interactive session, he said ***"****It is us that knows what comes into the community and we have our own ways of taking care of problems so that peace can reign you know that our elders are not too strong to do what we are doing"***.**

The emergence of militancy and other youth restiveness is an example of outburst of new power broker in the Niger Delta region. There are strong youth socio-political organizations as well as the vigilante groups that work with the village chairman and Village Heads to ensure that civil laws made by the Village Council are effectively enforced including security of lives and properties as well as built oil facilities of SPDC and other companies including local state, and federal government. Women association is another institution identified to be having great influence in community affairs. This was seen in all the communities surveyed. Interestingly, faith-based organization (FBOs), religious leaders of different church denominations were also identified as having so much influence on their followers. Most family issues between couples are settled by their Pastors as most especially women rely on them for counselling. Some respondents affirmed roles played by juju priest for one form of problem solving" or the other.

4.9.5: Conflict and Conflict Resolution Mechanisms in the Project Communities

Conflict is an important social variable in any EIA study. Its identification and resolution mechanisms in the project area was very crucial. According to Okoh (2005), the Niger Delta region, the crude oil bearing region of Nigeria has witnessed an unprecedented spate of violent conflicts in the recent past, and all efforts to quell the conflict seems to have failed to yield the desire results. This study chronological presents the trend of conflicts in the region. Worsening levels of poverty, lack of basic infrastructure, economic disempowerment, human rights violations, social disorder, absence of governance and ever-deepening integration into the global capitalist market economy (Tables 4.29, 4.30 & 4.31).

Table 4.29: Oil Companies/Communities Conflicts

S/N	Date	Community/LGA	State	Cause of action	Outcome
1	1971	Ejamah-Ebubu (Ogoni)	Rivers	Oil Spill	Destruction of farmlands threatening flora fauna
2	19711996		Bayelsa State	Oil Spills and Pollution	Statistics from the DPR indicates that between 1976 and 1996 a total of 4835 incidents resulted in the spillage of at least 2.446,332 barrels (102,7 million US gallons)
3	May 8, 1997	Elele Alimini	Rivers State	Oil Spill at Mininta Rumuekpe Pipeline	Oil production generates conflicts, large area of farmland, fishponds destroyed shell alleged it was caused by the tenant family.
4	March 27, 1998	Jones Creek Flow Station	Delta State	Oil Spills at Jones Creek Identified by Shell as pipeline failure	20,000 barrels (840,000 U.S gallons) killing large number of fishes
5	1987	Iko	Akwa Ibom	Series of disturbances in Iko following a protest against shell	Mobil Police burnt down 40 houses
6	1976-1996		Bayelsa State	Oil Spills and Pollution	Statistics from the DRP indicates that between 1976 and 1996 a total of 4835 incidents resulted in the spillage of at least 2.446,322 barrels (102.7 million U.S gallons).
7	October 30-31, 1990	U-Muechem-Etche	Rivers	Protest by youths against total neglect by SPDC and Government of Nigeria	The community was razed by mobile policemen. Over 100 people were killed, and 495 houses destroyed
8	October 1998	Jesse	Delta	Pipeline explosion	More than 1000 people died
9	July 2000	Adje near Warri	Delta	Pipeline explosion	Several hundred people died
10	November 1999	Odi	Bayelsa	That on November 4, 1999 and armed gang killed seven Nigerian policemen in Odi	Soldiers move into Odi and razed the community, 2483 people, including women and children died
11	July 10, 2005	Ikarama-Yengoa LGA	Bayelsa	Oil Spill	Serious impact on the flora and fauna including their arable land and swamp.
12	February 19, 2005 (saturday)	Odioma	Bayelsa	Payment of compensation to Bassambiri instead of Odioma by shell petroleum Development Company	More than 18 people were killed
13	July, 2005	Bille Pro test	River	The community said that for 45 years shell has been prospecting oil and gas in their locality and that they have nothing to show for their economic contribution to the nation (Nigeria) except impact.	Ecological violence through environmental pollution, destruction of the ecosystem health problems
14	October 14, 2000	Olugbobiri Southern Ijaw	Bayelsa	Unarmed youths approached the Tebidaba flow station to protest the failure of NAOC to complete certain agreed projects in the Olugbobiri community	Soldiers and Naval personnel at the flow station opened fire on the boasts conveying the youths, 8 were killed and another died later in hospital. Several bodies were not recovered, and more than 16 persons were injured.
15	January 1999	Ikeremor Zion, Opia and Ikenya	Delta	Armed soldiers aided and abetted by Chevron Nigeria limited raided the communities belonging to the Ijaw people.	The communities were burnt down leaving several people dead and injured
16	January, 30 1999	Ogulagha	Delta	Youths demanding for employment in recognition of the Kaiama declaration.	Many youths were shot and 19 died with many injured
17	May 17, 1999	Kokodiagbene	Delta	Soldiers escorting shell barge	Killed two youths of the Ijaw extraction

S/N	Date	Community/LGA	State	Cause of action	Outcome
18	May 28, 1998	Parable platform	Ondo	120 youths from llaje community went to the Chevron offshore drilling facility known as parable platform where they requested to meet with Chevron officials to demand compensation for environmental damage caused by canals cut from Chevron	Nigeria Navy and Mobile Police fired the demonstrators killing two people. Jolly Ogungbeje and Arolika Irowarinum.
19	December 2003	Rukpokwu-Obio-Akpor LGA	Rivers	Oil Spill	Fish ponds, farmlands and livelihood are seriously devastated
20		Ekeni-Ezetu	Bayelsa	Non-implementation of MOU by Texaco	Chevron-Texaco operates here.

Source: *Compiled by the Author, 2018*

Table 4.30: Inter-Community Conflicts in the Niger Delta Region

SN	Communities Involved	Causes	Year
1	Bassambiri and Ogbolomabiri	L.G.A (location of Headquarters)	1997
2	Akassa and koluama	land dispute	2002
3	Ogu and Bolou		2000
4	Ke and Bile		2001
5	Eleme and Okirika	Land dispute	2001
6	Okirika and Ikwerre	Land dispute	
7	Illajes and Ijaws	Territorial/land dispute	1999/1998
8	Ijaws and Itsekiri’s	LGA Creation/ Ward creation/Territorial/land dispute	2000/2004/1991
9	Andoni and Ogboni		1970/1974/1998
10	Urhobo’s and Itsekiri’s		1997/1998
11	Akassa and Egweama		2000
12	Biseni and Okordia	Land/Oil field	2002
13	Epedu Versus Emadike	Land	1999/2000
14	Amabolou and Ayama		2001
15	Ekeremor and Ogbodobiri	Privacy Issue	2004
16	Okpoama and Ewoama	Chieftaincy	1998
17	Biogbolo and Yeneizue	Land	2001
18	Okpoama and Twon-Brass	Land	1999
19	Peremabiri and Diebu		
20	Oluasiri (Nembe) and Orusangama (Kalabiri)	Territorial/land dispute	1994/95
21	Oleh Versus Olomoro	Oil field dipute	1999
22	Beletiema Versus Liama	Murder of a Woman	1997
23	Opuama and Ofonibiri		2000
24	Okuruama Versus Abuloma	Murder of a Woman	2005
25	Apoi Versus Agip	Oil Spillage	2003
26	Choba Youths Versus Wibros	Social amenities	2000
27	Egi youths Versus Agip	Social amenities	
28	Black Markets Crisis Youth Versus Military		
29	Okpoama-Turu Versus Agip	Social amenities	
30	Tebidaba Versus Agip	Social amenities	
31	Ikebiri Versus Agip	Social amenities	1998
32	Ojobo Versus shell SPDC	Violation of MOU. Social responsibilities	1998
33	Gbarain Versus SPDC	Social amenities	1992
34	Gbarain Oil Field owner versus SPDC	Environmental Impact Assessment (EIA)	1994
35	Gbarain Community versus SPDC	IOGP (EIA)	1992
36	Rukpokwu versus SPDC	Oil Spillage	2004
37	Epie communities versus SPDC	Oil Spillage	2003
38	Elekahia Youths versus Nkpogu Youths	Social responsibility	2000
39	Niger Delta Peoples Volunteer	Resources control, self-determination, convocation of national conference	2004
40	Niger Delta Vigilantee versus Niger Delta Peoples Volunteer Force	Protection of rights	2004
41	Obioku versus Odioma	Murder of twelve persons	2005
42	Olugbobiri vs Ologboro	Oil well field	2002
43	Opuoma and Oforibiri	Land dispute	2000

Source: Nengi 2015 and Akpan, 2018.

Table 4. 31: Intra-community conflicts

SN	Communities involved	Causes	Year
1	Ikanyabiri	Chieftaincy Tussle	2004
2	Ekeremor	Community Development Committee Leadership (CDC)	2004
3	Olugbobiri	CDC Leaders	2004
4	Epebu	Youths Leadership tussle	2004
5	Bassambiri	Political groups	2003
6	Imiringi		2000
7	Peremabiri	Control of Community resources (several person killed, houses burnt etc)	2000
8	Isongufuru versus Teme (Nembe-Ogbolomabiri)	Several killed/houses burnt	2000
9	Igbomotoru (Intra)	LGA Headquarters location	2001/2002
10	Enewari	Houses Burnt/destroyed	
11	Kalabari	Kingship Tussie	2000
12	Opobo	Kingship Tussie	Settled
13	Ogbakiri	Several people killed, houses destroyed	

Source: Adapted from Nengi James Op. Cit

Some studies (UNDP, (2010) Ukoh, (2010) Social Action Briefing, (2011) and Akpan (2018), reported that, conflicts in the Niger Delta and by extension the project communities are grouped under four(4) namely, intra-community, inter-community, inter-ethnic and between community and oil companies. Findings reveals that, that there has been increasing youth restiveness in communities within the region. Communities have come into conflict with oil companies, with each other, and with the security forces over a range of issues including payments of compensation for land acquired and for environmental damages caused by oil exploration activities. Proliferated armed groups have waged systematic campaigns against the government, oil companies and other donor agencies to have their demands met.

Findings reveals that, poverty oil spillage, neglect of stakeholders host communities by oil companies, high rate of unemployment, gas flaring. Lukewarm attitude to infrastructural development including roads, jetties, school blocks, health facilities, electricity, skill acquisition centres etc., failure to implement planned activities in the memorandum of understanding (MOU), non-compliance with court orders and rulings, poor communication as well as intimidation were identified as triggers and cause of conflicts in the project area communities and in the region. One whole, the study identified five (5) types of conflicts across the communities (Table 4.32).

Table 4.32: Conflict Profile and Resolution Mechanisms across Project Communities

S/N	Type of Conflict	Major Causes	Resolution Mechanisms
1.	Conflict within families	Poverty, unemployment and marital infidelity kids	Family Head through dialogue
2.	Conflict between families	Power and authority, property sharing and rights	Family Head by dialogue.
3.	Conflict within communities	Leadership tussle, resource sharing,	Dialogue

S/N	Type of Conflict	Major Causes	Resolution Mechanisms
	and interest groups	sectional/family dominance and marginalization	
4.	Conflict between communities	Resource ownership mainly water, land and forest reserves)	Dialogue/Conflict
5.	Conflicts between communities and companies	Not honouring MOU agreement, slow pace to community development	Dialogues and/or court ruling
6.	Conflicts between communities and government	Inadequate (lack) of infrastructural development projects	Dialogue/Court ruling

Source: Field Survey, 2018

The study shows that, conflicts arising within families are mainly caused by marital infidelity and leadership struggle and could be resolved by the village heads through dialogue. Also, conflicts arising within or between communities are caused by leadership struggle or ownership of resources (land and water). It could be resolved by dialogue or court approach. According to Mr. Boumokuma Sample a 46 year old youth leader of Odio-ama community, says "*it depends on the type of problem, some matter de need our community leaders to settle, example if pigin and mama fight or woman or man sleep with person wife or husband. This one we go settle am for community. But, if na another community wan to claim our land, that one na war and na for court wey such matter de go at last"*. Result also reveals that, conflicts emanate between communities and companies/government over lack of provision of infrastructures, unemployment of indigene, non-compliance to signed MoU, etc.

During FGD sessions, discussants admitted that, conflict do occur in the project communities and the resolution mechanism is applied due to the nature of the conflict and the capacity of the mediator(s). Most conflicts identified were resolved through dialogue and by court of law or negotiation using law enforcement agents especially Police. Family and community conflicts were best settled more with dialogue and negotiation unless where serious cases like kidnapping, murder, and armed robbery cases are involved, security agencies are usually contacted. SPDC (2014), Akpan (2018) Umoh (2017) and Ukoh (2010) upheld that, in using dialogue or negotiation special meetings are summoned by the elders-in-council, council of chiefs, elders and chiefs assembly, religious leaders, juju priests youth council and women groups. Matters are settled by imposing penalties such as fines, on the culprit, seizures of assets and ostracism. This result is consistent with SPDC (2014) reporting that this mechanism is quite successful and yielding good results.

Social Control Mechanisms across the Communities

During FGD sessions in the fourteen (14) project communities, social control mechanisms were critically assessed. Feedbacks received shows that, there are traditional and modern approaches to handling social tensions. Traditionally, there are various community norms, mores and traditional esteemed values which each member of the community (both natives and non-natives) is expected to adhere to. Study reveals that, infidelity among woman and stealing by any member of the community are considered deviant behaviours. There are penalties meted to the culprits and at worst case the person may be ostracised. Women and youths are in the forefront of enforcing these laws.

The Church and Chief priests also assist in keeping in check people's behaviours. For instance, community member(s) who steals could be threatened with invoking of curses on offenders by the juju priest. The church in also active in counselling, preachment using Holy Bible. Deviants who are Christian devout risk dis-fellowship by his or her church congregation. Those working in palaces or other sacred places in the community may face ostracism and rejection. It was found that, offenders may lose the chance of being recommended for employment in the companies or public service. Generally, it was found that, youth and women associations, vigilante groups, the church, chief priests, communities' elders and family heads have specific roles in social control across the communities studied. This result is consistent with Umoh and SPDC (2017).

4.9.6: Religion, Customs, Belief Systems and Cultural Heritage

Religious traditions

Majority (over 80%) of community members are Christians while traditional religious elements are still making the rounds. As Ijaw ancestral stock, it is crucial to hold in reverence the reminiscence of ancestors and religious traditions. One of the most prominent idols is one of the water spirits called *Owuamapu*. Most of the members believes that, water spirits are just like humans, they have their accomplishments and imperfections. There is also a belief, that every person had been one of the water spirits before he was born. They pray to water spirits. Each year festivals in honour of the spirits, which can last for a few days. During these celebrations, men wear fancy attires and carved masks, dance to the rhythm of drums and expose the impact of the water spirits through the mood and energy of their dancing (Plate 4.21).

Plate 4.21: Predominant Dance Festivals in the study area (a). boat regatta and (b). Masquerades dance

Language

The Ijaw language consists of two prominent groupings. The first, which is termed as either Western or Central Izon (Ijaw) consists of Western Ijaw speakers: Ekeremor, Sagbama (Mein), Bassan, Apoi, Arogbo, Boma (Bumo), Kabo (Kabuowei), Ogboin, Tarakiri, and Kolokuma-Opokuma (Yenagoa) [citation needed] Nembe, Brass, and Akassa (Akaha) dialects represent Southeast Ijo (Izon). [Citation needed]. Buseni and Okordia dialects are considered Inland Ijo. On the other hand, the second major Ijaw linguistic group is Kalabari. Although the term Eastern Ijaw is not the right term that is what Kalabari is considered as. Kalabari is the name of one of the Ijaw clans that reside on the eastern side of the Niger-Delta (Abonnema, Buguma, Bakana, Degema etc.) who form a major group in Rivers State. Other "Eastern" Ijaw clans are the Okrika, Ibani (the natives of Bonny, Finima, and Opobo) and Nkoroo. They are neighbours to the Kalabari people in present-day Rivers State, Nigeria.

Marriage

Unlike most tribes, the Ijaws have two forms of marriage. The first which is a small-dowry marriage, the groom is traditionally obliged to offer a payment to the wife’s family, which is typically cash. Here (this type of marriage) the children trace their line of inheritance through their mother to her family: Meaning that when the children grow up, they have more choices as to where they can live. They can either decide to live with their father’s people or mother’s people. In contrast to the first type, the second type of marriage is a large-dowry marriage. And here the children belong to the father’s family.

Belief

“Egbesu is the symbol of the goddess in Ijaw land and most parts of Niger Delta. It strictly behaves in war. That is our god of war. Egbesu rises up during the war season. Egbesu is not scared of anybody. No matters who you are. With the coming of Western civilization, the present day Ijaw seems to have changed from traditional worshipers to Christianity. However, there are some among them who still have faith in their traditional religious practices. In the traditional religion of the Ijaws, veneration of ancestors plays a central. While water spirits, known as ***Owuamapu***, figure prominently in the Ijaw pantheon. In addition, the Ijaw practice a form of divination called Igbadai, in which recently deceased individuals are interrogated on the causes of their death. They also believe that water spirits are like humans in having personal strengths and shortcomings and that humans dwell among the water spirits before being born. Traditionally, the Ijaws hold celebrations to honour the spirits, lasting for several days. And the highlight the festival is the role of masquerades. Here, men wearing elaborate outfits and carved masks dance to the beat of drums and manifest the influence of the water spirits through the quality and intensity of their dancing. Particularly spectacular masqueraders are taken to actually be in the possession of the particular spirits on whose behalf they are dancing. Interestingly, the Ijaws are one of the few peoples in the world known to practice ritual acculturation (enculturation). In this practice, it is possible for an individual, who hails from an entirely different tribe or group, to become an Ijaw after undergoing some certain rites. It is said that King Jaja of Opobo, the Igbo slave who rose to become a powerful Ibani (Bonny) chief in the 19th century, is an example (Plate 4.22).

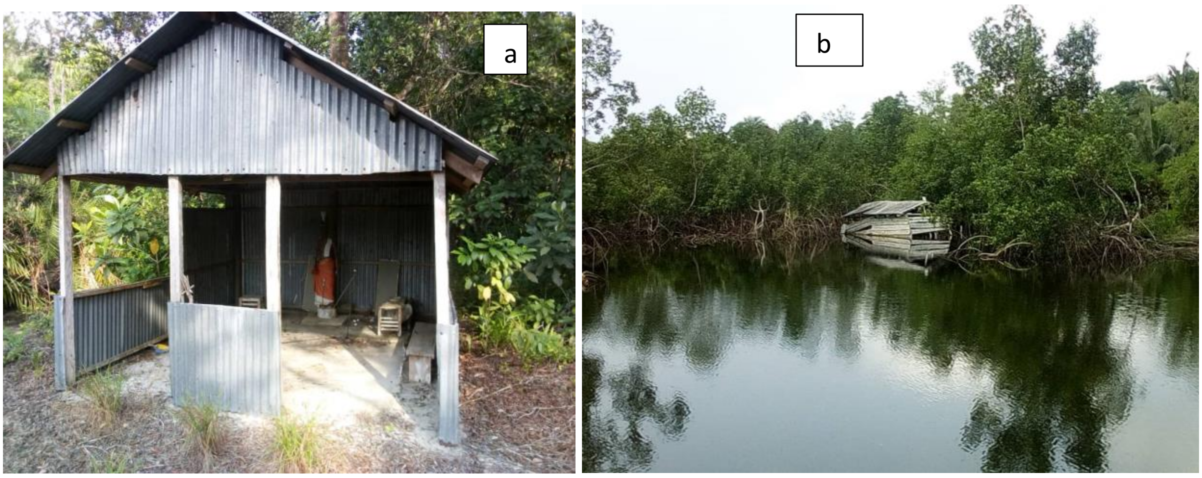


Plate 4.22: Sited Shrines in the Communities (a & b)

Calendar of cultural Events in the Study Area

Seigbein Fishing Festival in Sagbama is celebrated every 27th May yearly (Plate 4.23). This is an age-long annual tradition held at the Seigben Ogugu Lake in Amassoma, Southern Ijaw Local Government Area of the State. It is usually graced by beautiful dance performances of the Egbelegbele dance troupe among others. Other major activities that accompany the festival include a 'Love Boat Party' and singing. The festival is held every year on the 28th - 30th of May. The carnival nature of the celebration attracts people from all walks of life.

Plate 4.23: Display of Fishing Festival in Study Area

Other festivals identified in the study area are Eyal Awani Festival Idema in Ogbia LGA, Ceremonial, The Ancient War Canoe Regatta Nembe Eyal Asigho Okoroba . Isemi Festival, Famgbe Beach Festival Famgbe, Abadiyai Annual Festival Tabuama, Twon-Brass, Okoti Agori Masquerade Display Diebu in Southern Ijaw among others.

4.9.7: Natural Resource Acquisition, ownership and Management

Land Ownership and Land Use

Land is one of the free-gifts of nature. Its characteristics of immobility makes land resource unique and sustainable. Its uses have a wider range of peculiarities namely agriculture and non-agricultural uses of land. The land area of Bayelsa is approximately 10,773km^2 with a population density of 211.4/km^2. Brass and Nembe LGAs occupies a land area of 1,404km^2 and 760km^2 respectively. The average land area across the project communities ranges between 900km^2 – 1,110km^2.

Land Tenure, Use and Management

According to SPDC (2017), and NEST (1991), Nigeria is blessed with vast area of land resources. Land use in Nigeria is for both social, economic and development purposes. The manner in which land is acquired, owned, used and transferred to successors is referred to land tenure system, (Igbozurike, 1978). The Land use Act of 1978 stipulates that all land is hold in trust to the citizens by the government. In Nigeria, ownership is grouped under four classes regardless of who the law says holds the land in trust for. These classes are: individually – owned, family-owned, community-owned and government owned land (Table 4.33).

Table 4.33: Mapped Land Tenure System in the Study Area

SN	Land Ownership Classes	Principal Method of land acquisition
1.	Individual –owned	Inheritance
2.	Family-owned	Purchase
3.	Community – Owned	Exchange
4.	Government – owned	Pledge Gift

Source: Field survey, 2018

SPDC (2008) reported that, land has to be acquired through anyone of the six principal ways: inheritance, purchase, lease, pledge, exchange, and gift before ownership and access rights can be exercised over it. Findings reveal that most (60%) land in the project communities are owned and controlled the by communities and families. This was also applicable to the stretches of rivers and creeks adjourning such land. During FGD sessions across the communities it was noticed that, portions of land owned by families are shared to households within the families (compounds). The community Head occasionally leases land to non-indigenes on request and mission of some items as demanded by the community. The conditions attached to non-indigenes qualifying for this method of land acquisition is that, the lease has live and participate in community activities over a very long period.

It was also gathered that household members in distress may be allowed to lease their portion(s) of land to ease their pressing needs. Land use in the communities are group into two (2) agricultural and non-agricultural use (Plate 4.24). The main occupation across the 14 communities is fishing followed by farming. The demand for land for agricultural purposes is very low. There is high concentration of tree crops such as coconut, large timber trees, palm trees etc. vast and diverse types of houses factories etc. were also seen across the communities. Infrastructural facilities, including roads, electricity, sacred sites, etc. are grouped under non-agricultural use of land in the communities. The nature of pressure on land varies from primary to secondary activities. The study found that, petroleum (oil and gas) explorations and production and related activities have taken up some portions of land are becoming very prominent especially in Brass.

Plate 4.24: Agricultural Land Use in the study Area (a &b)

Forest and Water Resources

Across the fourteen (14) communities, forest and water resources abound. The mapped aquatic resources to include the following; fish obtain from the rivers and creeks, water transportation as common means of communities from one community to another (including goods). The communities are blessed with mangrove and freshwater swamps. Forest products such as timbers of various species fuel wood, wild fruits, medical plants, snails, vegetables and spices. Data gathered by observation in the study area reveals that there are wide variety of wildlife including crocodiles, monkey, donkeys, birds, reptiles, tigers etc. communities hunts this wildlife for food and other economic and social purposes. Across to these resources forest land and rivers are not restricted except areas considered as sacred sites or places and timber which exploitation is controlled to some extent by the forestry department of the Bayelsa and Rivers States Ministry of Agriculture as well as right-of-way (ROW) of oil companies.

The study reveals that, shrines and sacred land under the control of community chief priests of whose permission do other members of the communities access the land, often under his instructions and guidance. Some studies (SPDC, 2017) reported that, by forbidding farming, housing, industrial and other forms of development in these sacred lands, the communities indirectly help to conserve the biodiversity in their various domain. The practice enhances environmental sustainability.

4.9.8: Livelihood and Micro Economy

Livelihood and Micro Economy in the Proposed Project Communities

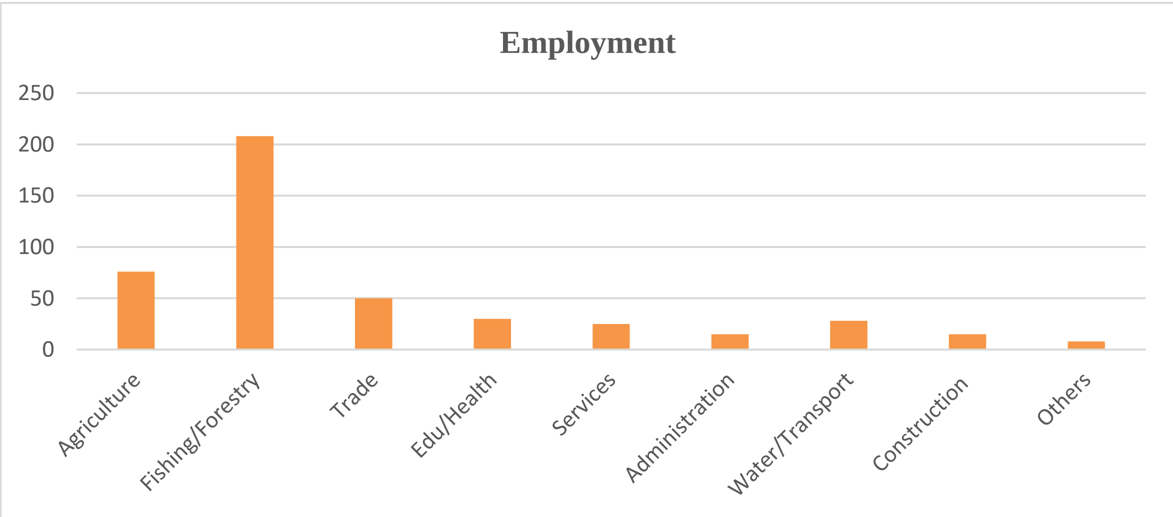
The micro economy of the Niger Delta region of Nigeria are known to be dependent on natural resources for their livelihoods, and SPDC (2017), estimated that over 60% of the population is, the region depends on the natural environment for their livelihood. Predominantly, fishing and agriculture (and other auxiliary/associated activities) are the two major traditional occupations of the Niger Delta peoples. During the colonial era, fretting was introduced as the third major economic activity in the region, Deduction from the FGD reveals that in fishing farming and forestry still account for about 44% of employment and that all the three economic activities have declined since the ascendancy of the oil industry. (UNDP 2006). Findings from this study reveals similar economy – activity – road – map (EARM) across the proposed project communities in Rivers and Beyelsa States respectively. Observation in the study area buttress the dominant livelihood activities are fishing and farming which are derived from water and land (Plate 4.25).

Over 60% of the respondents depend on fishing (associate fishing) and trading/water transportation as their major occupation across the project communities. Field visits and observation in the purposed project area shows that, large volume of water bodies in the study area naturally makes fishing the predominant economic activity. One outcome of the result is that, fishing through practiced in all the project communities. This implies some communities' fishes in small quantities in the sea ports while some other communities operate on large scale fishing using high powered fishing gears (depending on the volume of water). Agricultural activities are practiced in all the communities. They grow predominantly plantain/banana, coconut, and vegetables cassava. Picking of bush mangos, and other forest products include fetching of firewood and bush meat, livestock rearing, fruit harvesting and processing.

Plate 4.25: Hub of livelihood Activities in the study area (a - d)

Fishing activities through found in all the communities are more concentrated in Brass local government. Trading and water transportation over 20% of the population is involved in petty trading on agricultural and non-agricultural communities as well as water transportation. A small percentage (<15%) are engaged in contract business, industrial work, artisan (canoe making, tailoring, welding, engine boats repairs/maintenance, and hiring of boats, electrical works, lumbering and carpentry. Finding also reveals that less than 10% of the population are public/civil servants, apprenticeship or students in the study. Besides the livelihood activities discussed above, activities grouped under “others” form about 2% of economic activity in all the project communities. The availability of thick forests in some parts of the communities enhances seconding forms of economic activities such as lumbering, hunting, picking of periwinkles, palm fruit harvesting and processing. One general feature observed in all the communities is that, they are involved in one form of economic activity or the other as most fishing households were into farming and other income generating activities and vice versa. The study deduced that, the economic geography of the communities is characterized with interaction with neighbours and people of other culture in trade, anchored on local resource exploitation. The proposed project is not expected to disrupt artisanal fishing activities in the area.

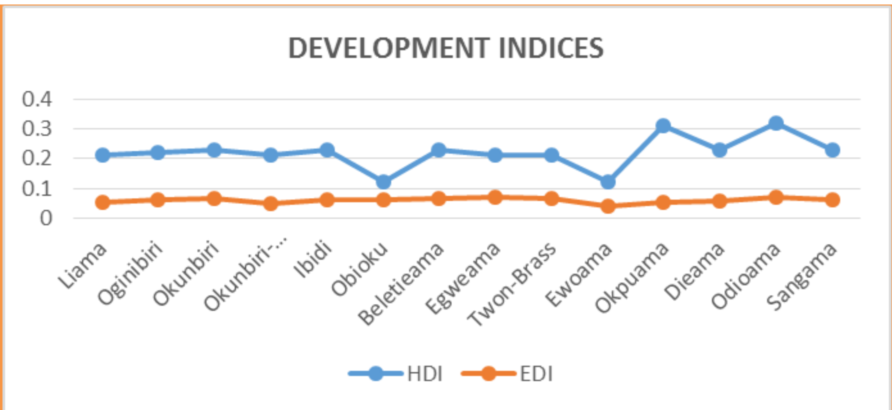
NDRMP, (2010) reported that, the economy of the Niger Delta region is largely driven by the informal sector in terms of percentage of people engaged in livelihood activities. Findings reveals that, the highest proportion of the population is engaged in farming forestry and fishing accounting for over 35%, while 45% of the respondents are self-employed in trade, education/health sectors, services/administration as well as water transportation, construction and other forms of secondary activities as presented in Figure 4.33. Result reveals that, 40% of the populace are not employed across the communities. Surprising, the study reveals that 10% of the respondents are unemployed graduates of Universities, Polytechnics and Colleges of education are unable to find suitable employment but engages in other menial jobs. During FGD sessions it was gathered that, those who actively participate in community service and with exemplary behaviour are rewarded by social clubs and community leaders with chieftaincy titles, most religious and traditional groups empowers some with financial benefits, etc. Community based organization and thrift association provide very strong social networks that unite members through a common set of shared values.



Source: Field survey, 2019

Figure 4.33: Employment Status in the Study Area

EMRL, (2016) reported that indicators of human development indices are life expectancy, education and gross domestic products (gdp). Across the 14 communities, life expectancy is highest in Delta (0.587) and lowest in Bayelsa (0.455). Education index is highest (0.683) in Akwa Ibom but lowest in Bayelsa (0.528) GDP index is highest (0.612) Delta and lowest in Ondo. Findings reveals that human development as well as economic participation indicators in the study area is higher in Lima, Oginbiri, Okunbiri and Okunbini-Beleu etc. but lower in Ibidi, Ewoama, Obioku. Economic participation index is very low across all the proposed project communities as presented in Figure 4.34. This finding is in tandem with the expectations of the community members requesting for improved social economic conditions in the study area.

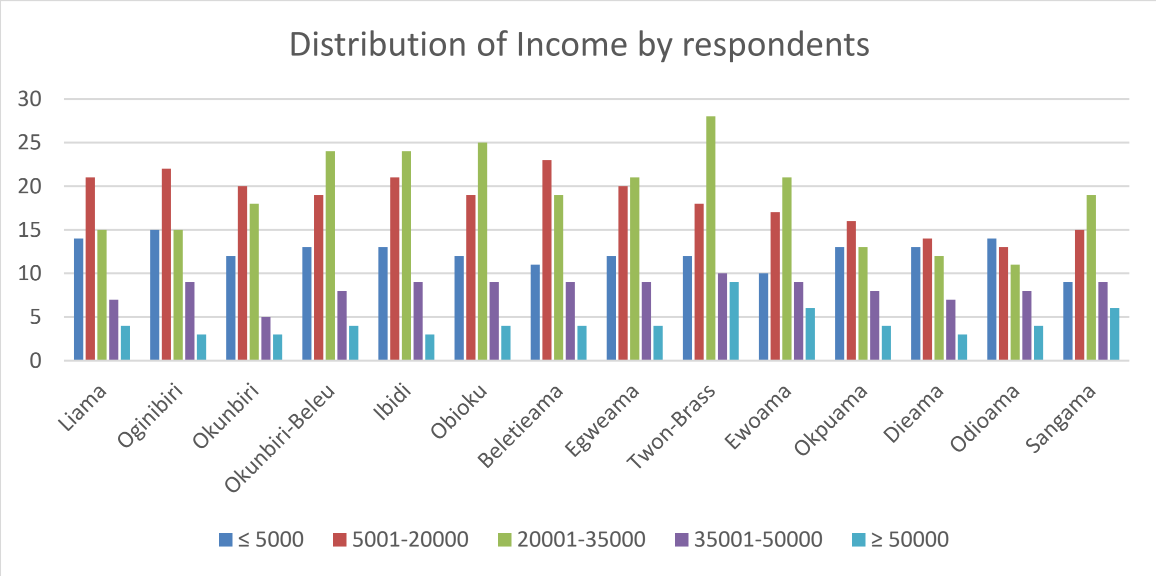


Communities	HDI	EDI
Liama	0.213	0.052
Oginibiri	0.221	0.061
Okunbiri	0.231	0.067
Okunbiri-Beleu	0.211	0.051
Ibidi	0.231	0.061
Obioku	0.123	0.062
Beletieama	0.231	0.064
Egweama	0.213	0.071
Twon-Brass	0.213	0.067
Ewoama	0.123	0.041
Okpuama	0.312	0.054
Dieama	0.231	0.056
Odioama	0.321	0.071
Sangama	0.231	0.061

Figure 4.34: Development Indices in the Study Area

Source: Field Survey, 2018

Income is one of the major determinants of household consumption, savings and expenditure. It is one of the most important variables that measure the welfare of households. It influences socio-economic status of individuals and its distribution pattern has the potential of influencing other demographic variables. Income distribution in the proposed project communities is presented in figure 12. Result shows that, over 50% of households earn between 5000 – 20,000 per month, about 40% earn between 20,001 – 35,000 per month. Less than 15% earn 50,000 and above. Analysis reveals that, concentration of income earners within 5000-35,000. This category of income earners are predominantly fisher folks and traders while income brackets of 35,001 -50,000 and above households are those with specialized skills working in oil companies, civil/public service, or contractors etc. Result shows that income earned by households is a function of skills acquired. These low-income group are mainly farmers and other artisans (unskilled), middle income earners (fisher folks, traders etc.) are semi-skilled while high income earners (Engineers, contractors etc.) are skilled personal (Figure 4.35).



Source: Field Survey, 2018

Figure 4.35: Income Distribution in the Study Area

Findings also reveals that personal income levels of self-employed rural households were difficult to assess because many rural household do not keep records of their income and are uncertain of their gross or net income. UNDP (2018) reported that, income levels have been found to be low in the Niger Delta region, with an average income of ₦5, 073 per month (about US$36 per month) which is lower than the national minimum wage of ₦7, 500 per month. There is considerable inequality in income distribution. A Gini coefficient index was used to determine the inequality index in the study area. For Bayelsa and Rivers, this coefficient stood at 0.4792 and 0.4757, respectively in 2004, a figure that is about equal to the national figure of 0.49 NBS (2004). In Brass, Nembe and Bonny Towns about 22% of households earn less than N10, 000 monthly while 26% and 66% in the Fishing settlements earn less than N10, 000 monthly. The high level of unemployment in the communities accounts for this low level of household incomes.

The distribution of respondents by occupational engagement is presented in figure 4.36. FGD session reveals that there is part-time or full-time engagement as shown above. Result shows that 84% of the households are into full-time engagement in fishing and trading/artisan, training while negligible proportion (24%) are into part time engagement in area of contract appointment, supplies and other secondary activities earlier discussed and SPDC (2011) estimated that, the annual income of households was N150,000 – N200,000.00.

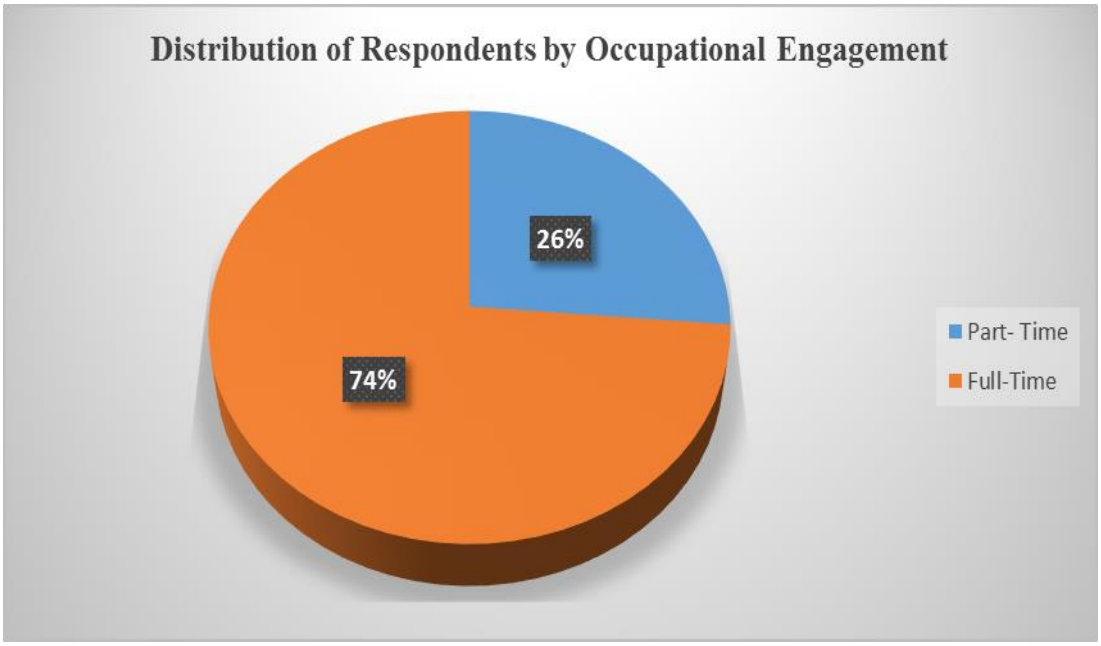
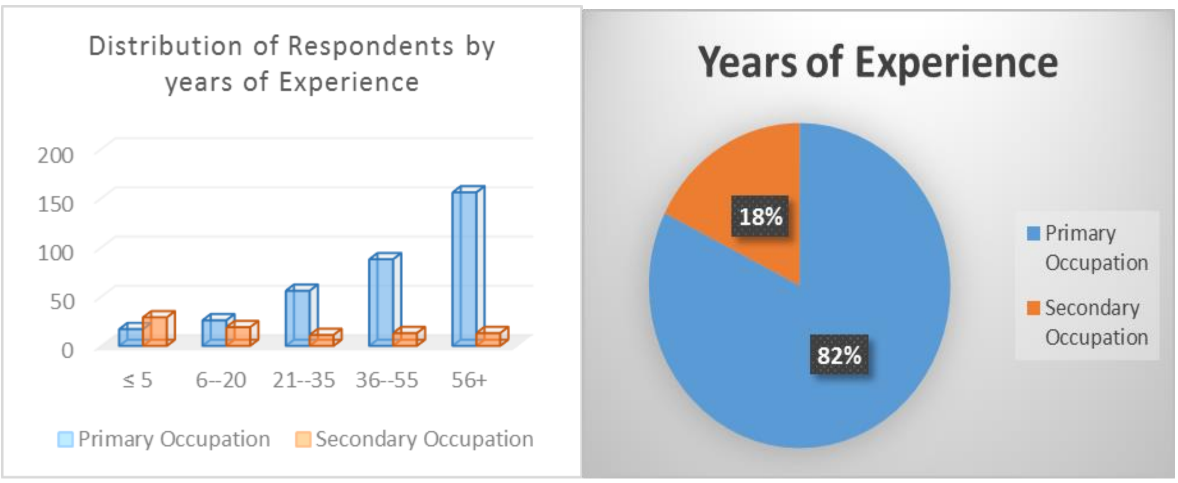


Figure 4.36: Distribution of respondents by Occupational Engagements
Source: Field survey, 2018

There are many studies that have linked years of experience to efficiency and wellbeing. Findings reveals that, the higher the experience gained by fishing/farming households in the study the better chances they stand in earning more income. Years of experience of occupation is presented in figures 13 and 14 (Figure 4.37). It shows that over 80% of households who engages in priming occupation have spent over 30 – 50 years. While those engaging in secondary occupation spent at least 5 to 20 years. Result further shows a paradigm shift from primary to secondary occupation. The reason was linked to explorative activities by the oil companies which has affected in some places restricted their fishing coverage in the study area. This result is consistent with NDRMP (2017) which stated oil exploration in Niger Delta region influences the growth of primary occupation (fishing, agriculture trading and water transportation.



Source: Field survey, 2018

Figure 4.37: Years of Experience in Primary Occupation (N)

Constraints to Major Productive Activities.

Table 4.34 shows constraints to major production activities in the project communities. During FGD session, discussants expressed concerns on constraints to production activities. These constraints were categorised under internal and external factors, except one factor that was crisis-cutting (access to market and market infrastructures. The internal factors identified are: low capital and knowledge/skills, inability to purchase or repair fishing gears, inadequate storage facilities, fire outbreaks in fishing settlements and external factors identified are oil potential, explorative activities by oil companies, high cost of transportation, restriction in fishing area due to facility installations, increase prices of inputs, as well as weak institutions. According to Mrs. Doukoro Pogonyo a 42 years old trader of Twon-Brass community says, *“if these problems are solved, we can do better in our communities”.*

Table 4.34: Constraints to Major Productive Activities

SN	Internal	External
1	Low capital	Oil pollution
2	Low knowledge and skills	Sea piracy ad robbery/kidnapping
3	Fishing gears	High cost of input
4	Inadequate storage facilities/preservation methods	Restriction in fishing area boundary disputes
5	Access to market and Market infrastructures	
6	Poor records keeping/	Weak social institutions
7	Fire outbreaks	

Source: Field Survey, 2018

Household Consumption and Expenditure

Figure 4.38 shows the consumption –expenditure profile of respondents in the proposed project communities. Many studies (SPDC and Akpan, (2014) linked household expenditure and consumption as a crude measure for quality of life. This is because the bundle of goods and services which the household can purchase is influenced by how much it can afford to spend on these items. Findings reveals that 53% income is spent on food and shelter/accommodation. These items are grouped under the basic necessities of life including clothing. Expenditure on education is 11% while communications/utility and transportation are 4% and 8% respectively. The availability of network providers (MTN, 9 mobile, glo etc) enhances inter personal communication, boost trade and other commercial as well as industrial activities in the study area. Households expenditure on health is 13%, social commitment, security and items grouped as “others” has a share of 7% and 4% respectively.

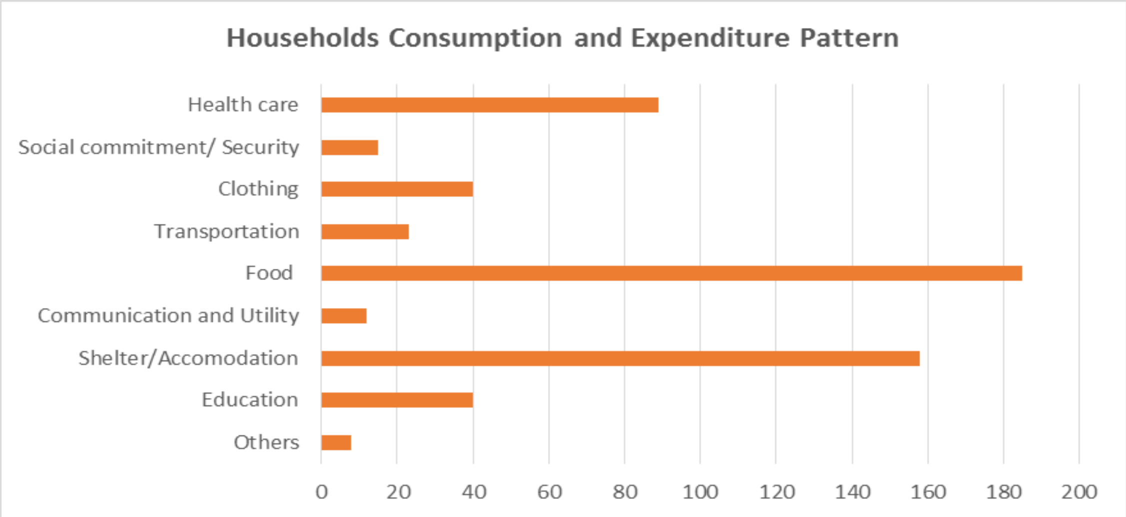


Figure 4.38: Household Consumption & Expenditure

Source: Field Survey, 2018

The implications are that, rural economy spend higher on basic consumables (food, shelter, clothing and transportation). It is astonished that, expenditure on health care is higher than education and clothing. This situation may be attributed to either poor hygienic conditions or due to environmental pollution caused by explorative industries in the study area. Increase expenditure on education is a measure of increase demand for educational services (at all levels) in the study area. The result is consistent with studies (Akpan, SPDC, Ebong) on household expenditure profile applicable in Bayelsa State and in the Niger Delta region of Nigeria. The prevalence prices of agricultural and non-agricultural goods are stated in Table 4.35.

Table 4.35: Prevalence Prices of Sampled Food and Non-Food Items

SN	Commodities	Prevalence Prices
1	Beans	50-80 a cup
2	Garri	10 cups for 100
3	Rice	80-100 a cup
4	Beef	300-500 a kolo
5	Palm oil	150-250 a bottle
6	Groundnut oil	500 a bottle
7	Salt	100-150 per cup
8	Fresh periwinkle	200 a cup
9	Eys	40 per Eys
10	Banana	1500-2000
11	Stock Fish	2300-2500
12	Magic Seasoning	250-300 a packet
13	Crayfish	500 a plate
14	Shirts	200-500 a modu
15	Roasted fish (average size)	200-250
16	Skirts	500-2000
17	Wrist Watches	400-1500
18	Wrapper	2500-5000 (Nipain Wax)
19	Rubber Slippers	250 a pier
20	Pepper (fresh)	200 a plate
21	Tomatoe	60 a tim
22	Equisi	250 per cup

SN	Commodities	Prevalence Prices
23	Ogbono	400 a wrap
24	Cover Shoes (open marker price)	1500-2500
25	Plastic buckets (medium size)	500
26	Fresh fish (average size)	1500
27	Plantain	2000-2500 a bunch
28	Paw-Paw/ Pineapple/Quara	200-500

Source: Field survey, 2018

Saving constitutes the basis for capital formation and accumulation, investment and growth of an economy at macro and micro levels as presented in Figure 4.39. During focus group discussion sessions, in the project communities, it reveals that, many informal financial institutions exist in the study area. More than 50% of the respondents save their money using traditional method of saving commonly referred to as (thrift association (***esusu***) with rotatory saving and credit associations. This is mostly done among the kindred's and associations, 20% keep their money at home and with groups/clubs called "professional clubs" respectively. Interestingly, about 10% saves their money in form of buying and storing of petroleum products (diesel, kerosene, petrol) in jerrycans, for future sales it is hopeful that in speculation prices will increase.

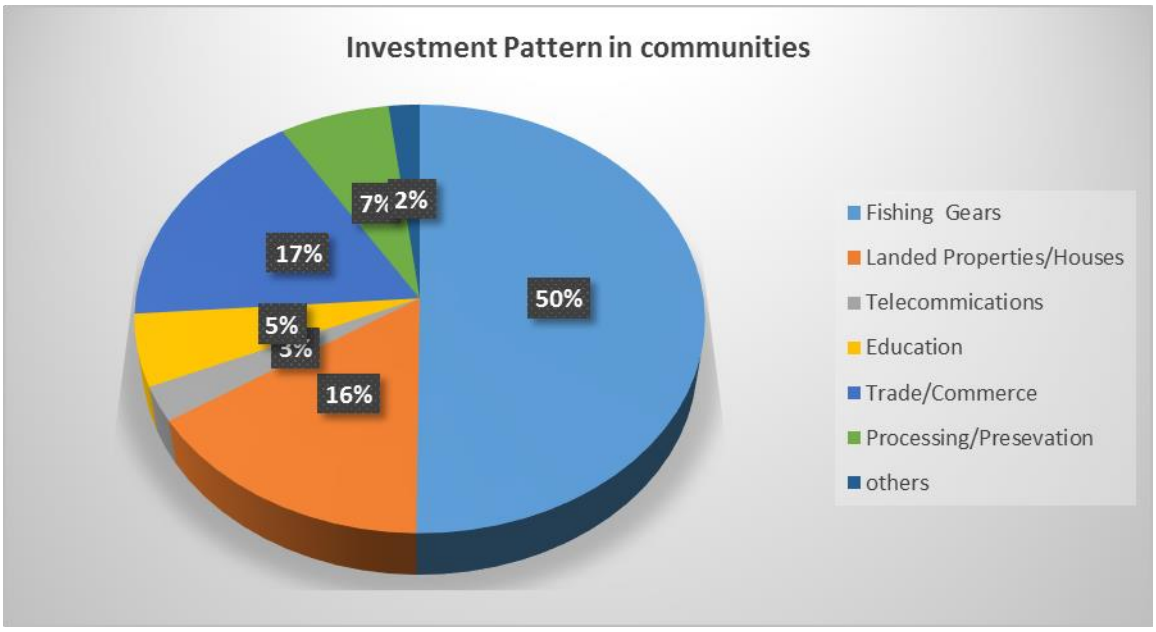


Figure 4.39: Annual Saving Modes and Investment Pattern

Source: Field survey, 2018

This saving mode was observed and practicable in all the communities across the proposed project area. Finding reveals that, 50% of household's investment is skewed to their primary occupation (fishing). The investment involves purchase of fishing gears and speed boats etc. qualitative information gathered during FGD & IDI sessions reveals that, 16% of households with huge financial status prefers building houses and renting out to migrant workers residing in the communities. Another area of household investment is in trade/commerce (17%), processing/preservation of fishes, (5%) on education and 2% for item group under others (Betgja, pools, etc).

Annual savings of the respondents across the communities was analysed and presented in Figure 4.40. Findings reveals that over 50% of the respondents saves between <50,000 – 100,000 annually from their primary occupation. 20% of some households in the study area saves between 201,000 – 30,000 annually while 5% saves between 301,000 to 401,000 and above. Over 20% of the households in the proposed project communities do not save due to very low-income status. This finding reveals that households who engages on fishing, farming saves lower than households who works either in multinational and other public institutions including contractors and traders. The study deduced that savings has been a culture of the households and serves as a safety net to many households in the study area. Generally, annual average savings in the study area is N200,000. Economically, savings are derived from income after deducting household consumption expenditure. A strong savings culture is expected to stimulate investment, all other things being equal. This study recommends that, community members need to cultivate a saving culture, particularly, using the banking system as this can qualify them for credit and other facilities from formal financial institutions which could be used for productive purposes.

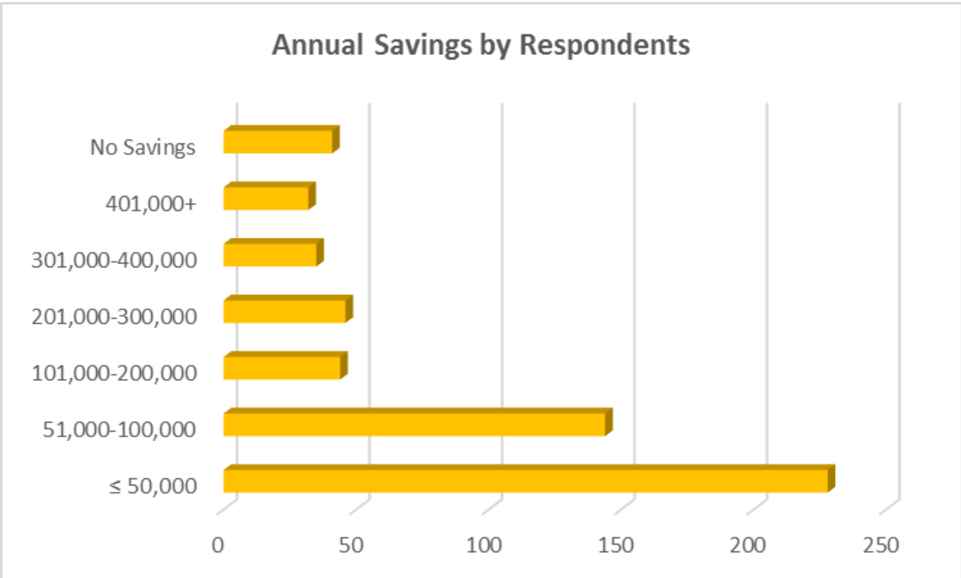


Figure 4.40: Annual Savings in the Study Area
Source: Field survey, 2018

One of the contending issues raised by the inhabitants across all the communities surveyed was changes in their fishing activities. As earlier presented in previous discourse, occupation, income, constraints to productive activities, and impacts on primary occupation of the households. Figure 4.41 shows the trend on primary occupation. Three domains of assessment were deployed in this study, namely no change in quantity, decreasing quantity and increasing quantity of fish catch. Result shows that 96% of the respondents agreed that, there is huge reduction/decline in quantity of fish harvested across the fishing ports in the study area. Only 4% affirmed that, there is no change (further probe reveals that, the few respondents (4%) spent less than 5 years in fishing.

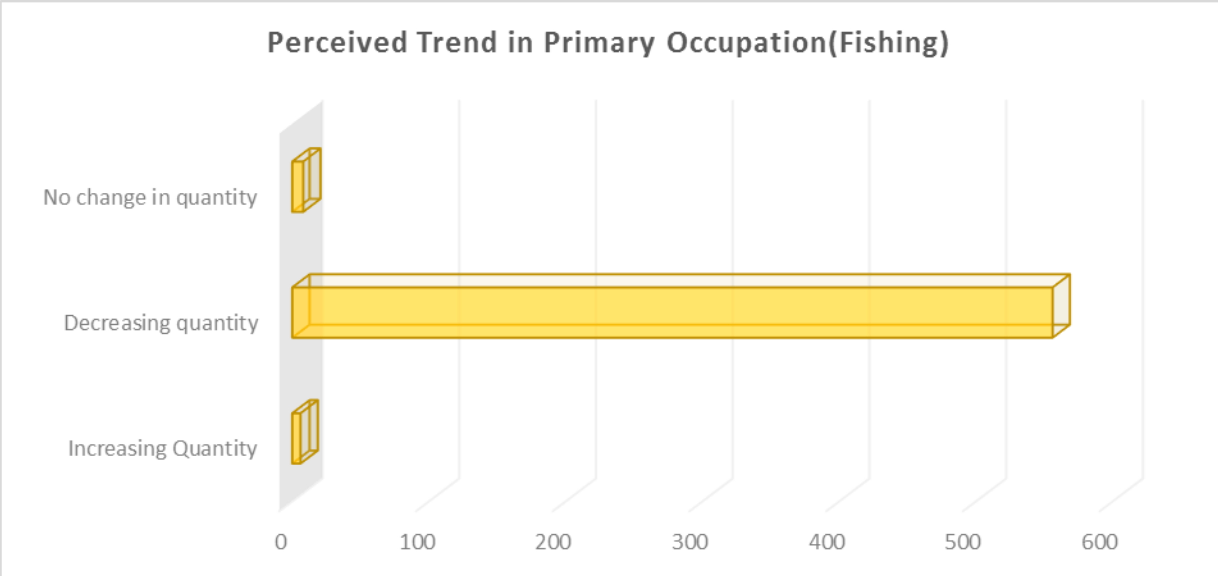


Figure 4.41: Perception of Respondents on Trend of Primary Occupation
Source: Field survey, 2018

4.9.9: Infrastructural Facilities & Quality of Life

One of the critical elements of development of any society is the availability of functional infrastructural facilities. Many studies have linked sustain growth and development to availability of infrastructural facilities. SPDC (2017) reported that the availability and quality of infrastructural facilities in a community to a large extent determine the quality of life in such community. Over 80% of impact assessment reports have shown that, SPDC has constructed, equipped and revitalized several infrastructural projects in the Niger Delta across sectors in over 450 communities. This is done under its social corporate responsibility or investments. Such investments included those in education, health, water and income-generating facilities, among others.

Road Infrastructures

Good road network in any society could facilitate the movement of goods and services especially farm produce/fishes from one place to another. During field visit, community visits infrastructure mapping reveals that, across the 14 communities there are evidence of roads constructed by SPDC, government, NDDC and other multinationals. These roads are grouped as follows: tarred road, untarred, footpath and jetties. There are feeder roads within the communities which make for easy intra-community movement of people and goods and services. Road transportation in these communities is by motor vehicles, heavy duty trucks, tricycles, commercial motor cycles, wheel barrows, and communities hand propeller trucks (Plate 4.26). Apart from road transportation, water transportation is an important affordable and accessible means of movement within and outside the proposed project communities. Observation reveals that water transportation is the major form of transport in the communities especially in Twon-Brass and other communities. All the water bodies in the communities within the radius of 5-20kms are accessible by water using outboard engines and hand-dug boats. There are several landed jetties that were constructed and donated to all the communities by SPDC.

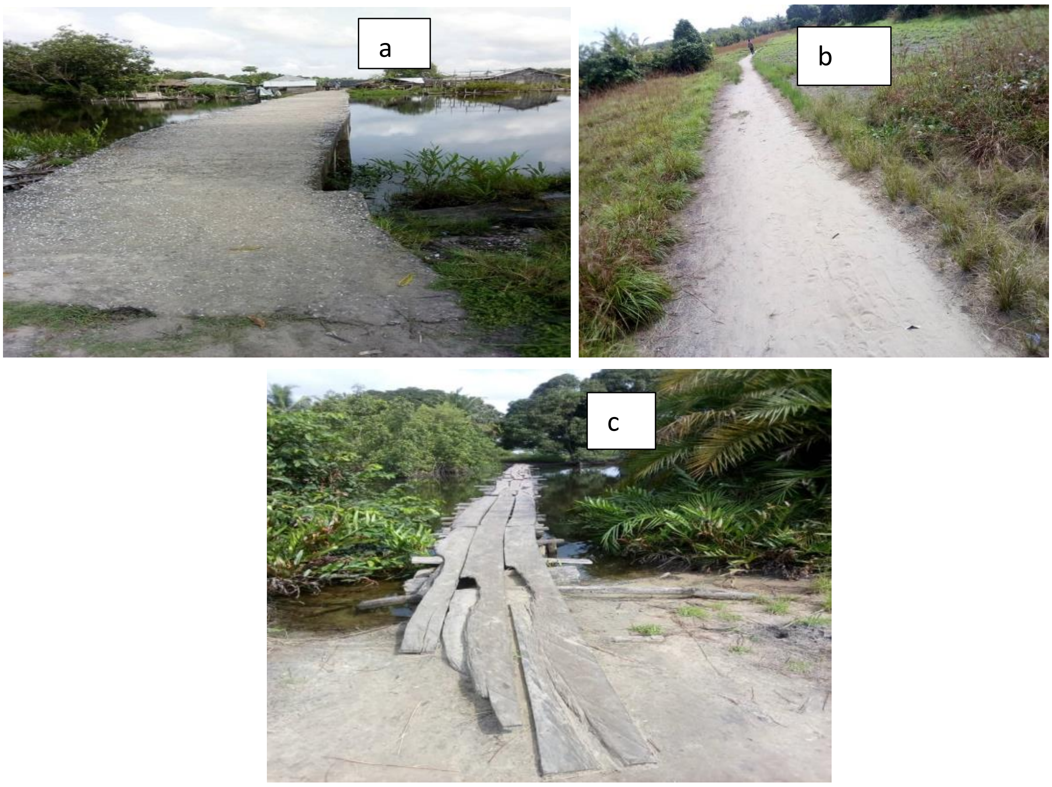


Plate 4.26: Available Road Infrastructures in the area (a-c)

Housing Type, Pattern, Quality and Ownership Status,

The housing pattern, type and structure with the study area reflect the coastal rural setting obtainable in similar communities in the Niger Delta region. Majority (84%) of the respondents live in their own-houses while few (18%) lived in rented apartments. House ownership could be an index of wealth and prosperity in a community. It was observed that, old traditional houses are aligned with modern bungalows and duplex constructed using both local (bamboo and wooden) as well as modern (bricks and zinc) made materials (Figure 4.42).

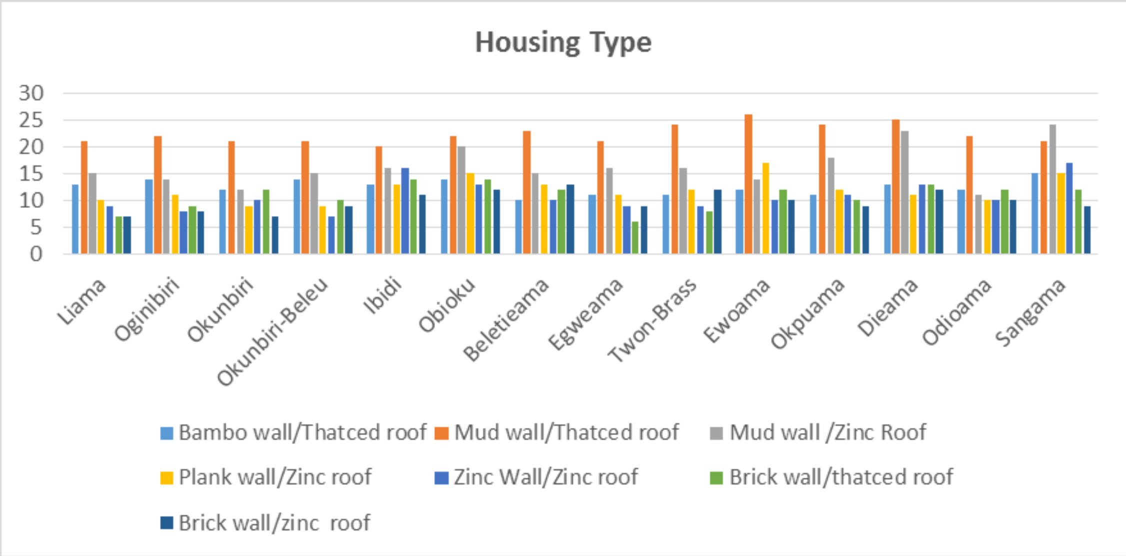


Figure 4.42: Housing Type, pattern and Quality and Ownership
Source: Field survey, 2018

The type of houses found in the study area are: bamboo wall with thatched roof, mud wall with thatched roof, mud wall with zinc roof, plank wall with zinc roof, zinc wall with zinc roof, brick wall with thatched roof, brick wall with zinc roof and others (bungalows), storey buildings). The predominant house type (56%) is mud wall with zinc and zinc wall with zinc roofs. Community expresses deep dissatisfaction over frequent replacement of roof due to acid rain and other hazardous chemical deposits. A good number of houses is also constructed with wooden planks and thatched roofs specially in the fishing settlements. The modern houses are built in flats with modal walling made of moulded cement blocks (bricks) and roofing materials made of long span corrugated aluminium sheets “some uses Cameroun zinc and Nigerian zinc” (Plate 4.27).

Plates 4.27: House Types in the Study Area (a-c)

Findings reveals that, most houses built with modern materials are good especially those located in permanent communities like Twon-Brass, Opuoama, Ibidi and Odioama etc. There high demand for houses in the area owing to influx of company and contract staff of companies. As an adaptation to both the high cost of conveying building materials from the town to the settlements and the environmental impacts of gas flaring including corrosion of roofs, most community members resort to building with zinc walls and roof as show in plates above. Generally, an average community member can afford accommodation either by building his/her apartment or by renting it.

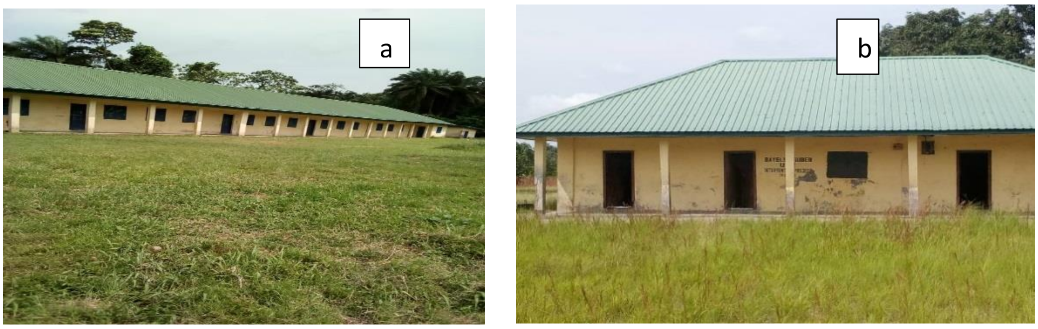
Possession of Household Properties

Household properties of members are categorized into two (2) assets and liabilities. Household assets mapped in the study communities include all serviceable items such as television and radio sets, motor vehicles, motorcycles and bicycles, number of engine and flying boats, drums/Jerrycans of fuel, phones, motor car(s)/vehicles/trucks, chairs/tables etc, computers, drums/ jerrycans of fuel, cooking utensils, fishing gears, building(s), refrigerators, generating set, non-serviceable household items (liabilities) were identify to include – unused fishing gears, unserviceable motor cars/bikes among others.

Educational Facilities (Primary, Secondary and Tertiary)

Access to educational facilities is one of the demands by the communities visited on the course of this study. There are several educational facilities across the proposed project.

These facilities are provided by private and public institutions including SPDC (Plate 4.28) and other multinationals. By observation, there are several public and privately-owned primary and post primary schools that provide education to the children. These schools relatively have capacities and structures that can be adjudged adequate for their pupils/students and teachers as at 2017/2018 school year. There are observable cases of dilapidated school blocks/halls, laboratories and libraries unfavourable for teaching and learning in some communities. One issue that came out strongly during the FGD session was the collective request for educational facilities in the study area. The support is in construction, security and payment of stipends to community hired teachers including bursary to students of higher institutions. At present according to UBEC, 2010, Bayelsa State is one of the states with highest number of pupil-teacher ratio in the South-South region of Nigeria.



Plates 4.28: School Block Constructed by SPDC (a&b)

Water Portable Water Supply Sanitation Facilities

Water, health and sanitation is an important asset of the people. Proper management of these assets enhances growth and reduces mortality rate and cost of medication. In the study communities, water supply and sources were identified. It reveals that all the fourteen (14) communities have water supported by SPDC. There are several abandoned and failed water facilities that was provided by agencies such as the defunct oil mineral producing and development commission (OMPADEC) in the eighties (80s) critical review of some related studies and publications by Natural Bureau of Statistics reveals that, water in communities of the Niger Delta states come from unsafe supply facilities, including rivers, lakes or ponds, unprotected wells or reservoirs and boreholes. The Bureau classify available sources of portable water for household consumption as: pipe borne, untreated pipe, borehole, protected well, unprotected well, river, Lake, Pond, vendor trucks and other categories. Observation and interaction with the community members also reveals that, there is alternative source of domestic water from the mono-pump (some not functional) which is also not portable due to fouling odour. Harvested rainwater is also used despite its contamination with carbon deposits. Health related effects are likely to be noticeable because of poor sources of water for domestic use (Plate 4.29).

Plates 4.29: Water sources in the communities (a&b)

Electricity Supply and Household Energy

Electricity supply is one of the major considerations of economic growth and trigger of development. The demand for power supply is increasing due to high power-electricity related activities. Observation and discussion with the community members reveal that, major towns, peri-urban and some satellite communities within the proposed project area are connected to the national grid of the power holding company (PHCN) have access to electricity especially Twon-Brass except some few settlements in the islands (Plate 4.30). SPDC, NDDC and defunct OMPADEC have played relevant roles in electricity distribution to the communities. Previous studies (SPDC 2014, 2017) narrated the impacts made by SPDC in supporting electricity supply in the project communities.

Findings from FGD sessions reveals that, SPDC and other multinationals have been supporting these communities through provision and fuelling of high-powered generators in the communities. Discussants affirms that, electricity supply in the communities have positive impacts on livelihood activities especially those operating business outfits such as barbing saloon, restaurants, welding shops, entertainment centres (Bet9ja), food preservation centres (cool rooms), tailoring shops as well as offices and other formal institutions. Study reveal that, most electricity facilities provided by the defunct OMPADEC has completely collapsed and malfunction and the people are anxious to have negotiations for possible reconnection.

Plates 4.30: Available sources of energy in the study area (a - c)

The discussants confirmed the availability of electricity at scheduled periods mainly from 4:45pm -6:20pm, 10:00pm, 2.00nm -2:4am. For communities using diesel, the reason for the rating is conservation of diesel while power holding distribution was equitable distribution. Similarly, household energy consumption by the communities is predominantly use of fuel wood fire wood. Over 60% of the respondents depend on fuel wood, 20% uses kerosene stoves while 10% uses gas as source of domestic energy. Discussants stressed that, the choice of household energy consumption is a direct function of their income. Findings deduced that, high income households use high cost energy (gas) while low income households used fuel wood as major source of domestic energy including solar power.

Communication and Major Means of Transportation -Jetties and communication facilities

Transportation and communication facilities are very important and essential elements of any society. There are organized means of transportation systems in all the propose communities (Plate 4.31). The means and types of transportation is informed by accessibility and type of activity to be embarked upon by the users. There are well constructed bridges, landing jetties and embankment in all the study area. Some communities are accessible by land and some by water. It was observed that appropriate and relevant means of transportation system were applicable. In terms of communication, both traditional (town announcer/crier) and modern (telecommunication) are still in use to designate information from one person to another. Modern telecommunication facilities or network provider available are: MTN, 9mobile, Glo, Airtel etc. individuals (80%) own mobile phones to facilitate communication in addition to television, radio sets and local as well as local and national tabloid (newspaper). Review reveals that, there is high demand for communication gadgets by the people.

Plates 4.31: Communication and Transportation facilities (a & b)

Recreational facilities and security

Availability of functional recreational facilities has a significant implication on quality of life and willingness of the people to live and remain there. SPDC (2014), Umoh and Akpan 2017 reported that, the number of functional social infrastructures has direct implications on the quality of life of citizenry. Finding reveals that bigger and permanent communities along the proposed project area has more and functional basic infrastructures than others while most of these facilities and amenities were provided by oil and gas companies especially SPDC and her partners. There are several private-oriented recreational facilities built and managed by the community members in addition to support facilities by government.

Several social and organizations meetings are held in these centres to discuss issues beneficial to the people. In some cases, it serves as a meeting points (hide out) to some mis-grants and criminal elements in the communities. They are usually busted by security agents and other vigilante groups in the communities. These facilities are civic centres, football pitch in open spaces, drinking parlours, among others. Beside the community security apparatus, there are heavy presence of government security personals i.e. Police, Army, Navy, Customs, Civil Defence, Military Police etc to boost security around the communities and facilities of SPDC and other oil and gas companies both on land and water.

Waste Management facilities

Domestic waste generated by households especially in core rural communities were seen disposed in nearby garden, except few houses deposited waste in waste bins and polythene bags. Human waste was deposited in water bodies close by using pie toilets (Plate 4.32) etc.

Plate 4.32: Pie toilet in the study area

Vehicular Volume Count (road and water), Origin and destination Survey, incidents and records of motoring Accidents

There is high volume of vehicular movement in the study area especially on land. For the past five to ten years there has been increasing occurrence of accidents in the study area due to vehicular movement of goods and services. The presence of Road safety and other security personnel especially Police and the military enhances smooth movement. Some communities that are not accessible by land experience high volume of movement of goods especially fish from the fishing settlement to another. Speed boats are usually used for this purpose. Traffic count both on water and land is relatively high. An average of 254 persons lost their lives in the past four years due to boat mishap (Plate 4.33).

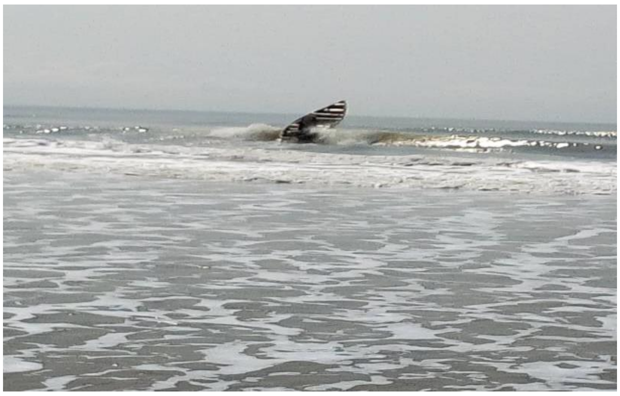


Plate 4.33: An incident of boat mishap in the study area

4.10: Perceptions, needs, interests, concerns and expectations from people's perceptions, fears and expectations of the projects

The relationship between the host communities and SPDC was described as good. The huge number of community members and their response during consultation and focus group discussions indicated that, the resident population is in support and acceptance of the proposed project OML 77 and 74 3D shoot seismic Data Acquisition Project. The reactions and participation of relevant community stakeholders reveals a high understanding of several of such oil and gas projects in the area. Over 80% of the residents expressed optimism that the proposed project could bring some positive socio-economic benefits to the communities.

The general disposition to the proposed project by the community members is predicated basically on the premise of positive benefits. The study critically s document the expected benefits likely to be felt from the project to include;

1. Award of scholarship which may likely gives more indigenes the opportunity to go to higher institutions.
2. Transportations and communication facilities and services; cargo boats, and GSM telephony facilities.
3. Create employment to qualified indigenes of the community which have attended and completed their studies in special fields in medicine, engineering, banking, etc.
4. Shoreline protection and embankment
5. Provision educational and health facilities to address the fear.
6. Construction of market and soft/interest free loan to women
7. Provision of basic infrastructure such as electricity, portable water, roads, recreational facilities, housing and security.
8. Improved tempo of economic activities through provision of electricity and other infrastructures.
9. Construction, equipping and rehabilitation of health facilities in the project area.
10. Construction and renovation of classroom blocks, science and technical laboratories/workshops in schools.
11. Construction and rehabilitation of landing jetties and bridges in the project communities.
12. Payment of compensation to deserving communities and indigenes on natural resource exploitation
13. Provision of security to indigenes to avert sea privacy which is a phenomenal threat in the project communities.
14. Suppliers in the communities to be considered in procurement and contract award.
15. Youth inclusion in key decision making between SPDC and the host proposed project communities.
16. Youths demands the payment of FTOs directly to them.
17. Construction of skill acquisition centre for the women and other physically challenged persons 18 Provision of preservation facilities example cool rooms.

Social problems and fears expressed by the communities.

Despite the anticipated benefits from the communities there are certain fears expressed by the respondents even the project. These include:

1. Reduction in quality and loss attain species of fishes (croaker) every other in the river.
2. Women frank bitterly over the issue of rape and violence especially on widows and activities of sea pirates.
3. The project may likely cause increase drugs intake and other substance abuse.
4. Economic hardship may increase due to slow pace of activities.
5. Increase crime rate, prostitution and cultism
6. Sickness and communal problems may arise.

7. Attack from unrepentant militants and kidnappers
8. Water pollution and land depredation from pipe laying may affect the communities' negatively.
9. Aquatic animals may migrate from the community.
10. Youth restiveness and teenage pregnancies are likely to occur amongst indigenous girls exposed to temptation of oil workers.
11. If expectations are nor implemented, it might likely bring rancour due to in transparency.
12. Reduction in number of endangered species (aquatic life)
13. Reduction of life expectancy of the inhabitants,
14. Possibility of oil spill and pollution is very high.

4.11: Health Impact Assessment (HIA)

This Health Impact Assessment (HIA) is a component of the Environmental Impact Assessment studies of the OML 77/74 host communities in Bayelsa and Rivers States. The HIA intends to provide information and insights into the quality of the health of the operational environment of the proposed seismic studies and oil and gas exploration in the area. The objectives of the HIA are:

1. To determine the demographic profile of the coastline host communities of the OML 77/74 field.
2. To describe the morbidity and mortality patterns in the host communities.
3. To assess the health care services infrastructure, types, and services rendered in the host communities.
4. To assess the knowledge, attitude, and health-seeking behaviours (KAB) of the people of the coastline host communities.
5. To evaluate the health care practices of the people of the coastline host communities.
6. To examine the environmental health factors/Concerns of the coastline host communities.

The data specific for this field study are as listed:

- The health facility inventory in the communities
- Data required to examine the morbidity and mortality pattern in the community; and
- Data to ascertain the quality of health care facilities/Health seeking behaviour of community members.
- Data required to ascertain the health and lifestyle Habits of members of the community.
- Data to assess public perceptions of the health impact of the project on the communities.

4.11.1: Demography

The population structure of the communities is typical of the developing countries, which represents a broad base of a young population and a narrow top, representing the population of the elderly and the aged. The communities are mainly rural, except for a few towns like Nembe and Twon Brass in Bayelsa State and Kula and Tombia in Rivers State. The area is populated predominantly by people of the Ijaw ethnic group, who are mainly fisherfolks, traders, and marine transporters wood loggers. There are reports in recent times, however, that the fishing yields have considerably declined over the last couple of years due to incessant crude oil spills and pollution of water bodies in the area.

Birth Rates

Over the years, a substantial increase in births has been recorded in both the Rivers and the Bayelsa communities. However, due to the prevailing weakness in the health care system, characterized by the preponderance of deliveries by traditional birth attendants (TBAs) and poor record keeping, it was impossible to accurately estimate the crude birth rate. Nevertheless, community residents during focus group discussions believed strongly that their population was rapidly growing compared to the past. The crude birth rate is the number of live births occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year. The Total Fertility Rate (TFR) which refers to the total number of children born or likely to be born to a woman in her lifetime if she were subject to the prevailing rate of age-specific fertility in the population is 4.8 in Bayelsa and 3.3 per 1,000 in Rivers. This measure is of great importance not only for determining the direction of motion of demographic trends, but it has application in determining the measures of population policy of a specific area or country.

Crude Death Rate (CDR)

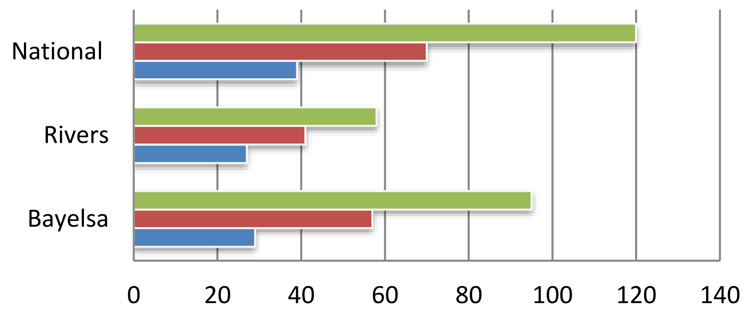
Deaths in the areas are said to be more predominant among children and young adults. The leading causes of deaths among children ranged from malaria, respiratory tract infections, measles and gastroenteritis and injuries from gang violence among young people. Among the elderly, diseases like hypertension, stroke and diabetes mellitus and cancer were often implicated. Crude death rate is the number of deaths occurring among the population of a given geographical area during a given year, per 1,000 mid-year total population of the given geographical area during the same year. An approximated total of 9.2 deaths per 1,000 population occurred in the Bayelsa communities and 7.8 per 1,000 population in the Rivers State communities in one year. These figures might have been grossly underestimated. Nevertheless, they are slightly higher than the National average of 12.5 per 1,000 persons per annum. (World Bank, 2017) From the focus group discussions, it was clear that most of the deaths occurred among women while trying to give birth and among children aged five years and below, as well as high gang and cult violence in the area.

Neonatal Mortality Rate (NMR)

The neonatal mortality rate in the Bayelsa axis is 29 per 1,000 live births, while that of the Rivers State axis is 27 per 1,000 live births. (NBS/UNICEF, 2017) Neonatal mortality measures the number of neonates, i.e., children aged zero to one month who die before they are one month old per 1,000 live births. This indicator brings to the fore problems related to or arising during pregnancy, like congenital abnormalities, low birth weight; problems of delivery like birth injuries, asphyxia; and problems that occur after delivery like neonatal tetanus infection and septicaemia. It reflects the weak health care system, in terms of qualified health care workforce, equipment and drugs. The high neonatal mortality rate observed could be related with the large number of births attended to by Traditional Birth Attendants (TBAs) in both axes of project area.

Infant Mortality Rate (IMR)

An infant mortality rate of 57 per 1,000 live births was reported in the Bayelsa communities over one year period, while in the Rivers communities, 41 per 1,000 live births were recorded. These indicators are significantly lower than the national average of 69 per 1000 live births (NPC, 2014) and 70 per 1,000 live births respectively (Figure 4.43). (NBS/UNICEF, 2017) The intensified National immunization campaigns and such nationwide vertical programmes as the Maternal, Newborn and Child Health week services that carry out immunization and other health care services might have contributed to the improvement. Infant mortality measures the probability of a child dying before his or her first birthday. It is defined as the number of children's deaths in the first year of life per 1,000 live births. This indicator indirectly measures the quality of childcare, including the prevention and management of childhood illnesses. It speaks specifically about the state of the health care, its common weaknesses and the socioeconomic conditions in general. Nigeria has recorded a decline in its infant mortality rate from 79 per 1000 live births in 2011 to 69 per 1000 live births in 2015. (UNICEF/WHO/World Bank/UN DESA, 2015)



	Bayelsa	Rivers	National
Under-five mortality rate*	95	58	120
Infant mortality rate*	57	41	70
Neonatal mortality rate*	29	27	39

Figure 4.43. Mortality rates among the children population

Under-Five Mortality Rate (U-5MR)

The U-5 mortality rate in the Bayelsa axis is 95 per 1,000, and that of the Rivers axis is 58 per 1,000. The figure is significantly lower than the national average of 120 per 1000 (NBS/UNICEF, 2017). Under-five mortality is the annual number of deaths of children under five years of age per 1,000 live births. It is measured as the number of children dying before the age of 5 years in the community per 1000 population. This health care indicator mirrors the health care services and utilization available to the people, the socioeconomic effects of poverty, undernutrition and basic sanitation.

Maternal Mortality Rate (MMR)

Information from women in the communities during focus discussions (FGDs) pointed out that maternal mortality is common in both the Bayelsa and Rivers communities under reference but could not quantify it. The discussants attributed the problem to the paucity of good quality health care facilities in the areas and the cultural practice of delivery by elderly women, who are said to be traditional birth attendants. Unfortunately, however, neither the weak health care system, nor these TBAs are able to manage the direct causes of maternal deaths during delivery, which include; severe bleeding, infection, high blood pressure, which occurred or worsened during pregnancy (pre-eclampsis or eclampsia), obstructed labour due to incompetent pelvis, and unsafe abortion. (WHO, 2014a) Maternal mortality ratio represents the annual number of deaths of women due to pregnancy, childbirth and puerperal conditions. It is the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and the site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes. From the account provided the FGDs and KIIs it obvious that women in the area are exposed to a high risk of dying while giving birth because of lack of qualified health care workers who could rescue pregnant women from pregnancy-related complications and adverse puerperal conditions.

4.11.2: Health Profile

Healthcare Facilities (Bayelsa State Axis)

The thrust of Primary Health Care (PHC) is to make good quality health care accessible and affordable to the people, especially the most vulnerable in society- women and children. In the Bayelsa axis, a total of three hospitals, nine healthcare centres, two health posts, and several patent medicine vendors operate at different levels of functionality. Others are unorthodox health care practitioners in the area are traditional medicine practitioners, herbalists, traditional birth attendants, and spiritual healers. The distribution of the healthcare facilities is displayed in Table 4.36.

Table 4.36: Types of Available Health Care Facilities

Distribution of Health Facilities Available in the communities						
Communities	Hospital	Primary Health Centre	Health Post	Traditional Medicine Healers	Patent Medicine Stores	Traditional Birth Attendants (TBAs)
Obioku	0	1	0	0	0	4
Odioma	0	1	0	1	1	3
Ibidi	0	0	0	1	1	3
Twon Brass	1	1	0	3	5	3
Okpoama	1	2	0	3	4	3
Beletiama	0	0	0	1	1	0

Distribution of Health Facilities Available in the communities						
Communities	Hospital	Primary Health Centre	Health Post	Traditional Medicine Healers	Patent Medicine Stores	Traditional Birth Attendants (TBAs)
Egweama	0	1	0	5	5	4
Ewoama	0	0	0	0	1	1
Sangana	1	0	0	1	7	1
Oginibiri	0	1	1	0	1	1
Okumbiribeleu	0	0	1	0	1	1
Liama	0	0	0	3	1	2
Dieama	0	1	0	3	1	3
Okunbiri (Opu-Okunbiri)	0	1	0	1	2	2

Healthcare Facilities (Rivers State Axis)

Availability and access to health care facilities varied in the communities and the distribution is represented in Table 4.37

Table 4.37: Types of Available Health Care Facilities

Type of Health Facilities						
Communities	**Hospital**	**Primary Health Centre**	**Health Post**	**Traditional Medicine Healers**	**Patent Medicine Stores**	**Traditional Birth Attendants (TBAs)**
Kula	0	1	0	3	7	5
Tombia		1	0	2	4	3
Elem Sangama	0	1	0	1	2	2
Abissa	0	1	0	2	2	2
Bakana	0	1	0	2	4	3
Abaji Okolo	0	0	0	2	0	1

Quality of health care facilities/health seeking behaviours of community members

Among the hospitals existing in the Bayelsa axis, the Sangana Cottage hospital was built by the Texaco Company and has one medical doctor in attendance. The hospital at Twon Brass has two doctors and three nurses in attendance, while the hospital at Okpoma also has a doctor in attendance. Most of the health centres are staffed by nurses and community health care officers. Nevertheless, there is a general shortage of qualified health workforce in these health care facilities. Many of the health workers reside in the state capital, Yenagoa and only visit the communities on specific days of the week. They complain about the lack of essential amenities and social infrastructures, like potable water, healthful accommodation, electricity and good schools for their children to attend. Some blame their non-residence in the communities on security, which they say is fragile because of the difficult terrain, that make it very easy for people to commit a crime and get away quickly without being arrested.

The Rivers State axis has five primary health care centres, in each of the communities, and a good number of patent medicine vendors and traditional birth attendants. Like the Bayelsa axis, these health centres are located within the communities, such that physical access does not constitute any problems to the people. However, one common feature of these health facilities is the non-availability of relevant drugs, equipment, and other supplies in sufficient variety and quantity. Necessary equipment like Sphygmomanometers, weighing scales, suction machines, thermometers, sterilization equipment, etc., are lacking. In most of the communities, medical services are limited to immunization services, that take place mainly during the national immunization campaign days and others, such as the maternal, newborn and child health outreach programmes that are nationwide in scope and are carried out on specific dates of the year for women and children.

For these and other reasons, the services provided the health care facilities in the area are very limited in scope and depth. The inhabitants of the area are, thus, compelled to make do with what is available, which are the services of patent medicine vendors, most of whom are without any form of medical training; traditional birth attendants, and herbalists. The patronage of these unskilled or poorly skilled health care service providers has severe consequences for the life of the people, especially for pregnant women and their unborn children. This fact was corroborated during focus group discussions with the men, women and youth groups. Moreover, this practice is not without some consequences because a good number of these perceived remedies sometimes come with side effects that might adversely compromise vital organs of the body like the liver, the kidneys, gastric system and the nervous system. Many of the drugs do not have clear cut doses and are used for multiple disease conditions simultaneously.

Medical emergencies and severe illnesses are usually referred out to the nearest general hospitals closest to the area. For communities in the Rivers State axis, the Degema General hospital or Abonnema General Hospital and sometimes, the University of Port Harcourt Teaching Hospital in Port Harcourt, or the Braithwaite Memorial Specialist Hospital (BMSH), both in Port Harcourt serve as referral centres. For communities in the Bayelsa State axis, medical evacuations are referred to the Nembe General Hospital or the Federal Medical Centre at Yenagoa. All the referral hospitals are quite some distance from the communities. In many instances, acutely or severely persons hardly make it alive to these centres because of the distance and the stress associated with the journey.

Morbidity Pattern

Common diseases in the area based on the health facility records of the Ministries of Health are infectious/communicable and non-communicable diseases. The common diseases found predominantly among the adult population include hypertension, stroke, diabetes mellitus, arthritis, pregnancy and birth-related complications in women, chronic liver disease, and chronic respiratory tract infections, inguinoscrotal hernia, peptic ulcer, injuries, and burns, etc (Figure 4.44 & 4.45).

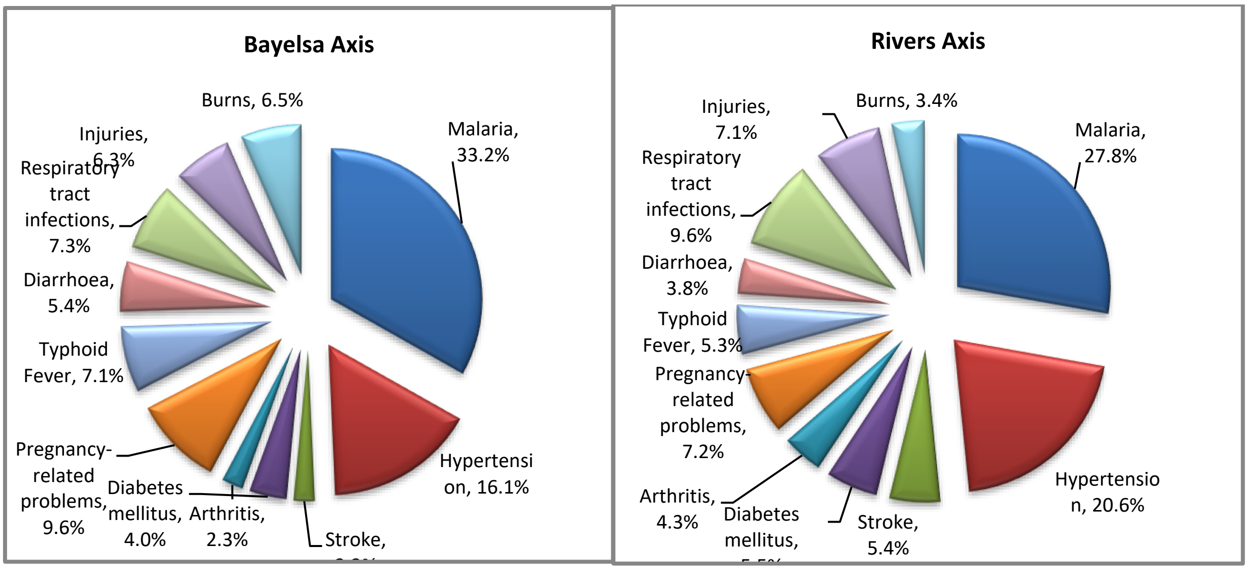


Figure 4.44: Disease Pattern in Bayelsa axis

Among the children, common diseases include malaria, febrile convulsions, respiratory tract infections, diarrhoea, skin lesions, worm infestations, measles, neonatal tetanus, and septicaemia, especially among children. It has remained the predominance of infectious diseases, especially among children with a recent gradual but steady rise in the prevalence of non-communicable diseases. Of these, greatest importance is attributed to malaria, diarrhea and acute respiratory infections.

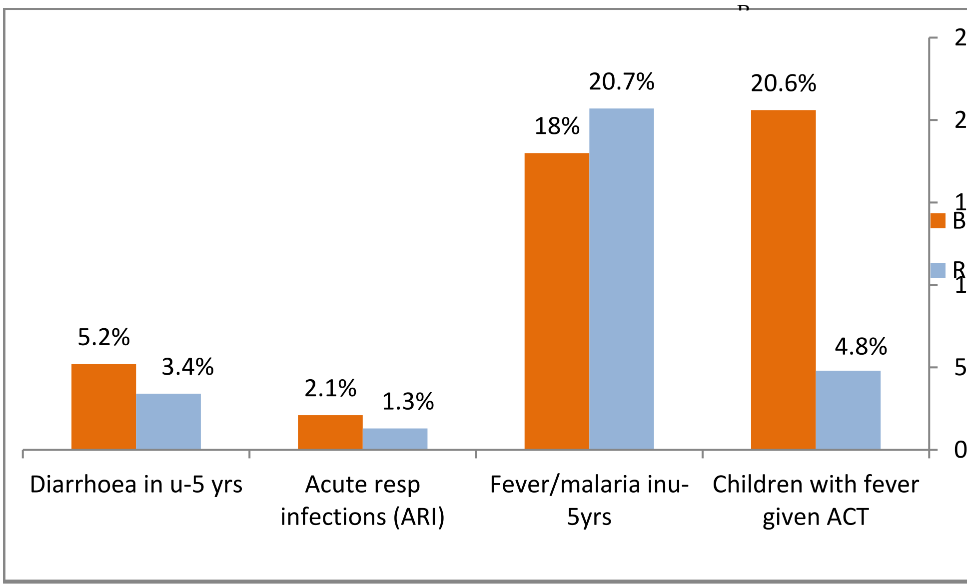


Figure 4.45: Morbidity Pattern Of The Children Under Five Years

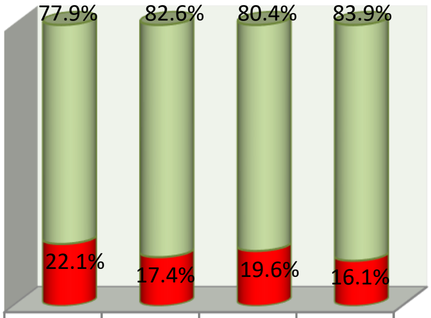
It is pertinent to note that malaria remains the highest disease burden in all the communities. Nigeria experiences an estimated 100 million malaria cases with over 300,000 deaths per year, with most of these deaths occurring in children. (WHO, 2015a). Nevertheless, various efforts by governments at different levels in Nigeria to stem the tide have not yielded the desired results. For instance, the vector control method of the use of insecticide-treated bednets (ITNs) to control malaria is yet to have universal acceptance and application. The method has struggled to get entrenched as a proven game changer. Table 4.38 shows the level of possession of ITNs and their use in households in the project areas. It is important to observe that possession and utilization of ITNs have remained not only low but inconsistent. A lot has been said about the inconveniences or discomfort associated it their usage, such as excessive heat. (Pulford al, 2011)

Table 4.38: The Possession and use of ITNs

Variable	Bayelsa (%)	Rivers (%)	Nigeria (%)
Percentage of population with access to an ITN in the household	37.9	27.8	49.5
Percentage of insecticide-treated nets (ITNs) that were used by anyone last night	65.4	57.2	69.1
Percentage of children age 0-59 months who slept under an ITN last night	36.8	29.8	49.1
Percentage of pregnant women age 15-49 years who slept under a mosquito net last night	11.8	11.6	39.6

Blood Pressure Profile of Adults

The blood pressure (BP) profile of the host communities showed that 77.9% and 80.4% of the males in Rivers and Bayelsa areas had normal blood pressure values, while 82.6% and 83.9% of the females in the Rivers and Bayelsa axes also had normal blood pressure. On the contrary, 22.1% and 19.6% of the males in Rivers and Bayelsa had elevated blood pressure, and 17.4% and 16.1% of the females in Rivers and Bayelsa had elevated blood pressure (Figure 4.46). Elevated blood pressure is when the systolic BP is above 140mm Hg or the diastolic BP is more than 100mm Hg. The obtained results were within the range in most other communities of the Niger Delta region and similar to reports from other parts of Nigeria, which is between 10% and 20%. (Akintunde, 2009) Hypertension causes over 5 million premature deaths globally each year and is a known risk factor for several chronic morbidities which include kidney failure, cardiovascular diseases and stroke. (WHO, 2015b).

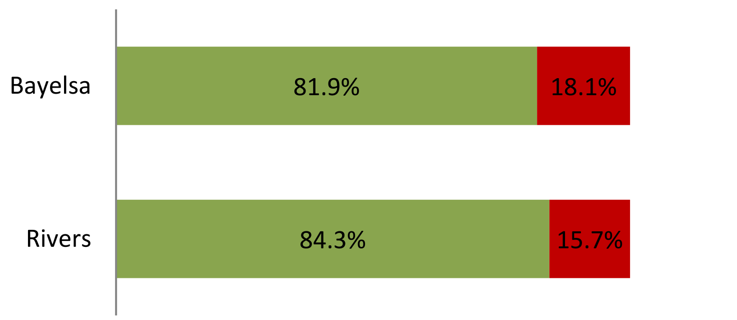


	Rivers		Bayelsa	
	Male	Female	Male	Female
Normal	77.9%	82.6%	80.4%	83.9%
High	22.1%	17.4%	19.6%	16.1%

Figure 4.46: Blood pressure profile in the communities

Assessment of Respiratory Functions

The forced vital capacity (FVC) of the lungs was used to determine the lung functions of adults in the project area. This was with a view to determining any airflow obstruction amongst sample. Forced vital capacity is defined as the amount of air that could be exhaled with force from the lungs after taking the deepest breath possible. Most healthy people will achieve values 3-5 litres, while individuals with compromised lung functions achieve much lower values, usually below 2.0-2.5 litres. Of those examined (81.29%) had normal FVC in the Bayelsa axis and (84.3%) had normal FVC in the Rivers axis (Figure 4.47). However, 18.1% and 15.7% had low FVC in the Bayelsa and Rivers axes respectively. Low FVC may be due to disease conditions like asthma or persistent indoor pollution from cooking fuels from domestic smoke, fossil fuels, as well as form gas particles from gas flaring sites for those residing close to the flare sites. All these factors contribute to the narrowing of the airways, thus compromising the lung functions and tissue perfusion in the affected individuals.

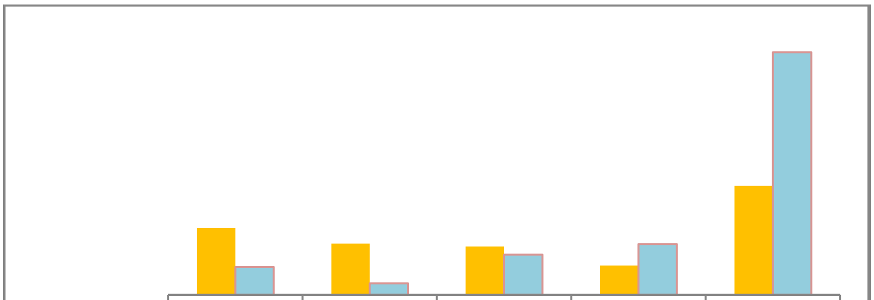


	Rivers	Bayelsa
Normal	84.3%	81.9%
Poor	15.7%	18.1%

Figure 4.47: Respiratory function in Rivers and Bayelsa axes

Maternal Health

Women’s health is to a considerable extent influenced by their access to reproductive health services (Figure 4.48). Therefore, ensuring unhindered access to good quality reproductive health services is a cardinal point in the reduction of maternal deaths and disabilities. And guarantees women’s contribution to the nation's socioeconomic value chain and upholds their human rights. Access to modern contraception, antenatal and delivery care services as well as the prevention of teenage pregnancies are important landmarks to consider in building a healthy environment for women. In the Bayelsa State axis, as much as 23.1% of the pregnant women had no antenatal care compared to 9.6% in Rivers State. Antenatal care service is a part of birth preparedness for a woman. It is a period for health promotion, disease prevention, early detection and treatment of complications, birth preparedness and complication readiness. The World Health organization new guideline recommends that a pregnant woman should at least eight contacts with her health care providers before delivery for a positive pregnancy experience. As part of antenatal care service, a woman is to receive preventive care for malaria, which is one of the most dreaded harmful health conditions in pregnancy. From our study, only 17.7 and 4% of the women, respectively received this service in both the Bayelsa and Rivers communities. Both areas are lagging and need improvement.



	Pregnant women without ANC	Pregnant women who took IPT during ANC	Teenage pregnancy rate	Use of any modern contraception	Skilled attendants at delivery
Bayelsa	23.1%	17.7%	16.7%	10.1%	37.6%
Rivers	9.6%	4.0%	13.9%	17.5%	83.7%

Figure 4.48: Women’s health access indicators

Concerning the use of any modern contraception, only 10.1% of the women in the Bayelsa and 17.5% in the Rivers axes have access. The benefits of effective contraception on maternal health can never be overemphasized. They include, child spacing to enable women to recover from the effects of previous pregnancy, reduce pregnancy-related risks, prevent teenage pregnancies and avoid unsafe abortions, and other economic benefits. Cleland et al., (2012) Young adolescents face a higher risk of complications and deaths because of pregnancy than other women. Despite the enormous advantages contraception confers to the reproductive health of women, its use has remained abysmally low in Nigeria and many developing countries.

According to the WHO, every day, approximately 830 women die from preventable causes related to pregnancy and childbirth globally. (WHO 2016) Almost all these maternal deaths (99%) of all occur in developing countries. These deaths are higher in women living in rural areas and among more deprived communities. Skilled care before, during and after childbirth can save the lives of women and newborn babies. It remains the only proven strategy to save the lives of women during delivery as the critical complications of delivery and puerperium which are haemorrhage, eclampsia, septicaemia, and criminal abortion can only be managed successfully by a skilled attendant at labour. (WHO 2016) Nevertheless, our study shows that for Bayelsa, only 37.6% of the deliveries were attended by skilled attendants, which are doctors, nurses, and midwives. This is against 83.7% for Rivers. The reasons are not far-fetched. Many rural and remote communities lack the needed resources; human, equipment, structures and drugs; and the funds for running effective and efficient health care. This is also coupled with the sociocultural attachment of the people in the age-long practice of patronizing traditional birth attendants.

4.11.3: Nutritional Status and Household Food Security

The dietary pattern in the project area comprises of the usual Nigeria staples made up of protein, carbohydrate, fat, vitamin, mineral, fibre, and water. There are also a variety of fruits and vegetables such as oranges, garden eggs, cucumber, etc. However, complaints about the high cost of food items, including fish which is native to the area is common among the people. This they attribute to diminishing household incomes. Some respondents claim that food security in their communities is threatened because of occasional security challenges that occur in the area. Among the children, the cultural practice of breastfeeding by women is very much practiced. However, many women have problems with the concept of exclusive breastfeeding, which they erroneously believe might adversely affect the nourishment of their babies because water, an important component for nourishment of the human body is not recommended in exclusive breastfeeding. By observation, most children appear well nourished. The nutritional status of children less than five years of age in the areas are provided in Figure 4.49.

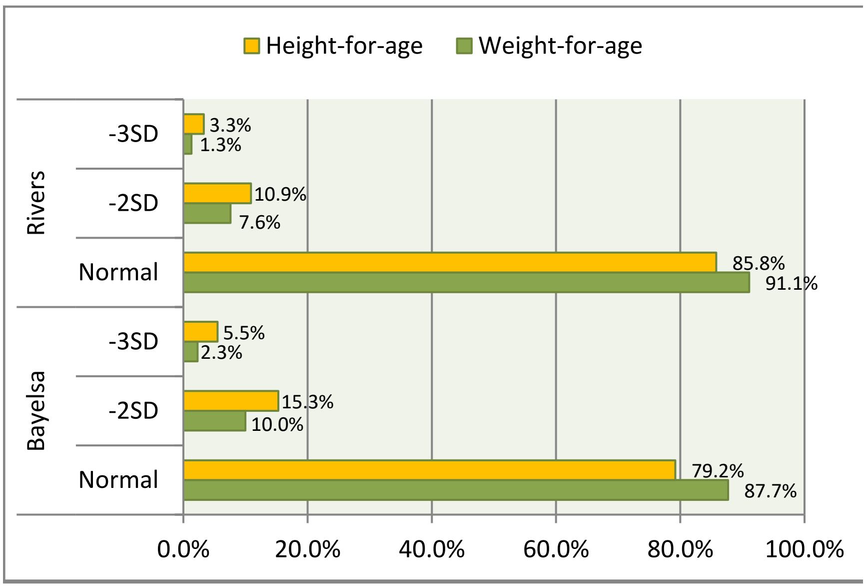


Figure 4.49 Nutritional status of children under five years

Nutritional status of children under five years of age is measured by the weight-for age and height-for–age parameters. Weight-for-age is a measure of both acute and chronic malnutrition. Children whose weight-for-age is two standard deviations below the median of the reference population are considered moderately underweight, while those whose weight-for-age is more than three standard deviations below the median are classified as severely underweight. This is an indication of failure to thrive or gain weight because of acute malnutrition from food shortages and other disease conditions like chronic diarrhoea, other chronic infections or immunodeficiency diseases, etc.

Nutritional values of the communities in the Bayelsa axis showed that 87.7% had normal weight-for-age, 10.0% were wasted (moderate weight-for-age), while 2.3% were severely wasted. In the communities of the Rivers axis, 91.1% had normal weight-for-age, 7.6% moderately wasted and 1.3% severely wasted.

Height-for-age is a measure of linear growth. When height-for-age is more than two standard deviations below the median value of the reference population, it is taken as short for their age and classified as moderate stunting. Children whose height-for-age is more than three standard deviations below the median are classified as severely stunted. Stunting is a reflection of chronic malnutrition as a result of failure to receive adequate nutrition over a long period and recurrent or chronic illness or prolonged adverse socioeconomic conditions**.**

Finding in the Bayelsa axis showed that 79.2% had normal height-for-age, 15.3% moderate height-for-age, and 5.5% had severe stunting. In the communities in the Rivers axis, 85.8% had normal height-for-age, 10.9% had moderate height-for-age, while 3.3% had severe height-for-age (stunted). These nutritional values are consistent with what generally prevails in the Niger Delta region. Other reasons why children slide into malnutrition apart from infections include, poor household hygiene practices, such as poor hand washing culture, and filthy environment, open disposal of sewage around living areas, and lack of potable water. Malnutrition influences the development of infections in children due to their underdeveloped immune system. (Abidoye & Tobin-West, 1999) It also predisposes children to cognitive impairment and learning difficulties. (Ricci *et al*., 2006)

4.11.4: Children Vaccinations

The percentage of children age 12-23 months and 24-35 months vaccinated against vaccine-preventable childhood diseases at any time before the survey and by their first birthday is presented in Table 4.39. A child is considered to be fully vaccinated if he/she has received a dose of BCG *(Bacillus Calmette-Guérin)* vaccine, at least three doses of Polio vaccine, three doses of Pentavalent vaccine (Diphtheria, Pertussis, Tetanus, *Hemophilus Influenza* Type B and Hepatitis B), one of Measles containing vaccine (MCV), Inactivated Polio vaccine (IPV) and Yellow Fever vaccine. Immunization coverage is said to be full in a situation whereby children have received all antigens defined by the Expanded Programme on Immunization (EPI) without regard to the specified age or time interval between doses as prescribed by the national schedule.

Table 4.39: Immunization Status of Children under-five years of age

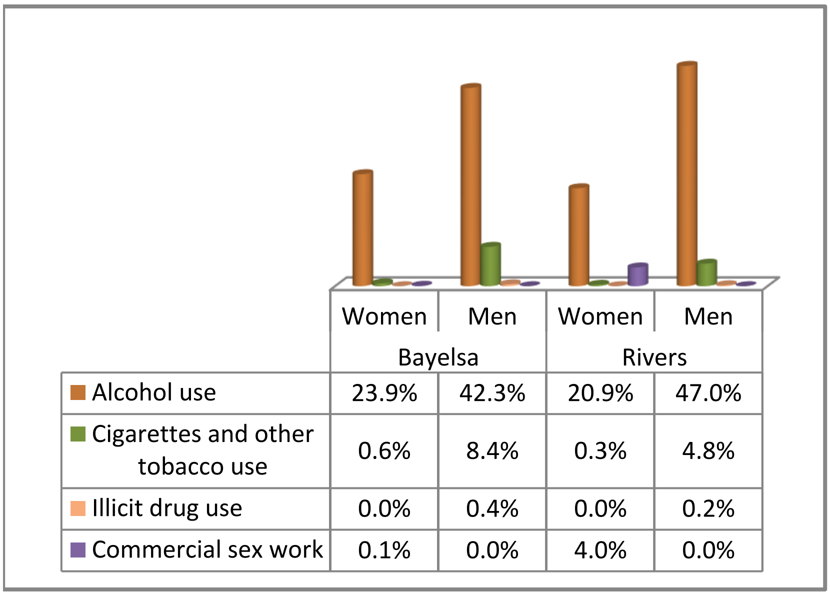
Antigen	Description	Bayelsa (%)	Rivers (%)
BCG	Children 12-23 months who received BCG vaccine by their 1st birthday	65.9	82.0
Hepatitis B	Children 12-23 months who received the 3rd dose of Hepatitis B vaccine by their 1st birthday	33.9	61.7
Oral Polio 3	Children 12-23 months who received the 3rd dose of OPV vaccine by their 1st birthday	35.4	56.0
Pentavalent 3	Children 12-23 months who received the 3rd dose of Pentavalent (DPT3) by their 1st birthday	4.6	66.0
Yellow fever	Children age 12-23 months who received yellow fever vaccine by their 1st birthday	45.8	69.4
Measles (MCV1)	Children age 12-23 months who received measles vaccine by their first birthday	51.6	70.7
Fully Immunized	Children age 12-23 months who received all the recommended vaccines by their 1st birthday.	28.5	44.8

The national target for immunization is to achieve a 'herd immunity' which is the resistance to the spread of infectious disease in a group or community because susceptible members of the community are few, making transmission in that community unlikely. Conservatively 'herd immunity' is said to occur when at least 80% of the children in a community are immunized for each of the specified childhood killer diseases. Herd immunity has remained elusive up till now in nearly all parts of Nigeria thus far. Some challenges have been revealed, and these include the difficulty in movement in the riverine terrain of the area and the frequent security breaches which have prevented or discouraged the health care workers in carrying out immunization activities. Immunization remains the most cost-effective interventions in the prevention of early childhood illnesses, disabilities, and early deaths. It currently averts an estimated 2 to 3 million deaths every year, according to the World Health Organization. (WHO, 2015a)

4.11.5: Social and Lifestyle Issues Affecting Health

Several social and lifestyle issues significantly impact on the human health. Some of these include excessive use of alcohol intake, tobacco and illicit drug use (Figure 4.50). Others are sexual promiscuity and unprotected sexual encounters with non-regular partners. Young persons and adolescents are especially vulnerable because they are at a critical period of life transition and are largely without access to appropriate information regarding age-appropriate sexual and reproductive health information and services. (UNICEF, 2012)

This survey noted that alcohol and tobacco are commonly consumed in all the communities assessed. Alcohol is culturally acceptable in nearly all social events and festivals, and this practice is similar in many other communities in the Niger Delta region. The use of alcohol and tobacco is commoner among younger male folks and lesser with the women folks. As much as (43.3%) adult males and 23.9% of adult females consume alcohol, while 8.4% of males and 0.6% female use any form of tobacco products. Some respondents admitted to knowing persons who abuse drugs and other prohibited substances, and acknowledge the problem is gradually on the increase in the area.



	Bayelsa		Rivers	
	Women	Men	Women	Men
Alcohol use	23.9%	42.3%	20.9%	47.0%
Cigarettes and other tobacco use	0.6%	8.4%	0.3%	4.8%
Illicit drug use	0.0%	0.4%	0.0%	0.2%
Commercial sex work	0.1%	0.0%	4.0%	0.0%

Figure 4.50: Social and Lifestyle issues affecting health

Excessive alcohol use is a risk factor for nutritional deficiencies, especially for the B-group of vitamins and anaemia. Severe cases lead to chronic liver diseases: fatty liver, alcoholic hepatitis, fibrosis, and liver cirrhosis. Others are heart diseases, cardiomyopathy, arrhythmias, stroke, and hypertension. Alcohol has also been implicated in causing nervous diseases, like Wernicke's syndrome, cancers and birth defects in children born to alcoholic mothers. Alcohol affects the emotional stability of abusers and produces negative impacts on work attitudes, productivity, and income of abusers. (Testino, 2008; Caan Woody & Jackie de, 2002) Similarly, chronic alcohol and drug abusers have a poor sense of judgment, a condition that could dispose individuals to multiple and unprotected sexual exposures with non-regular partners. These have severe consequences for sexually transmitted infections, including HIV infection. (Rojas *et al.*, 2014; Chanakira et al., 2015).

Smoking harms nearly every organ of the body. Some of these harmful and adverse effects are immediate, while others are delayed. Smoking raises blood pressure and puts stress on the heart. Over time, stress on the heart can weaken it, making it less able to pump blood to other parts of the body. Carbon monoxide from inhaled cigarette smoke also contributes to a lack of oxygen, making the heart work even harder. Smokers are more likely than nonsmokers to develop heart disease, stroke, and lung cancer. Estimates show that smoking increases the risk of coronary heart diseases, including heart attacks by 2 to 4 times, stroke by 2 to 4 times, men developing lung cancer by 25 times and women developing lung cancer by 25.7 times. Smoking causes diminished overall health, increased absenteeism from work, and increased health care utilization and cost. (US Health and Human Services, 2014)

4.11.6: Sexual Behaviour

Human sexual activity, human sexual practice or human sexual behaviour is how humans experience and express their sexuality. Sexual risk behaviour is not without the consequences of sexually transmissible infections, including HIV/AIDS. The majority of the respondents claim to have just one sexual partner. Investigation about condom use with a non-regular and non-cohabiting partner showed that the practice among men was significantly higher than in women. Many social scientists have attributed the disparity to the low status of women in the African society which has some cultural undertone. For this reason, their condom negotiation skills are weak. This situation partly explains why sexually transmitted infections commoner in women are than in men. (Aral Guinan, 1984) Regarding commercial sex work in the area, community members reported that commercial sex workers were available, especially those who are referred to as ‘camp followers’, because they go after migrant oil and gas workers and security personnel from one location to another. Nevertheless, commercial sex work is clandestine in its operation and may not be obvious in any form.

HIV/AIDS and other Sexually Transmissible Infections

Everyone in the project area, both the Bayelsa and Rivers axes, has at one time or the other heard about the human immunodeficiency virus infection or seen someone who is infected. Nevertheless, the proportion of individuals with comprehensive knowledge of the virus is still substantially low. The comprehensive knowledge of HIV/AIDS is defined as: (1) Knowledge that the use of and having just one HIV negative and faithful partner are protective against HIV (2) Knowledge that a healthy-looking individual can have HIV and (3) Rejecting the two most common misconceptions about HIV transmission, which are that mosquito bites can transmit HIV and that HIV can be transmitted by supernatural means. (Sahile, Mekuria & Yared, 2015) (Table 4.40).

Table 4.40: HIV/AIDS knowledge and Behaviour

Variable	Bayelsa		Rivers	
	Women	*Men*	*Women*	*Men*
Comprehensive knowledge of HIV/AIDS	43.5%	36.5%	45.9%	71.7%
Know HIV can be transmitted from mother-to-child	64.9%	38.5%	62.5%	66.3%
Have ever been tested and know HIV status	43.0%	42.1%	55.8%	75.8%
Use of a condom with a non-marital, non-cohabiting partner	32.3%	50.8%	32.0%	76.8%

Our findings show that less than half both the men and the female do not have comprehensive knowledge of HIV. This is despite all the various campaigns and information in the media, more than three decades after the emergence of the virus. And might partly explain why condom use has remained low in all areas.

4.11.7: Environmental and Social Health

The consequences of the environment on human health are very significant and cannot be overlooked. Human activities or events that constitute environmental risks have been proven to significantly impact on human health, either directly by exposing people to harmful agents, or indirectly, by disrupting life-sustaining ecosystems. (WHO, 2009) World Health Organization (WHO) has also estimated that about thirteen million deaths annually are generally linked to preventable environmental causes. (WHO, 2009) The parameters of the environment studied included water supply, waste management, sewage and sullage disposal methods, cooking practices, insect vector, and pest prevalence and control mechanisms. Others were air quality and noise levels.

4.11.8: Water Supply

Most members of the host communities derive their water supply from a variety of unwholesome sources. The primary sources are predominantly hand-dug wells, rainwater, commercial water (in sachets), popularly referred to in Nigeria as "pure water" and few private boreholes (deep wells). In some of the communities, water projects provided by organizations like SPDC, NDDC or the World Bank are uncompleted, abandoned or broken down. Most private boreholes in the area are for personal or commercial purposes, and therefore not freely or readily available for public use. The boreholes are more in the bigger towns and settlements, like Twon Brass, Okpoma, Kula, Tombia, and Bakana, while the smaller communities/settlements depended largely on rainwater and hand-dug wells (Table 4.41).

Table 4.41: Sources of Domestic water in the communities

Community	Municipal Water scheme	Borehole	Shallow well	Commercial water (water sachet/bottled water)	Rainwater
Bayelsa Communities					
Obioku	×	0	✓	✓	✓
Odioma	×	0	✓	✓	✓
Ibidi	× (bad)		✓	✓	✓
Twon Brass	×	✓	✓	✓	✓
Okpoama	×	✓	✓	✓	✓
Beleti-ama	×	0	✓	✓	✓
Egwe-ama	×	0	✓	✓	✓
Ewo-ama	×	0	✓	✓	✓
Sangana	×	0	✓	✓	✓
Oginibiri	×	0	✓	✓	✓
Okumbiri-Beleu	×	0	✓	✓	✓
Liama	×	0	✓	✓	✓
Die-ama	×	0	✓	✓	✓
Rivers communities					
Kula	×	✓	✓	✓	✓
Tombia	×	✓	✓	✓	✓
Elem Sangama	×	✓	✓	✓	✓
Abissa	×	0	✓	✓	✓

Community	Municipal Water scheme	Borehole	Shallow well	Commercial water (water sachet/bottled water)	Rainwater
Bakana	✗	✓	✓	✓	✓

✗Not available ✓Available

Based on the observation from the communities, more than 95% of the households are without safe drinking water, as against the WHO expected benchmark of less than 5% for resource-limited settings in developing countries (WHO, 1994). The estimated quantity of water per household was estimated at less than 10 – 15 litres per person per day. This is far lower than the WHO recommended value of 50 litres per person per day (WHO, 1994). In terms of physical access, most of the households had water within a 200m distance of their residence. The availability of potable water is an essential driver of good health. Water scarcity exposes households to potential risks of waterborne and water shortage diseases; such like poliomyelitis, infective hepatitis, typhoid and paratyphoid fevers, cholera, and others like trachoma and skin diseases, including scabies, etc. (Lucas &Gilles, 2003) Available evidence shows that the MDG targets of 75% coverage for safe drinking water by the year 2015 was not met in the project area, and the current SDG target is under severe threat of not being achieved. (WHO, 2015b).

4.11.9: Solid Waste Disposal

Solid waste management is the most pressing environmental challenge faced by both urban and rural areas in Nigeria and in the Niger Delta region. Several thousand tons of solid wastes are generated by households annually in the project area and is estimated that less than 20% is collected. The rest recklessly disposed of theirs in nearby water bodies, bushes and in and around the communities. This improper collection and disposal of municipal wastes are not only leading to environmental catastrophes like blocked drainages and flooding which many of the communities are already experiencing but some health effects. Rats, cockroaches, flies, and other disease vectors are attracted to solid wastes for food and in the process transmit diseases to man. Also, dangerous items such as broken glass, razor blades, needles, and other healthcare wastes pose risks of injury or poisoning, especially for scavengers. Solid wastes may also contaminate surface water bodies and shallow water wells that are the primary sources of domestic water in many of the communities. In all the communities in Bayelsa area, it is estimated that 37% of the households collect and dump their solid wastes in the river banks, 54% dump theirs openly in the communities, while 9% burn their wastes. For communities in the Rivers axis, 23% dispose theirs into water bodies, 67% openly dispose theirs in the communities, and 10% burn theirs (Figure 4.51).

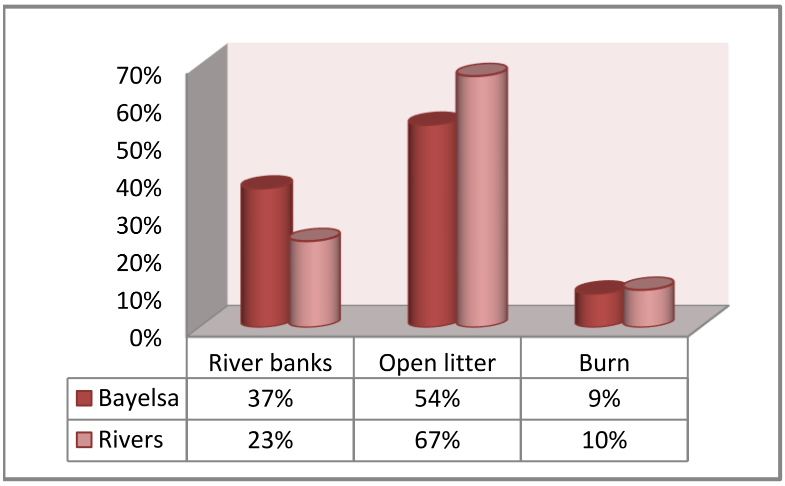


Figure 4.51: Sources of refuse disposal in the communities

4.11.10: Sewage and Sullage Disposal

Disposal of sewage and wastewater constitute and significant challenge in both axes. Most residents of the communities have their toilet facilities within the recommended 50m distance from their homes (Figure 4.52). Nevertheless, the principal method of disposal is the jetty-type (over-hung) toilets, whereby sewage is discharged directly into the waterbodies- rivers and streams. In most instances, the toilets are communally owned and shared. Only a few households in the larger communities use the water closet (WC) toilet system. The jetty-type toilet is unsanitary as it exposes sewage to disease vectors like flies, cockroaches, rodents, etc. Although this type of toilet system, appears to be culturally acceptable to the people from ancient times, their persistent use might perhaps be borne out of lack of alternatives.

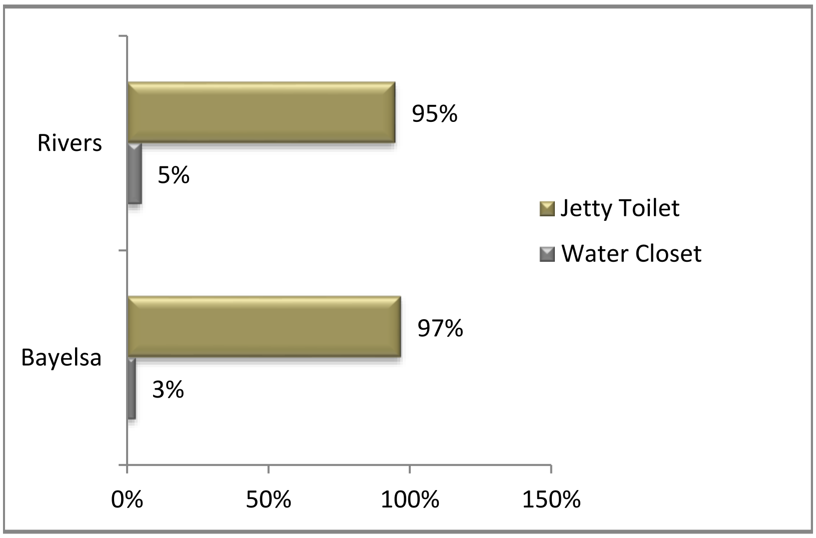


Figure 4.52: Sources of sewage disposal in the communities

The poor sanitary disposal of sewage is a risk factor for the spread of diarrhoeal diseases which are common childhood killers in Nigeria. (UNICEF, 2008; WHO, 2011a). Also, wastewater in the communities is in most cases channelled into the open environment. Such unhealthy practices not only are unsightly and produce offensive odours, they also have consequences for health. They provide favourable breeding sites for mosquitoes, which is the vector for malaria fever that is responsible for over 300,000 deaths annually in Nigeria, especially among children under five years of age. (USAID, 2011).

4.11.11: Cooking Practices

The predominant cooking fuels used in both axes of the project area are kerosene, firewood and charcoal (Figure 4.53). Other cooking fuels sparsely used are liquefied petroleum gas (LPG), and electric stoves. Nearly all the firewood is locally sourced from the nearby mangrove forest that is abundant in the area. The collection of firewood often includes cutting down trees and this practice is a major factor in irreversible environmental degradation. Most of the kerosene in circulation is adulterated. They are locally refined by illegal "artisanal" refiners and is popularly called "*Kpo-fire"* because it is highly inflammable and have caused several fire disasters and loss of lives and properties in the area. The main reason why people continue to use this illegally refined kerosene at the risk of their lives and property is because of the scarcity of good quality kerosene and the very cheap cost of the only alternative according to focus group discussants.

The cooking fuels commonly in use in the area have several health implications. Firewood, burned indoors, produces toxic fumes that threaten the health of children. According to the World Health Organization, smoke from indoor fires kills over 1.6 million people in developing countries every year. Exposure to household air pollution almost doubles the risk for childhood pneumonia, and in adults, increases the risk of deaths from stroke, ischaemic heart disease, chronic obstructive pulmonary disease (OP) and lung cancer. (WHO, 2014b)

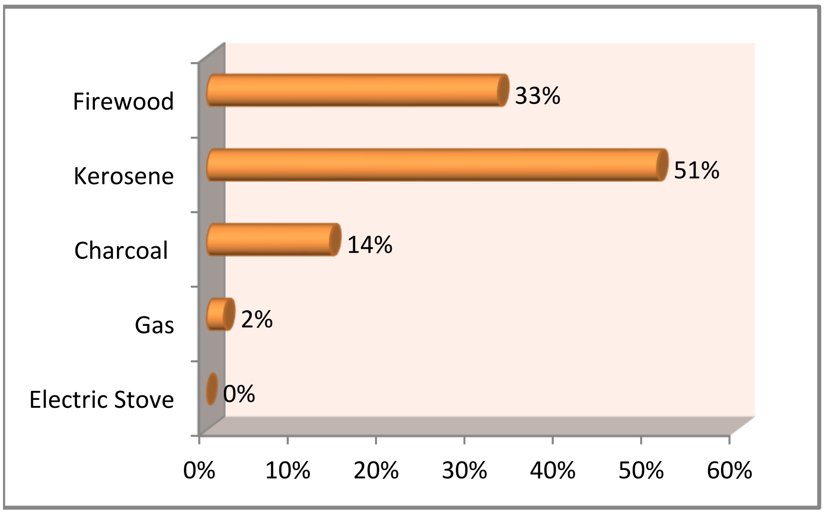


Figure 4.53: Sources of cooking fuels in the communities

4.11.12: Public Perception

Positive

The people are very optimistic that the proposed project will bring considerable benefits and improvements in their communities. They of the opinion that when fully operational the project will attract some infrastructural developments in the area like electricity, water projects, road infrastructures, etc. They also felt it could enhance their health care services and stimulate youth employment and business opportunities.

Negative

1. They fear that oil spillages might be rampant because of the operations of the project. They said that already, there are issues with the oil are gas pollution problem in parts of the Niger Delta.
2. They are concerned that their water bodies and swamps might be further polluted and might worsen the poor fish yield in the area and contribute to further depletion of crop yield for the few farmers in the area.
3. They are also concerned about acid rain which they said often corrode their roofs and make them incur huge financial expenses when replacing them.
4. A few individuals were apprehensive that the project might lead to an influx of good and bad people, a situation that could escalate crime in the area and other social vices which were hitherto alien to the area.
5. They also fear that the influx of people could fuel inflation in the area.

4.11.13: Community Expectations from SPDC

The people were full of expectations regarding the proposed project.

- All the communities appeal for potable water, as they do not have any.

- All the communities have issues with their health care services and therefore look forward to efforts that could lead to establishment of orthodox health care services in their communities.
- Unemployment and youth restiveness are a significant problem in the area. Therefore, any efforts aimed at engaging youths of the area in meaningful enterprises they believe will stem militancy and crime and restore their local economy.
- Electricity and road infrastructures are lacking in all communities. They, therefore, appealed for their provision also to enhance the economic potentials of the area.
- The sewage disposal methods in the area are mainly unsanitary and disease prone. The people will like to have more modern sewage disposal facilities.
- Women and youths are major players in the economy of the communities. Therefore, providing them with skills-based training and soft business loans will discourage crime and promote enterprise in the area for the good of all.
- The people will very much appreciate gestures like scholarships for secondary school and university level education for their children.
- They also requested contract awards for jobs within reach of the local communities be made available to them.

CHAPTER FIVE
POTENTIAL AND ASSOCIATED ENVIRONMENTAL IMPACT

5.1: Introduction

A number of methods exist for evaluating potential impacts of any project on the environment. These include the Overlays techniques (McHarg, 1968), Leopold matrix (Leopold et al., 1971), Battelle Environmental Evaluation System (Dee *et al*., 1973), and Peterson Matrix (Peterson *et al*., 1974) and ISO 14001. The method employed in this report is the ISO 14001 method. The ISO 14001 method is simple to apply and provides a high level of detail, and also relies on limited data. The following considerations were adopted in this impact assessment:

- Comprehensiveness- ability to handle all possible range of elements and combinations thereof;
- Selectivity-capability to identify early in the procedure those aspects that are important;
- Mutual exclusiveness-should be able to examine every component of an impact from different perspectives;
- Confidence limits-is the method able to ascertain and isolate uncertainties?
- Objectivity-should allow no bias either from the assessor or project initiator;
- Interactions-should be able to examine both sides of a coin and provide feedback.

5.2: Uncertainties

Any Impact Assessment contains five kinds of uncertainties. These are uncertainties due to:

- The natural variability of the environment, particularly the occurrence of rare events such as floods, unpredictable climate change and natural disasters;
- Inadequate understanding of the behaviour of the environment;
- Inadequate time-tested data for the area being assessed;
- Socio-economic uncertainties (inadequate data for prediction of human response to economic crises). There is always uncertainty in predicting the way a community will respond to the activities of oil companies in their domain.
- Health uncertainties such as the problem of determining the direct causes and effects of diseases, and that of ascertaining the disease vectors that are brought into the project environment by itinerant applicants.
- In this study, we have endeavored to use available cost-effective techniques and review of published data to mitigate these uncertainties where possible.

5.3: Impact Qualification

The identified impacts of the project were qualified based on the following four criteria:

- Beneficial or Adverse
- Short-term or long-term
- Reversible or irreversible
- Direct or indirect

Negative impacts are those that adversely affect the biophysical, health and social environments while positive impacts are those, which enhance the quality of the environment. For this study, short term means a period of time less than three months while any period greater than three months is considered long term. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent when the activity causing the impact is terminated. Below is the approach to impact assessment (Fig 5.1)

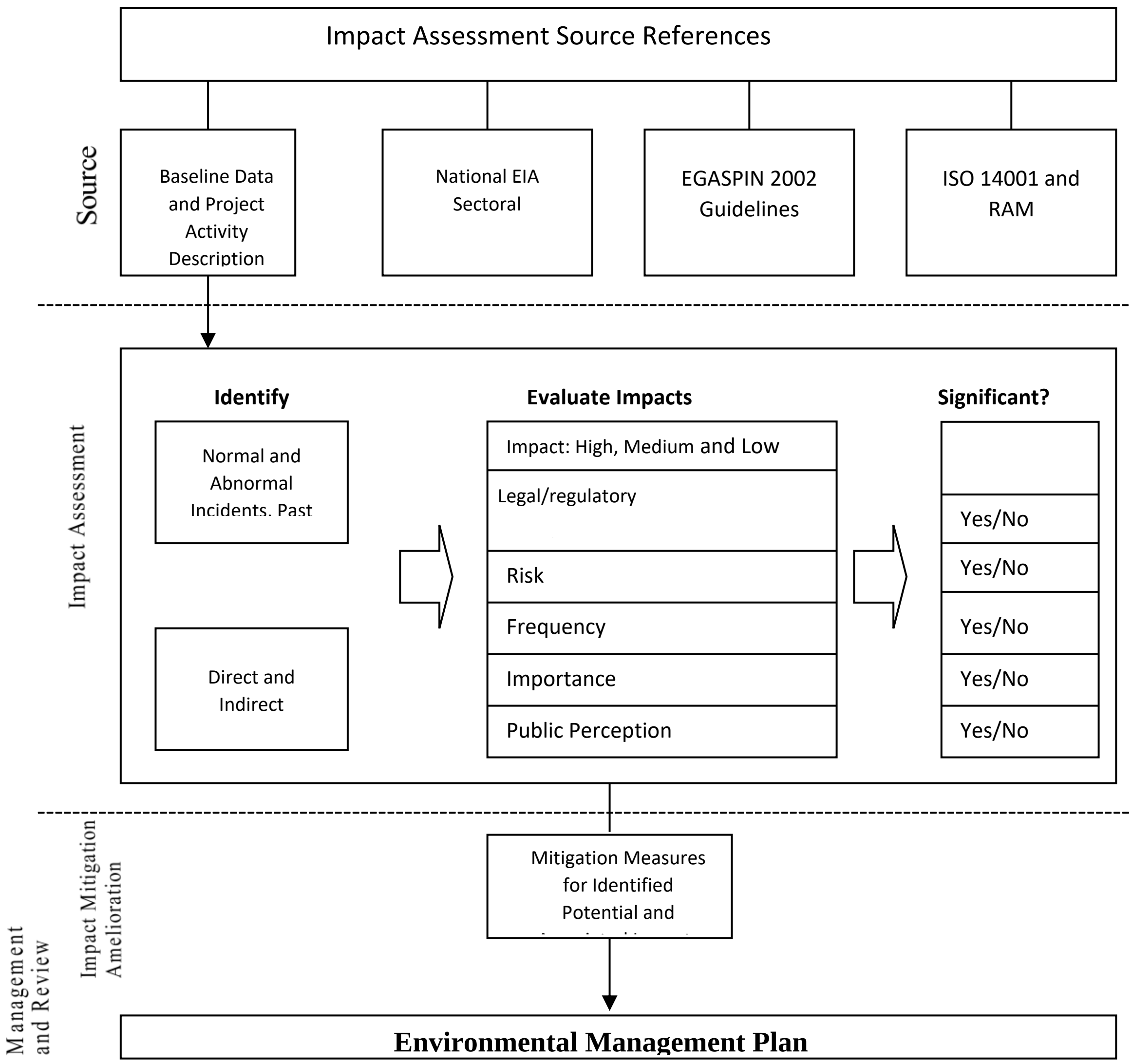


Fig. 5.1: Approach to Impact Assessment

5.4: Impact Assessment Methodology

Stage one: Classification

The first stage involved in the assessment of impact is impact classification. Impacts are classified as follows:

- Adverse (-) or Beneficial (+) in nature,
- Short term < 3 months (S) or Long term > 3 months (L), and
- Reversible (R) or Irreversible (I).

Adverse impacts are those, which impact negatively on the environmental components while beneficial impacts are those that enhance the quality of the environment. For this study, short term means a period of time less than three months while any period greater than three months is considered long term. By reversible/irreversible, is meant whether the environment can either revert to previous conditions or remain permanent once the activity causing the impact is terminated.

Stage two: Significance

The second stage involves evaluation to determine whether or not the impact is significant. The criteria and weighting scale employed in evaluation are as follows:

- Legal/regulatory requirements (L);
- Risk factor (R);
- Frequency of occurrence of impact (F);
- Importance of impact on an affected environmental component (I); and
- Public perception/interest (P).

The quantification scale of 0, 1, 3 and 5 was used. This is a modification of the arbitrary scale proposed by Vesilind, *et al*. (1994). The ratings are as described below and are adapted from The International Organization for Standardization (ISO, 14001) – Environmental Management System Approach.

Legal/Regulatory Requirements (L) – Is there a legal/regulatory requirement or a permit required?

- 0 = There is no legal/regulatory requirement
- 3 = There is legal/regulatory requirement
- 5 = There is a legal/regulatory requirement and permit required

Risk Factor (R) – What is the risk/hazard rating based on the Risk Assessment Matrix?

- 1 = Low risk
- 3 = Intermediate risk
- 5 = High risk

Frequency of Impact (F) – What is the frequency rating of impact based on the Risk Assessment Matrix?

- 1 = Low frequency (rare)
- 3 = Intermediate frequency (likely)
- 5 = High frequency (very likely)

Public interest/perception (P) – What is the rating of public perception and interest in proposed project and impacts based on consultation with stakeholders?

- 1 = Low interest/perception
- 3 = Intermediate interest/perception
- 5 = High interest/perception

Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions?

- 1 = Low
- 3 = Medium
- 5 = High

This approach combines the following factors in assessing the overall impact rating of the project on the environment:

- The sensitivity/vulnerability of the ecosystem components;
- The productivity evaluation/rating of the ecosystem components;
- Knowledge of the possible interactions between the proposed project and the environment;
- Envisaged sustainability of the project environment;
- The economic value of the proposed project activities; and
- Projected duration of the impact of each project activity on various environmental components.

The frequency of occurrence of each impact was determined from historical records while the importance of affected environmental component was determined through consultation and consensus of opinions. The perception of the communities and the general public on each potential impact and its effects as reported in the various reports reviewed were determined through consultation with the communities and consensus of opinions of environmental professionals. The overall impact rating is determined as shown in Table 5.1. The potential and associated impacts of the project are presented in Table 5.2.

Table 5.1: Impact Value and Rating

Impact value	Cut off values	Impact Rating
L+R+F+I+P	<8	Low
L+R+F+I+P	≥8 but <15	Medium
L+R+F+I+P	≥15	High
F + I	≥6	
P	= 5	
Positive		Positive

Table 5.2: Associated and Potential Impacts for OML 77 and 74 3D Seismic Data Acquisition Project

Project phase	Project Activities	Description of Impact	Impact Qualification									Impact Quantification							Impact rating
			Beneficial	Adverse	Direct	Indirect	Short term	Long term	Reversible	Irreversible	Local or Widespread	L	R	F	I	P	Total	F+I	
Premobilization	Permitting via consultation and signing of agreement (Securing of Social License to operate)	Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project	√		√		√		√		L	-	-	-	-	-	-	-	Positive
	Premobilization inspection of project equipment to quay side	Injuries and accidents		√	√		√		√		L	0	5	5	5	3	18	10	High
		Movement of personnel for pre-mobilization inspection		√	√			√		√	L	0	5	5	5	3	18	10	High
		Risk of kidnapping		√	√			√		√	L	0	5	5	5	3	18	10	High
Mobilization	Mobilization to Site (Transportation of equipment and personnel) by vessels	Risk of accident from vessel collision		√	√		√		√		L	0	5	3	5	3	16	8	High
		Impairment of water quality from vessel discharges (cooling water, ballast water, deck drainage)		√	√			√	√		L	3	3	1	3	3	13	4	Medium
		Damage to seabed / flora / fauna		√	√		√		√		L	0	3	1	1	1	6	2	Low
		Interference with		√	√		√		√		L	0	3	1	1	1	6	2	Low

Project phase	Project Activities	Description of Impact	Impact Qualification									Impact Quantification							Impact rating
			Beneficial	Adverse	Direct	Indirect	Short term	Long term	Reversible	Irreversible	Local or Widespread	L	R	F	I	P	Total	F+I	
		fishing activity																	
		Introduction of exotic/invasive species to sea		√	√		√		√		L	0	3	1	1	1	6	2	Low
		Impairment of air quality		√	√		√		√		L	3	3	1	3	3	13	4	Medium
		Nuisance (Noise, Vibration etc.) from Equipment		√	√		√		√		L	3	3	1	3	3	13	4	Medium
		Risk of Piracy and kidnapping		√	√			√		√	L/W	0	5	5	5	3	18	10	High
		Increase in STIs		√	√		√		√		L	3	3	1	3	3	13	4	Medium
	Mobilization (personnel via helicopter)	Increase in usage of airways with possibilities of accidents		√	√		√		√		L	0	5	3	5	3	16	6	High
		Increase in ambient noise level		√	√		√		√		L	3	3	1	3	3	13	4	Medium
Seismic Shooting	**Discharge of the acoustic energy source and data recording**	Disturbance to marine fauna (spawning sites and migratory routes of fishes)		√	√			√	√		L	3	3	3	3	3	15	6	High
		Possible death of marine fauna from seismic air guns		√	√			√	√		L	3	3	3	3	3	15	6	High
		Disaggregation of benthic organisms during nodes placement		√	√			√	√		L	3	3	3	3	3	15	6	High

Project phase	Project Activities	Description of Impact	Impact Qualification									Impact Quantification							Impact rating
			Beneficial	Adverse	Direct	Indirect	Short term	Long term	Reversible	Irreversible	Local or Widespread	L	R	F	I	P	Total	F+I	
		Increase in noise and vibration from seismic air guns		√	√		√		√		L	3	3	1	3	3	13	4	Medium
		Injuries to personnel from faulty equipment		√	√		√		√		L	0	3	1	1	1	6	2	Low
		Impairment of water quality from effluent discharges		√	√		√		√		L	3	3	1	3	3	13	6	High
		Interference with fishing activity		√	√		√		√		L	0	3	3	1	3	10	4	Medium
		Explosion from airguns		√	√		√		√		L	0	3	3	3	3	12	6	High
		Inclement weather conditions (Poor visibility, currents)		√	√		√		√		L/W	0	3	3	3	3	12	6	High
		Injuries and accident from vessel collision		√	√		√		√		L	0	3	1	3	3	10	6	High
		Piracy and kidnapping		√	√		√		√		L	0	3	5	3	5	16	8	High
		Opportunity for business and contracting	√		√		√		√		L	-	-	-	-	-	-	-	Positive
		Increase in waste generation		√	√		√		√		L	0	3	5	3	5	16	8	High
		Increase in STIs		√	√		√		√		L	0	3	3	1	3	10	4	Medium
Demobilization	**Demobilization (Transportation of equipment and personnel) by vessels**	Injuries and accidents from vessel collision		√	√		√		√		L	0	5	3	5	3	16	8	High
		Impairement of water		√	√			√	√		L	3	3	1	3	3	13	4	Medium

Project phase	Project Activities	Description of Impact	Impact Qualification									Impact Quantification							Impact rating
			Beneficial	Adverse	Direct	Indirect	Short term	Long term	Reversible	Irreversible	Local or Widespread	L	R	F	I	P	Total	F+I	
		quality from effluent discharges (ballast water, bilge water, deck drainage)																	
		Damage to seabed / flora / fauna		√	√		√		√		L	0	3	1	1	1	6	2	Low
		Interference with fishing activity		√	√			√		√	L	0	3	3	3	3	12	6	Medium
		Introduction of invasive species		√	√		√		√		L	0	3	1	1	1	6	2	Low
		Impairment of air quality		√	√		√		√		L	3	1	1	3	1	9	4	Medium
		Noise and vibration from engines of vessels		√	√		√		√		L	3	1	1	3	1	9	4	Medium
		Risk of Piracy and kidnapping		√	√			√		√	L/W	0	5	3	5	5	18	8	High
	Demobilization (personnel via helicopter)	Increase in usage of airways with possibilities of accidents		√	√		√		√		L	0	5	3	5	3	16	6	High
		Increase in ambient noise level		√	√		√		√		L	3	3	1	3	3	13	4	Medium

5.5: Significant Impacts

The potential sources of impacts from the seismic project as presented above include:

- vessel movement and positioning which may affect fishing activities and other sea users;
- underwater noise from airguns, which may have effects on marine mammals, turtles, fishes, benthic organisms and seabird;
- emissions and discharges from vessels which may affect air and water quality; and
- accidents or injury to personnel from work hazards.

Vessel Movement and Positioning

Fishing activities will be temporarily interrupted during the seismic survey within the prospect. Fishing boats and other vessels will be excluded from a 500m safety zone around the seismic vessel and survey corridor. The purpose of the safety or exclusion zone is to protect people and vessel and prevent damage to seismic survey equipment. In addition to the possibility of fishermen being temporarily displaced from a fishing area, there is the potential for survey vessels to damage nets, long lines, or traps.

Interruption of Fishing

Impacts of the proposed survey are considered potentially significant because fishermen would be temporarily excluded from preferred fishing sites and fishermen are likely to have a negative opinion on seismic operations at some time during the surveys. The disruption of fishing activities within this period may likely result to reduced fish catch and reduced income for fishermen especially if fishing area is within the prospect.

Underwater Noise from Airgun on Marine Life

Acoustic sources used for seismic survey have the potential to harm marine animals particularly if they swim beneath them. While death or serious injury is unlikely, marine mammals, turtles and fish may experience temporary or permanent auditory trauma if they are very close to an operating airgun array at full power. Beyond a few hundred meters laterally from the array, auditory trauma is unlikely but behavioural effects (e.g., avoidance) may result. The biological importance of such behavioural responses is not well understood. Potential impacts of seismic surveys on marine mammals have been reviewed extensively by Richardson *et al.,* (1995); Davis *et al.*, (1998); Gordon *et al,* (1998); Continental Shelf Associates, Inc., 2004. The key findings are as follows:

- there have been no documented instances of deaths or physical injuries of marine mammals from seismic surveys;
- there is a risk of temporary or permanent auditory trauma within a range of a few hundred meters of a typical airgun array. The range depends on a variety of factors including the size and configuration of the array, water depth, and the density structure of the water column;
- behavioural responses have been observed in many instances, primarily in mysticetes (baleen whales, including the humpback whale). However, the biological importance

of such behavioural responses to underwater noise has not been determined (ocean studies board, 2003); and

- airgun pulses and research on the auditory responses of marine mammals suggests that only large baleen whales may be susceptible to auditory risk from marine seismic sources.

While the risk of auditory trauma depends on proximity to the airgun array (i.e., duration of exposure), behavioural responses may occur at distances of many kilometres and are not necessarily predictable from the loudness of the sound source. Behavioural responses may vary depending on factors such as the age and status of the animal, the type of activity it is engaged in, and the social context (Mc Cauley et aI, 2000).

A number of studies have documented behavioural effects of marine mammals in response to seismic surveys (Richardson et al., 1995; McCauley et al., 2000; Stone, 2003; Holst et al., 2006; Miller et al., 2006). However, it is unclear how the behavioural changes may affect long-term health (Ocean Studies Board, 2003).

It has been reported that during seismic surveys several dolphin species have been seen less frequently when airguns were firing than when they were not firing. In addition, baleen whales, killer whales, and all the small odontocetes were farther from large airgun arrays during periods when airguns were firing than when the airguns were silent. In general, small odontocetes showed the strongest avoidance response to seismic activity, with baleen whales and killer whales showing some localized avoidance, pilot whales showing few effects, and sperm whales showing no observed effects from these data. Different groups of cetaceans may adopt different strategies for responding to acoustic disturbance from seismic surveys (Stone, 2003).

Fish

Fish presents a diverse spectrum of possible susceptibility to air gun array sound due to their migratory pattern. The known effects of seismic operation on fish populations in relation to distance of acoustic source are presented in Figure 5.3.

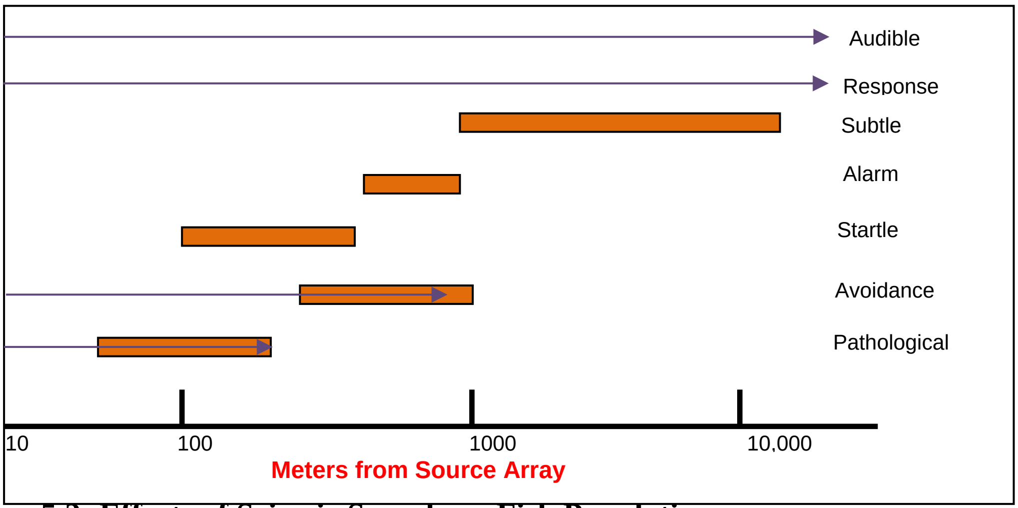


Figure 5.2: Effects of Seismic Sounds on Fish Population

Source: R.D McCauley, 1994

A summary of the likely potential effects of acoustic energy (airgun) on the fish populations is presented in Table 5.3.

Table 5.3: Airgun Effects on Fish

Distance from Array	Effect
Above 100m	Pathological effects
Above 500m	Startle response and schooling change
At 1000m	Reduction in catch, repulsion, alarm response, damage to auditory organs
Above 10,000m	Subtle behavioural response, temporary rising of threshold for hearing
Array at > 100km	Average hearing threshold

Source: R.D McCauley, 1994

The study shows that lethal or damage effects would be expected to be confined to the immediate vicinity (100m) of the source where sound pressure levels are at their greatest. This effect will be more prominent on eggs and larvae as well as adult fishes, when the seismic source is passing overhead or in close proximity and sound pressure levels are close to those of the source level. More severe startle would again be expected within close proximity (500m) of the source. These effects would again be expected from the array passing over the seismic area and could cause adult fish stocks to flee from the vicinity. However, these effects are expected to be temporary. At about 1000m from the sound source, alarm responses as well as damage to auditory maculae may be experienced by fishes. More subtle behavioural effects are expected at 1000m to 10000m from the source. Beyond 10000m very insignificant effects are envisaged on the fish community (Mc Cauley, 1994).

Studies into the avoidance have shown that fish will dive to deeper water to escape mechanical noise such as ship engines or seismic explosion. Once the survey has begun it is unlikely that there will be significant quantities of fish in the surface layer

Fish Larval and Plankton

Effects of seismic operations on fish eggs, larvae and fry have recently been observed to be of great concern. During certain periods, there is a large concentration of these organisms in the surface layer, close to likely airgun positions. However, unlike adult fish they have the ability to avoid the source of the shock waves. In the studies conducted on the impact on embryo, the effects of an airgun operated at 142bars and small (50g) charges of trinitrotoluene (TNT) on several species of fish eggs. The survival rates for eggs at a distance of 5m from the energy source were as follows:

- TNT - 30%
- Air gun - 87%

The TNT caused damage to the eggs while the airgun had little or no effect. Larvae are likely to be injured within a 5m radius of airguns. Larval fish are less sensitive to the effects of shock waves than eggs or post larval fish (fry) in which the swim bladder has developed (3months-6months of age). It is unlikely that significant amounts of eggs and larvae in relation to the total stock will be affected during the survey. The sardinellas also have long spawning periods and the surveying is therefore unlikely to seriously impact on their populations (SEEPL, 2010).

The effects of airguns on larvae and fry are also common to plankton species especially the plankton possessing bladders in close proximity to the airguns may entail ruptures leading to death.

Disturbance of Benthic Communities

The placement and retrieval of nodes on the seafloor may re-suspend bottom sediments and could result in minor physical impacts on benthic organisms. However, the impact is expected to be minimal.

Sea Turtles

Relatively little is known about sea turtle hearing ability or their dependency on sound, passive or active, for survival cues. Only two species, loggerhead and green sea turtles, have undergone auditory investigations. The anatomy of the sea turtle ear does not lend itself to aerial conduction but rather is structured for sound conduction through two media; bone and water.

Auditory testing and behavioural studies show that turtles can detect low frequency sounds (Ridgway *et al.,* 1969; Bartol *et al.,* 1999). Most common sound frequencies produced by seismic airguns overlap with the frequency range where turtle hearing is most sensitive (100 to 700 Hz). It is likely that sea turtles would be able to hear seismic activities for a considerable distance from the source of the shots and possibly experience some disturbance.

Seabirds

The impact of the seismic survey on pelagic bird species is expected to be insignificant. Though some species may dive below the water surface for prey, most of their time is spent resting on the water surface and in the air. These species would be unaffected by the seismic pressure waves generated below the surface. Local distribution of some pelagic species may be indirectly affected if fish prey species are redistributed out of the area due to behavioural avoidance of the disturbance.

Emission and Waste Discharges

Sources of air pollutants which can impact the atmosphere during the seismic survey include; sulphur oxides, carbon monoxide, nitrogen oxides, and volatile organic compounds (VOCs) These pollutants contribute to the global pollutant emission load leading to global warming and increased greenhouse effect. Exhaust emissions from ships and vessels are considered to be a significant source of air pollution in recent times, contributing to about 18-30% of all nitrogen oxide and 9% of sulphur oxide pollution worldwide. It is estimated that by 2015, up to 40% of air pollution over land would come from vessels in the sea. Sulphur in the air creates acid rain which damages crops and buildings. When inhaled, sulphur is known to cause respiratory problems and even increase the risk of a heart attack. Carbon dioxide emissions from vessels are currently estimated at 4 to 5% of the global total load this is expected to rise to about 72% by 2020 if no action is taken (IMO, 2009).

However, the impact of the seismic project on the air quality of the area is relatively short term and insignificant. Direct and long exposure of air pollutants to workers, on the vessels may be potentially detrimental.

Waste Discharges

Waste discharges from seismic vessels include sewage, grey waters, waste water, deck drainage, bilge waters etc from sinks, showers, galleys, laundry, and cleaning activities aboard these vessels.

These discharges contain a variety of pollutant substances, including faecal coliforms, detergents, oil and grease, organic compounds, hydrocarbons, nutrients, food waste, medical and dental waste etc. Untreated grey water from ships can contain pollutants at variable strengths and that can contain levels of faecal coliform bacteria several times greater than is typically found in untreated domestic wastewater. Grey water has the potential to cause adverse environmental effects because of concentrations of nutrients and other oxygen-demanding materials, in particular. Grey water is typically the largest source of liquid waste generated by vessels (about 90%-95%).

The impact of waste discharge on the environment is insignificant considering specific guidelines and procedures have been developed by various regulatory agencies to help reduce the impact to as low as possible.

Solid Waste

Solid waste generated aboard a vessel includes; glass, paper, cardboard, aluminium, steel cans, and plastics. They can be either non-hazardous or hazardous in nature. Solid waste that enters the ocean may become marine debris, and can then pose as threat to marine organisms, humans, coastal communities, and industries that utilise marine waters. They can also injure or kill marine mammals, fish, sea turtles and birds from entanglement with plastics and other solid waste. Seismic vessels typically manage solid waste by a combination of source reduction, waste minimisation, and recycling. However, most of solid waste generated at sea are bagged and brought back to land for proper disposal. Food waste maybe macerated and disposed offshore.

Interference on Navigable Waters

The associated impacts of the project on navigable waters in relation to the project are:

- Interference with other potential water users traversing the sailing route e.g. supply vessels and canoe fishermen within the prospect;
- Interference with artisanal motorised boat fishermen and industrial trawlers/shrimpers within the prospect area; and
- Cargo vessels/oil tankers interference with area.

Workplace Hazards

Accidents or injuries to personnel during the seismic survey can also occur if proper HSE awareness or supervision is not carried out. The impact of such accidents/injury is very significant; give the nature of the job which requires work team commitment. The injury of a person or group of people can easily bring the seismic survey to an abrupt end. This would lead to a huge capital and time lost. Sources of injury associated with the seismic process include:

- Loading and offloading of equipment for the survey;
- Entry into confined, enclosed, and other unlit area of the vessel;
- Paint spraying or removal leading to hazardous inhalation;
- Working on elevated surfaces, particularly near deck openings and edges;
- During oil and fuel removal and tank cleaning;
- Operations involving cranes, winch, gear, and equipment for material handling;
- Cutting and welding operations and use of compressed gas; and
- Activities involving working on ladders and gangways.

CHAPTER SIX
MITIGATION MEASURES

6.1: General

This chapter presents the approach and mitigation measures for the identified significant impacts of the proposed 3D Reshoot Seismic Data Acquisition project in OML 77 & 74. The classification of the mitigation controls (formal control, informal control, physical control, training and avoidance) are ranked from low to high in the matrix (Figure 6.1). This was used to determine the mitigation requirements for each impact taking into cognisance the scale, frequency and potential severity of impact; environmental sensitivities as well as political and economic concerns.

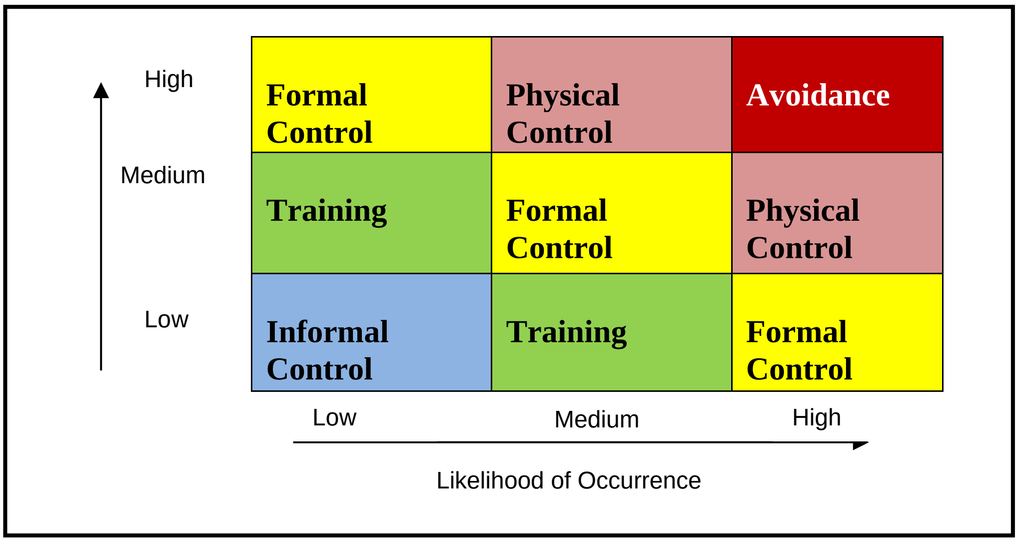


Figure 6.1: Matrix for determination of Mitigation Measures

Informal Control

This involves the application of sound judgment and best practice in mitigating the impacts of the seismic and drilling project activities.

Formal control

This involves the application of documented policy, process or procedure in mitigating the impacts of the project activities. It ensures that residual associated impacts are reduced to an acceptable level.

Physical control

This involves the application of physical processes, barriers or instruments (pegs, fence, gates, sign post etc), not necessarily requiring any special technology, in order to mitigate the impacts of the project.

Avoidance

This involves the modification of plans, designs or schedules in order to prevent the occurrence of an impact or impacts.

The specific mitigation measures satisfying the mitigation requirement were established putting the following into consideration.

- Best available techniques (BAT)
- On-site conditions; and
- Public concerns.

6.2: Mitigation Measures

Table 6.1 presents the mitigation measures proffered for the significant evaluation of the proposed 3D Reshoot Data Acquisition Project seismic survey. The table also documents the environmental resources that potentially will be impacted, point of impact and rating of residual impacts/risks following application of mitigation measures. As previously stated, these measures have been proffered following the principle of BAT which recognises international best practices.

Table 6.1: Mitigation Measures for Identified Significant Impacts of the OML 77 AND 74 3D Reshoot Data Acquisition Project

Project phase	**Project Activities**	**Description of Impact**	**Impact rating**	**Mitigation measures**	**Residual impact**
Premobilization	Permitting via consultation and signing of agreement (Securing of Social License to operate)	Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project	Positive	• Early stakeholders' engagement sessions shall be held, with all the agreed issues properly documented and signed. • Signing of MoU agreements with the community/stakeholders	Positive
	Premobilization inspection of project equipment to quay side	Injuries and accidents	High	• Visible warning signs shall be placed at strategic positions along the roads • SPDC shall ensure there is traffic control at strategic points around the quay side • SPDC shall ensure all vehicles observe the speed limits and large vehicles have warning lights to alert other road users • SPDC shall ensure all project vehicles are pre-mobbed and certified. • Reverse alarm shall be installed in all Operational vehicles • Speed control facilities such as IVMS and Strata shall be installed in all vehicle • The 12 Life Saving Rules (LSR) shall be enforced on all road users. • Effective journey Management system	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				• Emergency response shall be activated	
		Movement of personnel for pre-mobilization inspection	High	• SPDC shall ensure access control is implemented at the quay side.	Low
		Risk of kidnapping	High	SPDC shall: • Proper identification and management for all security threats and risk are highlighted • Develop adequate security strategy, plan and procedure for the project. • Ensure that security orientation and awareness/drills are conducted for the workforce • Ensure all countermeasures to mitigate identified threats are in place. • Ensure project non productive time are reduced to the barest minimum. • Regular drills are conducted. • All movements shall be undertaken only with Security Single Point Approval • Movement shall be under a GSA armed escort.	Medium
Mobilization	Mobilization to Site (Transportation of equipment and personnel)	Risk of accident from vessel collision	High	SPDC shall ensure • Adequate radio communication between merchant ships and standby vessels • Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS)	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
	by vessels			procedures are effective • Regular drills on abandon ship procedures shall be enforced • Activate Emergency response plan inline with SOLAS • Use of appropriate PFDs by the survey team.	
		Impairment of water quality from vessel discharges (cooling water, ballast water, deck drainage)	Medium	SPDC shall ensure full compliance to the following: • Standard Marine Operating procedures. • Standard maritime safety/ navigation procedures. • SPDC Oil Spill Contingency Management Plan • Engagement of Competent / Trained vessel operators. • Vessel Bunkering Procedure, including break-away procedure shall be reviewed and adhered to. • Transfer operations shall be conducted in daylight and suitable weather conditions, i.e. good visibility and low / moderate wind speed and sea state.	Low
		Impairment of air quality	Medium	SPDC shall: • Use only pre-mobbed and regularly maintained vessels, generators and other machines. • Use only low sulphur containing fuels and low NOx burners in large generators.	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				• Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems.	
		Nuisance (Noise, Vibration etc.) from Equipment	Medium	SPDC shall • use only pre-mobbed and regularly maintained equipment and water crafts. • Ensure availability and use of proper PPE by workforce • Provide acoustic mufflers for heavy engines with noise level above acceptable limits • Daily pep talk is carried out for workforce	Low
		Risk of Piracy and kidnapping	High	SPDC shall: • Ensure all countermeasures to mitigate identified threats are in place • Ensure project non productive time are reduced to the barest minimum. • Regular drills are conducted. • Movement shall be under a GSA armed escort.	Medium
	Mobilization (personnel via helicopter)	Increase in usage of airways with possibilities of accidents	High	SPDC shall ensure full compliance to the following: • Aviation Operating Procedures. • SPDC Aviation Audit of Heli-Deck. • SPDC / Contractor Emergency Response Plan • SPDC Oil Spill Contingency Management Plan • Heli-Ops conducted in daylight and suitable weather conditions, i.e. good visibility and low /	Medium

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				moderate wind speed and sea state. • BOSIET / HUET Training for all personnel using air transport.	
		Increase in ambient noise level	Medium	SPDC shall ensure full compliance to the following: • Entry to flight take off areas must be restricted to only persons who have their ears well protected • Flights shall be conducted timely and on schedule to reduce the duration of the impact. • SPDC/contractor shall maintain equipment to optimal working condition • Use of mufflers on diesel equipment and power generators	Low
		Increase in STIs	Medium	SPDC shall: • Step-up health education and sensitization activities prior commencing construction activities. • organize awareness session on sexually transmitted diseases, sexual behavior for workers and local hands that will be employed	Low
Seismic Shooting	**Discharge of the acoustic energy source and data recording**	Disturbance to marine fauna (spawning sites and migratory routes of fishes)	High	SPDC shall ensure: • Marine audit / inspection of seismic vessel shall be carried out to ensure compliance with international specified standards. • Soft start procedures for seismic source shall be	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				followed. • Marine Mammal Observers (MMO) shall be part of the seismic crew to ensure minimum interference with marine mammals. • Appropriate technology to minimize the impact of noise and vibration • Soft start protocols are adopted for shooting airguns (Noise emissions shall begin at low power, increasing gradually until full power is reached). • Acoustic Mitigation devices (PAM) shall be used to drive away marine mammals.	
		Possible death of marine fauna from seismic air guns	High	SPDC shall ensure: • ensure the presence of Marine Mammal Observer (MMOs) on board the vessel • a gradual increase of signal intensity at the beginning of the procedure (‘soft-start’ or ‘ramp-up’); • implementation of wildlife exclusion zones (EZs) within which air guns can be shut down or their use delayed if any marine mammal is detected • ensure restriction of night time seismic survey activity; • sensitive ecosystems (turtle nesting sites) are avoided during seismic data acquisition.	

Project phase	**Project Activities**	**Description of Impact**	**Impact rating**	**Mitigation measures**	**Residual impact**
				• Vessels use Passive Acoustic Monitoring to verify the presence of near-surface fish shoals within the mitigation zone.	
		Disaggregation of benthic organisms during nodes placement	High	• SPDC shall adopt due diligence to minimize adverse impacts on benthic organisms	Low
		Increase in noise and vibration from seismic air guns	Medium	SPDC shall: • ensure only pre-mobbed and regularly maintained equipment and water crafts. • Appropriate technology (acoustics) to minimize the impact of noise and vibration • Soft start protocols are adopted for shooting airguns (Noise emissions shall begin at low power, increasing gradually until full power is reached).	Low
		Impairment of water quality from effluent discharges	High	SPDC shall ensure compliance with MARPOL regulations.	Low
		Interference with fishing activity	Medium	SPDC shall ensure that: • All project vessels shall have high-rise beacons to fore warn other fishing vessels in the project location. • Marine notices shall be put in strategic locations • Radio monitoring of the area shall be	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				continuously conducted. • Provide timely information to stakeholders particularly fisher folk on the nature and timing of activities which may lead to direct interference with fishing activities/operations.	
		Explosion from air guns	High	SPDC shall ensure: • fire systems on board • emergency response system are in place	Medium
		Inclement weather conditions (Poor visibility, currents)	High	SPDC shall ensure: • Competence of vessel crew • Contractor vessel regulates speed and/or alter course in heavy weather as required by good seamanship, in order to avoid the possibility of damager to ship. • Daily weather forecast from the nearest synoptic station shall be shared with the vessel crew • Adequate steps to increase stability of the vessel shall be taken in ample time before the weather deteriorates such as pumping, ballasting etc.	Medium
		Injuries and accident from vessel collision	High	SPDC shall ensure • Adequate radio communication between merchant ships and standby vessels • Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS)	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				procedures are effective • Regular drills on abandon ship procedures shall be enforced • Activate Emergency response plan inline with SOLAS • Use of appropriate PFDs by the survey team.	
		Piracy and kidnapping	High	SPDC shall: • Ensure all countermeasures to mitigate identified threats are in place • Ensure project non productive time are reduced to the barest minimum. • Regular drills are conducted. • Movement shall be under a GSA armed escort.	Medium
		Opportunity for business and contracting	Positive	SPDC shall ensure adherence to local content policy.	Positive
		Increase in waste generation	High	SPDC shall: • Ensure compliance with MARPOL regulations. • Biological Sewage Treatment shall be carried out onboard. • Residual wastes shall be transferred onshore via consignment note. • All equipment using hydrocarbon fuel must be in optimum condition to reduce the generation of hazardous gases.	Low
		Increase in STIs	Medium	SPDC shall:	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				• Step-up health education and sensitization activities prior commencing construction activities. organize awareness session on sexually transmitted diseases, sexual behavior for workers and local hands that will be employed	
Demobilization	**Demobilization (Transportation of equipment and personnel) by vessels**	Injuries and accidents from vessel collision	High	SPDC shall ensure • Adequate radio communication between merchant ships and standby vessels • Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective • Regular drills on abandon ship procedures shall be enforced • Activate Emergency response plan inline with SOLAS • Use of appropriate PFDs by the survey team.	Low
		Impairement of water quality from effluent discharges (ballast water, bilge water, deck drainage)	Medium	SPDC shall ensure full compliance and adherence to the following: • Standard Marine Operating procedures. • Standard maritime safety/ navigation procedures. • SPDC Oil Spill Contingency Management Plan • Engagement of Competent / Trained vessel operators. • Vessel Bunkering Procedure, including break-	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				away procedure shall be reviewed and adhered to. • Emergency shut-off valves shall be put in place. • Transfer operations shall be conducted in daylight and suitable weather conditions, i.e. good visibility and low / moderate wind speed and sea state. • Risk Assessment operations shall be carried out. • Permit to Work Rule shall be adhered to.	
		Damage to seabed / flora / fauna	Medium	• SPDC shall develop and implement waste management plans for all wastes streams generated in accordance with regulatory requirements and standard practice.	Low
		Interference with fishing activity	Medium	SPDC shall ensure that: • All project vessels shall have high-rise beacons to fore warn other fishing vessels in the project location. • Marine notices shall be put in strategic locations, • Radio monitoring of the area shall be continuously conducted. • Notify Fishing Communities on time	Low
		Impairment of air quality	Medium	SPDC shall: • ensure regular maintenance of generators and other machines.	Low

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				• Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems.	
		Nuisance (Noise, Vibration etc.) from machinery	Medium	SPDC shall • ensure regular maintenance of generators and other machines. • Ensure availability and use of proper PPE by workforce • Provide acoustic mufflers for heavy engines with noise level above acceptable limits • Daily pep talk is carried out for workforce	Low
		Risk of Piracy and kidnapping	High	SPDC shall: • Ensure all countermeasures to mitigate identified threats are in place • Ensure project non productive time are reduced to the barest minimum. • Regular drills are conducted. • Movement shall be under a GSA armed escort.	Low
	Demobilization (personnel via helicopter)	Increase in usage of airways with possibilities of accidents	High	SPDC shall ensure full compliance to the following: • Aviation Operating Procedures. • SPDC Aviation Audit of Heli-Deck. • SPDC / Contractor Emergency Response Plan • SPDC Oil Spill Contingency Management Plan • Heli-Ops conducted in daylight and suitable weather conditions, i.e. good visibility and low /	Medium

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact
				moderate wind speed and sea state. • BOSIET / HUET Training for all personnel using air transport.	
		Increase in ambient noise level	Medium	SPDC shall ensure full compliance to the following: • Entry to flight take off areas must be restricted to only persons who have their ears well protected • Flights shall be conducted timely and on schedule to reduce the duration of the impact. • contractor shall maintain equipment to optimal working condition • Use of mufflers on diesel equipment and power generators	Low

6.3: Implementation of Mitigation Measures

The mitigation measures for the seismic and exploratory drilling that have been proffered and summarised in the previous sections are discussed below.

Seismic Survey Mitigation

Vessel Movements and Positioning

A safety zone will be established during seismic operations to protect people, fishing boats/vessels and prevent damage to seismic survey equipment. The safety zone will be a buffer point of about 200m around the outer edge of the vessels and nodes on the seabed. Based on the speed of the survey vessel, it is expected that the duration of exclusion at any particular point would be about 5 minutes.

Commercial vessels and other vessels will be notified by appropriate signals in accordance with International Maritime Law, including communications via radio, lights and flags. In addition, notices will be communicated via local port authorities and fishermen's associations to inform local people of the survey activity. A chase boat will be used to notify small fishing boats that do not have a radio or are unaware of the International Maritime signal conventions.

Consultation would be carried out in coastal communities and fishing camps close to the prospect area to inform them of SPDC activities. Alternate fishing grounds would be made available and agreed upon during such meetings. SPDC shall ensure contacts with communities are maintained throughout the project, to listen to their concerns and suggestion.

Emission and Waste Discharges

All air pollutant emissions and water discharges will be consistent with international and industry guidelines and will comply with DPR and FMEnv specified limits.

Workplace Hazards

The following mitigation measures are to be carried out in the course of this project to reduce the risk of impacts from accidental or workplace hazards:

- job hazard analysis of all aspects of the project before mobilisation
- job specification and assigning of responsibility to personnel before mobilisation to site;
- ensure all personnel adhere strictly to the use of personal protecting equipment (PPE) at all time during the project execution;
- trained and competent personnel with requisite offshore work certifications, BOSIET, etc shall be engaged; and
- Subject personnel to medical check before and after the seismic survey.

CHAPTER SEVEN
ENVIRONMENTAL MANAGEMENT PLAN

7.1: Introduction

Environmental management is concerned with a planned and integrated programme aimed at ensuring that adverse impacts of a proposed project are contained and brought to acceptable minimum levels, while the positive impacts are enhanced to optimize the benefits. Environmental management provides confidence on the part of project planners that a reliable scheme has been put in place to deal with any contingency that may arise during all phases of the project operations from mobilization to demobilization. In keeping with SPDC's policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design and will continue throughout the project life cycle.

Environmental management will be carried out in accordance with the provisions of ISO 14001, sections 4.3.2 to 4.3.4, which are reflected in SPDC HSSE & SP Control Framework (HSSE & SP CF). The HSE-MS addresses the overall approach adopted for management of HSE risks throughout the project operations phase by the project management team. HSE-MS document provides central guidance and co-ordination for project-wide documents - work procedures, standards, work practices, etc., and demonstrates how the Hazards and Effects Management Process (HEMP) will be applied on the project such that HSE risks are kept to As Low As Reasonably Practicable (ALARP). Good environmental management, which is part of SPDC's HSE-MS goals, has the following long term objectives:

- Ensure compliance with Legislations and Company policy;
- Achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- Provide strategy for overall planning, operation, audit and review;
- Enable project planners establish environmental priorities.

To provide assurance that the risk management and control procedures identified are implemented, a comprehensive EMP was developed (Table 5.2) for implementation throughout the project life cycle.

7.2: SPDC's Corporate HSE Program

It is the policy of Shell companies to conduct their activities in such a way as to take foremost account of the health and safety of all their employees and other persons, and to give proper regards to the conservation of the environment. In implementing this policy, Shell companies not only comply with the requirements of the relevant legislations but promote, in an appropriate manner, measures for the protection of health, safety, environment and the security of all who may be involved directly or indirectly with their activities. The Environmental Management activities initiated by SPDC are intended to implement the above policy and the policy will be applied to all stages of the project life cycle. The projects' HSE-MS is fully aligned to SPDC's corporate HSE programs.

7.3: Resourcing

Shell Petroleum Development Company (SPDC) considers environmental management as an important aspect of project procedures. Consequently, in any project for which project management team is set up, an environmental specialist always forms an integral part of the team. In this project, an environmental focal point has been appointed to liaise between the project managers and the environmental specialist, consultants as well as advises on all environmental issues in conformity with SPDC's HSSE & SP policy. Shell Petroleum Development Company (SPDC) recognizes the need to use external environmental consultants to supplement in-house environmental specialists. To this end, the environmental consultants will continue to provide expert advice to SPDC`s environmental managers throughout the Life cycle of this project.

7.4: Environmental Audits

Shell Petroleum Development Company (SPDC) has an audit scheme, as part of its programme on environmental management. The scheme is aimed at verifying the effectiveness of environmental control and highlighting areas of weakness in environmental management requiring further improvements. The audits are focused on areas of project perceived as having the highest environmental impacts. It is recognized that to be truly effective, these audits need to be conducted within the overall structured management systems. The structured approach is aimed at disseminating information, providing advice and assistance in its application, and at corporate assurance of performance in meeting the environmental requirement/targets. External audits are also carried out for SPDC assets and projects and SPDC subscribes to ISO 14001 standards.

7.5: Responsibilities and Training

Within SPDC, environmental protection, like safety, is a line responsibility for which staff, at all levels, have accountabilities. An environmental specialist assists the line management with advice on environmental matters, from an expert point of view. However, responsibility and accountability is clearly defined, from senior management who allocate resources and monitor environmental performance to individual contractors who have responsibility for environmentally sound practices in their workplace. All staff are aware of their responsibilities through induction and training opportunities as outlined in the projects' HSE-MS document. In addition, procedures, guidelines and notices advise staff on how to respond in the event of an environmental emergency. The Shell Corporate Environment Department is responsible for internal and facilitating external monitoring and auditing the environmental activities of this project.

7.6: Waste Management

The Waste Management Plan includes procedures for safe handling, control and disposal of generated waste in accordance with the SPDC procedure. Wastes emanating from the seismic activities are mainly sump oil discharge, ballast water discharge, grey water discharge, sewage discharge, solid waste discharge, faecal waste and waste from human activities such as biodegradable food remains. These wastes are handled in compliance with the Petroleum

(Drilling & Productions) Regulations, 1969, Sections 25, 36 49 and (b), (c) and (d), which stipulate *inter alia* that:

The licensee or lessee shall adopt all practical precautions, including the provision of up-to-date equipment to prevent the pollution of inland waters, rivers, creeks, water courses, the territorial waters of Nigeria or the high seas by oil, mud or other fluids or substances which might contaminate the water or marine life, and where any such pollution occurs or has occurred, shall take prompt steps to control and, if possible, end it."

The waste management strategy to be adopted in the proposed project has been highlighted in Section 2.4 of chapter two

7.7: Emergency Response Program

In compliance with all regulatory standards, as well as Health, Security, Safety, Environment and Social Performance (HSSE) & SP procedures shall form the basis for the execution of the project. However, emergency situations could still occur as a result of equipment failure, negligence and/or sabotage. Consequently, a site-specific contingency plan shall be developed as back up to site specific emergency response systems which shall be put in place to handle any incident emergency. As a minimum, the contingency plans that shall apply shall address the following emergency situations:

- Fires and explosions;
- Serious injury or illness;
- Water mishaps.

In order to accomplish the above targets, the EMP has considered each environmental, social and health impacts and parameters for their monitoring. It also specifies the responsible party/parties for each action, as well as parameters for monitoring.

7.8: Contractor Management

The contractor staff shall be well informed and trained on the HSSE & SP policies and guidelines and be made aware of SPDC's HSSE & SP performance targets including the 12 Life Saving Rules. All activities shall be executed within the confines of relevant legislation and stakeholders' interests. Contractors shall provide adequate health services as well as site first aid services for its workforce. Site health services shall be extended to visiting personnel. All project activities shall be properly managed through careful planning and the application of relevant HSSE & SP policies including the following:

- Enforcement of 12 Life Saving Rules.
- Job Hazard Analysis and toolbox meetings;
- Regular emergency drills

Table 7.1: Environmental Management Plan

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
Premobilization	Permitting via consultation and signing of agreement (Securing of Social License to operate)	Acceptance of project and co-operation/participation from stakeholders (communities and government) leading to peaceful and timely execution of the project	Positive	• Early stakeholders' engagement sessions shall be held, with all the agreed issues properly documented and signed. • Signing of MoU agreements with the community/stakeholders	Positive	Stakeholders' engagement reports/agreement	Once during premobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR
	Premobilization inspection of project equipment to quay side	Injuries and accidents	High	• Visible warning signs shall be placed at strategic positions along the roads • SPDC shall ensure there is traffic control at strategic points around the quay side • SPDC shall ensure all vehicles observe the speed limits and large vehicles have warning lights to alert other road users • SPDC shall ensure all project vehicles are pre-mobbed and certified. • Reverse alarm shall be installed in all Operational vehicles • Speed control facilities	Low	Site inspection/ stakeholder engagement reports Inventory of approved journey management forms	Once during premobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				such as IVMS and Strata shall be installed in all vehicle • The 12 Life Saving Rules (LSR) shall be enforced on all road users. • Effective journey Management system • Emergency response shall be activated				
		Movement of personnel for pre-mobilization inspection	High	• SPDC shall ensure access control is implemented at the quay side.	Low	Site Inspection report	Once during premobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Risk of kidnapping	High	SPDC shall: • Proper identification and management for all security threats and risk are highlighted • Develop adequate security strategy, plan and procedure for the project. • Ensure that security orientation and awareness/drills are conducted for the workforce • Ensure all countermeasures to mitigate identified threats	Medium	• Evidence of stakeholders engagements • Records of security incidences • Project security plan • Record of security orientation and awareness	Monthly	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				are in place. • Ensure project non productive time are reduced to the barest minimum. • Regular drills are conducted. • All movements shall be undertaken only with Security Single Point Approval • Movement shall be under a GSA armed escort.				
Mobilization	Mobilization to Site (Transportation of equipment and personnel) by vessels	Risk of accident from vessel collision	High	SPDC shall ensure • Adequate radio communication between merchant ships and standby vessels • Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective • Regular drills on abandon ship procedures shall be enforced • Activate Emergency response plan inline with SOLAS	Low	Inventory of approved journey management forms Basic swimming certification Vehicle Premob reports/permits IVMS checks/Reports	Omce during mobilization phase	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				• Use of appropriate PFDs by the survey team.				
		Impairment of water quality from vessel discharges (cooling water, ballast water, deck drainage)	Medium	SPDC shall ensure full compliance to the following: • Standard Marine Operating procedures. • Standard maritime safety/ navigation procedures. • SPDC Oil Spill Contingency Management Plan • Engagement of Competent / Trained vessel operators. • Vessel Bunkering Procedure, including break-away procedure shall be reviewed and adhered to. • Transfer operations shall be conducted in daylight and suitable weather conditions, i.e. good visibility and low / moderate wind speed and sea state.	Low	Work procedures Premob certificates Documentation from Tool Box meeting	Omce during mobilization phase	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Impairment of air quality	Medium	SPDC shall: • Use only pre-mobbed and regularly maintained vessels, generators and	Low	Premob certificates Maintenance	Omce during mobilization phase	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				other machines. • Use only low sulphur containing fuels and low NOx burners in large generators. • Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems.		records		
		Nuisance (Noise, Vibration etc.) from Equipment	Medium	SPDC shall • use only pre-mobbed and regularly maintained equipment and water crafts. • Ensure availability and use of proper PPE by workforce • Provide acoustic mufflers for heavy engines with noise level above acceptable limits • Daily pep talk is carried out for workforce	Low	Premob certificates Maintenance records	Omce during mobilization phase	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Risk of Piracy and kidnapping	High	SPDC shall: • Ensure all countermeasures to mitigate identified threats are in place • Ensure project non	Medium	• Evidence of stakeholders engagements • Records of security incidences	Monthly	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				productive time are reduced to the barest minimum. • Regular drills are conducted. • Movement shall be under a GSA armed escort.		• Project security plan • Record of security orientation and awareness		
		Increase in STIs	Medium	SPDC shall: • Step-up health education and sensitization activities prior commencing construction activities. • organize awareness session on sexually transmitted diseases, sexual behavior for workers and local hands that will be employed	Low	• Health awareness sessions	Once during mobilization phase	SPDC Head Seismic Acquisition/FMEnv/ DPR
	Mobilization (personnel via helicopter)	Increase in usage of airways with possibilities of accidents	High	SPDC shall ensure full compliance to the following: • Aviation Operating Procedures. • SPDC Aviation Audit of Heli-Deck. • SPDC / Contractor Emergency Response Plan • SPDC Oil Spill	Medium	Site inspection reports Audit reports Job Hazard Analysis	Once during mobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Contingency Management Plan • Heli-Ops conducted in daylight and suitable weather conditions, i.e. good visibility and low / moderate wind speed and sea state. • BOSIET / HUET Training for all personnel using air transport.				
		Increase in ambient noise level	Medium	SPDC shall ensure full compliance to the following: • Entry to flight take off areas must be restricted to only persons who have their ears well protected • Flights shall be conducted timely and on schedule to reduce the duration of the impact. • SPDC/contractor shall maintain equipment to optimal working condition • Use of mufflers on diesel equipment and power generators	Low	Premob certificates Maintenance records	Montthly during mobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR
Seismic Shooting	**Discharge of the acoustic energy**	Disturbance to marine fauna (spawning sites	High	SPDC shall ensure: • Marine audit / inspection	Low	Project Job Hazard Analysis	Once during seismic	SPDC Head Seismic Acquisition/FMEnv/

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	source and data recording	and migratory routes of fishes)		of seismic vessel shall be carried out to ensure compliance with international specified standards. • Soft start procedures for seismic source shall be followed. • Marine Mammal Observers (MMO) shall be part of the seismic crew to ensure minimum interference with marine mammals. • Appropriate technology to minimize the impact of noise and vibration • Soft start protocols are adopted for shooting airguns (Noise emissions shall begin at low power, increasing gradually until full power is reached). • Acoustic Mitigation devices (PAM) shall be used to drive away marine mammals.		Premob/Audit reports	shooting	DPR
		Possible death of marine fauna from seismic air guns	High	SPDC shall ensure: • ensure the presence of Marine Mammal		Project Job Hazard Analysis Premob/Audit	Once during seismic shooting	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				Observer (MMOs) on board the vessel • a gradual increase of signal intensity at the beginning of the procedure ('soft-start' or 'ramp-up'); • implementation of wildlife exclusion zones (EZs) within which air guns can be shut down or their use delayed if any marine mammal is detected • ensure restriction of night time seismic survey activity; • sensitive ecosystems (turtle nesting sites) are avoided during seismic data acquisition. • Vessels use Passive Acoustic Monitoring to verify the presence of near-surface fish shoals within the mitigation zone.		reports		
		Disaggregation of benthic organisms during nodes placement	High	• SPDC shall adopt due diligence to minimize adverse impacts on	Low	Project Job Hazard Analysis Premob/Audit	Once during seismic shooting	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				benthic organisms		reports		
		Increase in noise and vibration from seismic air guns	Medium	SPDC shall: • ensure only pre-mobbed and regularly maintained equipment and water crafts. • Appropriate technology (acoustics) to minimize the impact of noise and vibration • Soft start protocols are adopted for shooting airguns (Noise emissions shall begin at low power, increasing gradually until full power is reached).	Low	Equipment maintenance records	Once during seismic shooting	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Impairment of water quality from effluent discharges	High	SPDC shall ensure compliance with MARPOL regulations.	Low	Site report	Once during seismic shooting	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Interference with fishing activity	Medium	SPDC shall ensure that: • All project vessels shall have high-rise beacons to fore warn other fishing vessels in the project location. • Marine notices shall be put in strategic locations • Radio monitoring of the	Low	Site report	Once during seismic shooting	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				area shall be continuously conducted. • Provide timely information to stakeholders particularly fisher folk on the nature and timing of activities which may lead to direct interference with fishing activities/operations.				
		Explosion from air guns	High	SPDC shall ensure: • fire systems on board • emergency response system are in place	Medium	Site report	Once during seismic shooting	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Inclement weather conditions (Poor visibility, currents)	High	SPDC shall ensure: • Competence of vessel crew • Contractor vessel regulates speed and/or alter course in heavy weather as required by good seamanship, in order to avoid the possibility of damager to ship. • Daily weather forecast from the nearest synoptic station shall be shared with the vessel crew • Adequate steps to	Medium	Site report	Daily during seismic data acquisition	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				increase stability of the vessel shall be taken in ample time before the weather deteriorates such as pumping, ballasting etc.				
		Injuries and accident from vessel collision	High	SPDC shall ensure • Adequate radio communication between merchant ships and standby vessels • Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective • Regular drills on abandon ship procedures shall be enforced • Activate Emergency response plan inline with SOLAS • Use of appropriate PFDs by the survey team.	Low	Project HSE Plan Site induction report PTW documentations	Monthly	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Piracy and kidnapping	High	SPDC shall: • Ensure all countermeasures to mitigate identified threats are in place	Medium	• Records of security incidences • Project security plan	Monthly	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				• Ensure project non productive time are reduced to the barest minimum. • Regular drills are conducted. • Movement shall be under a GSA armed escort.		• Record of security orientation and awareness		
		Opportunity for business and contracting	Positive	SPDC shall ensure adherence to local content policy.	Positive	Contract documents /register or list of community members employed	Once during project phase	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Increase in waste generation	High	SPDC shall: • Ensure compliance with MARPOL regulations. • Biological Sewage Treatment shall be carried out onboard. • Residual wastes shall be transferred onshore via consignment note. • All equipment using hydrocarbon fuel must be in optimum condition to reduce the generation of hazardous gases.	Low	Waste consignment note	Monthly	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Increase in STIs	Medium	SPDC shall: • Step-up health education	Low	Health awareness sessions	Once during seismic data	SPDC Head Seismic Acquisition/FMEnv/

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				and sensitization activities prior commencing construction activities. • organize awareness session on sexually transmitted diseases, sexual behavior for workers and local hands that will be employed			acquisition	DPR
Demobilization	**Demobilization (Transportation of equipment and personnel) by vessels**	Injuries and accidents from vessel collision	High	SPDC shall ensure • Adequate radio communication between merchant ships and standby vessels • Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective • Regular drills on abandon ship procedures shall be enforced • Activate Emergency response plan inline with SOLAS • Use of appropriate PFDs by the survey team.	Low	Inventory of approved journey management forms Basic swimming certification	Monthly during mobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Impairement of water quality from effluent discharges (ballast water, bilge water, deck drainage)	Medium	SPDC shall ensure full compliance and adherence to the following: • Standard Marine Operating procedures. • Standard maritime safety/ navigation procedures. • SPDC Oil Spill Contingency Management Plan • Engagement of Competent / Trained vessel operators. • Vessel Bunkering Procedure, including break-away procedure shall be reviewed and adhered to. • Emergency shut-off valves shall be put in place. • Transfer operations shall be conducted in daylight and suitable weather conditions, i.e. good visibility and low / moderate wind speed and sea state. • Risk Assessment operations shall be	Low		Monthly during demobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	**Project Activities**	**Description of Impact**	**Impact rating**	**Mitigation measures**	**Residual impact**	**Parameter for monitoring**	**Frequency of Monitoring/ Formal Reporting**	**Responsible/ Action Party**
				carried out. • Permit to Work Rule shall be adhered to.				
		Damage to seabed / flora / fauna	Medium	• SPDC shall develop and implement waste management plans for all wastes streams generated in accordance with regulatory requirements and standard practice.	Low	Site inspection report	Monthly during demobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Interference with fishing activity	Medium	SPDC shall ensure that: • All project vessels shall have high-rise beacons to fore warn other fishing vessels in the project location. • Marine notices shall be put in strategic locations, • Radio monitoring of the area shall be continuously conducted. • Notify Fishing Communities on time	Low		Monthly during demobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
		Impairment of air quality	Medium	SPDC shall: • ensure regular maintenance of generators and other machines. • Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems.	Low	Site inspection report	Monthly during demobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Nuisance (Noise, Vibration etc.) from machinery	Medium	SPDC shall • ensure regular maintenance of generators and other machines. • Ensure availability and use of proper PPE by workforce • Provide acoustic mufflers for heavy engines with noise level above acceptable limits • Daily pep talk is carried out for workforce	Low	Site inspection report	Monthly during demobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Risk of Piracy and kidnapping	High	SPDC shall: • Ensure all countermeasures to mitigate identified threats are in place • Ensure project non	Low	• Records of security incidences • Project security plan • Record of	Monthly during demobilization	SPDC Head Seismic Acquisition/FMEnv/ DPR

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				productive time are reduced to the barest minimum. • Regular drills are conducted. • Movement shall be under a GSA armed escort.		security orientation and awareness		
	Demobilization (personnel via helicopter)	Increase in usage of airways with possibilities of accidents	High	SPDC shall ensure full compliance to the following: • Aviation Operating Procedures. • SPDC Aviation Audit of Heli-Deck. • SPDC / Contractor Emergency Response Plan • SPDC Oil Spill Contingency Management Plan • Heli-Ops conducted in daylight and suitable weather conditions, i.e. good visibility and low / moderate wind speed and sea state. • BOSIET / HUET Training for all personnel using air transport.	Medium	Site inspection reports Audit reports	Onnce during demob	SPDC Head Seismic Acquisition/FMEnv/ DPR
		Increase in ambient noise level	Medium	SPDC shall ensure full compliance to the following:	Low	Premob certificates	Onnce during demob	SPDC Head Seismic Acquisition/FMEnv/

Project phase	Project Activities	Description of Impact	Impact rating	Mitigation measures	Residual impact	Parameter for monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
				• Entry to flight take off areas must be restricted to only persons who have their ears well protected • Flights shall be conducted timely and on schedule to reduce the duration of the impact. • contractor shall maintain equipment to optimal working condition • Use of mufflers on diesel equipment and power generators		Maintenance records		DPR

CHAPTER EIGHT
CONCLUSION

The EIA for the proposed 3D Reshoot Seismic Data Acquisition Project in OML77 and 74 has been carried out using information obtained from field data gathering, observations, literatures and laboratory analysis of collected ecological data. The overall goal of the EIA is to ensure that potential environmental and social impacts of the proposed project are identified and evaluated, and adequate mitigation proffered for significant impacts. Thus, provides necessary data / evidence that will ensure the issuance of an environmental impact statement (EIS) for the project. The physico-chemical as well as biological characterisation of the seawater and sediment of the OML77 and 74 Field showed that the physical, chemical and biological characteristics of the seawater and surficial sediment were significantly consistent across sampling stations and compared well with values recorded at control stations. Analysis of air, water and sediment, fish, plankton and benthic fauna respectively, indicated peculiar characteristics of offshore marine environment. The distribution, diversity and abundance of biota relates to the nutrients and chemical composition of the ecosystems.

The potential and associated impacts assessment of the proposed development indicated that the project would beneficially and significantly impact on the national economy and the overall wellbeing of the Nigerian people by adding value to Nigeria's total natural gas and oil reserve; increased production capacity thereby meeting government domestic supply obligation and ultimately, enhancement of the overall export earnings for the nation. The adverse impacts of the project may result from impairment in air quality and seawater and disturbance of marine fauna from air guns. However, these adverse impacts can be reduced, prevented or ameliorated if the recommended mitigation measures are strictly followed and implemented. An EMP has been developed to ensure effective implementation of prescribed mitigation measures and for proactive environmental management throughout the project duration. Implementation of these measures will ensure a successful execution and completion of planned 3D Reshoot Seismic Data Acquisition Project in an environmentally safe and sustainable manner.

References

Abayomi, F. O. (2017) From "hunters" to "conservationists" seeking to change the ways in which rural communities in Nigeria self-identify. International Sea Turtle Symposium, At Las Vegas, Volume: 37th

Aguirre, A. A., Gardner, S. C., Marsh, J. C., Delgado, S. G., Limpus, C. J., and Nichols, W. J. (2006). Hazards associated with the consumption of sea turtle meat and eggs: a review for health care workers and the general public.Ecohealth 3, 141–153.

Aguirre, A. A., Spraker, T.R., Balazs, G.H., and Zimmerman, B. (1998) Spirorchidiasis and fibropapillomatosis in green turtles from the Hawaiian Islands. Journal of Wildlife Diseases 34:91-98.

AkaniG.C.andLuiselli L.(2009)Diversity and distribution of sea turtles in the niger delta, Nigeria. **Article** *in* Revue d Ecologie 64(4):369-374.

Aragones, L.V., Lawler, I.R., Foley, W.J. & Marsh, H. (2006) Dugong grazing and turtle cropping: grazing optimization in tropical seagrass systems? Oecologia, 149, 635– 647.

Arthur KE, Michelle CB, Limpus CJ (2008) Ontogenetic changes in the diet and habitat use in green turtles (Chelonia mydas) life his-tory. *Mar Ecol Prog Ser* 362:303–311.

Broderick AC, Glen F, Godley BJ, Hays GC (2002). Estimating the number of green and loggerhead turtles nesting annually in the Mediterranean. Oryx 36: 227-235.

Broderick AC, Godley BJ, Reece S, Downie JR (2000). Incubation periods and sex ratios of green turtles: highly female biased hatchling production in the eastern Mediterranean. Mar Ecol Prog Ser 202: 273-281.

Bull JJ (1980). Sex determination in reptiles. Q Rev Bid 55: 3-21.

CARR, A. AND OGREN L. 1959. The ecology and migrations of sea turtles, 3. Dermochelys in Costa Rica. Amer. Mus. Novitates, no. 1958, 29 pp., 13 figs.

Caut, S.E. Guirlet, P. Jouquet, M. Girondot. 2006. Influence of nest location and yolkless eggs on th hatching success of leather back turtle clutches in french guiana. *Canadian Journal of zoology*,84(6):901-916.

Chaing, M. 2003. The plight of the turtle . *Science world*.5:8

Eckert, K., S. Eckert. 1987. Growth Rate and Reproductive Condition of the Brnacle Conchoderma virgatum. Journal of crustacean biology, Vol. 7/No. 4: 682-690

Ernst, C., J. Lovich, R. Barbour. 1994. Turtles of the united state and canada. washington D.C USA. Smithonian Institution Press.

Evans, D. 2004. Raising awareness of sea turtle habitat. Endangered species Bulletin, 29(2):30-31

Forbes, G.A. 1996. The diet and feeding ecology of the green sea turtle (Chelonia mydas) in an algal based coral reef community. Ph.D. Diss., James Cook University of North Queensland, Australia. 340 pp

Gomuttapong, S. Klom-In, W. Kitana, J. Pariyanonth, P. Thirakhupt, K. and Kitana, N. (2013).

Green Turtle, Chelonia mydas, Nesting and Temperature Profile of the Nesting Beach at Huyong Island, the Similan Islands in Andaman Sea. ***Natural Resources*, 4, 357-361**

Higgins, B. M. 2003. Sea Turtle Husbandry. In: P. L. Lutz, Musick, J.A., Wyneken, J. (Eds.), The Biology of Sea Turtles, vol. 2, CRC Press, Boca Raton, pp. 411–440.

Hirth, H. F. (1971b). Synopsis of biological data on the green turtle, Chelonia mydas (Linnaeus) 1758. FAO Fisheries Synopsis No. 85, 1.1-8.19.

Houghton, J., T.K Doyle, M.W Wilson, J. Davenpot. 2006. Leatherback turtles and jellyfish in temperate coastal seas. *Ecology*. 3(201-209)

Ibim, A.T. and Douglas, S. (2017) Status of the Fin Fish of the Upper Sombrero River, Abua/Odual Local Govt. Area, Rivers State, Nigeria. *Journal of Agriculture and Social Research (*JASR*)*. Vol.16, No.1, pp 37-58. (Nigeria).

Ibim, A.T. and Bongilli, B. (2017). Ichthyofaunal Composition and Diversity of Middle Reaches of Sombreiro River in Degema and Akuku -Toru Local Government Areas, Rivers State. Nigerian Association for Aquatic Sciences of Nigeria (ISSN: 0189-8779). *Journal of Aquatic Sciences* (2017) 32 (1A): 1-12. DOI: https://dx.doi.org/10.4314/jas.v32i1A1. (Nigeria).

Ibim, A.T. and Bongilli, B. (2018). Fish Stock Status of the Middle Reach of the Sombreiro River of the Niger Delta Basin, Nigeria. *Proceedings of 6th NSCB Biodiversity Conference*; Uniuyo. 2018 (346 - 360pp).

Ibim, A.T. and Njoku, L. (2018). Fish assemblage of Amadi creek, Port Harcourt, Rivers State,
Nigeria. *American Scientific Research Journal for Engineering, Technology and Sciences (*ASRJETS*)*. Vol. 39, No. 1.

Kaska Y, Downie JR, Tippett R, Furness R (1998). Natural temperature regimes for loggerhead and green turtle nests in the eastern Mediterranean. *Can J Zoolog* 76: 723-729.

Nel R, Punt AE, Hughes GR (2013) Are coastal protected areas always effective in achieving population recovery for nesting sea turtle? PLoS ONE 8:e63525, Pacific Science 65:375–381.

Raidal, S., Ohara, M., Hobbs, R., and Prince, R. (1998). Gram−negative bacterial infections and cardiovascular parasitism in green sea turtles(Chelonia mydas). Aust. Vet. J.76, 415–417.

Robson G. S, Agnaldo S. M. Manuela B .B, Paulo A .H

Ross, J.P. (ed.) (1998). Crocodiles: Status Survey and Conservation Action Plan, 2nd Edition. IUCN/SSC Crocodiles Specialist Group: Gland, Switzerland

Russell, D.J., S. Hargrove, & G.H. Balazs. 2011. Marine sponges, other animal food, and nonfood

Seminoff, J., A. Reséndiz& W. Nichols.2002b. Diet of East Pacific green turtles (Chelonia mydas) in the Central Gulf of California, Mexico. J. Herpetol., 36(3): 447-453.

Spotila JR (2004) Sea Turtles: A Complete Guide to Their Biology, Behavior, and Conservation. JHU Press, Baltimore, 227 pp.

Spotila, J. 2004. Seaturtles. Baltimore and London: The john Hopkins University Press.

Spotila, J. R. 2004. Sea Turtles: A Complete Guide to Their Biology, Behavior and Conservation. Johns Hopkins University Press, Baltimore, MD. 228pp.

Appendix 1
DPR Approval

MINISTRY OF PETROLEUM RESOURCES

DEPARTMENT OF PETROLEUM RESOURCES

7 KOFO ABAYOMI STREET, VICTORIA ISLAND LAGOS

P.M.B. No: 12560
Telephone: 2790000, 4611777
Website: www.dprnigeria.com

Ref. No: DPR/HSE.02/001.101/2018/007
Date: 2nd March 2018

The Managing Director
Shell Petroleum Development Company
Freeman House
21/22 Marina
Lagos

SPDC RECEIVED
06 MAR 2018
TIME 14:21 HRS

Dear Sir,

APPROVAL OF TERMS OF REFERENCE FOR THE ENVIROMENTAL IMPACT ASSESSMENT OF OML 77 AND 74 3D RE-SHOOT SEISMIC DATA ACQUISITION PROJECT.

We refer to your with reference number SPDC-HSE-2018-0032L dated 17th January 2018 with which you transmitted the updated Environmental Screening Report (ESR) and Preliminary Environmental Impact Assessment (PIAR) as well as the Terms of Reference (TOR) for the Environmental Impact Assessment of the OML 77 & 74 3D Reshoot Seismic data acquisition project.

2. We have reviewed the submitted Terms of Reference for the EIA and noted that it has met our minimum requirements. Consequently, we are pleased to convey to you the Department's **acceptance** and **approval** of the TOR.

3. The field data gathering for the study shall be for **one season** and the collected samples shall be analysed for the following parameters:

S/N	Sample	Analysis	Parameters	Remarks
1.	**Sediment** 63 sampling stations + 3 controls	Physico-chemical	Colour, particle size, temperature, pH, salinity, THC, TPH, TOC, exchangeable cations (Na, K, Ca and Mg), Available PO_4^{3-} NH_4^+, NO_3^-, BTEX, redox potential, Oil & grease, heavy metals (Fe, Cd, Cr, Pb, Cu, Ba, Ni, V,	Sediment samples for BTEX shall be collected in glass bottles preserved in methanol. GC with a purge & trap system or GC-FID with a head space shall be used for the analysis of BTEX. Samples for PAH analysis shall be

			Ag, Co and Zn), etc.	conducted with a GC-MS. Oil & grease/TPH shall be analysed using infrared spectrophotometer.
		Microbiology	THB, THF, THUB, THUF, SRB and Faecal Coliform	
		Macro benthos	Benthic macro-invertebrate studies identification to the nearest taxonomic level as well as their species distribution, abundance, dominance, diversity and density, etc.	Different statistical tools such as Margalef index, Shannon's index, Evenness index and dendrogram shall be employed to make reasonable inferences.
2.	**Surface water 37 sampling stations + 3 controls**	Physico-chemical	Colour, Temperature, pH, DO, salinity, conductivity, depth and width, flow direction and flow rate, alkalinity, BTEX, TPH, TDS, TSS, Turbidity, THC, pH, DO, BOD_5, COD, anions/cations, NH_4^+, NO_3^-, NO_2^-, PO_4^{3-}, SO_4^{2-}, SiO_2, Na, K, Ca, Mn, Mg, Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Ba, Hg), etc.	Samples for BTEX samples shall be taken with vials. Analyses for BTEX, PAH, THC/Oil & grease shall be as stated above. Water profiling shall be done with a CTD profiler.
		Microbiology	THB, THF, THUB, THUF, SRB and faecal coliforms	
		Hydrobiology (Phytoplankton)	Identification to the nearest taxonomic level, Species diversity (composition, distribution and density) and productivity	Same as macro benthos above.

			(chlorophyll concentration)	
		Hydrobiology (Zooplankton)	Identification to the nearest taxonomic level, species diversity (composition, distribution and density)	-do-
		Fisheries	Species types, species diversity, fish spawning area, fish catch where possible, food & feeding habits, fish stock assessment, fish migration pattern, breeding habits, presence of protected species, fish spawning area, distribution catch assessment survey (CAS), breeding sites, migration routes and fishery activities.	Histological studies, fecundity, gonado-somatic ratio, etc. shall be reported as part of this study.
		Hydrodynamics	Water depth and width, flow direction and flow rate.	
3.	**Air Quality/Noise 12 sampling stations + 3 controls**	Ambient	VOCs, SO2, NO2, CH4, CO, CO2, temperature, Noise Levels, Particulates, wind speed and direction.	One (1) hour mean for each of the air quality parameters shall be taken per station.
4.	**Socio-economic study**	Impacts of proposed seismic survey on existing oil and gas infrastructure; marine transport routes and fishing activities in the 73 identified coastal communities to be assessed using literature review, questionnaires and Focus Group Discussions.		

5. On conclusion of this study, you are to submit the draft report in both electronic (compact disc) and hard copy to the DPR for review and approval. The electronic copy should also include a stand alone environmental dataset (physico-chemical and biological parameters) in Excel format covering all relevant environmental aspects in the study.

6. Finally, you are required to provide adequate notification to the DPR prior to mobilization for the field sampling campaign to enable us plan our participation in both the field data gathering campaign and subsequent laboratory analyses.

Yours faithfully,

Abdurrahman A. S.
for: Director, Petroleum Resources

FMEnv Approval

FEDERAL MINISTRY OF ENVIRONMENT

Environment House

Independence Way South, Central Business District, Abuja - FCT.
Tel: 09-2911 337 www.environment.gov.ng, ea-environment.org

ENVIRONMENTAL ASSESSMENT DEPARTMENT

Ref: FMEnv/EA/EIA/3995/Vol.1/X

Date: 7th June, 2018

The Manager Director,
Shell Petroleum Development Company Limited,
Freeman House, Marina,
Lagos State.

RE: ENVIRONMENTAL IMPACT ASSESSMENT (EIA) ToR APPROVAL OML 77/74 3D RE-SHOOT SEISMIC DATA ACQUISITION PROJECT

Please refer to your letter on the proposed OML 77 and 74 3D Reshoot Seismic Data Acquisition Project off-shore Niger Delta.

2. I am further directed to convey the Ministry's approval of the Terms of Reference (ToR) of the project.

3. Thank you for your cooperation.

Received
Time 07 JUN 2018
Signature
SHELL OFFICE ABUJA

A. O. Suleiman
For: Honourable Minister.

Appendix 2
Coordinate listing

Samples	Description	Eastings (Minna/Midbelt)	Northings (Minna/Midbelt)
AQ-1/SW-21	Air Quality/Surface Water	414701.29	9416.83
AQ-2/SW-22	Air Quality/Surface Water	466701.29	9416.83
AQ-3/SW-23	Air Quality/Surface Water	390797.56	18221.39
CON-1	Control	399445.42	3122.02
CON-2	Control	474346.80	24257.03
CON-3	Control	380761.25	21513.54
SD-58	Sediments	386701.29	5416.83
SD-59	Sediments	386701.29	9416.83
SD-60	Sediments	386701.29	17416.83
SD-61	Sediments	386701.29	21416.83
SD-63	Sediments	386701.29	29416.83
SD-1	Sediments	414701.29	5416.83
SD-2	Sediments	454701.29	5416.83
SD-4	Sediments	402701.29	9416.83
SD-6	Sediments	410701.29	9416.83
SD-7	Sediments	418701.29	9416.83
SD-12	Sediments	446701.29	9416.83
SD-14	Sediments	462701.29	9416.83
SD-16	Sediments	390846.81	14660.38
SD-17	Sediments	394807.12	14329.65
SD-18	Sediments	402410.25	14369.33
SD-19	Sediments	406701.29	13416.83
SD-20	Sediments	414701.29	13416.83
SD-21	Sediments	418701.29	13416.83
SD-22	Sediments	426701.29	13416.83
SD-23	Sediments	430701.29	13416.83
SD-24	Sediments	442486.76	14174.83
SD-25	Sediments	450701.29	13416.83
SD-26	Sediments	454701.29	13416.83
SD-27	Sediments	462701.29	13416.83
SD-28	Sediments	466701.29	13416.83
SD-29	Sediments	474701.29	13416.83
SD-30	Sediments	394873.27	18514.85
SD-31	Sediments	398648.37	18541.31
SD-32	Sediments	406701.29	17416.83
SD-34	Sediments	414701.29	17416.83
SD-39	Sediments	394701.29	21416.83
SD-40	Sediments	402701.29	21416.83
SD-41	Sediments	406701.29	21416.83
SD-42	Sediments	414701.29	21416.83
SD-62	Sediments	386701.29	25416.83
SD-44/AQ-4	Sediments/Air Quality	394701.29	9416.83
SD-45/AQ-5	Sediments/Air Quality	434701.29	9416.83
SD-46/AQ-6	Sediments/Air Quality	442701.29	9416.83
SD-47/AQ-7	Sediments/Air Quality	454701.29	9416.83
SD-48/AQ-8	Sediments/Air Quality	430701.29	17416.83
SD-49/AQ-9	Sediments/Air Quality	418701.29	21416.83
SD-50/AQ-10	Sediments/Air Quality	394701.29	25416.83
SD-3/SW-32	Sediments/Surface Water	390701.29	9416.83
SD-5/SW-35	Sediments/Surface Water	406701.29	9416.83
SD-8/SW-26/AQ-11	Sediments/Surface Water/Air Quality	422701.29	9416.83
SD-9/SW-27/AQ-12	Sediments/Surface Water/Air Quality	426701.29	9416.83
SD-11/SW-28	Sediments/Surface Water	438701.29	9416.83
SD-13/SW-36	Sediments/Surface Water	450701.29	9416.83
SD-15/SW-30	Sediments/Surface Water	470701.29	9416.83
SD-33/SW-29	Sediments/Surface Water	410701.29	17416.83
SD-35/SW-33	Sediments/Surface Water	418701.29	17416.83
SD-36/SW-34	Sediments/Surface Water	422701.29	17416.83
SD-37/SW-24	Sediments/Surface Water	426701.29	17416.83
SD-38/SW-25	Sediments/Surface Water	390701.29	21416.83
SD-43/SW-37	Sediments/Surface Water	398701.29	25416.83
SD-10/SW-35	Sediments/Surface Water	430701.29	9416.83

Samples	Description	Eastings (Minna/Midbelt)	Northings (Minna/Midbelt)
SW-38	Surface Water	386701.29	13416.83
SW-14	Surface Water	398701.29	9416.83
SW-15	Surface Water	458701.29	9416.83
SW-16	Surface Water	438701.29	13416.83
SW-17	Surface Water	402463.16	18633.92
SW-4	Surface Water	398582.23	14382.56
SW-5	Surface Water	410701.29	13416.83
SW-6	Surface Water	422701.29	13416.83
SW-8	Surface Water	446701.29	13416.83
SW-10	Surface Water	470701.29	13416.83
SW-11	Surface Water	398701.29	21416.83
SW-12	Surface Water	410701.29	21416.83
SW-13	Surface Water	422701.29	21416.83
SW-18/SD-54	Surface Water/Sediments	434701.29	17416.83
SW-19/SD-55	Surface Water/Sediments	390701.29	25416.83
SW-1/SD-56	Surface Water/Sediments	410701.29	5416.83
SW-2/SD-52	Surface Water/Sediments	446738.17	6000.85
SW-3/SD-53	Surface Water/Sediments	458701.29	5416.83
SW-7/SD-57	Surface Water/Sediments	434701.29	13416.83
SW-9/SD-51	Surface Water/Sediments	458701.29	13416.83

Appendix 3

A, Physico-Chemistry Results for Analysis of Water Samples

Sample ID	TEMP (℃)	PH APHA 4500	EC APHA 2510A µS/cm	TURB	DO APHA 4500 mg/l	TDS APHA 1030 mg/l	CL APHA 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APHA 5220D mg/l	BOD APHA 9210 mg/l	NO3 APHA 4500 mg/l	$N0^{2-}$ APHA 4500 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NH4 APHA 4500 mg/l	O/G ASTM D3921 mg/l	THC ASTM D3921 mg/l	TPH ASTM D3921 mg/l	PAH ASTM D4657 mg/l	BTEX ASTM D2600 mg/l
ASW 1 TOP	28.5	8.53	40500	0.0	5.9	28354	14625	16.0	0.01	20.0	162	0.9	0.2	0.68	640	0.11	0.09	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 2 TOP	28.2	8.51	40600	0.0	5.8	28427	14620	12.0	0.00	22.0	153	0.5	0.5	1.64	610	0.15	0.23	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 3 TOP	29.3	8.54	39300	0.0	5.9	27510	14192	10.0	0.01	18.0	178	0.7	0.5	1.62	730	0.39	0.25	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 4 TOP	29.9	8.57	39000	0.0	5.9	27300	14625	12.0	0.01	20.0	169	0.6	0.8	2.63	810	0.28	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 5 TOP	26.3	8.51	39700	0.0	5.8	27792	14336	16.0	0.02	24.0	182	0.7	1.0	3.28	803	0.64	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 6 TOP	27.9	8.46	39600	0.0	5.8	27741	14300	12.0	0.01	20.0	168	1.1	0.3	0.98	580	0.67	0.14	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 7 TOP	28.1	8.53	40000	0.0	5.9	28000	14444	12.0	0.01	22.0	160	0.5	0.9	2.95	790	0.23	0.41	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 8 TOP	27.3	8.52	39800	0.0	5.8	27860	14372	16.0	0.00	20.0	172	1.0	0.3	0.99	810	0.21	0.23	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 9 TOP	29.2	8.55	39600	0.0	5.9	27720	14300	12.0	0.01	18.0	167	1.3	0.7	2.29	912	0.83	0.35	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 10 TOP	29.2	8.54	40100	0.0	6.0	28074	14480	12.0	0.01	18.0	190	0.7	0.3	0.98	720	0.49	0.14	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 11 TOP	27.8	8.58	41100	0.0	6.0	28770	14842	12.0	0.01	16.0	168	0.5	0.7	2.29	903	0.21	0.32	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 12 TOP	28.7	8.58	40400	0.0	6.1	28281	14589	12.0	0.01	22.0	172	1.2	0.3	0.98	775	0.5	0.14	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 12 MID	28.1	8.58	43000	0.0	4.1	30100	15528	10.0	0.01	28.0	166	0.8	0.5	1.64	792	0.29	0.23	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 12 BOT	27.4	8.59	47000	0.0	3.4	32920	16972	14.0	0.00	36.0	171	0.6	0.9	2.99	784	0.43	0.41	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 13 TOP	29.0	8.52	40900	0.0	5.9	28630	14842	12.0	0.01	20.0	175	0.5	0.4	1.31	925	0.25	0.28	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 14 TOP	28.0	8.56	40900	0.0	5.8	28630	14625	12.0	0.01	24.0	169	0.3	0.8	2.63	871	0.28	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 15 TOP	29.0	8.54	40700	0.0	5.9	28490	14697	12.0	0.02	20.0	165	0.5	0.9	2.95	803	0.23	0.41	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 16 TOP	28.1	8.54	41100	0.0	5.9	28773	14842	16.0	0.01	20.0	171	0.7	0.3	0.98	920	0.51	0.14	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 17 TOP	29.0	8.54	40100	0.0	5.8	28070	14461	12.0	0.01	18.0	179	0.5	0.4	1.31	811	0.29	0.28	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 18 TOP	28.7	8.51	40000	0.0	5.8	28000	14444	12.0	0.00	18.0	184	0.6	0.7	2.29	704	0.83	0.35	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 19 TOP	30.7	8.53	41400	0.0	6.0	28982	14950	12.0	0.01	20.0	180	0.5	0.9	2.99	815	0.43	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 20 TOP	30.1	8.53	41100	0.0	6.0	24660	14842	16.0	0.00	22.0	167	0.8	0.5	1.64	802	0.29	0.23	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 21 TOP	28.6	8.57	41100	0.0	6.0	28770	14444	12.0	0.00	20.0	175	0.4	0.3	0.98	887	0.24	0.14	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 22 TOP	29.1	8.51	41100	0.0	6.1	28771	14697	16.0	0.01	24.0	177	0.4	0.5	1.64	670	0.31	0.23	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 23 TOP	28.5	8.59	41500	0.0	6.1	29071	14842	12.0	0.01	24.0	172	0.7	0.7	2.29	720	0.17	0.32	<0.001	<0.001	<0.001	<0.001	<0.001
ASW 24 TOP	29.3	858	41400	0.0	6.1	28982	14528	16.0	0.00	20.0	185	0.5	0.9	2.96	832	0.25	0.41	<0.001	<0.001	<0.001	<0.001	<0.001
S_1 TOP	28.1	8.54	40400	0.0	5.9	28281	14589	14.0	0.01	22.0	173	0.3	1.2	3.94	807	0.61	0.55	<0.001	<0.001	<0.001	<0.001	<0.001
S_2 TOP	26.3	8.55	39700	0.0	6.0	27971	14336	12.0	0.01	20.0	169	0.7	1.0	3.28	750	0.88	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
S_3 TOP	28.2	8.57	37900	0.0	5.7	26530	14192	12.0	0.01	22.0	173	0.5	0.5	1.64	821	0.16	0.23	<0.001	<0.001	<0.001	<0.001	<0.001
S_4 TOP	27.2	8.52	40000	0.0	5.9	28000	14372	12.0	0.01	18.0	179	0.3	0.9	2.95	728	0.21	0.41	<0.001	<0.001	<0.001	<0.001	<0.001
S_5 TOP	28.2	8.55	38400	0.0	5.8	26880	14372	10.0	0.01	18.0	184	0.5	1.3	4.27	840	0.18	0.60	<0.001	<0.001	<0.001	<0.001	<0.001
S_6 TOP	30.2	8.57	40500	0.0	6.1	28350	14336	16.0	0.00	18.0	180	0.7	1.1	3.61	810	0.27	0.51	<0.001	<0.001	<0.001	<0.001	<0.001
S_6 MID	29.0	8.56	47600	0.0	4.1	33321	14638	16.0	0.00	16.0	183	0.5	0.3	0.96	822	0.22	0.18	<0.001	<0.001	<0.001	<0.001	<0.001
S_6 BOT	28.7	8.57	48400	0.0	3.6	33887	14463	14.0	0.01	20.0	189	0.3	0.5	1.64	815	0.28	0.25	<0.001	<0.001	<0.001	<0.001	<0.001
S_7 TOP	27.9	8.51	41200	0.0	5.9	28841	14878	16.0	0.00	16.0	180	0.7	0.8	2.63	810	0.31	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
S_8 TOP	29.2	8.54	39400	0.0	5.9	27583	14228	8.0	0.01	16.0	173	0.3	0.5	1.64	734	0.31	0.23	<0.001	<0.001	<0.001	<0.001	<0.001

Sample ID	TEMP (℃)	PH APHA 4500	EC APHA 2510A µS/cm	TURB	DO APHA 4500 mg/l	TDS APHA 1030 mg/l	CL APHA 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APHA 5220D mg/l	BOD APHA 9210 mg/l	NO3 APHA 4500 mg/l	$N0^{2-}$ APHA 4500 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NH4 APHA 4500 mg/l	O/G ASTM D3921 mg/l	THC ASTM D3921 mg/l	TPH ASTM D3921 mg/l	PAH ASTM D4657 mg/l	BTEX ASTM D2600 mg/l
S_9 TOP	28.3	8.55	40000	0.0	5.8	28000	14444	12.0	0.01	26.0	168	0.5	0.7	2.99	801	0.28	0.33	<0.001	<0.001	<0.001	<0.001	<0.001
S_10 TOP	29.4	8.52	40700	0.0	6.0	28500	14480	14.0	0.01	24.0	171	0.8	1.1	3.61	920	0.47	0.51	<0.001	<0.001	<0.001	<0.001	<0.001
S_11 TOP	29.9	8.54	40600	0.0	6.0	28420	14480	12.0	0.01	22.0	180	0.4	0.8	2.63	855	0.28	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
S_12 TOP	29.8	8.59	40400	0.0	6.0	28287	11502	16.0	0.01	24.0	172	0.6	0.7	2.29	650	0.20	0.34	<0.001	<0.001	<0.001	<0.001	<0.001
S_13 TOP	28.3	8.53	40000	0.0	5.9	28000	11553	16.0	0.00	32.0	192	0.8	0.8	2.63	670	0.24	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
S_13 MID	28.0	8.52	44800	0.0	4.1	31360	12319	12.0	0.01	30.0	185	0.6	0.7	2.29	680	0.32	0.33	<0.001	<0.001	<0.001	<0.001	<0.001
S_13 BOT	27.8	8.53	46200	0.0	3.6	32340	13061	14.0	0.01	30.0	188	0.5	0.9	2.96	761	0.38	0.42	<0.001	<0.001	<0.001	<0.001	<0.001
S_14 TOP	27.3	8.56	39500	0.0	6.0	27650	13291	16.0	0.02	22.0	175	0.6	0.7	2.29	768	0.48	0.32	<0.001	<0.001	<0.001	<0.001	<0.001
S_14 MID	26.9	8.52	41600	0.0	4.1	29120	14160	14.0	0.01	28.0	169	0.3	0.8	0.26	865	0.51	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
S_14 BOT	26.5	8.50	42100	0.0	3.3	29740	15949	12.0	0.01	36.0	172	0.3	1.0	3.28	848	0.52	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
S_15 TOP	28.3	8.58	38000	0.0	5.9	26612	13722	16.0	0.01	20.0	166	0.8	1.2	3.94	784	0.48	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
S_15 MID	27.6	8.59	44100	0.0	4.1	28400	15925	16.0	0.01	24.0	187	0.5	1.4	4.51	786	0.40	0.65	<0.001	<0.001	<0.001	<0.001	<0.001
S_15 BOT	27.1	8.59	46300	0.0	3.2	32412	16719	14.0	0.00	32.0	173	0.3	0.8	2.63	690	0.32	0.38	<0.001	<0.001	<0.001	<0.001	<0.001
S_16 TOP	27.2	8.53	38400	0.0	5.9	26880	13393	16.0	0.01	24.0	180	0.4	0.9	2.96	640	0.38	0.44	<0.001	<0.001	<0.001	<0.001	<0.001
S_16 MID	27.4	8.54	41100	0.0	4.2	28770	16409	12.0	0.01	36.0	187	0.6	0.7	2.29	650	0.35	0.34	<0.001	<0.001	<0.001	<0.001	<0.001
S_16 BOT	27.1	8.54	44700	0.0	3.4	31290	17125	10.0	0.02	32.0	169	0.5	1.0	3.28	710	0.28	0.46	<0.001	<0.001	<0.001	<0.001	<0.001
S_17 TOP	29.4	8.53	39800	0.0	6.0	27862	13163	16.0	0.01	22.0	175	0.7	1.6	5.25	742	0.46	0.74	<0.001	<0.001	<0.001	<0.001	<0.001
S_17 MID	28.9	8.54	40100	0.0	4.2	28081	15157	12.0	0.01	24.0	167	0.3	1.6	5.26	768	0.23	0.75	<0.001	<0.001	<0.001	<0.001	<0.001
S_17 BOT	27.6	8.56	40300	0.0	3.6	28214	15362	12.0	0.01	32.0	165	0.3	1.4	4.59	782	0.31	0.66	<0.001	<0.001	<0.001	<0.001	<0.001
S_18 TOP	29.7	8.58	40600	0.0	6.0	28421	12882	12.0	0.01	18.0	177	1.1	1.2	3.94	650	0.34	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
S_19 TOP	27.9	8.54	40700	0.0	6.0	28491	13751	16.0	0.01	26.0	173	0.6	0.8	2.63	682	0.30	0.38	<0.001	<0.001	<0.001	<0.001	<0.001
S_19 MID	27.5	8.55	43900	0.0	4.0	30732	12678	12.0	0.01	34.0	168	0.5	0.9	2.95	782	0.28	0.46	<0.001	<0.001	<0.001	<0.001	<0.001
S_19 BOT	27.2	8.54	45200	0.0	3.4	31640	13317	12.0	0.01	30.0	175	0.5	1.0	3.29	798	0.26	0.48	<0.001	<0.001	<0.001	<0.001	<0.001
S_20TOP	28.3	8.54	38900	0.0	5.9	27230	14032	16.0	0.01	20.0	192	1.3	1.4	4.59	862	0.42	0.66	<0.001	<0.001	<0.001	<0.001	<0.001
S_20 MID	27.9	8.53	43600	0.0	4.1	30520	13368	12.0	0.01	30.0	188	0.7	1.6	5.25	768	0.44	0.76	<0.001	<0.001	<0.001	<0.001	<0.001
S_20 BOT	27.6	8.55	43900	0.0	3.3	30730	15029	12.0	0.01	24.0	180	0.5	0.9	2.95	760	0.38	0.48	<0.001	<0.001	<0.001	<0.001	<0.001
S_21 TOP	28.4	8.52	39700	0.0	5.9	27790	14336	16.0	0.01	20.0	175	0.9	0.8	2.63	651	0.24	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
S_21 MID	28.2	8.54	41700	0.0	4.2	29190	15058	16.0	0.00	28.0	192	0.5	0.9	2.96	681	0.30	0.44	<0.001	<0.001	<0.001	<0.001	<0.001
S_21 BOT	28.0	8.53	46900	0.0	3.9	32830	16936	14.0	0.01	26.0	187	0.3	1.2	3.94	714	0.38	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
S_22 TOP	28.6	8.55	40700	0.0	6.0	28491	14697	12.0	0.01	18.0	190	0.7	1.4	4.51	762	0.36	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
S_22 MID	28.1	8.55	45200	0.0	4.2	31648	16322	12.0	0.01	26.0	163	0.5	1.6	525	846	0.90	0.75	<0.001	<0.001	<0.001	<0.001	<0.001
S_22 BOT	27.7	8.54	46600	0.0	3.4	32620	16828	14.0	0.01	20.0	158	0.5	1.8	5.91	858	0.44	0.84	<0.001	<0.001	<0.001	<0.001	<0.001
S_23 TOP	28.7	8.57	40800	0.0	6.1	28560	14733	16.0	0.01	20.0	177	0.8	0.9	2.96	796	0.46	0.44	<0.001	<0.001	<0.001	<0.001	<0.001
S_23 MID	28.4	8.56	43400	0.0	4.2	30380	15672	10.0	0.02	32.0	183	0.6	0.9	2.96	782	0.48	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
S_23 BOT	27.7	8.56	45200	0.0	3.7	31642	16322	14.0	0.01	28.0	182	0.6	0.7	2.29	746	0.52	0.33	<0.001	<0.001	<0.001	<0.001	<0.001
S_24 TOP	29.0	8.57	40900	0.0	6.0	28630	14769	16.0	0.01	16.0	175	1.1	0.9	2.96	824	0.38	0.45	<0.001	<0.001	<0.001	<0.001	<0.001
S_24 MID	28.6	8.59	44100	0.0	4.0	30870	15925	12.0	0.01	24.0	178	0.9	1.0	3.29	818	0.42	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
S_24 BOT	28.1	8.59	48300	0.0	3.4	33810	17442	14.0	0.01	30.0	172	0.5	1.2	394	814	0.48	0.57	<0.001	<0.001	<0.001	<0.001	<0.001
SW_1 TOP	28.8	8.53	40300	0.0	5.9	28210	14553	16.0	0.01	22.0	169	0.9	1.9	4.51	782	0.32	0.68	<0.001	<0.001	<0.001	<0.001	<0.001

Sample ID	TEMP (℃)	PH APHA 4500	EC APHA 2510A µS/cm	TURB	DO APHA 4500 mg/l	TDS APHA 1030 mg/l	CL APHA 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APHA 5220D mg/l	BOD APHA 9210 mg/l	NO3 APHA 4500 mg/l	N0^{2-} APHA 4500 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NH4 APHA 4500 mg/l	O/G ASTM D3921 mg/l	THC ASTM D3921 mg/l	TPH ASTM D3921 mg/l	PAH ASTM D4657 mg/l	BTEX ASTM D2600 mg/l
SW_2 TOP	28.4	8.51	40900	0.0	5.8	28631	14552	12.0	0.01	28.0	182	1.2	0.6	1.97	780	0.36	0.28	<0.001	<0.001	<0.001	<0.001	<0.001
SW_3 TOP	28.9	8.56	39900	0.0	6.1	29981	14083	16.0	0.01	26.0	163	1.0	1.8	5.91	698	0.41	0.85	<0.001	<0.001	<0.001	<0.001	<0.001
SW_4 TOP	28.2	8.56	40500	0.0	5.8	28353	14625	16.0	0.01	24.0	172	0.6	1.8	5.93	695	0.38	0.84	<0.001	<0.001	<0.001	<0.001	<0.001
SW_5 TOP	29.4	8.53	39800	0.0	6.0	27862	13867	12.0	0.02	22.0	149	0.8	1.2	3.94	680	0.42	0.57	<0.001	<0.001	<0.001	<0.001	<0.001
SW_6 TOP	28.2	8.53	41700	0.0	5.8	29190	15058	12.0	0.01	20.0	172	1.3	1.8	5.91	762	0.48	0.85	<0.001	<0.001	<0.001	<0.001	<0.001
SW_7 TOP	27.5	8.52	40400	0.0	5.8	28280	14589	12.0	0.01	26.0	153	1.0	1.6	5.28	781	0.51	0.75	<0.001	<0.001	<0.001	<0.001	<0.001
SW_8 TOP	28.3	8.50	39200	0.0	5.8	27441	14156	16.0	0.00	24.0	169	0.8	0.8	2.63	762	0.52	0.38	<0.001	<0.001	<0.001	<0.001	<0.001
SW_9 TOP	29.0	8.52	40200	0.0	5.9	28140	14519	12.0	0.01	28.0	158	0.7	1.0	3.29	781	0.42	1.46	<0.001	<0.001	<0.001	<0.001	<0.001
SW_10 TOP	28.9	8.53	39800	0.0	6.0	27860	14697	16.0	0.01	22.0	172	0.6	1.4	4.51	824	0.41	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
SW_11 TOP	28.2	8.55	38400	0.0	5.8	26880	14878	14.0	0.01	20.0	165	0.6	1.4	4.51	852	0.46	0.66	<0.001	<0.001	<0.001	<0.001	<0.001
SW_12 TOP	28.0	8.53	40400	0.0	6.0	28290	14589	12.0	0.00	18.0	190	1.1	0.9	2.96	862	0.38	0.45	<0.001	<0.001	<0.001	<0.001	<0.001
SW_13 TOP	27.5	8.53	41400	0.0	5.9	28982	14769	12.0	0.00	18.0	183	1.0	1.6	5.28	843	0.44	0.75	<0.001	<0.001	<0.001	<0.001	<0.001
SW_14 TOP	28.2	8.54	40900	0.0	5.9	28630	14769	16.0	0.00	20.0	175	0.8	1.8	5.91	840	0.46	0.84	<0.001	<0.001	<0.001	<0.001	<0.001
SW_15 TOP	27.3	8.54	39900	0.0	5.9	27930	14408	12.0	0.00	20.0	182	0.6	1.6	5.28	790	0.50	0.76	<0.001	<0.001	<0.001	<0.001	<0.001
SW_16 TOP	28.2	8.59	38000	0.0	5.8	26600	13722	12.0	0.02	22.0	167	0.5	0.8	2.63	681	0.41	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_17 TOP	28.7	8.53	39800	0.0	5.8	27860	14444	16.0	0.01	24.0	159	0.7	0.9	2.96	691	0.46	0.42	<0.001	<0.001	<0.001	<0.001	<0.001
SW_18 TOP	27.5	8.53	39900	0.0	5.8	27930	14408	12.0	0.01	24.0	163	0.9	1.0	3.28	652	0.54	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
SW_19 TOP	32.0	8.54	40600	0.0	6.1	28422	14697	10.0	0.01	18.0	182	0.5	1.3	4.27	682	0.48	0.60	<0.001	<0.001	<0.001	<0.001	<0.001
SW_19 MID	29.6	8.56	44000	0.0	4.0	30800	15853	16.0	0.01	28.0	174	0.3	1.4	4.59	781	0.32	0.65	<0.001	<0.001	<0.001	<0.001	<0.001
SW_19 BOT	29.0	8.56	44300	0.0	3.4	31012	16322	14.0	0.01	26.0	170	0.2	1.6	5.25	784	0.36	0.75	<0.001	<0.001	<0.001	<0.001	<0.001
SW_20 TOP	30.5	8.54	41200	0.0	6.1	28842	14878	12.0	0.01	26.0	164	0.4	0.8	2.62	864	0.34	0.38	<0.001	<0.001	<0.001	<0.001	<0.001
SW_21 TOP	28.9	8.57	41700	0.0	6.1	29198	14842	12.0	0.01	22.0	172	0.7	0.9	2.96	682	0.41	0.44	<0.001	<0.001	<0.001	<0.001	<0.001
SW_22 TOP	28.4	8.56	40700	0.0	6.1	28492	14697	12.0	0.01	18.0	163	0.3	1.0	3.28	684	0.52	0.46	<0.001	<0.001	<0.001	<0.001	<0.001
SW_23 TOP	28.9	8.59	41500	0.0	6.1	29061	14842	14.0	0.00	24.0	178	0.7	1.4	4.59	723	0.50	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
SW_24 TOP	28.9	8.59	40900	0.0	6.1	28630	14769	16.0	0.00	20.0	173	0.5	0.8	2.63	742	0.42	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_25 TOP	30.2	8.49	41600	0.0	6.0	29127	15022	12.0	0.01	20.0	168	0.2	0.7	2.29	751	0.48	0.32	<0.001	<0.001	<0.001	<0.001	<0.001
SW_26 TOP	28.3	8.56	41100	0.0	5.8	28778	14842	14.0	0.01	18.0	170	0.7	1.4	4.59	869	0.32	0.66	<0.001	<0.001	<0.001	<0.001	<0.001
SW_27 TOP	28.8	8.48	40500	0.0	5.7	28352	14625	12.0	0.01	22.0	183	0.5	1.5	4.93	876	0.34	0.70	<0.001	<0.001	<0.001	<0.001	<0.001
SW_28 TOP	28.6	8.51	38800	0.0	5.9	27160	14011	16.0	0.01	18.0	149	1.3	1.7	5.58	764	0.41	0.80	<0.001	<0.001	<0.001	<0.001	<0.001
SW_29 TOP	28.4	8.54	40100	0.0	5.9	28071	14480	12.0	0.01	22.0	157	0.3	1.7	5.58	690	0.38	0.79	<0.001	<0.001	<0.001	<0.001	<0.001
SW_30 TOP	28.0	8.53	40300	0.0	5.9	28212	14553	12.0	0.01	22.0	163	0.7	1.4	4.59	694	0.36	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
SW_31 TOP	28.5	8.56	41000	0.0	5.8	28700	14806	16.0	0.01	26.0	172	0.5	0.9	2.96	784	0.91	0.42	<0.001	<0.001	<0.001	<0.001	<0.001
SW_32 TOP	28.5	8.57	40800	0.0	5.8	28560	14733	16.0	0.01	24.0	184	0.2	0.8	2.63	685	0.32	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_33 TOP	28.9	8.57	41700	0.0	6.1	29198	14300	16.0	0.00	24.0	169	0.4	0.9	2.96	698	0.31	0.42	<0.001	<0.001	<0.001	<0.001	<0.001
SW_34 TOP	30.8	8.52	41200	0.0	6.0	28840	14878	12.0	0.01	22.0	157	0.8	0.6	1.97	676	0.42	0.28	<0.001	<0.001	<0.001	<0.001	<0.001
SW_35 TOP	28.7	8.56	40500	0.0	6.1	28357	14625	12.0	0.01	24.0	201	0.7	0.8	2.63	781	0.95	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_36 TOP	28.0	8.57	40900	0.0	6.2	28633	14733	12.0	0.01	20.0	168	0.1	0.9	2.96	791	0.51	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
SW_37 TOP	28.9	8.52	40.300	0.0	5.9	28210	14522	10.0	0.01	24.0	167	0.5	1.2	3.94	695	0.54	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
SW_37 MID	28.3	8.53	42200	0.0	4.1	29541	15239	16.0	0.01	32.0	174	0.4	1.0	3.28	784	0.52	0.46	<0.001	<0.001	<0.001	<0.001	<0.001

Sample ID	TEMP (℃)	PH APHA 4500	EC APHA 2510A µS/cm	TURB	DO APHA 4500 mg/l	TDS APHA 1030 mg/l	CL APHA 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APHA 5220D mg/l	BOD APHA 9210 mg/l	NO3 APHA 4500 mg/l	$N0^{2-}$ APHA 4500 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NH4 APHA 4500 mg/l	O/G ASTM D3921 mg/l	THC ASTM D3921 mg/l	TPH ASTM D3921 mg/l	PAH ASTM D4657 mg/l	BTEX ASTM D2600 mg/l
SW_37 BOT	27.9	8.53	42600	0.0	3.6	29820	15383	12.0	0.01	22.0	192	0.1	1.4	4.59	689	0.48	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
SW_38 TOP	28.5	8.56	39700	0.0	6.0	27790	14336	12.0	0.01	20.0	184	0.6	1.4	4.597	848	0.46	0.42	<0.001	<0.001	<0.001	<0.001	<0.001
SW_38 MID	28.3	8.53	45900	0.0	4.1	32130	16575	14.0	0.01	22.0	168	0.3	0.8	2.63	682	0.31	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_38 BOT	28.1	8.55	48300	0.0	3.2	33812	17442	12.0	0.02	18.0	149	0.1	0.7	2.29	658	0.32	0.31	<0.001	<0.001	<0.001	<0.001	<0.001
SW_39 TOP	28.5	8.51	41200	0.0	5.7	28841	14878	16.0	0.01	24.0	176	0.5	0.9	2.96	640	0.41	0.94	<0.001	<0.001	<0.001	<0.001	<0.001
SW_40 TOP	28.3	8.53	38600	0.0	5.9	27022	13939	16.0	0.01	18.0	170	0.8	0.9	2.96	638	0.38	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
SW_40 MID	27.9	8.52	45700	0.0	4.1	31990	16503	14.0	0.00	16.0	163	0.5	1.0	3.38	671	0.32	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
SW_40 BOT	27.4	8.52	47000	0.0	3.3	32900	16972	16.0	0.01	20.0	164	0.2	1.4	4.59	681	0.30	0.65	<0.001	<0.001	<0.001	<0.001	<0.001
SW_41 TOP	28.6	8.52	39500	0.0	5.9	27650	14264	16.0	0.00	26.0	177	0.9	0.8	2.62	690	0.24	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_41 MID	28.1	8.54	42000	0.0	4.2	29400	15167	12.0	0.00	24.0	201	0.5	0.8	2.63	782	0.28	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
SW_41 BOT	27.8	8.55	47900	0.0	5.8	33530	17297	14.0	0.01	28.0	199	0.3	1.0	3.28	791	0.30	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
SW_42 TOP	28.9	8.57	41100	0.0	6.0	28770	14842	12.0	0.01	20.0	205	0.5	0.9	2.96	881	0.34	0.44	<0.001	<0.001	<0.001	<0.001	<0.001
SW_42 MID	28.3	8.58	43600	0.0	4.2	30520	15744	16.0	0.00	20.0	188	0.2	0.9	2.96	721	0.38	0.45	<0.001	<0.001	<0.001	<0.001	<0.001
SW_42 BOT	27.7	8.57	47200	0.0	3.6	33047	17044	14.0	0.01	18.0	176	0.2	1.2	3.94	854	0.41	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
SW_43 TOP	28.3	8.48	40900	0.0	6.0	28630	14769	16.0	0.01	18.0	178	0.6	1.0	3.28	691	0.38	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
SW_43 MID	27.9	8.59	41900	0.0	4.0	29331	15130	12.0	0.01	26.0	163	0.3	0.8	2.63	781	0.40	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
SW_43 BOT	27.7	8.58	48500	0.0	3.4	33950	17514	14.0	0.01	24.0	172	0.2	0.8	2.63	824	0.45	0.38	<0.001	<0.001	<0.001	<0.001	<0.001
SW_44 TOP	28.2	8.52	40500	0.0	5.8	28350	14625	16.0	0.01	26.0	181	0.7	1.2	3.94	681	0.38	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
SW_44 MID	27.7	8.54	42500	0.0	4.1	29751	15347	16.0	0.01	22.0	175	0.6	0.8	2.63	741	0.46	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
SW_44 BOT	27.4	8.53	44900	0.0	3.7	31430	16214	12.0	0.01	24.0	179	0.2	0.8	2.63	782	0.54	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_45 TOP	28.0	8.55	39500	0.0	5.8	27650	14264	16.0	0.01	20.0	201	0.4	0.7	2.29	693	0.41	0.33	<0.001	<0.001	<0.001	<0.001	<0.001
SW_45 MID	27.9	8.52	44000	0.0	4.0	30800	15889	12.0	0.00	24.0	206	0.2	0.9	2.96	671	0.49	0.44	<0.001	<0.001	<0.001	<0.001	<0.001
SW_45 BOT	27.4	8.54	46800	0.0	3.5	32761	16900	14.0	0.01	18.0	209	0.2	1.0	3.28	723	0.52	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
SW_46 TOP	30.8	8.56	40800	0.0	6.0	28560	14733	12.0	0.01	22.0	188	0.4	0.8	2.63	745	0.42	0.37	<0.001	<0.001	<0.001	<0.001	<0.001
SW_46 MID	29.6	8.56	46100	0.0	4.0	32271	16647	12.0	0.02	18.0	186	0.4	1.2	3.94	821	0.40	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
SW_46 BOT	29.0	8.58	46400	0.0	3.4	32486	16756	12.0	0.01	20.0	181	0.2	1.4	4.597	842	0.38	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
SW_47 TOP	31.5	8.52	40700	0.0	6.0	28492	14697	12.0	0.01	26.0	168	0.5	0.9	2.96	861	0.60	0.45	<0.001	<0.001	<0.001	<0.001	<0.001
SW_47 MID	27.1	8.55	42000	0.0	4.0	29400	15167	12.0	0.02	20.0	172	0.3	1.2	3.94	874	0.42	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
SW_47 BOT	26.2	8.56	47800	0.0	3.3	33463	17261	16.0	0.01	22.0	182	0.3	1.6	5.25	884	0.48	0.74	<0.001	<0.001	<0.001	<0.001	<0.001
SW_48 TOP	28.1	8.59	40800	0.0	6.1	28560	14733	16.0	0.01	20.0	189	0.2	0.8	2.63	659	0.24	0.36	<0.001	<0.001	<0.001	<0.001	<0.001
SW_48 MID	26.8	8.58	46200	0.0	4.2	32341	16683	14.0	0.01	20.0	182	0.2	0.9	2.94	652	0.29	0.42	<0.001	<0.001	<0.001	<0.001	<0.001
SW_48 BOT	24.9	8.55	47600	0.0	3.6	32320	17189	14.0	0.01	30.0	183	0.1	1.0	3.28	681	0.31	0.47	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 1 TP	28.6	8.51	42100	0.0	6.0	29470	15203	12.0	0.01	22.0	199	0.5	1.2	3.94	687	0.42	0.56	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 1MD	28.1	8.49	45200	0.0	4.7	31640	16322	8.0	0.00	30.0	181	0.4	1.4	4.59	724	0.48	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 1 BT	27.6	848	46100	0.0	3.2	32270	16647	14.0	0.01	28.0	187	0.2	1.8	5.92	784	0.51	0.84	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 2 TP	28.3	8.57	41900	0.0	6.0	29330	15131	16.0	0.01	22.0	179	0.9	0.9	2.96	789	0.42	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 2MD	28.0	8.58	42100	0.0	4.1	29472	14842	12.0	0.02	26.0	172	0.7	1.4	4.59	689	0.48	0.68	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 2 BT	27.4	8.59	42800	0.0	3.5	29960	15456	14.0	0.01	24.0	192	0.4	1.8	5.91	677	0.51	0.84	<0.001	<0.001	<0.001	<0.001	<0.001

Sample ID	TEMP (℃)	PH APHA 4500	EC APHA 2510A μS/cm	TURB	DO APHA 4500 mg/l	TDS APHA 1030 mg/l	CL APHA 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APHA 5220D mg/l	BOD APHA 9210 mg/l	NO3 APHA 4500 mg/l	$N0^{2-}$ APHA 4500 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NH4 APHA 4500 mg/l	O/G ASTM D3921 mg/l	THC ASTM D3921 mg/l	TPH ASTM D3921 mg/l	PAH ASTM D4657 mg/l	BTEX ASTM D2600 mg/l
CONTL 3 TP	29.1	8.51	38300	0.0	6.0	26813	13831	8.0	0.01	20.0	186	0.6	0.9	2.96	714	0.41	0.43	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 3MD	28.7	8.47	39300	0.0	4.1	27510	14192	8.0	0.01	24.0	192	0.3	0.6	1.97	758	0.45	0.28	<0.001	<0.001	<0.001	<0.001	<0.001
CONTL 3 BT	28.2	8.50	39700	0.0	3.6	27790	14336	14.0	0.01	20.0	188	0.2	0.6	1.98	761	0.54	0.28	<0.001	<0.001	<0.001	<0.001	<0.001

B, Metal Analysis Results for Water Samples

Sample ID	Ni ASTM D1886 mg/l	Fe ASTM D1068 mg/l	Pb ASTM D3559 mg/l	Cu ASTM D1688 mg/l	Cr ASTM D1687 mg/l	Zn ASTM D1691 (mg/l)	Cd ASTM D3557 mg/l	Mn ASTM D mg/l	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Hg ASTM D3866 mg/l	V ASTM D3373 mg/l	K ASTM D4192 mg/l	Na ASTM D4194 mg/l	Mg ASTM D4194 mg/l	Ca ASTM D4194 mg/
ASW 1 TOP	0.243	0.042	0.412	0.080	0.329	0.007	0.052	0.042	<0.01	N/A	<0.001	<0.001	387	10079	1157	409
ASW 2 TOP	0.212	0.018	0.385	0.025	0.120	0.012	0.054	0.014	<0.01	N/A	<0.001	<0.001	386	10010	1120	410
ASW 3 TOP	0.325	0.036	0.422	0.045	0.045	0.032	0.075	0.024	<0.01	N/A	<0.001	<0.001	350	10014	1226	418
ASW 4 TOP	0.030	0.025	0.294	0.075	<0.001	<0.001	0.081	0.111	<0.01	N/A	<0.001	<0.001	369	9816	1235	412
ASW 5 TOP	0.123	0.034	0.326	0.024	0.014	0.017	0.054	0.011	<0.01	N/A	<0.001	<0.001	372	10021	1218	403
ASW 6 TOP	0.351	0.039	0.471	0.014	0.025	0.234	0.035	0.035	<0.01	N/A	<0.001	<0.001	382	10001	1215	416
ASW 7 TOP	0.231	0.115	0.357	0.034	0.240	0.128	0.068	0.045	<0.01	N/A	<0.001	<0.001	372	10025	1225	413
ASW 8 TOP	0.142	0.064	0.266	0.011	0.214	0.034	0.049	0.028	<0.01	N/A	<0.001	<0.001	382	10256	1258	409
ASW 9 TOP	0.231	0.025	0.258	0.024	0.056	0.022	0.036	0.098	<0.01	N/A	<0.001	<0.001	378	10245	1240	411
ASW 10 TOP	0.680	0.122	0.545	0.067	<0.001	0.023	0.007	<0.001	<0.01	N/A	<0.001	<0.001	336	9532	1189	394
ASW 11 TOP	0.321	0.098	0.321	0.018	0.082	0.024	0.027	0.075	<0.01	N/A	<0.001	<0.001	329	9989	1235	386
ASW 12 TOP	0.516	0.053	0.308	0.038	0.122	0.133	0.061	<0.001	<0.01	N/A	<0.001	<0.001	345	9391	1102	406
ASW 12 MID	0.531	0.172	0.335	0.080	0.031	<0.001	0.063	0.097	<0.01	N/A	<0.001	<0.001	335	9714	1291	401
ASW 12 BOT	0.808	0.186	0.360	0.052	0.294	<0.001	0.060	0.090	<0.01	N/A	<0.001	<0.001	332	9829	1264	403
ASW 13 TOP	0.375	0.113	0.423	0.049	0.191	0.015	0.005	0.038	<0.01	N/A	<0.001	<0.001	331	10211	1214	403
ASW 14 TOP	0.128	0.107	0.335	0.024	0.023	0.022	0.078	0.034	<0.01	N/A	<0.001	<0.001	325	10222	1232	408
ASW 15 TOP	0.767	0.068	0.491	0.038	<0.001	0.086	0.065	<0.001	<0.01	N/A	<0.001	<0.001	369	10448	1207	402
ASW 16 TOP	0.342	0.053	0.269	0.017	0.023	0.018	0.072	0.018	<0.01	N/A	<0.001	<0.001	356	10231	1215	412
ASW 17 TOP	0.421	0.075	0.411	0.027	0.031	0.057	0.052	0.029	<0.01	N/A	<0.001	<0.001	372	9865	1113	421
ASW 18 TOP	0.449	0.119	0.380	0.015	0.162	0.044	0.095	0.057	<0.01	N/A	<0.001	<0.001	342	10115	1213	407
ASW 19 TOP	0.253	0.064	0.335	0.024	0.045	0.030	0.068	0.054	<0.01	N/A	<0.001	<0.001	338	10212	1228	415
ASW 20 TOP	0.234	0.029	0.318	0.011	0.024	0.071	0.054	0.037	<0.01	N/A	<0.001	<0.001	326	9865	1240	418
ASW 21 TOP	1.038	0.124	0.309	0.059	0.067	<0.001	0.090	0.050	<0.01	N/A	<0.001	<0.001	359	10178	1258	407
ASW 22 TOP	0.326	0.098	0.422	0.012	0.042	0.028	0.039	0.025	<0.01	N/A	<0.001	<0.001	362	9978	1111	420
ASW 23 TOP	0.235	0.113	0.298	0.026	0.024	0.068	0.037	0.085	<0.01	N/A	<0.001	<0.001	375	9897	1242	421
ASW 24 TOP	0.412	0.109	0.327	0.024	0.018	0.035	0.039	0.082	<0.01	N/A	<0.001	<0.001	378	10124	1124	419
S_1 TOP	0.346	0.086	0.205	0.071	0.151	0.027	0.046	0.023	<0.01	N/A	<0.001	<0.001	371	10074	1241	409
S_2 TOP	0.236	0.121	0.339	0.078	0.026	0.026	0.021	0.037	<0.01	N/A	<0.001	<0.001	377	10045	1235	414
S_3 TOP	0.124	0.134	0.405	0.029	0.124	0.045	0.063	0.078	<0.01	N/A	<0.001	<0.001	383	10230	1240	418
S_4 TOP	0.324	0.067	0.365	0.058	0.134	0.022	0.029	0.055	<0.01	N/A	<0.001	<0.001	384	10111	1422	413
S_5 TOP	0.325	0.114	0.284	0.047	0.089	0.074	0.035	0.098	<0.01	N/A	<0.001	<0.001	380	10234	1124	417
S_6 TOP	0.312	0.096	0.367	0.018	0.026	0.066	0.017	0.042	<0.01	N/A	<0.001	<0.001	359	10124	1212	421
S_6 MID	0.345	0.102	0.382	0.231	0.028	0.118	0.034	0.051	<0.01	N/A	<0.001	<0.001	376	10236	1204	423
S_6 BOT	0.349	0.126	0.394	0.332	0.183	0.138	0.062	0.063	<0.01	N/A	<0.001	<0.001	382	9986	1235	419
S_7 TOP	1.099	0.068	0.420	0.084	0.226	<0.001	0.094	0.084	<0.01	N/A	<0.001	<0.001	358	9320	1253	407
S_8 TOP	0.312	0.125	0.392	0.071	0.012	0.033	0.056	0.048	<0.01	N/A	<0.001	<0.001	362	9856	1224	400
S_9 TOP	0.277	0.082	<0.001	0.039	<0.001	0.060	0.041	<0.001	<0.01	N/A	<0.001	<0.001	386	9134	1159	410
S_10 TOP	0.707	0.074	0.249	0.036	0.014	0.022	0.052	0.075	<0.01	N/A	<0.001	<0.001	377	9586	1160	411
S_11 TOP	0.486	0.038	0.204	0.053	<0.001	0.062	0.049	<0.001	<0.01	N/A	<0.001	<0.001	389	9252	1290	407
S_12 TOP	0.287	0.069	0.354	0.118	0.145	0.015	0.038	0.019	<0.01	N/A	<0.001	<0.001	385	9568	1288	408

Sample ID	Ni ASTM D1886 mg/l	Fe ASTM D1068 mg/l	Pb ASTM D3559 mg/l	Cu ASTM D1688 mg/l	Cr ASTM D1687 mg/l	Zn ASTM D1691 (mg/l)	Cd ASTM D3557 mg/l	Mn ASTM D mg/l	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Hg ASTM D3866 mg/l	V ASTM D3373 mg/l	K ASTM D4192 mg/l	Na ASTM D4194 mg/l	Mg ASTM D4194 mg/l	Ca ASTM D4194 mg/
S_13 TOP	0.232	0.072	0.395	0.018	0.118	0.064	0.026	0.021	<0.01	N/A	<0.001	<0.001	391	9499	1232	404
S_13 MID	0.325	0.116	0.411	0.066	0.123	0.082	0.047	0.035	<0.01	N/A	<0.001	<0.001	389	9564	1245	407
S_13 BOT	0.434	0.129	0.426	0.079	0.136	0.119	0.061	0.057	<0.01	N/A	<0.001	<0.001	386	9689	1234	410
S_14 TOP	0.418	0.117	<0.001	0.021	0.249	<0.001	0.065	0.018	<0.01	N/A	<0.001	<0.001	392	9619	1250	406
S_14 MID	0.425	0.128	0.092	0.028	0.256	0.002	0.073	0.022	<0.01	N/A	<0.001	<0.001	382	9986	1254	416
S_14 BOT	0.463	0.134	0.117	0.049	0.277	0.016	0.092	0.029	<0.01	N/A	<0.001	<0.001	378	10125	1024	426
S_15 TOP	0.234	0.094	0.382	0.023	0.092	0.027	0.031	0.027	<0.01	N/A	<0.001	<0.001	375	9864	1101	421
S_15 MID	0.365	0.107	0.387	0.036	0.124	0.029	0.045	0.039	<0.01	N/A	<0.001	<0.001	385	10100	1243	432
S_15 BOT	0.421	0.119	0.395	0.058	0.187	0.038	0.051	0.063	<0.01	N/A	<0.001	<0.001	387	10105	1125	435
S_16 TOP	0.124	0.051	0.296	0.014	0.124	0.021	0.033	0.027	<0.01	N/A	<0.001	<0.001	386	10235	1240	425
S_16 MID	0.124	0.072	0.364	0.026	0.137	0.039	0.058	0.049	<0.01	N/A	<0.001	<0.001	387	10011	1234	430
S_16 BOT	0.136	0.098	0.392	0.059	0.148	0.062	0.073	0.081	<0.01	N/A	<0.001	<0.001	390	10024	1248	440
S_17 TOP	0.221	0.081	0.327	0.023	0.136	0.012	0.023	0.029	<0.01	N/A	<0.001	<0.001	372	10026	1342	401
S_17 MID	0.293	0.113	0.419	0.038	0.145	0.028	0.039	0.043	<0.01	N/A	<0.001	<0.001	380	9986	1245	409
S_17 BOT	0.300	0.137	0.426	0.063	0.172	0.035	0.041	0.068	<0.01	N/A	<0.001	<0.001	382	9789	1325	406
S_18 TOP	0.138	0.064	0.159	0.060	0.174	0.030	0.153	0.012	<0.01	N/A	<0.001	<0.001	378	9619	1223	405
S_19 TOP	0.124	0.049	0.225	0.026	0.216	<0.001	0.017	0.021	<0.01	N/A	<0.001	<0.001	377	9869	1235	402
S_19 MID	0.315	0.062	0.210	0.058	0.322	0.002	0.025	0.032	<0.01	N/A	<0.001	<0.001	390	9048	1249	408
S_19 BOT	0.474	0.091	<0.001	0.048	0.239	0.040	0.053	<0.001	<0.01	N/A	<0.001	<0.001	369	9076	1274	412
S_20TOP	0.211	0.124	0.342	0.073	0.243	<0.001	0.028	<0.001	<0.01	N/A	<0.001	<0.001	370	9354	1198	405
S_20 MID	0.224	0.136	0.425	0.081	0.282	0.058	0.043	0.005	<0.01	N/A	<0.001	<0.001	386	9427	1223	402
S_20 BOT	0.325	0.139	0.438	0.096	0.315	0.076	0.052	0.019	<0.01	N/A	<0.001	<0.001	345	9354	1232	403
S_21 TOP	0.268	0.047	0.030	0.068	0.194	0.043	0.071	<0.001	<0.01	N/A	<0.001	<0.001	369	9423	1211	408
S_21 MID	0.312	0.073	0.151	0.072	0.218	0.068	0.095	0.005	<0.01	N/A	<0.001	<0.001	370	9986	1251	410
S_21 BOT	0.315	0.095	0.187	0.085	0.265	0.083	0.113	0.011	<0.01	N/A	<0.001	<0.001	376	10034	1260	412
S_22 TOP	0.134	0.071	0.223	0.053	0.226	0.032	0.045	0.023	<0.01	N/A	<0.001	<0.001	377	9976	1226	414
S_22 MID	0.326	0.093	0.315	0.074	0.239	0.048	0.069	0.041	<0.01	N/A	<0.001	<0.001	380	9989	1228	418
S_22 BOT	0.341	0.121	0.352	0.096	0.312	0.063	0.083	0.074	<0.01	N/A	<0.001	<0.001	386	10123	1230	420
S_23 TOP	0.385	0.062	<0.001	0.070	0.156	<0.001	0.069	0.080	<0.01	N/A	<0.001	<0.001	385	9078	1241	402
S_23 MID	0.422	0.087	0.095	0.093	0.234	0.008	0.083	0.094	<0.01	N/A	<0.001	<0.001	387	9099	1293	410
S_23 BOT	0.431	0.114	0.183	0.159	0.241	0.023	0.115	0.138	<0.01	N/A	<0.001	<0.001	390	9998	1246	412
S_24 TOP	0.123	0.029	0.352	0.136	0.268	0.011	0.024	0.034	<0.01	N/A	<0.001	<0.001	375	10123	1212	403
S_24 MID	0.138	0.054	0.395	0.138	0.269	0.023	0.026	0.036	<0.01	N/A	<0.001	<0.001	372	10032	1213	407
S_24 BOT	0.223	0.087	0.428	0.142	0.273	0.026	0.034	0.041	<0.01	N/A	<0.001	<0.001	362	10045	1124	403
SW_1 TOP	0.312	0.068	0.389	0.023	0.113	0.022	0.041	0.023	<0.01	N/A	<0.001	<0.001	386	10021	1134	406
SW_2 TOP	0.421	0.045	0.352	0.011	0.015	0.032	0.052	0.042	<0.01	N/A	<0.001	<0.001	365	10010	1124	409
SW_3 TOP	0.135	0.039	0.295	0.024	0.026	0.047	0.075	0.011	<0.01	N/A	<0.001	<0.001	382	10024	1248	410
SW_4 TOP	0.028	0.052	0.324	0.034	0.034	0.051	0.068	0.089	<0.01	N/A	<0.001	<0.001	375	10028	1124	412
SW_5 TOP	0.310	0.131	0.381	0.084	0.047	0.035	0.019	0.073	<0.01	N/A	<0.001	<0.001	345	10032	1325	413
SW_6 TOP	0.402	0.061	0.426	0.075	0.068	0.041	0.017	0.028	<0.01	N/A	<0.001	<0.001	384	10024	1230	418
SW_7 TOP	0.124	0.078	0.338	0.062	0.048	0.067	0.039	0.059	<0.01	N/A	<0.001	<0.001	381	10027	1142	419

Sample ID	Ni ASTM D1886 mg/l	Fe ASTM D1068 mg/l	Pb ASTM D3559 mg/l	Cu ASTM D1688 mg/l	Cr ASTM D1687 mg/l	Zn ASTM D1691 (mg/l)	Cd ASTM D3557 mg/l	Mn ASTM D mg/l	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Hg ASTM D3866 mg/l	V ASTM D3373 mg/l	K ASTM D4192 mg/l	Na ASTM D4194 mg/l	Mg ASTM D4194 mg/l	Ca ASTM D4194 mg/
SW_8 TOP	0.015	0.064	0.429	0.086	0.072	0.069	0.047	0.050	<0.01	N/A	<0.001	<0.001	376	10039	1132	420
SW_9 TOP	0.082	0.046	0.198	0.031	0.024	0.045	0.048	0.060	<0.01	N/A	<0.001	<0.001	370	10040	1212	421
SW_10 TOP	0.045	0.062	0.055	0.052	0.399	0.111	0.108	0.070	<0.01	N/A	<0.001	<0.001	374	9987	1114	396
SW_10 MID	0.109	0.084	0.124	0.065	0.411	0.124	0.117	0.082	<0.01	N/A	<0.001	<0.001	386	10152	1128	412
SW_10 BOT	0.151	0.127	0.279	0.078	0.489	0.184	0.119	0.094	<0.01	N/A	<0.001	<0.001	391	10198	1213	425
SW_11 TOP	0.230	0.049	0.343	0.062	0.252	0.076	0.034	0.070	<0.01	N/A	<0.001	<0.001	356	9998	1206	406
SW_11 MID	0.245	0.076	0.452	0.072	0.268	0.089	0.044	0.087	<0.01	N/A	<0.001	<0.001	362	10029	1213	424
SW_11 BOT	0.268	0.092	0.539	0.082	0.276	0.096	0.103	0.123	<0.01	N/A	<0.001	<0.001	381	10078	1229	458
SW_12 TOP	0.014	0.125	0.358	0.059	0.283	0.117	0.096	0.084	<0.01	N/A	<0.001	<0.001	357	10121	1080	409
SW_13 TOP	0.018	0.098	0.349	0.034	0.257	0.063	0.054	0.093	<0.01	N/A	<0.001	<0.001	346	10210	1258	415
SW_14 TOP	0.098	0.064	0.316	0.057	0.189	0.039	0.081	0.026	<0.01	N/A	<0.001	<0.001	355	10023	10051	413
SW_15 TOP	0.122	0.081	0.298	0.023	0.253	0.091	0.022	0.049	<0.01	N/A	<0.001	<0.001	362	10125	1234	410
SW_16 TOP	0.089	0.069	0.412	0.028	0.086	0.056	0.037	0.073	<0.01	N/A	<0.001	<0.001	372	10256	1244	421
SW_17 TOP	0.078	0.125	0.328	0.062	0.194	0.061	0.041	0.049	<0.01	N/A	<0.001	<0.001	380	10241	1228	428
SW_18 TOP	0.098	0.103	<0.001	0.025	0.182	0.036	0.011	0.023	<0.01	N/A	<0.001	<0.001	371	9989	1255	401
SW_18 MID	0.124	0.119	<0.001	0.039	0.226	0.072	0.018	0.037	<0.01	N/A	<0.001	<0.001	387	10011	1268	435
SW_18 BOT	0.135	0.126	<0.001	0.057	0.238	0.081	0.046	0.043	<0.01	N/A	<0.001	<0.001	392	10029	1294	481
SW_19 TOP	0.238	0.068	0.371	0.032	0.005	0.096	0.042	0.033	<0.01	N/A	<0.001	<0.001	384	9989	1245	427
SW_19 MID	0.278	0.084	0.405	0.049	0.013	0.118	0.065	0.054	<0.01	N/A	<0.001	<0.001	346	9945	1126	397
SW_19 BOT	0.293	0.132	0.428	0.072	0.029	0.132	0.073	0.081	<0.01	N/A	<0.001	<0.001	342	10235	1128	385
SW_20 TOP	0.012	0.056	0.204	0.077	0.243	0.043	0.045	0.040	<0.01	N/A	<0.001	<0.001	355	9884	1236	405
SW_21 TOP	0.405	0.083	0.249	0.061	0.211	0.054	0.039	0.052	<0.01	N/A	<0.001	<0.001	365	10235	1200	417
SW_22 TOP	0.148	0.051	0.325	0.075	0.229	0.047	0.083	0.062	<0.01	N/A	<0.001	<0.001	372	10052	1213	426
SW_23 TOP	0.230	0.063	0.414	0.053	0.012	0.005	0.012	0.053	<0.01	N/A	<0.001	<0.001	354	10090	1224	406
SW_24 TOP	0.325	0.049	0.327	0.029	0.186	0.019	0.036	0.021	<0.01	N/A	<0.001	<0.001	371	10012	1245	412
SW_25 TOP	0.245	0.114	0.339	0.033	0.232	0.037	0.028	0.015	<0.01	N/A	<0.001	<0.001	372	10014	1236	415
SW_26 TOP	0.124	0.036	0.283	0.021	0.267	0.026	0.022	0.026	<0.01	N/A	<0.001	<0.001	370	10018	1238	418
SW_27 TOP	0.190	0.083	0.372	0.039	0.223	0.024	0.035	0.027	<0.01	N/A	<0.001	<0.001	376	10013	1375	420
SW_28 TOP	0.234	0.055	0.349	0.031	0.209	0.029	0.061	0.015	<0.01	N/A	<0.001	<0.001	386	10021	1285	428
SW_29 TOP	0.308	0.067	0.368	0.065	0.235	0.037	0.046	0.039	<0.01	N/A	<0.001	<0.001	387	10024	1345	412
SW_30 TOP	0.522	0.081	0.299	0.034	0.258	0.015	0.022	0.027	<0.01	N/A	<0.001	<0.001	385	10031	1248	423
SW_31 TOP	0.421	0.054	0.324	0.028	0.230	0.093	0.051	0.046	<0.01	N/A	<0.001	<0.001	387	10028	1345	423
SW_32 TOP	0.143	0.109	0.336	0.061	0.195	0.067	0.072	0.052	<0.01	N/A	<0.001	<0.001	372	10026	1248	428
SW_33 TOP	0.205	0.067	0.349	0.038	0.211	0.038	0.044	0.039	<0.01	N/A	<0.001	<0.001	356	10075	1213	410
SW_34 TOP	0.068	0.038	0.342	0.052	0.219	0.009	0.061	0.055	<0.01	N/A	<0.001	<0.001	378	10065	1234	412
SW_35 TOP	0.123	0.124	0.358	0.063	0.228	0.052	0.044	0.063	<0.01	N/A	<0.001	<0.001	356	10023	1023	414
SW_36 TOP	0.254	0.084	0.327	0.049	0.261	0.006	0.068	0.061	<0.01	N/A	<0.001	<0.001	389	10045	1234	413
SW_37 TOP	0.465	0.063	<0.001	0.054	0.314	0.145	0.022	0.049	<0.01	N/A	<0.001	<0.001	376	10036	1245	416
SW_37 MID	0.353	0.097	<0.001	0.069	0.323	0.181	0.064	0.054	<0.01	N/A	<0.001	<0.001	348	10068	1287	407
SW_37 BOT	0.524	0.112	<0.001	0.078	0.339	0.195	0.088	0.069	<0.01	N/A	<0.001	<0.001	388	10065	1290	409
SW_38 TOP	0.412	0.053	0.294	0.063	0.218	0.013	0.057	0.071	<0.01	N/A	<0.001	<0.001	345	10056	1238	410

Sample ID	Ni ASTM D1886 mg/l	Fe ASTM D1068 mg/l	Pb ASTM D3559 mg/l	Cu ASTM D1688 mg/l	Cr ASTM D1687 mg/l	Zn ASTM D1691 (mg/l)	Cd ASTM D3557 mg/l	Mn ASTM D mg/l	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Hg ASTM D3866 mg/l	V ASTM D3373 mg/l	K ASTM D4192 mg/l	Na ASTM D4194 mg/l	Mg ASTM D4194 mg/l	Ca ASTM D4194 mg/
SW_38 MID	0.423	0.072	0.326	0.069	0.225	0.021	0.069	0.082	<0.01	N/A	<0.001	<0.001	362	10075	1246	413
SW_38 BOT	0.453	0.125	0.335	0.078	0.263	0.038	0.081	0.096	<0.01	N/A	<0.001	<0.001	376	10086	1345	418
SW_39 TOP	0.230	0.084	0.364	0.045	0.247	0.046	0.052	0.052	<0.01	N/A	<0.001	<0.001	356	10012	1235	409
SW_40 TOP	0.152	0.068	0.391	0.063	0.231	0.003	0.046	0.054	<0.01	N/A	<0.001	<0.001	368	10023	1123	406
SW_40 MID	0.286	0.094	0.267	0.078	0.236	0.012	0.062	0.061	<0.01	N/A	<0.001	<0.001	360	10034	1230	407
SW_40 BOT	0.345	0.146	0.324	0.085	0.261	0.019	0.079	0.064	<0.01	N/A	<0.001	<0.001	366	10046	1230	410
SW_41 TOP	0.226	0.049	0.315	0.047	0.210	<0.001	0.033	0.045	<0.01	N/A	<0.001	<0.001	370	10016	1233	408
SW_41 MID	0.245	0.068	0.398	0.051	0.180	0.001	0.045	0.046	<0.01	N/A	<0.001	<0.001	374	10018	1240	413
SW_41 BOT	0.327	0.096	0.469	0.052	0.184	0.021	0.047	0.052	<0.01	N/A	<0.001	<0.001	380	10023	1243	420
SW_42 TOP	0.012	0.113	0.331	0.034	0.024	0.021	0.022	0.017	<0.01	N/A	<0.001	<0.001	368	10024	1235	412
SW_42 MID	0.078	0.120	0.395	0.038	0.053	0.034	0.031	0.026	<0.01	N/A	<0.001	<0.001	372	10028	1258	413
SW_42 BOT	0.124	0.136	0.422	0.041	0.055	0.041	0.041	0.035	<0.01	N/A	<0.001	<0.001	386	10045	1266	416
SW_43 TOP	0.208	0.083	0.325	0.013	0.025	0.001	0.024	0.060	<0.01	N/A	<0.001	<0.001	372	10325	1250	403
SW_43 MID	0.256	0.088	0.447	0.037	0.228	0.006	0.049	0.079	<0.01	N/A	<0.001	<0.001	388	10333	1249	407
SW_43 BOT	0.334	0.127	0.459	0.041	0.318	0.018	0.054	0.081	<0.01	N/A	<0.001	<0.001	390	10338	1246	410
SW_44 TOP	0.112	0.063	0.321	0.022	0.028	0.034	0.061	0.074	<0.01	N/A	<0.001	<0.001	372	10231	1236	403
SW_44 MID	0.230	0.087	0.339	0.031	0.037	0.044	0.065	0.077	<0.01	N/A	<0.001	<0.001	376	10236	1240	405
SW_44 BOT	0.247	0.117	0.345	0.036	0.039	0.048	0.068	0.079	<0.01	N/A	<0.001	<0.001	379	10348	1241	408
SW_45 TOP	0.245	0.068	0.356	0.032	0.041	0.027	0.026	0.062	<0.01	N/A	<0.001	<0.001	365	10124	1242	412
SW_45 MID	0.318	0.096	0.394	0.042	0.043	0.038	0.028	0.071	<0.01	N/A	<0.001	<0.001	372	10245	1243	413
SW_45 BOT	0.335	0.105	0.443	0.048	0.047	0.039	0.031	0.076	<0.01	N/A	<0.001	<0.001	376	10256	1248	414
SW_46 TOP	0.098	0.057	0.129	0.051	0.017	0.005	0.041	0.077	<0.01	N/A	<0.001	<0.001	368	10350	1268	406
SW_46 MID	0.294	0.098	0.141	0.071	0.057	0.041	0.052	0.054	<0.01	N/A	<0.001	<0.001	375	10460	1298	409
SW_46 BOT	0.345	0.115	0.265	0.079	0.069	0.048	0.055	0.058	<0.01	N/A	<0.001	<0.001	382	9865	1258	416
SW_47 TOP	0.178	0.083	0.158	0.014	0.028	0.024	0.061	0.053	<0.01	N/A	<0.001	<0.001	372	10245	1243	418
SW_47 MID	0.211	0.092	0.194	0.032	0.228	0.041	0.074	0.072	<0.01	N/A	<0.001	<0.001	385	10273	1290	413
SW_47 BOT	0.285	0.112	0.237	0.042	0.034	0.043	0.079	0.087	<0.01	N/A	<0.001	<0.001	326	10132	1282	417
SW_48 TOP	0.045	0.063	0.116	0.018	0.038	0.030	0.048	0.046	<0.01	N/A	<0.001	<0.001	327	10142	1231	420
SW_48 MID	0.345	0.085	0.164	0.027	0.039	0.041	0.051	0.048	<0.01	N/A	<0.001	<0.001	323	9865	1232	426
SW_48 BOT	0.568	0.096	0.236	0.034	0.042	0.048	0.055	0.057	<0.01	N/A	<0.001	<0.001	326	9989	1223	430
CONTL 1 TP	0.764	0.024	0.094	0.025	0.166	0.010	0.018	1.0) 0 .122	<0.01	N/A	<0.001	<0.001	376.6	9948	1124	400
CONTL 1 MD	0.760	0.011	0.105	0.054	0.082	0.032	<0.001	2.0) < 0.001	<0.01	N/A	<0.001	<0.001	370.8	9959	1205	401
CONTL 1 BT	0.354	0.045	0.107	0.041	0.152	0.075	<0.001	3.0) 0 .014	<0.01	N/A	<0.001	<0.001	373.4	9968	1160	403
CONTL 2 TP	0.974	0.014	0.289	0.022	0.172	0.038	0.009	4.0) 0 .051	<0.01	N/A	<0.001	<0.001	379.9	9863	1243	406
CONTL 2 MD	0.265	0.023	0.664	0.034	0.038	0.071	<0.001	5.0) 0 .157	<0.01	N/A	<0.001	<0.001	380.9	9783	1269	408
CONTL 2 BT	1.060	0.017	0.695	0.051	0.036	0.075	<0.001	6.0) 0 .126	<0.01	N/A	<0.001	<0.001	383.9	9968	1288	410

Sample ID	Ni ASTM D1886 mg/l	Fe ASTM D1068 mg/l	Pb ASTM D3559 mg/l	Cu ASTM D1688 mg/l	Cr ASTM D1687 mg/l	Zn ASTM D1691 (mg/l)	Cd ASTM D3557 mg/l	Mn ASTM D mg/l	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Hg ASTM D3866 mg/l	V ASTM D3373 mg/l	K ASTM D4192 mg/l	Na ASTM D4194 mg/l	Mg ASTM D4194 mg/l	Ca ASTM D4194 mg/
CONTL 3 TP	0.133	0.437	<0.001	0.029	<0.001	0.008	<0.001	7.0) 0 .075	<0.01	N/A	<0.001	<0.001	390.4	9563	1145	408
CONTL 3 MD	0.695	0.045	<0.001	0.038	0.002	0.022	0.012	8.0) 0 .108	<0.01	N/A	<0.001	<0.001	383.3	9789	1177	409
CONTL 3 BT	0.721	0.044	<0.001	0.047	0.004	0.081	0.059	9.0) 0 .023	<0.01	N/A	<0.001	<0.001	375.6	10231	1255	411

C, Micro-Biology Results for Water Samples

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB	COLIFORM
ASW 1 TOP	NIL	NIL	$2.21X10^2$	$1.61X10^2$	NA	0
ASW 2 TOP	NIL	NIL	$1.93X10^2$	$1.22X10^2$	NA	0
ASW 3 TOP	NIL	NIL	$2.41X10^2$	$1.02X10^2$	NA	0
ASW 4 TOP	NIL	NIL	$2.09X10^2$	$1.53X10^2$	NA	0
ASW 5 TOP	NIL	NIL	$1.89X10^2$	$1.67X10^2$	NA	0
ASW 6 TOP	NIL	NIL	$1.77X10^2$	$1.12X10^2$	NA	1
ASW 7 TOP	NIL	NIL	$2.11X10^2$	$1.19X10^2$	NA	0
ASW 8 TOP	NIL	NIL	$2.21X10^2$	$1.07X10^2$	NA	0
ASW 9 TOP	NIL	NIL	$1.95X10^2$	$1.38X10^2$	NA	2
ASW 10 TOP	$0.10X10^1$	NIL	$2.31X10^2$	$1.56X10^2$	NA	0
ASW 11 TOP	NIL	NIL	$2.02X10^2$	$1.33X10^2$	NA	0
ASW 12 TOP	NIL	NIL	$2.12X10^2$	$1.17X10^2$	NA	2
ASW 12 MID	NIL	NIL	$1.86X10^2$	$1.12X10^2$	NA	0
ASW 12 BOT	NIL	NIL	$2.17X10^2$	$1.43X10^2$	NA	2
ASW 13 TOP	NIL	$0.20X10^1$	$1.99X10^2$	$1.09X10^2$	NA	0
ASW 14 TOP	NIL	NIL	$2.13X10^2$	$1.11X10^2$	NA	0
ASW 15 TOP	NIL	NIL	$2.01X10^2$	$1.18X10^2$	NA	1
ASW 16 TOP	NIL	NIL	$2.11X10^2$	$1.32X10^2$	NA	0
ASW 17 TOP	NIL	NIL	$2.31X10^2$	$1.09X10^2$	NA	0
ASW 18 TOP	NIL	NIL	$2.18X10^2$	$1.14X10^2$	NA	0
ASW 19 TOP	NIL	NIL	$1.93X10^2$	$1.02X10^2$	NA	0
ASW 20 TOP	NIL	NIL	$2.14X10^2$	$1.16X10^2$	NA	2
ASW 21 TOP	NIL	NIL	$2.13X10^2$	$1.21X10^2$	NA	0
ASW 22 TOP	NIL	NIL	$2.13X10^2$	$1.11X10^2$	NA	1
ASW 23 TOP	NIL	NIL	$2.28X10^2$	$1.03X10^2$	NA	0

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB	COLIFORM
ASW 24 TOP	NIL	NIL	$1.86X10^2$	$1.18X10^2$	NA	0
S_1 TOP	NIL	NIL	$2.17X10^2$	$1.12X10^2$	NA	0
S_2 TOP	NIL	NIL	$2.24X10^2$	$1.07X10^2$	NA	1
S_3 TOP	NIL	NIL	$1.92X10^2$	$1.01X10^2$	NA	0
S_4 TOP	NIL	NIL	$2.01X10^2$	$1.31X10^2$	NA	2
S_5 TOP	NIL	NIL	$1.78X10^2$	$1.21X10^2$	NA	0
S_6 TOP	NIL	NIL	$2.35X10^2$	$1.03X10^2$	NA	0
S_6 MID	NIL	NIL	$2.03X10^2$	$1.24X10^2$	NA	0
S_6 BOT	NIL	NIL	$1.82X10^2$	$1.17X10^2$	NA	1
S_7 TOP	NIL	NIL	$2.41X10^2$	$1.28X10^2$	NA	0
S_8 TOP	NIL	NIL	$1.83X10^2$	$1.02X10^2$	NA	0
S_9 TOP	NIL	NIL	$1.68X10^2$	$1.12X10^2$	NA	2
S_10 TOP	NIL	$0.10X10^1$	$2.11X10^2$	$1.08X10^2$	NA	0
S_11 TOP	NIL	NIL	$2.13X10^2$	$1.21X10^2$	NA	0
S_12 TOP	NIL	NIL	$2.32X10^2$	$1.09X10^2$	NA	0
S_13 TOP	NIL	NIL	$2.07X10^2$	$1.16X10^2$	NA	1
S_13 MID	NIL	NIL	$1.72X10^2$	$1.32X10^2$	NA	0
S_13 BOT	NIL	NIL	$1.81X10^2$	$1.18X10^2$	NA	0
S_14 TOP	NIL	NIL	$2.02X10^2$	$1.22X10^2$	NA	0
S_14 MID	NIL	NIL	$2.14X10^2$	$1.03X10^2$	NA	0
S_14 BOT	NIL	NIL	$2.01X10^2$	$1.07X10^2$	NA	0
S_15 TOP	NIL	NIL	$2.13X10^2$	$1.21X10^2$	NA	0
S_15 MID	NIL	NIL	$1.82X10^2$	$1.33X10^2$	NA	0
S_15 BOT	NIL	NIL	$1.93X10^2$	$1.14X10^2$	NA	0
S_16 TOP	NIL	NIL	$2.12X10^2$	$1.19X10^2$	NA	0
S_16 MID	NIL	NIL	$1.82X10^2$	$1.11X10^2$	NA	0
S_16 BOT	NIL	NIL	$1.72X10^2$	$1.02X10^2$	NA	2
S_17 TOP	NIL	NIL	$2.37X10^2$	$1.18X10^2$	NA	0
S_17 MID	NIL	NIL	$1.82X10^2$	$1.21X10^2$	NA	0
S_17 BOT	NIL	NIL	$2.01X10^2$	$1.14X10^2$	NA	0
S_18 TOP	NIL	NIL	$2.41X10^2$	$1.11X10^2$	NA	0
S_19 TOP	NIL	NIL	$2.03X10^2$	$1.12X10^2$	NA	0
S_19 MID	NIL	NIL	$2.12X10^2$	$1.03X10^2$	NA	1
S_19 BOT	NIL	NIL	$1.86X10^2$	$1.22X10^2$	NA	0
S_20TOP	NIL	NIL	$2.28X10^2$	$1.28X10^2$	NA	0
S_20 MID	NIL	NIL	$1.82X10^2$	$1.02X10^2$	NA	0
S_20 BOT	NIL	NIL	$1.73X10^2$	$1.11X10^2$	NA	0
S_21 TOP	NIL	NIL	$2.03X10^2$	$1.31X10^2$	NA	0
S_21 MID	NIL	NIL	$1.91X10^2$	$1.01X10^2$	NA	0

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB	COLIFORM
S_21 BOT	NIL	NIL	$1.23X10^2$	$1.02X10^2$	NA	0
S_22 TOP	NIL	NIL	$2.10X10^2$	$1.36X10^2$	NA	0
S_22 MID	NIL	NIL	$1.82X10^2$	$1.24X10^2$	NA	0
S_22 BOT	NIL	NIL	$2.01X10^2$	$1.19X10^2$	NA	0
S_23 TOP	NIL	NIL	$2.23X10^2$	$1.21X10^2$	NA	0
S_23 MID	NIL	NIL	$1.83X10^2$	$1.01X10^2$	NA	0
S_23 BOT	NIL	NIL	$1.68X10^2$	$1.17X10^2$	NA	0
S_24 TOP	NIL	NIL	$2.23X10^2$	$1.19X10^2$	NA	0
S_24 MID	NIL	NIL	$1.73X10^2$	$1.31X10^2$	NA	0
S_24 BOT	NIL	NIL	$2.06X10^2$	$1.08X10^2$	NA	0
SW_1 TOP	NIL	NIL	$2.23X10^2$	$1.15X10^2$	NA	0
SW_2 TOP	NIL	NIL	$2.09X10^2$	$1.06X10^2$	NA	0
SW_3 TOP	NIL	NIL	$2.21X10^2$	$1.21X10^2$	NA	1
SW_4 TOP	NIL	NIL	$2.19X10^2$	$1.02X10^2$	NA	0
SW_5 TOP	NIL	NIL	$2.32X10^2$	$1.13X10^2$	NA	0
SW_6 TOP	NIL	NIL	$1.95X10^2$	$1.22X10^2$	NA	0
SW_7 TOP	NIL	NIL	$1.82X10^2$	$1.18X10^2$	NA	2
SW_8 TOP	NIL	NIL	$2.12X10^2$	$1.02X10^2$	NA	1
SW_9 TOP	NIL	NIL	$2.33X10^2$	$1.17X10^2$	NA	0
SW_10 TOP	NIL	NIL	$2.18X10^2$	$1.12X10^2$	NA	0
SW_11 TOP	NIL	NIL	$1.83X10^2$	$1.13X10^2$	NA	0
SW_12 TOP	NIL	NIL	$1.95X10^2$	$1.25X10^2$	NA	0
SW_13 TOP	NIL	NIL	$2.07X10^2$	$1.01X10^2$	NA	2
SW_14 TOP	NIL	NIL	$2.21X10^2$	$1.15X10^2$	NA	0
SW_15 TOP	NIL	NIL	$2.12X10^2$	$1.28X10^2$	NA	0
SW_16 TOP	NIL	NIL	$2.25X10^2$	$1.31X10^2$	NA	0
SW_17 TOP	NIL	NIL	$2.19X10^2$	$1.23X10^2$	NA	0
SW_18 TOP	NIL	NIL	$1.98X10^2$	$1.14X10^2$	NA	1
SW_19 TOP	NIL	NIL	$1.77X10^2$	$1.33X10^2$	NA	0
SW_19 MID	NIL	NIL	$2.02X10^2$	$1.28X10^2$	NA	0
SW_19 BOT	NIL	NIL	$2.31X10^2$	$1.09X10^2$	NA	0
SW_20 TOP	NIL	NIL	$1.81X10^2$	$1.24X10^2$	NA	0
SW_21 TOP	NIL	NIL	$2.14X10^2$	$1.04X10^2$	NA	0
SW_22 TOP	NIL	NIL	$2.32X10^2$	$1.27X10^2$	NA	0
SW_23 TOP	NIL	NIL	$1.94X10^2$	$1.16X10^2$	NA	2
SW_24 TOP	NIL	NIL	$1.82X10^2$	$1.32X10^2$	NA	0
SW_25 TOP	NIL	NIL	$2.19X10^2$	$1.27X10^2$	NA	2
SW_26 TOP	NIL	NIL	$2.01X10^2$	$1.25X10^2$	NA	0
SW_27 TOP	NIL	NIL	$1.92X10^2$	$1.18X10^2$	NA	0

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB	COLIFORM
SW_28 TOP	NIL	NIL	$2.22X10^2$	$1.11X10^2$	NA	1
SW_29 TOP	NIL	NIL	$2.09X10^2$	$1.22X10^2$	NA	0
SW_30 TOP	NIL	NIL	$2.34X10^2$	$1.06X10^2$	NA	1
SW_31 TOP	NIL	NIL	$1.92X10^2$	$1.34X10^2$	NA	0
SW_32 TOP	NIL	NIL	$1.84X10^2$	$1.21X10^2$	NA	4
SW_33 TOP	NIL	NIL	$1.81X10^2$	$1.07X10^2$	NA	3
SW_34 TOP	NIL	NIL	$2.13X10^2$	$1.21X10^2$	NA	1
SW_35 TOP	NIL	NIL	$1.98X10^2$	$1.03X10^2$	NA	0
SW_36 TOP	NIL	NIL	$2.11X10^2$	$1.23X10^2$	NA	3
SW_37 TOP	NIL	NIL	$2.26X10^2$	$9.60X10^1$	NA	0
SW_37 MID	NIL	NIL	$1.88X10^2$	$1.19X10^2$	NA	0
SW_37 BOT	NIL	NIL	$1.72X10^2$	$8.40X10^1$	NA	0
SW_38 TOP	NIL	NIL	$2.01X10^2$	$1.28X10^2$	NA	0
SW_38 MID	NIL	NIL	$1.92X10^2$	$7.30X10^1$	NA	0
SW_38 BOT	NIL	NIL	$1.81X10^2$	$8.40X10^1$	NA	0
SW_39 TOP	NIL	NIL	$1.87X10^2$	$9.80X10^1$	NA	0
SW_40 TOP	NIL	NIL	$2.09X10^2$	$1.31X10^2$	NA	0
SW_40 MID	NIL	NIL	$1.83X10^2$	$1.06X10^2$	NA	0
SW_40 BOT	NIL	NIL	$1.66X10^2$	$9.50X10^1$	NA	0
SW_41 TOP	NIL	NIL	$2.16X10^2$	$1.24X10^2$	NA	0
SW_41 MID	NIL	NIL	$2.03X10^2$	$1.01X10^2$	NA	0
SW_41 BOT	NIL	NIL	$1.84X10^2$	$1.11X10^2$	NA	0
SW_42 TOP	NIL	NIL	$2.31X10^2$	$1.12X10^2$	NA	0
SW_42 MID	NIL	NIL	$1.58X10^2$	$8.70X10^1$	NA	1
SW_42 BOT	NIL	NIL	$2.13X10^2$	$1.27X10^2$	NA	0
SW_43 TOP	NIL	NIL	$2.35X10^2$	$1.19X10^2$	NA	0
SW_43 MID	NIL	NIL	$2.09X10^2$	$1.23X10^2$	NA	0
SW_43 BOT	NIL	NIL	$1.82X10^2$	$9.80X10^1$	NA	0
SW_44 TOP	NIL	NIL	$2.28X10^2$	$1.32X10^2$	NA	0
SW_44 MID	NIL	NIL	$1.97X10^2$	$8.20X10^1$	NA	0
SW_44 BOT	NIL	NIL	$2.01X10^2$	$1.33X10^2$	NA	0
SW_45 TOP	NIL	NIL	$2.32X10^2$	$1.17X10^2$	NA	0
SW_45 MID	NIL	NIL	$1.81X10^2$	$8.70X10^1$	NA	0
SW_45 BOT	NIL	NIL	$1.62X10^2$	$9.30X10^1$	NA	0
SW_46 TOP	NIL	NIL	$2.11X10^2$	$1.25X10^2$	NA	0
SW_46 MID	NIL	NIL	$1.75X10^2$	$8.70X10^1$	NA	0
SW_46 BOT	NIL	NIL	$2.24X10^2$	$1.72X10^2$	NA	0
SW_47 TOP	NIL	NIL	$2.16X10^2$	$1.03X10^2$	NA	0
SW_47 MID	NIL	NIL	$2.02X10^2$	$1.41X10^2$	NA	0

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB	COLIFORM
SW_47 BOT	NIL	NIL	2.34X102	$1.13X10^{2}$	NA	0
SW_48 TOP	NIL	NIL	$1.83X10^{2}$	$1.01X10^{2}$	NA	0
SW_48 MID	NIL	NIL	$2.37X10^{2}$	$1.16X10^{2}$	NA	0
SW_48 BOT	NIL	NIL	$1.89X10^{2}$	$1.09X10^{2}$	NA	0
CONTL 1 TP	NIL	NIL	$2.13X10^{2}$	$1.11X10^{2}$	NA	0
CONTL 1 MD	NIL	NIL	$2.27X10^{2}$	$1.15X10^{2}$	NA	0
CONTL 1 BT	NIL	NIL	$2.01X10^{2}$	$1.22X10^{2}$	NA	2
CONTL 2 TP	NIL	NIL	$2.37X10^{2}$	$1.02X10^{2}$	NA	0
CONTL 2 MD	NIL	NIL	$1.86X10^{2}$	$1.12X10^{2}$	NA	0
CONTL 2 BT	NIL	NIL	$2.17X10^{2}$	$1.10X10^{2}$	NA	0
CONTL 3 TP	NIL	NIL	$2.19X10^{2}$	$1.03X10^{2}$	NA	0
CONTL 3 MD	NIL	NIL	$2.08X10^{2}$	$1.19X10^{2}$	NA	0
CONTL 3 BT	NIL	NIL	$1.78X10^{2}$	$1.18X10^{2}$	NA	0

B, SEDIMENT Results – (Physico-Chemistry)

Sample Point ID.	pH APHA 4500-H	REDOX (mV)	TEMP	colour	CL APHA 2510A (mg/kg)	TOC APHA 5310 (%)	NO_3 APHA 4500 mg/kg	PO_4 APHA 4500 (mg/kg)	NH_4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			THC ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %				
ASWD 1	7.12	-6.9	15.8	GREY	9994	2.41	1.3	0.14	0.60	-	52.83	47.17	<0.001	<0.001	<0.001	<0.001
ASWD 2	7.72	-54.6	16.5	GREY	9172	2.12	0.9	0.18	0.42	-	54.05	45.95	6.0	<0.001	<0.001	<0.001
ASWD 3	7.47	-33.7	16.8	GREY	9461	3.05	1.1	0.40	0.51	-	52.83	47.17	12.7	<0.001	<0.001	<0.001
ASWD 4	7.35	-25.7	16.2	GREY	9024	2.09	0.5	0.56	0.23	-	52.94	47.06	6.0	<0.001	<0.001	<0.001
ASWD 5	7.50	-35.6	15.1	GREY	10508	1.97	0.7	0.21	0.32	-	54.55	45.45	6.9	<0.001	<0.001	<0.001
ASWD 6	7.59	-43.4	15.5	GREY	9281	1.76	0.1	0.27	0.05	-	52.94	47.06	5.7	<0.001	<0.001	<0.001
ASWD 7	7.06	-17.5	16.5	GREY	9353	2.91	0.3	0.19	0.14	-	52.50	47.50	12.7	<0.001	<0.001	<0.001
ASWD 8	7.64	-42.3	17.7	GREY	10111	2.93	0.7	0.79	0.32	-	51.20	48.59	6.0	<0.001	<0.001	<0.001

Sample Point ID.	pH APHA 4500-H	REDOX (mV)	TEMP	colour	CL APHA 2510A (mg/kg)	TOC APHA 5310 (%)	NO_3 APHA 4500 mg/kg	PO_4 APHA 4500 (mg/kg)	NH_4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			THC ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %				
ASWD 9	7.72	-52.9	17.4	GREY	8883	3.81	0.3	0.36	0.42	-	51.37	47.95	20.0	0.08	<0.001	<0.001
ASWD 10	7.79	-59.6	17.0	GREY	9784	2.79	0.9	0.18	0.42	-	51.33	48.47	12.0	<0.001	<0.001	<0.001
ASWD 11	7.48	-33.8	16.5	GREY	9492	1.43	0.3	0.27	0.14	-	53.53	46.23	6.7	<0.001	<0.001	<0.001
ASWD 12	7.61	-41.7	16.8	GREY	9136	1.12	0.7	0.44	0.32	-	52.72	47.17	12.7	<0.001	<0.001	<0.001
ASWD 13	7.61	-41.6	16.5	GREY	8811	1.51	0.3	0.21	0.18	-	48.29	51.51	12.0	<0.001	<0.001	<0.001
ASWD 14	7.79	-56.4	16.2	GREY	8631	1.24	0.5	0.28	0.23	-	51.35	48.63	6.7	<0.001	<0.001	<0.001
ASWD 15	7.46	-29.2	17.1	GREY	9461	1.65	0.7	0.24	0.32	-	53.19	46.54	5.7	<0.001	<0.001	<0.001
ASWD 16	7.42	-29.4	16.2	GREY	8261	1.44	0.4	0.48	0.21	-	51.47	48.44	<0.001	<0.001	<0.001	<0.001
ASWD 17	7.57	-38.8	17.4	GREY	8197	1.21	1.3	0.40	0.61	-	51.27	48.57	6.0	<0.001	<0.001	<0.001
ASWD 18	7.87	-69.3	16.7	GREY	8999	3.12	0.8	0.49	0.37	-	51.25	48.71	12.0	<0.001	<0.001	<0.001
ASWD 19	7.27	-11.9	16.5	GREY	10003	1.35	0.5	0.56	0.23	-	53.41	46.45	5.7	<0.001	<0.001	<0.001
ASWD 20	7.44	-31.6	16.9	GREY	8486	1.43	0.7	0.64	0.35	-	51.24	48.68	13.3	<0.001	<0.001	<0.001
ASWD 21	7.47	-33.5	16.0	GREY	8197	1.97	0.4	0.74	0.21	-	51.85	48.04	17.0	0.03	<0.001	<0.001
ASWD 22	7.56	-38.5	16.3	GREY	8267	2.09	0.6	0.15	0.28	-	52.58	47.32	6.3	<0.001	<0.001	<0.001
ASWD 23	7.42	-31.7	16.9	GREY	9190	1.21	0.2	0.75	0.32	-	52.91	47.03	18.0	0.04	<0.001	<0.001
ASWD 24	7.63	-43.1	17.2	GREY	8522	0.88	0.8	0.42	0.38	-	51.26	48.69	12.7	<0.001	<0.001	<0.001
SD_1	6.98	-7.8	16.8	GREY	10833	1.65	1.2	0.89	0.56	-	54.52	45.43	5.7	<0.001	<0.001	<0.001
SD_2	7.23	19.7	17.4	GREY	9.281	1.44	1.4	0.71	0.65	-	51.27	48.57	12.0	<0.001	<0.001	<0.001
SD_3	7.28	-22.4	17.9	GREY	9606	0.19	0.8	0.45	0.37	-	55.41	44.56	6.3	<0.001	<0.001	<0.001
SD_4	7.53	-51.4	16.8	GREY	8883	0.31	0.5	0.22	0.23	-	53.08	46.84	6.0	<0.001	<0.001	<0.001

Sample Point ID.	pH APHA 4500-H	REDOX (mV)	TEMP	colour	CL APHA 2510A (mg/kg)	TOC APHA 5310 (%)	NO_3 APHA 4500 mg/kg	PO_4 APHA 4500 (mg/kg)	NH_4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			THC ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %				
SD_5	7.50	-34.6	16.7	GREY	8558	0.26	1.1	0.89	0.51	-	54.20	45.45	12.7	<0.001	<0.001	<0.001
SD_6	7.56	-38.4	16.0	GREY	9497	0.54	1.3	0.24	0.61	-	53.03	46.93	6.7	<0.001	<0.001	<0.001
SD_7	7.44	-31.9	16.2	GREY	8811	0.46	0.7	0.47	0.32	-	52.17	47.83	12.7	<0.001	<0.001	<0.001
SD_8	7.64	-57.3	15.7	GREY	9569	0.59	0.6	0.18	0.28	-	51.85	48.01	5.7	<0.001	<0.001	<0.001
SD_9	7.89	-69.8	16.4	GREY	8558	0.64	0.8	0.40	0.37	-	53.80	46.12	12.0	<0.001	<0.001	<0.001
SD_10	7.47	-32.2	17.0	GREY	9281	1.09	0.8	0.29	0.32	-	52.79	47.13	12.7	<0.001	<0.001	<0.001
SD_11	7.48	-35.5	16.8	GREY	8261	1.17	1.3	0.25	0.61	-	53.31	46.64	6.7	<0.001	<0.001	<0.001
SD_12	7.56	-39.5	16.5	GREY	9533	0.33	0.7	0.67	0.33	-	53.82	46.13	12.7	<0.001	<0.001	<0.001
SD_13	7.27	-21.8	17.2	GREY	9606	0.28	0.6	0.48	0.28	-	51.77	48.20	18.0	0.05	<0.001	<0.001
SD_14	7.40	-29.9	16.7	GREY	9858	0.29	0.5	0.27	0.24	-	51.26	48.69	12.7	<0.001	<0.001	<0.001
SD_15	7.49	-32.8	16.2	GREY	9678	0.59	0.4	0.21	0.20	-	54.18	45.72	6.7	<0.001	<0.001	<0.001
SD_16	7.47	-33.7	16.9	GREY	9894	0.46	1.2	0.51	0.54	-	53.64	46.24	12.0	<0.001	<0.001	<0.001
SD_17	7.42	-30.8	16.3	GREY	9858	1.39	1.3	0.78	0.61	-	54.99	44.81	6.3	<0.001	<0.001	<0.001
SD_18	7.49	-33.8	16.2	GREY	8992	1.84	0.3	0.59	0.64	-	54.10	45.78	6.0	<0.001	<0.001	<0.001
SD_19	7.63	-48.1	16.9	GREY	9172	1.17	0.9	0.44	0.42	-	54.03	45.72	12.0	<0.001	<0.001	<0.001
SD_20	7.62	-41.9	15.4	GREY	8919	1.97	0.6	0.55	0.29	-	55.43	44.35	6.7	<0.001	<0.001	<0.001
SD_21	7.54	-37.8	16.8	GREY	9281	0.88	1.4	0.69	0.64	-	52.49	47.24	<0.00	<0.001	<0.001	<0.001
SD_22	7.32	-24.8	16.5	GREY	9432	1.61	1.2	0.88	0.55	-	54.46	45.38	6.3	<0.001	<0.001	<0.001
SD_23	7.57	-38.8	17.2	GREY	9100	1.96	0.5	0.56	0.26	-	54.99	44.80	12.7	<0.001	<0.001	<0.001
SD_24	7.61	-40.6	16.5	GREY	8883	2.11	0.5	0.45	0.22	-	53.36	46.40	18.0	0.04	<0.001	<0.001

Sample Point ID.	pH APHA 4500-H	REDOX (mV)	TEMP	colour	CL APHA 2510A (mg/kg)	TOC APHA 5310 (%)	NO_3 APHA 4500 mg/kg	PO_4 APHA 4500 (mg/kg)	NH_4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			THC ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %				
SWD_1	7.46	-30.3	17.1	GREY	9227	2.73	0.7	0.21	0.33	-	48.38	51.41	6.3	<0.001	<0.001	<0.001
SWD_2	7.43	-28.9	16.4	GREY	9457	1.03	0.4	0.24	0.19	-	47.37	52.63	6.7	<0.001	<0.001	<0.001
SWD_3	7.25	-21.3	16.8	GREY	9100	1.61	0.2	0.20	0.09	-	46.04	53.71	12.0	<0.001	<0.001	<0.001
SWD_4	7.45	-32.5	17.8	GREY	9100	1.94	1.2	0.88	0.55	-	48.93	50.97	6.0	<0.001	<0.001	<0.001
SWD_5	7.78	-52.5	16.3	GREY	9172	2.49	0.8	0.24	0.37	-	47.47	52.20	11.3	<0.001	<0.001	<0.001
SWD_6	7.53	-35.1	18.7	GREY	9227	2.14	0.7	0.19	0.33	-	51.28	48.72	13.3	<0.001	<0.001	<0.001
SWD_7	7.39	-29.8	18.2	GREY	8946	2.75	1.1	0.21	0.51	-	48.83	50.96	6.3	<0.001	<0.001	<0.001
SWD_8	7.54	-35.6	18.6	GREY	8631	1.68	0.8	0.18	0.37	-	48.78	51.20	5.7	<0.001	<0.001	<0.001
SWD_9	7.74	-54.7	18.0	GREY	8742	1.46	0.4	0.24	0.19	-	47.83	52.17	6.0	<0.001	<0.001	<0.001
SWD_10	7.81	-62.3	17.2	GREY	8883	2.24	0.8	0.14	0.37	-	49.04	50.73	12.0	<0.001	<0.001	<0.001
SWD_11	7.48	-34.8	16.2	GREY	9202	1.92	0.5	0.38	0.22	-	47.81	53.87	6.3	<0.001	<0.001	<0.001
SWD_12	7.71	-49.8	16.8	GREY	8844	1.27	0.7	0.47	0.33	-	43.10	56.80	11.3	<0.001	<0.001	<0.001
SWD_13	7.58	-39.5	16.0	GREY	9281	0.96	0.4	0.18	0.20	-	45.45	54.50	12.0	<0.001	<0.001	<0.001
SWD_14	7.55	-38.2	16.5	GREY	9151	1.47	0.8	0.16	0.37	-	47.62	52.34	6.3	<0.001	<0.001	<0.001
SWD_15	7.43	-30.9	15.4	GREY	9457	2.47	0.8	0.29	0.37	-	47.92	52.20	11.0	<0.001	<0.001	<0.001
SWD_16	7.50	-34.9	16.8	GREY	8919	2.49	0.5	0.42	0.26	-	44.44	55.51	6.0	<0.001	<0.001	<0.001
SWD_17	7.86	-68.2	18.2	GREY	9281	1.64	1.0	0.21	0.46	-	48.10	51.93	11.3	<0.001	<0.001	<0.001
SWD_18	7.40	-33.4	17.5	GREY	8631	2.54	0.4	0.24	0.21	-	46.34	53.62	6.7	<0.001	<0.001	<0.001
SWD_19	7.53	-35.8	16.5	GREY	8775	1.44	0.7	0.60	0.33	-	49.55	50.40	6.0	<0.001	<0.001	<0.001
SWD_20	7.34	-25.8	16.2	GREY	9208	2.00	0.5	0.57	0.23	-	48.90	51.23	12.7	<0.001	<0.001	<0.001

Sample Point ID.	pH APHA 4500-H	REDOX (mV)	TEMP	colour	CL APHA 2510A (mg/kg)	TOC APHA 5310 (%)	NO_3 APHA 4500 mg/kg	PO_4 APHA 4500 (mg/kg)	NH_4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			THC ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %				
SWD_21	7.55	-38.3	16.4	GREY	8992	0.69	0.2	0.76	0.09	-	48.94	51.02	6.7	<0.001	<0.001	<0.001
SWD_22	7.56	-38.7	16.9	GREY	9281	1.06	0.8	0.14	0.37	-	47.83	52.12	6.3	<0.001	<0.001	<0.001
SWD_23	7.57	-38.8	16.7	GREY	9461	1.34	0.1	0.16	0.05	-	43.55	56.41	6.7	<0.001	<0.001	<0.001
SWD_24	7.65	-44.2	16.1	GREY	9208	1.74	0.9	0.18	0.42	-	47.83	52.13	6.0	<0.001	<0.001	<0.001
SWD_25	7.78	-55.8	17.2	GREY	8992	1.97	1.5	0.20	0.63	-	46.81	53.19	12.7	<0.001	<0.001	<0.001
SWD_26	7.21	-18.7	16.5	GREY	9208	2.77	1.1	0.29	0.51	-	47.27	52.70	12.0	<0.001	<0.001	<0.001
SWD_27	7.69	-50.7	17.2	GREY	9172	2.15	0.5	0.24	0.37	-	47.54	52.43	6.3	<0.001	<0.001	<0.001
SWD_28	7.26	-21.7	17.6	GREY	9534	1.89	0.3	0.21	0.14	-	51.02	48.93	<0.001	<0.001	<0.001	<0.001
SWD_29	7.38	-27.8	17.1	GREY	9461	1.26	0.5	0.51	0.23	-	52.08	47.90	6.7	<0.001	<0.001	<0.001
SWD_30	7.54	-36.8	16.8	GREY	9208	1.04	0.2	0.16	0.13	-	53.70	46.24	<0.001	<0.001	<0.001	<0.001
SWD_31	7.35	-26.2	16.2	GREY	9100	0.84	0.5	0.19	0.23	-	51.92	48.04	6.0	<0.001	<0.001	<0.001
SWD_32	7.48	-34.2	18.4	GREY	8992	0.70	0.9	0.26	0.42	-	57.36	42.66	12.0	<0.001	<0.001	<0.001
SWD_33	7.53	-37.2	16.7	GREY	9172	1.19	0.8	0.15	0.37	-	53.13	46.95	6.3	<0.001	<0.001	<0.001
SWD_34	7.31	-24.8	16.0	GREY	8956	0.95	0.3	0.19	0.14	-	56.10	43.86	11.3	<0.001	<0.001	<0.001
SWD_35	7.52	-37.5	16.2	GREY	9497	1.14	0.7	0.14	0.33	-	51.09	48.78	6.7	<0.001	<0.001	<0.001
SWD_36	7.42	-30.9	16.7	GREY	9281	1.26	0.4	0.20	0.19	-	51.17	48.75	12.0	<0.001	<0.001	<0.001
SWD_37	7.49	-46.3	16.4	GREY	9387	1.09	0.8	0.14	0.37	-	51.96	47.92	6.3	<0.001	<0.001	<0.001
SWD_38	7.45	-32.5	17.4	GREY	9358	0.97	0.4	0.10	0.19	-	51.35	48.63	12.0	<0.001	<0.001	<0.001
SWD_39	7.43	-36.8	18.5	GREY	9281	1.00	0.6	0.14	0.29	-	49.74	50.19	12.7	<0.001	<0.001	<0.001
SWD_40	7.34	-23.9	17.7	GREY	9208	1.71	0.2	0.12	0.09	-	49.29	50.56	6.7	<0.001	<0.001	<0.001

Sample Point ID.	pH APHA 4500-H	REDOX (mV)	TEMP	colour	CL APHA 2510A (mg/kg)	TOC APHA 5310 (%)	NO_3 APHA 4500 mg/kg	PO_4 APHA 4500 (mg/kg)	NH_4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			THC ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %				
SWD_41	7.38	-28.1	18.4	GREY	9100	1.53	0.3	0.18	0.14	-	52.70	47.11	11.3	<0.001	<0.001	<0.001
SWD_42	7.30	-28.9	16.7	GREY	9136	1.07	0.8	0.29	0.37	-	51.16	48.81	6.3	<0.001	<0.001	<0.001
SWD_43	7.45	-31.8	16.9	GREY	9172	1.16	0.4	0.22	0.21	-	52.78	47.17	12.0	<0.001	<0.001	<0.001
SWD_44	7.50	-35.9	17.2	GREY	9208	1.20	0.5	0.50	0.23	-	47.83	52.15	6.3	<0.001	<0.001	<0.001
SWD_45	7.34	-22.9	17.6	GREY	9353	0.77	0.7	0.14	0.33	-	45.83	54.12	12.0	<0.001	<0.001	<0.001
SWD_46	7.39	-29.7	16.5	GREY	9461	1.07	0.2	0.25	0.12	-	48.78	51.19	6.3	<0.001	<0.001	<0.001
SWD_47	7.54	-36.7	17.0	GREY	9786	1.13	0.8	0.34	0.37	-	47.84	52.08	12.0	<0.001	<0.001	<0.001
SWD_48	7.42	-31.1	16.7	GREY	9852	0.78	1.0	0.29	0.46	-	45.13	54.76	<0.001	<0.001	<0.001	<0.001
CONTRL 1	7.35	-26.2	21.5	GREY	8956	1.52	0.7	0.16	0.33	-	70.32	29.63	6.7	<0.001	<0.001	<0.001
CONTRL 2	7.40	-28.8	20.1	GREY	9786	1.69	0.5	0.18	0.23	-	15.79	84.20	17.0	0.02	<0.001	<0.001
CONTRL 3	7.32	-18.5	20.8	GREY	9208	0.90	0.9	0.29	0.42	-	27.37	72.60	6.3	<0.001	<0.001	<0.001

Metal Result (Sediment)

Sample Point ID.	Ni ASTM D1886 mg/kg	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cu ASTM D1688 mg/kg	Cr ASTM D1687 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	Ba ASTM D4382 mg/kg	Co ASTM D3558 mg/kg	Ag ASTM D3223 mg/kg	V ASTM D3373 mg/kg	K ASTM D4192 mg/kg	Na ASTM D4194 mg/kg	Mg ASTM D4194 mg/kg	Ca ASTM D4192 mg/kg
ASWD 1	19.336	7849	2.869	9.619	58.912	38.282	6.543	10.0	10.124	<0.001	<0.001	577	11147	2982	1068
ASWD 2	32.252	6897	1.963	11.558	49.652	33.957	5.864	9.0	10.521	<0.001	<0.001	578	11450	2865	1078
ASWD 3	93.295	7239	2.345	11.300	83.576	28.451	5.481	13.0	11.264	<0.001	<0.001	610	11739	2789	1089
ASWD 4	82.120	7124	2.112	12.218	45.381	25.369	8.647	7.0	13.254	<0.001	<0.001	543	11345	2653	1034
ASWD 5	19.898	6985	2.448	11.619	37.333	36.822	10.107	10.0	12.036	<0.001	<0.001	594	1215	2818	1009

Sample Point ID.	Ni ASTM D1886 mg/kg	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cu ASTM D1688 mg/kg	Cr ASTM D1687 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	Ba ASTM D4382 mg/kg	Co ASTM D3558 mg/kg	Ag ASTM D3223 mg/kg	V ASTM D3373 mg/kg	K ASTM D4192 mg/kg	Na ASTM D4194 mg/kg	Mg ASTM D4194 mg/kg	Ca ASTM D4192 mg/kg
ASWD 6	25.450	6897	3.102	11.852	35.216	23.964	9.332	12.0	15.214	<0.001	<0.001	513	11345	2456	1045
ASWD 7	142.188	6777	2.198	6.858	34.516	34.268	7.696	9.0	12.347	<0.001	<0.001	641	11606	2966	1034
ASWD 8	50.151	7036	2.682	12.683	32.259	30.851	3.918	14.0	10.217	<0.001	<0.001	598	11028	2923	1037
ASWD 9	46.123	7564	1.953	8.653	39.521	35.272	5.964	8.0	13.471	<0.001	<0.001	543	11125	2789	1014
ASWD 10	68.292	7139	2.356	9.156	34.743	43.606	5.597	11.0	10.268	<0.001	<0.001	584	11279	2432	1048
ASWD 11	56.132	6897	2.161	10.342	38.435	39.523	8.102	11.0	15.230	<0.001	<0.001	513	11456	2123	1012
ASWD 12	103.799	7246	<0.001	11.641	47.768	40.957	<0.001	14.0	11.216	<0.001	<0.001	600	11479	2458	1151
ASWD 13	78.456	7234	1.584	8.643	52.314	43.101	3.924	8.0	10.402	<0.001	<0.001	523	11342	2312	1109
ASWD 14	68.953	6897	2.336	10.279	33.824	29.573	6.628	6.0	12.440	<0.001	<0.001	518	11120	2340	1103
ASWD 15	7.941	6647	<0.001	7.060	21.983	25.925	<0.001	9.0	10.230	<0.001	<0.001	548	11655	2681	1216
ASWD 16	25.456	7851	3.215	5.964	29.347	36.247	7.358	8.0	15.630	<0.001	<0.001	516	11345	2342	1218
ASWD 17	150.968	6647	2.376	8.198	22.849	42.124	9.734	12.0	13.401	<0.001	<0.001	636	11926	2550	1217
ASWD 18	85.123	7125	3.216	6.225	25.362	37.852	7.256	10.0	12.230	<0.001	<0.001	578	11345	2312	1234
ASWD 19	53.842	7107	<0.001	5.763	<0.001	5.100	1.287	9.0	15.215	<0.001	<0.001	692	11062	2574	1217
ASWD 20	42.321	6897	0.955	6.215	31.541	29.472	5.332	13.0	12.478	<0.001	<0.001	542	11412	2234	1240
ASWD 21	38.369	7125	2.036	10.279	35.826	35.228	6.134	8.0	15.247	<0.001	<0.001	523	11328	2228	1105
ASWD 22	42.128	6953	4.008	5.382	41.217	38.116	5.327	8.0	13.269	<0.001	<0.001	542	11123	2214	1112
ASWD 23	52.360	7012	2.963	9.127	30.278	35.241	5.337	11.0	11.478	<0.001	<0.001	548	11058	2236	1114
ASWD 24	39.456	6857	2.347	7.395	28.683	37.225	4.953	15.0	18.521	<0.001	<0.001	524	11850	2214	1135
SD_1	3.931	6812	3.980	15.660	70.633	24.786	5.403	12.0	11.025	<0.001	<0.001	719	11095	2651	1216

Sample Point ID.	Ni ASTM D1886 mg/kg	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cu ASTM D1688 mg/kg	Cr ASTM D1687 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	Ba ASTM D4382 mg/kg	Co ASTM D3558 mg/kg	Ag ASTM D3223 mg/kg	V ASTM D3373 mg/kg	K ASTM D4192 mg/kg	Na ASTM D4194 mg/kg	Mg ASTM D4194 mg/kg	Ca ASTM D4192 mg/kg
SD_2	2.877	6832	4.166	11.032	37.851	21.637	3.328	14.0	10.258	<0.001	<0.001	578	11295	2665	1231
SD_3	116.213	6699	<0.001	14.177	26.518	56.908	7.681	11.0	11.036	<0.001	<0.001	594	11485	2755	1230
SD_4	78.235	7893	3.968	12.182	38.247	61.098	5.335	9.0	10.254	<0.001	<0.001	536	11356	2560	1135
SD_5	68.235	7456	2.968	7.349	32.812	52.281	9.281	14.0	11.471	<0.001	<0.001	524	11456	2345	1120
SD_6	322.108	6727	<0.001	9.898	39.528	26.087	11.870	16.0	10.236	<0.001	<0.001	576	11672	2679	1228
SD_7	32.273	7125	2.665	8.246	28.438	50.117	10.569	11.0	13.056	<0.001	<0.001	645	11876	2456	1345
SD_8	42.123	6682	5.177	13.822	34.860	27.010	8.360	13.0	15.214	<0.001	<0.001	606	11930	2189	1216
SD_9	80.665	6772	5.803	13.329	64.960	36.667	1.117	9.0	16.106	<0.001	<0.001	658	11959	2568	1232
SD_10	52.124	6568	3.865	10.352	39.241	29.543	5.332	6.0	14.050	<0.001	<0.001	564	11564	2315	1203
SD_11	45.902	6562	5.137	11.156	58.267	46.181	2.990	8.0	13.518	<0.001	<0.001	703	11653	2523	1224
SD_12	46.789	6986	3.693	8.255	42.316	28.149	5.327	10.0	13.036	<0.001	<0.001	645	11234	2145	1245
SD_13	90.578	6643	4.007	2.602	92.379	33.821	4.593	13.0	13.715	<0.001	<0.001	749	11664	2378	1214
SD_14	98.797	6537	3.478	4.506	103.513	8.704	2.435	6.0	15.223	<0.001	<0.001	757	11851	2959	1215
SD_15	60.951	6556	4.602	10.436	29.963	40.155	6.650	11.0	14.213	<0.001	<0.001	704	11922	2424	1222
SD_16	42.356	7893	2.863	8.112	32.543	25.281	5.392	13.0	16.125	<0.001	<0.001	658	11245	2345	1325
SD_17	35.621	6987	3.669	7.231	28.238	20.452	3.452	16.0	13.163	<0.001	<0.001	568	11421	2215	1245
SD_18	28.120	7125	5.141	9.328	27.147	18.473	6.451	12.0	16.124	<0.001	<0.001	612	11325	2145	1325
SD_19	20.856	6897	4.331	5.451	24.125	19.145	5.473	15.0	14.111	<0.001	<0.001	564	11120	2451	1284
SD_20	24.125	7124	4.218	6.542	22.234	16.754	8.275	11.0	16.034	<0.001	<0.001	645	11325	2312	1120
SD_21	35.128	7235	3.995	3.241	17.245	14.234	8.452	9.0	13.524	<0.001	<0.001	586	11123	2145	1286

Sample Point ID.	Ni ASTM D1886 mg/kg	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cu ASTM D1688 mg/kg	Cr ASTM D1687 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	Ba ASTM D4382 mg/kg	Co ASTM D3558 mg/kg	Ag ASTM D3223 mg/kg	V ASTM D3373 mg/kg	K ASTM D4192 mg/kg	Na ASTM D4194 mg/kg	Mg ASTM D4194 mg/kg	Ca ASTM D4192 mg/kg
SD_22	82.256	7546	4.106	6.287	24.248	18.354	9.458	12.0	18.124	<0.001	<0.001	623	11205	2132	1125
SD_23	56.630	7589	3.667	5.124	18.234	15.234	10.245	9.0	17.902	<0.001	<0.001	584	11325	2145	1320
SD_24	72.34	6897	4.168	7.124	15.234	20.248	8.234	14.0	12.568	<0.001	<0.001	523	11452	2130	1345
SWD_1	112	6605	<0.001	7.627	24.659	27.815	4.715	11.0	15.147	<0.001	<0.001	717	11562	2754	1221
SWD_2	26.885	6533	<0.001	7.172	5.068	25.103	<0.001	9.0	16.258	<0.001	<0.001	741	11073	2567	1212
SWD_3	23.250	6534	3.262	6.235	4.238	26.234	8.753	12.0	12.369	<0.001	<0.001	653	11231	2245	1125
SWD_4	14.415	6323	4.286	14.037	21.556	41.274	5.656	7.0	15.698	<0.001	<0.001	649	11998	2494	1208
SWD_5	16.245	6423	2.669	6.234	31.280	32.178	4.235	11.0	14.217	<0.001	<0.001	564	11456	2312	1124
SWD_6	128	6421	3.640	8.040	32.404	36.595	5.532	13.0	15.324	<0.001	<0.001	594	11646	2467	1208
SWD_7	135	5897	3.845	5.032	30.124	28.145	4.389	9.0	12.326	<0.001	<0.001	545	11456	2123	1235
SWD_8	120	7125	4.251	5.289	21.312	23.234	3.128	8.0	13.694	<0.001	<0.001	563	11312	2135	1345
SWD_9	132	5889	4.152	13.636	22.120	33.005	<0.001	11.0	17.265	<0.001	<0.001	543	11219	2551	1200
SWD_10	60.252	6987	3.294	9.234	15.031	20.148	1.258	13.0	14.959	<0.001	<0.001	546	11312	2123	1245
SWD_11	50.231	6852	3.622	12.158	14.235	22.234	2.280	15.0	12.365	<0.001	<0.001	653	11125	2245	1325
SWD_12	42.356	7125	4.271	10.234	13.289	17.235	5.124	13.0	12.354	<0.001	<0.001	542	11325	2214	1245
SWD_13	36.895	6235	3.642	10.234	12.145	18.124	4.235	8.0	17.265	<0.001	<0.001	611	11860	2145	1325
SWD_14	65.913	5779	4.226	11.168	70.093	31.213	4.295	10.0	13.698	<0.001	<0.001	589	11235	2245	1245
SWD_15	21.842	5099	3.171	9.347	30.993	30.189	5.914	13.0	15.263	<0.001	<0.001	602	11706	2596	1205
SWD_16	26.128	5207	<0.001	9.420	27.089	15.617	8.556	12.0	14.254	<0.001	<0.001	581	11977	2654	1195
SWD_17	52.362	6987	0.996	6.231	26.123	19.234	9.123	14.0	17.263	<0.001	<0.001	623	11345	2145	1245

Sample Point ID.	Ni ASTM D1886 mg/kg	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cu ASTM D1688 mg/kg	Cr ASTM D1687 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	Ba ASTM D4382 mg/kg	Co ASTM D3558 mg/kg	Ag ASTM D3223 mg/kg	V ASTM D3373 mg/kg	K ASTM D4192 mg/kg	Na ASTM D4194 mg/kg	Mg ASTM D4194 mg/kg	Ca ASTM D4192 mg/kg
SWD_18	21.578	5943	<0.001	5.774	21.130	18.275	<0.001	9.0	18.452	<0.001	<0.001	695	11385	2826	1188
SWD_19	35.623	6897	3.725	4.128	16.234	12.018	3.265	11.0	13.258	<0.001	<0.001	546	11235	2456	1234
SWD_20	28.456	7123	4.183	6.238	14.234	22.123	6.125	9.0	14.265	<0.001	<0.001	568	11125	2315	1245
SWD_21	28.456	6987	3.952	5.128	12.423	21.324	5.324	12.0	16.321	<0.001	<0.001	562	11223	2145	1452
SWD_22	36.780	7012	4.012	7.235	10.234	20.128	7.238	13.0	14.785	<0.001	<0.001	532	11325	2114	1246
SWD_23	40.280	6897	3.963	6.234	9.123	16.897	4.235	11.0	18.029	<0.001	<0.001	546	11256	2104	1325
SWD_24	23.123	6789	4.218	6.123	5.123	18.124	6.128	9.0	15.214	<0.001	<0.001	543	11456	2135	1125
SWD_25	36.235	6789	3.736	7.124	4.286	14.234	2.18	6.0	16.321	<0.001	<0.001	542	11235	2314	1452
SWD_26	18.012	5591	3.657	4.639	7.620	47.491	0.690	11.0	12.348	<0.001	<0.001	579	11524	2825	1182
SWD_27	17.084	5774	5.342	9.869	6.183	46.427	2.160	15.0	15.214	<0.001	<0.001	614	11814	2893	1192
SWD_28	80.857	5527	<0.001	12.643	30.321	28.470	10.619	9.0	13.695	<0.001	<0.001	572	11079	2928	1201
SWD_29	103.171	4194	4.999	6.356	0.209	44.656	8.401	6.0	15.247	<0.001	<0.001	692	11152	2006	1211
SWD_30	74.235	5689	3.928	7.235	10.234	32.012	13.258	8.0	14.026	<0.001	<0.001	653	11235	1986	1256
SWD_31	65.123	6897	4.251	7.238	11.246	25.236	10.234	11.0	15.030	<0.001	<0.001	589	11325	2013	1253
SWD_32	129	7483	4.539	10.105	36.796	28.565	0.238	16.0	14.289	<0.001	<0.001	665	11489	2074	1202
SWD_33	58.235	6958	3.692	9.234	29.234	27.234	11.234	13.0	15.024	<0.001	<0.001	525	11356	2245	1125
SWD_34	77.361	7397	5.135	8.166	68.615	43.993	4.559	11.0	17.023	<0.001	<0.001	640	11725	2885	1217
SWD_35	125	7026	<0.001	16.133	64.355	39.587	5.084	14.0	13.078	<0.001	<0.001	664	11982	2935	1220
SWD_36	63.890	5689	4.607	10.240	24.373	23.045	4.789	5.0	15.486	<0.001	<0.001	589	11458	2456	1124
SWD_37	45.360	4563	3.531	12.234	22.124	20.145	6.234	9.0	13.547	<0.001	<0.001	586	12560	2345	1135

Sample Point ID.	Ni ASTM D1886 mg/kg	Fe ASTM D1068 mg/kg	Pb ASTM D3559 mg/kg	Cu ASTM D1688 mg/kg	Cr ASTM D1687 mg/kg	Zn ASTM D1691 mg/kg	Cd ASTM D3557 mg/kg	Ba ASTM D4382 mg/kg	Co ASTM D3558 mg/kg	Ag ASTM D3223 mg/kg	V ASTM D3373 mg/kg	K ASTM D4192 mg/kg	Na ASTM D4194 mg/kg	Mg ASTM D4194 mg/kg	Ca ASTM D4192 mg/kg
SWD_38	74.230	6589	4.820	11.248	19.238	21.234	4.237	11.0	16.321	<0.001	<0.001	658	11245	2412	1325
SWD_39	27.009	6764	3.697	9.154	18.233	47.471	9.866	16.0	15.231	<0.001	<0.001	716	12057	2790	1210
SWD_40	56.89	7112	3.584	8.235	20.351	30.124	6.012	11.0	16.315	<0.001	<0.001	548	11205	2245	1145
SWD_41	65.32	6897	4.227	6.238	24.123	24.212	5.126	13.0	14.265	<0.001	<0.001	612	11325	2345	1224
SWD_42	45.231	5689	4.328	7.231	28.395	21.328	10.234	10.0	15.214	<0.001	<0.001	548	11421	2245	1325
SWD_43	21.53	6789	4.215	6.389	26.348	26.235	9.234	9.0	14.096	<0.001	<0.001	646	12388	2821	1238
SWD_44	66.002	6876	3.957	13.375	35.346	37.269	0.925	10.0	18.954	<0.001	<0.001	674	12334	2767	1236
SWD_45	43.561	5789	4.824	10.235	26.235	30.125	3.245	12.0	16.998	<0.001	<0.001	586	11325	2345	1325
SWD_46	45.789	6589	5.113	6.238	20.124	23.124	6.234	9.0	13.258	<0.001	<0.001	542	11452	2124	1245
SWD_47	41.235	5687	3.967	5.356	18.237	20.147	8.127	11.0	15.477	<0.001	<0.001	543	11215	2451	1236
SWD_48	29.458	5678	3.852	6.328	17.659	19.238	10.235	10.0	15.684	<0.001	<0.001	562	11235	2145	1526
CONTRL 1	24.931	6728	24.148	0.403	<0.001	8.974	2.191	13.0	19.456	<0.001	<0.001	640.7	10379	2653.9	609
CONTRL 2	29.655	7167	20.732	1.848	<0.001	24.511	<0.001	11.0	20.123	<0.001	<0.001	626.6	10345	2668.4	614
CONTRL 3	20.055	7342	25.406	1.337	<0.001	15.167	<0.001	17.0	16.123	<0.001	<0.001	680.2	10856	2751.2	621

Microbiology Result (Sediment)

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
ASWD 1	NIL	NIL	$2.01X10^{2}$	$1.51X10^{1}$	NA
ASWD 2	NIL	NIL	$2.22X10^{2}$	$9.20X10^{1}$	NA
ASWD 3	NIL	NIL	$2.31X10^{2}$	$8.10X10^{1}$	NA
ASWD 4	NIL	NIL	$2.09X10^{2}$	$9.20X10^{1}$	NA
ASWD 5	NIL	NIL	$2.14X10^{2}$	$9.10X10^{1}$	NA

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
ASWD 6	NIL	NIL	$1.92X10^2$	$1.12X10^1$	NA
ASWD 7	NIL	NIL	$2.01X10^2$	$7.20X10^1$	NA
ASWD 8	NIL	NIL	$2.21X10^2$	$1.16X10^1$	NA
ASWD 9	NIL	NIL	$2.35X10^2$	$1.09X10^1$	NA
ASWD 10	NIL	NIL	$1.86X10^2$	$8.20X10^1$	NA
ASWD 11	NIL	NIL	$2.02X10^2$	$9.10X10^1$	NA
ASWD 12	NIL	NIL	$1.98X10^2$	$8.20X10^1$	NA
ASWD 13	NIL	NIL	$1.79X10^2$	$9.10X10^1$	NA
ASWD 14	NIL	NIL	$2.07X10^2$	$1.11X10^1$	NA
ASWD 15	NIL	NIL	$2.32X10^2$	$9.30X10^1$	NA
ASWD 16	NIL	NIL	$1.97X10^2$	$8.10X10^1$	NA
ASWD 17	NIL	NIL	$2.01X10^2$	$1.07X10^1$	NA
ASWD 18	NIL	NIL	$1.98X10^2$	$9.50X10^1$	NA
ASWD 19	NIL	NIL	$2.02X10^2$	$1.12X10^1$	NA
ASWD 20	NIL	NIL	$2.18X10^2$	$9.70X10^1$	NA
ASWD 21	NIL	NIL	$1.96X10^2$	$8.10X10^1$	NA
ASWD 22	NIL	NIL	$1.32X10^2$	$7.70X10^1$	NA
ASWD 23	NIL	NIL	$9.20X10^1$	$5.80X10^1$	NA
ASWD 24	NIL	NIL	$1.12X10^2$	$6.20X10^1$	NA
SD_1	NIL	NIL	$2.17X10^2$	$8.10X10^1$	NA
SD_2	NIL	NIL	$2.30X10^2$	$7.30X10^1$	NA
SD_3	NIL	NIL	$2.11X10^2$	$6.20X10^1$	NA
SD_4	NIL	NIL	$2.09X10^2$	$7.10X10^1$	NA
SD_5	NIL	NIL	$1.87X10^2$	$5.90X10^1$	NA
SD_6	NIL	NIL	$2.16X10^2$	$8.30X10^1$	NA
SD_7	NIL	NIL	$1.66X10^2$	$4.70X10^1$	NA
SD_8	NIL	NIL	$2.01X10^2$	$6.20X10^1$	NA
SD_9	NIL	NIL	$1.31X10^2$	$4.60X10^1$	NA
SD_10	NIL	NIL	$2.19X10^2$	$7.70X10^1$	NA
SD_11	NIL	NIL	$2.31X10^2$	$8.90X10^1$	NA
SD_12	NIL	NIL	$2.19X10^2$	$7.20X10^1$	NA
SD_13	NIL	NIL	2.32X10	$9.90X10^1$	NA
SD_14	NIL	NIL	$2.11X10^2$	$7.80X10^1$	NA
SD_15	NIL	NIL	$2.34X10^2$	$1.03X10^1$	NA
SD_16	NIL	NIL	$2.26X10^2$	$6.30X10^1$	NA
SD_17	NIL	NIL	$2.32X10^2$	$1.21X10^2$	NA
SD_18	NIL	NIL	$2.37X10^2$	$8.10X10^2$	NA
SD_19	NIL	NIL	$2.12X10^2$	$8.20X10^1$	NA
SD_20	NIL	NIL	$2.21X10^2$	$9.40X10^1$	NA
SD_21	NIL	NIL	$1.92X10^2$	$8.40X10^1$	NA

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
SD_22	NIL	NIL	$2.13X10^2$	$1.11X10^2$	NA
SD_23	NIL	NIL	$2.17X10^2$	$8.60X10^1$	NA
SD_24	NIL	NIL	$2.17X10^2$	$9.30X10^1$	NA
SWD_1	NIL	NIL	$1.96X10^2$	$6.20X10^1$	NA
SWD_2	NIL	NIL	$2.13X10^2$	$9.10X10^1$	NA
SWD_3	NIL	NIL	$1.83X10^2$	$8.20X10^1$	NA
SWD_4	NIL	NIL	$2.16X10^2$	$5.40X10^1$	NA
SWD_5	NIL	NIL	$1.94X10^2$	$7.10X10^1$	NA
SWD_6	NIL	NIL	$2.18X10^2$	$6.60X10^1$	NA
SWD_7	NIL	$0.20X10^1$	$2.10X10^2$	$7.00X10^1$	NA
SWD_8	NIL	NIL	$2.13X10^2$	$9.10X10^1$	NA
SWD_9	NIL	NIL	$1.83X10^2$	$8.20X10^1$	NA
SWD_10	NIL	NIL	$2.12X10^2$	$8.20X10^1$	NA
SWD_11	NIL	NIL	$2.32X10^2$	$9.30X10^1$	NA
SWD_12	NIL	NIL	$2.18X10^2$	$6.60X10^1$	NA
SWD_13	NIL	NIL	$1.94X10^2$	$7.10X10^1$	NA
SWD_14	NIL	$0.10X10^1$	$2.10X10^2$	$9.20X10^1$	NA
SWD_15	NIL	NIL	$1.86X10^2$	$8.20X10^1$	NA
SWD_16	NIL	NIL	$2.15X10^2$	$8.70X10^1$	NA
SWD_17	NIL	NIL	$2.17X10^2$	$1.21X10^1$	NA
SWD_18	NIL	$0.20X10^1$	$2.36X10^2$	$9.10X10^1$	NA
SWD_19	NIL	NIL	$2.49X10^2$	$8.50X10^1$	NA
SWD_20	NIL	$0.40X10^1$	$2.28X10^2$	$1.02X10^1$	NA
SWD_21	NIL	$0.20X10^1$	$2.19X10^2$	$9.30X10^1$	NA
SWD_22	NIL	NIL	$2.21X10^2$	$7.80X10^1$	NA
SWD_23	NIL	$0.10X10^1$	$2.17X10^2$	$9.80X10^1$	NA
SWD_24	NIL	$0.10X10^1$	$2.41X10^2$	$1.14X10^2$	NA
SWD_25	NIL	NIL	$2.33X10^2$	$8.30X10^1$	NA
SWD_26	NIL	NIL	$2.32X10^2$	$8.00X10^1$	NA
SWD_27	NIL	NIL	$2.21X10^2$	$8.70X10^1$	NA
SWD_28	NIL	NIL	$2.31X10^2$	$1.12X10^2$	NA
SWD_29	NIL	NIL	$2.28X10^2$	$9.30X10^2$	NA
SWD_30	NIL	NIL	$2.11X10^2$	$8.10X10^1$	NA
SWD_31	NIL	$0.30X10^1$	$2.42X10^2$	$1.21X10^1$	NA
SWD_32	NIL	$0.10X10^1$	$2.01X10^2$	$9.30X10^1$	NA
SWD_33	NIL	NIL	$2.21X10^2$	$8.80X10^1$	NA
SWD_34	NIL	NIL	$2.21X10^2$	$9.60X10^1$	NA
SWD_35	NIL	NIL	$2.13X10^2$	$5.10X10^1$	NA
SWD_36	NIL	NIL	$2.11X10^2$	$7.30X10^1$	NA
SWD_37	NIL	NIL	$2.32X10^2$	$6.80X10^1$	NA

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
SWD_38	NIL	NIL	$1.94X10^2$	$7.10X10^1$	NA
SWD_39	NIL	NIL	$2.09X10^2$	$1.02X10^2$	NA
SWD_40	NIL	NIL	$2.11X10^1$	$8.30X10^1$	NA
SWD_41	NIL	NIL	$2.06X10^2$	$8.00X10^1$	NA
SWD_42	NIL	NIL	$2.31X10^2$	$7.20X10^1$	NA
SWD_43	NIL	NIL	$2.33X10^2$	$8.30X10^1$	NA
SWD_44	NIL	NIL	$2.24X10^2$	$8.40X10^1$	NA
SWD_45	NIL	NIL	$2.17X10^2$	6.20X10	NA
SWD_46	NIL	NIL	$2.32X10^2$	$6.80X10^1$	NA
SWD_47	NIL	NIL	$2.10X10^2$	9.20X10	NA
SWD_48	NIL	NIL	$2.02X10^2$	8.10X10	NA
CONTRL 1	NIL	NIL	$2.14X10^2$	$8.10X10^1$	NA
CONTRL 2	NIL	NIL	$2.28X10^2$	$9.20X10^1$	NA
CONTRL 3	NIL	NIL	$2.18X10^2$	$6.10X10^1$	NA

METEOROLOGICAL/GASEOUS EMISSION FIELD MEASUREMENT DATA SHEET

Station: SPDC JK FIELD	Date: 03/12/18	Project: EIA, EES STUDY	Facility: SPDC

In-situ Measurements

Field Air Quality Measurements:

S/N	Parameter	Unit	DPR Limits (1hr)	ASW 6 03/12/18	ASW 5 03/12/18	ASW 7 03/12/18	ASW 8 03/12/18	ASW 16 03/12/18	ASW 15 03/12/18
1	SO_X	µg/m^3	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NO_X	µg/m^3	400	9.9	<1.42	2.8	<1.42	2.8	2.8
3	COx	µg/m^3	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H_2S	µg/m^3		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	C_XH_Y	ppm		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6	Smoke Density	Ringlemann	2.0	N/A	N/A	N/A	N/A	N/A	N/A
7	Wind Direction	N/A	N/A	N	NE	NE	N	NE	N
8	Wind Speed	m/s	N/A	0.9	0.3	1.2	1.7	3.7	2.4
9	Amb. Temperature	^{O}C	N/A	30.7	33.8	35.1	35.7	33.6	32.6
10	Relative Humidity	%	N/A	70.1	64.3	60.8	59.2	60.7	69.2
11	Atm. Pressure	Pa	N/A	1008	1007	1005	1004	1003	1003
12	Noise Level	dBA	80-100	74.3	75.1	74.9	75.5	77.9	76.1
13	SPM_{10}	µg/m^3	60-90	19	21	24	26	48	50

Station: SPDC JK FIELD				Date: 04/12/18 – 05/12/18		Project: EIA, EES STUDY		Facility: SPDC	
In-situ Measurements Field Air Quality Measurements:									
S/N	**Parameter**	**Unit**	**DPR Limits (1hr)**	**ASW 17 04/12/18**	**ASW 18 04/12/18**	**ASW 19 04/12/18**	**ASW 10 04/12/18**	**ASW 4 05/12/18**	**ASW 3 05/12/18**
1	SO_X	µg/m^3	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NO_X	µg/m^3	400	5.7	2.8	2.8	2.8	5.7	5.7
3	COx	µg/m^3	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H_2S	µg/m^3		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	C_XH_Y	ppm		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6	Smoke Density	Ringlemann	2.0	N/A	N/A	N/A	N/A	N/A	N/A
7	Wind Direction	N/A	N/A	NE	NE	N	N	NE	NE
8	Wind Speed	m/s	N/A	0.6	1.0	1.8	1.6	1.2	1.4
9	Amb. Temperature	^{O}C	N/A	31.3	33.9	31.9	32.6	27.2	29.7
10	Relative Humidity	%	N/A	76.5	72.4	71.1	70.2	84.4	78.9
11	Atm. Pressure	Pa	N/A	1006	1006	1003	1003	1006	1006
12	Noise Level	dBA	80-100	77.5	78.4	76.4	76.6	74.9	76.7
13	SPM_{10}	µg/m^3	60-90	23	38	40	36	46	50

				Date: 05/12/18 – 06/12/18		Project: EIA, EES STUDY		Facility: SPDC	
In-situ Measurements Field Air Quality Measurements:									
S/N	**Parameter**	**Unit**	**DPR Limits (1hr)**	**ASW 2 05/12/18**	**ASW 1 05/12/18**	**ASW 20 05/12/18**	**ASW 19 05/12/18**	**ASW 11 06/12/18**	**ASW 12 06/12/18**
1	SO_X	µg/m^3	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NO_X	µg/m^3	400	4.3	2.8	2.8	1.42	8.52	4.30
3	COx	µg/m^3	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H_2S	µg/m^3		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	C_XH_Y	ppm		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6	Smoke Density	Ringlemann	2.0	N/A	N/A	N/A	N/A	N/A	N/A
7	Wind Direction	N/A	N/A	N	N	NW	NW	NE	NE
8	Wind Speed	m/s	N/A	0.7	0.8	1.7	3.1	1.4	3.3
9	Amb. Temperature	^{O}C	N/A	35.0	35.3	33.9	31.8	30.1	31.3
10	Relative Humidity	%	N/A	58.7	58.5	68.5	70.3	80.9	73.8
11	Atm. Pressure	Pa	N/A	1006	1006	1003	1003	1007	1007
12	Noise Level	dBA	80-100	75.9	77.5	76.4	76.2	75.9	75.2
13	SPM_{10}	µg/m^3	60-90	23.	24	22	39	29	24

Station: SPDC JK FIELD	**Date: 06/12/18 – 07/12/18**	**Project: EIA, EES STUDY**	**Facility: SPDC**

In-situ Measurements Field Air Quality Measurements:

S/N	**Parameter**	**Unit**	**DPR Limits (1hr)**	**10.0) ASW 22 11.0) 06/12/18**	**12.0) ASW 21 13.0) 06/12/18**	**14.0) ASW 14 15.0) 06/12/18**	**16.0) ASW 13 17.0) 06/12/18**	**18.0) ASW 24 19.0) 07/12/18**	**20.0) ASW 23 21.0) 07/12/18**
1	SO_X	µg/m^3	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NO_X	µg/m^3	400	1.42	2.80	2.80	2.80	7.10	4.30
3	COx	µg/m^3	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H_2S	µg/m^3		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	C_XH_Y	ppm		<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
6	Smoke Density	Ringlemann	2.0	N/A	N/A	N/A	N/A	N/A	N/A
7	Wind Direction	N/A	N/A	NE	NE	SW	SW	NW	NW
8	Wind Speed	m/s	N/A	3.1	2.8	0.9	1.4	2.3	1.7
9	Amb. Temperature	^OC	N/A	34.1	34.8	34.0	34.7	29.1	31.1
10	Relative Humidity	%	N/A	66.9	60.9	62.3	60.4	82.7	80.5
11	Atm. Pressure	Pa	N/A	1007	1006	1004	1004	1008	1008
12	Noise Level	dBA	80-100	74.9	74.8	75.1	76.3	75.3	75.9
13	SPM_{10}	µg/m^3	60-90	27	30	22	22	28	28

Station: SPDC JK FIELD	**Date: 27/11/18**	**Project: EIA, EES STUDY**	**Facility: SPDC**

In-situ Measurements Field Air Quality Measurements:

S/N	**Parameter**	**Unit**	**DPR Limits (1hr)**	**22.0) CTL 1 23.0) 27/11/18**	**24.0) CTL 2 25.0) 29/11/18**	**26.0) CTL 3 27.0) 07/12/18**
1	SO_X	µg/m^3	350	<19.9	<19.9	<19.9
2	NO_X	µg/m^3	400	<1.42	<1.42	<1.42
3	COx	µg/m^3	30	<8.7	<8.7	<8.7
4	H_2S	µg/m^3		<1.1	<1.1	<1.1
5	C_XH_Y	ppm		<1.0	<1.0	<1.0
6	Smoke Density	Ringlemann	2.0	N/A	N/A	N/A
7	Wind Direction	N/A	N/A	SW	SW	SW
8	Wind Speed	m/s	N/A	3.0	0.8	2.5
9	Amb. Temperature	^OC	N/A	30.5	32.6	32.0
10	Relative Humidity	%	N/A	75.3	68.3	69.5
11	Atm. Pressure	Pa	N/A	1005	1007	1008
12	Noise Level	dBA	80-100	77.9	73.4	75.3
13	SPM_{10}	µg/m^3	60-90	32.0	32.0	30.0

Appendix 4

Hydrobiology and Fisheries

Checklist of Benthic fauna in the OML 77 and 74 field

	Gastrpoda												Bivalvia							
	Bela atlantidae	***Conus marmoreus***	***Eucithara dubiosa***	***Eucithara abbreviata***	***Eucithara amabilis***	***Glyphoturris rugirima***	***Heterocithara sp.***	***Stigmaulax elenae***	***Ophrodermella inermis***	***Ptychosyrinx chilensis***	***Vokesimurex elenensis***	**Sum total**	***Mercenaria mercenaria***	***Mya arenaria***	***Cerastoderma glaucum***	***Chlamys opercularis***	***Aequipectan opercularis***	**Sum total**	**TOTAL**	**Total Number of**
1	0	0	0	0	0	0	1	0	0	4	1	6	10	7	5	0	2	24	30	8
2	0	0	0	0	0	0	1	1	0	0	0	2	15	22	4	0	0	41	43	5
3	2	0	0	0	0	2	1	0	0	0	0	3	7	0	0	0	3	10	13	5
4	0	0	0	0	0	1	0	1	0	0	0	2	2	0	0	0	1	3	5	4
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	12	1	2	0	1	14	14	2
7	0	2	0	0	0	0	0	0	0	0	0	2	14	9	0	0	0	23	25	3
8	0	0	0	0	1	0	2	0	0	0	0	3	4	14	0	0	0	18	21	4
9	0	0	0	0	1	0	0	0	0	0	0	1	37	1	0	0	2	40	41	4
10	0	0	0	0	0	0	0	0	0	0	0	0	19	0	7	0	7	33	33	3
11	0	2	0	2	0	0	0	0	0	0	0	2	6	10	11	0	2	29	31	7
12	0	0	0	0	0	0	0	0	0	0	1	1	15	0	2	0	9	26	27	5
13	0	1	0	0	1	0	0	1	0	0	2	5	27	0	0	0	11	38	43	7
14	0	12	0	0	0	1	0	0	0	4	0	1	2	13	6	0	0	21	22	7
15	0	0	0	0	2	3	0	0	0	0	0	5	13	0	0	0	6	19	24	5
16	0	0	0	0	0	0	0	0	0	0	0	0	6	2	0	0	0	8	8	2
17	0	0	0	0	0	0	0	0	0	0	0	0	0	6	0	0	0	6	6	1
18	0	0	0	0	0	0	0	0	0	0	0	0	16	0	0	0	0	16	16	1
19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	24	24	1

	Gastrpoda												Bivalvia							
	Bela atlantidae	*Conus marmoreus*	*Eucithara dubiosa*	*Eucithara abbreviata*	*Eucithara amabilis*	*Glyphoturris rugirima*	*Heterocithara sp.*	*Stigmaulax elenae*	*Ophrodermella inermis*	*Ptychosyrinx chilensis*	*Vokesimurex elenensis*	Sum total	*Mercenaria mercenaria*	*Mya arenaria*	*Cerastoderma glaucum*	*Chlamys opercularis*	*Aequipectan opercularis*	Sum total	TOTAL	Total Number of
20	0	0	0	0	0	0	**1**	0	0	0	0	**1**	**1**	**8**	0	0	0	9	10	3
21	0	0	0	0	0	0	0	0	0	0	0	**0**	**1**	0	1	0	0	2	2	2
22	0	0	0	0	0	0	0	0	0	0	0	0	0	**13**	0	0	0	13	13	13
23	0	0	0	0	0	0	0	0	0	0	0	**0**	**1**	**33**	**1**	0	0	35	35	3
24	0	0	0	0	0	0	**4**	0	0	0	0	**4**	**6**	**11**	**6**	0	**1**	**24**	**28**	**5**
25	0	**2**	0	0	0	0	0	0	0	**1**	0	**3**	**3**	**27**	**3**	0	**3**	**36**	**39**	**6**
26	0	**2**	0	0	0	0	0	0	0	0	**1**	**3**	**21**	**11**	**1**	0	0	33	36	5
27	**1**	**1**	0	0	0	0	0	0	0	**1**	**1**	**4**	**8**	0	**8**	0	**4**	**20**	**24**	**7**
28	0	0	0	0	0	0	0	0	0	0	0	**0**	**23**	**4**	**1**	0	**11**	**41**	**41**	**4**
29	0	0	0	0	0	0	**2**	0	0	0	0	**2**	**27**	0	0	0	**2**	**29**	**31**	**3**
30	0	**1**	0	0	0	0	0	0	0	0	0	**1**	**2**	0	0	0	0	2	3	2
31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	0	0	0	0	0	0	0	0	0	0	0	**0**	**4**	**2**	0	0	0	6	6	2
33	0	0	0	0	0	0	**1**	0	0	0	0	**1**	**20**	0	0	0	0	20	21	2
34	0	0	0	0	0	0	0	0	0	0	0	0	0	**18**	5	0	0	23	23	2
35	0	0	0	0	0	0	0	0	0	0	0	**0**	**11**	0	0	0	0	11	11	1
36	0	0	0	0	0	0	0	0	0	0	0	**0**	**29**	0	0	0	0	29	29	1
37	0	0	0	0	0	0	0	0	0	0	0	**0**	**10**	0	0	0	0	10	10	1
38	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
39	0	0	0	0	0	0	0	0	0	0	0	**0**	**16**	0	0	0	0	16	16	1
40	0	0	0	0	0	0	**1**	0	0	0	0	1	0	0	0	0	**6**	**6**	**6**	**3**
41	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
42	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**	2	0	0	4	4	2

	Gastrpoda												Bivalvia							
	Bela atlantidae	*Conus marmoreus*	*Eucithara dubiosa*	*Eucithara abbreviata*	*Eucithara amabilis*	*Glyphoturris rugirima*	*Heterocithara sp.*	*Stigmaulax elenae*	*Ophrodermella inermis*	*Ptychosyrinx chilensis*	*Vokesimurex elenensis*	Sum total	*Mercenaria mercenaria*	*Mya arenaria*	*Cerastoderma glaucum*	*Chlamys opercularis*	*Aequipectan opercularis*	Sum total	TOTAL	Total Number of
*43**	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
44	0	0	0	0	0	0	0	0	0	0	0	0	16	3	7	0	5	31	31	4
45	0	0	0	0	3	0	0	0	0	0	0	3	5	0	0	0	4	9	12	4
46	0	0	0	0	0	0	0	0	0	0	0	0	42	0	4	0	0	46	46	2
47	0	0	0	0	0	0	0	0	0	0	0	0	14	0	2	0	7	23	23	3
48	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
49	0	0	0	0	0	0	0	0	0	0	0	0	0	34	0	0	0	34	34	1
50	0	0	0	0	0	0	0	0	0	0	2	2	0	0	3	0	0	3	5	2
51	0	0	0	0	0	0	0	0	0	0	0	0	6	2	12	0	1	21	21	4
52	0	0	0	0	0	0	0	0	0	0	1	1	8	4	13	0	10	35	36	5
53	0	0	0	0	0	2	0	0	0	0	1	3	11	24	0	1	3	39	42	6
54	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
55	0	0	0	0	0	3	0	0	0	0	0	3	4	9	7	0	3	23	26	5
56	0	0	0	0	0	0	1	0	0	0	0	1	23	0	0	0	5	28	29	3
57	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	1	1
58	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	1	11	11	2
59	0	0	0	0	0	0	0	0	0	0	0	0	15	0	1	0	0	16	16	2
60	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
61	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
62	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
63	4	1	0	0	0	1	0	0	1	0	2	9	11	6	18	1	4	40	49	10
Ctrl 1	6	2	0	0	0	0	0	0	0	0	0	8	7	3	9	1	6	26	34	7
Ctrl 2	4	2	1	0	0	0	1	0	2	1	0	11	6	12	5	0	4	27	38	9

	Gastrpoda												Bivalvia							
	Bela atlantidae	***Conus marmoreus***	***Eucithara dubiosa***	***Eucithara abbreviata***	***Eucithara amabilis***	***Glyphoturris rugirima***	***Heterocithara sp.***	***Stigmaulax elenae***	***Ophrodermella inermis***	***Ptychosyrinx chilensis***	***Vokesimurex elenensis***	**Sum total**	***Mercenaria mercenaria***	***Mya arenaria***	***Cerastoderma glaucum***	***Chlamys opercularis***	***Aequipectan opercularis***	**Sum total**	**TOTAL**	**Total Number of**
Ctrl 3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1	1
Total	17	26	1	2	8	13	17	3	3	11	12	95	590	311	146	3	125	1175	1270	213
% Total	1.33	2.05	0.08	0.16	0.63	1.02	1.34	0.24	0.24	0.87	0.94	7.48	46.46	24.49	11.50	0.24	9.84	92.52	100	

Composition of the Phytoplankton Species in the Control and Sample Stations of OML 77 & & 74 Fields.

	Bacillariophyceae																		Dinophyceae									Fragilariophyceae	Haptophyceae	Dictyochophyceae		
	Ditylum sp.	***Entomoneis sp.***	***Fragilariopsis sp.***	***Leptocylindrus sp.***	***Licmophora sp.***	***Melosira sp.***	***Navicula sp***	***Nitzschia sp***	***Chaetoceros spp***	***Coscinodiscus sp.***	***Rhizosolenia sp.***	***Skeletonema sp.***	***Stephanopyxis sp.***	***Pleurosigma sp***	***Pseudo-nitzschia sp.***	***Thalassionema sp.***	***Thalassiosira sp.***	***Sub Total***	***Alexandrium sp.***	***Dinophysis sp.***	***Ceratium furca***	***Ceratium fusus***	***Tripos longipes***	***Noctiluca scintillans***	***Protoperidinium sp.***	***Scrippsiella sp.***	***Sub Total***	***Asterionella sp.***	***Coccolithophora sp***	***Dictyocha sp.***	***TOTAL***	***Total Number of***
1	8	0	0	7	0	0	0	0	8	0	6	0	0	3	0	0	0	32	0	0	0	6	0	0	4	4	14	0	10	0	56	9
2	0	0	0	8	0	0	0	0	0	0	12	0	0	5	0	0	0	25	0	0	0	7	7	0	4	4	22	0	13	0	60	8
3	0	0	0	0	0	0	0	0	0	0	10	0	0	4	6	0	0	20	0	0	4	8	5	5	6	6	34	3	8	0	65	11
4	0	0	0	0	0	0	0	0	4	0	0	11	0	0	4	0	0	19	0	4	6	0	11	0	7	7	35	7	0	0	61	9
5	0	0	11	0	0	0	0	0	2	4	0	10	0	0	1	0	0	28	0	4	4	0	0	2	8	8	26	3	0	0	57	11
6	0	0	10	0	0	0	0	0	4	4	0	13	0	0	0	0	0	31	6	6	0	0	0	0	0	0	12	0	0	0	43	4
7	0	0	13	0	0	0	0	0	4	6	0	8	0	0	0	0	0	31	9	7	0	0	0	0	0	0	16	4	0	0	51	6
8	0	0	8	0	0	0	0	4	6	7	0	0	4	2	0	0	0	31	10	8	0	0	0	0	4	0	22	8	0	0	61	10
9	0	0	0	0	0	0	0	0	7	8	4	0	4	0	0	0	0	23	4	0	0	0	10	0	2	0	16	0	0	0	39	7

10	0	4	0	0	0	0	0	0	0	0	4	0	6	5	0	0	0	19	8	0	0	4	6	6	4	0	28	6	4	0	57	11
11	0	2	0	0	0	0	0	0	0	0	6	0	7	0	0	0	0	15	0	0	0	6	0	0	4	0	10	5	4	0	34	6
12	0	4	0	0	0	0	0	0	0	0	7	0	8	0	0	0	0	19	0	0	6	8	9	0	6	0	29	2	6	0	56	9
13	0	4	0	0	0	0	0	0	0	6	8	0	0	7	0	0	0	25	0	0	1	4	0	5	7	0	17	2	7	0	51	10
14	0	6	0	0	0	0	0	0	0	5	0	4	0	0	0	0	4	19	0	0	3	0	0	4	0	0	7	0	8	0	34	7
15	0	0	0	0	0	0	0	0	0	2	0	4	0	0	0	0	2	8	0	0	4	0	0	0	0	0	4	4	0	0	16	5
16	0	0	0	0	0	0	0	0	0	2	0	6	0	7	0	0	4	19	3	0	6	0	3	5	0	0	17	0	0	0	36	8
17	0	0	0	0	0	0	0	0	5	0	6	7	0	0	4	0	4	26	2	0	6	8	0	0	0	0	16	1	0	0	43	9
18	0	8	3	0	0	0	0	3	6	3	5	8	0	8	6	0	6	56	5	0	2	0	5	7	0	0	19	8	5	0	88	16
19	5	5	2	0	0	9	5	1	5	0	2	0	0	7	5	0	0	46	3	2	5	0	3	5	0	0	18	2	4	8	78	18
20	0	7	0	9	6	8	5	8	3	9	2	0	0	0	0	0	0	57	5	0	5	8	5	0	0	0	23	10	0	3	93	15
21	0	0	4	5	4	6	0	0	11	10	0	0	0	0	0	0	0	40	0	0	5	4	6	0	5	0	20	4	6	0	70	12
22	0	0	6	8	3	12	0	0	13	5	3	5	0	0	0	0	8	63	13	0	8	3	12	0	6	0	42	7	0	0	112	15
23	0	0	8	0	11	10	0	0	6	7	0	4	2	0	0	8	5	61	5	0	0	0	10	0	5	5	25	8	0	0	94	14
24	0	0	0	0	0	0	0	0	0	9	9	0	0	0	0	3	7	28	7	0	0	5	0	0	3	0	15	2	0	0	45	8
25	3	13	0	0	4	5	4	6	0	13	10	6	0	0	0	0	0	64	5	8	0	7	0	0	11	0	31	0	5	12	112	15
26	0	0	0	0	7	8	3	8	5	8	5	0	0	0	0	0	0	44	2	8	0	0	8	0	13	0	31	0	3	5	83	13
27	0	0	0	0	8	0	7	4	0	3	7	0	0	0	0	0	0	29	0	0	0	1	5	0	6	0	12	3	0	0	44	9
28	0	0	0	0	0	0	0	0	0	8	9	0	0	0	0	0	0	17	5	0	8	0	0	0	0	0	13	0	0	0	30	4

29	0	0	0	0	0	0	0	0	0	6	13	5	8	0	0	12	13	57	8	0	3	0	9	0	0	3	23	6	0	0	86	9
30	0	0	0	0	0	0	0	0	0	9	8	3	8	0	0	5	0	33	0	0	8	0	3	0	5	0	16	0	0	0	49	8
31	0	0	0	0	0	0	3	0	0	6	3	0	0	0	0	0	0	12	0	0	0	4	6	0	0	0	10	2	0	0	24	5
32	3	0	0	0	0	0	8	0	0	0	8	0	0	0	0	0	0	19	5	0	0	0	5	0	0	0	10	0	0	0	29	5
33	2	0	0	0	0	0	6	0	0	0	6	0	0	0	0	0	0	14	0	0	0	4	0	0	0	0	4	5	0	0	23	6
34	5	0	0	0	0	0	6	0	0	0	9	0	0	0	0	0	0	20	3	0	0	0	7	0	0	0	10	0	0	0	30	5
35	0	0	0	0	0	0	9	0	0	0	6	0	0	0	0	0	0	15	2	0	0	2	4	0	0	0	8	4	0	0	27	6
36	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	1	0	5	0	7	0	0	3	16	6	0	0	29	6
37	4	5	3	0	0	0	0	0	0	3	0	0	0	0	0	0	0	15	0	0	4	1	0	0	0	2	7	0	5	0	27	8
CT1	0	0	6	0	0	0	0	0	0	8	0	0	0	0	0	0	0	14	3	5	8	0	0	3	0	5	24	0	0	0	38	6
CT2	0	3	4	0	0	0	0	0	0	6	0	0	0	5	0	0	0	18	0	0	0	1	0	2	0	0	3	9	3	0	33	7
CT3	0	2	1	0	0	0	0	0	0	7	0	0	0	2	0	0	0	12	4	3	0	0	0	1	0	7	15	8	2	0	37	10
TOTAL	37	63	79	37	43	58	56	34	89	164	168	94	47	55	26	28	53	1131	118	55	101	91	146	45	110	54	720	129	93	28	2101	360
% TOTAL	1.76	3.00	3.76	1.76	2.05	2.76	2.67	1.62	4.24	7.81	8.00	4.47	2.24	2.62	1.24	1.33	2.52	53.83	5.62	2.62	4.81	4.33	6.95	2.14	5.24	2.57	34.27	6.14	4.43	1.33	100	

Composition of the Zooplankton Species in the Control and Sample Stations of OML 77 & & 74 Fields.

	Hexanauplia													Oligotrichea				Malacostraca			Polychaeta	Stenolaemata	Branchiopoda	Calanoida		
	Aegisthus mucronatus	*Acartia tonsa*	*Acrocalanus longicornis*	*Elminius modestus (nauplius)*	*Bestiolina arabica.*	*Semibalanus balanoides*	*Canthocalanus pauper*	*Calanopia elliptica*	*Euchaeta concinna.*	*Ambunguipes spp.*	*Oithona nana*	*Oithona setigera*	*Sub Total*	*Strobilidium sp.*	*Tintinnus sp*	*Tintinniopsis sp.*	*Sub Total*	*Euphausia recurve*	*Alpheus spp.*	*Sub Total*	*Tomopteris spp.*	*Actinopora sp.*	*Daphnia sp*	*Calanoides spp.*	*Total*	*Total Number Of Species*
1	13	7	8	5	0	13	0	0	6	12	0	0	64	0	0	0	0	8	3	11	0	3	12	0	90	11
2	5	8	0	7	0	6	0	0	8	10	0	0	44	0	0	0	0	0	11	11	0	0	10	0	65	8
3	7	2	0	9	0	0	0	0	0	0	0	0	18	0	0	0	0	0	0	0	0	5	0	0	23	4
4	5	0	0	13	5	0	3	12	0	0	4	6	48	13	0	0	13	0	4	4	0	7	5	8	85	12
5	2	0	0	8	3	5	0	0	0	8	3	12	41	0	0	0	0	0	7	7	0	0	8	12	68	11
6	0	3	0	3	0	0	0	0	0	5	11	10	32	0	0	0	0	0	8	8	0	1	0	0	41	7
7	5	0	8	8	0	0	0	0	0	0	0	0	21	0	0	0	0	0	0	0	0	0	0	0	21	3
8	8	6	3	6	0	0	0	0	0	9	0	0	32	0	0	0	0	0	0	0	0	11	0	0	43	6
9	0	0	8	9	0	0	0	0	0	3	0	0	20	0	0	0	0	0	0	0	0	0	0	0	20	3
10	0	2	0	10	0	0	0	0	0	2	3	0	17	0	0	0	0	0	0	0	0	12	0	0	29	5
11	5	0	0	0	0	0	3	0	0	5	8	0	21	0	0	0	0	0	0	0	0	0	0	0	21	4
12	0	5	0	0	0	0	2	0	0	0	6	0	13	0	0	0	0	0	0	0	0	4	0	0	17	4

	Hexanauplia													Oligotrichea				Malacostraca			Polychaeta	Stenolaemata	Branchiopoda	Calanoida		
13	3	0	0	0	0	0	5	0	0	7	12	0	27	0	0	0	0	0	0	0	0	0	0	0	27	4
14	2	4	0	0	0	0	0	0	0	4	10	0	20	0	0	0	0	0	0	0	0	2	0	0	22	5
15	1	6	5	0	0	0	7	0	0	7	0	0	26	0	0	0	0	0	0	0	0	0	0	0	26	5
16	0	0	4	3	5	0	4	0	3	0	0	0	19	5	0	0	5	0	0	0	0	1	0	0	25	7
17	3	0	8	8	0	0	0	0	6	0	0	0	25	0	3	0	3	0	0	0	0	0	0	5	33	5
18	0	9	0	6	3	0	0	0	4	0	0	0	22	3	2	5	10	0	0	0	0	1	0	0	33	8
19	4	11	0	12	2	0	0	0	1	0	0	0	30	2	1	2	5	0	0	0	0	0	0	3	38	9
20	0	0	0	10	1	0	0	0	3	5	0	0	19	1	0	6	7	0	0	0	0	2	0	2	30	8
21	0	0	0	0	0	0	3	0	0	0	0	0	3	0	3	0	3	0	0	0	0	3	0	1	10	4
22	0	12	0	0	3	0	2	0	0	4	0	0	21	3	0	5	8	0	0	0	0	0	0	0	29	6
23	0	0	0	0	0	0	5	0	0	0	0	0	5	0	5	7	12	0	3	3	0	4	5	3	32	7
24	0	0	7	3	0	0	0	0	0	2	0	0	12	0	0	0	0	0	18	18	0	4	0	0	34	5
25	0	11	0	18	0	0	7	0	0	0	0	0	36	0	4	2	6	0	6	6	0	0	3	0	51	7
26	0	10	3	6	0	4	4	0	0	3	0	0	30	0	0	0	0	0	12	12	0	4	2	0	48	9
27	0	13	5	12	0	4	4	0	0	0	0	0	38	0	6	0	6	4	10	14	0	2	1	0	61	8
28	0	8	0	10	0	6	6	0	0	6	0	0	36	0	0	2	2	4	0	4	0	4	0	0	46	8
29	0	0	0	0	11	7	7	0	0	0	0	0	25	0	4	0	4	6	0	6	0	4	0	0	39	6
30	0	0	0	0	10	8	8	0	0	0	0	0	26	0	0	3	3	7	0	7	0	6	0	0	42	6
31	0	0	0	0	13	0	0	0	0	7	0	0	20	0	0	5	5	8	0	8	0	7	0	0	40	5
32	0	3	4	0	8	0	0	0	0	5	0	0	20	0	5	4	9	0	0	0	6	8	0	0	43	8
33	0	7	6	0	0	4	0	0	0	11	0	0	28	0	0	0	0	0	0	0	4	0	0	4	36	6
34	0	3	4	4	0	2	0	0	11	0	0	0	24	0	2	0	2	0	0	0	1	0	0	4	31	8

	Hexanauplia													Oligotrichea				Malacostraca			Polychaeta	Stenolaemata	Branchiopoda	Calanoida		
35	6	0	0	4	0	4	0	0	10	0	0	0	24	0	0	0	0	0	0	0	0	0	0	6	30	5
36	9	4	0	6	0	4	0	0	13	0	0	0	36	0	0	0	0	0	0	0	0	0	0	7	43	6
37	10	8	0	7	0	6	0	0	8	0	0	4	43	0	0	2	2	0	0	0	0	0	0	8	53	8
CT1	4	0	0	8	0	7	0	0	0	10	0	0	29	0	0	0	0	0	0	0	0	0	0	0	29	4
CT2	8	6	0	0	4	0	0	0	0	6	0	0	24	4	6	5	15	0	0	0	0	4	0	0	43	7
CT3	0	5	0	0	4	0	0	0	0	0	0	0	9	2	0	0	2	0	0	0	0	6	0	0	17	4
Total	100	153	73	195	72	80	70	12	73	131	57	32	1048	33	41	48	122	37	82	119	11	105	46	63	1514	256
% Total	6.61	10.11	4.82	12.88	4.76	5.28	4.62	0.79	4.82	8.65	3.76	2.11	69.22	2.18	2.71	3.17	8.06	2.44	5.42	7.86	0.73	6.94	3.04	4.16	100	

Appendix 5
Scoping report

The Shell Petroleum Development Company of Nigeria Limited

SCOPING WORKSHOP REPORT FOR THE ENVIRONMENTAL IMPACT ASSESSMENT STUDY OF OML 77/74 SEISMIC DATA ACQUISITION

AND

JK FIELD EXPLORATION/APPRAISAL WELLS DRILLING

HELD AT MARTHOCRYSTAL HOTEL, YENAGOA, BAYELSA STATE AND MAIN HALL, SHELL RESIDENTIAL AREA, PORT HARCOURT, RIVERS STATE

MAY 2018

EXECUTIVE SUMMARY

The Shell Petroleum Development Company of Nigeria Limited (SPDC), operator of the NNPC/Shell/TEPNG/Agip Joint venture on behalf of its Joint Venture partners, plans to embark on a seismic data acquisition survey in OML 77 and 74. A Scoping Workshop, as part of the Federal Ministry of Environment process for conducting Environmental Impact Assessments (EIAs) was held at the Martho Crystal Hotel, Yenagoa, Bayelsa State and Shell Club Main Hall, Shell Residential Area, Aba Road, Port Harcourt, Rivers State on 18th and 24th April, 2018 respectively. A total of 294 participants from 49 communities (Yenagoa - 44 and Port-Harcourt – 5) and their Royal Highnesses within the proposed project area, representatives of Federal Ministry of Environment and, Non-Governmental Organisation (Pro Natura) participated in the exercise.

The representatives of the Federal Ministry of Environment reiterated the importance of this exercise to the EIA delivery process and in the establishment of mutual relationship and trust between SPDC and the project area communities and stakeholders. Anike Kakayor opened the session in Bayelsa on behalf of the Environment Manager while the Manager himself, Augustine Igbuku opened the session in Rivers State on behalf of SPDC management and the Project Leadership. Richard Michael led the event presentations.

Objectives of the Scoping workshop:

- Comply with regulatory requirements for conducting an EIA.
- Engage communities within the project area of influence on the development and its benefits.
- Scope and evaluate community concerns to inform business decisions on project.

Highlights

- SPDC presented the EIA framework in relation to the project, the project`s technical scope covering the seismic data acquisition and proposed activities.
- Presentations were made on the Environmental Studies scope for the project (Biophysical, Social and Health Profile) and importance of EIA scoping
- Communities welcomed the development and expressed interests in playing active roles during the EIA and project delivery processes.
- The scoping syndicate and plenary sessions held to identify potential community concerns and associated impacts on their culture and environment throughout the project lifecycle.
- Communities expressed concerns on: 1) the impact on fishery resources 2) labour related issues 3) influx of job seekers 4) the benefits of the projects to communities and 5) GMoU implementation.
- SPDC reiterated its commitment to sustain strong relationships with communities, regulators and government in the delivery of the projects.

LIST FACILITATORS

S/N	Names	Designation
1	Augustine Igbuku	Environment Manager
2	Stanley Amam	Environmental Studies Lead
3	Suleiman Isah	Head Seismic Acquisition, Seismic Acquisition
4	Reuben Jonah	Seismic Damages Supervisor, Seismic Acquisition
5	Michael Richard	HSE ADVISER - Pipeline & Civil Matrix, Project Maturation & Assurance
6	Anike Kakayor	SP Discipline Adviser, Social Performance & Social Investment
7	Godswill Bornu	ESHIA Support, ESHIA Support
8	Adesola Ojesanmi	ENVIRONMENT INSPECTOR (IMPACT ASSMT), S&E Environment
9	Michael Ogbuefi	HSE Inspector, S&E Environment
10	Mary Oni	HSE Inspector, S&E Environment
11	Jude Nnaji	SENIOR RESEARCH ADVISOR,
12	Eteh, Enyinnaya	Cluster Lead, Swamp East, Onshore & Shelf Exploration
13	Daniel Amogu	Senior Exploration Geoscientist
14	Arthur Essaghagh	Senior Research Advisor
15	Alex Onumbu	Community Relations Coordinator Land 2, Stakeholder Relations Nigeria
16	Kessington Okorie	Community Relations Coordinator BOGT/SOKU, Stakeholder Relations Nigeria
17	Esther Okorogheye	COMMUNITY RELATIONS SUPPORT -SWAMP 2 EAST, Stakeholder Relations Nigeria
18	Gabriel Ikpi	Senior Research Advisor
19	Aremu Okinola	Senior Research Advisor
20	Nkechi Amadi	Subsurface Data Analyst-Geophysics, Seismic Acquisition
21	Preye Dakolo	Trainee Geophysicist, Seismic Acquisition

Regulator

S/N	Names	Designation
1	Johnbosco Okeke	Federal Ministry of Environment, Abuja

1.0: INTRODUCTION

The Shell Petroleum Development Company Limited conducted an Environmental Impact Assessment Scoping Workshop for the OML 77 and 74 at the Martho Crystal Hotel, Yenegoa, Bayelsa State and Shell Club Main Hall, Shell Residential Area, Port Harcourt, Rivers State on 18th and 24th April 2018 respectively. Scoping workshop is a mandatory stage in the Federal Ministry of Environment EIA process (EIA Act Cap E12 LFN, 2004**)** held with all preliminarily identified stakeholders together for the first time to discuss the project and its EIA process. It is an early and open process for determining the scope of issues to be addressed, identify significant concerns relating to the proposed project/activity. It provides an opportunity for proponents to recognize and classify key environmental impacts (negative and positive) and issues of the indigenous /impacted communities and groups. It is usually held in a workshop setting, where various stakeholders made up Community Representatives, Regulators (Federal Ministry of Environment, Department of Petroleum Resources), State and Local Governments including Non-Governmental Organizations and other interested parties (depending on the scope of a project) are consulted and facilitated by a predesigned agenda (Appendix 2). The principal aim of this engagement workshop is to provide information to the stakeholders and consultants to enable them to understand the characteristics of the development and its proposed environment for the purposes of undertaking an Environmental Impact Assessment (EIA) on the project.

The major objectives of this engagement include:

- To provide a brief description of the project;
- To identify and inform stakeholders.
- To find out the concerns of stakeholders.
- To consider feasible and practical alternatives.
- To identify the main issues and impacts to be studied.
- To define the boundaries of the impact assessment study.
- To agree on means of public involvement and methods of analysis.
- To identify the way forward for the stages of impact assessment and the consultation process.

Plate 1: Workshop Banner

2.0: THE SCOPING EXERCISE

Invited stakeholders' representatives started arrived the venues as early as 8:30am, with heightened enthusiasm and great expectations to hear from SPDC. After accreditation and registration (Plates 2), upon presentation of their Invitations Letters, they were ushered into the Hall.

Plates 2: Cross section of Participants accreditation and Registration

2.1: EVENT ATTENDANCE

The workshops were well attended. Stakeholders that participated include communities within the project area, Federal Ministry of Environment, Rivers State and Bayelsa State Ministries of Environment and SPDC staff. Brass and Akuku Toru LGAs of Rivers and Bayelsa States neighbouring the project area were invited but could not send representatives. Detailed list of participants is shown in Appendix 2.

2.2: EVENT KICKOFF

The workshops commenced at 10:00am with opening prayers (Plate 3) by volunteered community representatives.

Plate 3a and b: Opening Prayers at the events

Jonah Reuben (Seismic Damages Supervisor.) made introductory remarks and presented Safety Instructions and Ground Rules (Plate 4). This was followed by the introduction of the workshop participants (Plate 5) thus, setting the scene for the commencement of the workshop programme. Key regulators present included representatives of Federal Ministry of Environment, Bayelsa and Rivers States Ministries of Environment (Plate 6a and b).

Plate 4: Initial Safety Briefing and Ground Rules Presentation

Plate 5: Cross section of Community Leaders introducing members of their entourage

The Regulators introduced themselves and the SPDC team also introduced themselves.

Plate 6a: Representatives of Bayelsa State and Federal Ministries of Environment

Plate 6b: Representatives of Rivers State Ministry of Environment at the event

In his keynote address, the representative of the Minister for Environment at the Yenagoa event, reiterated the importance of scoping workshops (Plate 7). This was followed by yet another opening remark by Anike Kakayor, the representative of the Environment Manager. Augustine Igbuku, the Environment Manager SPDC himself at the Port Harcourt event encouraged active participation of all stakeholders at the event to achieve a meaningful outcome (Plate 8). This was followed by key presentations.

Plates 7: FMENV representative making opening remarks

Plate 8: Opening remark by Environment Manager

3.0: PRESENTATIONS

In both events, presentations kick-started with the Importance of EIA and Scoping (Plate 9) presented by Richard Michael, the Project Environmental Adviser.

Plates 9a and b: Importance of EIA and Scoping Presentations

Suleiman Isah, Head of Seismic Acquisition presented the scope of the Seismic Project scope and coverage areas (Plate 9c) whilst Enyinnaya Eteh/Daniel Amogu presented the Exploration/Appraisal Wells Drilling Scope (Plate 9d). Adesola Ojesanmi/Jude Nnaji spoke on the biophysical aspects (Plate 10) whilst Anike Kakayor and Godswill Bornu spoke on Social Impact Assessment and Health Impact Assessment respectively (Plates 11 &12).

Plate 9c Seismic scope presentation at the two venues

Plate 9d: Exploration/Appraisal Wells Scope Presenter

Plate 10: Biophysical/Ecological Impact Assessment Presentation going on

Plate 11: Socio-Economic Impact Assessment Presentation

Plate 12: Health Impact Assessment Presentation

4.0: PLENARY AND SYNDICATE SESSIONS

After Tea break, came the Plenary Session for questions and answers which was followed by Stakeholder's Analysis to identify those that were invited and omitted, corrections, etc. Alex Onumbu (Plates 13a and b) led this aspect which followed the sequence below:

- Who should be involved?
- Who has been excluded?
- What should be done about it?

Plate 13a: Stakeholders Analysis session at the event

Plate 13b: Stakeholders on Stakeholders Analysis

Participants were asked to identify any missing primary, secondary or tertiary stakeholders from the list displayed. The session saw corrections on community names, proper identification and categorisation of communities to their respective states and local government areas as well as documentation of omitted communities (Appendix 3).

5.0: IDENTIFICATION OF PROJECT POTENTIAL IMPACTS

SYNDICATE SESSION

The syndicate sessions were facilitated by SPDC representatives where stakeholders identified likely key project impacts, both positive and negative, and associated mitigation and enhancement measures. **Participants were divided into syndicate groups. Each group was assigned proposed project activity to identify likely but critical social, health and environmental issues/impact in the order of the most significant, environmental receptors that will be affected and mitigation/enhancement measures to address both negative/positive impacts. The seismic scope had six syndicate groups whereas Exploration/Appraisal Well drilling scope had six syndicate groups as stated sections 5.1 and 5.2 below.** Plates 14 and 15 show stakeholders brainstorming section to identify possible positive and negative impacts from project phases and activities. The facilitators are also seen clarifying issues raised by the stakeholders in different groups.


Plate 14: Cross section of syndicate seesions

Plate 15: Cross section of syndicate analysis

After the brainstroming section, leaders of each group presented at plenary their findings, and recommentations. Plates 16 and 17 show plenary presentations of the syndicate outcome.

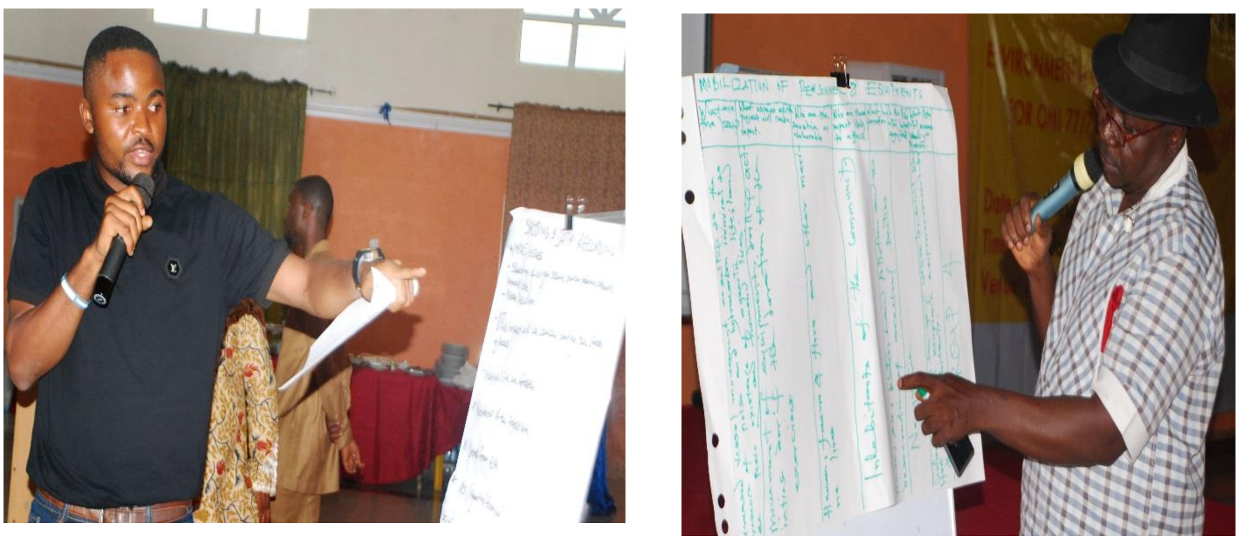


Plate 16: Syndicate presentations at Yenagoa

Plates 17: Synicate presentation at the Port Hrcourt Event

5.1: OUTCOME OF SYNDICATE SESSION FOR OML 74/77 SEISMIC PROJECT

Mobilization of Personnel and Equipment (Group 1)

▪ A What is the issue/impact?	▪ B What aspect of the project will cause the impact and when is it likely to occur?	▪ C What are the sensitive or vulnerable receptors that could be impacted?	▪ D Who are these impacts likely to affect?	▪ E What information (project data/env. data) do you need to predict the magnitude of the impact	▪ F Is the potential impact significant? (both positive or negative impact)	▪ G What potential measures would you propose to enhance or eliminate or reduce the impact?
Air pollution	Exhaust effluents from vessels engine	Air	Humans, aquatic flora and fauna	Baseline air quality measurements	Not significant	Use well maintained vessels, Use of solar propelled vessels
Noise pollution	Vessel movement	Humans and animals	Communities and workers	Baseline noise measurements	Not significant	Use of vessels with less noise, use well maintained vessels
Water pollution	Leaks from the vessel	Aquatic habitat	Aquatic flora and fauna, man	Baseline information on the water quality	Significant	Use of well-maintained vessels
Erosion, and accidents	Transportation of workers and materials off site and vessel move	Human beings, aquatic flora and fauna	Fishermen, community		Yes, both positive and negative	Inform community, reduce movement time
Disruption of fishing activities	Transportation of workers and materials off site and vessel move	Socio-economics	Fishermen, community	Discussion with fishermen	Yes, both positive and negative	Inform community, reduce movement time

Seismic Data Recording (Group 2)

▪ A What is the issue/impact?	▪ B What aspect of the project will cause the impact and when is it likely to occur?	▪ C What are the sensitive or vulnerable receptors that could be impacted?	▪ D Who are these impacts likely to affect?	▪ E What information (project data/env. data) do you need to predict the magnitude of the impact	▪ F Is the potential impact significant? (both positive or negative impact)	▪ G What potential measures would you propose to enhance or eliminate or reduce the impact?
Vibration	Shooting the air gun	Aquatic habitat,	Farmers, fishermen, hunters, community, Economic crops.	Visible dead organisms	Yes, it is significant and negative.	Reduce the time for shooting and recording, Provide alternative form of livelihood for fishermen
Noise pollution	The shooting proper	Man/animals, birds, air	Man (increase heart palpitations) /animals, birds	Ambient noise level, Community health data	Significant negative	Reduce shooting time, do not shoot at night

Demobilization (Group 3)

▪ A What is the issue/impact?	▪ B What aspect of the project will cause the impact and when is it likely to occur?	▪ C What are the sensitive or vulnerable receptors that could be impacted?	▪ D Who are these impacts likely to affect?	▪ E What information (project data/env. data) do you need to predict the magnitude of the impact	▪ F Is the potential impact significant? (both positive or negative impact)	▪ G What potential measures would you propose to enhance or eliminate or reduce the impact?
Erosion, and accidents	Transportation of workers and materials off site and vessel move	Human beings, aquatic flora and fauna	Fishermen, community		Yes, both positive and negative	Inform community, reduce movement time
Disruption of	Transportation of	Socio-economics	Fishermen,	Discussion with	Yes, both	Inform community,

▪ A What is the issue/impact?	▪ B What aspect of the project will cause the impact and when is it likely to occur?	▪ C What are the sensitive or vulnerable receptors that could be impacted?	▪ D Who are these impacts likely to affect?	▪ E What information (project data/env. data) do you need to predict the magnitude of the impact	▪ F Is the potential impact significant? (both positive or negative impact)	▪ G What potential measures would you propose to enhance or eliminate or reduce the impact?
fishing activities	workers and materials off site and vessel move		community	fishermen	positive and negative	reduce movement time
Air pollution	Exhaust effluents from vessels engine	Air	Humans, aquatic flora and fauna	Baseline air quality measurements	Not significant	Use well maintained vessels, Use of solar propelled vessels
Noise pollution	Vessel movement	Humans and animals	Communities and workers	Baseline noise measurements	Not significant	Use of vessels with less noise, use well maintained vessels
Water pollution	Leaks from the vessel	Aquatic habitat	Aquatic flora and fauna, man	Baseline information on the water quality	Significant	Use of well-maintained vessels

5.2: OUTCOME SYNDICATE SESSIONS SESSIONS FOR JK FIELD EXPLORATION/APPRISAL WELLS DRILLING

Mobilization (Group 1)

▪ A **What is the issue/impact?**	▪ B **What aspect of the project will cause the impact and when is it likely to occur?**	▪ C **What are the sensitive or vulnerable receptors that could be impacted?**	▪ D **Who are these impacts likely to affect?**	▪ E **What information (project data/env. data) do you need to predict the magnitude of the impact**	▪ F **Is the potential impact significant? (both positive or negative impact)**	▪ G **What potential measures would you propose to enhance or eliminate or reduce the impact?**
Traffic Jam Vehicle collision	Use of incompetent personnel, other road users	People, (injury/fatality, damage to equipment, environmental spill	Host communities and other road users			Train operators. Create awareness to the local populace, Engagement of road marshals.
Emission to Air	Poor equipment condition, unintended release		People	Baseline air quality	Yes, significant	Put in place a good emergency response. Provide hospitals
Noise pollution	Unintended release		Communities and workers	Proper community engagement on the impacts of the project and precautions to take.		Build clinics in the communities
Community agitation	Recruitment of community Workers	Peace and security in the communities	Communities and workers	Engagement	Positive and significant	Recruit semi-skilled and unskilled labour at each community as work progresses

Rig Movement and Positioning (Group 2)

Drilling (Group 3)

▪ A What is the issue/impact?	▪ B What aspect of the project will cause the impact and when is it likely to occur?	▪ C What are the sensitive or vulnerable receptors that could be impacted?	▪ D Who are these impacts likely to affect?	▪ E What information (project data/env. data) do you need to predict the magnitude of the impact	▪ F Is the potential impact significant? (both positive or negative impact)	▪ G What potential measures would you propose to enhance or eliminate or reduce the impact?
Change of land topography	Removal of drill cuttings from underground to the surface	Plant habitat	Farmers, fishermen, hunters, community, Economic crops.	Flooding in places which hitherto had not been flooded.	Yes, it is significant and negative.	
Blockage of water or drainage	Vegetation clearing and excavation the soil	Water body	Man/animals, birds		Significant negative	Proper work supervision. Apply best practice
Noise and air pollution	The pumping of chemicals into the well bore if not well managed can cause contamination of underground water	Man/animals, birds, air	Man/animals, birds	Hearing loss, insomnia/audio crises, cough, respiratory tract infection	Significant negative	Use of standard and approved equipment for the job. Provision of health facilities
	Generators, Hammer(pilling) heavy duty machines	Man/animals, birds	Man/animals, birds		Significant negative	Use of standard and approved equipment for the job. Provision of health facilities
	Dusts, toxic fumes, carbon monoxide from exhaust pipes.	Man/animals, birds	Man/animals, birds		Significant negative	Use of standard and approved equipment for the job
Accident	Blow Out		Workers and people		Negative	
Waste mgt	Drilling waste	Soil and surface water	Aquatic animals and ground water		Negative	

Demobilization(Group 5)

▪ A What is the issue/impact?	▪ B What aspect of the project will cause the impact and when is it likely to occur?	▪ C What are the sensitive or vulnerable receptors that could be impacted?	▪ D Who are these impacts likely to affect?	▪ E What information (project data/env. data) do you need to predict the magnitude of the impact	▪ F Is the potential impact significant? (both positive or negative impact)	▪ G What potential measures would you propose to enhance or eliminate or reduce the impact?
Noise and air Pollution. Erosion, Diseases and accidents	Transportation of workers and materials off site and Rig move	Human beings, animals, Plants, air, water and soil.	Communities, NGOS and Govt	Use of old vehicles, machines and unskilled personnel	Yes, both positive and negative	1) Construction of good road, 2) Use of sound vehicles and equipment and skilled personnel to man the equipment.3) Train and retain personnel. 4) Use simple machines
Water pollution	Rig movement	Aquatic habitat, man	Community, fishermen	Water borne diseases, loss of revenue to fishermen	negative	Use competent persons, use well maintained vessels to avoid leaks

6.0: STAKEHOLDERS CONCERNS/QUESTIONS/RECOMMENDATIONS ON/FOR THE PROJECT

The following are some concerns expressed by community members about the projects

1. How does the company and the government official plan to ensure that the concerns and recommendations from this activity would be implemented and not just “a tick in the box”?
2. The activity would impact on fish catch especially as the activities shall be happening quite close to the shoreline implying that the fishes would be driven far into the sea, what are the plans to mitigate this concern?
3. Are there plans to recruit unskilled and semi-skilled labour from the community?
4. What benefits would these activities draw to the community?
5. What are the plans to manage the health burden that the activity would impose on the community?
6. Quite a number of communities were not invited, is there any reason for that?
7. How soon will this activity start?
8. What radius was used to determine the area of influence?
9. The GMoU has not been effective, are there plans to manage the GMoU better?
10. How would the communities that do not have oil and gas resources be compensated for the impact of these activities?
11. The community is gradually suffering erosion of the shoreline, the activity would further exacerbate this. What plans does SPDC have to manage this?

SPDC Team answered the questions clarifying project activities scope and phases. The Minister’s representatives also re-affirmed the Ministry’s commitment to follow-up on the development of the EMP for the activities to see that all their concerns are not only addressed but managed adequately. In all, Stakeholders expressed support for the projects and pledged their co-operation for their execution.

The closing remarks were made by Isah Suleiman at the events, whilst thanking all for effective participation. The event ended by 5:00pm in Yenagoa and 3:25pm in Port Harcourt. Closing Prayer was said and stakeholders posed for group pictures.

APPENDICES

1. Event Photo Gallery

2. SCOPING WORKSHOP AGENDA IN YENAGOA AND PORT HARCOURT

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING WORKSHOP/STAKEHOLDERS' ENGAGEMENT FOR OML 77/74 SEISMIC DATA ACQUISITION AND JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

Agenda

Facilitators:	Environmental Studies Team
Date:	Wednesday 18th April, 2018
Venue:	Mathocrystal Hotel, Plot 45, Imiringi Road, Yenagoa, Bayelsa State
Project Title:	OML 77/74 Seismic Data Acquisition/JK Exploratory and Appraisals Wells Projects

Time	Activities	Action Party
09:00 - 09:20	Introduction of Participants/Ground Rules	Alex Onumbu
09:20 - 09:30	Opening Remarks by Environment Manager	Augustine Igbuku
09:30 - 09:50	The IA Process & Importance of Scoping	Richard Michael
09:50 - 10:30 10:30 - 11:00	Technical - Seismic Technical - Drilling	Suleiman Isah Enyinnaya Eteh
11:00 - 11:25	Tea/Coffee	All
11:25 - 11:45	Biophysical Scope	Jude Nnaji
11.45 - 12:05	Social Scope	Anike Kakayor
12.05 - 12:25 12:25 - 13:00	Health Scope Question and Answer	Godswill Bornu Adesola Ojesanmi
13:00 - 13:30	**Session 1 (Plenary):** Stakeholders Analysis	Alex Onumbu
13:30 - 14:00	**Session 2 (Syndicate):** Identification of key issues (Environmental, Health & Social concerns) in relation to the project	Richard Michael
14:00 -14:15	Tea/Coffee Break	All
14:15 -14:45	Feedback from the syndicate groups	Representatives of syndicate groups
14:45 -14:50 14:50 - 14:55	Closing Remarks Closing Prayer	Project Manager To Be Appointed from Community reps
	Lunch Break/Departure	

Agenda

OML 77/74 SEISMIC DATA ACQUISITION PROJECT ENVIRONMENTAL IMPACT ASSESSMENT SCOPING WORKSHOP/STAKEHOLDERS' ENGAGEMENT

Facilitators: Environmental Studies Team

Date: Tuesday 24th April, 2018

Venue: Shell Residential Area Club Conference Hall, Aba Road, Port Harcourt, Rivers State.

Project Title: OML 77/74 Seismic Data Acquisition Project

Time	Activities	Action Party
09:00 - 09:20	Introduction of Participants/Ground Rules	Reuben Jonah
09:20 - 09:30	Opening Remarks by Environment Manager	Augustine Igbuku
09:30 - 09:50	The IA Process & Importance of Scoping	Richard Michael
09:50 -10:10	Technical	Suleiman Isah Enyinnaya Ete
10:10 -10:25	Tea/Coffee	All
10:25 -10:35	Biophysical Scope	Jude Nnaji
10.35-10:45	Social Scope	Anike Kakayor
10.55-11:05 11:05-11:30	Health Scope Question and Answer	Godswill Bornu Adesola Ojesanmi
11:30 –11:55	Session 1 (Plenary): Stakeholders Analysis	Kessington Okorie
11:55-12:20	Session 2 (Syndicate): Identification of key issues (Environmental, Health & Social concerns) in relation to the project	Richard Michael
12:20 -12:30	bREAK	
12:30-13:40	Feedback from the syndicate groups	A Rep from each syndicate group
13:40-13:45 13:45-13:50	Closing Remarks Closing Prayer	Project Manager To Be Appointed from Community
	Lunch Break/Departure	

3. LIST OF OMITTED COMMUNITIES

1. Daulagha-ama
2. Ingite-ama
3. Maria-ama
4. Clever-ama
5. Egwe-ama
6. Egweama Ama-ogbo
7. Wagitia
8. Egereregere
9. Yegeama (Gbene)
10. Location
11. Jehovah-kiri
12. Ijawei-kiri
13. Potakoti-kiri
14. Kemmer town
15. Cameroun-ama
16. Berekiri
17. Fishtown
18. Ononiweitoru
19. Dieama Kingdom
20. Abadiama
21. Otokolopiri
22. Ikei
23. Appiama
24. Alafurughakiri
25. Egedekiri
26. Basuokiri
27. Odioma Kingdom
28. Dasaba
29. New Camp
30. Ogbai-kiri
31. Ekebeleu-ama
32. Igbabeleu
33. Beletie-ama
34. Omonikiri (Kolokiri)
35. UAC-ama
36. Okumbiribeleu
37. Obi Imbikiba
38. Liama-Ogbo Community
39. Egelefie-ama
40. Sikoko-ama
41. Minibie
42. Itohono-ama
43. Ya-ama
44. Bara-ama
45. Otuo (Sangana)
46. Oginibiri-ama
47. Otolo-ama
48. Akpamu-ama
49. Mini-Beleu
50. Igberingulogu
51. Mini-Amgba
52. Epelipeli-Beleu
53. Tubugbene
54. Iwokoro-ama
55. Kabulu-ama
56. Obongh0-Anigba
57. Opugbene
58. Oruwo
59. Hewaritimiyo
60. Tikpa-ama
61. Tikoro-ama
62. Tonteremie-ama
63. Sambo-ama
64. Ada-Spiff Town
65. Bonnykiri
66. Adamkiri
67. Twon Brass
68. Shidi ama
69. Owukubo community
70. Aganaga
71. Apena-okolo
72. Oyankiama
73. Bra ama
74. Teifie Community
75. Beinama-Akassa
76. Inginiekiri-Akassa
77. Ibiama-Akassa
78. Martin kiri
79. Iseleama
80. Agadama
81. Rotimi-ama
82. New camp
83. Otuo Sangana
84. Moko-ama
85. Zala ama
86. Bio ama

87. Abadi ama
88. Ogbodo ama
89. Owis ama
90. Ohimoi ama
91. Tukpakiri ama
92. Opugbene ama
93. Yaibie
94. Minibei
95. Ogboloiteli
96. Obongho
97. Opu-gbene

4. LIST OF ATTENDEES AT YENAGOA AND PORT HARCOURT EVENTS

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/STAKEHOLDER'S ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUISITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Tuesday, 24th April, 2018

S/No	Name	Community/Affiliation	Signature
1	CHF Robinson E. Elkins	Abissa (Kingdom)	
2	Chief Elekima A. Agada	Abissa	
3	Hon. Wariboko Basoene	ABISSA (CDC CHAIRMAN)	
4	Juliet McPhilips	ABISSA, Women Leader	
5	Robson Ekerebo	ABISSA, YOUTH LEADER	
6	CHF INYE N. NUMEKARIBO	IBURO AMA LEADER	
7	CHF ELEKIMA S. PERI	Iburo Ama Ekine Member (CHF)	
8	Otonye R. Bobmanuel	IBURO AMA Woman Leader	
9	Hon. Kings Amachree	IBURO-AMA Youth Leader	
10	BRIGGS ALLEN. APAKIRIBIA	IBURO AMA C.D.C CHAIRMAN	
11	Chief Karibo Lordgogo	Paramount Ruler Johnson Ama-	
12	Chf. Inalapuye Bob-Manuel	Johnson Ama. Chf. Rep. Council of chfs	
13	Daere R. Amachree	Johnson Ama. C.D.C.	
14	EVANS E. ONUKIO	Johnson Ama Youth leader	
15	MD. ADABA EKINE	JOHNSON-AMA WOMAN LEADER	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/STAKEHOLDER'S ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUISITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Tuesday, 24th April, 2018

S/No	Name	Community/Affiliation	Signature
1	CHF. TAMUNOKURO AMAKIRI	(ANGAEABIO AMA)	
2	CHF. MARK TARIAH	✓	
3	ALABOTA MORA ODUTO	WOMAN LEADER	
4	ELDER. OTUMBA LAWSON	CDC CHAIRMAN	
5	ELDER. NGERI, BOBMANUEL	YOUTH LEADER	
6	CHF COMR MINAIBIYE LAW DOUGLAS	PARAMOUNT RULER (ABAJI OKLO)	
7	CHF TONYE EREKEOSIMA	CHIEF IN COUNCIL (A ✓	
8	MR DIMABO MACWILLIAMS	CHAIRMAN CDC ✓	
9	MR SOMINA B. T. WEST	YOUTH LEADER ✓	
10	MRS PRISCILLA DONPEDRO A.	WOMAN LEADER ✓	
11			
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ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/STAKEHOLDER'S ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUISITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Tuesday, 24th April, 2018

S/No	Name	Community/Affiliation	Signature
1	Onyeagba Deborah C.	Pro Natura International (PNI)	
2	Emmanuel I. Oye	R/S Ministry of Environment	
3	Nimi Elele	R/S Min of Environment	
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ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/STAKEHOLDER'S ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUISITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Tuesday, 24th April, 2018

S/No	Name	Community/Affiliation	Signature
1	Jude Nnaji	SPDC	
2	Edogun Iyobosa Stella	✓ ✓	
3	Ukaegbu Kingsley OE	✓ ✓	
4	Boma Godswill	✓ ✓	
5	Ilamina Ebinum	✓	
6	Orji MARY	✓	
7	Preye Dakolo	✓	
8	Daniel Amegu	✓	
9	Isah Suleiman	✓	
10	Richard Michael	✓	
11	ADESOLA OGESANMI	✓	
12	ANIKE KAKAYOR	✓	
13	ADOKIYE DOUGLAS	✓	
14	ALEX ONUMBU	✓	
15	MARK NEWALL	✓	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/STAKEHOLDER'S ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUISITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Tuesday, 24th April, 2018

S/No	Name	Community/Affiliation	Signature
1	Okoroafuaye Esther	SPDC Swamp East CRO	
2	Amadi Nkechi	SPDC Seismic Acquisition	
3	Etompe Davies	SPDC CR	
4	Igbuku Austin	SPDC – Environment	
5	Stanley Amam	SPDC – Environment	
6	KESSINGTON OKORIE	SPDC – CRC	
7	Dr. Ene Alogo. C.	SPDC – Sabbatical	
8	UZOMA. E.S.K	SPDC Health Impact Assessment	
9	Reuben JONAH	SPDC	
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ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	SUPER WOLO	OTUO (OPU-OTUO)	
2	SUNDAY BENJAMIN	OTUO	
3	FAITHINGO SOLOMON	OTUO	
4	GODDAY IOBBIN	OTUO	
5	JACK SAMPSON	OTUO	
6	SAMUEL REMEMBER	MINIBIE	
7	JOSEPH THEOPHILUS	MINIBIE	
8	GOODLUCK GEORGE	MINIBIE	
9	DANIEL AMBROSE	MINIBIE	
10	IBIERE AWULABA	MINIBIE	
11	Iyenemi Basuo	Cape Numbi	
12	Mnebo [illegible]	✓	
13	Owubokiri Theophilus	Cape Numb.	
14	Ene Wang Pala	Cape Num	
15	Medonal Philip.	Cape Numb	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name AKANAGA	Community / Affiliation	Signature
1	CHF TEIDBARABHDEMI	AKANAGA	
2	CHIEF ENE	✓	
3	MR IKAIGBINYO MARK	✓	
4	MR BENJAMIN OPUENE	✓	
5	MRS AYEBATONYE BARA	✓ AKANAGA	
6	CHIEF (HRH) I-OMIEH-OKOLO	APIMOKOLO	
7	Chief Sougha. C. Chamen	✓	
8	HON CLEVER MUNAFA	✓	
9	Solomon Solomon	✓	
10	NUMOIPRE Chinedu	✓	
11	Chief Wilson Oruwori	AKabelea	
12	HRH A. ALALI-IKPEYAIGULA	✓	
13	Suoyo Gift	✓	
14	Elder Numotee Graham	✓	
15	Ibeinmo Fekuma	✓	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Chief ThankGod E-Seriyai	Odioama, HRH Reps	[signature]
2	Chief Innocent L-Nagha	Odioama, Chief	[signature]
3	Hon. Philemon K. Dickson	Odioama, CDC	[signature]
4	Mr Forcebray I. Ekelekpe	Odioama, Youth President	[signature]
5	Mdm Boumokuma Sample	Odioama, Women Leader	[signature]
6	Ch. Dickson Idomo	Egbabele Com. Chief	[signature]
7	Mr Lyon K. Gbalipre	Igbabe	[signature]
8	Doumowei David	✓	[signature]
9	FRANK OKPARA	✓	[signature]
10	LYON INAINGO. K.	✓ IGBABELEU	[signature]
11	Chief (Hon) B N Amamo-Ikpalgpi	Beletiema HRH	[signature]
12	Chief Kasidigha Isaac	✓	[signature]
13	Madam Ayerite Otuturu	✓ women leader	[signature]
14	Mr /Betimi Brown	✓ CDC	[signature]
15	Joel Kilson	Beletiema Youth leader	[signature]

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Chief Emieaye Doctor	Tubu Ama	
2	Chief Japhet Iwokura	Tubu Ama	
3	Prince Eleman	Tubu Ama	
4	Francis Igoni	Tubu Ama	
5	Doris Micah	Tubu Ama	
6	HRH PKIC Consul-oluku	Emewe'ibie	
7	Chief K.C. Sling-olali	" "	
8	Chief M.J. Kole Erehamote	" "	
9	Mrs Dorcas Ndanbo	" "	
10	Mr. France Cijo	" "	
11	Chief Famous Y. Bein	KOIIKIRI	
12	Chief Abraham Tebie	"	
13	Jackson Ebisima	"	
14	Ibitani Abraham	"	
15	Teinabo Yousuo	"	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Chief Ikpuku	Okolobie	[signature]
2	ADAM DOMO	OKOLOBIE	[signature]
3	IKELEMO AYEBAEMI	OKOLOBIE	[signature]
4	MATTHEW TELIMOYE	OKOLOBIE	[signature]
5	Mrs Kete Fred	Okolobie	[signature]
6	CHIEF OOB OWEPGAH	SANGANA TOWN	[signature]
7	KANDUGOOD ANGILA	SANGANA TOWN	[signature]
8	AMOS IKIDIGI	SANGANA TOWN	[signature]
9	CHIEF DIBIRI ENDURANCE	SANGANA TOWN	[signature]
10	Ayibatonye John	SANGANA TOWN	[signature]
11	O. TONTE IYABI	EWO-AMA	[signature]
12	CHIEF A. SELE-IINGO	EWO-AMA	[signature]
13	CHIEF A. F EKINE-SIKA	EWO-AMA	[signature]
14	MAD. JONAS, M. E	EWO-AMA	[signature]
15	INOWEI W. JOSHUA	EWO-AMA	[signature]

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	CH. L.S.E. OYEFIEKUMA	LIAMA	
2	CHIEF W S ANABOYAI	LIAMA	
3	AYIEBAEMI AYEBAESIN	LIAMA CDC	
4	ALAKIRI OMUNGU	LIAMA	
5	HELEN WILLIAMS	LIAMA	
6	HRH, KING. M. G. BOKOLO [illegible]	OBIOKU	
7	CHIEF H. J. KULAIN	OBIOKU	
8	AMAOBUF. ERIYE	OBIOKU	
9	STEPHEN AYEBANOA	OBIOKU CDC	
10	DANIEL BEREFAMO	OBIOKU YOUTH PRESIDENT	
11	HRH EDWARD INATIMI	KONGHO	
12	CHIEF N. I. OKURU	KONGHO CHRMAN	
13	CDC Pisilbo Robert	Kongho	
14	Youth Pres Bere Okodi	Kongho	
15	Woman Margaret -D	Kongho	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Chf. Daniel Okodi-Otombo	Owutubu Community	
2	Chf. Sunday J. Igbosse-Indawari		
3	Deputy Chf. N. Scent		
4	Amabebo Patience		
5	Wellington .O. Benson		
6	Chief I.A Buwei Kemeya	Apparanbie Community	
7	Chief Gorsuch E.-Daye		
8	Ebenezer Igakumo		
9	Omientimi Vestor I.D		
10	GIRRAH D. ROSSAH		
11	CHF. FAYESEIMO KOKO-IKU	TEFIE COMMUNITY	
12	OGOFE MAIHEIN		
13	ROBERT SAMPSON		
14	KONYE FRANCIS		
15	HELENA PORCEBERTY		

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	BARALATE SLINK	OKPOAMA HRM REP	
2	CHF I A YOUSM OGBULU	" REP CHIEFS COUNCIL	
3	CHF T.J. WARIGHAYE_DUNDAS	" CDC CHAIRMAN	
4	MR DILANGEFA EBITIMI	" YOUTH PRESIDENT	
5	MISS EINBIGIMIEKUMA SLINK	" WOMEN REP	
6	NOAH OPAENG	BEKEKIRI	
7	Famous Ekeny	✓	
8	HRH Suebarigo	BEKEKIRI	
9	Dowye Awulaba	BEKEKIRI	
10	Maria Festu	✓	
11	Mcebi Bob Awulabah	Ogbokiri	
12	SHELL AMORONI	"	
13	Selekumo Allen	"	
14	CHF. A.J. EKERU KPEKI	"	
15	George B-Samuel	"	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	JOHN FRIDAY IJEDE	FISH TOWN	
2	JOHN PAIBOYE	FISH TOWN	
3	ALEXANDER INIATIMI	FISH TOWN	
4	HRH N.O.A. NWAMAMAH VII	FISH TOWN	
5	RACHEAL BEIMONYO	FISH TOWN	
6	HIGHNESS. ROLAND G. NOKO	BUO-AMA COMMUNITY	
7	HON. FELIX. A. BOUKORU	"	
8	SAM EPELLE	BUO-AMA	
9	AYEBAKURO Clement	BUO-AMA	
10	MERCY SAMSON	BUO-AMA	
11	H H Iwoboranyo	Oyankeyama	
12	C.D.C Daniel Frank	"	
13	Chief Fubara	"	
14	YOUTH PRES. ABRAHAM G.	OYANKIAMA	
15	OTORI GOBGIFI	OYANKIAMA	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	N.G. M Kpeteka	Humnu	
2	IRO SAMUEL	✓	
3	ALAKEAE MIEDIAKam	✓	
4	BESTA JEREMIAH	✓	
5	Hon Pius Miediakumo	✓	
6	HRH R.D. OKIYA	OKUNBIRIBELEU	
7	Chief S.F. Okserhori	✓	
8	INEIMI FINI	✓	
9	Gbonlne Kefa	✓	
10	Blessing Abel	✓	
11	Chief Rowland Simeon	Opu-Okumbiri	
12	DAVID N OTIMBA	✓	
13	MD PWABERE	✓	
14	Combst Rowland	✓	
15	CHIEF SADANIEN	✓	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	OMANCI E. OMANCI	EGweama	
2	CHIEF E.G. Igbelegbe	Igwe-ama	
3	IYAGBA ADA	EGWEAMA	
4	SATURDAY DUANYO IGIRIGI	EGWEAMA	
5	WORIPAGA DUMOBOTE	EGWEAMA	
6	HRH. B. E. AMAONE (KABAX)	DIE-AMA	
7	CHF. OMIEKA S. P ORUFAWARI	DIEAMA	
8	CHIEF TONIPRE N. APOLLOS	DIE-AMA	
9	TEKENATE KITCHENER	DIE-AMA	
10	Selekuma Graham	Die-ama	
11	CF. BARALAYE KULEHA Opu Alcassa	Opu Alcassa	
12	Chief Lo Rogoh Abei	–	
13	Rose	✓	
14	JACOB JOSEPH BOB	✓	
15	TIMIEBI INATIMI F.	✓	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Barnabas Iyogbokiri	Bugokiri	
2	Abahan Isiah	✓✓	
3	Sayelefe. Agines	Bugokiri	
4	Mamgungisia. James	Bukokiri	
5	Ekalema Elekima	Bakori	
6	Ekiye Bristo	Kerubenimukiri	
7	Gbogiboni Theo.	Kere benymukiri	
8	Aeme. Magnus	✓✓	
9	Eferekum M.C	✓✓	
10	Dennis. Orawari	Kerubenimukiri	
11	Jonathan Igoniko	Gbogbokiri	
12	Isekema Amawari	GBOGBOKIRI	
13	Peve - Biwari	gbogbokiri	
14	Igbogimi Adawari	Gbogbokiri	
15	Paul. Barango	✓✓	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Elder M. C. Ikonibo	Theophiluskiri	
2	Chief Igoni Amangala.	vv	
3	Amafu. Inye.	vv	
4	Elelawo E C JP.	Theophilus sikiri	
5	Martins Gbawaigo	vv	
6	Amafu Gbosis	Pukokiri.	
7	Eremasi Macmillian	"	
8	Daufa. Dokari	Pukokiri Community.	
9	Ebisim Adowari	Pukokiri	
10	Obunbiri Assali JP.	Pakokiri	
11	Ekiomi Layefa.	Akassali	
12	Pokumo Bonasi	vv	
13	Ikoni Bobmanuel	vv	
14	Efekima. Basuo	vv	
15	Jeremiah Nangi.	vv	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Barono Ibubara	Otuo Community	
2	Faith Gborala	Otuo Community	
3	Sagbe Ozimu	Otuo Community	
4	Chief O. Lloyd	Otuo Community	
5	[illegible]	Otuo Community	
6	Ekwemi Layeta	Okunbiri Community	
7	Pokumo Banasi	√√ √√	
8	Ikoni Bob-Manuel	√√ √√	
9	Elekuma Basuo	√√ √√	
10	Jeremiah Mangi	Okunbiri Community	
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ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	HRH KING FRANCIS MENE-DAULAGHA	IBIDI	18-04-2018
2	Wogite	CHIEF	18-04-2018
3	OTOKOLO AYEBANUMOMOPIRE	CDC CHAIRMAN	
4	OMIETIMI CLEVER	IBIDI / PRESIDENT	
5	Deborah Mene	Ibidi / women Leader	
6	HH Golden William-Sintoh	TWON BRASS KINGDOM	
7	Chf Moses I.F Iyafa	✓ ✓ ✓	
8	Ololo Inatimi	✓ ✓ ✓	
9	Abah Ebiegberi R.	✓ ✓ ✓	
10	Mrs Douglas Doris	✓ ✓ ✓	
11	chf Irighs-Spiff Inikio	Palm Mbikiri	
12	CHF MOSES KAKAIN	PALM IMBIKIRI	
13	Mr. George Nelson	PALM IMBIKIRI	
14	Talbert Emmanuel	PALM IMBIKIRI	
15	Andrew Karina	PALM IMBIKIRI	

ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Okeke Johnbosco	Federal Ministry of Environment	[signature]
2	Angaule - O. Angaule	BYMBNY	[signature]
3	Oyise E-Elliot	BYMENEY.	[signature]
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ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Obah Lilian Nkruter	Pro-Natura International	[signature]
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ENVIRONMENTAL IMPACT ASSESSMENT SCOPING/ STAKEHOLDERS' ENGAGEMENT WORKSHOP FOR OML 77/74 SEISMIC DATA ACQUSITION/JK EXPLORATORY AND APPRAISAL WELLS PROJECTS

ATTENDANCE REGISTER, Wednesday, 18th April, 2018

S/No	Name	Community / Affiliation	Signature
1	Preye Dakolo	SPDC	
2	Michael Ogbuefi	SPDC	
3	Isah Suleiman	SPDC	
4	ENYIANAYA ETEH	SPDC	
5	Anike Kakayor	SPDC	
6	Jude Nnaji	SPDC	
7	BORNU GODSWILL	SPDC	
8	ADESOLA OJESANMI	SPDC	
9	Richard N. Michael	SPDC	
10	Amaechi Nkechi	SPDC	
11	Douglas Adokiye	SPDC	
12	Jude Okeke	SPDC	
13	Owei Brelaori	SPDC	
14	Alex Omunlori	SPDC	
15	Reuben Jonah	SPDC	

Appendix 6

Minutes of Meeting (MoM)

Minutes of Meeting of SPDC/FMENV Critical Project EIA Engagements

Attendance:

1.	Mr. John Alonge -	Director Environment Assessment - FMENV
2.	Mr. Abass Sulieman -	Deputy Director Environment Assessment - FMENV
3.	Mr. Kevin Ihebinike -	Deputy Director Environment Assessment - FMENV
4.	Mr. Mukaila Ojikutu-	Environment Manager - SPDC
5.	Dr. Stanley Amam -	Environment Studies Lead - SPDC - Reporting
6.	Mrs. Onyekachi Igwe-	Senior Government Relations Adviser - SPDC

Venue: Federal Ministry of Environment, Brown Building Abuja

Date: 26 February 2019

Agenda:

- Review, advise and progress critical SCIN projects EIA.

Highlights

1. FMENV Director welcomed the SPDC team.
2. SPDC Environment Manager thanked the Director and team for their availability to meet at short notice. He thanked the team for the recently received EIA approvals for the Enwhe and Uzu FDP and appreciated their continued commitments to working collaboratively with SPDC to actualize her growth program.

Critical Projects List with SPDC and FMENV Response /actions

S/N	PROJECT	PROJECT STATUS	ACTION
1	Nun River Dredging	• Prayer to update 2007 approved EIA EMP and use that to manage sweeping works • Scope covers river sweeping works in Nun River and Diebu Creek to allow vessel for well head maintenance works	• SPDC to register EMP and submit same to FMENV • EMP will be subjected to public display for 21 days • SPDC and FMENV to review EMP in parallel with Public display • Public comments to be included in jointly reviewed EMP before FMENV approval is issued.

SN	PROJECT	PROJECT STATUS	ACTION
2	Lagos Infrastructure Dev project	• Clarify if Lagos State Ministry for Environment has parallel laws with the FMENV. • Clarify duplicate project registration, charges and site visits	• FMENV has overall authority for Environment Assessments • No State Ministry has parallel Environmental Assessment laws • FMENV involves all State Ministries in Env Assessments • SPDC to advise LSMEV to clarify requests with FMENV • SPDC to escalate to Minister if required
2	Gbaran Single Well	• Prayer to use approved EIA and EMP to manage the drilling of and hook up of GB2B well • Formal letter sent to FMENV.	• SPDC to update EMP to include the 5km flowline not originally included in EIA as long as flowline is within the existing ROW. • SPDC to submit EMP to FMENV for review and approval.
3	Afam Gas Supply 2 Project	• FMENV to advise site visit for week of 11-15 March. Acknowledged letter to ministry date is 9th Nov 2018	• FMENV to advice exact date from the week preceding planned site visit. • SPDC (Kacol) to follow up this action with the Ministry
4	Okoloma Nodal Compression Project	• FMENV to advise site visit for week of 11-15 March. Acknowledged letter to ministry date is 9th Nov 2018	• ditto
5	Gbaran Uble Phase 2 Integrated Oil and Gas Project (Gbaran, Kolocreek and Koroama)	• Request to use EMP to continue the management of project impact. • Current approval expires May 27th. • Request to manage impact of 2 Kolocreek Wells on the FMEnv approved EIA. • Letter sent to FMEnv on 14th Dec 2018 and now awaiting final response.	• SPDC to resend letter to FMENV requesting approval to use EMP to manage project impact or approve extension of EIA to accommodate drilling of 2 Kolocreek wells at expiration of current permit by May 27th

S/N	PROJECT	PROJECT STATUS	ACTION
6	Bonny Deep EIA	• Reconfirm FMENV receipt of payment advise .. • Progress with next steps	• SPDC confirmed that Public display ended 25th Feb and confirmation of newspaper adverts and radio jingles has been advised the FMENV. • Ministry to advise date and modalities for Panel Review • SPDC (Kachi) to follow up with FMENV.
7	Soku Nodal Compression Project (SNC2)	• Drafted letter to FMENV to request **desktop EIA** approach to manage project leveraging on available/valid environmental data from the Soku GP/FS EES revalidation of 2018 . **(Project FID is June 2019)** • FMENV had acknowledged Letter of project registration, proposal and NGN 50,000 receipt on 15th Nov 2018.	• SPDC requested use of EMP to manage SNC2 project since this involves siting compressor in Soku Field only – scope of work is same as earlier approved Gbaran Nodal Compressor (GNC) EMP/EIA approved in 2018. • SPDC confirmed that SNC2 is covered within the Soku Field with valid Environmental data. • FMENV to review own project files and advise decision • SPDC (Kachi) to follow up with FMENV. • SPDC to share available data of Soku studies with DPR
8	OML 77/74	• FMENV to confirm accelerated project approval post EIA report submission in March. • EIA Permit required to carry out seismic activity in June.	• FMENV confirms project can be approved before Seismic activity scheduled for June. • SPDC to accelerate report and submit by March 2019.
9	Bonga North EIA to FMENV	Request FMENV approval to use 1 season to validate EIA based on subsisting EIA approval for Bonga Main ▪ Project is a tie-in to Bonga Main ▪ Project location is 17 km from Bonga Main ▪ 14 wells (7 production, 7 injection wells) ▪ 1 season field data gathering is planned ▪ FMENV involvement: participation in field data gathering, payment of EIA fees, EIA report to be submitted to them.	• Share DPR approved 1 season FDG for study • FMENV is willing to adopt 1 season approach after confirmation of DPR approved ToR.

AOB

1. FMENV requested SPDC to urgently advise on progress of action on already approved 1 season EIA for the H Block Project.
2. FMENV requested SPDC to involve FMENV in future HAZIDs and HAZOPs for capacity building purposes.
3. FMENV requested SPDC to retrain some FMENV staff on TBOSIET to enable full support to offshore studies – SPDC Environment Manager to confirm doability.
4. SPDC to develop an Environment discipline capacity building event to train FMENV staff
5. SPDC to schedule Environmental compliance visits to review compliance with approvals and permit provisos
6. SPDC to involve FMENV in environment studies not requiring their direct participation to support wider project considerations in the event these may become part future EIAs requiring considerations with the FMENV. This ensures understanding and support during such project developments.

Meeting closed at 15:00

Signed

For FMENV

SULEIMAN ABBAS

For SPDC

ONYEKACHI IGWE

Appendix 7
Attendance sheet

ATTENDANCE SHEET

JOINT DPR/SPDC QA/QC LABORATORY INSPECTION FOR THE ENVIRONMENTAL SAMPLES OF OML 77/74 SEISMIC DATA ACQUISITION AND JK EXPLORATION AND APPRAISAL WELLS PROJECTS /EA-EIA FIELDS EOD/EE

ATTENDANCE SHEET

Date: 8/11/2018

S/N	Name	Designation	Phone number	Signature
1	[illegible] Ogunsanmi	SPDC	08056709060	
2	Ali Mala	DPR	07032205922	
3	Obua Uetie	IESL	07065431192	
4	Nwsunya Kingsley	IESL	07039515980	
5	Ekpor Vivian	IESL	08032750664	
6	Egbe Chinyere	IESL	08037751957	
7	Ibanga, Aniuti	IESL	08035469607	
8	Ozumba Benita	IESL	08032310366	
9.	Kursah Eric	IESL	0803748N42	
10.	Alexander Azeilania	IESL	07035707373	
11	OLADUNI BODE	IESL	08166470280	
12	Williams Bolts A	IESL	08082036086	
13	AKpotohwo, E Kennedy	DPR	08036460323	
14	Michael Richard	SPDC	07070324034	