



The Shell Petroleum Development Company of Nigeria Limited

**ENVIRONMENTAL IMPACT ASSESSMENT  
FOR THE**

**EA/EJA FURTHER OIL DEVELOPMENT  
PROJECT (REVALIDATION OF BASELINE)**

**FINAL REPORT**

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### Abbreviations and Acronyms

°C	-	Degree Celsius
µg	-	Microgram
µm	-	Micrometre
ALARP	-	As Low as Reasonably Practicable
BH	-	Borehole
BOD <sub>5</sub>	-	Five-day Biochemical Oxygen Demand
BOP	-	Blow Out Preventer
BOPD	-	Barrels of Oil Per Day
Bscf	-	Billion standard cubic feet
Ca	-	Calcium
Cfu	-	Colony forming units
Cfu/g	-	Colony forming units/gramme
Cfu/ml	-	Colony forming units/millilitre
Cl <sup>-</sup>	-	Chloride ion
cm	-	Centimetre
CO	-	Carbon monoxide (Carbon II Oxide)
Co	-	Cobalt
CO <sub>2</sub>	-	Carbon Dioxide (Carbon IV Oxide)
COD	-	Chemical Oxygen Demand
Cr	-	Chromium
dB(A)	-	Decibel
DO	-	Dissolved Oxygen
DPR	-	Department of Petroleum Resources
EC	-	Electrical Conductivity
EGASPIN	-	Environmental Guidelines and Standards for the Petroleum Industry
EIA	-	Environmental Impact Assessment
EMP	-	Environmental Management Plan
FOD	-	Further Oil Development
g	-	Gramme
H <sub>2</sub> S	-	Hydrogen Sulphide
Ha	-	Hectare
HUB	-	Hydrocarbon Utilizing Bacteria
HUF	-	Hydrocarbon utilizing fungi
HYD/B	-	Hydrocarbon degrading bacteria
ITCZ	-	Inter Tropical Convergent Zone
ITD	-	Inter-Tropical-Discontinuity
K	-	Potassium
Kg	-	Kilogram

Km	-	Kilometre
Km <sup>2</sup>	-	Square Kilometre
L	-	Litre
Meq	-	Milli-equivalent
Mg	-	Magnesium
mg	-	Milligramme
mg/kg	-	Milligramme per kilogramme
mg/l	-	Milligramme per litre
ml	-	Millilitre
mm	-	Millimetre
MMscf/d	-	Million Standard Cubic Feet Per Day
Mn	-	Manganese
MPN	-	Most Probable Number
NA	-	Not applicable
Na	-	Sodium
Ni	-	Nickel
NH <sub>4</sub> -N	-	Ammonium Nitrogen
NO <sub>2</sub> -N	-	Nitrite Nitrogen
NO <sub>3</sub> -N	-	Nitrate Nitrogen
NNPC	-	Nigeria National Petroleum Corporation
NO <sub>x</sub>	-	Nitrogen Oxides
NTU	-	Turbidity unit
NW	-	North West
OML	-	Oil Mining Lease
PAH	-	Polycyclic Aromatic Hydrocarbon
Pb	-	Lead
pH	-	Hydrogen ion concentration
PPE	-	Personal Protective Equipment
ppm	-	Parts per million
SCiN	-	Shell Companies in Nigeria
SO <sub>2</sub>	-	Sulphur dioxide
SO <sub>4</sub> <sup>2-</sup>	-	Sulphate ion
sp	-	Species (Sing.)
SPDC	-	Shell Petroleum Development Company of Nigeria Limited
SPM	-	Suspended particulate matter
Spp	-	Species (Pl.)
SS	-	Suspended solids
SW	-	South West
TDS	-	Total Dissolved Solids

TF	-	Total Fungi
THB	-	Total Heterotrophic Bacteria
THC	-	Total hydrocarbon
TOC	-	Total Organic Carbon
TOR	-	Terms of Reference
TSS	-	Total Suspended Solids
V	-	Vanadium
VOCs	-	Volatile Organic Compounds
W	-	West
WHO	-	World Health Organization
Zn	-	Zinc

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## **Executive Summary**

### **ES 1.0: Background Information**

The Shell Petroleum Development Company of Nigeria (SPDC) on behalf of the Joint Venture Partners (Nigerian National Petroleum Corporation, Total Exploration and Production Nigeria and Nigerian Agip Oil Company) intends to develop 70.5 MMstb of contingent oil resources in EA and EJA fields to increase the fields' economic production life. The development project was initiated to optimise the full-life cycle further development of the asset and was conceptualised to mature the contingent resources in the fields. The project involves the drilling of 15 new wells and 3 work over wells from existing platforms and 5 new wells from a new drilling centre, with a tie-back to existing platforms and pipeline system.

As part of the Department of Petroleum Resources (DPR) Environmental Impact Assessment process highlighted in Part VIII – A, Section 3.1.2 of EGASPIN, 2002, the assessment of impacts, focused on the selected project option for potential significant and adverse environmental effects. Consequently, SPDC was mandated by DPR to conduct an Environmental Impact Assessment (EIA) for the EA/EJA FOD Project which will be subjected to review and approval by DPR. This EIA (a revalidation of earlier EIA conducted in 2016) contains the proposed project activities, project options/alternatives, existing environmental conditions, impact qualification and quantification and potential/associated impacts of the proposed activities.

### **ES 2.0: Project Location**

The EA/EJA field is shallow offshore located in the south-eastern section of OML 79 about 90km southeast of Warri and 15km from the mouth of the Dodo River in Bayelsa State at a water depth range of 13 to 30m. EA/EJA field was developed using a floating production, storage and offloading (FPSO) called “Sea Eagle” as the main facility processing fluids from the drilling platforms. Oil is evacuated by tanker and produced gas is exported through the offshore gas gathering system (OGGS) to Bonny NLNG plant.

### **ES 3.0: Objectives of the Environmental Impact Assessment**

The aim of the EIA is to address the environmental issues associated with the EA/EJA development in line with corporate policies and expectations, in order to meet all requirements and secure necessary support and approval for the development as part of responsible environmental management. The objectives of the Environmental Impact Assessment include:

- satisfy federal, state and local authorities on environmental matters as applicable to the development;
- generate data to establish the current environmental baseline conditions of the study area;
- identify and evaluate the associated and potential impacts of the proposed activity on ecological components;

- establish control and cost-effective strategies and procedures for adoption during the proposed field development to ensure environmental sustainability;
- develop an Environmental Management Plan (EMP) for the proposed development; and
- provide information and evidence needed for developing an Environmental Impact Statement (EIS) for the proposed developmental project.

### **ES 3.0: Proposed Project Scope**

The EA/EJA FOD project scope comprises of 3 workover wells, 15 new wells to be drilled from existing wellhead platform, and 5 new wells in a new platform. Other activities include the installation of well hook-up piping system and ancillaries, well control systems, process automation, instrumentation, control, safeguarding and gas-lift piping. Existing infrastructure comprising evacuation pipelines and umbilical (composite electrical & fibre optic cables) from existing platforms to the Sea Eagle FPSO including processing facilities on the Sea Eagle FPSO are sufficient to support this development.

### **ES 4.0: Proposed Project Activities**

The activities to be carried out for the project:

- Pre-Construction phase – Pipeline/Bulk lines offshore route survey (for the 5 wells scope);
- Mobilisation: Movement of personnel and equipment to site;
- Site preparation for the new wellhead platform;
- Fabrication of Well head Platform;
- Transportation/movement of Well Head Platform from fabrication base to site;
- Installation and positioning of Wellhead Platform;
- Well Drilling: 15 oil wells from existing DPA, DPB and DPJ Wellhead Platform & 5 oil wells from a new wellhead platform DPC;
- Piping/flow lines, well hook-up for the 15 wells from the existing platforms. A new 5 Well Head Platform – DPC with offshore Pipelines/Bulk lines;
- Civil works/related infrastructure for the new platform (DPC);
- Pipe welding, coating and testing;
- Hydro testing of pipelines/Bulk lines (DPC);
- Commissioning of pipelines; and
- Demobilisation of personnel and equipment.

### **ES 5.0: Initial Identification and Analysis of Project Options and Alternatives**

#### ***Project Options/Alternatives***

The development options proposed by EA/EJA FOD studies were centred on optimal well placements, slot availability in existing or proposed platforms, recompletion opportunities and timing of new wells. Scenarios focus on several alternatives with a view to optimizing well placements and the drilling sequence to maximize recovery in view of the key value drivers for

the project. Furthermore, the project options took cognizance of Environmental, Safety and Operational considerations. The Project options were based on Location, Drilling, Pipelines and the need for an FPSO.

### ***Project Options***

Four project options were considered. These include No Project, Delayed Project, Produce all Wells from New locations/Platforms and Produce more wells from existing platforms/locations in the EA/EJA field. The last option Produce more wells from existing platforms/locations in the EA/EJA field was recommended. It offered the following advantages (1) Reduce Environmental footprint (2) Availability of valid existing environmental data (3) Additional wells will be hooked up to the already existing Sea Eagle FPSO and as such the infrastructure, hardware, software and processes will be the same (4) It will encourage the use of new technology such as the Conductor Sharing/Splitter Wellheads Systems (CSW) which will maximize the use of the existing platform slots, lower project development costs and reduce installation time (5) Fast tracked/early first oil date (6) Optimized human and material resources and (7) Optimized energy usage on the Sea Eagle FPSO. The disadvantages of this option were (1) Drilling from existing location could be challenging and (2) Increase pressure on existing facilities in the EA/EJA field.

### ***Drilling Options***

The drilling options considered were five. They included (1) Chase the barrel (2) Minimum CAPEX (3) Maximum Recovery (4) Minimum CAPEX and Optimized Development and (5) Maximum Production and Maximum CAPEX. The drilling option recommended was option 3 Maximum Recovery. It had the following advantages (1) Increased hydrocarbon recovery and (2) Optimal lifecycle development of the field. The disadvantages in this drilling option included (1) Increased capital expenditure (2) Increased risks (3) Increased impact on the environment (4) More additional footprints.

### ***Surface facility (FPSO) options***

Three surface facility options were considered. They include (1) New FPSO/No FPSO (2) FPSO Re-deployment and (3) Tie-Back to existing Sea Eagle FPSO. The option considered was the third option, Tie-Back to existing Sea Eagle FPSO. The advantages of this option include (1) Reduced Cost (2) Accelerated First Oil Date (3) Reduced Environmental Foot print (4) Availability of valid existing data (5) Reduced Risk (5) Optimized human and material resources (6) Optimized energy usage and (7) Production process is already tested and running.

### ***Pipeline Route Options***

The Site and Concept Analyses (SCAN) tool was used to weigh the selection criteria and the identified pipeline route options were compared with each other and a ranking of the route options developed. Selection criteria used for the evaluation include: Seabed obstructions,

Environmental Impact/Seabed Features – Depressions, Pock marks, etc, Pipeline Crossings and pipeline length. Five routes were considered:

- Route 1 (2672m): Departs DP-C on a North-Westerly path, turns to the South West and finally turns east towards DP-B. Crosses 3 pipelines twice and an umbilical
- Route 2 (2310m): Departs DP-C on a North-Westerly path, turns to the South West and finally turns east towards DP-B. Crosses 3 pipelines twice and an umbilical
- Route 3 (1930m): Departs DP-C on a North-Westerly path, turns to the South West and finally turns east towards DP-B before crossing any existing facilities. Only crosses 2 pipelines and an umbilical at the platform approach. In close proximity to existing spud cans at the DP-B approach.
- Route 4 (1740m): Departs DP-C on a North-Easterly path, turns to the South East and finally turns west towards DP-B after crossing 3 pipelines twice and an umbilical.
- Route 5 (1340m): Approximately straight line between both platforms. Crosses 3 pipelines twice and an umbilical before approaching DP-B from the South. Traverses small depressions and rig approach area.

Based on the criteria for route selection and the SCAn tool Option 2 was the most favourable route.

#### **ES 6.0: Decommissioning/Abandonment**

The No Further Activity (NFA) of the EA/EJA field is currently 2022, and with this project it shall extend to 2027. The Sea Eagle shall be taken out of service then, and all other facilities shall be decommissioned in line with SPDC decommissioning plan and standard offshore practice.

#### **ES 7.0: Waste Management**

Wastes from the drilling and flow lines construction shall be managed in accordance with the current SPDC waste management policy and other regulatory requirements. The strategy for waste management will include waste segregation at source, reduction, recycling, reuse, treatment of toxic and hazardous wastes to make them innocuous before disposal.

#### **ES 8.0: Description of the Existing Environment**

The current environmental status of the EA/EJA field has been investigated, evaluated, described and documented in this report. The purpose of the EIA are two folds (1) to establish, before the execution of the new project components, the status of the various environmental components that were likely to be impacted by the proposed project (2) to determine the impact of the existing facilities (FPSO discharges, platform corrosion and pipeline leaks and corrosion) on the various components of the environment within the EA/EJA field. The environmental components evaluated comprised ecological parameters that affected the seawater and sediment. In addition, the status of the various ecological components of the project area were assessed from review

and comparison of data obtained in 2018 with data obtained in 2001 and 2011 (EIA of EA field (2001), EES of EA FOD (2011) and EIA FOD 2015). Statistical tools such as analyses of variance (ANOVA), Chi square goodness of fit test, ratio 1:1 and Dunnett's test were employed to determine spatial variations between the control stations and sampling stations, their sources and variations with time (trend). The atmospheric condition of EA/EJA field located in OML 079 in the Gulf of Guinea has been evaluated by monitoring some noise levels, microclimatic and air quality parameters.

### ***Meteorology, Noise and Air Quality***

SO<sub>x</sub>, NO<sub>x</sub>, CO<sub>x</sub> and H<sub>2</sub>S were not detected in any of the sampling locations both in the Field operations area and at the control locations, they were taken to be within DPR set limits per Hour. This implies that SO<sub>x</sub>, NO<sub>x</sub> and CO<sub>x</sub> were within their 350, 400 and 30 µg/m<sup>3</sup> DPR hourly limits. SO<sub>2</sub> was within its <19.9 µg/m<sup>3</sup> limit per hour, CO<sub>x</sub> was within its <8.7 µg/m<sup>3</sup> limit and H<sub>2</sub>S was within its <1.1 µg/m<sup>3</sup> limit. Though NO, CO<sub>x</sub>, SO<sub>x</sub> and H<sub>2</sub>S are combustion products thus being expected in the area of operation in the Field including the FPSO operations and other oil prospecting and production activities, their non-detection in any of the sampling locations could be an indication of good operational practice and better maintenance of the identified combustion sources. Suspended particulate matter (SPM) was detected in all the sampling locations including the control stations. It was measured to have minimum of 0.5 µg/m<sup>3</sup> and maximum of 42.0 µg/m<sup>3</sup> at EA82 and it also fell within DPR limits of 60-90 µg/m<sup>3</sup>.

The minimum ambient noise levels in the field operations area during the study was 68.9 dB(A) while the maximum level was 75.4 dB(A). At the control sites the ambient minimum noise levels were 70.9 dB(A) but the maximum levels were 73.2 dB(A). The previous report shows that the minimum ambient noise levels in the field operations area during the study were 56.9 – 72.8 dB(A) with the maximum levels of 63.8 – 80.8 dB(A). At the control sites the ambient minimum noise levels were 58.8 – 62.0 dB(A) but the maximum levels were 69.8 – 79.5 dB(A). Though the measured minimum noise levels at the Field operations area were higher than the mean 60.4 dB(A) obtained at the control points, these were within the 70 dB(A) industrial area ambient noise limit of the World Bank and within the 85 dB(A) 8-hour shop floor limit of the DPR. Maximum noise levels at the Field operations area breached the 70 dB(A) industrial area limit only in about 31% of the sampling locations but within the DPR's 85 dB(A) 8-hour shop floor limit in all the investigated sites. In all the sampling locations during the study, sources of noise were production activities and the sampling vessel. However, at the control stations sampling vessel was the major source. With the obtained results of the ambient noise level in the study area being below the limits, the EA/EJA field operations could be described as not impacting negatively on the ambient noise levels of the host environment. This may mean that those identified noise sources were properly maintained.

The trending of air quality from 2011 to 2018 revealed an increasing trend VOCs, SPM and noise which were attributed to ongoing activities in the field at the time of studies such as gas flaring and power generation. However, all concentrations were below regulatory limits. From the concentrations of air quality parameters and ambient noise levels obtained during the study, the investigated airshed can be classified as un-degraded using the World Bank and DPR limits. The sources of air pollutants and noise identified during the study could be referred to as under proper maintenance.

### ***Surface Water Studies***

#### ***Physico-chemistry***

Seawater heavy metal concentrations were generally higher in the sampling stations than the control. A significant increase in seawater heavy metal and TPH concentrations with decreasing distance from FPSO suggested the facility as a possible source. Polycyclic Aromatic Hydrocarbons and BTEX were not detected in the seawater. Oil and Grease and TPH were generally below 10 mg/l which are well below the DPR effluent discharge limit of 20 mg/l. Surface water trending from 2001 showed increasing concentrations of most parameters attributed mainly to increasing impacts of land-based and maritime human activities including coastal waste discharges and crude oil operations. Surface water trending showed increasing concentration of most parameters attributed mainly to increasing impacts of land-based and maritime human activities including coastal waste discharges and crude oil operations.

#### ***Microbiology of Seawater***

There was generally no significant horizontal variation in the population of microbial parameters (THB, TF HUB and HUF) between sampling stations and control stations indicating that impact of facilities (FPSO and platforms) on some microbial parameters was insignificant. However, significantly high faecal coliforms associated with the discharge of treated sanitary waste water were observed in most of the platforms close to the FPSO. However, the faecal coliform population in all the instances was within the DPR offshore and near shore discharge limits of 400MPN/100ml and 200MPN/100ml respectively for treated sanitary waste water.

#### ***Phytoplankton***

Interestingly, all the 44 phytoplankton species were present at all the control stations during the survey. Results of the Multivariate analyses, clearly indicated that all the sampling sites were linked together at 65% similarity, implying high similarity in the species composition and abundance at the various sampling points. Four major families of phytoplankton were recorded; namely Bacillariophyceae (Diatoms), Chlorophyceae (Green algae), Cyanophyceae (Blue-green algae) and Dinophyceae (Dinoflagellates). In all the stations, Bacillariophyceae (Diatoms) were the dominant family and contributed a minimum of 49.95%. The Chlorophyceae (Green algae), and Cyanophyceae (Blue-green algae) made the least contribution to phytoplankton flora in terms of species composition. Relatively, this division of phytoplankton contributed 15.30 – 15.75% of the number of species in the whole study area. From the previous studies,

Bacillariophyta were also the dominant family and contributed a minimum of 47.5% in proposed platform near EA – DP-J and a maximum of 86.21% of the species in the proposed platform northeast of EA DP-A. The Euglenophyta made the least contribution to phytoplankton flora in terms of species composition. Relatively, this division of phytoplankton contributed 1.64 - 10.34 % of the number of species in the whole study area. The second dominant phytoplankton division are the Cyanophyta and they contributed 12.31 - 32.76% while Chlorophyta contributed 4.92 - 19.97% of the total count. Major species of Bacillariophyta in the study area include *Amphora ovals*, *Biddulphia aurita*, *Corethron sp*, and *Coscinodiscus rothii*, Key species of chlorophyta include *Closterium lineatum*, *Halosphaera spheroides*, *Phacolus* and *Scenedesmus acuminatus*. In all, the dominance pattern of the various families of phytoplankton was, Bacillariophyta> Cyanophyta> Chlorophyta> Dinophyta>Euglenophyta.

A comparison of Phytoplankton indices from 2001 to 2018 showed increasing trend in the phytoplankton species number from 19 species in 2001 to over 80 species in 2011 and 2015 followed by a decrease in 2018 (max 44 species). In contrast, an over 6-fold increase occurred in the density of phytoplankton in 2018 compared to 2015. A decrease in phytoplankton diversity with concomitant increase in density shows a tendency towards eutrophic conditions. Irrespective of the year of study, Bacillariophyceae (Diatoms) remained the most dominant phytoplankton around Sea Eagle FPSO showing the high stability in the system with minimal environmental stress. Diatoms are widely reported as the most abundant and dominant phytoplankton taxa in unpolluted tropical coastal waters.

### **Zooplankton**

The presence of fish eggs in the zooplankton of the area is a signal of fish production capacity of the area interplayed with other fish larvae which were predominantly recorded in the zooplankton. The abundance and high diversity of copepod crustaceans in the water column of the OML 79 Field interplayed with high Marglaef's index, is an indication of clean environment.

The previous report on zooplankton fauna indicate that facilities around the EA/EJA FOD were categorized into rotifers, cladocerans, molluscan larvae, decapod and copepod crustaceans, euphausians and pisces. From the percentage composition of each of these major zooplankton in all the facility and in all the stations, rotifers was the dominant zooplankton group and contributed a 12.5 - 32% of the zooplankton species. Major species of zooplankton that were recorded in the study area include *Asplanchna brightwelli*, *Asplanchna priodonta*, *Condonella ucinata* and *Brachionus angularis*. Similarly the Cladocera were the second dominant group. Members of this group include *Chydorus sp*, *Polyphemus pediculus*, *Alona affinis* and *Alona intermidia*. Larval forms of fish (Pisces) made the least contribution to zooplankton.

The order of dominance of zooplankton was represented by Crustacean copepods > Cladocera > Pices Larvae/fish eggs > Polychaete larvae > Rotifera>Appendicular > Crustacean decapods >

Mollusca Larvae > Chaetognatha. Zooplankton was characterized by marked increasing trend in species diversity and density from 2001 to 2015. While species diversity decreased in 2018, zooplankton density increased almost 10-fold in 2018 compared to 2015. Decreasing diversity combined with increasing density of organisms usually point to a stressed system. The presence of polychaetes in the plankton of 2018 is also a pointer to the subtle pollution of the system as polychaetes are usually associated with polluted/organically enriched environments. Generally, Copepoda dominated the zooplankton community during all studies, reflecting the typical community structure in the tropical oceans and showing the relative stability in the area.

### ***Sediment Studies***

The sediments were moderately reducing (negative redox potentials) but considered normal for clay dominated environments. Sediment TOC was generally low suggesting absence of organic pollution. Sediment heavy metals were mostly below detection limits but chromium and cobalt showed values that were higher than those of the controls while all other metals detected including nickel, iron, lead, zinc, cadmium and barium were similar to those of the control levels. PAH and BTEX were not detected in the sediments. Oil and grease and TPH varied generally with no apparent trend compared to control. Sediment TPH levels were however generally low compared to the DPR target limit of 50 mg/kg indicating absence of any significant oil pollution in the area. The absence of PAH and BTEX compounds in the sediment were indicative of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area.

The possible impact of the existing facilities on sediment quality was assessed by comparing average values of results obtained during the Sea Eagle EIA (2001), FOD-EIA (2011), and EE study (2015) as well as EIA 2018. Apart from decreasing trend observed in Redox, measurements in 2018 were characterized by increases in iron, copper, zinc, chromium, cobalt and cadmium. Although some parameters measured at the FPSO showed a decreasing trend with distance from the facility, the apparent increases observed in this trending may be attributed to both crude oil related operations and other marine and land-based inputs of contaminants.

### ***Microbiology of Sediment***

In many of the facilities there were higher counts of the microbial populations (THB, TF and SRB) in the sampling stations than in the control stations. The high heterotrophic microbial populations were attributed to the availability of readily oxidizable organic substrates introduced into the sediment from the sinking of heavier portions of the treated sanitary waste water from the FPSO. The hydrocarbonoclastics were not identified in the sediments including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were also not identified across the receptor distances including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project.



### ***Benthic fauna***

The most noted bio-indicator macrobenthic group, the Polychaeta- were generally scanty within the field. Polychaetes are known to thrive well where the environment is under the threat of oil pollution. The scanty nature of this very important bio-indicator signals the ecological stability of the OML 79 Field. This interplayed by the dominance of the Mollusca group of macrobenthos and the Scaphopods (*Dentilium vulgare*) is a strong indication that OML 79 field is not presently threatened by oil pollution. Total of 23,509 macrobenthos were recorded from 9 major groups of macrobenthos during the study within the OML 79. Previous report showed that Benthic fauna identified in the EA/EJA field belonged to polychaetes, crustaceans, bivalves, gastropods, bivalves, insecta and pisces. During the present study, the general pattern of benthos in the area was in the following order: Gastropod molluscs> Bivalve Molluscs> Bryozoans> Echinodermata> Scaphopoda> Polychaeta (Annelids) > Sponges> Crustacea> Chordata. Trending of benthos data within Sea Eagle FPSO showed a marked increasing trend in benthos density and species numbers from 2001 to 2011 with a reduction in 2015 followed by over 20-fold increase in 2018. Such variation may be linked to sediment quality and overlying water hydrodynamics. The stability of the area over the years is apparent from the dominance of the benthos by molluscs. The occurrence of Polychaetes from 2001 is a further support to the stability of the ecosystem. In previous studies, Polychaetes were generally the dominant benthic organisms in all the facilities and all the stations. This group of benthos contributed 26 to 50% of total count of benthos in the study area and consisted mainly of *Arenicola marina*, *Capitella capitata*, *Notomastus laterella*, *Nereis diversicolor*, *Nereis virens*. The second dominant benthos were the crustaceans with a contribution ranging from 18 - 33% of the total count of benthos. Key species of crustaceans include *Ballanus*, *Alpheus monodi*, *Gammarus*, *Tianid* sp.

### ***Fisheries***

Thirteen (13) species of fish belonging to 11 families were identified in the field. Available literature also shows that four (4) more species can also be found in the locality (Schneider, 1990). Clupeid fishes namely *Pseudotolithus elongatus*, *Ethmalosa fimbriata*, *Ilisha africana*, *Sardinella*, *Pellonula*, were the most abundant fish and constitute about 25% of the fish in terms of number. Fishing activity was largely by artisanal fishers who operate in motorised and un-motorised wooden canoes. The fecundity of *Pseudotolithus typus* (the longneck croaker) which was observed to be the most commercially important fish species in the artisanal fisheries within the OML79 field during the 2018 studies was generally high. Apart from the high fecundity, other parameters of fish condition such as gonadosomatic index (GSI), condition factor (K) and Gonad – free weight, were high which could be attributed to a stable and unpolluted environment. This was supported by the observed high intensity of artisanal fisheries activities in the area.

Tissue levels of heavy metals measured in the fish species (Gills, Stomach and Muscle) was in the following order: Co > Cr > Cd/Ni > Pb. The heavy metals levels were generally below the

stipulated WHO, FEPA and FAO limits for seafood. From the observed concentrations of the heavy metal in the tissues, heavy metals were not accumulated in the fish to any significantly extent that would be detrimental to the ecosystem. Similarly, the results of the TPH analysis of the fish tissues showed that the TPH values were well below the UNESCO/WHO/UNEP (1992) maximum permissible limit of 100.0 mg/kg indicating that the environment was not polluted with petroleum hydrocarbons and that the fish species were safe for human consumption. BTEX were not detected in the fish specimens.

### ***Marine wildlife***

Wildlife reported in Nigeria's near-coast waters include marine mammals and sea turtles. The mammals include members of the toothed whales, the *Odontoceti* and the common dolphin (*Dolphinus delphis*). Other whales such as *Dolphinus and Steno* and the manatee belonging to the genus *Tricheus* have also been observed in Nigerian coastal waters and the wider Gulf of Guinea. Among the marine reptiles, the sea turtles belonging to the Cheloniidae and Dermochelidae and consisting of five genera and six species (Dublin-Green and Tobor, 1992) have been reported. Some of the documented sea turtle species and their IUCN status include:

- Green sea turtle (*Chelonia mydas*) = EN (endangered)
- Hawksbill sea turtle (*Eretmochelys imbricata*) = CR (critically endangered)
- Leatherback sea turtle (*Dermochelys coriacea*) = CR (critically endangered)
- Loggerhead turtle (*Caretta caretta*) = EN (endangered)
- Olive ridley (*Lepidochelys olivacea*) = EN (endangered)

The FAO Species ID Sheets (1981) also gave the following periods as breeding seasons for the different turtle species;

- Leatherback - September to February
- Olive Ridley - August to December
- Green turtle - July to November
- Hawksbill - September to February
- Loggerhead - April to September

Offshore drilling including oil rig operations are known to negatively impact marine wildlife in multiple ways.

### **Social Profile**

The proposed EA/EJA FOD project is contiguous to about twelve major neighbouring communities including Ezetu, Ekeni, Bisangbene, Amatu I, Amatu II, Letugbene, Orobiri, Azamabiri, Agge, Bilabiri I, Bilabiri II and Ogbeintu. Ezetu and Ekeni communities are located in the Southern Ijaw Local Government Area while the remaining 10 communities are located in Ekeremor Local Government Area (LGA) of Bayelsa State, situated in the South-South geopolitical zone of Nigeria. Principally, these communities lie between the Ramos and Pennington Rivers. With respect to ethnicity, all the communities within the area are homogeneously Ijaw (or Izon). The settlement pattern of the habitations in the area is scattered and linear along the

coastal sand bars. Despite the diversities in cultural beliefs, the people freely move between their traditional religious/cultural practices and Christianity as situation demands. However, Christianity is increasingly becoming the dominant and covenanted religion. All communities in the study area have communal deities and shrines, sacred bushes, sacred streams and waters.

The population of the communities is increasing and shows a skewed distribution in favour of lower age-cohorts of persons below 18 years old, with high dependency ratio. The sex-ratio is approximately 1.13 males to 1 female with a modal educational level of primary school attainment. The declined rate of divorced household heads in the area between 2008 (6.4%) and 2012 (1%) is an indication that the indigenes valued marriage. The 2012 field survey showed an average of 8 persons per dwelling unit with about 37% households having between 7 and 10 persons in a family as against 46.2% of households in 2008 having 7-10 persons.

The local economy is consistently dominated by fishing, farming and petty trading. However, there is reduction in the number of fisher folks and increased in number of crop farmers in the communities, and the income generated have also nominally increased between 2008 and 2012. The general quality of life measured in terms of housing types, productive and household asset ownership, and presence of functional social infrastructure in the communities was noted to be consistently low, suggesting poor standard of living and high level of poverty among the residents of the communities. Alcoholism is becoming a lifestyle in the coastal communities as well as smoking of cigarettes and Indian hemp especially among the youths. It is common to see youths smoking and drinking strong beverages in public places.

There exists a strong leadership structure at the community level in the study area. Governance system is typical of well-developed hierarchical structure that is gender and age sensitive, which have in-built mechanism to provide social cohesion, security and conflict management, prevention and resolution.

The general opinion of the inhabitants was that the communities have received more of negative impacts than positive impacts from the existing EA (Sea Eagle) facility located about 15 km offshore.

### **Community Health Profile**

The commonest ailments and diseases in the EA/EJA neighbouring communities are: malaria, skin rashes, conjunctivitis, cough, respiratory diseases, gastro-enteritis, hernias, leg ulcers and sexually transmissible infections. The integrated disease surveillance response data for Bayelsa State, (for both in-patients and out-patients) in 2005 revealed that the top three diseases recorded in the State were infectious diseases: malaria 49.88%, diarrhoea 23.65% and sexually transmissible infections 20.24%. Mortality (deaths) among the most vulnerable population

groups, children under-five years and women of child-bearing age, have been reported to be high in Bayelsa State.

A major deficiency in the EA/EJA neighbouring communities is the lack of healthcare facilities. The main sources of healthcare delivery in the area are patent medicine stores, traditional healers and traditional birth attendants (TBA). To treat the severely sick, community members travel to Warri in Delta State and Yenagoa in Bayelsa State. The immunization coverage in the communities is low as Bayelsa State lags behind the regional and national average.

The nutritional pattern in the community follows the general trend in several parts of the country in which starchy food constitute a large part of the family diet. These starchy foods include cassava, rice, yam, garri, dried cassava chaff (kpokpo garri) etc. Fish and other seafoods such as, shrimps, crayfish, and oysters are the sources of protein.

The awareness of the existence of STI in the communities was high. Despite the high awareness of the existence of HIV/AIDS, some respondents have low knowledge of the mode of its transmission. The proportion of women and men with comprehensive knowledge of HIV/AIDS in Bayelsa State was found to be higher, than figures for South-South zone and Nigeria. Alcoholic beverages were freely available and at all times in the communities, while about 20% of the adult males in the communities smoke cigarette.

Access to potable water is a major problem in the area. Water for drinking and sundry domestic needs is obtained from hand dug wells (often of high salinity), creeks and rainwater. The wastes generated in the area were from domestic, agricultural and fishing activities. These wastes are disposed by open dumping on land, water bodies and at times used as manure in the farms. There is no waste recycling. The houses are mainly small huts with inadequate ventilation and overcrowded.

### **Consultations**

The identified stakeholders for EA/EJA FOD project were governments (Federal, Bayelsa State, Southern Ijaw and Ekeremor LGAs), regulators (FMEnv, Bayelsa State Ministry of Environment, DPR.), 11 communities, CBOs, NGOs, Media, consultants, etc. The scoping workshop held on Thursday September 05, 2013 at the conference hall of Matho-Crystal hotel, Yenagoa served as the first contact between SPDC and the various stakeholders and the neighbouring communities involved with the project. Stakeholders were made to express their perceptions and expectations, identify potential impacts (adverse and beneficial), propose measures to mitigate the negative impacts and enhance the positive impacts.

Interaction with the community was positive and there was widespread appreciation of the consultation process undertaken. The requests made by the various communities are summarized

as follows: creation of job opportunities for the neighbouring communities during the project execution phase; provision of potable water, electricity, cottage hospitals and river transportation; involvement of the communities in the EIA study; and implementation of appropriate mitigation measures.

In response SPDC advised the communities to include areas of concerns relating to the provision of infrastructure in their Participatory Rural Appraisal Programmes for greater attention by SPDC. In addition, SPDC reiterated that all complaints/issues raised outside the context of the project shall be sent to appropriate authorities. The workshop outcome is among the basis for the EIA study as consultation will be continuous and all mitigation measures shall be implemented.

### **ES 9.0: Impact Assessment**

The significant potential impacts from the proposed project activities, the significant existing impacts from operation of the existing facilities and the cumulative impacts derived from the combination of both the potential and the existing impacts were assessed. The ISO 14001 method was used for evaluating the potential impacts.

#### ***Potential Impacts***

The significant potential impacts from the various project activities in the various project phases (Premobilization, Mobilization, Construction, Operation, Demobilization and Abandonment) were identified. The significant negative/adverse impacts included impairment of air quality, risk of accidents, risk of piracy and kidnapping, increase in noise and vibration, interference with fishing activities and contamination of water bodies. All these impacts occurred generally during most of the project phases.

#### ***Existing impacts***

The significant existing impacts between 2001 and 2018 were determined and combined together as existing impacts. The existing impacts from operations within the EA/EJA field (FPSO, existing platforms, and pipelines) included impairment of air quality due to VOC and SPM concentrations above regulatory limits probably due to gas flaring and other sources of emission. Existing impacts also included above regulatory levels of Pb, Fe, Cr, Cu, Ni, Cd, Z, Ni, N, P, and TPH in the surface water and sediment possibly from chemicals spills, drill cuttings, and mud and well as land-based and ocean vessel's discharges.

#### **Cumulative impacts**

These were derived from the combination of both Potential and Existing impacts. Mitigation measures were then proffered for these cumulative impacts.

### **ES 10.0: Mitigation Measures**

Mitigation measures have been provided for the negative impacts rated significant (moderate or major). Negligible/minor impacts shall be addressed by existing SPDC standard operating practices. The proffered measures are intended to reduce the impacts to As Low As Reasonably Practicable (ALARP). The proposed measures took into account the following:

- Department of Petroleum Resources guidelines and standards,
- National, regional and international Environmental laws,
- Best Available Technology for Sustainable Development;
- Social wellbeing and
- Concerns of stakeholders

Risk of Accident shall be mitigated by ensuring SPDC journey management plans are complied with, only pre-mobbed water and air borne crafts are used, workers have TBOSIET certificate and use appropriate PPE (life jackets and work vests/floaters) and are swim certified. Also emergency response, first aid measures and Medevac procedure shall be put in place in addition to daily toolbox meetings, proven project induced injuries, accidents and fatalities on third parties are compensated.

Risk of Piracy and Kidnapping shall be mitigated by ensuring that adequate security strategy is developed for the project, all necessary arrangements are made with responsible government security agents to improve security, security management plan for the project is adhered to, security orientation and awareness drills are conducted for workforce and neighbouring community youths are provided with worthwhile ventures such as skills acquisition.

Impairment of air quality shall be mitigated by use of only pre-mobbed and well-maintained water crafts, vessels, generators and other machines, ensuring that only low sulphur fuels and low NOx burners are used in large generators and turbines. Impairment of air quality as it relates to VOC and SPM shall be mitigated by ensuring that ambient air quality is monitored in line with DPR requirements, combustion systems are regularly maintained and standard equipment which meet existing emission requirements are used.

Increase in Noise and Vibration shall be mitigated by use of only pre-mobbed and regularly maintained equipment and water craft, provision of acoustic mufflers for heavy engines with high noise levels, enclosure of high sound energy equipment in noise insulators, use of appropriate PPE such as ear muffs/plugs and not deploying workers with hearing impairment to site.

Injuries and death from blowouts shall be mitigated by ensuring the use of only skilled and certified personnel, use of appropriate blowout prevention fluids, use of appropriate mud density, ensuring that emergency response procedures are in place, job hazard assessments and daily pep talks conducted and blowout preventer (BoP) used during drilling.

Surface water and sediment pollution from chemicals, drill cuttings and muds by heavy metals, nutrients and petroleum hydrocarbons shall be mitigated by ensuring that oil-based mud are recycled, wells are drilled with water-based mud in top hole, SPDC waste management plans are in place and followed, effluents from decommissioning activities are treated to regulatory standards before discharge.

Interference with fishing activities shall be mitigated by provision of timely information to stakeholders particularly the fisher folks in the nature and timing of activities which may lead to direct interference with fishing activities.

Impact of waste shall be mitigated by ensuring that all waste generated are managed in line with SPDC waste management guidelines, involving regular collection and monitoring of waste from cradle to grave, oily wastes properly segregated and contained before disposal, sanitary wastes treated in sewage treatment plants etc, manage radioactive wastes in line with Nigerian Nuclear Regulatory Authority (NNRA) approved procedures.

Loss of employment shall be mitigated by making the workers aware that the employment is temporal, supporting microcredit schemes, implementing worker disengagement plans, supporting skills acquisition plans of government, NGOs and CBOs

Gas flaring shall be mitigated by ensuring no routine flaring of associated gas, sending all AG to NLNG via OGGS. Pollution from Produced water shall be mitigated by treating to regulatory standards before discharge. Exposure to radiation material shall be mitigated by conducting health awareness training prior to commencement of activities, carrying out routine medical check-ups for radiation exposure, provision of radiation monitors at site, use of radiography aprons to protect from radiation, warning signs during radiation emitting activities, radiation emitting activities carried out in line with standard specification

Inhalation of welding fumes, soft tissue damage from welding sparks and conjunctivitis from welding flash shall be mitigated by providing awareness sessions on health risks and safety precautions for welding operations, use of skilled personnel, use of appropriate PPEs (welding masks, jacket, gloves, boots and coveralls) during welding, provision of approved site clinic by contractor, pre-employment medical fitness certification of welders.

Potentials of conflict from labour issues shall be mitigated by ensuring that contractors respond to complaints by locals promptly on activities of their workers and deploying GMOU provisions on community labour issues.

Stress on existing security structure shall be mitigated by making arrangements with government security agents (Navy) to improve security, engaging stakeholders to minimize resentment, ensuring security management plan in place before mobilization and ensuring security awareness by all workers.

### **ES 11.0: Environmental Management Plan**

An environmental management plan has been designed for the field development project to guide the implementation and assessment of the effectiveness of the mitigation measures in controlling identified significant associated and potential impacts. The plan provides for management commitment/responsibility, training/awareness programmes for the workforce, audit and compliance monitoring of the various environmental components.

### **ES 12.0: Conclusion**

The EA/EJA FOD Project Environmental Impact Assessment has been conducted and details obtained described herein. The environmental description was based on recent data obtained from the Field Data Gathering (FDG) of the EA FOD areas conducted in November 2018 as well as from comparison with past studies.

The area of influence of the proposed project (drilling of wells, platforms and pipeline construction activities) were also covered during the FDG. The environmental components covered include: Air quality and noise, Surface water, Sediment, Hydrobiology and fisheries, Social and Health Profile. The results showed that air quality and noise levels were generally within the DPR limits of daily average values and compared favourably with the control stations. A significant increase in sea water heavy metal and TPH concentrations with decreasing distance from FPSO suggested the facility as a possible source. However, other anthropogenic sources such as effluents from water crafts cannot be ruled out. Similarly, the concentration of heavy metals and organics were generally within the DPR target and intervention values for micro pollutants in sediments.

This EIA has identified, revalidated and addressed the environmental issues and proffered mitigation measures to reduce negative impacts associated with the proposed project. In addition to the above studies, SPDC conducts weekly Environmental compliance monitoring in the EA/EJA field and has a robust waste management system for existing facilities in the EA/EJA field. This demonstrates SPDC's resolve to sustain a mechanism for internationally acceptable environmental management practice. In the light of the above, having evaluated all potential, associated and cumulative impacts of the existing facilities and the proposed project in the



EA/EJA field, proffered mitigation measures and developed an Environmental Management Plan in line with international best practises, we hope that an approval/permit to commence work is granted.

## **CHAPTER ONE INTRODUCTION**

### **1.1: Introduction**

The Shell Petroleum Development Company of Nigeria (SPDC) on behalf of the Joint Venture Partners (Nigerian National Petroleum Corporation, Total Exploration and Production Nigeria and Nigerian Agip Oil Company) intends to develop 70.5 MMstb of contingent oil resources in EA and EJA fields to increase the fields' economic production life. The development project was initiated to optimise the full-life cycle further development of the asset and was conceptualised to mature the contingent resources in the fields. The project involves drilling 15 new wells and 3 work over wells from existing platforms and 5 new wells from a new drilling centre, with a tie-back to existing platforms and pipeline system. The total well count is 20 new wells and 3 work over wells. The existing infrastructure, comprising evacuation pipelines, and composite umbilicals from DP-B to the Sea Eagle FPSO including processing facilities on the Sea Eagle FPSO which would be sufficient to support this development. are all proposed. The future field expansion would involve the development of drilling platform D and K (DP-D and DP-K).

As part of the Department of Petroleum Resources (DPR) Environmental Impact Assessment process highlighted in Part VIII – A, Section 3.1.2 of EGASPIN, 2002, a Preliminary Assessment of Impacts was conducted for the field in 2016. This is a revalidation of the work earlier done and involves the identification, evaluation of field development impacts or risks, mitigation of adverse impact and management of the project.

Consequently, SPDC has been mandated by DPR to conduct this Environmental Impact Assessment Report (EIA) for the EA/EJA Further Oil Development (FOD) Project which will be subjected to review and approval by DPR. This EIA contains the proposed project activities, project options/alternatives, environmental conditions, impact qualification and quantification of the existing impacts of facilities in the EA/EJA field and the potential/associated impacts of the proposed activities and environmental management plan.

### **1.2: Objectives of the Environmental Impact Assessment**

The EIA aims at identifying and addressing, the environmental issues or complexity associated with the field development in line with corporate policies and regulatory compliance, in order to secure necessary support and approval for the commencement of project.

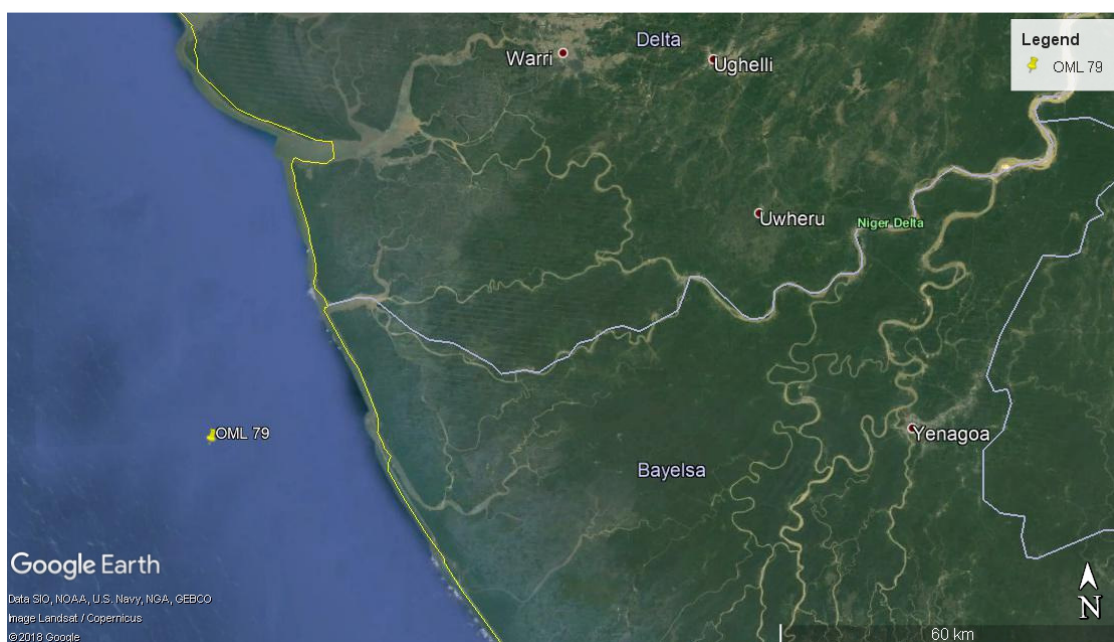
Objectives of the SPDC -FOD EIA are as follows:

- satisfy federal, state and local authorities on environmental matters as applicable to the development;
- generate data to establish the current environmental baseline conditions of the study area;
- identify and evaluate the associated and potential impacts of the proposed activity on ecological components;

- establish control and cost-effective strategies and procedures for adoption during the proposed field development to ensure environmental sustainability;
- develop an Environmental Management Plan (EMP) for the proposed development; and
- provide information and evidence needed for developing an Environmental Impact Statement (EIS) for the proposed developmental project.

### 1.3: Project Location

The fields are located in shallow offshore in the south-eastern section of OML 79 about 90km southwest of Warri and 15 km from the mouth of the Dodo River in Bayelsa State at a water depth range of 13 to 30 m (Fig. 1.1). The EA/EJA field was discovered in 1965 and has been in production since December 2002.



**Fig.1.1: OML 79 Location**

### 1.4: EIA Scope of Study

The EIA scope includes:

- review of national and international regulations/ policies relating to the field development and associated activities to be carried out;
- review outcome / reports of previous environmental studies associated with past/ongoing oil/gas exploration and production activities in the study area;
- description of the proposed field development activities to enable impact identification and analysis;
- conduct one (1) season survey to update/revalidate environmental condition data;
- identify, predict and evaluate potential and associated impacts of the field development activities in the brown field environment;
- develop effective mitigation/ amelioration measures and monitoring programmes; and

- prepare EIA report following current regulatory guidelines and procedures.

### 1.5: EIA Methodology

The EIA methodology adopted (Fig. 1.2) was designed to ensure that the process complied with the Federal Ministry of Environment (FMEnv) and DPR requirements and guidelines. Information on the study area, activity design together with past experiences, were used for impact identification and evaluation and establishing mitigation and enhancement measures.

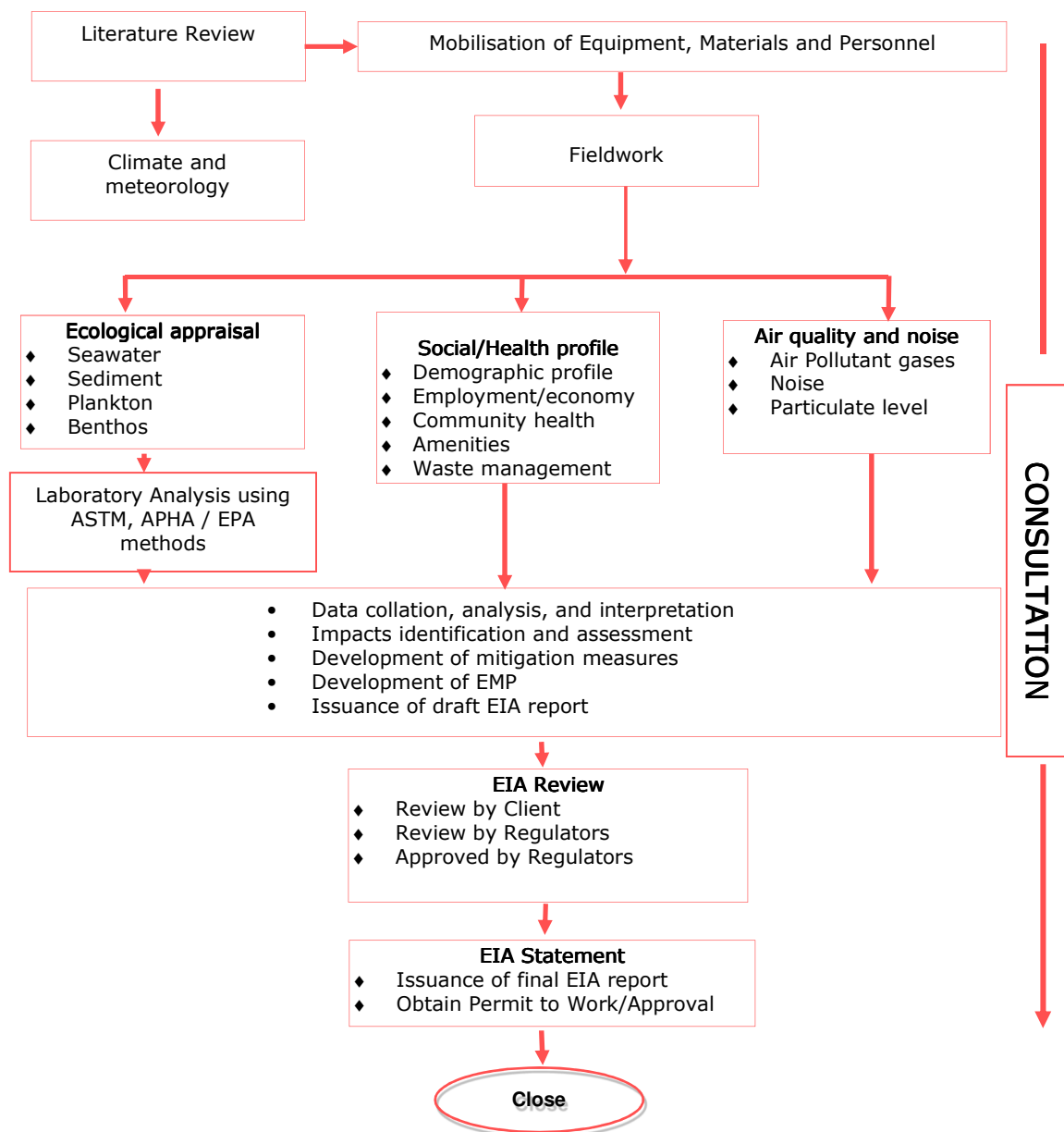


Figure 1.2: EIA Execution Process

### **Preliminary Activities and Field Data Gathering**

These includes activities leading to field survey and includes; EIA registration and notifications with DPR, EIA screening, Terms of Reference (ToR), desktop studies (literature review), material/ equipment preparation, mobilisation of materials and personnel to field. A one season field data gathering was carried out as earlier mentioned.

### **Sampling Design**

Samples for analysis were obtained from existing and additional (new) facilities designed and approved by SPDC and DPR respectively. These sample points took into cognisance existing facilities layout, existing/ proposed wells locations, spatial cardinal point distribution and meteorological/hydrological characteristics.

### **Data Analysis and Interpretation**

Samples obtained from the field survey exercise were transferred to the laboratory for analyses. Results obtained were interpreted and used for this study.

### **Impact Assessment and Mitigation**

The potential/ associated adverse and beneficial impacts of the field development activities on the existing environment were identified at this stage of the EIA. Identification, evaluation and characterisation of the impacts were carried out using specific criterion such as legal/ regulatory requirements, magnitude of impact, risk posed by impact, public perception and importance of affected environmental component. Results of identification and evaluation are presented in chapter five.

Mitigation measures designed to prevent, reduce or offset adverse impacts on the environment to as low as reasonably practicable were considered and documented in chapter six.

### **Environmental Management Plan**

An Environmental Management Plan (EMP) was developed as documented in chapter seven. The EMP is a tool used to ensure that all mitigation measures are implemented and adhered to during the project execution phases. The EMP enables a rapid response if an unforeseen environmental impact occurs.

### **1.6: 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:

### **1.6.1: Environmental Laws and Guidelines Guiding Environmental Management in Nigeria**

#### ***The Mineral Oil (Safety) Regulations, 1963***

Sections 37 and 40 of the mineral oil (safety) regulations, 1963, require provision of personal protective equipment (PPE) and the safety measures for workers in drilling and production operation in accordance with international standards.

#### ***Petroleum (Drilling and Production) Regulations (1969)***

The Petroleum (Drilling and Production) Regulations (1969), empowers the holder of an OPL to do practically anything in the area covered by the license {Section 15 (1)}, but Section 15(2) holds such a holder responsible for all the actions of his agents and contractors.

#### ***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.

#### ***FMEnv Sectoral and Procedural Guidelines for Oil and Gas (1995)***

In compliance with its mandate, FEPA issued the EIA Procedural Guidelines and Sectoral Guidelines for Oil and Gas Projects in 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. 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 labeling 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.

***FEPA (Now FMEnv) National Guidelines for Spilled Oil Fingerprinting (Act 14 of 1999)***

This provides guidelines for spilled oil fingerprinting applicable throughout Nigeria, in order to improve the quality of the environment and to free it from pollutants and other environmental and health hazards.

***Environmental Impact Assessment Act CAP E12 LFN 2004***

This Act provides guidelines for activities of development projects for which EIA is mandatory in Nigeria. The Act also stipulates the minimum content of an EIA as well as a schedule of projects, which require mandatory EIAs.

***National Oil Spill Detection and Response Agency (NOSDRA), 2006***

The National Oil Spill Detection and Response Agency (NOSDRA) was established in 2006 as the lead Agency in ensuring timely, effective and appropriate response to oil spills, through clean up and remediation of all impacted sites to all best practical extent.

***Associated Gas Re-Injection Act No. 99 of 1979 (CAP 26)***

An Act to compel every company producing oil and gas in Nigeria to submit preliminary programmes for gas reinjection and detailed plans for implementation of gas re-injection.

***Endangered Species (Control of International Trade and Traffic) Act 11 of 1985***

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.

**1.6.2: International Laws and Regulations guiding Environmental Management**

Nigeria is signatory to several laws, treaties and regulations that govern the environment.

Among these are:

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

- Convention on the Migratory Species of Wild Animals (Bonn Convention)
- Convention on Biological Diversity
- Convention Concerning the Protection of the World Cultural and National Heritage Sites (World Heritage Convention)
- Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal and.
- 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.

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

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

***Convention on Biological Diversity***

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.

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

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.

### **1.6.3: Bayelsa State Regulations**

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.

### **1.6.4: SPDC Policies and Principles**

Shell Petroleum Development Company (SPDC) operates under the guidelines of Shell International 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 order 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 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 off 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
- Defence 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 so as to maintain our readiness at all times.

### **1.7: Declaration**

Shell Petroleum Development Company (SPDC) in its capacity as the operator of the EA/EJA field hereby declares her intention to abide by the existing international and national laws and regulations regarding environmental protection during the operations of the facilities in the Field. Shell Petroleum Development Company (SPDC) is committed to the implementation of the Environmental Management Plan (EMP) covering the EA/EJA field. Shell Petroleum Development Company (SPDC) avows that it has prepared this EIA using the best available expertise in personnel, equipment and internationally acceptable methods.

## **CHAPTER TWO PROJECT JUSTIFICATION**

### **2.1: Introduction**

The FOD opportunity was identified in the 1999 preproduction field development plan (FDP) as Phase Two. Phase one is already on stream (started December 2002). The FDP also identified EJA deep exploration as an upside for future development in a success case. The execution of this project comprises green field and brown field executions for the EA/EJA Further Oil Development Project. This subsection highlights the Project overview, Project scope, Project activities and Options/Alternatives.

### **2.2: Need for the Project**

The EA/EJA Further oil development will achieve three main objectives:

- Develop the remaining oil and gas resources of the EA/EJA field and realise the financial benefits to the partners;
- Further contribute to the Nigerian Economy; and sustain the employment of staff and the development of infrastructure through a targeted community development programme as contained in the Social performance plan of the EA/EJA field; and
- Since it will extend the EA/EJA production, the EA Asset team will have the opportunity to keep on developing the skills and capabilities of local staff to international standards, as is already been done through short term deployment.

The EA/EJA FOD is an opportunity to develop 70 million barrels of oil equivalent (MMboe) of discovered hydrocarbon resources in EA/EJA fields (and an upside of 20 MMstb Expectation from EJA deep prospect) to increase the fields' economic production life beyond 2022 NFA economic life.

### **2.3: Value of the Project**

The project would have positive impact on the economy and improve quality of life and enhance the viability of the EA operations as follows:

- Economy: Full field development will enhance oil production and purposeful utilization of associated gas via existing OGGs pipeline to NLNG, and foreign exchange earnings from the sale of oil and gas, are positive signs of real development.
- Quality of life: Enhance the opportunities contained in the Social Performance Plan, as already being done by the EA Asset team, to improve quality of life of the neighbouring communities.
- The main driver for the EA/EJA FOD project is full field development implementation of the 1999 pre-production FDP. This will address the production decline in the EA/EJA fields, utilize the available ullage in the Sea Eagle FPSO and thus reduce the unit operating cost of the facility. The project will thus, further enhance the economic viability of the EA operation.

## **2.4: Envisaged Sustainability**

Oil and gas are non-renewable natural resources, hence, the need to consider their sustainability within the limits of availability. Sustainability is anchored on sound economic, social and environmental health. It is based not only on compliance with regulatory and corporate standards and guidelines, but also largely on performance improvement. In recent times, environmental managers have discovered that sustainable development means that they have to take into account labour conditions, employee's health and safety, community relations and other soft social and cultural factors, as well as uncertain environmental factors in relation to ecosystems. The thrust of the EA/EJA field sustainable development programme is derived from the SPDC's sustainable development management framework.

### **2.4.1 Economic Sustainability**

The EA/EJA field have proven reserves of oil and gas. Drilled reserves in the phase one have economically and commercially supported the operations of the Sea Eagle, with the export of oil through tankers and gas to NLNG via the OGGs Riser platform (RPA). SPDC policy on local content and employment of indigenous contractors will be applied in the project. Skilled and unskilled indigenous labour will be hired in the construction phase. The main contractors employed in this development shall be required to award minor contracts to local indigenous contractors for jobs in which they have the required expertise, when the need arises in line with the EA/EJA FOD Social Performance Plan. Such jobs will include but not limited to labour supply, catering, leasing, fabrication, etc. Efforts will be made also to upgrade the technical and managerial capacities of such indigenous contractors.

### **2.4.2 Technical Sustainability**

The EA/EJA FOD Project is technically sustainable because of SPDC's track record of strict adherence to Nigerian National (and International) engineering codes and standards. Only proven technologies that are economically viable with minimal environmental, social and health impacts shall be utilised in the execution of the project.

### **2.4.3 Environmental Sustainability**

The aim is to ensure that current use of the environment and its natural resources does not damage prospects for use by future generations. SPDC shall comply with all statutory regulations and its own corporate guidelines on Environmental Sustainability, whilst continuously striving towards performance improvement. Elimination of routine gas flaring is a positive step in the direction of sustainable development and will thus support transition to environmental sustainability. Adequate implementation of the environmental management plan will assure environmental sustainability.

#### **2.4.4 Social Sustainability**

The EA and EJA FOD project will attract a lot of improvements in the social wellbeing of communities neighbouring the project area. Some category of jobs including some sub-contracting services shall be employed from the communities, resulting in financial upliftment and reduction in the number of unemployed youths that presently besiege the Niger Delta Region. This project will also attract contribution to the already existing Global Memorandum of Understanding (GMoU) between SPDC and the communities. Under the GMoU platform funding is provided by SPDC with which communities agree, prioritise and execute and manage sustainable community projects in their area.

### **2.5: Identification and Analysis of Project Options and Alternatives**

#### **2.5.1: Project Options**

The development options proposed by EA/EJA FOD studies are centred on optimal well placements, slot availability in existing or proposed platforms, recompletion opportunities and timing of new wells. Scenarios focus on several alternatives with a view to optimizing well placements and the drilling sequence to maximize recovery in view of the key value drivers for the project. Furthermore, the project options took cognizance of Environmental, Safety and Operational considerations. The Project options were based on Location, Drilling, Pipelines and the need for an FPSO. The advantages and disadvantages of each project option are presented in **Table 2.1** while **Table 2.2** presents the drilling options considered.

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Table 2.1: Project Options considered

<b>Project Options</b>	<b>Advantages</b>	<b>Disadvantages</b>	<b>Remarks</b>
No Project Option	<ul style="list-style-type: none"> <li>• No impact on Environment</li> <li>• No new risks</li> <li>• No additional pressure on the existing infrastructures in the EA/EJA field</li> </ul>	<ul style="list-style-type: none"> <li>• Production level will drop as there will be no replacement wells for retiring wells.</li> <li>• Stakeholders will not be able to increase their oil production target</li> <li>• Huge investments that have already been committed into Phase 1 development and preliminary activities would be lost.</li> <li>• Loss of revenue to the Federal Government and SPDC from inability to adequately optimize the reserves in the EA/EJA field</li> </ul>	Not recommended
Delayed Project Option	<ul style="list-style-type: none"> <li>• More time to plan and assess environmental risks</li> <li>• Higher return on investment</li> </ul>	<ul style="list-style-type: none"> <li>• This will lead to a delay in achieving First Oil Date</li> <li>• Loss of expected revenue for the period of delay</li> <li>• Low capacity utilization of the Sea Eagle FPSO</li> </ul>	Not recommended
Produce all Wells from New locations/Platforms	<ul style="list-style-type: none"> <li>• Drilling from new location is less complicated.</li> <li>• Risk of delay and not delivering on promises to stakeholders is Low.</li> <li>• Large environmental footprint.</li> </ul>	<ul style="list-style-type: none"> <li>• New Subsea Infrastructure (Manifolds, pipelines) and Production Facility would be required</li> <li>• Need to acquire/validate environmental data</li> <li>• High Unit Technical Cost (UTC)</li> <li>• Risk of additional environmental impact</li> <li>• Possible delay in project execution</li> </ul>	Not recommended
Produce more wells from existing	<ul style="list-style-type: none"> <li>• Reduce Environmental footprint</li> </ul>	<ul style="list-style-type: none"> <li>• Drilling from existing location could be challenging.</li> </ul>	<b>Recommended</b>

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Options	Advantages	Disadvantages	Remarks
platforms/locations in the EA/EJA field	<ul style="list-style-type: none"> <li>• Availability of valid existing environmental data</li> <li>• Additional wells will be hooked up to the already existing Sea Eagle FPSO and as such the infrastructure, hardware, software and processes will be the same.</li> <li>• It will encourage the use of new technology such as the Conductor Sharing/Splitter Wellheads Systems (CSW) which will maximize the use of the existing platform slots, lower project development costs and reduce installation time.</li> <li>• Fast tracked/early first oil date.</li> <li>• Optimized human and material resources.</li> <li>• Optimized energy usage on the Sea Eagle FPSO</li> </ul>	<ul style="list-style-type: none"> <li>• Increase pressure on existing facilities in the EA/EJA field</li> </ul>	



Table 2.2: Drilling Options considered

S/N	Option	Option Description	Advantages	Disadvantages	Remarks
1	Chase the barrel	Drill a total of 15 new wells from available slots in existing platforms and carry out 3 recompletions on existing wells.	<ul style="list-style-type: none"> <li>• Reduced capital expenditure</li> <li>• Reduced risks</li> <li>• Reduced impact on the environment</li> <li>• No additional foot print</li> </ul>	Less hydrocarbon recovery	Not Recommended
2	Minimum CAPEX	Drill a total of 10 new wells from existing slots in existing platforms and 3 recompletions on existing wells.	<ul style="list-style-type: none"> <li>• Reduced capital expenditure</li> <li>• Reduced risks</li> <li>• Reduced impact on the environment</li> <li>• No additional foot print</li> </ul>	Less hydrocarbon recovery	Not recommended
3	Maximum Recovery	Drill a total of 20 new wells. 15 wells from existing slots. 5 wells from new slots and 3 recompletions wells	<ul style="list-style-type: none"> <li>• Increased hydrocarbon recovery than options 1 and 2</li> <li>• Optimal lifecycle development of the field</li> </ul>	<ul style="list-style-type: none"> <li>• Increased capital expenditure</li> <li>• Increased risks</li> <li>• Increased impact on the environment comparative to options 1&amp;2</li> <li>• More additional footprints</li> </ul>	<b>Recommended</b>
4	Minimum CAPEX + Optimized Development	<ul style="list-style-type: none"> <li>• Drill a total of 12 wells 3 recompletions</li> </ul>	Less hydrocarbon recovery than option 3	<ul style="list-style-type: none"> <li>• Increased capital expenditure</li> <li>• Increased risks</li> </ul>	Not recommended

Environmental Impact Assessment of EA/EJA Further Oil Development Project

S/N	Option	Option Description	Advantages	Disadvantages	Remarks
		<p>wells.</p> <ul style="list-style-type: none"> <li>• Construction of a new Platform in EA to host the two extra wells that could not be drilled from existing platforms.</li> </ul>		<ul style="list-style-type: none"> <li>• Increased impact on the environment</li> <li>• More additional footprints</li> </ul>	
5	Maximum Production + Maximum CAPEX	<ul style="list-style-type: none"> <li>• Drilling a total of 23 new wells and 3 recompletions as follows:</li> <li>• 15 new wells from existing platforms.</li> <li>• 5 new wells from new platform in EA and</li> <li>• 3 new wells from new platform in EJA.</li> </ul>	More hydrocarbon recovery than option 3	<ul style="list-style-type: none"> <li>• Increased capital expenditure more than option 3</li> <li>• Increased risks</li> <li>• Increased impact on the environment</li> <li>• More additional footprints</li> </ul>	Not recommended

**2.5.2: Surface Facilities Options**

The surface facilities options are presented in **Table 2.3**.

Table 2.3: Surface facilities Options

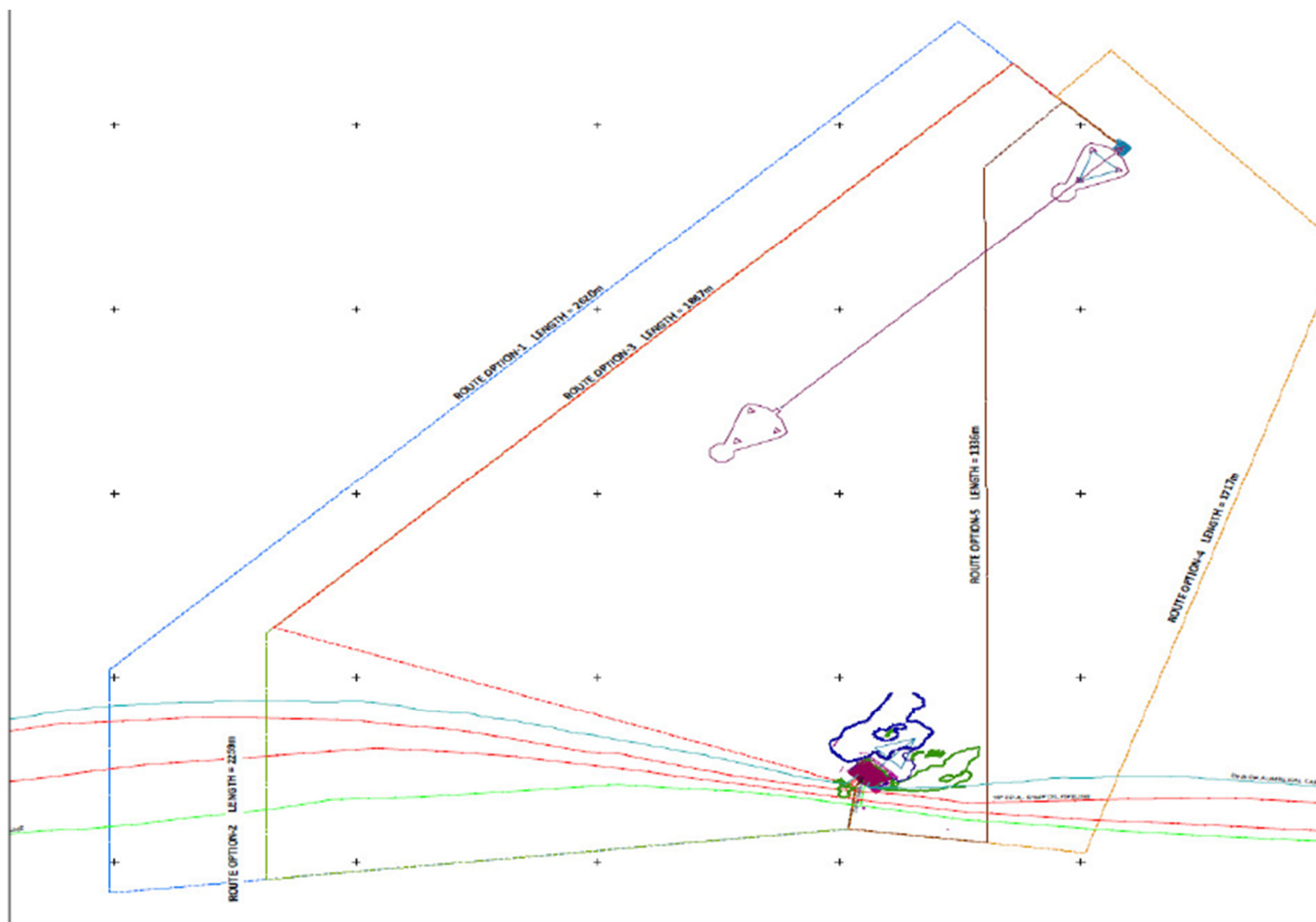
<b>Project concept</b>	<b>Advantages</b>	<b>Disadvantages</b>	<b>Remarks</b>
New FPSO/No FPSO	No restricted capacity to produce new oil	<ul style="list-style-type: none"> <li>• High Cost of facility</li> <li>• Increased Environmental foot print</li> <li>• Possible delay in First Oil Date</li> </ul>	Not recommended
FPSO Re-deployment	<ul style="list-style-type: none"> <li>• Lower cost than New FPSO</li> <li>• No delay in First Oil Date</li> </ul>	<ul style="list-style-type: none"> <li>• Difficulty in finding FPSO that will meet EA/EJA field Processing and Subsea Hookup Requirements.</li> <li>• Increased Environmental foot print.</li> <li>• Higher overall costs</li> </ul>	Not recommended
Tie-Back to existing Sea Eagle FPSO	<ul style="list-style-type: none"> <li>• Reduced Cost</li> <li>• Accelerated First Oil Date</li> <li>• Reduced Environmental Foot print</li> <li>• Availability of valid existing data</li> <li>• Reduced Risk</li> <li>• Optimized human and material resources</li> <li>• Optimized energy usage</li> <li>• Production process already tested and running</li> </ul>	Restricted capacity to produce new oil due to Haulage on Sea Eagle FPSO	<b>Recommended</b>

### 2.5.3: Pipeline Route Selection

The Site and Concept Analyses (SCAN) tool was used to weigh the selection criteria and the identified pipeline route options were compared with each other and a ranking of the route options developed. Selection criteria used for the evaluation include: Seabed obstructions, Environmental Impact/Seabed Features (Depressions, Pock marks, Currents, etc), Pipeline Crossings and pipeline length. Five options were identified and assessed during the route selection exercise using the route map produced by SPDC geomatics team. The route selection options are summarized in **Table 2.4**.

Table 2.4: Route Selection Options

Option	Route Length (m)	Description
Route 1	2672	Departs DP-C on a North-Westerly path, turns to the South West and finally turns east towards DP-B. Crosses 3 pipelines twice and an umbilical
Route 2	2310	Departs DP-C on a North-Westerly path, turns to the South West and finally turns east towards DP-B. Crosses 3 pipelines twice and an umbilical
Route 3	1930	Departs DP-C on a North-Westerly path, turns to the South West and finally turns east towards DP-B before crossing any existing facilities. Only crosses 2 pipelines and an umbilical at the platform approach. In close proximity to existing spud cans at the DP-B approach.
Route 4	1740	Departs DP-C on a North-Easterly path, turns to the South East and finally turns west towards DP-B after crossing 3 pipelines twice and an umbilical.
Route 5	1340	Approximately straight line between both platforms. Crosses 3 pipelines twice and an umbilical before approaching DP-B from the South. Traverses small depressions and rig approach area.



**Figure 2.1: EA/EJA FOD Proposed pipeline route map**

### Parameter Ranking

A number of route selection criteria (otherwise called parameters) were considered based on their relevance for the route assessments and selection. These parameters are presented in **Table 2.5**.

Table 2.5: Parameters for Evaluation and Descriptions

S/N	Parameters	Remark
1	Seabed Obstructions – Platforms, wells, wrecks, spud-cans	Obstructions due to the existing platform (DP-B) and also rig and vessel visits to the platform
2	Environmental Impacts/Seabed Features – Depressions, Pock marks, Currents etc.	Occurring features in the seabed due to hydrocarbon exploration activities
3	Construction Limitations – Pipeline Crossings	Existing pipelines from DP-A to DP-B to FPSO

S/N	Parameters	Remark
4	Construction Limitations – Cable / Umbilical crossings	Existing umbilicals from the platform (DP-B) to the FPSO and also to DP-A
5	Pipeline length	Key determinant of the cost
6	Cost	Cost of procurement, installation, etc. Is a key parameter in any project
7	DEM-1 Derogations required (Process Safety considerations)	Derogations to be considered during execution due to the terrain and constructability issues

**Table 2.6** shows the different options against the ranking parameters considered:

Table 2.6: Route Options against ranking parameters

S/N	*TECO P spectrum	Route Selection criteria	Route 1	Route 2	Route 3	Route 4	Route 5
1	T,C	Seabed Obstructions - Platforms, wells, wrecks, spud-can)	No	No	No	No	Yes
2	T, P	Environmental Impact/Seabed Features (Depressions, Pock marks, etc)	No	No	Yes	No	Yes
3	T	Construction Limitations: Pipeline Crossings	6	6	2	6	6
4	T	Construction Limitations: Cable/Umbilical Crossings	1	1	1	1	1
5	E,C	Pipeline Length (m)	2670.00	2310.00	1930.00	1740.00	1340.00
6	E,C	Cost (\$)	22,952,000	20,936,000	13,808,000	16,744,000	14,504,000
7	T	DEM-1 Derogations Required (Process Safety	0	0	1	0	0

Environmental Impact Assessment of EA/EJA Further Oil Development Project

S/N	*TECO P spectrum	Route Selection criteria	Route 1	Route 2	Route 3	Route 4	Route 5
		Considerations )					

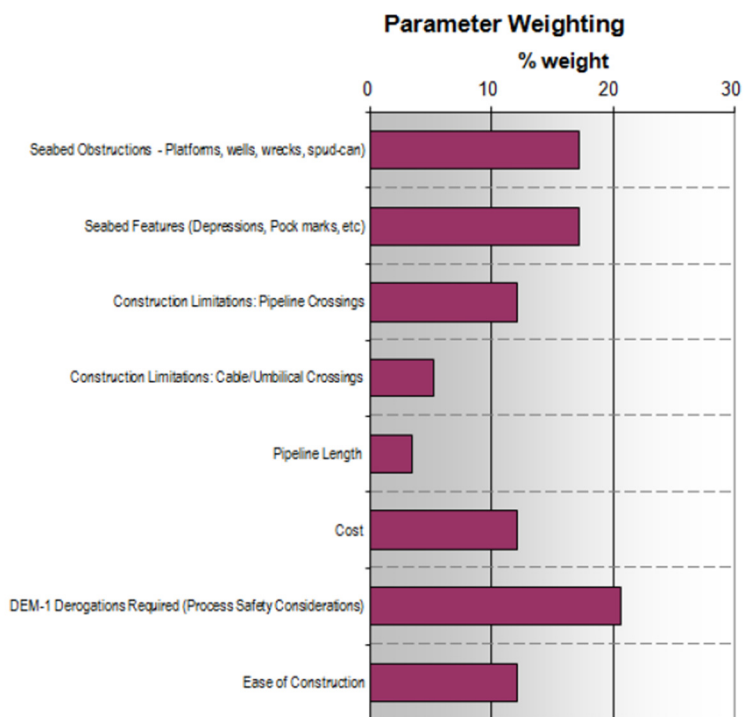
\*T - technical issues; E - economic issues; C - commercial aspects; O – operations and P – politics.

From Figure 2.2, it can be seen that the parameter with the highest weighting is DEM-1 Derogations Required (Process Safety Considerations), followed by the seabed obstructions (platforms, wells, wrecks, spud-cans) and features (depressions, pock marks, etc).

Parameter Weighting Matrix											
Parameter Weighting Matrix Instructions Score each Parameter with a 2, 1 or 0 as follows: 2. The parameter in the column is more important than the parameter in the row. 1. The parameter in the column is of equal importance to the parameter in the row. 0. The parameter in the column is of less importance than the parameter in the row.											
	TECOP Spectrum	Seabed Obstructions - Platforms, wells, wrecks, spud-can)	Seabed Features (Depressions, Pock marks, etc)	Construction Limitations: Pipeline Crossings	Construction Limitations: Cable/Umbilical Crossings	Pipeline Length	Cost	DEM-1 Derogations Required (Process Safety Considerations)	Ease of Construction	Weighting (%)	
Seabed Obstructions - Platforms, wells, wrecks, spud-can)	T, C		1	0	0	0	0	2	1	17	
Seabed Features (Depressions, Pock marks, etc)	T, s-P	1		0	0	0	0	2	1	17	
Construction Limitations: Pipeline Crossings	T	2	2		1	0	2	0	0	12	
Construction Limitations: Cable/Umbilical Crossings	T	2	2	1		0	2	2	2	5	
Pipeline Length	E, C	2	2	2	2		2	1	1	3	
Cost	E, C	2	2	0	0	0		1	2	12	
DEM-1 Derogations Required (Process Safety Considerations)	T	0	0	2	0	1	1		2	21	
Ease of Construction	T	1	1	2	0	1	0	2		12	
<b>Sum of Scores (for calculation purposes only)</b>		58	10	10	7	3	2	7	12	7	100
<b>Weighting %</b>		100	17	17	12	5	3	12	21	12	

Figure 2.2: Ranking of Parameters

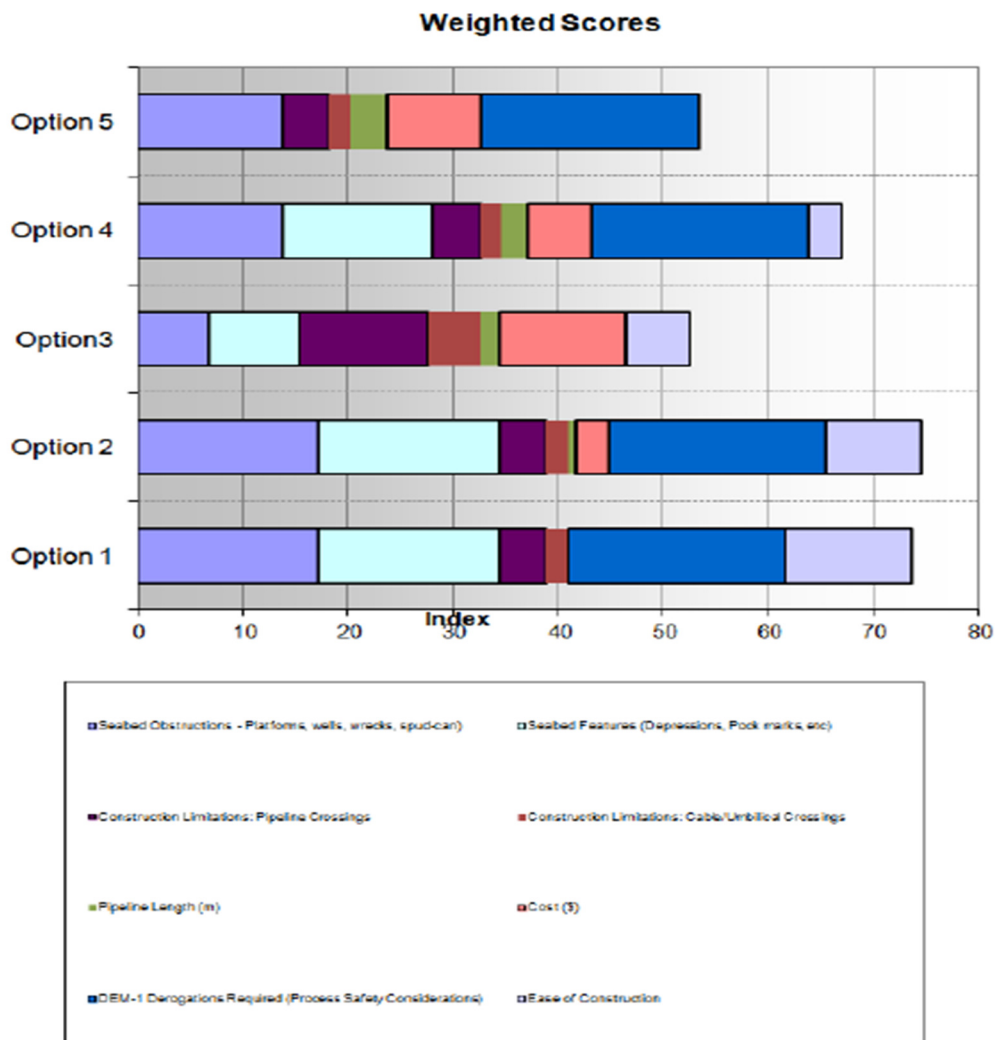
The parameter weighting of the ranking parameters is presented in Fig 2.3.



**Figure 2.3: Relative impact of the ranking parameters**

The results of the weighting scores for the pipeline route options are presented in Fig 2.4. Based on the ranking, the most favourable route is Option 2. However, experience has shown that it might be difficult to ensure that the pipelines are constructed within the prescribed corridors. This potential especially with regards to the front-runner option from the SCAn outputs (option 2), might result in the pipelines being laid in the rig approach corridor and bear attendant consequences. For this reason, although Option 2 is clearly a front-runner, consideration should be given to Option 1 which is similar to Option 2 and is a close runner-up score wise.





**Figure 2.4: Results of the weighting scores for the pipeline route options**

## 2.6: Project Activities and Description

The activities to be carried out for the project:

- Pre-Construction phase – Pipeline/Bulk lines offshore route survey (for the 5 wells scope);
- Mobilisation: Movement of personnel and equipment to site;
- Site preparation for the new wellhead platform;
- Fabrication of Well head Platform;
- Transportation/movement of Well Head Platform from fabrication base to site;
- Installation and positioning of Wellhead Platform;
- Well Drilling: 15 oil wells from existing DP-A, DP-B and DP-J Wellhead Platform & 5 oil wells from a new wellhead platform DP-C;

- Piping/flow lines, well hook-up for the 15 wells from the existing platforms. A new 5 Well Head Platform – DP-C with offshore Pipelines/Bulk lines;
- Civil works/related infrastructure for the new platform (DP-C);
- Pipe welding, coating and testing;
- Hydro testing of pipelines/Bulk lines (DP-C);
- Commissioning of pipelines; and
- Demobilisation of personnel and equipment.

## **CHAPTER THREE PROJECT/PROCESS DESCRIPTION**

### **3.1: Project Overview**

The EA/EJA Further Oil Development (FOD) project has been planned for maximum exploration of oil resources including appraisal opportunities in the EA and EJA field. FOD opportunity was identified in the 1999 pre-production FDP (Field Development Plan) as Phase 2. Phase 1 has been on stream since December, 2002. The FDP also identified EJA deep exploration as an upside for future development in a success case. The EA/EJA FOD Project is to maximise the EA and EJA field's production. The project aims to develop 70.5 MMstb of discovered oil resources in EA/EJA fields (and an upside of 20 MMstb from EJA deep prospect) to increase the fields' economic production life from beyond 2022 no further activity (NFA) economic life. The work scope is modification of three unmanned Wellhead Platforms (WHPs) and drilling and completion of 15 wells from these WHPs, piping, hook-up and commissioning and drilling of 5 new wells from a new platform (DPC).

### **3.2: Project Objectives**

Currently, the Sea Eagle NFA economic production limit is the year 2022, but production will decline to 20 Kbpod by 2016. The development project was initiated to optimise the full-life cycle further development of the asset and was conceptualised to mature the contingent resources in the fields. The EA FOD is an opportunity to develop 70MMboe of discovered hydrocarbon resources in EA/EJA fields (and an upside of 20 MMstb Expectation from EJA deep prospect) to increase the fields' economic production life beyond 2022 NFA economic life.

The EA/EJA FOD project aligns with SPDC's strategic goals and priorities by developing OML 79 and thus makes the case for renewal of its license. The project will develop additional 68.11MMstb of oil and 14.99Bscf associated sales gas contingent resource (2C) from EA and EJA field via drilling and completion of 20 new development wells and 3 work-over wells. The project will however be executed in two phases, 15 new wells and 3 work-overs first, [54.26MMstb of oil and 14.11Bcf of sales gas] and 5 wells requiring a new platform [13.85MMstb of oil and 0.73Bcf of sales gas] will come later subject to management approval post value engineering exercise.

The business objective of this project is to develop additional 68.11MMstb of oil and 14.99Bscf associated sales gas contingent resource in the EA/EJA fields within the expected production life of the FPSO (Sea Eagle). The main business drivers for the EA/EJA Further Oil Development project include:

- Achieving full field development (i.e. maximizing/ultimate recovery from the discovered wells);
- Improving cash flow from operating asset and contribute to SPDC growth aspiration;
- Utilizing the available ullage in the FPSO to maximize asset utilization;

- Reducing the unit operating cost by increasing the production in the field; and
- Testing the EJA Deep exploration scope with circa 20MMstb (2U) potential upside.

### 3.3: Project Schematics

The result of the evaluation and economic considerations favour the ullage fill concept, the following field development schematics (Fig. 3.1) has been proposed in line with previous Field Development Plans (FDP).

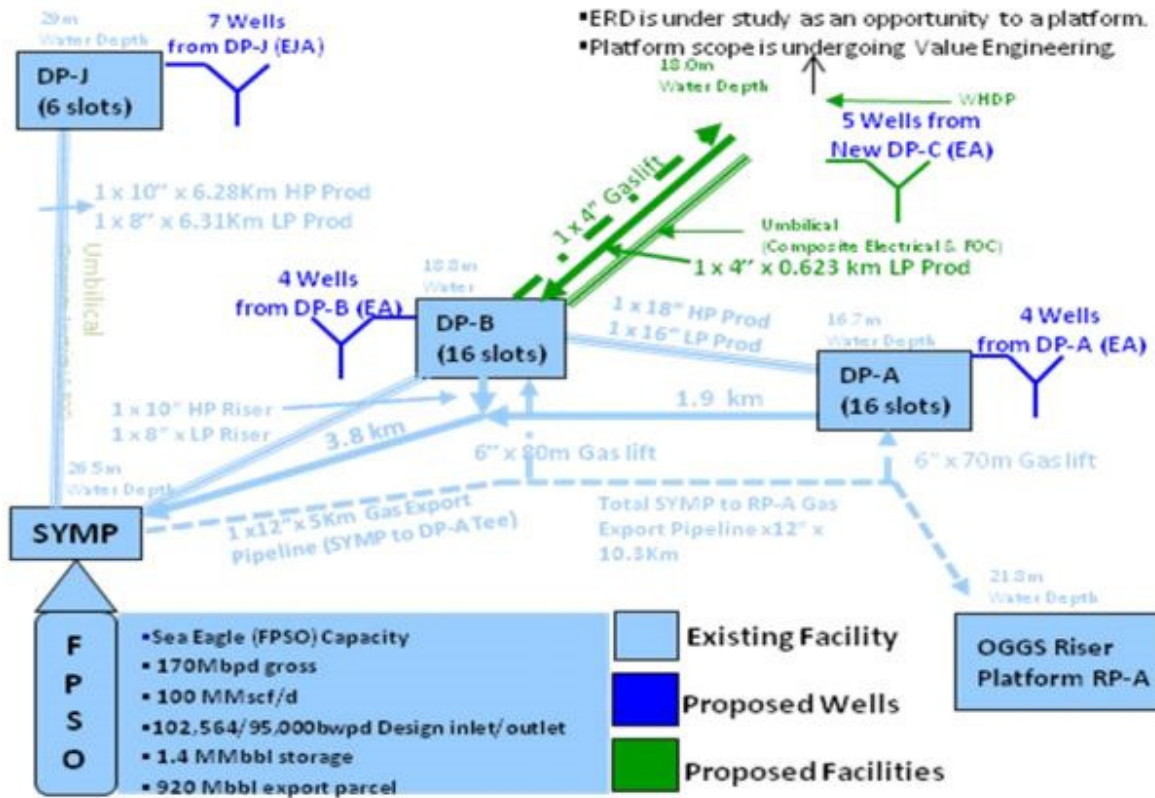


Figure 3.1a: Schematic for EA-FOD Project Facilities

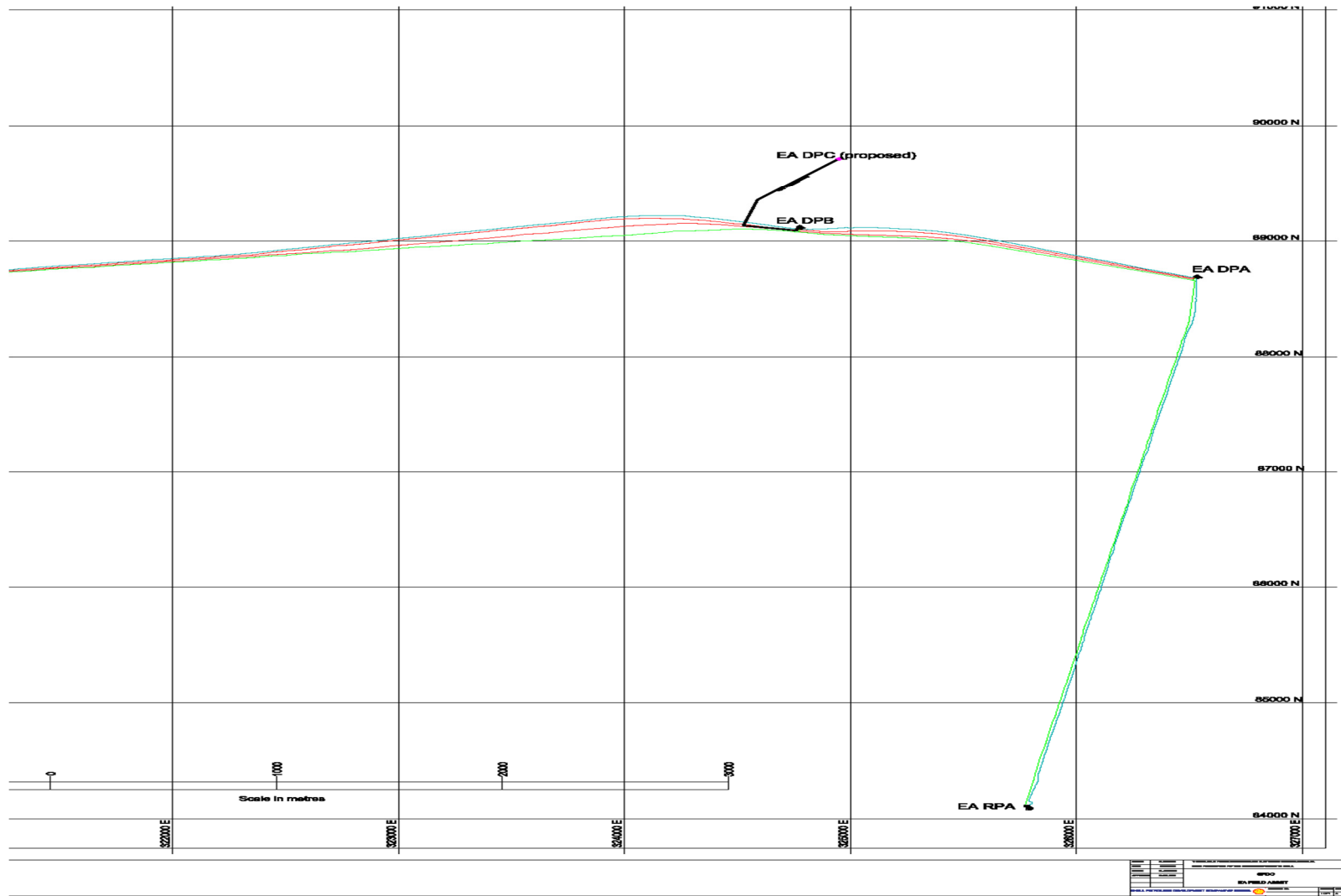


Figure 3.1b: Pipeline schematics and configurations within the EA FOD project area

### 3.4: Outline of Existing Facilities

EA / EJA field was developed using FPSO called Sea Eagle as the main facility processing fluids from the drilling platforms. Oil is evacuated by tanker and produced gas is exported through the offshore gas gathering system (OGGS) to Bonny NLNG plant. The area has 5000 m exclusion zone. There are three existing drilling platforms in the EA/EJA fields; all designed as unmanned and the wells are produced into either a high or a low pressure (LP) flow lines depending on the LTHP. Every well is connected to the Test, High Pressure (HP) and Low Pressure (LP) manifolds. The produced hydrocarbons are piped through a subsea bulk line to the Sea Eagle FPSO for processing. Lift gas for use on DP-A and DP-B is tapped from the 12 inch export gas line to OGGS through 6 inch spurs. The Sea Eagle FPSO is moored to a soft yoke mooring platform (SYMP). The well fluids arrive on the topsides as HP and LP fluids and are routed to dedicated separators. The control system is such that, from the FPSO, a well can be directed to any of the three manifolds. The combined fluids are subsequently routed to a common final separator. The hydrocarbon fluid from the field is produced into and processed on the Sea Eagle FPSO, after which the processed oil is stored on the FPSO before being transferred to export tankers while the associated gas is dehydrated and exported to NLNG through OGGS. The existing infrastructure comprising evacuation pipelines, and composite umbilicals from existing platforms to the Sea Eagle FPSO including processing facilities on the Sea Eagle FPSO are sufficient to support the 15 wells hook up and 3 work over wells scope. A new platform and a pipeline scope would be required for the 5 wells scope as shown in Table 3.1a.

Table 3.1a: The major facilities existing in the EA/EJA Fields

S/No	Description
1	2 x I6 Slot Drilling and Production Platform DP-And DP-B comprising 4 legged jacket with topsides consisting of ESDV (Emergency Shutdown Valve) deck, Cellar deck, main deck and a top deck.
2	6 Slot Drilling and Production Platform DP-J comprising 4-legged jacket with topsides consisting of ESDV deck, Cellar deck, main deck and a top deck.
3	OGGS Riser Platform (RP-A)
4	Sea Eagle FPSO with a Soft Yoke Mooring Platform (SYMP): Oil processing facility to export specifications, associated gas (AG) processing facilities for exporting gas to NLNG via OGGS RP-A, Water treatment and disposal. Capacity: 170Mbpd Gross + 100MMScfd, 1.4MMbbl Storage, 920Mbbbl Export Parcel, Water Treatment Package Design inlet/outlet (102,564/95,000bwpd).
6	2 x 18" x 5.7km (1HP and 1 LP) production line running from DP-A to FPSO
7	2 x 10" (1HP and 1LP) production tie-back running from DP-B to DP-A – FPSO
8	1 x 10" x 6.28km HP and 1 x 8" x 6.1km LP production lines running from DP-J to FPSO
9	12" x 10.3 Km FPSO – OGGS RP-A gas export pipeline
10	Umbilical`s provide power and Instrumentation & Control in the EA/Eja field connecting SYMP to DP-B, DP-B to DP-A, SYMP to DP-J, DP-A to OGGS Riser Platform RP-A.

Lift gas off-take for the wells producing to DP-A and DP-B drilling and production platforms is provided through 6-inch spur lines with subsea barred Tee-off along the 12" Sea Eagle – OGGs RP-A gas export pipeline. There is no lift gas pipeline for the wells producing to DP-J platform.

Three drilling platforms; DP-A, DP-B and DP-J were installed in water depths of 15 to 30 meters as part of the EA Phase 1 development. The purpose of these three installations is to produce and transfer well fluids to the Sea Eagle FPSO for processing. The field has a total of 33 producers; 19 wells producing on DP-A, 12 wells producing on DP-B and 2 wells producing on DP-J. The drilling platforms are connected to the FPSO by subsea pipelines and a composite umbilical carrying power and control signals. The design of DP-A and DP-B is based on modular topsides and a jacket with four main legs, anchored by piles through the jacket legs. The deck layout incorporates 16 well slots in a 4 by 4 configuration. DP-J is a smaller version of DP-A and DP-B, incorporating 6 well slots.

All the platforms support Mobile Offshore Drilling Unit (MODU) with a cantilevered drilling derrick module to drill from above the top deck of the platform. For each of the remote installations, the wells feed into one of two manifolds per platform. Production from individual wells can be diverted via the third manifold to a multiphase test-metering skid, where oil gas and water production is measured. Corrosion Inhibitor is added before the well fluids are piped off the drilling platform to the Sea Eagle.

DP-A, DP-B and DP-J is normally unmanned with no provision for emergency accommodation or shelter. A minimum crew of three visit a platform and access for maintenance or other activities e.g. pig launching, is by boat landing area on the north side of each platform with the boat always remaining in attendance during the visit. No helideck facilities are provided on any of the drilling platforms.

Minimal control systems are provided on the drilling platforms, consistent with the process equipment on board. Emergency Shutdown including riser valve closure can be initiated from the Sea Eagle Central Control Room (CCR). A fusible loop fire detection system in the well bay area will initiate a platform ESD upon detection of a fire. Instrumentation, including Closed Circuit Television (CCTV) is monitored remotely from the Sea Eagle. All other processes onboard are manually operated with status indication relayed back to the Sea Eagle CCR.

A detailed process facilities description including set points is available in the Sea Eagle Process Operating Procedures Manual (POPM). DP-A, DP-B and DP-J; OD-OP04-024 version A3, OD-OP04-025 version A3 and OD-OP04-026- version A3 respectively. A central power generation system is provided on the Sea Eagle FPSO for the EA /EJA field. Electrical power generation on the Sea Eagle is provided by:

- Main Power Generation Packages A-87001/2/3/4/5.
- Emergency Generator GD-87152.

- Essential Services Generator GD-87151.

Each of the Main Power Generation Packages comprise a dual fuel gas turbine which is coupled through a reduction gearbox to an air cooled, brushless, synchronous 12.5 MVA, 11 kV, 3 phase, 50 Hz alternator set. The turbines normally operate on a fuel gas supply. A diesel fuel supply is available in the event that the fuel gas supply is not available.

The main generators supply the main 11 kVA switchboard. During normal operation, power from this Switchboard is distributed to the following:

- Sea Eagle Process and Utility Equipment
- Soft Yoke Mooring Platform (SYMP)
- Drilling Platforms
- Offshore Gas Gathering System (OGGS) Platform.

The total design load, for the above equipment, can be met by four generating units with one unit acting as a spare. Four units need to be on-line before the Gas Compression Drive Motors can be started. In the event of loss of main power, a backup supply is available for selected items of equipment. This back-up supply is provided by the diesel-driven emergency generator and/or the Essential Services Generator that are located in the Sea Eagle Machinery Space. These generators supply emergency and essential switchboards that distribute power supplies to the selected users. In addition to the back-up provided by the diesel-driven generators, battery back-up supplies are provided for selected safety and control systems.

### **3.5: Proposed Project Scope**

The EA/EJA FOD project scope is summarised as follows:

- A. 15 new wells will be drilled and work over (Appendix 3.1) will be carried out on 3 wells; all from existing platforms. This comprises
- 4 new wells and 3 work-over wells from DP-A,
  - 4 wells will be drilled from DP-B and
  - 7 wells will be drilled from DP-J.
  - Installation of well hook-up piping system and ancillaries, well control systems, process automation, instrumentation, control and safeguarding and gas lift piping. Existing infrastructure; comprising evacuation pipelines and umbilical (composite electrical and fibre optic cables) from existing platforms to the Sea Eagle FPSO including processing facilities on the Sea Eagle FPSO are sufficient to support this development.
- B. 5 new wells will be drilled from a new drill centre DP-C. Project scope comprises:
- Construct and install 1 Well head drilling platform for 5 wells (DP-C)
  - Construct and install:
    - Tie-back pipeline (DP-C to DP-B) – 1 No. 6-inch 1.5 km LP bulk line
    - 1x4-inch 1.5 km gaslift line;
    - 1.5 km Umbilical



- Fabricate hook-up pieces and connect wellheads to the bulklines on the platforms
- Drill and complete 5 new wells DP-C.

Rig tendering is in progress thus descriptions of rigs, well heads and key drilling equipment are not available. However, 10K/2000HP Shallow draft offshore Jack-up drilling and Work over rigs; Mud system working pressure – 5000psi, Test Pressure – 7500psi; H<sub>2</sub>S monitoring system, Combustible gas monitoring system shall likely be used.

### **3.5.1: Wells Scope**

The 5 well scope will incorporate a new drill center from a new platform. Below are the descriptions of the Utility system, Topside configuration, and Substructure, General and common facilities.

#### ***Utility Systems:***

Base case requirement is composite umbilical system with electrical power cable and fibre optic cable bundle. Two J-tubes (1 on DP-C and 1 on DP-B) are to be installed. The cables are to be sized during FEED and hence the umbilical and J-tubes sizes are to be determined. A confirmation of the capacity of existing switchboards, cables and generators to integrate the power distribution system with the entire EA/EJA FOD project is required.

#### ***Topsides***

The selected platform concept has 2 decks with a total deck height of about 8 m and 4 m inter-deck height. The well slots shall be 4 in number (2 x 30” and 2 x 36”) with inter-slot spacing of about 2.5m and guide slots on the topside of 40”. The Topside shall be designed to safely support the worst expected load and load combinations (including environmental and accidental loads) from topside equipment as it relates to the deck specific functions and mode of operations (e.g. construction, drilling, and production operations). The platform layout concept shall ensure also that the possible/identified jack-up rigs to be used at the DP-C platform can reach the furthestmost well slot from the platform rig approach face while maintaining required rig spud can and transom distances from the platform.

#### ***Substructure***

The selected concept is a 4 legged straight/un-battered jacket with piles driven through the 4 legs. Appurtenances on the jacket include, among others, a V-shaped boat catcher, boat landing, J-tube, mud-mat and two risers. The jacket shall be designed to safely support the worst expected load and load combinations (including environmental & accidental loads) from the topsides and appurtenances over different modes of operations on the platform (e.g. construction, drilling, and production operations). Risers supported on the jacket shall be positioned to minimise exposure to accidental damage.

#### ***General and Common Facilities***

The Sea Eagle FPSO is the main facility for processing produced hydrocarbon fluids from the drilling platforms. The existing Control room on the FPSO will continue to serve as control

and monitoring centre. All new hardware installed for the EA/EJA FOD will be integrated with the existing SIS/PAS/F&G systems.

***Spare Parts and Special Tools***

Given that the tie-in to DP-B facilities will be in a brown field environment, necessary measures must be taken to minimize the risk of fire and other hazards associated with concurrent operations and this may involve the use of special tools and machines during tie-in. Spares stocking on site will be required for the new facility, to ensure target availability which will be determined during FEED.

***Movables***

Hardcopy design documentation (folders, CDs) for operations personnel will be kept in existing EA document control centre. No major additional movable assets are envisaged on the FPSO.

***Office Facilities for Company Personnel***

Existing facilities in the FPSO will be utilized to accommodate any extra operations personnel due to this project.

Table 3.1b: Surface location coordinates for the proposed EA/EJA fields (OML 79) FOD Project

S/N	Field	Platform	Surface location coordinates	
			Easting	Northing
1	EJA	J	317338.79	93687.85
2	EJA	J	317337.02	93689.6
3	EJA	J	317338.75	93691.32
4	EJA	J	317338.79	93687.85
5	EJA	J	317338.75	93691.32
6	EJA	J	317342.24	93691.37
7	EJA	J	317337.02	93689.6
8	EA	A	326544.05	88695.23
9	EA	A	362537.5	88691.5
10	EA	A	326538.75	88690.21
11	EA	A	326538.75	88690.21
12	EA	A	326542.28	88693.56
13	EA	A	326540.01	88688.87
14	EA	A	326539.76	88696.21
15	EA	B	324781	89122.52
16	EA	B	324780.99	89122.52
17	EA	B	324786.59	89120.39
18	EA	B	324784.44	89125.96
19	EA	C	324951	89719

S/N	Field	Platform	Surface location coordinates	
			Easting	Northing
20	EA	C	324951	89719
21	EA	C	324951	89719
22	EA	C	324951	89719
23	EA	C	324951	89719

### 3.5.2: Pipeline Scope for DPC

The pipeline scope is only for the new platform DPC. This project will:

- Construct and install a total of 3 km tie-back pipeline (DP-C to DP-B).
- 1x6-inch 1.5 km LP bulkline.
- 1x4-inch 1.5 km gaslift line.
- 1.5 km Umbilical.

### 3.6: Project Activities Description

The activities to be carried out for the project:

- Pre-Construction phase – Pipeline/Bulk lines offshore route survey (for the 5 wells scope);
- Mobilisation: Movement of personnel and equipment to site;
- Site preparation for the new wellhead platform;
- Fabrication of Well head Platform;
- Transportation/movement of Well Head Platform from fabrication base to site;
- Installation and positioning of Wellhead Platform;
- Well Drilling: 15 oil wells from existing DP-A, DP-B and DP-J Wellhead Platform & 5 oil wells from a new wellhead platform DP-C;
- Piping/flow lines, Well hook-up for the 15 wells from the existing platforms and 5 Wells from the new well head Platform – DP-C with offshore Pipelines/Bulk lines;
- Structural works/related infrastructure for the new platform (DP-C);
- Pipe welding, coating and testing;
- Hydro testing of pipelines/Bulk lines (DP-C);
- Commissioning of pipelines;
- Well head instrumentation and ancillary hook-ups
- Control and safeguarding systems hook-up and
- Demobilisation of personnel and equipment.

### 3.7: Details of Main Project Activities

The main project activities are covered under the following headings:

#### 3.7.1: Design Considerations

The facilities and pipeline, which shall have a design life of 25 years, shall be constructed in accordance with SPDC's DEPs, standard construction specifications and relevant government

and other regulatory standards. Innovative technology that will reduce negative impact of facilities construction on the environment shall be utilized during the construction phase. All wastes generated during construction shall be disposed in accordance with approved industry regulations (DPR). Emission to the atmosphere and noise pollution shall be minimized to acceptable regulatory limits. All the facilities shall have in-built special containment facilities for hydrocarbon spills, if any.

Table 3.2: EA/EJA Field Well Logging Plan

Hole Size	Casing	Logs Required	Justification/Remarks
16/17 ½ inch	13 3/8"	MWD/GR/RES Mud logs	<ul style="list-style-type: none"> <li>• Directional Surveys and correlation</li> <li>• Aid correlation and picking of the first casing point in shale</li> </ul>
12 ¼ inch 9 5/8"		MWD/GR Mud Logs GR/RES/DEN/NEU	<ul style="list-style-type: none"> <li>• Directional Surveys and correlation</li> <li>• Aid correlation of D &amp; I that will be obtained from MWD.</li> <li>• Ditch cutting samples to monitor oil shows or gas counts</li> <li>• Aid reservoir correlation, fluid identification and stratigraphic/structural control</li> </ul> Pilot Hole: to appraise present contacts
		<b>CASED HOLE LOGS (PCL)</b>	
		CBL/GR	For Cement bond/Zonal Isolation evaluation
8 ½ -inch		MWD/GR Mud Logs GR/RES/DEN/NEU	<ul style="list-style-type: none"> <li>• Directional Surveys and correlation</li> <li>• Aid correlation of D &amp; I that will be obtained from MWD.</li> <li>• Ditch cutting samples to monitor oil shows or gas counts</li> <li>• Aid reservoir correlation, fluid identification and stratigraphic/structural control</li> <li>• Pilot Hole: to appraise present contacts</li> </ul>
6-inch		MWD/GR/Res Mud Logs	

Table 3.3: EA/EJA Field Well Summary

Well Name	Well Code	Deviation	HOLE SECTIONS/CASING SCHEMES (ftah/ftss)				
			16" 13-3/8" Csg	12-1/4" 9-5/8" Csg	8-1/2" 7" Liner	8-1/2" 6-5/8" Reslink	6" 4-1/2" Reslink
EJA D5000BN	EJAZ010T	Horizontal	3070	6277	9199		10767
EJA D5000B	EJAZ009T	Horizontal	3073	6935	9255		11364
EJA C7000A1	EJAZC70W013	Horizontal	3141	7105		8525	
EJA C7000A3	EJAZC70W015	Horizontal	3339	7291	9305		10629
EJA C7000A2	EJAZC70W014	Horizontal	3123	6293		7662	
EJA D5000A	EJAZ008T	Horizontal	3135	6490	8742		9823
EA B5000A	EAZZB40W056S /EAZZ056L	Horizontal	2220	5515		7615	
EA B7000A	EAZZ059T / EAZZ060T	Horizontal	2282	5816		7210	
EA D7000M	EAZZD70W078	Horizontal	2065	5634	10123		11123
EA D4000P	EAZZ055T	Horizontal	2153	4844	7300		8670
EA B8000C/C5000C	EAZZB80W068/ EAZZC50W070 (TSD)	Horizontal	2058	5402		6302	
EA C7000C	EAZZ026T	Horizontal	2135	6656		7399	
EA B8000C1	EAZZB80W067	Horizontal	2618	7623		8623	

Bulk/flow lines shall have approved anti-corrosion coating. Coating shall be done before transportation to the site. The handling, loading and stacking of coated pipes shall be carried out strictly in accordance with the SPDC standard specifications.

**3.7.2: Conceptual and Detailed Design**

The conceptual design for the new facilities involves structural design of new platform, pipeline sizing, process simulation, slug catcher, material selection and requisition. The detailed design is part of the Engineering Procurement and Commission (EPC) contract, which covers mechanical hook up of flow lines on the platform, and the installation of a new platform, with all associated facilities. The 15 wells hook up detail engineering design shall be executed differently by a separate contractor. For the 5 wells scope the EPC will include the design and installation of corrosion inhibition plant, instrumentation, electrical, detailed process and pipeline design including interface to the existing facilities, material requisition, start-up/commissioning procedures and production of operators and maintenance manuals. The design contractor is to ensure a fit-for-purpose design.

**General Basis for Design**

***Quality Assurance of Design***

In a design of an offshore facility such as this, it is imperative that certain basic parameters must be defined in the overall project specification to ensure that the full objectives of the

project are realized. SPDC has, therefore, specified the following quality objectives for the design:

- Compliance with statutory requirements;
- System must meet performance requirements;
- Production availability;
- Environment and safety;
- Operability and maintainability;
- Life expectancy;
- Extendibility; and
- Compatibility with existing facilities

#### ***Applicable Standards and Codes***

The engineering design, procurement and installation will be in accordance with the latest revisions of the following Statutory Codes and Standards: Federal Republic of Nigeria National Standards, SHELL Design and Engineering Practices (DEPs), SPDC Standard Facility Design Manuals, and applicable international standards and manuals.

#### ***Availability and Residual Flaring Target***

No flaring is carried out presently at the EA/EJA field platforms. The new DPC platform is not designed with a flare boom.

#### ***Flaring at Sea Eagle***

EA/EJA FOD will not increase the flaring capacity of the Sea Eagle. Presently Sea Eagle is producing below capacity. Capacity of the facility is 170,000bbls/day, but now producing about 45000bbls/d. EA/EJA FOD is bringing in 40,000bbls/day. This is still far below the design capacity.

#### ***Fire Protection***

Minimal control systems are provided on the drilling platforms, consistent with the process equipment on-board. Emergency Shutdown including riser valve closure can be initiated from the Sea Eagle Central Control Room (CCR). A fusible loop fire detection system in the well bay area will initiate a platform ESD upon detection of a fire. Instrumentation, including Closed Circuit Television (CCTV) is monitored remotely from the Sea Eagle. All other processes on-board are manually operated with status indication relayed back to the Sea Eagle CCR. A detailed process facilities description including set points is available in the Sea Eagle Process Operating Procedures Manual (POPM) DP-A, DP-B and DP-J; OD-OP04-024 Version A3, OD-OP04-025 Version A3 and OD-OP04-026- Version A3, respectively.

#### **Process Design**

##### ***Process configuration***

This project is not bringing in any new process facility. The maximum volume of production from the FOD project is in the likelihood of 50,000bbls/day. The Sea Eagle FPSO oil processing facility has a capacity of 170Mbdpd Gross + 100MMScfd, 1.4MMbbl Storage,

920Mbbbl Export Parcel and Water Treatment Package Design inlet/outlet (102,564/95,000bwpd). The EA/EJA FOD will deliver a peak incremental production of 40 kbopd through the new wells and platform. The capacities of key existing process facilities on the Sea Eagle FPSO have been checked and considered adequate to handle the forecast production.

- No separation is done on the drilling platforms; hence no separation is expected on DP-C. Separation is only done on the Sea Eagle FPSO.
- Though the EA/EJA FOD produces additional oil, in order to increase compressor operability and energy efficiency, a turn down study is recommended to look at the far future.

## **Mechanical Design**

### ***Pumps***

Process pumps will be designed in accordance with API 610 specification and DEP 31.29.03.30-GEN. Pumps shall be installed to evacuate liquids from the closed drain vessel only on the new platform (DPC). Sizing and capacity of the pumps shall be determined during the FEED Control and it shall be integrated with the Control and Safeguarding System.

### ***Compressor***

Though the EA/EJA FOD produces additional oil, in order to increase compressor operability and energy efficiency, a turn down study is recommended to look at the far future.

### **3.7.3: Pipelines**

Design will be in accordance with the requirements of offshore Pipeline Engineering and other relevant DEP's. Design shall be carried out in the following steps:

- Pipeline system layout and routing.
- Pipeline preliminary sizing and flow assurance.
- Pipeline materials and wall thickness.
- Pipeline stability and preliminary strength assessment.
- Identification of special design and construction features

The pipeline route selection was carried out in accordance with DEP 31.40.00.10-Gen-Specification and DEP 31.40.00.10-Gen-Informative. The 4" Gas lift line and the 6" bulk line for the DPC-DPB routes follow as closely as possible the shortest distances between the start and end points indicated above, unless specific requirements dictate route deviations. Such requirements are:

- Obstructions (e.g. wrecks, wellheads).
- Pipeline or cable crossings.
- Existing pipeline or cable.
- Seabed conditions.
- Grouping of pipelines and/or cables in corridors.

The optimal route imposed minimal impact on the environment. Route selection was subjected to the statutory requirement for EIA. Considerations to improve access and re-routing to avoid areas where there may be difficulties with the pipeline construction were made during this study. The following points were also considered:

- Future route deviations shall be within the pipeline minimum bend radii.
- Deeper water areas considered where the choice exists.
- Pipeline and cable crossings minimized.
- Shipping channels, ship wrecks, fishing areas anchoring locations and unstable seabed.
- The risers were located away from boat landing areas to minimise the risk due to impact from boats.
- The angle of pipeline approach, where the minimum pipeline approach angle to a platform is greater than 30°
- The dropped object zone for dropped objects from material handling operations was avoided.
- Consideration shall be given to avoiding anchor patterns of vessels (supply boats and construction vessels) alongside installation and presence of adjoining pipelines.
- If the direct approach of a pipeline to the riser base intersects a jack-up rig approach corridor, analysis should be carried out to assess the risk of damage to the pipeline during the approach and positioning of the jack up rig.
- Pipeline approaches were selected with reduction in the number of bends, avoidance of pipeline crossings and positioning of spare pipeline risers. Other routing requirements for offshore pipeline risers shall be in line with section 4.0 Riser Routing and Location of DEP 31.40.10.10-Gen, Riser Design.
- The distance between parallel pipelines should not be less than 10m.
- The crossing of existing pipelines and submarine cables should be at right angles (Ref. ISO 13623 sect. 6.9.5). If this imposes an excessive additional route length, lower crossing angles may be used, but not lower than 30 °.

All the sizing for the new proposed pipelines was done using the PIPESIM system analysis for the single branch. The optimum line size for the different cases was selected based on the criteria (includes DEP criteria) listed below:

- Liquid velocity (1 – 4 m/s).
- Gas velocity (5 – 10 m/s).
- Erosional velocity ratio (less than 1).
- Capacity utilisation and flow regime.

The carbon steel material grade selected for the bulk line and the gas lift line is API 5L X52 which is equivalent to ISO 3183 L360. The bulk line and gas lift line wall thicknesses are determined based on ASME B31.4, B31.8 and specific conditions in the Pipeline Engineering Specification DEP 31.40.00.10 – Gen. The governing criterion in the selection of pipe wall thickness and material grade for the pipelines is based on the conditions stated below:



- Minimum wall thickness for pressure containment.
- Diameter-to-wall thickness ratio shall not exceed 60.

The required wall thickness and steel grade of the pipeline for pressure containment is evaluated based on design pressure, design factor, nominal pipe diameter and the steel's specified minimum yield strength.

- a) Hydrostatic collapse.
- b) Local buckling.
- c) Propagation buckling.

Buckling and collapse analyses are performed in order to assess whether the pipeline is safe from failure by buckling or collapse due to external pressure. The check is of primary importance during pipeline installation when the pipeline is empty while being subjected to the external hydrostatic head of the surrounding water.

Three distinct cases relevant to buckling as a result of external pressure are considered:

#### ***Pigging and Inspection***

Pigging facilities will be installed on each pipeline for removal of liquids. Pipelines shall be designed for intelligent pigging. The design of the Pig Trap systems for the new platform shall be guided by DEP 31.40.10.14-Gen., Design of Pig Trap Systems for Transmission Pipelines. A routine pipeline pigging, and evaluation of the quantity and identity of removed debris could be used to manage scale. Tie-in points are to be made available on the platform and mobile pig traps are to be provided for pigging, when the need arises.

#### ***Corrosion Protection***

Pipelines shall be provided with suitable corrosion protection and monitoring systems, in line with offshore pipeline installation practise. In addition, corrosion inhibition chemical shall be injected at the platforms as currently practiced. Corrosion scale in bulk lines will be managed by pigging.

#### ***Design Pressure, Temperature and Material Selection***

The determination of design pressures temperatures and the material selection of equipment the rules from the Shell DEP standards will be followed. The materials selection will be based on the process conditions as indicated in the heat and mass balance and on the process flow diagrams. In summary, existing well production flowlines are rated for the well CITHP and is class 600 rated. Similarly, new production flowlines will be class 600 rated with a maximum design temperature of 60 degree centigrade. Lines will be sized in accordance with the gross fluid volumes in the forecast production profile. The gas lift system up to and including the gas lift manifolds will be a class 900 rated system and hence will be compatible

with the rating of the FPSO gas compression and pipeline export system. An overpressure protection system is to be considered in the design for these new gaslift lines to allow for the event where production is closed downstream of the tree without isolation of gas lift.

Based on sensitivity analysis done on the maximum and minimum flow rates and production forecasts for the EA/EJA FOD 5 wells scope, considering the operating parameters (mainly the flow velocity requirement), the recommended optimal bulkline size for evacuating the DP-C 5 Wells Scope production is the 6" bulkline. This recommended bulkline size and design parameters would be reviewed during detailed engineering phase using dynamic analysis. The gas lift pipeline hydraulics analysis shall also be revalidated. All bulklines will be designed to replicate the design parameters of existing bulklines in the EA/Eja field (95.6barg design pressure and 60°C design Temperature).

### **3.8: Pre-mobilization Activities**

Pre-construction activities include (not necessarily in sequential order), but are not limited to:

- Permission to survey (PTS) and OPL applications;
- Conceptual and detailed design of the EA/EJA FOD facilities and
- Offshore survey of pipeline route/right-of-way (RoW) and facilities installation areas.

### **3.9: Construction Phase**

#### ***Pre-Mobilization/Mobilization***

Estimated population of workers for the project during mobilization and construction will be about 100, with a maximum of 150 at peak periods. Majority of these will be at the contractor's base, on land for fabrication and other management activities. Logistics and accommodation shall be provided for personnel using offshore accommodation facilities on vessels. Each vessel accommodating the personnel would have its own waste management process.

#### ***Site Preparation Activities***

##### ***Site Surveys and Clearing***

Offshore Environment Surveys will only be done.

##### ***Piling***

Piling shall be carried out to install the new platform (DPC), in line with offshore practice.

#### ***Pipeline Construction***

##### ***Welding and Radiography***

Pipeline installation shall be via an S-Lay vessel given the water depth. This activity shall involve welding of the bulk lines on the offshore lay-barge moving along the approved pipeline route. The line pipes shall be procured with capped bevel ends, a pipe storage barge shall be moored next to the lay-barge. The pipelines shall be coated with three-layer polyethylene coating to provide external corrosion protection. Field joints shall be coated with shrinkable sleeves.

Visual inspection and 100% radiography (non-destructive testing-NDT) of the welds shall be done as the welding progresses. Weld repairs shall be carried out where necessary, prior to pipeline pressure testing. Waste generated from welding and NDT activities shall be contained and safely disposed (for solid waste via the contractor's scrap/waste dump ashore). Successful welds shall be laid on the sea bed

### ***Hydrostatic Testing***

Hydrostatic testing, which is the flooding of pipeline with treated water in order to determine its strength, shall also be conducted. The water used shall be filtered sea water. The hydrostatic pressure on the pipeline is set to 1.5 times minimum allowable operating pressure or 90% of hoop stress whichever is less, and the test is held for 24 hours. When releasing the water back into the environment after the hydrostatic test, the test water will be cleaned of any harmful chemicals such as corrosion inhibitors, oxygen scavenger and biocides before disposal. Discharge would be made in such a manner that it does not stir up sediments.

During design, an assessment of the free spans will be conducted to determine limits on allowable span lengths for installation stage. Survey data would also yield seabed profile along the proposed route to identify the length and positions of pipeline spans. This will form the basis for determining if the spans are allowable (no support required) or further remedial works will be required (e.g rock dump).

## **3.10: Operation and Maintenance**

### ***Operation Philosophy***

Tie-in to the existing EA/EJA field operations philosophy.

### ***Facility Availability and Criticality***

Tie-in to the existing EA/EJA field operations.

### ***Facilities Safeguarding Philosophy***

Tie-in to the existing EA/EJA field safeguarding philosophy.

## **Maintenance Philosophy**

### ***(a) Upkeep of Structures***

Maintenance and inspection activities, based on periodic inspection to determine the condition of structures and performance of their protection system include: refurbishment activity to restore the integrity of structures, replacement of and coating system applied to structures based on time maintenance schedule.

### ***(b) Containment of Hydrocarbons***

Periodic (monthly) inspections will be carried out to determine the condition of all elements of the process fluid containment envelope as well as any protective coatings applied thereon. Inspection programmes for certifiable pressure vessels, pressure/vacuum relieving devices

will be inspected to meet the requirements of the Minerals Oils (Safety) Regulations of Nigeria. Refurbishment activity to restore the integrity to the envelope will be based on their condition. Where appropriate, economic systems to mitigate the effects of corrosion shall be put in place and their effectiveness routinely monitored.

**(c) Control and Protection**

Control and protection system will be based on periodic inspections/calibration/testing both their input and output functions as detailed in the Maintenance Job Routines (MJR). Non-availability of hydrocarbon production caused by such inspection/calibrations/test will be accounted for in the Production Plan. Change of set points will be controlled by the plant change procedure.

**(d) Hazard Detection System**

Maintenance of hazard detection systems will be based on periodic inspection/calibrations/testing of both their input and output functions. Non-availability of hydrocarbon production caused by such inspections/calibrations /test will be accounted as already being practiced for the existing facilities in the EA/Eja field.

**(e) Shutdown system**

Maintenance of shut down system, both initiation and activation devices, will be based on periodic full function testing of both their input and output functions to ensure operation in accordance with SPDC guidelines, in line with the EA/Eja field practise.

***Pre-commissioning***

An SPDC pre-commissioning team, consisting of the project co-ordinator, production, maintenance and HSE personnel will be set up close to the completion of construction and installation works, and will be involved in the following pre-commissioning activities:

- Checking vendor data,
- Preparing commissioning procedures,
- Preparing test equipment/procedures,
- Checking project documentation,
- Assembling relevant project reference data,
- Checking individual system.

A commissioning plan is being developed and will be used during Pre-commissioning /commissioning.

**3.11: Decommissioning/ Abandonment**

***Demolition and Site Clean-up***

The demolition exercise is carried out with skill and diligence to avoid spill of hazardous liquids and damage to the environment. At the end of demolition, various solid wastes are sorted according to their types and then disposed of according to SPDC-EA/EJA Fields waste disposal guidelines.

**Rehabilitation of Site**

Since it is offshore environment, after the completion of the project, all vessels shall be decommissioned. The facilities shall be handed over to the EA Asset team as approved by the Project to Asset (PtA) documentation.

**3.12: Waste Management**

The types of wastes generated during the construction activities shall be classified as: solid wastes, liquid wastes, and gaseous wastes. Wastes will be generated from the various project activities. However, the bulk of waste generated will be from logistics, drilling operations, processing of increased oil production and decommissioning activities. The anticipated wastes from these activities include domestic wastes (e.g. food and trash), sanitary wastes, spent drill cuttings, used drilling muds, grey water, noxious gases and oily waters. Details of waste types, estimated quantities that will be generated are presented in **Table 3.10**. SPDC has in place a separate fit-for-purpose Waste Management Plan for the EA/EJA FOD activities and this will be deployed even when additional wells are completed. Detailed strategies are provided on intended waste identification, characterization methods, storage, tracking, monitoring and audit of the waste disposal sites which are applicable for oil spill management. These include but not limited to the following:

**Treated Produced water** – Treatment shall be achieved with the PW treatment system to less than or equal to OIWOB at 30 ppm before discharge to sea. Non-spec water is diverted to slop tank for further treatment.

**Treated Slop** – Treatment shall be achieved by gravity separation / chemical aid to less than or equal to OIWOB at 30 ppm before discharge to sea.

**Treated sewage** – Treatment by batch method in a sewage treatment tank using a mix of aerobic bacteria action degrading the solid waste and chlorine to dis-infect the water before discharge to sea.

**Ballast water** – Will be treated in line with EGASPIN requirements prior to discharge into the sea.

**Bilge** – Batch treatment through Oily Water Separator with online analyser; Discharge quality also max of 30 ppm above which the OWS diverts it back to the Bilge holding tank.

**Waste Food** – Macerated and discharged into the sea.

Possible sources of waste and control measures are listed in **Table 3.4**.

Table 3.4: Waste Sources and Control Measures

Operation	Source	Control measure
-----------	--------	-----------------

Operation	Source	Control measure
Drilling	Oil on Cuttings and cement returns.  Cement residue from surge or day tank	Synthetic Oil-Based Mud (XP-07) will be used below 13 3/8" casing depth. Cuttings from the SBM will be discharged to the sea in 200 ft. of water after knocking down oil on cuttings to 5%.  Cuttings from water-based mud systems will be discharged overboard.  Discharge to the sea usually less than 250 sacks
Completion	Brine NaCl Discharge	Solids free lightweight non-toxic completion brine will be used.
BOP Actuation	Actuation fluid discharge	Water based fluid will be used.
General	Scrap metals	All will be collected on the rig and sent onshore to SPDC designated dumping sites
	Plastics	Shall be collected and recycled
	Waste oil	Onshore disposal
	Hazardous chemicals	Acids will be neutralized and dumped.
	Rubbish	Will be compacted and returned to shore for authorized disposal
Rig Bilge	Oily water Discharges	Controlled to less than 40ppm by the rig oil/ water separation system or sent to the trading tanker via the FPSO.
Power generation	Combustion products, CO <sub>2</sub>	Release to atmosphere
Human waste	Domestic sewage	Will be treated and dumped overboard
Galley waste		Returned to shore for disposal
Xmas Tree actuation	Hydraulic oil	Full return line system
Domestic waste	Food waste	Macerated and disposed overboard
CO <sub>2</sub>	Emissions from use of generators, barges, diesel used for marine operations, etc.	Anticipated volume is insignificant, but Air Quality Monitoring will be done

Wastes will be generated from the various project activities. However, the bulk of waste generated will be from logistics, drilling operations, processing of increased oil production and decommissioning activities. The anticipated wastes from these activities include domestic wastes (e.g. food and trash), sanitary wastes, spent drill cuttings, used drilling muds, grey water, noxious gases and oily waters. Details of waste types, estimated quantities that will be generated and corresponding waste management methods that will be used are

provided in Table 2.9. Detailed strategies are provided on intended waste identification, characterization methods, storage, tracking, monitoring and audit of the waste disposal sites which are applicable for oil spill management.

Table 3.5: Waste Types, Estimated Quantities and Corresponding Management Methods

Waste type	Estimated Quantities	Management Method/Strategy
<b>SOLIDS</b>		
Drill Cuttings	72,000 total bbls of water-based mud cuttings; 58,000 total bbls of synthetic mud cuttings.	Continuous: Drill Cuttings may be discharged overboard by shunting to the bottom provided DPR oil content limitations are satisfied.
Maintenance Wastes	Varies	Intermittent: Includes metal turnings, sock filters, sand blast waste, oily rags, etc. Included in waste-to-shore for recycle or proper disposal.
Rubbish and Trash	650 lb/day (based on 130 POB @ 5 lb /person/day).	Continuous: Consists of paper waste, packaging wastes, etc. Typically included in waste-to-shore for landfill disposal.
Solvent Drums, Paint Cans, Hazardous Solids	Varies	Intermittent: Waste-to-shore; Proper disposal method is secured.
<b>LIQUIDS</b>		
Drilling Fluids	5,500 bbl/well of water-based mud for top-hole section.	Intermittent: Recycle mud to extinction; Use water-based mud; Waste-to-shore for treatment and disposal.
Deck Drainage	23.67 MMgal/yr (based on annual rainfall of 121", deck area of 79,000 ft <sup>2</sup> , and 80% capture rate).	Intermittent: Treat for oil removal and discharge overboard.
Black Water	3,705 gal/day (based on 150 POB @ 28.5 gal/person/day).	Continuous: Treatment system to accommodate 120 operators and 30 temporary personnel. Biological treatment, removal of solids & floatables; disinfect.
Grey Water	4,550 gal/day (based on 130 POB @ 35 gal /person/day).	Continuous: Drain screens to prevent entrance of floatable into collection system.
<b>GASES</b>		
Burner Boom	CO = 2.16 TPD NO <sub>x</sub> = 5.18 TPD VOC = 4.00 TPD	Intermittent: Minimize through best practices/ procedures; Smokeless flare design in use.
Main Engines	CO = 1.05 TPD NO <sub>x</sub> = 4.62 TPD VOC = 0.12 TPD	Continuous: Use of low-sulfur diesel fuel; Equipment designed for low emissions; Implement preventive maintenance and inspection program.
Diesel Drivers	CO = 0.19 TPD NO <sub>x</sub> = 0.85 TPD VOC = 0.03 TPD	Intermittent: Most emissions from exercises and drills; Use of low-sulfur diesel fuel; Equipment designed for low emissions; Implement preventive maintenance and inspection program.
Fugitives	VOC = 0.02 TPD	Continuous: Implement Leak Detection and Repair Program.
Storage Tanks	Negligible	Continuous: Low vapor pressure liquids limit emissions.

### Waste Management Plan

The Waste Management Plan is presented in Figure 3.2.

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 (TDDU)	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														

	Waste Name	Category	Major Source	Reuse/recycle	Use as fuel	Composting	Return to Supplier	Incineration	Chemical Conversion	Maceration	Waste Water System	Land treatment	Solidification/Stabilisation Thermal Destruction Unit (TDDU)	Inject to subsurface	Discharge to surface	Land fill
6	Ceramics	Non- Hazardous	Infrastructure/Galley													
7	Contaminated Soil (Oil & Chemical)	Hazardous	Oil Spills													
8	Electric Bulbs	Hazardous	FPSO Topsides Modules/Accommodation													
9	Fan Belts	Non- Hazardous	Maintenance/workshop													
10	Fluorescent Tubes/Bulbs	Hazardous	Accommodation & Topsides Infrastructure													
11	Food Waste	Non- Hazardous	Catering													



Environmental Impact Assessment of EA/EJA Further Oil Development Project

S/ N	Waste Name	Category	Major Source	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 (STDU)	Inject to subsurface	Discharge to surface	Land fill
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								●	●				
19	Packaging Materials	Non- Hazardous	Material Warehouse/Galley stores	●				●								
20	Paper Waste	Non- Hazardous	Office operations	●				●								
21	Pigging Waste	Hazardous	Pipelines operations									●				
22	Plastics (include Drums)	Non- Hazardous	Accommodation/Office/ & operations	●												
23	Printer Cartridges and Toner	Hazardous	Office operations	●				●								
24	Sewage	Hazardous	Accommodation/office							●						
25	Spent / Obsolete Chemicals	Hazardous	Production operations					●				●				
26	Spent Chemicals Containers	Hazardous	Production operations	●				●								
27	Water Filters	Non- Hazardous	Accommodation water treatment plant	●				●								●
28	Scrap Metals (include Drums)	Non- Hazardous	Pipelines, operations maintenance	●												

Figure 3.2: Waste Management Plan

### **3.13: Decommissioning and Abandonment**

The Shell Petroleum Development Company Limited's corporate policy is that all assets including wells, production facilities, flowlines, pipelines and infrastructure, which have reached the end of their useful life, shall be decommissioned and either dismantled and removed, or abandoned, in accordance with statutory requirements and the Group standards. Sites shall be left in a safe and environmentally acceptable condition. A risk assessment will ensure that nothing will be left that is a significant hazard for other users of the area or for the environment in general. This means, for instance, that flowlines and pipelines in and on the seabed can only be left behind if they are cleaned and do not present further risks to other users. When the decision is taken, a Decommissioning Plan will be developed which will consider all feasible options and take account of the then current technology all in accordance with the above SPDC policy and the statutory requirements.

### 3.14: Project Schedule

The EIA approval is anticipated to be obtained Q2 2019. Details of the project schedule are presented in Fig 3.5.

A7240	Complete EIA Revalidation	0%	29-Apr-19
A6550	Farm-in Rig DPJ	0%	17-May-19
A6440	Pre-drill hookup scope for DP-A	0%	30-May-19
A6420	Complete Pre-Fabrication works for DPB	0%	12-Jun-19
A6390	Procurement (Piping, Gaskets, Flanges, etc) (Full Procurement)	0%	12-Jun-19
A1770	Mobilise Rig to EA Field	0%	19-Jun-19
A1790	Rig (Shengli) Complete Forcados Drilling	0%	19-Jun-19
A6470	Removal of boat catcher and crane DPA	0%	23-Jun-19
EAMS018	Commence Drilling in EA	0%	30-Jun-19
A7000	Debris (Geophysical ) Survey & Draft Report for DP-B	0%	02-Jul-19
A7880	Complete delivery of Materials for First two Wells(1st Oil)	0%	02-Aug-19
A6400	Procurement (Choke valves, ESD valves, Diverter Valves etc)	0%	22-Aug-19
A6450	Adv. T/I + HW (DPB & Pre-Drill Hook-up DPB)	0%	03-Sep-19
A6520	Drilling of 1st Well EA Complete.	0%	03-Sep-19
A6510	Hook-up 1st Well EA Complete	0%	21-Sep-19
A6530	Precommissioning/WH Tie-in for 1st Oil Complete (DPA)	0%	29-Sep-19
A3500	Complete Pre-commissioning DPJ	0%	11-Jan-20
A6490	Removal of boat catcher and crane DPB	0%	17-Jan-20
A6480	Re-installation of boat catcher and crane DPA	0%	05-Feb-20
EAMS080	Complete drilling	0%	26-May-20
A6540	Complete Post-Drill Hook-up Scope.	0%	05-Jun-20
A6500	Re-installation of boat catcher and crane DPB	0%	16-Jun-20
A3510	Demobilization from site	0%	22-Jun-20
EAMSS011	Project Complete	0%	09-Nov-20
<b>EA-FOD-P-94-110319A.1.3 On-stream Milestones</b>			
		20-Oct-19	29-Nov-19
A7650	1st Oil-DPJ	0%	20-Oct-19
EAMS014	1st Oil-DPA	0%	29-Nov-19
DP-C	EAZZB40W061	0%	Jul-20
DP-C	EAZZB40W062	0%	Sep-20
DP-C	EAZZB60W084T	0%	Dec-20
DP-C	EAZZ05T	0%	Feb-21
DP-C	EAZZ058T	0%	May-21

Fig 3.3: Project Activities and Schedule

## CHAPTER FOUR ENVIRONMENTAL DESCRIPTION

### 4.1: Introduction

The current environmental status of the EA/EJA field has been described in this 2018 EIA revalidation study which included, a one-season field data gathering conducted from 1<sup>st</sup> to 9<sup>th</sup> November, 2018. The DPR approval for the TOR and SOW for the study is given in Appendix 1. Approved study locations and sampling map for the Field data gathering exercise is given in Appendices 6 and 7 respectively. The purpose of the EIA are two folds (1) to determine the impact of the existing facilities (FPSO discharges, platform corrosion and pipeline leaks and corrosion) on the various components of the environment within the EA/EJA field; (2) to establish before the execution of the new project components, the status of the various environmental components that are likely to be impacted by the proposed project. The environmental components evaluated comprised ecological parameters that affected the seawater and sediment quality. In addition, the status of the various ecological components of the project area were assessed from review and comparison of data obtained in 2018 with data obtained in the past (i.e. from the 2001 EIA of EA field, 2011 EES of EA FOD, as well as the 2016 EIA). Environmental sensitivities likely to be affected and investigated include:

- Air quality and noise.
- Surface water quality.
- Sediment quality.
- Hydrobiology and fisheries.
- Social and Health profile.

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

In the recent study (EE/Biological monitoring of the EA/EJA FOD, 2016), sampling points were radially established at 200 m, 500 m, 800 m, 1,200 m, 2,500 m and 5000 m perpendicularly in the four cardinal directions (North, South, East and West) from the overboard discharge point and drilling platforms (DP). The areas of influence of the proposed and existing facilities (DP-A, DP-B, DP-C, DP-J and other ancillary facilities) were sampled during the 2018 field data gathering/revalidation exercise (**Appendix 1c**).

Data used in this report from previous studies include but not limited to the following:

- Environmental Evaluation and Biological Monitoring Study on the EA/EJA Further Oil Development Project 2016;
- Environmental Evaluation Study and Extension of the Fate and Effects Study of Produced Water Discharged from EA Sea Eagle FPSO (OML -079) 2012;
- Sea Eagle Quarterly Environmental Compliance Monitoring Reports;
- A Study of Chronic Effects on the Marine Environment from long term discharge of produced water in EA field 2004;
- Environmental Impact Assessment of EA Development Project, Final Report 2001.

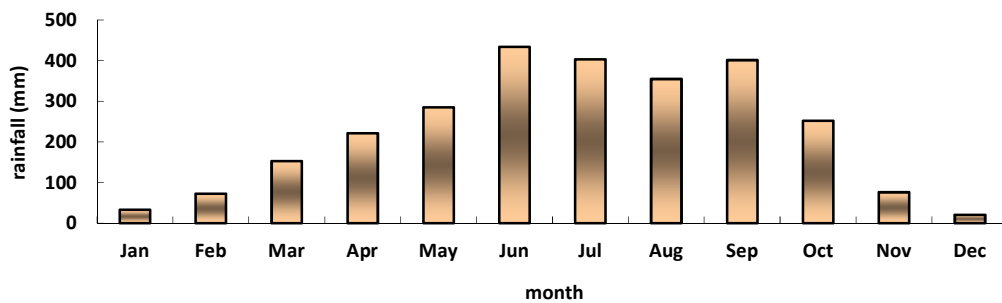
## 4.2: Environmental components

### 4.2.1: Climate and Meteorology

The study area is located in the Gulf of Guinea and it shares the same climatic conditions with it. Its climate is influenced by the Atlantic Ocean characterized with both the dry and wet seasons associated with the movement of the Inter-Tropical Convergence Zone (ITCZ) north and south of the equator. While the dry season (November to March) is characterised by the northeast trade winds, the wet season (April to October) is characterised by the Southwest monsoon. Ten-year meteorological information on Warri obtained from the Nigerian Meteorological Agency, NIMET was considered for the climatic description of the area. The EA/EJA field is about 15 km off the Niger Delta, south west of Warri (SPDC, 2001).

#### *Rainfall*

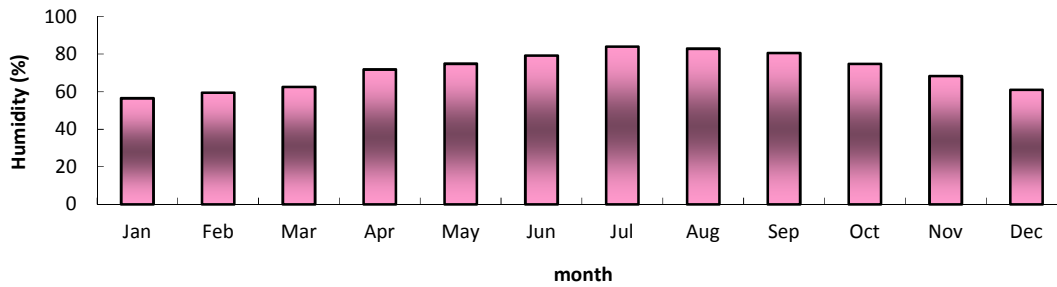
The mean monthly rainfall in the study area ranges between 20.7 and 434.0 mm (**Fig. 4.1a**) with an annual rainfall in excess of 3000 mm. Though it rains throughout the year, November to January is its lowest rainfall period. Rainfall gradually increases from February to June when it experiences the first peak which is followed by the second peak in September.



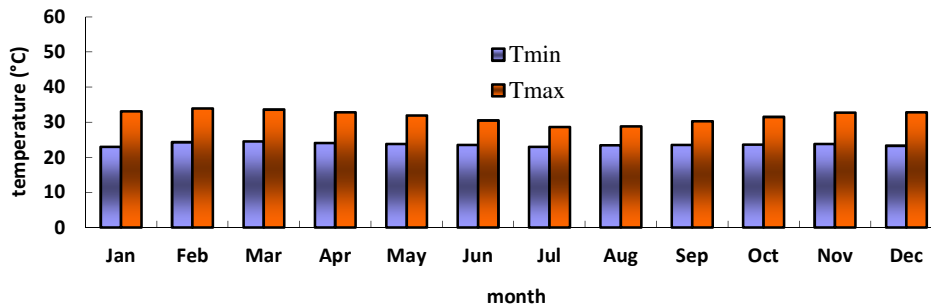
**Fig. 4.1a: Mean Rainfall Distribution in the Study Area (NIMET, 2018)**

#### *Relative humidity and air temperature*

Its monthly relative humidity is 56.5 – 84.0% (**Fig. 4.1b**) with the highest in July (peak of wet season) and the minimum in January (peak of dry season) which agree with the field measured data (**Appendix 2a**). While its mean monthly minimum air temperature is 23.0 – 24.5 °C the mean maximum temperature is 28.6 - 33.9 °C using the ten-year period (2005 – 2014) data from NIMET (2018) (**Fig 4.1c**).



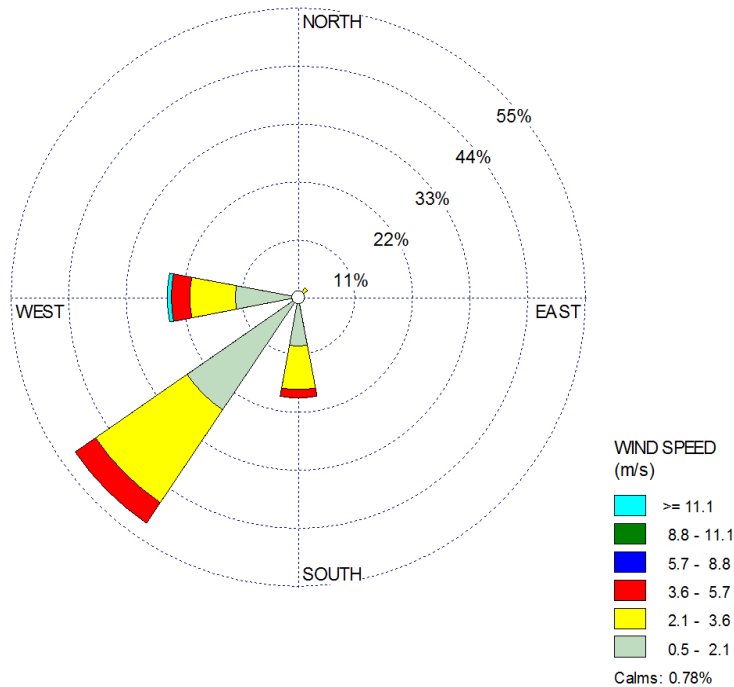
**Fig. 4.1b: Mean Relative Humidity Distribution (NIMET, 2018)**



**Fig. 4.1c: Mean Air Temperature Distribution (NIMET, 2018)**

**Wind Pattern**

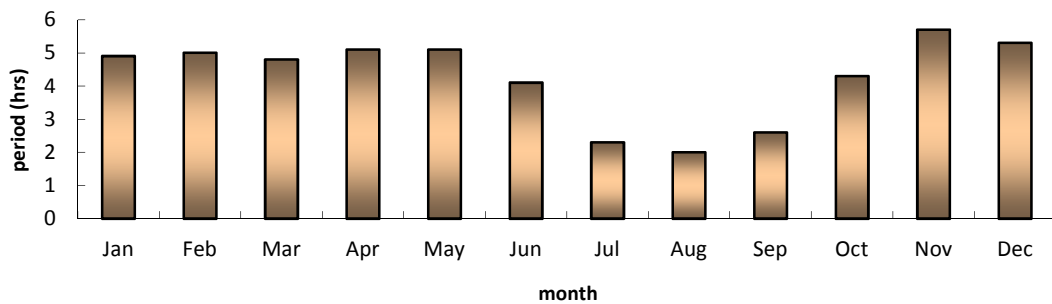
In the study area, surface wind is characterized by small diurnal variation influenced by sea breezes resulting from the warming of the sea. It reaches maximum level during the night due to radiation cooling leading to instability in the surface layer. The wind speed is usually a gentle breeze (0.4 - 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 average of 3.9 m/s in the southwest, which all fall within the climatic wind data for the area (Fig 4.1d).



**Fig. 4.1d: Wind Speed and Prevailing Direction in the Study Area (NIMET, 2018)**

**Sunshine Pattern**

The daily/monthly sunshine period in the area is 2.0 – 5.7 hours (**Fig. 4.1e**) with the minimum and maximum in August and November respectively. The generally short sunshine rate in August could be attributed to the greater cloudiness and higher rainfalls of the period. Conversely, the higher November rate is due to the prevalent clear skies when the ITCZ has once more started its Northward migration.



**Fig. 4.1e: Sunshine Periods in the Study Area (NIMET, 2018)**



#### 4.2.2: Air quality and Noise

##### EA-FPSO

The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, CXHY were measured at 500m and 800m from the prevailing wind direction (SW) of emission sources of the Sea Eagle FPSO. Within the investigated airshed, the gaseous pollutants were within background levels and not significantly different ( $p>0.05$ ) from concentrations obtained in the control stations. Similarly, the noise levels were 75.4 dBA and 72.8 dBA at the 500m and 800m distances from the FPSO. A test of significance using a non- parametric statistical tool showed there was no significant variation ( $p=0.915$ ) from the point sources around the FPSO over the 500m, 800m distances and the control stations in the prevailing wind direction. The noise levels in the investigated airshed complied with the DPR limits of 80 to 100dBA for 8 hour exposure. Furthermore, a test of significance in the PM10 data from the point sources on the FPSO showed a significant reduction ( $p=0.004$ ) around the 800m distance when compared to the 500m and the control stations. The variance may be attributed to the effect of prevailing wind speed and its impact on the reduction in particulates. This finding lends credence to similar studies by Kim *et al*, 2015. The summary of the microclimatic data and field measurements for air quality parameters around the EA FPSO are presented in Table 4.2a. Detailed results are presented in Appendix 2a.

Table 4.2a: Field Measured 1-Hour Air Quality Parameters during the Study (FPSO)

Parameters	500m	800m	Control			DPR limits	P value
	EA4	EA8	C1	C2	C3		
SO <sub>x</sub> µg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	<19.9	350	
NO <sub>x</sub> µg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	<14.2	200	
COµg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	<8.7	30	
H <sub>2</sub> Sµg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1	<1.1		
C <sub>x</sub> H <sub>y</sub> µg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0	<1.0		
Smoke Density	N/A	N/A	N/A	N/A	N/A		
Wind Direction	SW	SW	SW	SW	SW		
Wind Speed,m/s	0.9	4.0	2.3	2.9	1.4		0.119
Amb. Temperature, °C	39.3	31.1	34.5	35.8	29.4		0.283
Relative Humidity, %	52.8	73.7	58.7	60.2	76.2		0.141
Atm. Pressure, Pa	1010	1007	1005	1009	1007		0.641
Noise Level, dBA	75.4	72.8	70.9	70.9	73.2	80-100	0.915
SPM <sub>10</sub> µg/m <sup>3</sup>	39.0 <sup>a</sup>	5.0 <sup>b</sup>	28.0 <sup>a</sup>	30.0 <sup>a</sup>	31.0 <sup>a</sup>	150-230	0.004

P<0.05: Significant; p>0.05: Non-significant

Similar letters indicate values that are not significantly different

### OGGS RPA

The summary of the microclimatic data and field measurements for air quality parameters along the OGGS RPA is presented in Table 4.2b. The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, C<sub>x</sub>H<sub>y</sub> were measured at 800m and the control station from the prevailing wind direction (SW). Within the OGGS RPA airshed, the gaseous pollutants were below the equipment detection limits and compared favourably with the control stations. The noise levels measured at the 800m distance from the OGGS RPA and control stations were 75.2 dBA and 70.9 dBA respectively and complied with the DPR limits of 80 to 100 dBA for 8 hour exposure. A test of significance using the chi square goodness of fit test showed that no significant variation (p=0.801) was observed in the PM<sub>10</sub> levels at the 800m distance of the OGGS RPA and the control stations. The PM<sub>10</sub> values in the investigated airshed complied with the DPR limits of 150 to 230 µg/m<sup>3</sup>.

Table 4.2b: Field Measured 1-Hour Air Quality Parameters during the Study (OGGS)

Parameters	800m	CONTROL			DPR limits	P value
	EA26	C1	C2	C3		
SO <sub>x</sub> µg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	350	-
NO <sub>x</sub> µg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	200	-
COµg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	30	-
H <sub>2</sub> Sµg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1		-
C <sub>x</sub> H <sub>y</sub> µg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0		-
Smoke Density	N/A	N/A	N/A	N/A		-
Wind Direction	SW	SW	SW	SW		-
Wind Speed,m/s	3.3	2.3	2.9	1.4		0.720
Amb. Temperature, °C	33.3	34.5	35.8	29.4		0.710
Relative Humidity, %	63.4	58.7	60.2	76.2		0.800
Atm. Pressure, Pa	1009	1005	1009	1007		0.689
Noise Level, dBA	75.2	70.9	70.9	73.2	80-100	0.900
SPM <sub>10</sub> µg/m <sup>3</sup>	38.0	28.0	30.0	31.0	150-230	0.801

P<0.05: Significant; p>0.05: Non-significant

### DPK

The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, C<sub>x</sub>H<sub>y</sub> were measured at 500m and the control station from the prevailing wind direction (SW). Within the investigated airshed, the gaseous pollutants were below the equipment detection limits and compared favourably with the control stations. The noise levels measured at the 500m distance from the DPA and control stations were 74.2 dBA and complied with the DPR limits of 80 to 100 dBA for 8 hour exposure. A test of significance using the chi square goodness of fit test showed that no significant variation (p=0.615) was observed in the PM10 levels at the 500m distance of the DPK and the control stations. The PM10 values in the investigated airshed complied with the DPR limits of 150 to 230µg/m<sup>3</sup> for one hour mean value. The summary of the microclimatic data and field measurements for air quality parameters around along the DPK is presented in Table 4.2c.

Table 4.2c: Field Measured 1-Hour Air Quality Parameters during the Study (DPK)

Parameters	500m	CONTROLS			DPR limits	P value
	EA38	C1	C2	C3		
SO <sub>x</sub> µg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	350	-
NO <sub>x</sub> µg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	200	-
COµg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	30	-
H <sub>2</sub> Sµg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1		-
C <sub>x</sub> H <sub>y</sub> µg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0		-
Smoke Density	N/A	N/A	N/A	N/A		-
Wind Direction	SW	SW	SW	SW		-
Wind Speed, m/s	1.7	2.3	2.9	1.4		0.212
Amb. Temperature, °C	30.5	34.5	35.8	29.4		0.844
Relative Humidity, %	63.2	58.7	60.2	76.2		0.548
Atm. Pressure, Pa	1006	1005	1009	1007		0.922
Noise Level, dBA	74.2	70.9	70.9	73.2	80-100	0.800
SPM <sub>10</sub> µg/m <sup>3</sup>	29.0	28.0	30.0	31.0	150-230	0.615

P<0.05: Significant; p>0.05: Non-significant

### DPJ

The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, C<sub>x</sub>H<sub>y</sub> were measured at three receptor locations (200m, 500m and 800m) from the DPJ area along the prevailing wind direction. The gaseous pollutants recorded in the investigated airshed were below the equipment detection limits and not significantly different (p>0.05) from concentrations in the control stations. Furthermore, the noise levels were 70.6 dBA, 77.8 dBA and 70.9 dBA at the 200m, 500m and 800m distances from the DPJ and showed no spatiotemporal patterns. No significant variation (p=0.914) was observed when the receptor locations were compared with the control. The similarity in the airshed maybe attributed to prevailing ambient conditions around the DPJ area and the control. A test of significance in the PM10 data from DPJ and receptor locations

showed a temporal reduction ( $p=950$ ) from DPJ. The PM10 levels were  $38.0\mu\text{g}/\text{m}^3$  (200m),  $32\mu\text{g}/\text{m}^3$  (500m) and  $27.0\mu\text{g}/\text{m}^3$  (800m). The reduction in PM10 levels from DPJ across the receptor distances maybe attributed to the effects of wind speed on particulates. The study by Kim et al, 2015 corroborates this finding. The summary of the microclimatic data and field measurements for air quality parameters around the DPJ are presented in Table 4.2d.

Table 4.2d: Field Measured 1-Hour Air Quality Parameters during the Study (DPJ)

Parameters	200m	500m	800m	CONTROLS			DPR limits	P value
	EA53	EA50	EA56	C1	C2	C3		
SO <sub>x</sub> μg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9	350	-
NO <sub>x</sub> μg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2	200	-
COμg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7	30	-
H <sub>2</sub> Sμg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1		-
C <sub>x</sub> H <sub>y</sub> μg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0		-
Smoke Density	N/A	N/A	N/A	N/A	N/A	N/A		-
Wind Direction	SW	SW	SW	SW	SW	SW		-
Wind Speed,m/s	1.3	2.2	2.4	2.3	2.9	1.4		0.304
Amb. Temperature, °C	34.9	30.9	28.4	34.5	35.8	29.4		0.818
Relative Humidity, %	63.8	75.3	77.3	58.7	60.2	76.2		0.728
Atm. Pressure, Pa	1005	1006	1009	1005	1009	1007		0.900
Noise Level, dBA	70.6	77.8	70.9	70.9	70.9	73.2	80-100	0.914
SPM <sub>10</sub> μg/m <sup>3</sup>	38.0	32.0	27.0	28.0	30.0	31.0	150-230	0.950

P<0.05: Significant; p>0.05: Non-significant

### DPC

The summary of the microclimatic data and field measurements for air quality parameters around the DPC are presented in Table 4.2e. The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, C<sub>x</sub>H<sub>y</sub> were measured at two receptor locations (200m and 500m) from the DPC area along the prevailing wind direction. The gaseous pollutants recorded in the investigated airshed were below the equipment detection limits and not significantly different ( $p>0.05$ ) from concentrations in the control stations. Furthermore, the noise levels were 68.9 dBA and 68.9 dBA at the 200m and 500m distances from the DPC. No significant variation ( $p=0.918$ ) was observed when the receptor locations were compared with the control. The similarity in the airshed maybe attributed to prevailing ambient conditions around the DPC area and the control. The levels of particulates were significantly different ( $p=0.000$ ) at the 500m receptor location compared to the 200m location and the control stations. The PM10 levels were  $20.0\mu\text{g}/\text{m}^3$  and  $6.0\mu\text{g}/\text{m}^3$  at the 200m and 500m receptor locations respectively. The sharp drop in the PM10 values at the 500m receptor location maybe attributed to the influence of wind velocity (6.1m/s) around the DPC as highlighted in previous sections. The PM 10 values however complied with the DPR limits of 150 - 230  $\mu\text{g}/\text{m}^3$  for one hour mean values.

Table 4.2e: Field Measured 1-Hour Air Quality Parameters during the Study (DPC)

Parameters	200m	500m	CONTROL			DPR limits	P value
	EA63	EA61	C1	C2	C3		
SO <sub>x</sub> µg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	<19.9	350	
NO <sub>x</sub> µg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	<14.2	200	
COµg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	<8.7	30	
H <sub>2</sub> Sµg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1	<1.1		
C <sub>x</sub> H <sub>y</sub> µg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0	<1.0		
Smoke Density	N/A	N/A	N/A	N/A	N/A		
Wind Direction	SW	SW	SW	SW	SW		
Wind Speed,m/s	2.6	6.1	2.3	2.9	1.4		
Amb. Temperature, °C	28.2	28.9	34.5	35.8	29.4		0.818
Relative Humidity, %	85.1	77.5	58.7	60.2	76.2		0.118
Atm. Pressure, Pa	1011	1010	1005	1009	1007		0.900
Noise Level, dBA	68.9	68.9	70.9	70.9	73.2	80-100	0.918
SPM <sub>10</sub> µg/m <sup>3</sup>	20.0 <sup>a</sup>	6.0 <sup>b</sup>	28.0 <sup>a</sup>	30.0 <sup>a</sup>	31.0 <sup>a</sup>	150-230	0.000

P<0.05: Significant; p>0.05: Non-significant

Similar letters indicate values that are not significantly different

### DPA

The summary of the microclimatic data and field measurements for air quality parameters around the DPA area is presented in Table 4.2f. The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, C<sub>x</sub>H<sub>y</sub> were measured at 500m and the control station from the prevailing wind direction (SW). Within the DPA airshed, the gaseous pollutants were below the equipment detection limits and compared favourably with the control stations. The noise levels measured at the 500m distance from the DPA and control stations were 71.3 dBA and 70.65±0.92 dBA respectively and complied with the DPR limits of 80 to 100 dBA for 8 hour exposure. A test of significance using the chi square goodness of fit test showed that no significant variation (p=0.210) was observed in the PM10 levels at the 500m distance of the DPA and the control stations. The PM10 values in the investigated airshed complied with the DPR limits of 150 to 230 µg/m<sup>3</sup>

Table 4.2f: Field Measured 1-Hour Air Quality Parameters during the Study (DPA)

Parameters	500m		CONTROL			DPR limits	P value
	EA78	EA82	C1	C2	C3		
SO <sub>x</sub> µg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	<19.9	350	
NO <sub>x</sub> µg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	<14.2	200	
CO <sub>x</sub> µg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	<8.7	30	
H <sub>2</sub> Sµg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1	<1.1		
C <sub>x</sub> H <sub>y</sub> µg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0	<1.0		
Smoke Density	N/A	N/A	N/A	N/A	N/A		
Wind Direction	SW	SW	SW	SW	SW		
Wind Speed,m/s	1.4	2.6	2.3	2.9	1.4		0.752
Amb. Temperature, °C	27.2	27.6	34.5	35.8	29.4		0.350
Relative Humidity, %	84.2	80.3	58.7	60.2	76.2		0.112
Atm. Pressure, Pa	1005	1007	1005	1009	1007		0.800
Noise Level, dBA	71.3	70.0	70.9	70.9	73.2	80-100	0.939
SPM <sub>10</sub> µg/m <sup>3</sup>	30.0	42.0	28.0	30.0	31.0	150-230	0.210

P<0.05: Significant; p>0.05: Non-significant

### DPD

The concentration of SO<sub>2</sub>, NO<sub>2</sub>, CO<sub>2</sub>, H<sub>2</sub>S, C<sub>x</sub>H<sub>y</sub> were measured at 500m and the control station from the prevailing wind direction (SW). Within the DPD airshed, the gaseous pollutants were below the equipment detection limits and were not significantly different from the control stations. The noise levels measured at the 500m distance from the DPD and control stations were 74.9 dBA and 72.05±1.63 dBA respectively and complied with the DPR limits of 80 to 100 dBA for 8 hour exposure. A test of significance using the chi square goodness of fit test showed that no significant variation (p=0.909) was observed in the PM10 levels at the 500m distance of the DPD and the control stations. The PM10 values in the investigated airshed complied with the DPR limits of 150 to 230 µg/m<sup>3</sup>. The summary of the microclimatic data and field measurements for air quality parameters around the DPA area is presented in Table 4.2g.

Table 4.2g: Field Measured 1-Hour Air Quality Parameters during the Study (DPD)

Parameters	500m		CONTROL			DPR limits	P value
	EA92	EA93	C1	C2	C3		
SO <sub>x</sub> µg/m <sup>3</sup>	<19.9	<19.9	<19.9	<19.9	<19.9	350	
NO <sub>x</sub> µg/m <sup>3</sup>	<14.2	<14.2	<14.2	<14.2	<14.2	200	
COµg/m <sup>3</sup>	<8.7	<8.7	<8.7	<8.7	<8.7	30	
H <sub>2</sub> Sµg/m <sup>3</sup>	<1.1	<1.1	<1.1	<1.1	<1.1		
C <sub>x</sub> H <sub>y</sub> µg/m <sup>3</sup>	<1.0	<1.0	<1.0	<1.0	<1.0		
Smoke Density	N/A	N/A	N/A	N/A	N/A		
Wind Direction	SW	SW	SW	SW	SW		
Wind Speed,m/s	1.2	1.1	2.3	2.9	1.4		0.800
Amb. Temperature, °C	30.9	33.4	34.5	35.8	29.4		0.719
Relative Humidity, %	74.8	68.5	58.7	60.2	76.2		0.614
Atm. Pressure, Pa	1006	1006	1005	1009	1007		0.9
Noise Level, dBA	74.8	74.9	70.9	70.9	73.2	80-100	0.909
SPM <sub>10</sub> µg/m <sup>3</sup>	27.0	26.0	28.0	30.0	31.0	150-230	0.715

P<0.05: Significant; p>0.05: Non-significant

#### ***Historical trends of ambient air quality and noise***

The air quality variables around the EA FOD project area along different receptor distances showed generally increasing trends in the microclimatic data, SPM and noise levels from 2011 to 2018 (Table 4.2h). The gaseous pollutants (SO<sub>2</sub> and NO<sub>2</sub>) across the different receptor distances (200m, 500m, 800m) at the drilling platforms were below the equipment detection limits and complied with the DPR limits for one hourly mean values of 350 and 200 µg/m<sup>3</sup> respectively. Furthermore, the trends for Suspended Particulates and Noise levels were significant (p=0.000, p=0.032) and showed an increasing trend from 2011 to 2018. The increasing trends may be attributed to secondary sources around the coastline and vessel movement around the Estuary area. A test of significance using the *a posteriori* Duncan Multiple Range (DMR) test showed that the source of variation was the 2011 data sets as it was significantly lower around all the drilling platforms compared to the 2015 and 2018 data sets. **It was worthy to note, that no significant variation was observed in the 2015 and 2018 data sets across the receptor distances and drilling platforms.** This may be attributed to the general ambient conditions and the fact that project activities are yet to commence around the EA FOD project area.

Table 4.2h: Mean Meteorological and Air Pollutants and Noise levels data

Parameter		EIA 2011	EIA 2015	EIA 2018	DPR Limit	P value
Meteorology	Ambient Air Temperature, °C	29.8±2.4	26.3±3.1	28.5±2.8	N/A	0.933
	Wind Speed, m/s	0.92±0.89	3.8±1.8	2.2±3.9	N/A	0.049
	Wind Direction	-	NE/SW	SW		
Air Quality	SO <sub>x</sub> (as SO <sub>2</sub> ) µg/m <sup>3</sup>	<0.01	<0.01	<0.01	350	
	NO <sub>x</sub> (as NO), µg/m <sup>3</sup>	<0.01	<0.01	<0.01	200	
	VOC, µg/m <sup>3</sup>	<0.01 <sup>b</sup>	0.98 <sup>a</sup> ±0.11	<1.0 <sup>b</sup>		
	SPM, µg/m <sup>3</sup>	0.15±0.06	10.31±4.2	25.1±5.1	150-230	0.000
Noise	Noise Level, dB(A)	45.56±1.18 <sup>b</sup>	71.1 <sup>a</sup> ±2.5	72.8 <sup>a</sup> ±0.98	80-100	0.032

P<0.05: Significant; p>0.05: Non-significant

Similar letters indicate values that are not significantly different



### 4.2.3: Surface Water quality

#### *FPSO*

Table 4.3a shows the summary results of physicochemical measurements in surface water at different receptor distances of 200m, 500m, 800m, 1200m and 2500m from the FPSO compared with control. Detailed results are presented in **Appendix 2b**.

#### *Physicochemistry*

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the FPSO were not significantly different when compared ( $p=0.886$ ) to the control ( $27.53\pm 0.67$  °C). There were no definite patterns in the ambient temperature from the 200m receptor locations to the 2500m which may be attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from  $28.07\pm 1.32$  °C at the 200m receptor distance to  $27.8\pm 0.82$  °C at the 2500m distance in the direction of the persistent bottom currents from the FPSO. Temperature values around the FPSO are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations ( $p=0.900$ ). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish reproduction (Yokogawa, 2016). The pH ranged from  $8.51\pm 0.04$  at the 200m receptor distance to  $8.52\pm 0.07$  at the 2500m distance and  $8.48\pm 0.07$  at the control station.

The salt related parameters were in the range of  $39166.67\pm 4860.38$   $\mu\text{S/cm}$ ,  $14143.33\pm 1755.25$  mg/l,  $27417\pm 3401.79$  mg/l at the 200m receptor distance for Electrical conductivity, salinity as chloride and Total dissolved solids to  $37860\pm 5772.17$   $\mu\text{S/cm}$ ,  $13671.8\pm 2084.28$  mg/l and  $26506.6\pm 4037.31$  mg/l at the 2500m receptor distance. No significant variation ( $p=0.610$ ,  $p=0.650$  and  $p=0.800$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters may be attributed to general hydrodynamic conditions (fluxes in salts, swells and other water perturbations). The parameters were within those expected in estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters: DO ( $p=0.730$ ), BOD ( $p=0.900$ ) and COD ( $p=0.850$ ) were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different from the control stations across the receptor distances from 200m to 2500m. The mean DO levels ranged from  $4.93\pm 1.59$  mg/l at the 200m distance from the FPSO to  $4.76\pm 1.52$  mg/l at the 2500m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from  $0.225\pm 0.09$  mg/l to  $0.27\pm 0.21$  mg/l and  $199\pm 22.80$  mg/l to  $188.67\pm 28.29$  mg/l at the 200m and 2500m receptor distances compared to the controls ( $0.3\pm 0.1$  mg/l and  $190\pm 1.73$  mg/l). The BOD and COD levels are characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006).



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Table 4.3a: Summary results of physicochemical measurements in surface Water at EDP (EAGLE FPSO) compared with control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	2500m (Mean ± SD)	Control (Mean ± SD)	P value
TEMP, °C	28.07±1.32	28.53±1.71	28.13±0.40	28.72±1.39	27.8±0.82	27.53±0.67	0.886
pH	8.51±0.04	8.53±0.04	8.54±0.040	8.50±0.05	8.52±0.07	8.48±0.07	0.900
COND, µS/cm	39166.67±4860.38	37575±3491.30	40966.67±1721.43	37280±4344.77	37860±5772.17	43133.33±680.69	0.610
TURB, NTU	0±0	0±0	0±0	0±0	0±0	0±0	
DO, mg/l	4.93±1.59	5.2±1.40	4.47±1.36	5.4±1.06	4.76±1.52	4.93±1.67	0.730
TDS mg/l	27417±3401.79	26304±2443.81	28680±1209.66	26097.6±3042.60	26506.6±4037.31	30194±476.14	0.800
Cl, mg/l	14143.33±1755.25	13568.75±1260.98	14793.67±621.80	13462.2±1568.83	13671.8±2084.28	15576±246.00	0.650
ALK mg/l	12±4	11±2	13.33±2.31	14.4±2.19	12±2.83	9.33±2.31	0.821
Colour, Pt/Co	0.01±0.01	0.01±0.01	0.01±0.01	0.01±0.004	0.01±0.01	0±0	1.000
TSS mg/l	58±3.46	57±4.76	57.33±11.55	57.2±10.06	58.8±21.57	45.33±1.15	0.920
COD mg/l	199±22.80	182±22.65	203.2±12.74	191±7.38	188.67±28.29	190±1.73	0.850
BOD mg/l	0.225±0.09	0.27±0.21	0.38±0.31	0.2±0.17	0.27±0.21	0.3±0.1	0.900
SO <sub>4</sub> mg/l	886.33±82.89	918.75±136.14	846.67±52.65	928.8±30.45	921.6±73.74	903.33±55.64	0.610
PO <sub>4</sub> mg/l	0.34±0.08	0.58±0.30	0.61±0.26	0.472±0.27	0.48±0.25	0.44±0.23	0.750
NO <sub>3</sub> mg/l	1.8±0.44	1.93±0.45	1.7±0.62	1.84±0.36	2.08±0.25	1.33±0.25	0.800
NH <sub>4</sub> mg/l	0.83±0.20	0.89±0.21	0.79±0.29	0.96±0.38	0.96±0.11	0.62±0.12	0.981
NO <sub>2</sub> <sup>-</sup> mg/l	5.91±1.43	6.32±1.48	5.58±2.06	6.04±1.20	6.83±0.82	4.38±0.83	0.832
OG mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	

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Parameters	200m	500m	800m	1200m	2500m	Control	P value
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.14±0.10	0.16±0.05	0.23±0.06	0.21±0.04	0.14±0.04	0.21±0.01	0.700
Fe mg/l	0.27±0.05	0.29±0.16	0.27±0.03	0.36±0.09	0.24±0.15	0.38±0.05	0.888
Pb mg/l	0.05±0.01	0.04±0.02	0.05±0.01	0.03±0.02	0.04±0.03	0.01±0.001	0.810
Cu mg/l	N/A	N/A	N/A	N/A	N/A	N/A	
Cr mg/l	0.11±0.03	0.13±0.09	0.18±0.02	0.12±0.05	0.08±0.05	0.08±0.06	0.933
Zn mg/l	0.10±0.05	0.12±0.05	0.12±0.04	0.1±0.05	0.12±0.02	0.14±0.10	0.981
Cd mg/l	0.13±0.06	0.08±0.03	0.11±0.02	0.09±0.02	0.09±0.06	0.09±0.04	0.840
Ba mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.08±0.05	0.055±0.06	0.04±0.02	0.04±0.02	0.05±0.05	0.13±0.04	0.900
Co mg/l	N/A	N/A	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/l	373.33±14.57	375±4.97	372±25.98	369.6±15.18	370.8±16.24	362.67±30.60	0.951
Na mg/l	9736.33±122.09	9886±12.70	9872±116.53	9731±345.67	10169.2±418.07	9926.67±51.38	0.818
Mg mg/l	1267±26.85	1260.75±30.45	1270.33±12.22	1244.8±19.33	1263±15.07	1248±18.68	0.900
Ca mg/l	469.67±15.57	473.25±9.18	479.67±15.31	454.6±19.63	481.2±4.97	468.33±6.51	0.823
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	6.5±2.1 <sup>a</sup>	2.19 ±1.15 <sup>b</sup>	9.8±0.72 <sup>a</sup>	1.59±0.28 <sup>b</sup>	7.3±3.3 <sup>a</sup>	6.1±2.2 <sup>a</sup>	0.039
TF x 10 <sup>2</sup> (cfu/ml)	3.8 ±4.68 <sup>a</sup>	0.89±0.20 <sup>b</sup>	3.7 ±0.11 <sup>a</sup>	0.80±0.60 <sup>b</sup>	4.1 ±2.5 <sup>a</sup>	4.7 ±3.0 <sup>a</sup>	0.040

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<b>Parameters</b>	<b>200m</b>	<b>500m</b>	<b>800m</b>	<b>1200m</b>	<b>2500m</b>	<b>Control</b>	<b>P value</b>
Faecal coliform (MPN/100ml)	0±0	0±0	0±0	1±2.24	0±0	1.67±2.89	
SRB (cfu/ml)	0	0	0	0	0	0	

P<0.05 – Significant; p>0.05 – Not significant

Means highlighted are significantly different from the Control (Dunnett's test)

### ***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Average levels of nitrate and phosphates ranged from  $1.8 \pm 0.44$  mg/l at 200 m to  $2.08 \pm 0.25$  mg/l at 2500 m;  $0.34 \pm 0.08$  mg/l at 200 m to  $0.48 \pm 0.25$  mg/l at 2500 m and  $1.33 \pm 0.25$  mg/l and  $0.44 \pm 0.23$  mg/l in the control station respectively. Similarly, nitrite levels also compared favourably with the control stations as concentrations varied from  $5.91 \pm 1.43$  mg/l at the 200m receptor distance to  $6.83 \pm 0.82$  mg/l at the 2500m distance in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=0.800$ ), phosphates,  $p=0.750$ ) and control across the receptor locations. The levels of limiting nutrients suggest an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992). Levels of phosphates and nitrates around the EA FOD project area are suggestive of coastal influences from catchments areas.

### ***Heavy metals***

Detailed results of heavy metals in surface water are presented in Appendix 2c. The metals, Barium, Silver and Vanadium were not detected ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.700$ ), Fe ( $p=0.888$ ), Pb ( $p=0.810$ ), Cr ( $p=0.933$ ), Zn ( $p=0.981$ ), Cd ( $p=0.840$ ) and Mn ( $p=0.900$ ) were not significantly different from the control stations at the 200m, 500m, 800m, 1200m and 2500m. Mean heavy metal concentrations were generally low and within background levels. The heavy metal concentrations ranged from  $0.14 \pm 0.10$  -  $0.21 \pm 0.01$  mg/l (Ni);  $0.27 \pm 0.05$  -  $0.24 \pm 0.15$  mg/l (Fe);  $0.05 \pm 0.01$  -  $0.04 \pm 0.03$  mg/l (Pb);  $0.11 \pm 0.03$  -  $0.08 \pm 0.05$  mg/l (Cr);  $0.10 \pm 0.05$  -  $0.12 \pm 0.02$  mg/l (Zn);  $0.13 \pm 0.06$  -  $0.09 \pm 0.06$  mg/l (Cd) and  $0.08 \pm 0.05$  -  $0.05 \pm 0.05$  mg/l (Mn) at the 200m and 2500m receptor locations from the FPSO in the direction of persistent bottom current. The mean concentrations of heavy metals compared favourably with the control station (Ni;  $0.21 \pm 0.01$  mg/l, Fe;  $0.38 \pm 0.05$  mg/l, Pb;  $0.01 \pm 0.001$  mg/l, Cr;  $0.08 \pm 0.06$  mg/l, Zn;  $0.14 \pm 0.10$  mg/l, Cd;  $0.09 \pm 0.04$  mg/l and Mn;  $0.13 \pm 0.04$  mg/l).

### ***Organics***

The THC, TPH, PAH and Oil and grease concentration were not detected ( $<0.001$  mg/l) in the recipient water body across the receptor locations from 200m to 2500m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

### ***Microbiology***

The summary of the microbial load of the recipient water body is presented in Table 4.4a. Detailed results are presented in Appendix 2d. The THB and TF were in the order of  $10^2$  cfu/ml. THB ranged from  $6.5 \pm 2.1 \times 10^2$  cfu/ml to  $7.3 \pm 3.3 \times 10^2$  cfu/ml while TF ranged from  $3.8 \pm 4.6 \times 10^2$  cfu/ml to  $4.1 \pm 2.5 \times 10^2$  cfu/ml at the 200m and 2500m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load were significantly different (THB,  $p=0.039$ ; TF,  $p=0.040$ ) when compared to the control stations with the variance at the

500m and 1200m receptor distances providing a source of the variance. The variation maybe attributed to natural fluctuations in carbon fluxes across the receptor distances from the FPSO in the direction of the persistent bottom currents. The hydrocarbonoclastis (HUB and HUF) were not encountered in the water body at the various receptor distances including the control stations. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the 1200m receptor distance ( $1\pm 2.24$  MPN/100ml) and the control stations ( $1.67\pm 2.89$  MPN/100ml). No significant variation was observed at this distance (1200m) compared to the control. Influences from the coastal waters may be responsible for the observed variation. Furthermore, sulphur reducing bacteria (SRBs) were not identified across the receptor distances from 200m to 2500m including the control station which indicates unlikelihood of biogenic souring during the operation phase of the project.

### **OGGS - RPA**

Table 4.3b shows the summary results of physicochemical measurements in surface water at different receptor distances of 500m, 800m and 1200m from the OGGS-RPA area compared with control. Detailed results are presented in **Appendix 2**.

#### ***Physicochemistry***

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the OGGS-RPA were not significantly different when compared ( $p=0.950$ ) to the control ( $27.53\pm 0.67$  °C). There were no definite patterns in the ambient temperature from the 200m receptor locations to the 1200m which may be attributed to similarity in hydrodynamic conditions within the coastal waters. The ambient temperature in the recipient water body ranged from  $27.9\pm 1.70$  °C at the 500m receptor distance to  $28.47\pm 0.59$  °C at the 1200m distance in the direction of the persistent bottom currents from the OGGS-RPA. Temperature values around the OGGS-RPA are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations ( $p=1.000$ ). The pH of the recipient water suggests an estuarine ecosystem and consistent with desirable ranges for fish growth and reproduction (Yokogawa, 2016). The pH ranged from  $8.46\pm 0.02$  at the 500m receptor distance to  $8.50\pm 0.01$  at the 1200m distance and  $8.48\pm 0.07$  at the control station.

The salt related parameters, Electrical conductivity, salinity as chloride and Total dissolved solids ranged from  $43700\pm 2121.32$   $\mu$ S/cm, 46400 mg/l and  $42233.33\pm 1616.58$  mg/l at the 500m receptor distance to  $43133.33\pm 680.69$   $\mu$ S/cm, 14890 $\pm$ 41.57 mg/l and  $29565.67\pm 1133.05$  mg/l at the 1200m receptor distance respectively. No significant variation ( $p=0.910$ ,  $p=0.712$  and  $p=0.610$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters may be attributed to general hydrodynamic conditions (fluxes in salts, swells and water

perturbations). The parameters were within normal range for estuarine environments in the Niger delta.

The levels of oxygen related parameters: were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different (DO ( $p=1.000$ ), BOD ( $p=0.750$ ) and COD ( $p=0.815$ )) from the control stations across the receptor distances from 500m to 1200m. The mean DO levels ranged from  $4.55\pm 1.91$  mg/l at the 500m distance from the OGGs RPA to  $5.77\pm 0.06$  mg/l at the 1200m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from  $0.1\pm 1.70$  mg/l to  $0.15\pm 0.07$  mg/l to and  $151\pm 2.83$  mg/l to  $177.67\pm 8.50$  mg/l at the 500m and 1200m receptor distances respectively compared to the controls ( $0.3\pm 0.1$  mg/l and  $190\pm 1.73$  mg/l). The BOD levels suggest low levels of organic inputs into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006). However, the COD levels were relatively high suggesting moderate levels of organic pollution possibly arising from coastal discharges and matitime inputs of organic wastes.

#### ***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from  $1.35\pm 0.07$  mg/l at 500 m to  $1\pm 0.36$  mg/l at 1200 m;  $0.37\pm 0.06$  mg/l at 500 m to  $0.54\pm 0.30$  mg/l at 1200 m and  $1.33\pm 0.25$  mg/l to  $0.44\pm 0.23$  mg/l in the control station. Similarly, nitrite and ammonium-nitrogen levels also compared favourably with the control stations with concentrations varying from  $4.43\pm 0.23$  mg/l to  $3.28\pm 1.18$  mg/l and  $0.64\pm 0.02$  to  $0.47\pm 0.17$  mg/l at the 500m and 1200m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=0.800$ ), phosphates,  $p=0.750$ ) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

#### ***Heavy metals***

The concentration of Barium, Silver and Vanadium were below detection levels ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.815$ ), Fe ( $p=0.918$ ), Pb ( $p=0.510$ ), Cr ( $p=1.000$ ), Zn ( $p=0.815$ ), Cd ( $p=0.900$ ) and Mn ( $p=0.412$ ) were not significantly different from the control stations at the 500m, 800m and 1200m receptor distances. Mean heavy metal concentrations were generally within background levels from the 500m to 1200m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from  $0.13\pm 0.11$  to  $0.17\pm 0.04$  mg/l,  $0.44\pm 0.09$  to  $0.28\pm 0.05$  mg/l,  $0.04\pm 0.02$  to  $0.09\pm 0.12$  mg/l,  $0.05\pm 0.03$  to  $0.14\pm 0.11$  mg/l,  $0.10\pm 0.01$  to  $0.09\pm 0.04$  mg/l,  $0.11\pm 0.05$  to  $0.084\pm 0.03$  mg/l and  $0.10\pm 0.08$  to  $0.09\pm 0.02$  mg/l respectively in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

#### ***Organics***



The THC, TPH, PAH and Oil and grease concentration were not detected ( $<0.001$ ) in the recipient water body across the receptor locations from 800m to 1200m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

### Microbiology

The summary of the microbial load of the recipient water body is presented in Table 4.3b. The THB and TF were in the order of  $10^2$  cfu/ml and ranged from  $1.91 \pm 0.11 \times 10^2$  cfu/ml,  $9.9 \pm 3.3 \times 10^2$  cfu/ml to  $1.80 \pm 2.9 \times 10^2$  cfu/ml,  $8.2 \pm 2.4 \times 10^2$  cfu/ml at the 500m and 1200m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control ( $p=1.000$ ;  $p=0.610$ ). The hydrocarbonoclastis were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the control stations ( $1.67 \pm 2.89$  MPN/100ml) and may be attributed to influences from the coastal waters or discharges from marine water crafts plying the navigational route. Furthermore, SRBs were not identified across the receptor distances from 500m to 1200m including the control station and indicates unlikelihood of biogenic souring during the operation phase of the project.

Table 4.3b: Summary results of physicochemical measurements in surface Water at OGGS - RPA compared with control

Parameters	500m (Mean $\pm$ SD)	800m (Mean $\pm$ SD)	1200m (Mean $\pm$ SD)	Control (Mean $\pm$ SD)	P value
TEMP, °C	27.9 $\pm$ 1.70	27.5	28.47 $\pm$ 0.59	27.53 $\pm$ 0.67	0.950
pH	8.46 $\pm$ 0.02	8.5	8.50 $\pm$ 0.01	8.48 $\pm$ 0.07	1.000
COND, $\mu$ S/cm	43700 $\pm$ 2121.32	46400	42233.33 $\pm$ 1616.58	43133.33 $\pm$ 680.69	0.910
TURB, NTU	0 $\pm$ 0	0	0 $\pm$ 0	0 $\pm$ 0	
DO, mg/l	4.55 $\pm$ 1.91	5.4	5.77 $\pm$ 0.06	4.93 $\pm$ 1.67	1.000
TDS mg/l	30590 $\pm$ 1484.92	32480	29565.67 $\pm$ 1133.05	30194 $\pm$ 476.14	0.610
Cl, mg/l	15780.5 $\pm$ 765.80	16756	14890 $\pm$ 41.57	15576 $\pm$ 246.00	0.712
ALK mg/l	14 $\pm$ 2.83	16	12 $\pm$ 0	9.33 $\pm$ 2.31	0.500
COLOUR Pt/Co	0 $\pm$ 0	0	0.01 $\pm$ 0.01	0 $\pm$ 0	
TSS mg/l	79 $\pm$ 1.41 <sup>a</sup>	90 <sup>a</sup>	89.33 $\pm$ 1.15 <sup>a</sup>	45.33 $\pm$ 1.15 <sup>b</sup>	0.049
COD mg/l	151 $\pm$ 2.83	161	177.67 $\pm$ 8.50	190 $\pm$ 1.73	0.851
BOD mg/l	0.15 $\pm$ 0.07	0.3	0.1 $\pm$ 1.70	0.3 $\pm$ 0.1	0.750
SO4 mg/l	904.5 $\pm$ 38.89	845	851.67 $\pm$ 35.23	903.33 $\pm$ 55.64	0.600
PO4 mg/l	0.37 $\pm$ 0.06	0.38	0.54 $\pm$ 0.30	0.44 $\pm$ 0.23	0.321

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Parameters	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
NO3 mg/l	1.35±0.07	2	1±0.36	1.33±0.25	0.810
NH4 mg/l	0.64±0.02	0.93	0.47±0.17	0.62±0.12	0.501
N02- mg/l	4.43±0.23	6.57	3.28±1.18	4.38±0.83	0.833
O/G mg/l	<0.001	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.13±0.11	0.196	0.17±0.04	0.21±0.01	0.815
Fe mg/l	0.44±0.09	0.287	0.28±0.05	0.38±0.05	0.918
Pb mg/l	0.04±0.02	0.021	0.09±0.12	0.09±0.001	0.510
Cu mg/l	N/A	N/A	N/A	N/A	
Cr mg/l	0.05±0.03	0.12	0.14±0.11	0.08±0.06	1.000
Zn mg/l	0.10±0.01	0.148	0.09±0.04	0.143±0.10	0.815
Cd mg/l	0.11±0.05	0.06	0.084±0.03	0.09±0.04	0.900
Ba mg/l	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.10±0.08	0.06	0.09±0.02	0.13±0.04	0.412
Co mg/l	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	
K mg/l	387.5±0.71	390	377±7	362.67±30.60	0.852
Na mg/l	10161.5±102.53	9689	9946.67±62.23	9926.67±51.38	0.900
Mg mg/l	1269.5±17.68	1259	1254±11.27	1248±18.68	0.811
Ca mg/l	461±2.83	482	460.33±24.17	468.33±6.51	0.850
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	1.91±0.11	1.74±3.4	1.80±2.9	1.63±04.4	1.000
TF x 10 <sup>2</sup> (cfu/ml)	9.9±3.3	7.5±1.8	8.2±2.4	9.1±4.0	0.610
Faecal coliform (MPN/100ml)	0±0	0	0±0	1.67±2.89	
SRB (cfu/ml)	0	0	0	0	

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

P<0.05 – Significant; p>0.05 – Not significant

**DPK**

Table 4.3c shows the summary results of physicochemical measurements in surface water at different receptor distances of 200m, 500m, 800m and 1200m from the DPK area compared with control. Detailed results are presented in **Appendix 2**.

**Physicochemistry**

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the DPK were not significantly different when compared ( $p=1.000$ ) to the control ( $27.53\pm 0.67$  °C). There were no definite patterns in the ambient temperature from the 200m receptor locations to the 1200m and maybe attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from  $28.4\pm 0.46$  °C at the 200m receptor distance to  $27.55\pm 0.35$  °C at the 1200m distance in the direction of the persistent bottom currents from the DPK area. Temperature values around the DPK area are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations ( $p=1.000$ ). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish growth and reproduction (Yokogawa, 2016). The pH ranged from  $8.50\pm 0.04$  at the 200m receptor distance to  $8.45\pm 0.00$  at the 1200m distance and  $8.48\pm 0.07$  at the control station.

The salt related parameters, Electrical conductivity, salinity as chloride and Total dissolved solids ranged from  $39380\pm 827.77$   $\mu\text{S}/\text{cm}$ ,  $14220.33\pm 298.79$  mg/l and  $27566\pm 579.44$  mg/l at the 200m receptor distance to  $40300\pm 0$   $\mu\text{S}/\text{cm}$ ,  $14553\pm 0$  mg/l and  $28210\pm 0$  mg/l at the 1200m receptor distance. No significant variation ( $p=0.930$ ,  $p=0.900$  and  $p=0.918$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters maybe attributed to general hydrodynamic conditions (fluxes in organic and inorganic salts, swells and water perturbations). The parameters were within estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters, DO, BOD and COD, were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different (DO ( $p=1.000$ ), BOD ( $p=0.600$ ) and COD ( $p=0.750$ )) from the control stations across the receptor distances from 200m to 1200m. The mean DO levels ranged from  $5.83\pm 0.06$  mg/l at the 200m distance from the DPK to  $5.8\pm 0.14$  mg/l at the 1200m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from  $0.47\pm 0.40$  mg/l to  $0.35\pm 0.35$  mg/l and  $188\pm 4.58$  mg/l to  $189.5\pm 9.19$  mg/l at the 200m and 1200m receptor distances compared to the controls ( $0.3\pm 0.1$  mg/l to  $190\pm 1.73$  mg/l). The BOD levels suggest low levels of organic and inorganic inputs into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006). The COD levels were relatively elevated suggesting moderate levels of organic pollution.

### ***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from  $1.3\pm 0.26$  mg/l at 200 m to  $1.7\pm 0.71$  mg/l at 1200 m;  $0.37\pm 0.05$  mg/l at 200 m to  $0.46\pm 0.35$  mg/l at 1200 m and  $1.33\pm 0.25$

mg/l;  $0.44 \pm 0.23$  mg/l in the control station. Similarly, nitrite and ammonia-nitrate levels also compared favourably with the control stations as concentrations varied from  $4.27 \pm 0.87$  mg/l to  $5.59 \pm 2.33$  mg/l and  $0.61 \pm 0.12$  to  $0.79 \pm 0.33$  mg/l at the 200m and 1200m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=1.000$ ), phosphates,  $p=1.000$ ) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

### ***Heavy metals***

The metals, Barium, Silver and Vanadium were not detected ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.800$ ), Fe ( $p=0.708$ ), Pb ( $p=0.500$ ), Cr ( $p=0.400$ ), Zn ( $p=0.352$ ), Cd ( $p=1.000$ ) and Mn ( $p=0.900$ ) were not significantly different from the control stations at the 200m, 500m, 800m and 1200m receptor distances. Mean heavy metal concentrations were generally within background levels from the 200m to 1200m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from  $0.17 \pm 0.07$  to  $0.16 \pm 0.07$  mg/l,  $0.30 \pm 0.05$  to  $0.45 \pm 0.05$  mg/l,  $0.04 \pm 0.01$  to  $0.02 \pm 0.001$  mg/l,  $0.12 \pm 0.07$  to  $0.04 \pm 0.01$  mg/l,  $0.10 \pm 0.05$  to  $0.08 \pm 0.04$  mg/l,  $0.09 \pm 0.01$  to  $0.10 \pm 0.02$  mg/l and  $0.02 \pm 0.02$  to  $0.02 \pm 0.01$  mg/l in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

### ***Organics***

The THC, TPH, PAH and Oil and grease concentration were not detected ( $<0.001$  mg/l) in the recipient water body across the receptor locations from 800m to 1200m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

### ***Microbiology***

The summary of the microbial load of the recipient water body is presented in Table 4.3c. The THB and TF were in the order of  $10^2$  cfu/ml and ranged from  $7.1 \pm 3.3 \times 10^2$  cfu/ml,  $3.6 \pm 1.8 \times 10^2$  cfu/ml to  $7.9 \pm 7.0 \times 10^2$  cfu/ml,  $5.1 \pm 1.8 \times 10^2$  cfu/ml at the 200m and 1200m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control ( $p=1.000$ ;  $p=0.610$ ). The hydrocarbonoclastis were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the 800m ( $0.5 \pm 1$  MPN/100ml) and 1200m ( $0.5 \pm 0.71$  MPN/100ml) with elevated levels at the control stations ( $1.67 \pm 2.89$  MPN/100ml) which may be attributed to influences from the coastal waters or discharges from marine water crafts plying the navigational route. Furthermore, SRBs were not identified across the receptor distances from 200m to 1200m

including the control station and indicates unlikelihood of biogenic souring during the operation phase of the project.

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Table 4.3c: Summary results of physicochemical measurements in surface Water at DPK compared with control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
TEMP, °C	28.4±0.46	28.875±0.5	28.58±0.74	27.55±0.35	27.53±0.67	1.000
pH	8.50±0.04	8.47±0.03	8.46±0.01	8.45±0	8.48±0.07	1.000
COND, µS/cm	39380±827.77	40875±1223.04	40950±946.92	40300±0	43133.33±680.69	0.930
TURB, NTU	0±0	0±0	0±0	0±0	0±0	
DO, mg/l	5.83±0.06	5.7±0.14	5.85±0.06	5.8±0.14	4.93±1.67	1.000
TDS mg/l	27566±579.44	28613.5±855.59	28665.25±662.90	28210±0	30194±476.14	0.918
Cl, mg/l	14220.33±298.79	14760.75±441.68	14787.5±342.16	14553±0	15576±246.00	0.900
ALK mg/l	8±0	11±2	12±3.27	10±2.83	9.33±2.31	0.702
COLOUR Pt/Co	0±0	0.003±0.01	0.01±0.01	0.01±0	0±0	
TSS mg/l	77.33±9.45	73±4.76	68±3.65	64±2.83	45.33±1.15	0.610
COD mg/l	188±4.58	156.25±40.61	187.25±10.69	189.5±9.19	190±1.73	0.750
BOD mg/l	0.47±0.40	0.23±0.10	0.63±0.10	0.35±0.35	0.3±0.1	0.600
SO <sub>4</sub> mg/l	907.33±14.19	849±44.67	935.25±72.49	957±22.63	903.33±55.64	0.955
PO <sub>4</sub> mg/l	0.37±0.05	0.62±0.14	0.53±0.25	0.46±0.35	0.44±0.23	1.000
NO <sub>3</sub> mg/l	1.3±0.26	1.68±0.39	1.73±0.43	1.7±0.71	1.33±0.25	1.000
NH <sub>4</sub> mg/l	0.61±0.12	0.78±0.18	0.80±0.20	0.79±0.33	0.62±0.12	0.812
N02- mg/l	4.27±0.87	5.50±1.27	5.67±1.40	5.59±2.33	4.38±0.83	1.000
O/G mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.17±0.07	0.18±0.08	0.20±0.06	0.16±0.07	0.21±0.01	0.800
Fe mg/l	0.30±0.05	0.37±0.02	0.32±0.03	0.45±0.05	0.38±0.05	0.708
Pb mg/l	0.04±0.01	0.04±0.01	0.04±0.01	0.02±0.001	0.013±0.001	0.500
Cu mg/l	N/A	N/A	N/A	N/A	N/A	
Cr mg/l	0.12±0.07	0.14±0.03	0.10±0.06	0.04±0.01	0.08±0.06	0.400
Zn mg/l	0.10±0.05	0.12±0.03	0.08±0.02	0.08±0.04	0.14±0.10	0.352
Cd mg/l	0.09±0.01	0.09±0.01	0.07±0.02	0.10±0.02	0.09±0.04	1.000

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Parameters	200m	500m	800m	1200m	Control	P value
Ba mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.02±0.02	0.03±0.02	0.03±0.04	0.02±0.01	0.13±0.04	0.900
Co mg/l	N/A	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/l	372.67±23.97	366.75±27.18	381.75±17.88	366±16.97	362.67±30.60	0.800
Na mg/l	10097±289.14	9814.25±242.61	9752±150.92	9863±5.66	9926.67±51.38	0.919
Mg mg/l	1268.33±18.58	1264.25±21.41	1275.5±32.77	1274.5±27.58	1248±18.68	1.000
Ca mg/l	450.33±6.66	467.75±6.18	464.25±15.73	467±8.49	468.33±6.51	1.000
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	7.1±3.3	6.5±4.1	8.1±4.2	7.9±7.0	9.8±8.1	0.818
TF x 10 <sup>2</sup> (cfu/ml)	3.6±1.8	4.8±2.0	3.3±2.5	5.1±1.8	8.2±4.2	0.600
Faecal coliform (MPN/100ml)	0±0	0±0	0.5±1 <sup>b</sup>	0.5±0.71 <sup>b</sup>	1.67±2.89 <sup>a</sup>	0.021
SRB (cfu/ml)	0	0	0	0	0	

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

P<0.05 – Significant; p>0.05 – Not significant

**DPJ**

Table 4.3d shows the summary results of physicochemical measurements in surface water at different receptor distances of 200m, 500m, 800m and 1200m from the DPJ area compared with control. Detailed results are presented in **Appendix 2**.

***Physicochemistry***

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the DPJ were not significantly different when compared ( $p=0.970$ ) to the control ( $27.53\pm 0.67$  °C). There were no definite patterns in the ambient temperature from the 200m receptor locations to the 1200m and maybe attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from 29.5 °C at the 200m receptor distance to  $26.6\pm 1.41$ °C at the 1200m distance in the direction of the persistent bottom currents from the DPJ area. Temperature values around the DPJ area are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations ( $p=1.000$ ). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish reproduction (Yokogawa, 2016). The pH ranged from 8.4 at the 200m receptor distance to  $8.15\pm 0.32$  at the 1200m distance and  $8.48\pm 0.07$  at the control station.

The salt related parameters were in the range of 37100 $\mu$ S/cm, 13397mg/l, 25980mg/l at the 200m receptor distance for Electrical conductivity, salinity as chloride and Total dissolved solids to 32750 $\pm$ 7990.31 $\mu$ S/cm, 11826.5 $\pm$ 2885.70mg/l and 22932 $\pm$ 5597.46mg/l respectively at the 1200m receptor distance. No significant variation ( $p=0.740$ ,  $p=0.400$  and  $p=0.650$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters maybe attributed to general hydrodynamic conditions (fluxes in organic and inorganic salts, swells and water perturbations). The parameters were within estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different (DO ( $p=1.000$ ), BOD ( $p=0.610$ ) and COD ( $p=0.300$ )) from the control stations across the receptor distances from 200m to 1200m. The mean DO levels ranged from 5.6mg/l at the 200m distance from the DPK to  $5.3\pm 0.14$ mg/l at the 1200m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from 0.7mg/l to  $0.35\pm 0.21$ mg/l and 162mg/l to  $198\pm 15.56$ mg/l at the 200m and 1200m receptor distances compared to the controls ( $0.3\pm 0.1$ mg/l and  $190\pm 1.73$ mg/l). The BOD levels suggest low levels of organic inputs into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006). The COD levels is suggestive of moderate levels of organic pollution attributable to inputs from riverine discharges, marine vessels and other maritime activities.



### ***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from 1.6 mg/l at 200 m to  $1.75 \pm 0.36$  mg/l at 1200 m; 0.21 mg/l at 200 m to  $0.29 \pm 0.18$  mg/l at 1200 m and  $1.33 \pm 0.25$  mg/l;  $0.44 \pm 0.23$  mg/l in the control station. Similarly, nitrite and ammonia-nitrate levels also compared favourably with the control stations as concentrations varied from 5.25mg/l to  $5.75 \pm 1.16$ mg/l and 0.74 to  $0.82 \pm 0.16$ mg/l at the 200m and 1200m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=1.000$ ), phosphates,  $p=0.900$ ) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

### ***Heavy metals***

The concentration of Barium, Silver and Vanadium were not detected ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.800$ ), Fe ( $p=0.725$ ), Pb ( $p=0.750$ ), Cr ( $p=0.261$ ), Zn ( $p=0.119$ ), Cd ( $p=0.800$ ) and Mn ( $p=0.241$ ) were not significantly different from the control stations at the 200m, 500m, 800m and 1200m receptor distances. Mean heavy metal concentrations were generally within background levels from the 200m to 1200m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from 0.165 to  $0.13 \pm 0.05$  mg/l, 0.575 to  $0.37 \pm 0.07$  mg/l, 0.012 to  $0.04 \pm 0.003$  mg/l, 0.121 to  $0.04 \pm 0.003$  mg/l, 0.121 to  $0.04 \pm 0.05$  mg/l, 0.106 to  $0.043 \pm 0.03$  mg/l and 0.07 to  $0.02 \pm 0.03$  mg/l in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

### ***Organics***

The THC, TPH, PAH and Oil and grease concentration were not detected ( $<0.001$  mg/l) in the recipient water body across the receptor locations from 800m to 1200m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

### ***Microbiology***

The summary of the microbial load of the recipient water body is presented in Table 4.3d. The THB and TF were in the order of  $10^2$ cfu/ml and ranged from  $2.47 \times 10^2$ cfu/ml,  $1.01 \times 10^2$ cfu/ml to  $7.1 \pm 1.0 \times 10^2$ cfu/ml,  $5.2 \pm 3.3 \times 10^2$ cfu/ml at the 200m and 1200m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control ( $p=0.105$ ;  $p=0.061$ ). Similarly, the hydrocarbonoclastis were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the

control stations ( $1.67 \pm 2.89$ MPN/100ml) and maybe attributed to influences from the coastal waters or discharges from marine water crafts plying the navigational route. Furthermore, SRBs were not identified across the receptor distances from 200m to 1200m including the control station and indicates unlikelihood of biogenic souring during the operation phase of the project.

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Table 4.3d: Summary results of physicochemical measurements in surface Water at the DP-J compared with control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
TEMP, °C	29.5	28.77±0.40	27.425±1.03	26.6±1.41	27.53±0.67	0.970
pH	8.4	8.43±0.03	8.42±0.03	8.15±0.32	8.48±0.07	1.000
COND, µS/cm	37100	39700±556.78	34850±2531.80	32750±7990.31	43133.33±680.69	0.740
TURB, NTU	0	0±0	0±0	0±0	0±0	
DO, mg/l	5.6	5.83±0.06	5.75±0.1	5.3±0.14	4.93±1.67	1.000
TDS mg/l	25980	27794.33±394.15	24399.75±1775.24	22932±5597.46	30194±476.14	0.650
Cl, mg/l	13397	14336.33±200.98	12584.75±914.53	11826.5±2885.70	15576±246.00	0.400
ALK mg/l	16	13.33±2.31	12±3.27	14±2.83	9.33±2.31	0.121
COLOUR Pt/Co	0.01	0.003±0.01	0.005±0.01	0.01±0	0±0	
TSS mg/l	70	68.67±6.11	65±3.83	69±1.41	45.33±1.15	0.420
COD mg/l	162	180.33±3.06	153.75±6.90	198±15.56	190±1.73	0.300
BOD mg/l	0.7	0.33±0.23	0.65±0.48	0.35±0.21	0.3±0.1	0.610
SO <sub>4</sub> mg/l	742	888.33±93.43	654.25±96.58	673.5±301.93	903.33±55.64	0.342
PO <sub>4</sub> mg/l	0.21	0.41±0.30	0.32±0.04	0.29±0.18	0.44±0.23	0.900
NO <sub>3</sub> mg/l	1.6	1.47±0.61	1.525±0.33	1.75±0.36	1.33±0.25	1.000
NH <sub>4</sub> mg/l	0.74	0.68±0.28	0.71±0.15	0.82±0.16	0.62±0.12	1.000
N02- mg/l	5.25	4.82±2.01	5.01±1.10	5.75±1.16	4.38±0.83	1.000
O/G mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.165	0.18±0.05	0.19±0.03	0.13±0.05	0.21±0.01	0.800
Fe mg/l	0.575	0.46±0.07	0.47±0.09	0.37±0.07	0.38±0.05	0.725
Pb mg/l	0.012	0.02±0.01	0.02±0.01	0.04±0.003	0.013±0.001	0.750
Cu mg/l	N/A	N/A	N/A	N/A	N/A	
Cr mg/l	0.121	0.14±0.15	0.10±0.08	0.04±0.05	0.08±0.06	0.261

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Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
Zn mg/l	0.106	0.07±0.03	0.06±0.02	0.043±0.03	0.143±0.10	0.119
Cd mg/l	0.07	0.114±0.02	0.06±0.02	0.02±0.03	0.09±0.04	0.800
Ba mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.021	0.14±0.10	0.01±0.01	0.04±0.03	0.13±0.04	0.241
Co mg/l	N/A	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/l	346	371.33±14.19	346.75±28.77	367±2.83	362.67±30.60	0.981
Na mg/l	9785	9721±55.43	9802±86.08	9880±134.35	9926.67±51.38	0.830
Mg mg/l	1285	1259.33±18.15	1244.25±6.65	1264±1.41	1248±18.68	1.000
Ca mg/l	457	449.67±12.01	472±9.06	469±24.04	468.33±6.51	0.800
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	2.47	3.3±1.9	6.5±4.0	7.1±1.0	4.5±2.7	0.105
TF x 10 <sup>2</sup> (cfu/ml)	1.01	2.5±0.51	3.0±0.21	5.2±3.3	2.2±1.0	0.061
Faecal coliform (MPN/100ml)	0	0±0	0±0	0±0	1.67±2.89	
SRB (cfu/ml)	0	0	0	0	0	

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

P<0.05 – Significant; p>0.05 – Not significant

### **EA-DPB PLATFORM**

Table 4.3e shows the summary results of physicochemical measurements in surface water at different receptor distances of 500m and 800m from the DPB area compared with control. Detailed results are presented in **Appendix 2**.

#### *Physicochemistry*

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the DPB were not significantly different when compared ( $p=0.900$ ) to the control ( $27.53\pm 0.67$  °C). There were no definite patterns in the ambient temperature from the 500m receptor locations to the 800m and maybe attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from 28.1 °C at the 500m receptor distance to  $27.1\pm 0.17$ °C at the 800m distance in the direction of the persistent bottom currents from the DPB area. Temperature values around the DPB area are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations ( $p=1.000$ ). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish reproduction (Yokogawa, 2016). The pH ranged from 8.51 at the 500m receptor distance to  $8.44\pm 0.01$  at the 800m distance and  $8.48\pm 0.07$  at the control station.

The salt related parameters were in the range of 40700 $\mu$ S/cm, 14697mg/l, 28493mg/l at the 500m receptor distance for Electrical conductivity, salinity as chloride and Total dissolved solids to 33666.67 $\pm 57.74$  $\mu$ S/cm, 12157 $\pm 20.78$ mg/l and 23572 $\pm 38.11$ mg/l respectively at the 800m receptor distance. No significant variation ( $p=0.628$ ,  $p=0.750$  and  $p=0.600$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters maybe attributed to general hydrodynamic conditions (fluxes in organic and inorganic salts, swells and water perturbations). The parameters were within estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different (DO ( $p=1.000$ ), BOD ( $p=0.918$ ) and COD ( $p=0.411$ )) from the control stations across the receptor distances from 500m to 800m. The mean DO levels ranged from 4.8 mg/l at the 500m distance from the DPB to  $5.87\pm 0.06$  mg/l at the 800m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from 0.2 mg/l to  $0.17\pm 0.12$  mg/l and 187 mg/l to  $190\pm 6.93$  mg/l at the 500m and 800m receptor distances compared to the controls ( $0.3\pm 0.1$ mg/l and  $190\pm 1.73$ mg/l). The BOD levels suggest low levels of organic into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006) while the COD levels is suggestive moderate organic pollution attributable to coastal and riverine discharges as well as maritime inputs from vessels and other activities.

***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from 1.9mg/l at 500 m to 2.23±0.06mg/l at 800 m; 0.39mg/l at 200 m to 0.29±0.13mg/l at 800 m and 1.33±0.25 mg/l; 0.44±0.23 mg/l in the control station. Similarly, nitrite and ammonia-nitrate levels also compared favourably with the control stations as concentrations varied from 6.24mg/l to 7.34±0.18mg/l and 0.88 to 1.03±0.02 mg/l at the 500m and 800m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates, p=0.718), phosphates, p=0.622) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

***Heavy metals***

The concentration of Barium, Silver and Vanadium were not detected (<0.001 mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni (p=0.149), Fe (p=1.000), Pb (p=0.500), Cr (p=0.710), Zn (p=0.800), Cd (p=0.918) and Mn (p=0.070) were not significantly different from the control stations at the 500m and receptor distances. Mean heavy metal concentrations were generally within background levels from the 500m to 800m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from 0.08 to 0.23±0.02mg/l, 0.31 to 0.35±0.05mg/l, 0.021 to 0.02±0.001mg/l, 0.03 to 0.07±0.06mg/l, 0.16 to 0.13±0.05mg/l, 0.08 to 0.06±0.01mg/l and 0.09 to 0.02±0.01mg/l in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

***Organics***

The THC, TPH, PAH and Oil and grease concentration were not detected (<0.001 mg/l) in the recipient water body across the receptor locations from 500m to 800m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

***Microbiology***

The summary of the microbial load of the recipient water body is presented in Table 4.3e. The THB and TF were in the order of 10<sup>2</sup> cfu/ml and ranged from 5.8 x 10<sup>2</sup> cfu/ml, 2.1x10<sup>2</sup> cfu/ml to 9.9±2.5x10<sup>2</sup> cfu/ml, 3.1±1.4 x10<sup>2</sup> cfu/ml at the 500m and 800m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control (p=0.450; p=0.810). Similarly, the hydrocarbonoclasts were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the 500m and

control stations (1.67±2.89MPN/100ml) and maybe attributed to influences from the coastal waters. Furthermore, SRBs were not identified across the receptor distances from 200m to 1200m including the control station and indicates unlikelihood of biogenic souring during the operation phase of the project.

Table 4.3e: Summary results of physicochemical measurements in surface Water at the EA-DPB Platform compared to control

Parameters	500m (Mean ± SD)	800m (Mean ± SD)	Control (Mean ± SD)	P value
TEMP, °C	28.1	27.1±0.17	27.53±0.67	0.900
pH	8.51	8.44±0.01	8.48±0.07	1.000
COND, µS/cm	40700	33666.67±57.74	43133.33±680.69	0.628
TURB, NTU	0	0±0	0±0	
DO, mg/l	4.8	5.87±0.06	4.93±1.67	1.000
TDS mg/l	28493	23572±38.11	30194±476.14	0.600
Cl, mg/l	14697	12157±20.78	15576±246.00	0.750
ALK mg/l	12	14.67±2.31	9.33±2.31	0.312
COLOUR Pt/Co	0	0.003±0.006	0±0	
TSS mg/l	64	90.67±4.62	45.33±1.15	0.150
COD mg/l	187	190±6.93	190±1.73	0.411
BOD mg/l	0.2	0.17±0.12	0.3±0.1	0.918
SO <sub>4</sub> mg/l	889	816.67±25.40	903.33±55.64	0.810
PO <sub>4</sub> mg/l	0.39	0.29±0.13	0.44±0.23	0.622
NO <sub>3</sub> mg/l	1.9	2.23±0.06	1.33±0.25	0.718
NH <sub>4</sub> mg/l	0.88	1.03±0.02	0.62±0.12	0.922
NO <sub>2</sub> - mg/l	6.24	7.34±0.18	4.38±0.83	0.510
O/G mg/l	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	
Ni mg/l	0.08	0.23±0.02	0.21±0.01	0.149
Fe mg/l	0.31	0.35±0.05	0.38±0.05	1.000
Pb mg/l	0.021	0.02±0.001	0.013±0.001	0.500
Cu mg/l	N/A	N/A	N/A	
Cr mg/l	0.03	0.07±0.06	0.08±0.06	0.710
Zn mg/l	0.16	0.13±0.05	0.14±0.10	0.800
Cd mg/l	0.08	0.06±0.01	0.09±0.04	0.918
Ba mg/l	<0.01	<0.01	<0.01	
Mn mg/l	0.09	0.02±0.01	0.13±0.04	0.070
Co mg/l	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	
K mg/l	387	380±3.46	362.67±30.60	0.811

Parameters	500m (Mean ± SD)	800m (Mean ± SD)	Control (Mean ± SD)	P value
Na mg/l	9897	10064±51.96	9926.67±51.38	0.900
Mg mg/l	1268	1262.67±4.04	1248±18.68	0.889
Ca mg/l	479	470±20.78	468.33±6.51	0.720
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	5.8	9.9±2.5	6.3±0.5	0.450
TF x 10 <sup>2</sup> (cfu/ml)	2.1	3.1±1.4	1.1±0.4	0.810
Faecal coliform (MPN/100ml)	2 <sup>a</sup>	0±0 <sup>b</sup>	1.67±2.89 <sup>a</sup>	
SRB (cfu/ml)	0	0	0	

\*The mean difference is significant at the 0.05 level. Means highlighted are significantly different from the Control (Dunnett's test); P<0.05 – Significant; p>0.05 – Not significant

### EA-DPC

Table 4.3f shows the summary results of physicochemical measurements in surface water at different receptor distances of 200m, 500m and 800m from the DPC area compared with control. Detailed results are presented in **Appendix 2**.

#### *Physicochemistry*

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the DPC were not significantly different when compared (p=0.100) to the control (27.53±0.67 °C). There were no definite patterns in the ambient temperature from the 200m receptor locations to the 800m and maybe attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from 27.63±0.75°C at the 200m receptor distance to 27.97±0.91°C at the 800m distance in the direction of the persistent bottom currents from the DPC area. Temperature values around the DPC area are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations (p=1.000). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish reproduction (Yokogawa, 2016). The pH ranged from 8.48±0.04 at the 200m receptor distance to 8.51±0.05 at the 800m distance and 8.48±0.07 at the control station.

The salt related parameters were in the range of 37000±3502.86µS/cm, 13361.33±1265.07mg/l, 25902.67±2448.65mg/l at the 800m receptor distance for Electrical conductivity, salinity as chloride and Total dissolved solids to 38333.33±4101.63µS/cm, 13842.33±1481.31mg/l and 26841±2873.93mg/l at the 800m receptor distance. No significant variation (p=0.810, p=0.650 and p=0.733) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters maybe attributed to general hydrodynamic conditions (fluxes in organic and



inorganic salts, swells and water perturbations). The parameters were within estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters DO, BOD and COD were within ranges of an oxygenated and mesotrophic ecosystem. The levels of DO ( $p=0.700$ ), BOD ( $p=0.810$ ) and COD ( $p=0.818$ ) were not significantly different from the control stations across the receptor distances from 200m to 800m. The mean DO levels ranged from  $5.3\pm 0.95$  mg/l at the 200m distance from the DPC to  $6\pm 0.10$  mg/l at the 800m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from  $0.17\pm 0.06$  mg/l to  $0.13\pm 0.06$  mg/l and  $191\pm 7.21$  mg/l to  $188.335.51$  mg/l at the 200m and 800m receptor distances compared to the controls ( $0.3\pm 0.1$  mg/l and  $190\pm 1.73$  mg/l). The BOD levels suggest low levels of organic and inorganic inputs into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006) while the relatively elevated levels of COD is suggestive of moderate levels of organic pollution.

#### ***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from  $2.13\pm 0.31$  mg/l at 200 m to  $1.9\pm 0.36$  mg/l at 800 m;  $0.53\pm 0.38$  mg/l at 200 m to  $0.51\pm 0.31$  mg/l at 800 m and  $1.33\pm 0.25$  mg/l;  $0.44\pm 0.23$  mg/l in the control station. Similarly, nitrite and ammonia-nitrate levels also compared favourably with the control stations as concentrations varied from  $7.01\pm 1.00$  mg/l to  $6.24\pm 1.18$  mg/l and  $0.99\pm 0.14$  to  $0.88\pm 0.17$  mg/l at the 200m and 800m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=0.820$ ), phosphates,  $p=0.743$ ) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

#### ***Heavy metals***

The concentration of Barium, Silver and Vanadium were not detected ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.720$ ), Fe ( $p=0.853$ ), Pb ( $p=0.808$ ), Cr ( $p=0.510$ ), Zn ( $p=0.678$ ), Cd ( $p=0.753$ ) and Mn ( $p=0.652$ ) were not significantly different from the control stations at the 500m and receptor distances. Mean heavy metal concentrations were generally within background levels from the 500m to 800m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from  $0.13\pm 0.06$  to  $0.18\pm 0.03$  mg/l,  $0.35\pm 0.05$  to  $0.38\pm 0.05$  mg/l,  $0.04\pm 0.04$  to  $0.02\pm 0.003$  mg/l,  $0.03\pm 0.02$  to  $0.067\pm 0.03$  mg/l,  $0.08\pm 0.02$  to  $0.10\pm 0.07$  mg/l,  $0.11\pm 0.01$  to  $0.09\pm 0.04$  mg/l and  $0.06\pm 0.07$  to  $0.03\pm 0.02$  mg/l in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

#### ***Organics***

The THC, TPH, PAH and Oil and grease concentration were not detected ( $<0.001$  mg/l) in the recipient water body across the receptor locations from 200m to 800m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

### Microbiology

The summary of the microbial load of the recipient water body is presented in Table 4.3f. The THB and TF were in the order of  $10^2$  cfu/ml and ranged from  $2.19 \pm 3.3 \times 10^2$  cfu/ml,  $1.20 \pm 8.73 \times 10^2$  cfu/ml to  $1.90 \pm 0.30 \times 10^2$  cfu/ml,  $1.11 \pm 1.5 \times 10^2$  cfu/ml at the 200m and 800m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control ( $p=0.854$ ;  $p=0.618$ ). The hydrocarbonoclastis were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at control stations ( $1.67 \pm 2.89$  MPN/100ml) and maybe attributed to influences from the coastal waters. The SRBs were not identified across the receptor distances from 200m to 800m including the control station which indicates unlikelihood of biogenic souring during the operation phase of the project.

Table 4.3f: Summary results of physicochemical measurements in surface Water at the Proposed EA-DPC compared to control

Parameters	200m	500m	800m	Control	P value
	(Mean $\pm$ SD)	(Mean $\pm$ SD)	(Mean $\pm$ SD)	(Mean $\pm$ SD)	
TEMP, °C	27.63 $\pm$ 0.75	28.7	27.97 $\pm$ 0.91	27.53 $\pm$ 0.67	1.000
pH	8.48 $\pm$ 0.04	8.52	8.51 $\pm$ 0.05	8.48 $\pm$ 0.07	1.000
COND, $\mu$ S/cm	37000 $\pm$ 3502.86	39200	38333.33 $\pm$ 4101.63	43133.33 $\pm$ 680.69	0.810
TURB, NTU	0 $\pm$ 0	0	0 $\pm$ 0	0 $\pm$ 0	
DO, mg/l	5.3 $\pm$ 0.95	5.9	6 $\pm$ 0.10	4.93 $\pm$ 1.67	0.700
TDS mg/l	25902.67 $\pm$ 2448.65	27442	26841 $\pm$ 2873.93	30194 $\pm$ 476.14	0.733
Cl, mg/l	13361.33 $\pm$ 1265.07	14156	13842.33 $\pm$ 1481.31	15576 $\pm$ 246.00	0.650
ALK mg/l	13.33 $\pm$ 2.31	12	14.67 $\pm$ 2.31	9.33 $\pm$ 2.31	0.518
COLOUR Pt/Co	0.01 $\pm$ 0.01	0.01	0.003 $\pm$ 0.01	0 $\pm$ 0	
TSS mg/l	80.67 $\pm$ 8.33 <sup>a</sup>	78 <sup>a</sup>	83.33 $\pm$ 11.72 <sup>a</sup>	45.33 $\pm$ 1.15 <sup>b</sup>	0.043
COD mg/l	191 $\pm$ 7.21	192	188.335.51	190 $\pm$ 1.73	0.818
BOD mg/l	0.17 $\pm$ 0.06	0.2	0.13 $\pm$ 0.06	0.3 $\pm$ 0.1	0.810
SO <sub>4</sub> mg/l	846 $\pm$ 19.70	862	878 $\pm$ 100.54	903.33 $\pm$ 55.64	0.919
PO <sub>4</sub> mg/l	0.53 $\pm$ 0.38	0.33	0.51 $\pm$ 0.31	0.44 $\pm$ 0.23	0.743
NO <sub>3</sub> mg/l	2.13 $\pm$ 0.31	1.8	1.9 $\pm$ 0.36	1.33 $\pm$ 0.25	0.820
NH <sub>4</sub> mg/l	0.99 $\pm$ 0.14	0.83	0.88 $\pm$ 0.17	0.62 $\pm$ 0.12	0.904
N02- mg/l	7.01 $\pm$ 1.00	5.91	6.24 $\pm$ 1.18	4.38 $\pm$ 0.83	0.710
O/G mg/l	<0.001	<0.001	<0.001	<0.001	

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Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	Control (Mean ± SD)	P value
THC mg/l	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.13±0.06	0.15	0.18±0.03	0.21±0.01	0.720
Fe mg/l	0.35±0.05	0.514	0.38±0.05	0.38±0.05	0.853
Pb mg/l	0.04±0.04	0.033	0.02±0.003	0.013±0.001	0.808
Cu mg/l	N/A	N/A	N/A	N/A	
Cr mg/l	0.03±0.02	0.047	0.067±0.03	0.08±0.06	0.510
Zn mg/l	0.08±0.02	0.132	0.10±0.07	0.143±0.10	0.678
Cd mg/l	0.11±0.01	0.046	0.09±0.04	0.09±0.04	0.753
Ba mg/l	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.06±0.07	0.067	0.03±0.02	0.13±0.04	0.652
Co mg/l	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	
K mg/l	368.67±5.69	389	349.33±26.76	362.67±30.60	0.800
Na mg/l	9951.67±62.94	9689	9902.67±186.66	9926.67±51.38	0.938
Mg mg/l	1256±9.64	1258	1262.33±7.37	1248±18.68	0.901
Ca mg/l	467.67±4.51	467	471.33±11.59	468.33±6.51	0.853
HUFx 10 <sup>1</sup> (cfu/ml)	0	0	0	0	
HUB x 10 <sup>1</sup> (cfu/ml)	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	2.19±3.3	2.81	1.90±0.30	2.84±1.15	0.854
TF x 10 <sup>2</sup> (cfu/ml)	1.20±8.73	1.42	1.11±1.5	9.3±4.0	0.618
Faecal coliform (MPN/100ml)	0±0	0	0±0	1.67±2.89	
SRB (cfu/ml)	0	0	0	0	

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

P<0.05 – Significant; p>0.05 – Not significant

**EA-DPA**

Table 4.3g shows the summary results of physicochemical measurements in surface water at different receptor distances of 200m, 500m, 800m and 1200m from the DPA area compared with control. Detailed results are presented in **Appendix 2**.

***Physicochemistry***

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the DPA were not significantly different when compared ( $p=1.000$ ) to the control ( $27.53\pm 0.67$  °C). There were no definite patterns in the ambient temperature from the 200m receptor locations to the 1200m and maybe attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from 27.3°C at the 200m receptor distance to 27.7°C at the 1200m distance in the direction of the persistent bottom currents from the DPA area. Temperature values around the DPA area are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally consistent (alkaline) across the receptor distances and compared favourably with the control stations ( $p=1.000$ ). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish reproduction (Yokogawa, 2016). The pH ranged from 8.44 at the 200m receptor distance to 8.54 at the 1200m distance and  $8.48\pm 0.07$  at the control station.

The salt related parameters were in the range of 43300  $\mu\text{S/cm}$ , 15636 mg/l, 30310 mg/l at the 200m receptor distance for Electrical conductivity, salinity as chloride and Total dissolved solids respectively to 34970 $\mu\text{S/cm}$ , 12628mg/l and 24479mg/l at the 1200m receptor distance. No significant variation ( $p=0.813$ ,  $p=0.703$  and  $p=0.820$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters maybe attributed to general hydrodynamic conditions (fluxes in organic and inorganic salts, swells and water perturbations). The parameters were within estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different (DO ( $p=0.350$ ), BOD ( $p=0.800$ ) and COD ( $p=0.718$ )) from the control stations across the receptor distances from 200m to 1200m. The mean DO levels ranged from 3.1 mg/l at the 200m distance from the DPA to 5.9 mg/l at the 1200m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from 0.1 to 0.1 mg/l and 171 mg/l to 178 mg/l at the 200m and 1200m receptor distances compared to the controls ( $0.3\pm 0.1$  mg/l and  $190\pm 1.73$  mg/l). The BOD levels suggest low levels of organic and inorganic inputs into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006).

***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from 0.9mg/l at 200 m to 1.9mg/l at 1200 m; 0.6mg/l at 200 m to 0.32mg/l at 1200 m and  $1.33\pm 0.25$  mg/l;  $0.44\pm 0.23$  mg/l in the control station. Similarly, nitrite and ammonia-nitrate levels also compared favourably with the control stations as concentrations varied from 2.96 mg/l to 6.24 mg/l and 0.42 to 0.88 mg/l at the 200m and 1200m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=0.853$ ), phosphates,  $p=0.510$ ) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

***Heavy metals***

The concentration of Barium, Silver and Vanadium were not detected ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.710$ ), Fe ( $p=0.753$ ), Pb ( $p=0.514$ ), Cr ( $p=0.054$ ), Zn ( $p=0.180$ ), Cd ( $p=0.300$ ) and Mn ( $p=0.918$ ) were not significantly different from the control stations at the receptor distances. Mean heavy metal concentrations were generally within background levels from the 200m to 1200m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from 0.10 to 0.231 mg/l, 0.428 to 0.452 mg/l, 0.054 to 0.045 mg/l, 0.01 to 0.03mg/l, 0.116 to 0.077 mg/l, 0.071 to 0.116mg/l and 0.19 to 0.05 mg/l in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

***Organics***

The THC, TPH, PAH and Oil and grease concentration were not detected ( $<0.001$ ) in the recipient water body across the receptor locations from 200m to 1200m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

***Microbiology***

The summary of the microbial load of the recipient water body is presented in Table 4.3g. The THB and TF were in the order of  $10^2$ cfu/ml and ranged from  $2.34 \times 10^2$  cfu/ml,  $1.01 \times 10^2$  cfu/ml to  $1.52 \times 10^2$  cfu/ml,  $1.11 \times 10^2$  cfu/ml at the 200m and 1200m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control ( $p=0.848$ ;  $p=0.652$ ). The hydrocarbonoclastis were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the 200m (5 MPN/100ml) and control stations ( $1.67\pm 2.89$  MPN/100ml) and maybe attributed to influences from the coastal

waters. Furthermore, SRBs were not identified across the receptor distances from 200m to 800m including the control station and indicates unlikelihood of biogenic souring during the operation phase of the project.

Table 4.3g: Summary results of physicochemical measurements in surface Water at the Proposed EA-DPA compared to control

Parameters	200m	500m	800m	1200m	Control	P-value
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	
TEMP, °C	27.3	27.575±0.59	27.9±0.10	27.7	27.53±0.67	1.000
pH	8.44	8.52±0.03	8.541±0.01	8.54	8.48±0.07	1.000
COND, µS/cm	43300	37037.5±3501.15	39666.67±2830.78	34970	43133.33±680.69	0.813
TURB, NTU	0	0±0	0±0	0	0±0	
DO, mg/l	3.1	5.15±1.43	5.8±0	5.9	4.93±1.67	0.350
TDS mg/l	30310	25035.75±3816.53	27768±1980.12	24479	30194±476.14	0.820
Cl, mg/l	15636	13374.75±1264.38	14324±1022.54	12628	15576±246.00	0.703
ALK mg/l	8	12±0	10.67±2.31	8	9.33±2.31	0.618
COLOUR Pt/Co	0.01	0.003±0.01	0.01±0.01	0.02	0±0	
TSS mg/l	86	80.5±6.61	80.67±10.07	92	45.33±1.15	0.048
COD mg/l	171	184±4.76	191±3.61	178	190±1.73	0.718
BOD mg/l	0.1	0.23±0.15	0.17±0.06	0.1	0.3±0.1	0.800
SO <sub>4</sub> mg/l	871	859.75±41.62	881±21.52	850	903.33±55.64	0.725
PO <sub>4</sub> mg/l	0.6	0.23±0.04	0.27±0.14	0.32	0.44±0.23	0.510
NO <sub>3</sub> mg/l	0.9	1.65±0.37	1.67±0.42	1.9	1.33±0.25	0.853
NH <sub>4</sub> mg/l	0.42	0.77±0.18	0.78±0.19	0.88	0.62±0.12	0.908
N02- mg/l	2.96	5.42±1.21	5.47±1.37	6.24	4.38±0.83	0.524
O/G mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.10	0.13±0.03	0.17±0.04	0.231	0.21±0.01	0.710
Fe mg/l	0.428	0.44±0.10	0.43±0.03	0.452	0.38±0.05	0.753
Pb mg/l	0.054	0.03±0.02	0.023±0.010	0.045	0.013±0.001	0.514
Cu mg/l	N/A	N/A	N/A	N/A	N/A	
Cr mg/l	0.01	0.04±0.05	0.12±0.09	0.03	0.08±0.06	0.054
Zn mg/l	0.116	0.15±0.03	0.149±0.06	0.077	0.143±0.10	0.180
Cd mg/l	0.071	0.04±0.03	0.06	0.116	0.09±0.04	0.300
Ba mg/l	<0.01	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.19	0.09±0.07	0.07±0.06	0.05	0.13±0.04	0.918
Co mg/l	N/A	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/l	389	371.75±19.72	372±7.21	356	362.67±30.60	0.840

Parameters	200m	500m	800m	1200m	Control	P-value
Na mg/l	9989	9877.75±81.69	9817.33±111.33	9789	9926.67±51.38	0.966
Mg mg/l	1270	1252.25±17.42	1245.6±6.03	1244	1248±18.68	0.800
Ca mg/l	485	461±15.68	457.67±17.39	492	468.33±6.51	0.779
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	2.34	1.33±0.85	9.9±0.35	1.52	2.01±0.99	0.848
TF x 10 <sup>2</sup> (cfu/ml)	1.01	1.2±0.46	1.45±0.91	1.11	1.35±0.42	0.652
Faecal coliform (MPN/100ml)	5	0±0	0±0	0	1.67±2.89	0.101
SRB (cfu/ml)	0	0	0	0	0	

P<0.05 – Significant; p>0.05 – Not significant

## DPD

Table 4.3h shows the summary results of physicochemical measurements in surface water at different receptor distances of 500m, 800m and 1200m from the DPD area compared with control. Detailed results are presented in **Appendix 2**.

### *Physicochemistry*

The ambient temperature of the recipient water body at different receptor distances in the direction of the persistent bottom currents from the DPD were not significantly different when compared (p=1.000) to the control (27.53±0.67 °C). There were no definite patterns in the ambient temperature from the 500m receptor locations to the 1200m and maybe attributed to similar hydrodynamic factors within the coastal waters. The ambient temperature in the recipient water body ranged from 28.1±0.57°C at the 500m receptor distance to 27.84±0.71°C at the 1200m distance in the direction of the persistent bottom currents from the DPD area. Temperature values around the DPD area are not unusual in coastal water bodies around the Niger delta (NDES, 2008).

The pH values were generally alkaline across the receptor distances and compared favourably with the control stations (p=1.000). The pH of the recipient water suggests an estuarine ecosystem and consistent with ranges for desirable fish reproduction (Yokogawa, 2016). The pH ranged from 8.52±0.01 at the 500m receptor distance to 8.53±0.01 at the 1200m distance and 8.48±0.07 at the control station.

The salt related parameters were in the range of 40600±416.33 µS/cm, 14661.25±150.28 mg/l, 28420.25±291.03 mg/l at the 500m receptor distance for Electrical conductivity, salinity as chloride and Total dissolved solids respectively to 40340±517.69 µS/cm, 14567±187.23 mg/l and 28238±362.38 mg/l at the 1200m receptor distance. No significant variation (p=0.919,

$p=0.953$  and  $p=0.710$ ) were observed in the salt related parameters at the receptor distances when compared to the control stations. The uniformity in these parameters maybe attributed to general hydrodynamic conditions (fluxes in organic and inorganic salts, swells and water perturbations). The parameters were within estuarine environment ranges in the Niger delta.

The levels of oxygen related parameters were within ranges of an oxygenated and mesotrophic ecosystem. The DO, BOD and COD levels were not significantly different (DO ( $p=0.846$ ), BOD ( $p=0.781$ ) and COD ( $p=0.859$ )) from the control stations across the receptor distances from 500m to 1200m. The mean DO levels ranged from  $5.75\pm 0.06$  mg/l at the 500m distance from the DPD to  $5.16\pm 1.13$  mg/l at the 1200m distance. DO levels were within ranges that provide adequate support for aquatic life (Chapman, 1996). The BOD<sub>5</sub> and COD levels ranged from  $0.28\pm 0.09$  to  $0.18\pm 0.04$  mg/l and  $183.5\pm 13.08$  to  $178.6\pm 5.27$  mg/l respectively at the 500m and 1200m receptor distances compared to the controls ( $0.3\pm 0.1$  mg/l and  $190\pm 1.73$  mg/l). The BOD levels suggest low levels of organic inputs into the recipient water bodies and characteristic of non-polluted water bodies (Chapman and Kimstach, 1992; Muray, 2006). The COD levels are relatively elevated and suggest moderate levels of organic pollution.

#### ***Nutrients***

Nitrate and phosphate are major nutrients for phytoplankton growth in the marine environment. Mean levels of nitrate and phosphates ranged from  $1.8\pm 0.14$ mg/l at 500 m to  $1.02\pm 0.08$ mg/l at 1200 m;  $0.44\pm 0.13$ mg/l at 500 m to  $0.46\pm 0.22$  mg/l at 1200 m and  $1.33\pm 0.25$  mg/l;  $0.44\pm 0.23$  mg/l in the control station. Similarly, nitrite and ammonia-nitrate levels also compared favourably with the control stations as concentrations varied from  $5.91\pm 0.47$ mg/l to  $3.35\pm 0.27$  mg/l and  $0.84\pm 0.07$  to  $0.48\pm 0.04$  mg/l at the 500m and 1200m receptor distances in the direction of the persistent bottom current. There were no significant differences in the limiting nutrients (nitrates,  $p=0.850$ ), phosphates,  $p=1.000$ ) and control across the receptor locations. The levels of limiting nutrients are suggestive of an unpolluted ecosystem (Vollenweider and Kerekes, 1982; Chapman and Kimstach, 1992).

#### ***Heavy metals***

The concentration of Barium, Silver and Vanadium were not detected ( $<0.001$  mg/l) in the recipient water across the receptor locations and the control stations. The mean values of Ni ( $p=0.615$ ), Fe ( $p=0.808$ ), Pb ( $p=0.200$ ), Cr ( $p=0.680$ ), Zn ( $p=0.992$ ), Cd ( $p=0.422$ ) and Mn ( $p=0.315$ ) were not significantly different from the control stations at the receptor distances. Mean heavy metal concentrations were generally within background levels from the 500m to 1200m receptor distances. Nickel, Fe, Pb, Cr, Zn, Cd and Mn ranged from  $0.18\pm 0.04$  to  $0.18\pm 0.07$  mg/l,  $0.39\pm 0.03$  to  $0.38\pm 0.02$  mg/l,  $0.024\pm 0.01$  to  $0.03\pm 0.01$  mg/l,  $0.03\pm 0.02$  to  $0.08\pm 0.04$  mg/l,  $0.13\pm 0.06$  to  $0.12\pm 0.02$  mg/l,  $0.11\pm 0.02$  to  $0.07\pm 0.05$  mg/l,  $0.04\pm 0.02$  to  $0.07\pm 0.02$  mg/l in the direction of the persistent bottom current. The concentrations of these heavy metals are within ranges for unpolluted water bodies.

#### ***Organics***



The THC, TPH, PAH and Oil and grease concentration were not detected (<0.001 mg/l) in the recipient water body across the receptor locations from 500m to 1200m and 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 and suggestive of the low hydrocarbon burden of the EA FOD project area.

### Microbiology

The summary of the microbial load of the recipient water body is presented in Table 4.3h. The THB and TF were in the order of  $10^2$ cfu/ml and ranged from  $1.09 \pm 0.41 \times 10^2$ cfu/ml,  $0.98 \pm 0.25 \times 10^2$  cfu/ml to  $1.17 \pm 2.7 \times 10^2$ cfu/ml,  $1.10 \pm 0.93 \times 10^2$ cfu/ml at the 500m to 1200m receptor distances respectively. The THB and TF microbial load is suggestive of the availability of utilizable organic substrates in the recipient water body. The microbial load at the receptor distances compared favourably with the control ( $p=0.540$ ;  $p=0.130$ ). The hydrocarbonoclastis were not identified in the water body including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organism is suggestive of the low hydrocarbon burden of the EA FOD project area and corroborates with the analytical test results of THC, BTEX and TPH. Faecal coliforms were identified only at the control stations ( $1.67 \pm 2.89$ MPN/100ml) and maybe attributed to influences from the coastal waters. Furthermore, SRBs were not identified across the receptor distances from 500m to 800m including the control station and indicates unlikelihood of biogenic souring during the operation phase of the project.

Table 4.3h: Summary results of physicochemical measurements in surface Water at the EA-DPD Platform compared to control

Parameters	500m (Mean $\pm$ SD)	800m (Mean $\pm$ SD)	1200m (Mean $\pm$ SD)	Control (Mean $\pm$ SD)	P value
TEMP, °C	28.1 $\pm$ 0.57	28.1 $\pm$ 0.85	27.84 $\pm$ 0.71	27.53 $\pm$ 0.67	1.000
pH	8.52 $\pm$ 0.01	8.53 $\pm$ 0.01	8.53 $\pm$ 0.01	8.48 $\pm$ 0.07	1.000
COND, $\mu$ S/cm	40600 $\pm$ 416.33	41900 $\pm$ 2121.32	40340 $\pm$ 517.69	43133.33 $\pm$ 680.69	0.919
TURB, NTU	0 $\pm$ 0	0 $\pm$ 0	0 $\pm$ 0	0 $\pm$ 0	
DO, mg/l	5.75 $\pm$ 0.06	5.8 $\pm$ 0.14	5.16 $\pm$ 1.13	4.93 $\pm$ 1.67	0.846
TDS mg/l	28420.25 $\pm$ 291.03	29330 $\pm$ 1484.92	28238 $\pm$ 362.38	30194 $\pm$ 476.14	0.710
Cl, mg/l	14661.25 $\pm$ 150.28	15130.5 $\pm$ 765.79	14567 $\pm$ 187.23	15576 $\pm$ 246.00	0.953
ALK mg/l	10 $\pm$ 2.31	12 $\pm$ 0	10.4 $\pm$ 2.19	9.33 $\pm$ 2.31	0.819
COLOUR Pt/Co	0.01 $\pm$ 0.01	0.01 $\pm$ 0.01	0.01 $\pm$ 0.01	0 $\pm$ 0	
TSS mg/l	87.5 $\pm$ 6.81	92 $\pm$ 5.66	84.4 $\pm$ 4.97	45.33 $\pm$ 1.15	0.051
COD mg/l	183.5 $\pm$ 13.08	187 $\pm$ 11.31	178.6 $\pm$ 5.27	190 $\pm$ 1.73	0.859
BOD mg/l	0.28 $\pm$ 0.09	0.15 $\pm$ 0.07	0.18 $\pm$ 0.04	0.3 $\pm$ 0.1	0.781
SO <sub>4</sub> mg/l	864.75 $\pm$ 25.60	889.5 $\pm$ 85.56	903.6 $\pm$ 59.72	903.33 $\pm$ 55.64	0.905
PO <sub>4</sub> mg/l	0.44 $\pm$ 0.13	0.46 $\pm$ 0.07	0.46 $\pm$ 0.22	0.44 $\pm$ 0.23	1.000
NO <sub>3</sub> mg/l	1.8 $\pm$ 0.14	1.8 $\pm$ 0.28	1.02 $\pm$ 0.08	1.33 $\pm$ 0.25	0.850
NH <sub>4</sub> mg/l	0.84 $\pm$ 0.07	0.84 $\pm$ 0.13	0.48 $\pm$ 0.04	0.62 $\pm$ 0.12	0.540

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<b>Parameters</b>	<b>500m</b>	<b>800m</b>	<b>1200m</b>	<b>Control</b>	<b>P value</b>
	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	
N02- mg/l	5.91±0.47	5.91±0.93	3.35±0.27	4.38±0.83	0.110
OG mg/l	<0.001	<0.001	<0.001	<0.001	
THC mg/l	<0.001	<0.001	<0.001	<0.001	
TPH mg/l	<0.001	<0.001	<0.001	<0.001	
PAH mg/l	<0.001	<0.001	<0.001	<0.001	
BTEX mg/l	<0.001	<0.001	<0.001	<0.001	
Ni mg/l	0.18±0.04	0.22±0.004	0.18±0.07	0.21±0.01	0.615
Fe mg/l	0.39±0.03	0.3±0.02	0.38±0.02	0.38±0.05	0.808
Pb mg/l	0.024±0.01	0.06±0.04	0.03±0.01	0.013±0.001	0.200
Cu mg/l	N/A	N/A	N/A	N/A	
Cr mg/l	0.03±0.02	0.12±0.02	0.08±0.04	0.08±0.06	0.680
Zn mg/l	0.13±0.06	0.12±0.01	0.12±0.02	0.14±0.10	0.992
Cd mg/l	0.11±0.02	0.03±0.02	0.07±0.05	0.09±0.04	0.422
Ba mg/l	<0.01	<0.01	<0.01	<0.01	
Mn mg/l	0.04±0.02	0.03±0.01	0.07±0.02	0.13±0.04	0.315
Co mg/l	N/A	N/A	N/A	N/A	
Ag mg/l	<0.001	<0.001	<0.001	<0.001	
V mg/l	<0.001	<0.001	<0.001	<0.001	
K mg/l	367.5±28.73	366±11.31	367.8±9.73	362.67±30.60	0.841
Na mg/l	9800±51.96	10015±325.27	9711.2±278.29	9926.67±51.38	0.900
Mg mg/l	1248±10.80	1238±4.24	1233.8±30.38	1248±18.68	0.877
Ca mg/l	452.75±11.59	459±5.66	459.4±21.20	468.33±6.51	0.985
HUFx10 <sup>1</sup> (cfu/ml)	0	0	0	0	
HUB x10 <sup>1</sup> (cfu/ml)	0	0	0	0	
THB x 10 <sup>2</sup> (cfu/ml)	1.09±0.41	1.20±0.53	1.17±2.7	1.33±1.4	0.540
TF x 10 <sup>2</sup> (cfu/ml)	0.98±0.25	0.85±0.39	1.10±0.93	1.01±0.54	0.130
Faecal coliform (MPN/100ml)	0±0	0±0	0±0	1.67±2.89	
SRB (cfu/ml)	0	0	0	0	

P<0.05 – Significant; p>0.05 – Not significant

**Surface Water Trending**

Parameters that showed temporal increasing patterns in the surface water from 2001 to 2018 include: pH ( $p=0.910$ ), COD ( $p=0.000$ ), Pb ( $p=0.000$ ), Fe ( $p=0.101$ ), Zn ( $p=0.382$ ), Cr ( $p=0.000$ ), Ni ( $p=0.215$ ), Redox ( $p=0.401$ ), Mg ( $p=0.000$ ), TDS ( $p=0.811$ ) and TSS ( $p=0.000$ ) (Table 4.3i). However, only Mg, Cr and TSS were significantly different from the baseline values. The variation maybe attributed to changes in land use patterns over years as wells as variability in biotic and abiotic processes in riverine systems and their respective watershed (Huser *et al*, 2011). A test of significance using the one factor ANOVA for which pair-wise differences were detected by DMR test, showed that higher concentration were observed in 2018 (COD, Mg), 2015 (Alkalinity, BOD) and 2001 (Sulphate). No change was observed in the concentration of As, Cu, V, Oil and grease, THC, PAH and BTEX. Temperature ( $p=1.000$ ), EC ( $p=0.715$ ), DO ( $p=0.600$ ,  $p=0.000$ ), BOD ( $p=0.000$ ), Nitrate ( $p=0.210$ ), Phosphate ( $p=0.061$ ), Turbidity ( $p=0.000$ ), Na ( $p=0.410$ ), Ca ( $p=0.000$ ), Salinity ( $p=0.600$ ) and Alkalinity ( $p=0.000$ ) showed negative trend (decreasing) from the baseline studies in 2001). Large scale drivers responsible for the declining levels of these surface water quality variables include: general in-stream chemistry, climatic changes and changes in land use patterns especially around the coastline. The decreasing trend in alkalinity is of concern because of its impact on climate change but this is a global problem associated with decreasing capacity of ocean waters to absorb the ever-increasing levels of carbon dioxide. The opposite trend showed by BOD and COD is an indication that while organic loads are decreasing, reduced species of inorganic pollutants (including nutrients and heavy metals) are relatively increasing possibly arising from anthropogenic discharges. The concentration of these surface water variables were within ranges for surface water bodies in the Niger Delta (NDES, 2008).

Table 4.3i: Surface water quality trending for the period 2001 to 2018

Parameter	EA FOD, 2001	EA FOD, 2011	EA FOD, 2015	EA FOD, 2018	P value
pH		7.74	8.93	8.51±0.04	0.910
Temperature (°C)	29.95	26.82	28.08	28.07±1.32	1.000
Conductivity (µS/cm)		47234	46000	39166.67±4860.38	0.715
DO (mg/l)	7.09	6.15	5.5	4.93±1.59	0.600
COD (mg/l)		6.04 <sup>b</sup>	136.8 <sup>a</sup>	199±22.80 <sup>a</sup>	0.000
BOD (mg/l)		3.97 <sup>a</sup>	9.9 <sup>a</sup>	0.23±0.09 <sup>b</sup>	0.000
Nitrate (mg/l)	0.32	1.11	1.1	1.8±0.44	0.210
Phosphate (mg/l)	0.07	0.09	1.5	0.34±0.08	0.061
Arsenic (mg/l)		<0.001	<0.001		
Lead(mg/l)	<0.005	<0.002	1.4	0.05±0.01	0.000
Iron (mg/l)	0.18	0.91	1.49	0.27±0.05	0.101
Copper (mg/l)	<0.005	0.185	<0.05	-	
Zinc (mg/l)	<0.005	0.367	0.11	0.10±0.05	0.382
Chromium (mg/l)	<0.01	<0.001	1.79	0.11±0.03	0.000
Nickel (mg/l)	<0.01	<0.002	0.71	0.14±0.10	0.215
Vanadium (mg/l)		<0.001	<0.05	<0.001	
Cadmium (mg/l)		<0.005	0.13	0.13±0.06	1.000
TPH (mg/l)		0.003	0.62	<0.001	
Redox, mV	196.2		236.3		0.401
Turbidity (mg/l)			2.7	0.00	0.000
Mg, mg/l	865 <sup>a</sup>		190.67 <sup>b</sup>	1267±26.85 <sup>a</sup>	0.000
Na, mg/l	10000		6362	9736.33±122.09	0.410
Ca, mg/l	2300 <sup>a</sup>		283.5 <sup>b</sup>	469.67±15.57 <sup>b</sup>	0.000
TDS (mg/l)			23200	27417±3401.79	0.811
Salinity as chloride (mg/l)			18203.8	14143.33±1755.25	0.600
ALK (mg/l)			60.7	12±4	0.000
TSS (mg/l)			0.7	58±3.46	0.000
SO4 (mg/l)	17000 <sup>a</sup>		1216.7 <sup>b</sup>	886.33±82.89 <sup>b</sup>	0.000
O/G (mg/l)		<0.01	1.95	<0.001	
THC (mg/l)		<0.01	0.62	<0.001	
TPH		1.45	4.76	<0.001	
PAH (mg/l)	<0.01	<0.001	<0.01	<0.001	
BTEX (mg/l)	<0.01	<0.001	<0.01	<0.001	

p>0.05 – Not significantly different; p<0.05 – Significantly different

	Increasing trend
	Decreasing trend
	No change

#### 4.2.4: Sediment quality

##### EDP-EAGLE FPSO

Table 4.4a shows the summary results of physicochemical measurements in sediments at different receptor distances of 200m, 500m, 800m, 1200m and 2500m from the FPSO compared with control. Detailed results are presented in **Appendix 2**

##### *Physico-chemistry*

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 200m (7.40) to the 2500m (7.42) receptor locations. There were no discernable patterns with regards to distance from the FPSO, however the pH compared favorably ( $p=1.000$ ) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed moderately reduced conditions in the sediments. The redox potentials ranged from  $-27.53\pm 2.12$  mV at the 200m receptor location to  $-29.28\pm 3.88$  mV at the 2500m receptor location. The Eh levels were not significantly different ( $p=0.841$ ) from the control location ( $-25.77\pm 9.87$  mV) and across the receptor distances (200m to 2500m) from the FPSO. The Redox potential values around the FPSO were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008).

The sediment chloride level suggests an estuarine ecosystem as values ranged from  $15478\pm 957.16$  mg/kg around the 200m receptor distances to  $17653.33\pm 1298.97$  mg/kg at the 2500m distance from the FPSO. The levels of chloride were observed to increase with distance and maybe attributed to natural variation in the interstitial waters related to the salinity of the overlying waters. No significant variation ( $p=0.616$ ) was observed when compared with the control stations ( $17653.33\pm 1298.97$  mg/kg).

##### *Organic Load*

The TOC levels ranged from  $1.3\pm 0.56\%$  at 200m to  $1.33\pm 0.22\%$  at 2500m receptor distance. There was no significant variation ( $p=0.508$ ) when compared to the control locations ( $1.93\pm 1.65\%$ ) and no distinct pattern was observed in relation to distance from the FPSO. The sediment texture was generally dominated by clay ( $>95\%$ ) ( $p=0.508$ ) across the receptor distances. Notwithstanding the clay texture, the TOC levels were generally low. Although clay has a high affinity for organics, the TOC levels were within normal values (1 to 3%) at the 200m, 800m, 1200m, 2500 for unpolluted sediments (USEPA, 2002).

##### *Nutrients*

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from  $1.16\pm 0.81$  to  $1.08\pm 0.28$  mg/kg and  $0.16\pm 0.06$  to  $0.21\pm 0.04$  mg/kg at the 200m and 2500m receptor distances from the FPSO compared to the control locations ( $1.27\pm 0.31$  mg/kg,  $0.16\pm 0.02$  mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=1.000$ ; Phosphate,  $p=0.300$ ). 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.

### ***Exchangeable cations***

The mean concentration of exchangeable cations, K, Na, Mg and Ca in the bottom sediments ranged from 458.33±16.01 to 458.6±14.25 mg/kg; 11428.33±183.19 to 11400±306.95 mg/kg; 1443±68.11 to 1407.4±38.220 mg/kg and 532.66±28.93 to 546.2±20.141 mg/kg at the 200m to the 2500m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably with the control locations (K, 443.33±13.43mg/kg; Na, 11456±23.30mg/kg; Mg, 1450.66±21.03mg/kg and Ca, 556.33±13.20mg/kg) (Potassium (p=0.781), Sodium (p=0.830), Magnesium (p=0.542) and Calcium (p=0.919)). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al*, 2010).

### ***Heavy metals***

Silver and Vanadium were not detected (<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations. Detectable heavy metal concentrations in the sediment were within normal ranges for a brown field. Chromium (p=0.000) and Cobalt (p=0.000) were significantly different when compared to the control stations but showed no apparent pattern with relation to distance from the FPSO. A test of significance using the Duncan Multiple range tests showed variation at the 500m receptor distance for Cr and at the control location for Co. The variation at these distances may be attributed to contribution from secondary sources along the coastline and neighboring catchments area (Estuary area, Ramos river and Dodo river). The concentration of Ni (p=0.942), Fe (p=0.519), Pb (p=0.215), Cu (p=0.300), Zn (p=0.150), Cd (p=0.111), Ba (p=0.810) were not significantly different from the control locations as the concentration ranged from 1.41±0.01 to 1.31±0.17 mg/kg; 13057.6±2900.43 to 12547.6±1903.01 mg/kg; 14.17±4.88 to 23.71±6.24 mg/kg; 12.91±1.52 to 11.02±4.13 mg/kg; 49.53±7.728 to 49.97±13.02 mg/kg; 5.06±2.137 to 3.30±1.75 mg/kg and 10±1.73 to 10.2±2.77 mg/kg respectively at the 200m and 2500m receptor distances. The concentration of heavy metals was however within levels for brown fields in the Niger delta.

### ***Hydrocarbons***

The PAH and BTEX concentration (p<0.001 mg/kg) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Concentrations of oil and grease and TPH varied widely with no clear trend between the study location and control. Oil and grease (p=0.000), Aliphatics (p=0.000) and TPH (p=0.000) concentration were significantly different from the

control locations as concentration at the 2500m receptor locations were higher compared to other receptor locations.

### **Microbiology**

The summary of the microbial load of the sediment is presented in Table 4.4a. The THB and TF were in the order of  $10^2$  and  $10^1$  cfu/g and ranged from  $1.56 \pm 0.85 \times 10^2$  to  $1.63 \pm 0.39 \times 10^2$  cfu/g and  $4.03 \pm 0.19 \times 10^1$  to  $1.48 \pm 1.50 \times 10^1$  cfu/g at the 200m and 2500m receptor distances. The THB and TF microbial load 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. The microbial load at the receptor distances compared favourably with the control ( $p=0.214$ ;  $p=0.105$ ). The hydrocarbonoclastis were not identified in the sediments including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 200m to 2500m including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project.

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Table 4.4a: Summary results of physicochemical measurements in sediment at EDP-EAGLE FPSO area compared to control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	2500m (Mean ± SD)	Control (Mean ± SD)	P value
pH	7.40±0.06	7.65±0.37	7.36±0.06	7.69±0.38	7.42±0.13	7.44±0.18	1.000
TEMP, °C	8.53±0.35	8.175±0.22	8.97±0.50	9±0.53	8.84±0.34	8.63±0.67	1.000
Redox, mV	-27.53±2.122	-36.9±15.79	-26.63±3.30	-39.38±20.87	-29.28±3.88	-25.77±9.87	0.841
Cl, mg/kg	15478±957.16	17257.5±444.88	17506.66±1283.56	17199±918.30	17537.2±506.17	17653.33±1298.97	0.616
TOC, %	1.3±0.56	0.71±0.28	1.80±1.15	1.262±0.91	1.33±0.22	1.93±1.65	0.508
PO4, mg/kg	0.16±0.06	0.2725±0.04	0.19±0.07	0.264±0.07	0.208±0.04	0.16±0.02	0.300
NO3 mg/kg	1.16±0.81	1.03±0.32	1.1±0.53	1.1±0.31	1.08±0.28	1.27±0.31	1.000
NH4 mg/kg	0.543±0.38	0.48±0.14	0.51±0.24	0.512±0.13	0.518±0.13	0.6±0.13	0.912
Sand, %	0	0	0	0	0	0	
Silt%	4.66±0.55	4.81±0.06	4.44±0.11	4.63±0.59	4.72±0.39	5.00±0.06	1.000
Clay%	95.23±0.59	95.12±0.07	95.26±0.33	95.282±0.58	95.186±0.39	94.90±0.02	1.000
O & G mg/kg	4±3.46	7.5±5.74	18±10.39	9.6±6.84	20.4±32.47	18±20.784	0.000
ALIPH mg/kg	<0.001	<0.001	0.8±0.60	0.5±0	2.4±2.83	<0.001	0.000
TPH mg/kg	0±0	3±3.46	10±6.92	4.5±3	12±23.62	10±17.32	0.000
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.41±0.01	3.34±3.85	1.19±0.15	1.43±0.53	1.31±0.17	0.902±0.04	0.942
Fe mg/kg	13057.6±2900.43	13346±2317.17	14033±714.92	10344.2±4013.16	12547.6±1903.01	13657±457.47	0.519
Pb mg/kg	14.174±4.88	28.751±6.77	26.40±9.75	26.7936±8.41	23.71±6.24	22.67±4.39	0.215
Cu mg/kg	12.91±1.52	8.98±6.17	10.64±7.54	16.49±19.90	11.02±4.13	10.81±0.94	0.300
Cr mg/kg	14.45±3.85	16.186±6.54	44.33±1.35	25.9524±9.50	26.563±9.04	30.59±19.81	0.000
Zn mg/kg	49.53±7.728	34.36±15.94	39.65±8.03	56.40±26.49	49.97±13.02	57.15±14.16	0.150
Cd mg/kg	5.06±2.137	6.61±3.18	1.18±0.584	3.36±1.53	3.30±1.751	4.16±2.18	0.111
Ba mg/kg	10±1.73	10.75±1.70	7±1.73	10±1.41	10.2±2.77	13.67±2.52	0.810
Co mg/kg	32.15±17.009	38.63±30.41	60.343±15.66	43.99±23.65	43.445±21.782	16.52±13.44	0.000
Ag mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/kg	458.33±16.01	458.25±39.38	468.66±27.06	470.2±19.60	458.6±14.25	443.33±13.43	0.781
Na mg/kg	11428.33±183.19	11574.25±430.55	11255.33±181.89	11405.2±153.10	11400±306.95	11456±23.30	0.830
Mg mg/kg	1443±68.11	1451.25±50.64	1388±51.97	1397.8±32.27	1407.4±38.220	1450.66±21.03	0.542
Ca mg/kg	532.66±28.93	568±24.79	531.33±10.21	550.4±27.56	546.2±20.141	556.33±13.20	0.919
HUF cfu/g	0	0	0	0	0	0	



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Parameters	200m	500m	800m	1200m	2500m	Control	P value
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	
HUB cfu/g	0	0	0	0	0	0	
THB x10 <sup>2</sup> cfu/g	1.56±0.85	1.03±0.46	1.83±0.58	1.34±0.40	1.63±0.39	1.24±0.10	0.214
TFx10 <sup>1</sup> cfu/g	4.03±0.19	5.5±0.47	6.3±4.78	5.2±0.4	1.48±1.50	5.6±1.92	0.105
SRB cfu/g	0	0	0	0	0	0	

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

P<0.05 – Significant; p>0.05 – Not significant

## **OGGS – RPA**

Table 4.4b shows the summary results of physicochemical measurements in sediments at different receptor distances of 500m to 1200m from the OGGS – RPA and the control locations. Detailed results are presented in **Appendix 2**.

### ***Physico-chemistry***

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 500m ( $7.41 \pm 0.07$ ) to the 1200m ( $7.45 \pm 0.04$ ) receptor locations. There were no discernable patterns with regards to distance from the OGGS – RPA, however the pH compared favorably ( $p=1.000$ ) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed a moderately reducing condition in the sediments. The redox potentials ranged from  $-23.2 \pm 5.37$  mV at the 500m receptor location to  $-26.07 \pm 2.21$  mV at the 1200m receptor location. The Eh levels were not significantly different ( $p=0.810$ ) from the control location ( $-25.77 \pm 9.87$  mV) and across the receptor distances (500m to 1200m) from the OGGS – RPA. The Redox potential values around the OGGS – RPA were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008).

The chloride levels are characteristic of an estuarine ecosystem with values ranging from  $16055 \pm 920.65$  mg/kg around the 500m receptor distances to  $17419.5 \pm 276.47$  mg/kg at the 1200m distance from the OGGS – RPA. The levels of chloride were observed to increase with distance and may be attributed to natural variation in the interstitial waters. No significant variation ( $p=0.680$ ) was observed when compared with the control stations ( $17653.33 \pm 1298.97$  mg/kg).

### ***Organic Load***

The TOC levels ranged from  $1.41 \pm 0.16\%$  at 500m to  $1.31 \pm 0.32\%$  at 1200m receptor distance. There was no significant variation ( $p=0.810$ ) when compared to the control locations ( $1.93 \pm 1.65\%$ ) and no distinct pattern was observed in relation to distance from the OGGS – RPA. The sediment texture was dominated by clay ( $>94\%$ ). Notwithstanding the high affinity of organics to clay sediments, the TOC levels were within normal range (1 to 3%) at the 200m, 800m, 1200m, 2500 for unpolluted sediments (USEPA, 2002).

### ***Nutrients***

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from  $0.85 \pm 0.64$  to  $1.2 \pm 0.78$  mg/kg and  $0.20 \pm 0.05$  to  $0.24 \pm 0.11$  mg/kg at the 500m and 1200m receptor distances from the OGGS – RPA compared to the control locations ( $1.27 \pm 0.31$  mg/kg,  $0.16 \pm 0.02$  mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=0.710$ ; Phosphate,  $p=0.812$ ). 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.

### ***Exchangeable cations***

The mean concentration of exchangeable cations in the bottom sediments ranged from 471.5±20.50 to 478.33±22.30 mg/kg; 11570±101.82 to 11426.33±175.74 mg/kg; 1371.5±70.00 to 1393±66.64 mg/kg and 535±8.48 to 532.66±4.50 mg/kg for K, Na, Mg and Ca respectively at the 500m to the 1200m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably with the control locations (K, 443.33±13.43 mg/kg; Na, 11456±23.30 mg/kg; Mg, 1450.66±21.03 mg/kg and Ca, 556.33±13.20 mg/kg) (Potassium (p=0.705), Sodium (p=0.600), Magnesium (p=0.719) and Calcium (p=0.800)). The concentration of cations were within limits of stability of organic matter in sediments (Adeline *et al.*, 2010).

### ***Heavy metals***

Silver and Vanadium concentration were not detected (<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations. The heavy metal concentrations in the sediment were within normal ranges for a brown field. Cobalt (p=0.041) was significantly different when compared to the control stations but showed no discernable pattern in relation to distance from the OGGs RPA. A test of significance using the Duncan Multiple range tests showed the highest concentration at the 500m receptor distance. The variation may be attributed to coastal influences and discharges from navigating vessels around the OGGs RPA area. The concentration of Ni (p=0.810), Fe (p=0.752), Pb (p=0.308), Cu (p=0.100), Zn (p=0.870), Cd (p=0.090), Ba (p=0.620) were not significantly different from the control locations with the concentration ranging from 1.33±0.15 to 1.10±0.136 mg/kg; 9590.5±5271.48 to 12180.67±4351.67 mg/kg; 27.78±9.10 to 15.65±8.88 mg/kg; 14.25±1.82 to 6.47±2.31 mg/kg; 20.70±6.92 to 23.49±12.44 mg/kg; 49.95±2.33 to 55.99±5.93 mg/kg, 5.27±2.73 to 1.28±0.81 mg/kg and 6±2.82 to 10.33±1.52 mg/kg respectively at the 500m and 1200m receptor distances. The concentration of these heavy metals were within normal levels for unpolluted sediments in the Niger delta.

### ***Hydrocarbons***

The PAH, BTEX and aliphatics concentration (p<0.001 mg/kg) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Similarly, Oil and grease (p=0.000) and TPH (p=0.000) concentration were significantly different from the control locations as concentration at the 500m receptor locations were higher compared to other receptor locations. The high concentration of Oil and grease and TPH suggests inputs of petrogenic discharges around the OGGs RPA area.

### **Microbiology**

The summary of the microbial load of the sediment is presented in Table 4.4b. The THB and TF were in the order of  $10^2$  and  $10^1$  cfu/g and ranged from  $11.53 \pm 0.54 \times 10^2$  to  $1.15 \pm 0.22 \times 10^2$  cfu/g and  $4.1 \pm 0.71 \times 10^1$  to  $5.1 \pm 0.73 \times 10^1$  cfu/g at the 500m and 1200m receptor distances. The THB and TF microbial load 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. The microbial load at the receptor distances compared favourably with the control ( $p=0.710$ ;  $p=0.915$ ). The hydrocarbonoclastis were not identified in the sediments including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 500m to 1200m including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project.

Table 4.4b: Summary results of physicochemical measurements in sediment at OGGS – RPA Platform compared to control

Parameters	500m	800m	1200m	Control	P value
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	
pH	7.41±0.07	7.49	7.45±0.04	7.44±0.18	1.000
TEMP, °C	8.7±0.28	7.9	8.63±0.77	8.63±0.67	1.000
Redox, mV	-23.2±5.37	-28.1	-26.07±2.21	-25.77±9.87	0.810
Cl, mg/kg	16055±920.65	148/84	17419.5±276.47	17653.33±1298.97	0.680
TOC, %	1.41±0.16	1.59	1.31±0.32	1.93±1.65	0.900
PO4, mg/kg	0.20±0.05	0.22	0.24±0.11	0.16±0.02	0.812
NO3 mg/kg	0.85±0.64	0.9	1.2±0.78	1.27±0.31	0.710
NH4 mg/kg	0.4±0.29	0.42	0.56±0.36	0.6±0.13	0.900
Sand, %	0	0	0	0	
Silt%	5.19±0.22	5.17	5.07±0.38	5.00±0.06	1.000
Clay%	94.695±0.24	94.65	94.87±0.40	94.90±0.02	1.000
O & G mg/kg	27±29.69 <sup>a</sup>	6 <sup>b</sup>	14±9.16 <sup>b</sup>	18±20.78 <sup>a</sup>	0.000
ALIPH mg/kg	<0.001	<0.001	<0.001	<0.001	
TPH mg/kg	18±25.45 <sup>a</sup>	0 <sup>c</sup>	6±6 <sup>b</sup>	10±17.32 <sup>a</sup>	0.000
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.33±0.15	1.28	1.10±0.136	0.90±0.04	0.810
Fe mg/kg	9590.5±5271.48	13083	12180.67±4351.67	13657±457.47	0.752
Pb mg/kg	27.78±9.10	37.78	15.65±8.88	22.67±4.39	0.308
Cu mg/kg	14.25±1.82	6.43	6.47±2.31	10.81±0.94	0.100
Cr mg/kg	20.70±6.92	19.09	23.49±12.44	30.59±19.81	0.180
Zn mg/kg	49.95±2.33	36.91	55.99±5.93	57.15±14.16	0.870
Cd mg/kg	5.27±2.73	1.02	1.28±0.81	4.17±2.18	0.090
Ba mg/kg	6±2.82	10	10.33±1.52	13.67±2.52	0.620
Co mg/kg	55.481±1.07	38.6	40.07±17.36	16.52±13.44	0.041
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	471.5±20.50	488	478.33±22.30	443.33±13.43	0.705
Na mg/kg	11570±101.82	11284	11426.33±175.74	11456±23.30	0.600
Mg mg/kg	1371.5±70.00	1428	1393±66.64	1450.66±21.03	0.719
Ca mg/kg	535±8.48	542	532.66±4.50	556.33±13.20	0.800
HUF cfu/g	0	0	0	0	
HUB cfu/g	0	0	0	0	
THB x10 <sup>2</sup> cfu/g	1.53±0.54	2.01	1.15±0.22	1.24±0.02	0.710
TFx10 <sup>1</sup> cfu/g	4.1±0.71	8.20	5.1±0.73	5.6±0.92	0.915
SRB cfu/g	0	NA	0	0	

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

## DPK

Table 4.4c shows the summary results of physicochemical measurements in sediments at different receptor distances of 200m to 1200m from the DPK and the control locations. Detailed results are presented in **Appendix 2**.

### *Physico-chemistry*

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 200m ( $7.49 \pm 0.10$ ) to the 1200m ( $7.39 \pm 0.09$ ) receptor locations. There were no discernable patterns with regards to distance from the DPK, however the pH compared favorably ( $p=1.000$ ) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed relatively reduced conditions in the sediments. The redox potentials ranged from  $-29.03 \pm 7.05$  mV at the 200m receptor location to  $-22.45 \pm 5.58$  mV at the 1200m receptor location. The Eh levels were not significantly different ( $p=0.910$ ) from the control location ( $-25.77 \pm 9.87$  mV) and across the receptor distances (200m to 1200m) from the DPK. The Redox potential values around the DPK were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008). The chloride levels in the sediments suggests an estuarine ecosystem as values ranged from  $16877.6 \pm 2281.56$  mg/kg around the 200m receptor distances to  $16802 \pm 1149.75$  mg/kg at the 1200m distance from the DPK. The levels of chloride which were observed to increase with distance may be attributed to natural variation in the interstitial waters. No significant variation ( $p=0.704$ ) was observed when compared with the control stations ( $17653.33 \pm 1298.97$  mg/kg).

### *Organic Load*

The TOC levels ranged from  $1.98 \pm 0.98\%$  at 200m to  $0.99 \pm 0.37\%$  at 1200m receptor distance. There was no significant variation ( $p=0.819$ ) when compared to the control locations ( $1.93 \pm 1.65\%$ ) and no distinct pattern was observed in relation to distance from the DPK. Despite the textural class of the sediments, which was generally dominated by clay ( $>95\%$ ) ( $p=1.000$ ) across the receptor distances the TOC levels were low and well within normal levels (1 to 3%) at the 200m, 800m and 1200m for unpolluted sediment (USEPA, 2002).

### *Nutrients*

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from  $0.87 \pm 0.06$  to  $1.25 \pm 0.21$  mg/kg and  $0.18 \pm 0.07$  to  $0.29 \pm 0.02$  mg/kg at the 200m and 1200m receptor distances from the DPK compared to the control locations ( $1.27 \pm 0.31$  mg/kg,  $0.16 \pm 0.02$  mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=0.913$ ; Phosphate,  $p=0.701$ ). 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.

### ***Exchangeable cations***

The mean concentration of exchangeable cations, K,Na,Mg and Ca in the bottom sediments ranged from 475±45.90 to 463.5±12.02 mg/kg; 11579±84.07 to 11410±120.20 mg/kg; 1489.67±19.75 to 1407.5±75.66 mg/kg and 538.6±22.03 to 557.5±12.02 mg/kg respectively at the 200m to the 1200m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably (Potassium (p=1.000), Sodium (p=0.814), Magnesium (p=0.720) and Calcium (p=1.000)) with the control locations (K, 443.33±13.43 mg/kg; Na, 11456±23.30 mg/kg; Mg, 1450.66±21.03 mg/kg and Ca, 556.33±13.20 mg/kg). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al*, 2010).

### ***Heavy metals***

The heavy metal concentrations in the sediment were within normal ranges for a brown field. Cobalt (p=0.000) was significantly different when compared to the control stations but showed no discernable pattern with relation to distance from the DPK. A test of significance using the Duncan Multiple range tests showed the highest concentration at the 500m receptor distance. The variation maybe attributed to coastal influences and discharges from navigating vessels around the DPK area. The concentration of Ni (p=0.888), Fe (p=0.992), Pb (p=0.743), Cu (p=0.604), Cr (p=0.500), Zn (p=0.718), Cd (p=0.101), Ba (p=0.749) were not significantly different from the control locations as the concentration ranged from 1.25±0.13 to 1.29±0.01 mg/kg; 12796±1507.67 to 14017.5±605.99 mg/kg; 20.44±6.46 to 31.14±6.71 mg/kg; 9.70±10.04 to 8.28±0.94 mg/kg; 39.01±5.84 to 15.66±2.75 mg/kg; 41.754±8.40 to 62.906±27.04 mg/kg, 0.64±0.293 to 2.14±0.43 mg/kg, and 8.6±1.52 to 8±1.41 mg/kg respectively at the 200m and 1200m receptor distances. The concentrations of these heavy metals were within normal levels for brown fields in the Niger delta. Silver and Vanadium were not detected (<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations.

### ***Hydrocarbons***

The PAH, BTEX and aliphatics concentration (p<0.001) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Oil and grease (p=0.000) and TPH (p=0.000) concentration were significantly different from the control locations with concentration at the control locations being higher when compared to other receptor locations.

### ***Microbiology***

The summary of the microbial load of the sediment is presented in Table 4.4c. The THB and TF were in the order of 10<sup>2</sup> and 10<sup>1</sup> cfu/g and ranged from 1.54±0.68 x10<sup>2</sup> to 1.88±0.42x10<sup>2</sup> cfu/g and 1.91±0.85 x10<sup>1</sup> to 4.6±0.71x10<sup>1</sup> cfu/g at the 200m and 1200m receptor distances. The THB and TF microbial load 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 stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 200m to 1200m including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project.



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Table 4.4c: Summary results of physicochemical measurements in sediment at DP-K compared to control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
pH	7.49±0.10	7.46±0.03	7.46±0.05	7.39±0.09	7.44±0.18	1.000
TEMP, °C	9.33±0.37	8.96±0.51	8.83±0.12	9.5±0.141	8.63±0.67	1.000
Redox, mV	-29.03±7.05	-24.9±1.92	-26.5±3.89	-22.45±5.58	-25.77±9.87	0.910
Cl, mg/kg	16877.6±2281.56	17528.33±1449.00	17160.67±1893.39	16802±1149.75	17653.33±1298.97	0.704
TOC, %	1.98±0.98	2.13±0.71	0.92±0.61	0.99±0.37	1.93±1.65	0.819
PO4, mg/kg	0.18±0.07	0.27±0.12	0.35±0.07	0.29±0.02	0.16±0.02	0.701
NO3 mg/kg	0.87±0.06	1.16±0.81	1.03±0.45	1.25±0.21	1.27±0.31	0.913
NH4 mg/kg	0.40±0.028	0.547±0.37	0.48±0.20	0.58±0.09	0.6±0.13	0.980
Sand, %	0	0	0	0	0	
Silt%	4.42±0.75	4.56±0.19	4.84±0.51	4.625±0.30	5.00±0.06	1.000
Clay%	95.36±0.76	95.07±0.61	94.73±0.735	95.115±0.38	94.90±0.02	1.000
O & G mg/kg	6±0	8±3.46	<0.001	<0.001	18±20.784	0.000
ALIPH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/kg	<0.001	2±3.46	<0.001	<0.001	10±17.32	0.000
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.25±0.13	1.22±0.18	1.20±0.09	1.29±0.01	0.90±0.04	0.888
Fe mg/kg	12796±1507.67	14998.66±269.76	14457.6±887.15	14017.5±605.99	13657±457.47	0.990
Pb mg/kg	20.438±6.46	12.25±14.21	20.8±15.30	31.14±6.71	22.67±4.39	0.743
Cu mg/kg	9.70±10.04	12.20±3.78	14.46±9.47	8.28±0.94	10.81±0.94	0.604
Cr mg/kg	39.01±5.84	78.42±5.74	22.379±3.21	15.66±2.75	30.59±19.81	0.500
Zn mg/kg	41.754±8.40	49.81±7.01	47.05±5.92	62.906±27.04	57.15±14.16	0.718
Cd mg/kg	0.64±0.293	4.55±3.64	2.91±0.843	2.14±0.43	4.17±2.18	0.101
Ba mg/kg	8.6±1.52	8.6±1.52	13±3	8±1.41	13.67±2.52	0.749
Co mg/kg	25.40±32.13	50.82±20.86	33.81±35.22	30.93±31.08	16.52±13.44	0.000
Ag mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/kg	475±45.90	461.33±29.36	456.33±34.77	463.5±12.02	443.33±13.43	1.000
Na mg/kg	11579±84.07	11515.66±108.49	11522.33±86.58	11410±120.20	11456±23.30	0.814
Mg mg/kg	1489.67±19.75	1360±46.51	1381.333±39.87	1407.5±75.66	1450.66±21.03	0.720

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<b>Parameters</b>	<b>200m</b>	<b>500m</b>	<b>800m</b>	<b>1200m</b>	<b>Control</b>	<b>P value</b>
	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	
Ca mg/kg	538.6±22.03	557.667±15.50	557.66±31.34	557.5±12.02	556.33±13.20	1.000
HUF cfu/g	0	0	0	0	0	
HUB cfu/g	0	0	0	0	0	
THB cfu/gx 102	1.54±0.68	1.89±0.33	1.28±0.47	1.88±0.42	1.24±1.02	0.819
THF cfu/g x 101	1.91±0.85	4.03±0.89	2.01±0.20	4.6±0.71	5.6±1.92	0.031
SRB cfu/g	0	0	0	0	0	

P<0.05 – Significant; p>0.05 – Not significant

## EA-DPJ PLATFORM

Table 4.4d shows the summary results of physicochemical measurements in sediments at different receptor distances of 200m to 1200m from the DPJ and the control locations. Detailed results are presented in **Appendix 2**.

### *Physico-chemistry*

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges with values from the 200m (7.41) to the 1200m (7.53±0.11) receptor locations. According to Ponnampereuma (1972) intense reduction in submerged sediments tend to buffer sediments close to pH 7.0. There were no discernable patterns with regards to distance from the DPJ, however the pH compared favorably ( $p=1.000$ ) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed a relatively moderate reducing condition in sediments. The redox potentials ranged from -23.3 mV at the 200m receptor location to -23.65±0.07 mV at the 1200m receptor location. Submerged sediments usually display a range of redox potentials from +700 mV, which indicates highly oxidized sediment, to -300 mV, which indicates highly reduced sediment (DeLaune et al., 1976). The Eh levels were not significantly different ( $p=0.815$ ) from the control location (-25.77±9.87 mV) and across the receptor distances (200m to 1200m) from the DPJ. The Redox potential values around the DPJ were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008). The chloride level suggests an estuarine ecosystem as values ranged from 16243 mg/kg around the 200m receptor distances to 14819.5±91.21 mg/kg at the 1200m distance from the DPJ. The levels of chloride were observed to increase with distance which may be attributed to natural variation in the interstitial waters. No significant variation ( $p=0.700$ ) was observed when compared with the control stations (17653.33±1298.97mg/kg).

### *Organic Load*

The TOC levels ranged from 1.16% at 200m to 0.49±0.28% at 1200m receptor distance. There was no significant variation ( $p=0.920$ ) when compared to the control locations (1.93±1.65%) and no distinct pattern was observed in relation to distance from the DPJ. The TOC levels were within normal ranges (1 to 3%) at the 200m, 500m, 800m and 1200m for unpolluted sediments (USEPA, 2002) and thus capable of supporting biotic fauna in sediments. Although clay has a high affinity for organic carbon, the levels of TOC in sediments were low irrespective of the textural classification which was generally dominated by clay (>95%) ( $p=1.000$ ) across the receptor distances.

### *Nutrients*

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from 1.7 to 0.9±0 mg/kg and 0.41 to 0.39±0.01 mg/kg at the 200m and 1200m receptor distances from the DPJ compared to the control locations (1.27±0.31 mg/kg, 0.16±0.02 mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=0.825$ ; Phosphate,  $p=0.881$ ). 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.

### ***Exchangeable cations***

The mean concentration of exchangeable cations, K, Na, Mg and Ca, in the bottom sediments ranged from 511 to 459.5±2.12 mg/kg; 11547 to 11634.5±282.13 mg/kg; 1421 to 1390.5±62.93 mg/kg and 559 to 562±42.42 mg/kg respectively at the 200m to the 1200m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably (Potassium (p=0.650), Sodium (p=0.812), Magnesium (p=0.818) and Calcium (p=1.000)) with the control locations (K, 443.33±13.43 mg/kg; Na, 11456±23.30 mg/kg; Mg, 1450.66±21.03 mg/kg and Ca, 556.33±13.20 mg/kg). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al*, 2010).

### ***Heavy metals***

The heavy metal concentrations in the sediment were within normal ranges for a brown field. Cobalt (p=0.000) and Copper (p=0.040) were significantly different when compared to the control stations but showed no discernable pattern with relation to distance from the DPJ. A test of significance using the Duncan Multiple range tests showed the highest concentration at the 500m receptor distance. The variation maybe attributed to coastal influences and discharges from navigating vessels around the DPJ area. The concentration of Ni (p=0.610), Fe (p=0.800), Pb (p=1.000), Cr (p=0.416), Zn (p=0.600), Cd (p=0.210), Ba (p=0.712) were not significantly different from the control locations as the concentration ranged from 1.36 to 1.35±0.86 mg/kg; 12259 to 14068.5±474.46 mg/kg; 22.79 to 31.12±9.28 mg/kg; 35.564 to 29.366±13.15 mg/kg; 62.35 to 58.351±8.99 mg/kg; 1.63 to 1.31±1.75 mg/kg and 9 to 9.5±0.70 mg/kg at the 200m and 1200m receptor distances. The concentrations of these heavy metals were within normal levels for brown fields in the Niger delta. Silver and Vanadium were not detected (<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations.

### ***Hydrocarbons***

The PAH, BTEX and aliphatics concentration (p<0.001 mg/kg) were not detected in the bottom sediments across the receptor locations including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Oil and grease (p=0.000) and TPH (p=0.000) concentrations were significantly different from the control locations with concentration at the control locations being higher when compared to other receptor locations.

### ***Microbiology***

The summary of the microbial load of the sediment is presented in Table 4.4d. The THB and TF were in the order of 10<sup>2</sup> and 10<sup>1</sup> cfu/g and ranged from 1.23x10<sup>2</sup> to 1.35±0.77x10<sup>2</sup> cfu/g

and  $2.80 \times 10^1$  to  $4.61 \pm 3.4 \times 10^1$  cfu/g at the 200m and 1200m receptor distances. The THB and TF microbial load 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. The hydrocarbonoclastis were not identified in the sediments including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. Similarly, the SRBs were not identified across the receptor distances from 200m to 1200m including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project. The absence of SRBs may be related to the low levels of organic carbon in the sediments and absence of optimum redox conditions.

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Table 4.4d: Summary results of physicochemical measurements in sediment at EA-DPJ Platform compared to control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
pH	7.41	7.36±0.06	7.49±0.28	7.53±0.11	7.44±0.18	1.000
TEMP, °C	9.3	9.1±0.62	8.53±0.05	8.65±0.77	8.63±0.67	0.918
Redox, mV	-23.3	-21.2±3.78	-21.1±3.00	-23.65±0.07	-25.77±9.87	0.815
Cl, mg/kg	16243	17592.6±1148.41	16579.66±1277.98	14819.5±91.21	17653.33±1298.97	0.700
TOC, %	1.16	1.91±1.45	0.895±0.37	0.49±0.28	1.93±1.65	0.920
PO4, mg/kg	0.41	0.18±0.045	0.25±0.05	0.39±0.01	0.16±0.02	0.881
NO3 mg/kg	1.7	1.13±0.12	0.66±0.25	0.9±0	1.27±0.31	0.825
NH4 mg/kg	0.79	0.55±0.06	0.31±0.11	0.42±0	0.6±0.13	0.719
Sand, %	0	0	0	0	0	
Silt%	5.3	4.48±0.09	4.25±0.42	4.145±0.21	5.00±0.06	0.942
Clay%	94.04	95.07±0.32	95.383±0.71	95.255±0.78	94.90±0.02	1.000
O & G mg/kg	6	10±6.93	12±10.39	<0.001	18±20.784	0.000
ALIPH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/kg	<0.001	2±3.46	4±6.92	<0.001	10±17.32	0.000
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.36	1.145±0.13	1.284±0.05	1.35±0.86	0.90±0.04	0.610
Fe mg/kg	12259	13167.33±1354.82	14376.67±816.78	14068.5±474.46	13657±457.47	0.800
Pb mg/kg	22.79	26.09±10.19	27.32±6.21	31.12±9.28	22.67±4.39	1.000
Cu mg/kg	23.52	8.75±5.82	5.79±4.83	15.95±3.63	10.81±0.94	0.040
Cr mg/kg	35.564	30.376±12.25	40.37±25.66	29.366±13.15	30.59±19.81	0.416
Zn mg/kg	62.35	42.70±6.16	50.81±10.60	58.351±8.99	57.15±14.16	0.600
Cd mg/kg	1.63	5.00±3.72	4.95±3.30	1.31±1.75	4.17±2.18	0.210
Ba mg/kg	9	12±4.58	7.33±2.081	9.5±0.70	13.67±2.52	0.712
Co mg/kg	7.20	24.49±15.14	34.22±20.23	14.27±8.90	16.52±13.44	0.000
Ag mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	

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<b>Parameters</b>	<b>200m</b>	<b>500m</b>	<b>800m</b>	<b>1200m</b>	<b>Control</b>	<b>P value</b>
	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	
K mg/kg	511	452±28.82	438±18.19	459.5±2.12	443.33±13.43	0.650
Na mg/kg	11547	11367±404.30	11524±230.52	11634.5±282.13	11456±23.30	0.812
Mg mg/kg	1421	1392.6±59.67	1377±33.15	1390.5±62.93	1450.66±21.03	0.818
Ca mg/kg	559	555.66±23.62	557.66±20.42	562±42.42	556.33±13.20	1.000
HUF cfu/g	NIL	NIL	NIL	NIL	0	
HUB cfu/g	NIL	NIL	NIL	NIL	0	
THB x102cfu/g	1.23	1.26±1.78	1.24±1.64	1.35±0.77	1.24±1.20	1.000
TFx101 cfu/g	2.80	4.26±1.05	5.26±4.2	4.61±3.4	5.6±2.19	0.418
SRB cfu/g	NA	NA	NA	NA	0	

P<0.05 – Significant; p>0.05 – Not significant

**EA-DPB**

Table 4.4e shows the summary results of physicochemical measurements in sediments at different receptor distances of 500m to 800m from the DPB and the control locations. Detailed results are presented in **Appendix 2**.

***Physico-chemistry***

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 500m (7.43) to the 800m (7.42±0.07) receptor locations. According to Ponnampurna (1972) intense reduction in submerged sediments tend to buffer sediments close to pH 7.0. There were no discernable patterns with regards to distance from the DPB, however the pH compared favorably (p=1.000) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed a relatively moderate reducing conditions in the sediments. The redox potentials ranged from -28.3mV at the 500m receptor location to -28.4±4.15mV at the 800m receptor location. Submerged sediments usually display a range of redox potentials from +700 mV, which indicates highly oxidized sediment, to -300 mV, which indicates highly reduced sediment (DeLaune et al., 1976). The Eh levels were not significantly different (p=0.918) from the control location (-25.77±9.87mV) and across the receptor distances (500m to 800m) from the DPB. The Redox potential values around the DPB were within normal ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008). The chloride level suggests an estuarine ecosystem with values ranging from 17744 mg/kg around the 500m receptor distances to 16228±164.10 mg/kg at the 800m distance from the DPB. The levels of chloride were observed to increase with distance which may be attributed to natural variation in the interstitial waters. No significant variation (p=0.800) was observed when compared with the control stations (17653.33±1298.97 mg/kg).

***Organic Load***

The TOC levels ranged from 0.88% at 500m to 1.27±0.22% at 800m receptor distance. There was no significant variation (p=0.918) when compared to the control locations (1.93±1.65%) and no distinct pattern was observed in relation to distance from the DPB. Considering that the texture of the sediments was dominantly clay(>95%) (p=1.000), the TOC levels were low. The TOC levels were within normal ranges (1 to 3%) at the 500m and 800m levels for organic matter in sediments (USEPA, 2002) and thus capable of supporting biotic fauna in sediments.

***Nutrients***

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from 1.2 to 1.06±0.47 mg/kg and 0.09 to 0.16±0.02 mg/kg at the 500m and 800m receptor distances from the DPB compared to the control locations (1.27±0.31 mg/kg, 0.16±0.02 mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate, p=1.000; Phosphate, p=0.732). 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.

#### ***Exchangeable cations***

The mean concentration of exchangeable cations, K, Na, Mg and Ca, in the bottom sediments ranged from 469 to 469±14.11 mg/kg; 11514 to 11430±31.76 mg/kg; 1518 to 1435.6±18.50 mg/kg and 542 to 548±21.28 mg/kg respectively at the 500m to the 800m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably (Potassium (p=0.982), Sodium (p=0.818), Magnesium (p=0.842) and Calcium (p=0.900)) with the control locations (K, 443.33±13.43 mg/kg; Na, 11456±23.30 mg/kg; Mg, 1450.66±21.03 mg/kg and Ca, 556.33±13.20 mg/kg). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al*, 2010).

#### ***Heavy metals***

The heavy metal concentrations in the sediment were within normal ranges for a brown field. Nickel (p=0.771), Fe (p=0.909), Pb (p=0.840), Cr (p=0.782) and Co (p=0.818) showed decreasing concentration with distance but were not significantly different when compared to the control locations. Peak values were observed in the 500m receptor location which may be attributed to coastal influences due to its proximity. Similarly, Cu (p=0.200), Zn (p=0.714), Cd (p=0.059) and Ba (p=0.451) showed increasing concentration with distance. The heavy metal concentrations ranged from 1.23 to 1.10±0.32 mg/kg (Nickel), 13158 to 11890±1722.94 mg/kg (Iron), 37.58 to 37.01±2.30 mg/kg (Lead), 7.92 to 14.96±4.15 mg/kg (Copper), 24.60 to 18.07±10.08 mg/kg, 43.52 to 56.30±23.88 mg/kg (Zinc), 0.52 to 6.75±3.27 mg/kg (cadmium), 7 to 10.66±3.78 mg/kg (Barium) and 32.02 to 13.02±10.65 mg/kg (Cobalt) at the 500m to 800m receptor locations. The concentrations of these heavy metals were within normal levels for brown fields in the Niger delta. Silver and Vanadium were not detected (<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations.

#### ***Hydrocarbons***

The PAH, BTEX and aliphatics concentration (p<0.001) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Oil and grease (p=0.000) and TPH (p=0.000) concentration were significantly different from the control locations with concentration at the control locations being higher when compared to other receptor locations.

#### **Microbiology**

The summary of the microbial load of the sediment is presented in Table 4.4e. The THB and TF were in the order of  $10^2$  and  $10^1$  cfu/g and ranged from  $1.16 \times 10^2$  to  $1.58 \pm 0.48 \times 10^2$  cfu/g and  $9.10 \times 10^1$  to  $6.6 \pm 2.1 \times 10^1$  cfu/g at the 500m and 800m receptor distances. The THB and TF microbial load 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 stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 500m to 800m including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project.

Table 4.4e: Summary results of physicochemical measurements in sediment at EA-DPB compared to control

Parameters	500m (Mean $\pm$ SD)	800m (Mean $\pm$ SD)	Control (Mean $\pm$ SD)	P value
pH	7.43	7.42 $\pm$ 0.07	7.44 $\pm$ 0.18	1.000
TEMP, °C	8.8	8.83 $\pm$ 0.30	8.63 $\pm$ 0.67	1.000
Redox, mV	-28.3	-28.4 $\pm$ 4.15	-25.77 $\pm$ 9.87	0.918
Cl, mg/kg	17744	16228 $\pm$ 164.10	17653.33 $\pm$ 1298.97	0.800
TOC, %	0.88	1.27 $\pm$ 0.22	1.93 $\pm$ 1.65	0.814
PO4, mg/kg	0.09	0.22 $\pm$ 0.10	0.16 $\pm$ 0.02	0.732
NO3 mg/kg	1.2	1.06 $\pm$ 0.47	1.27 $\pm$ 0.31	1.000
NH4 mg/kg	0.59	0.49 $\pm$ 0.21	0.6 $\pm$ 0.13	1.000
Sand, %	0	0	0	
Silt%	5.24	5.70 $\pm$ 0.72	5.00 $\pm$ 0.06	1.000
Clay%	94.66	94.85 $\pm$ 0.47	94.90 $\pm$ 0.02	1.000
O & G mg/kg	6 <sup>b</sup>	8 $\pm$ 6.92 <sup>b</sup>	18 $\pm$ 20.78 <sup>a</sup>	0.000
ALIPH mg/kg	<0.001	<0.001	<0.001	
TPH mg/kg	0	2 $\pm$ 3.46	10 $\pm$ 17.32	0.000
PAH mg/kg	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	
Ni mg/kg	1.23	1.10 $\pm$ 0.32	0.90 $\pm$ 0.04	0.771
Fe mg/kg	13158	11890 $\pm$ 1722.94	13657 $\pm$ 457.47	0.909
Pb mg/kg	37.58	37.01 $\pm$ 2.30	22.67 $\pm$ 4.39	0.840
Cu mg/kg	7.92	14.96 $\pm$ 4.15	10.81 $\pm$ 0.94	0.200
Cr mg/kg	24.60	18.07 $\pm$ 10.08	30.59 $\pm$ 19.81	0.782
Zn mg/kg	43.52	56.30 $\pm$ 23.88	57.15 $\pm$ 14.16	0.714
Cd mg/kg	0.52	6.75 $\pm$ 3.27	4.17 $\pm$ 2.18	0.059
Ba mg/kg	7	10.66 $\pm$ 3.78	13.67 $\pm$ 2.52	0.451
Co mg/kg	32.02	13.02 $\pm$ 10.65	16.52 $\pm$ 13.44	0.818
Ag mg/kg	<0.001	<0.001	<0.001	
V mg/kg	<0.001	<0.001	<0.001	
K mg/kg	469	469 $\pm$ 14.11	443.33 $\pm$ 13.43	0.982
Na mg/kg	11514	11430 $\pm$ 31.76	11456 $\pm$ 23.30	0.818
Mg mg/kg	1518	1435.6 $\pm$ 18.50	1450.66 $\pm$ 21.03	0.842
Ca mg/kg	542	548 $\pm$ 21.28	556.33 $\pm$ 13.20	0.900

HUF cfu/g	NIL	NIL	NIL	
HUB cfu/g	NIL	NIL	NIL	
THB x102cfu/g	1.16	1.58±0.48	1.24±1.20	0.914
TFx101 cfu/g	9.10	6.6±2.1	5.6±2.19	0.992
SRB cfu/g	0	0	0	

P<0.05 – Significant; p>0.05 – Not significant

### PROPOSED PLATFORM – DPC

Table 4.4f shows the summary results of physicochemical measurements in sediments at different receptor distances of 200m to 800m from the DPC and the control locations. Detailed results are presented in **Appendix 2**

#### *Physico-chemistry*

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 200m (7.36±0.06) to the 800m (7.39±0.06) receptor locations. According to Ponnampereuma (1972) intense reduction in submerged sediments tend to buffer sediments close to pH 7.0. There were no discernable patterns with regards to distance from the DPC, however the pH compared favorably (p=1.000) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed a moderately reduced condition in the sediments. Submerged sediments usually display a range of redox potentials from +700 mV, which indicates highly oxidized sediment, to -300 mV, which indicates highly reduced sediment (DeLaune et al., 1976). The redox potentials ranged from -23.96±6.56 mV at the 200m receptor location to -27.2±5.72 mV at the 800m receptor location. The Eh levels were not significantly different (p=0.900) from the control location (-25.77±9.87 mV) and across the receptor distances (200m to 800m) from the DPC. The Redox potential values around the DPC were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008). The chloride level suggests an estuarine ecosystem as values ranged from 15556±432.46 mg/kg around the 200m receptor distances to 15491±695.56 mg/kg at the 800m distance from the DPC. The levels of chloride were observed to increase with distance which may be attributed to natural variation in the interstitial waters. No significant variation (p=0.818) was observed when compared with the control stations (17653.33±1298.97 mg/kg).

#### *Organic Load*

The TOC levels ranged from 3.62±6.1% at 200m to 1.175±0.36% at 800m receptor distance. The TOC level at 200m was significantly higher (P=0.000) than those of other distances from the proposed platform whole the lowest was obtained at 500m (<0.10%). Although the TOC levels were generally within normal ranges (1 to 3%) in unpolluted sediments (USEPA, 2002) the level obtained at 200m indicate moderate organic contamination possibly due to natural inputs from overlying waters. The textural classification which was generally dominated by clay (>94%) (p=1.000) across the receptor distances, so the observed variations in TOC cannot be attributed to substrate texture.

### ***Nutrients***

Nitrate and phosphate are major nutrients for microbial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from  $1.33\pm 0.25$  to  $1.2\pm 0.3$  mg/kg and  $0.23\pm 0.01$  to  $0.23\pm 0.10$  mg/kg at the 200m and 800m receptor distances from the DPC compared to the control locations ( $1.27\pm 0.31$  mg/kg,  $0.16\pm 0.02$  mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=0.900$ ; Phosphate,  $p=0.732$ ). 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.

### ***Exchangeable cations***

The mean concentration of exchangeable cations, K, Na, Mg and Ca, in the bottom sediments ranged from  $475.33\pm 14.29$  to  $455.33\pm 24.13$  mg/kg;  $11540.33\pm 98.35$  to  $11544.66\pm 180.26$  mg/kg;  $1443.33\pm 11.15$  to  $1510.33\pm 80.37$  mg/kg and  $541\pm 16.09$  to  $553\pm 16.46$  mg/kg respectively at the 200m to the 800m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably (Potassium ( $p=0.910$ ), Sodium ( $p=0.890$ ), Magnesium ( $p=0.710$ ) and Calcium ( $p=0.829$ )) with the control locations (K,  $443.33\pm 13.43$  mg/kg; Na,  $11456\pm 23.30$  mg/kg; Mg,  $1450.66\pm 21.03$  mg/kg and Ca,  $556.33\pm 13.20$  mg/kg). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al.*, 2010).

### ***Heavy metals***

The heavy metal concentrations in the sediment were within normal ranges for a brown field and compared favorably with concentrations around the control location. Nickel ( $p=1.000$ ), Fe ( $p=0.815$ ), Pb ( $p=0.942$ ), Cu ( $p=0.210$ ), Cr ( $p=0.310$ ), Zn ( $p=0.700$ ), Cd ( $p=0.818$ ), Ba ( $p=0.759$ ) and Co ( $p=0.819$ ) ranged from  $1.139\pm 0.04$  to  $1.202\pm 0.05$  mg/kg,  $7438.66\pm 112.22$  to  $9305.33\pm 3202.84$  mg/kg,  $27.957\pm 4.18$  to  $30.26\pm 7.32$  mg/kg,  $6.12\pm 2.20$  to  $12.56\pm 7.24$  mg/kg,  $25.202\pm 3.04$  to  $31.26\pm 1.36$  mg/kg,  $43.13\pm 20.24$  to  $50.808\pm 23.98$  mg/kg,  $2.85\pm 1.51$  to  $2.53\pm 1.97$  mg/kg,  $10.66\pm 2.08$  to  $10.33\pm 4.04$  mg/kg and  $23.07\pm 15.94$  to  $15.35\pm 7.18$  mg/kg at the 200m and 800m receptor distances respectively. Silver and Vanadium were not detected ( $<0.001$  mg/kg) in the bottom sediments across the receptor distances including the control locations.

### ***Hydrocarbons***

The PAH and BTEX concentration ( $p<0.001$  mg/kg) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Oil and grease ( $p=0.000$ ) and TPH ( $p=0.000$ ) concentration were significantly different from the control locations with concentration at the

500m receptor distance and control locations being higher when compared to other receptor locations. The high concentration of Oil and grease and TPH at control suggests low hydrocarbon burden around the DPC area.

### Microbiology

The summary of the microbial load of the sediment is presented in Table 4.4f. The THB and TF were in the order of  $10^2$  and  $10^1$  cfu/g and ranged from  $1.22 \pm 2.3 \times 10^2$  to  $1.76 \pm 4.8 \times 10^2$  cfu/g and  $4.1 \pm 3 \times 10^1$  to  $7.2 \pm 0.17 \times 10^1$  cfu/g at the 200m and 800m receptor distances. The THB and TF microbial load 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 stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 200m to 800m including the control station and indicate unlikelihood of biogenic hydrogen sulphide corrosion (Neria-Gonzalez *et al.*, 2006) and crude souring (Hubert and Voordouw., 2007) during the operation phase of the project.

Table 4.4f: Summary results of physicochemical measurements in sediment at the DP-C Platform compared to control

Parameters	200m	500m	800m	Control	P value
	(Mean $\pm$ SD)	(Mean $\pm$ SD)	(Mean $\pm$ SD)	(Mean $\pm$ SD)	
pH	7.36 $\pm$ 0.06	7.45	7.39 $\pm$ 0.06	7.44 $\pm$ 0.18	1.000
TEMP, °C	8.36 $\pm$ 0.25	8.3	8.4 $\pm$ 0.43	8.63 $\pm$ 0.67	1.000
Redox, mV	-23.96 $\pm$ 6.56	-26.1	-27.2 $\pm$ 5.72	-25.77 $\pm$ 9.87	0.900
Cl, mg/kg	15556 $\pm$ 432.46	17420	15491 $\pm$ 695.56	17653.33 $\pm$ 1298.97	0.818
TOC, %	3.62 $\pm$ 6.1 <sup>a</sup>	<0.10 <sup>c</sup>	1.175 $\pm$ 0.36 <sup>b</sup>	1.93 $\pm$ 1.65 <sup>b</sup>	0.000
PO <sub>4</sub> , mg/kg	0.23 $\pm$ 0.01	0.12	0.23 $\pm$ 0.10	0.16 $\pm$ 0.02	0.723
NO <sub>3</sub> mg/kg	1.33 $\pm$ 0.25	1.8	1.2 $\pm$ 0.3	1.27 $\pm$ 0.31	0.900
NH <sub>4</sub> mg/kg	0.62 $\pm$ 0.11	0.84	0.57 $\pm$ 0.14	0.6 $\pm$ 0.13	1.000
Sand, %	0	0	0	0	
Silt%	5.38 $\pm$ 0.86	4.62	5.30 $\pm$ 1.07	5.00 $\pm$ 0.06	1.000
Clay%	94.52 $\pm$ 0.87	95.23	95.07 $\pm$ 0.29	94.90 $\pm$ 0.02	1.000
O & G mg/kg	4 $\pm$ 3.46 <sup>b</sup>	18 <sup>a</sup>	6 $\pm$ 6 <sup>b</sup>	18 $\pm$ 20.78 <sup>a</sup>	0.000
ALIPH mg/kg	<0.001	1	<0.001	<0.001	
TPH mg/kg	0 $\pm$ 0 <sup>b</sup>	12 <sup>a</sup>	0 $\pm$ 0 <sup>b</sup>	10 $\pm$ 17.32 <sup>a</sup>	0.000
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.139 $\pm$ 0.04	1.259	1.202 $\pm$ 0.05	0.90 $\pm$ 0.04	1.000
Fe mg/kg	7438.66 $\pm$ 112.22	14895	9305.33 $\pm$ 3202.84	13657 $\pm$ 457.47	0.815
Pb mg/kg	27.957 $\pm$ 4.18	38.331	30.26 $\pm$ 7.32	22.67 $\pm$ 4.39	0.942
Cu mg/kg	6.12 $\pm$ 2.20	14.269	12.56 $\pm$ 7.24	10.81 $\pm$ 0.94	0.210
Cr mg/kg	25.202 $\pm$ 3.04	78.76	31.26 $\pm$ 1.36	30.59 $\pm$ 19.81	0.310
Zn mg/kg	43.13 $\pm$ 20.24	50.618	50.808 $\pm$ 23.98	57.15 $\pm$ 14.16	0.700
Cd mg/kg	2.85 $\pm$ 1.51	4.606	2.53 $\pm$ 1.97	4.17 $\pm$ 2.18	0.818

Parameters	200m	500m	800m	Control	P value
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	
Ba mg/kg	10.66±2.08	12	10.33±4.04	13.67±2.52	0.759
Co mg/kg	23.07±15.94	32.248	15.35±7.18	16.52±13.44	0.819
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	475.33±14.29	466	455.33±24.13	443.33±13.43	0.910
Na mg/kg	11540.33±98.35	11821	11544.66±180.26	11456±23.30	0.890
Mg mg/kg	1443.33±11.15	1471	1510.33±80.37	1450.66±21.03	0.710
Ca mg/kg	541±16.09	558	553±16.46	556.33±13.20	0.829
HUF cfu/g	NIL	NIL	NIL	NIL	
HUB cfu/g	NIL	NIL	NIL	NIL	
THB x10 <sup>2</sup> cfu/g	1.22±2.3	1.62	1.76±4.8	1.24±1.2	0.900
TFx101 cfu/g	4.1±3	6.7	7.2±0.17	5.6±2.19	0.852
SRB cfu/g	NA	NA	NA	0	

P<0.05 – Significant; p>0.05 – Not significant

#### A- DPA PLATFORM

Table 4.4g shows the summary results of physicochemical measurements in sediments at different receptor distances of 200m to 1200m from the DPA and the control locations. Detailed results are presented in **Appendix 2**.

#### *Physico-chemistry*

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 200m (7.55) to the 1200m (7.56) receptor locations. According to Ponnampuruma (1972) intense reduction in submerged sediments tend to buffer sediments close to pH 7.0. There were no discernable patterns with regards to distance from the DPA, however the pH compared favorably (p=1.000) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed a moderately reduced condition in the sediments. Submerged sediments usually display a range of redox potentials from +700 mV, which indicates highly oxidized sediment, to -300 mV, which indicates highly reduced sediment (DeLaune et al., 1976). The redox potentials ranged from -34.3 mV at the 200m receptor location to -34.5 mV at the 1200m receptor location. The Eh levels were not significantly different (p=0.810) from the control location (-25.77±9.87 mV) and across the receptor distances (200m to 1200m) from the DPA. The Redox potential values around the DPA were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008). The chloride level suggests an estuarine ecosystem with values ranging from 16706 mg/kg around the 200m receptor distances to 16380 mg/kg at the 1200m distance from the DPA. The levels of chloride were observed to increase with distance which may be attributed to natural variation in the interstitial waters. No significant variation (p=0.818) was observed when compared with the control stations (17653.33±1298.97mg/kg).

**Organic Load**

The TOC levels ranged from 0.59% at 200m to 0.06% at 1200m receptor distance. There was no significant variation ( $p=0.918$ ) when compared to the control locations ( $1.93\pm 1.65\%$ ) except at the 500m receptor distance ( $<0.10\%$ ). A test of significance using the Duncan Multiple Range test showed variation in the TOC levels around the control location (0.06%). The TOC levels were within normal range (1 to 3%) for unpolluted sediments across the receptor locations including the control suggesting. There was no relationship with the textural class which was generally dominated by clay ( $>94\%$ ) ( $p=1.000$ ).

**Nutrients**

Nitrate and phosphate are major nutrients for algal growth and bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from 1.6 to 1.6 mg/kg and 0.21 to 0.08 mg/kg at the 200m and 1200m receptor distances from the DPA compared to the control locations ( $1.27\pm 0.31$  mg/kg,  $0.16\pm 0.02$  mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=0.800$ ; Phosphate,  $p=0.782$ ). 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.

**Exchangeable cations**

The mean concentration of exchangeable cations, K, Na, Mg and Ca, in the bottom sediments ranged from 443 to 449vmg/kg; 11511 to 11422vmg/kg; 1459 to 1473vmg/kg and 542 to 524vmg/kg respectively at the 200m to the 1200m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably (Potassium ( $p=0.923$ ), Sodium ( $p=0.814$ ), Magnesium ( $p=0.800$ ) and Calcium ( $p=0.996$ ) ) with the control locations (K,  $443.33\pm 13.43$  mg/kg; Na,  $11456\pm 23.30$  mg/kg; Mg,  $1450.66\pm 21.03$  mg/kg and Ca,  $556.33\pm 13.20$  mg/kg). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al.*, 2010).

**Heavy metals**

The heavy metal concentrations in the sediment were within normal ranges for a brown field and compared favorably with concentrations around the control location except Copper, Chromium and Cobalt. Nickel ( $p=0.922$ ), Fe ( $p=0.842$ ), Pb ( $p=0.714$ ), Zn ( $p=0.510$ ), Cd ( $p=0.819$ ), Ba ( $p=0.850$ ) and Co ( $p=0.819$ ) ranged from 1.4 to 0.533 mg/kg, 13471 to 14040 mg/kg, 31.517 to 13.591 mg/kg, 36.59 to 30.68 mg/kg, 3.821 to 6.64 mg/kg, 12 to 8 mg/kg at the 200m and 1200m receptor distances respectively. Silver and Vanadium were not detected

(<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations.

### ***Hydrocarbons***

The PAH, Aliphatics and BTEX concentration ( $p < 0.001$  mg/kg) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. Oil and grease ( $p = 0.000$ ) and TPH ( $p = 0.000$ ) concentration were significantly different from the control locations with concentration at the 500m receptor distance and control locations being higher when compared to other receptor locations. The higher concentration of Oil and grease and TPH at the control suggests the low hydrocarbon burden around the DPA area.

### **Microbiology**

The summary of the microbial load of the sediment is presented in Table 4.4g. The THB and TF were in the order of  $10^2$  and  $10^1$  cfu/g and ranged from  $1.02 \times 10^2$  to  $2.01 \times 10^2$  cfu/g and  $5.3 \times 10^1$  to  $5.70 \times 10^1$  cfu/g at the 200m and 1200m receptor distances. The THB and TF microbial load 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 stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 200m to 1200m including the control station and indicate unlikelihood of biogenic hydrogen sulphide corrosion (Neria-Gonzalez *et al.*, 2006) and crude souring (Hubert and Voordouw., 2007) during the operation phase of the project.



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Table 4.4g: Summary results of physicochemical measurements in sediment at the EA-DPA Platform compared to control

Parameters	200m (Mean ± SD)	500m (Mean ± SD)	800m (Mean ± SD)	1200m (Mean ± SD)	Control (Mean ± SD)	P value
pH	7.55	7.42±0.09	7.46±0.14	7.56	7.44±0.18	1.000
TEMP, °C	8.6	9.225±0.45	8.533±0.15	8.4	8.63±0.67	1.000
Redox, mV	-34.3	-25.425±4.81	-29.73±8.20	-34.5	-25.77±9.87	0.810
Cl, mg/kg	16706	16265.25±747.5	15859.66±619.53	16380	17653.33±1298.97	0.700
TOC, %	0.59	1.58±0.26	0.23±0.04	0.06	1.93±1.65	0.000
PO4, mg/kg	0.21	0.18±0.09	0.14±0.06	0.08	0.16±0.02	0.782
NO3 mg/kg	1.6	1.05±0.23	1.5±0.26	1.6	1.27±0.31	0.800
NH4 mg/kg	0.74	0.49±0.12	0.7±0.12	0.74	0.6±0.13	1.000
Sand, %	0	0	0	0	0	
Silt%	5.23	4.57±0.43	5.08±0.59	4.67	5.00±0.06	0.900
Clay%	94.71	95.345±0.42	94.83±0.62	95.25	94.90±0.02	1.000
O & G mg/kg	<0.001 <sup>c</sup>	16.5±29.13 <sup>a</sup>	8±3.46 <sup>b</sup>	6 <sup>b</sup>	18±20.78 <sup>a</sup>	0.000
ALIPH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
TPH mg/kg	<0.001	12±24	2±3.46	<0.001	10±17.32	0.000
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.4	1.24±0.08	1.002±0.12	0.533	0.90±0.04	0.922
Fe mg/kg	13471	12877.75±797.61	13255±1168.39	14040	13657±457.47	0.842
Pb mg/kg	31.517	31.26±5.93	26.38±13.47	13.591	22.67±4.39	0.714
Cu mg/kg	4.311	15.05±8.15	9.12±6.75	12.561	10.81±0.94	0.000
Cr mg/kg	59.36	24.45±4.29	17.94±5.34	26.07	30.59±19.81	0.031
Zn mg/kg	36.59	45.57±10.93	39.47±12.92	30.68	57.15±14.16	0.510
Cd mg/kg	3.821	3.25±2.95	5.02±3.026	6.64	4.17±2.18	0.819
Ba mg/kg	12	12.5±2.64	8.66±1.52	8	13.67±2.52	0.850
Co mg/kg	28.949	34.2125±18.86	17.947±9.09	11.142	16.52±13.44	0.050
Ag mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
V mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	
K mg/kg	443	468.75±16.19	455±18.08	449	443.33±13.43	0.923

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<b>Parameters</b>	<b>200m</b>	<b>500m</b>	<b>800m</b>	<b>1200m</b>	<b>Control</b>	<b>P value</b>
	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	<b>(Mean ± SD)</b>	
Na mg/kg	11511	11439.5±75.21	12436±1775.42	11422	11456±23.30	0.814
Mg mg/kg	1459	1438.5±13.02	1454±28.82	1473	1450.66±21.03	0.800
Ca mg/kg	542	539.25±16.04	542.33±13.05	524	556.33±13.20	0.996
HUF cfu/g	0.10	NIL	NIL	NIL	0	
HUB cfu/g	0.20	NIL	NIL	NIL	0	
THB x10 <sup>2</sup> cfu/g	1.02	1.62±4.3	1.27±2.3	2.01	1.24±1.2	0.283
TFx10 <sup>1</sup> cfu/g	5.3	6.5±2.9	5.8±1.9	5.70	5.6±1.9	0.991
SRB cfu/g	NA	NA	NA	NA	0	

P<0.05 – Significant; p>0.05 – Not significant

**EA - DPD**

Table 4.4h shows the summary results of physicochemical measurements in sediments at different receptor distances of 500m to 1200m from the DPD and the control locations. Detailed results are presented in **Appendix 2**.

***Physico-chemistry***

The sediment pH which regulates biogeochemical activities in the underlying water was within the near neutral ranges and ranged from the 500m ( $7.38\pm 0.13$ ) to the 1200m ( $7.422\pm 0.09$ ) receptor locations. According to Ponnampertuma (1972) intense reduction in submerged sediments tend to buffer sediments close to pH 7.0. There were no discernable patterns with regards to distance from the DPD, however the pH compared favorably ( $p=1.000$ ) with the control locations. Similarly, the Redox potential, an indicator of the degree of oxidation of sediments showed a moderately reduced condition in the. Submerged sediments usually display a range of redox potentials from +700 mV, which indicates highly oxidized sediment, to -300 mV, which indicates highly reduced sediment (DeLaune et al., 1976). The redox potentials ranged from  $-22.8\pm 7.18$  mV at the 500m receptor location to  $-25.6\pm 6.93$  mV at the 1200m receptor location. The Eh levels were not significantly different ( $p=0.898$ ) from the control location ( $-25.77\pm 9.87$  mV) and across the receptor distances (500m to 1200m) from the DPD. The Redox potential values around the DPD were within ranges for estuarine bottom sediments of coastal waters within the Niger delta area (NDES, 2008). The chloride level suggests an estuarine ecosystem with values ranging from  $15990.25\pm 977.29$  mg/kg around the 500m receptor distances to  $16327\pm 1408.71$  mg/kg at the 1200m distance from the DPD. The levels of chloride were observed to increase with distance which may be attributed to natural variation in the interstitial waters. No significant variation ( $p=0.940$ ) was observed when compared with the control stations ( $17653.33\pm 1298.97$  mg/kg).

***Organic Load***

The TOC levels ranged from  $0.375\pm 0.51\%$  at 500m to  $0.782\pm 0.33\%$  at 1200m receptor distance. There was no significant variation ( $p=0.832$ ) when compared to the control locations ( $1.93\pm 1.65\%$ ). The TOC levels were within the low ranges (0 to 1%) across the receptor locations including the control location suggesting absence of organic pollution. TOC was not related to the textural class of sediments which was generally dominated by clay (>94%) ( $p=1.000$ ) across the receptor distances corroborates with the levels of TOC.

***Nutrients***

Nitrate and phosphate are major nutrients for bacterial mineralization of organic matter in sediments. The nitrate and phosphate concentration ranged from  $0.85\pm 0.19$  to  $1.14\pm 0.27$  mg/kg and  $0.1925\pm 0.08$  to  $0.212\pm 0.07$  mg/kg at the 500m and 1200m receptor distances from the DPD compared to the control locations ( $1.27\pm 0.31$  mg/kg,  $0.16\pm 0.02$  mg/kg). There was no significant difference in concentrations between the receptor distances and the control stations (Nitrate,  $p=0.742$ ; Phosphate,  $p=0.788$ ). 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.

#### ***Exchangeable cations***

The mean concentration of exchangeable cations, K, Na, Mg and Ca in the bottom sediments ranged from 446.75±11.11 to 444.4±16.08 mg/kg; 11430.75±76.5 to 11445.4±47.58 mg/kg; 1470.25±9.63 to 1470.8±46.61 mg/kg and 552.5±20.07 to 554.6±20.23 mg/kg at the 500m to the 1200m receptor distances in the direction of the bottom current. The exchangeable cations were within normal ranges for near neutral pH sediments and compared favourably (Potassium (p=1.000), Sodium (p=0.949), Magnesium (p=0.914) and Calcium (p=0.900) ) with the control locations (K, 443.33±13.43 mg/kg; Na, 11456±23.30 mg/kg; Mg, 1450.66±21.03 mg/kg and Ca, 556.33±13.20 mg/kg). The concentration of cations was within limits of stability of organic matter in sediments (Adeline *et al*, 2010).

#### ***Heavy metals***

The heavy metal concentrations in the sediment were within normal ranges for a brown field and compared favorably with concentrations around the control location. Nickel (p=0.878), Fe (p=0.711), Pb (p=0.505), Cu (p=0.871), Cr (p=0.704), Zn (p=0.609), Cd (p=0.771), Ba (p=0.800) and Co (p=0.518) ranged from 1.37±0.58 to 1.21±0.17 mg/kg, 12050±868.15 to 11646.2±3545.28 mg/kg, 18.10±11.14 to 26.35±10.84 mg/kg, 3.80±4.89 to 6.06±5.08 mg/kg, 23.55±12.10 to 38.35±25.04 mg/kg, 38.67±6.15 to 41.34±12.64 mg/kg, 1.97±1.52 to 6.16±3.65 mg/kg, 12.25±2.629 to 13.4±2.07 mg/kg and 14.92±14.74 to 33.24±11.49 mg/kg at the 500m and 1200m receptor distances respectively. Silver and Vanadium were not detected (<0.001 mg/kg) in the bottom sediments across the receptor distances including the control locations.

#### ***Hydrocarbons***

The PAH, and BTEX concentration (p<0.001 mg/kg) were not detected in the bottom sediments across the receptor location including the control locations. The absence of BTEX and PAH are indicators of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area. The concentration of Oil and grease (p=0.808) and TPH (p=0.515) were generally similar to the control stations across the receptor locations, although relatively elevated levels were observed around the control locations.

#### ***Microbiology***

The summary of the microbial load of the sediment is presented in Table 4.4h. The THB and TF were in the order of 10<sup>2</sup> and 10<sup>1</sup> cfu/g and ranged from 1.78±4.1x10<sup>2</sup> to 1.62±4.4x10<sup>2</sup> cfu/g and 5.7±2.72x10<sup>1</sup> to 4.8±1.4x10<sup>1</sup> cfu/g at the 500m and 1200m receptor distances. The THB and TF microbial load 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 stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms

corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were not identified across the receptor distances from 500m to 1200m including the control station and indicate unlikelihood of biogenic hydrogen sulphide corrosion (Neria-Gonzalez *et al.*, 2006) and crude souring (Hubert and Voordouw., 2007) during the operation phase of the project.

Table 4.4h: Summary results of physicochemical measurements in sediment EA-DPD compared to control

Parameters	500m	800m	1200m	Control	P value
	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)	
pH	7.38±0.13	7.51±0.08	7.422±0.09	7.44±0.18	1.000
TEMP, °C	8.67±0.52	8.7±0.70	8.7±0.39	8.63±0.67	1.000
Redox, mV	-22.8±7.18	-31±6.78	-25.6±6.93	-25.77±9.87	0.898
Cl, mg/kg	15990.25±977.29	16055±1012.57	16327±1408.71	17653.33±1298.97	0.940
TOC, %	0.375±0.51	0.495±0.06	0.782±0.33	1.93±1.65	0.832
PO <sub>4</sub> , mg/kg	0.1925±0.08	0.17±0.02	0.212±0.07	0.16±0.02	0.788
NO <sub>3</sub> mg/kg	0.85±0.19	0.85±0.35	1.14±0.27	1.27±0.31	0.742
NH <sub>4</sub> mg/kg	0.3975±0.08	0.395±0.162	0.532±0.12	0.6±0.13	0.811
Sand, %	0	0	0	0	
Silt%	4.98±0.24	5.03±0.26	4.964±0.70	5.00±0.06	0.900
Clay%	94.79±0.55	94.93±0.32	94.654±0.58	94.90±0.02	1.000
O & G mg/kg	10.5±9	9±4.24	13.2±23.00	18±20.784	0.808
ALIPH mg/kg	0.7±0.42	<0.001	<0.001	<0.001	
TPH mg/kg	4.5±5.74	3±4.24	8.4±18.78	10±17.32	0.515
PAH mg/kg	<0.001	<0.001	<0.001	<0.001	
BTEX mg/kg	<0.001	<0.001	<0.001	<0.001	
Ni mg/kg	1.37±0.58	1.25±0.27	1.21±0.17	0.90±0.04	0.878
Fe mg/kg	12050±868.15	13211.5±351.43	11646.2±3545.28	13657±457.47	0.711
Pb mg/kg	18.10±11.14	17.81±10.37	26.35±10.84	22.67±4.39	0.505
Cu mg/kg	3.80±4.89	12.62±5.23	6.06±5.08	10.81±0.94	0.871
Cr mg/kg	23.55±12.10	19.90±10.66	38.35±25.04	30.59±19.81	0.704
Zn mg/kg	38.67±6.15	57.52±13.61	41.34±12.64	57.15±14.16	0.609
Cd mg/kg	1.97±1.52	4.55±1.46	6.16±3.65	4.17±2.18	0.771
Ba mg/kg	12.25±2.629	15±2.82	13.4±2.07	13.67±2.52	0.800
Co mg/kg	14.92±14.74	26.089±2.75	33.24±11.49	16.52±13.44	0.518
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	446.75±11.11	475±11.31	444.4±16.08	443.33±13.43	1.000
Na mg/kg	11430.75±76.5	11452.5±7.77	11445.4±47.58	11456±23.30	0.949
Mg mg/kg	1470.25±9.63	1426.5±3.53	1470.8±46.61	1450.66±21.03	0.914
Ca mg/kg	552.5±20.07	566.5±6.36	554.6±20.23	556.33±13.20	0.900
HUF cfu/g	NIL	NIL	NIL	0	
HUB cfu/g	NIL	NIL	NIL	0	
THB x10 <sup>2</sup> cfu/g	1.78±4.1	1.05±4.9	1.62±4.4	1.24±1.2	0.844
TFx101 cfu/g	5.7±2.72	6.1±1.44	4.8±1.4	5.6±2.1	0.900
SRB cfu/g	NIL	NIL	NIL	0	

### **SEDIMENT TRENDING**

The possible impact of the existing facilities on sediment quality was assessed by comparing average values of results obtained during the Sea Eagle EIA (2001), FOD-EIA (2011), and EE study (2015) as well as EIA 2018 (**Table 4.4i**). From the multiple comparisons the present study showed significant changes in levels of pH, Redox, nitrate, phosphate, arsenic, barium, manganese, copper, vanadium cobalt, mercury, cadmium and TPH. Appart from reduction observed in Redox, measurements in 2018 were characterized by increases in iron, copper, zinc, chromium, cobalt and cadmium. Although some parameters measured at the FPSO showed a decreasing trend with distance from the facility, the apparent increases observed in this trending may be attributed to both crude oil related operations and other marine and land-based inputs of contaminants. Waste management practices particularly in municipal areas of Nigeria are still very basic with most of the wastes reaching the marine environment untreated. There is also a long history of shipping operations in Nigerian waters with highly unregulated waste management practices which may contribute to the observed trend.

**Sediment Texture:** The sediment texture showed a significant modification towards clayey from silty clay a possible result of impact of coastal forest degradation and ensueing erosional transport of materials to the ocean and well as impacts of discharges from drilling activities and facility operations.

**Redox Potential:** Within the limits of available data for comparisons, redox potentials showed a decreasing trend from oxidizing conditions in 2001 to moderately reducing conditions in 2015 and 2018 which may be associated with changes in sediment texture due to increasing input of clay materials rich in organics possible from land-based and riverine sources as well as drilling operations.

**Heavy metals:** A number of heavy metals including arsenic, barium, copper, cadmium, vanadium, cobalt and mercury showed increasing trends while iron, zinc and chromium, showed decreasing trends. The increasing trends in most heavy metals may be linked to increasing non-point and point discharges of municipal wastes into coastal waters as well as discharges linked to shipping and oil and gas operations.

**Nutrients:** Decreasing trends were recorded in concentrations of nitrate and phosphate which also coincides with the decreasing trends in levels of essential trace metals like iron and zinc and may point to increased biological uptake including microbial assimilation during degradation of organics in sediments. The increasingly reducing conditions of sediments may also be a contributory factor because negative redox potentials are associated with the mobilization of these nutrients from sediments to the overlying waters.

**Hydrocarbons:** TPH showed an increasing trend with the highest level in 2018 which could be attributed to various sources of inputs including land-based, shipping and oil and gas operations.

Table 4.4i: Sediment quality trending for the period 2001 to 2018 around the EA-FOD

Parameter	Sea Eagle EIA (2001)	Sea Eagle EIA (2011)	EDP-EAGLE FPSO (2015)	2018
pH	7.4	7.47	8.42	7.36-7.69
Temperature (oC)		26.82	17.76	8.17-9
Redox (mV)	230		-82.3	-39.38- -26.63
Nitrate (mg/kg)		110.75	2.69	1.03-1.16
Phosphate (mg/kg)		141.54	5.23	0.16-0.27
Arsenic (mg/kg)		<0.001	0.8	
Barium (mg/kg)		<0.001	123.7	7-10.75
Lead (mg/kg)	<1	31.49	13.37	14.17-28.75
Iron (mg/kg)	17200	1212.15	5680	10344-14033
Manganese (mg/kg)	147		564	
Copper (mg/kg)	6.53	10.91	14.09	8.98-16.49
Zinc (mg/kg)	49.5	45.87	30.41	34.36-56.4
Chromium (mg/kg)	21	18.45	5.46	14.45-44.33
Nickel (mg/kg)	11.5	19.96	14.06	1.19-3.34
Vanadium (mg/kg)		<0.001	12.4	<0.001
Cobalt (mg/kg)		0.067	7.48	32.15-60.34
Mercury (mg/kg)		<0.001	0.04	
Cadmium	0.05	2.71	5.31	1.18-6.61
TPH (mg/kg)		1.45	4.76	0-12
Colour				Grey
CL APHA 2510A mg/kg			11208.39	16559.92
TOC APHA 5310 %			0.10	2.41
NH <sub>4</sub> APHA 4500 mg/kg				0.71-1.80
PARTICLE SIZE ASTM P 2487 – 92	Sand %		<10	-
	Silt %		30	4.82
	Clay %		65	94.98
O & G ASTM D 3921 mg/kg			8.32	4-20.4
ALIPH ASTM D 3921 mg/kg				<0.001-2.4
PAH ASTM D4657 mg/kg			<0.001	<0.001
BTEX ASTM D2600 mg/kg			<0.001	<0.001
	Increasing trend			Decreasing trend



**4.2.5: Aquatic Biology**

***Phytoplankton***

The check-list of the phytoplankton families and species within the OML 79 field is presented in Appendix 3a. A total of 44 phytoplankton species from 4 major families were enumerated during the study. The Bacillariophyceae (Diatoms) had the highest number of species (high species richness), with 21 species. This was followed by the Dinophyceae (Dinoflagellates) with 9 species and Chlorophyceae and Cyanophyceae with 7 species each. All species and families of the phytoplankton encountered are normal for unpolluted marine community. Forty-four (44) phytoplankton species were present at all the control stations during the survey. Results of the Multivariate analyses, indicated that all the sampling sites were linked together at 65% similarity, implying high similarity in the species composition and abundance at the various sampling points including the controls. Table 4.5a shows the relative abundance of the major phytoplankton groups enumerated during the study. The order of dominance was Bacillariophyceae>Chlorophyceae>Cyanophyceae>Dinophyceae

Table 4.5a: Relative abundance of the major phytoplankton families within the OML 79 Field during the study

<b>Major phytoplankton Families</b>	<b>Density (cells/l)</b>	<b>Relative Abundance (%)</b>
Bacillariophyceae (Diatoms)	19,592	49.95
Chlorophyceae (Green algae)	6,003	15.30
Cyanophyceae (Blue-green algae)	6,179	15.75
Dinophyceae (Dinoflagellates)	7,453	19.00
<b>Total abundance (N)</b>	<b>39,227</b>	<b>100.0</b>

**Ecological index values of the phytoplankton**

Table 4.5b presents the ecological indices of phytoplankton in the field. The number of phytoplankton species ranged from 32 (station EA62) to 44 (all control stations). Margalef’s index varied between 5.37 (EA20) and 7.05 (EA36), while Shannon-Wiener index (H) ranged between 2.30 (EA46) and 2.65 (EA CTL 2) and Pielou’s Evenness ranged between 0.010 (EA43) – 0.121(EA9).

Table 4.5b: Ecological indices of phytoplankton within the OML 79 Field during the study

S/N	Parameter (Index)	Mean	Range
1	Number of species (S)	38	32 – 44
2	Number of individuals (N)	980.75	6,003 – 19,592
3	Shannon-Wiener Index (H)	2.48	2.30 – 2.65
4	Margalef’s Index (d)	6.21	5.37 – 7.05
5	Pielou’s Evenness Index (E)	0.07	0.010 – 0.121

Considering the ecological index values of 5.37 – 7.05 with a mean of 6.21 for Margalef’s Index (d), 2.30 – 2.65 with a mean of 2.48 for Shannon-Wiener Index (H) and 0.01 – 0.121 with a mean of 0.07 for Pielou’s Evenness Index (E). We could draw an ecological inference on the pollution status of the OML 79 Field. Generally, Margalef’s Index values ranging between 1 and 3, indicate moderately polluted environment, while values greater than 3

indicate clean environment and values less than 1 are known to characterize heavily polluted conditions (Ali et al, 2003; Mason, 1998; Salam *et al*, 2005).

The Shannon index increases as both the richness and the evenness of the community increase. Typical values are generally between 1.5 and 3.5 in most ecological studies, and the index is rarely greater than 4. In Shannon Wiener legislation, the aquatic environment (soil/water) is classified as – very good when  $H'$  is  $> 4$ , good quality 4- 3, moderate quality 3- 2, poor quality 2-1 and very poor quality  $<1$ . A community becomes more dissimilar as the stress increases and accordingly species diversity decreases with poor water quality. A community dominated by relatively few species indicates environmental stress (Plafkin *et al.*, 1989). The value of 2.3 to 2.65 obtained during the study represents a system with moderate quality or moderately stressed environment (low pollution level).

The high abundance of the Diatoms in the phytoplankton of the OML 79 Field, again, strongly supports the ecological stable nature and balanced primary productivity of the OML 79 Field as is apparent from the Pielou's Index values of between 0.010 – 0.121 with a mean of 0.07. Low values of the index are indications of even distribution of species within a given ecosystem.

#### ***Phytoplankton trends***

**Table 4.5c** compares the Phytoplankton Indices from 2001 to 2018. The indices considered for trending were the number species, the population density, the taxonomic dominance pattern and the dominant taxon. An increasing trend was observed in the phytoplankton species number from 19 species in 2001 to over 80 species in 2011 and 2015 while a marked decrease was observed in 2018 (max 44 species). In contrast, an over six fold increase occurred in the density of phytoplankton in 2018 compared to 2015. A decrease in phytoplankton diversity with concomitant increase in density shows a tendency towards eutrophic conditions. Irrespective of the year of study, Bacillariophyceae (Diatoms) remained the most dominant phytoplankton around Sea Eagle FPSO showing the high stability in the system with minimal environmental stress. Diatoms are widely reported as the most abundant and dominant phytoplankton taxa in unpolluted tropical coastal waters.

Table 4.5c: Trending of phytoplankton data in the study area (2001 to 2018)

Parameter	2001 EIA	EER 1011 WET	EER 2011 DRY	EER 2015	EIA 2018
No. of Species of Phytoplankton	19	65 – 84	79 – 107	75 – 83	32-44
Total Phytoplankton Count /ml (x1000/l)	-	2179 - 3351	2302 - 3768	1626 - 3315	6,003-19,592
Major Divisions/Dominance Pattern	Bacillariophyta >Dinophyceae >Cyanophyta	Bacillariophyta > Cyanophyta > Chlorophyta > Dinophyta >Euglenophyta	Bacillariophyta > Cyanophyta > Chlorophyta > Dinophyta > uglephyta	Bacillariophyta > Cyanophyta > Chlorophyta > Dinophyta > uglephyta	Bacillariophyta >Chlorophyta >Cyanophyta >Dinophyta
Dominant Division	Diatoms Bacillariophyta	Bacillariophyta	Bacillariophyta	Bacillariophyta	Bacillariophyta
	Increasing trend			Decreasing trend	

#### **Primary Productivity (as Chlorophyll-a)**

Concentrations of chlorophyll-*a* (algal biomass) is normally used as an index of the productivity (Yao *et al.*, 2010; Rahaman *et al.*, 2013) and trophic condition of aquatic ecosystem (Steele, 1962; Cullen, 1982; Boyer *et al.*, 2008; Rahaman *et al.*, 2013). It reflects the net result (standing stock) of both growth and loss process (Rahaman *et al.*, 2013). There is always a good general agreement between planktonic primary production and algal biomass (Job *et al.*, 2011; Rahaman *et al.*, 2013). Algal biomass is associated with the visible symptoms of eutrophication and is considered the principal variable to use as a trophic state indicator (Rahaman *et al.*, 2013; Ekanem *et al.*, 2018).

Table 4.6d shows the summary results chlorophyll-*a* measurements from both the control and study stations averaged over the study area.

 Table 4.5d: Chlorophyll-*a* concentration ( $\mu\text{g/l}$ ) within the OML 79 Field

Samples category	Study area samples ( $\mu\text{g/l}$ )	Control area samples ( $\mu\text{g/l}$ )
First sample	455.84	528.92
Second sample	402.11	573.41
Third sample	438.43	566.38
Mean $\mu\text{g/l}$	432.13	556.23

The control stations showed significantly ( $P < 0.05$ ) higher concentrations of chlorophyll-*a* ranging between 528.92 and 573.41  $\mu\text{g/l}$  with an average value of 556.23  $\mu\text{g/l}$  than the study area with a range of between 438.11-455.84  $\mu\text{g/l}$  and a mean of 432.13  $\mu\text{g/l}$ . The high

chlorophyll-*a* concentrations recorded within the OML 79 Field corroborates the high phytoplankton density observed in the area. The higher concentration of Chlorophyll-*a* in the control area samples compared to the study area indicates a possible subtle environmental stress related to coastal discharges of nutrients. Raymondt, (1980), Cullen (1982) and Rahawan, *et al.*, (2013) are respectively of the view that primary productivity of any two locations in a particular habitat or environment may be influenced by the degree and variability of human activities interplayed with the prevailing meteorological and hydrological characteristics within the different area. Generally, in an open tropical stable and unpolluted marine environment, Chlorophyll-*a* concentration ranging between 110 and 370  $\mu\text{g l}^{-1}$  has been considered good for fish production and fish yield (Cullen, 1982; Mann, 2000; Castro & Huber, 2005; Yao *et al.*, 2010). Higher values of Chlorophyll-*a* were obtained in this study showing the high productivity of the waters of the OML 79 Field. Similar ranges of chlorophyll-*a* concentration have been reported in other unpolluted oceans (Raymondt, 1980, Jeffrey, 1974), the Cross River Estuary of Nigeria (Akpan, 1993) and the Nile (Talling and Rzosuka, 1967).

**Zooplankton**

A total of 62 species of permanent zooplankton (Holoplankton) and meroplankton at different developmental stages from 8 major zooplankton groups, were enumerated in the water column of the OML 79 Field. The Copepod crustacean was composed of 10 species, Decapod crustacean 4 species and Cladocera 8 species. Others were Pisces (Chordata) larvae (8species), Appendiculata (6 species), Polychaeta larvae (8 species), Rotifera (7 species), Chaetognatha (Arrow worms) (5 species) and Mollusca (Gastropod/Bivalve) larvae (6 species). In terms of species richness, the Copepod crustacean were the most diverse (10) species, with the least diverse being the decapods crustacean. The zooplankton was dominated by Crustaceans made up of copepods, decapods and cladocera.

**Abundance of the major zooplankton groups**


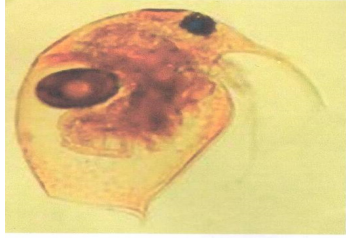

Appendix 3b presents the detailed results of zooplankton studies from the OML 79 Field. Summary results are presented in Table 4.6a which shows the abundance (numerical and relative) of the major zooplankton while Table 4.6b shows the associated ecological indices.

**Table 4.6a: Relative abundance of the major zooplankton groups within the OML 79 Field during the study (October/November 2018)**

S/N	Major zooplankton groups	Number of individuals (Cells/l)	Relative abundance (%)
1.	Crustacea (Copepods)	7044	26.40
2.	Crustacean (Decopods)	1597	5.99
3.	Cladocera	3672	13.76

4.	Rotifera	2833	10.69
5.	Chaetognatha (Arrow worms)	1112	4.17
6.	Mollusca (Gashopods/Bivalves) Larvae.	1293	4.85
7.	Pices (Chordata) Larvae	3668	13.75
8.	Appendicular	2453	9.19
9.	Polychaete (Annelids) Larvae	2988	11.20
	Overall abundance (N)	26,680	100.0

The crustacean copepods comprised 7044 individuals making up 26.40% of the total zooplankton population in the area. The crustacean decapods comprised 1597 (5.99%), cladocerans 3672 individuals (13.76%), rotifers, 2853 (10.69%), chaetognatha, 1112 individuals (4.17%), mollusca 1293 individuals (4.85%), pices, 3668 individuals (13.75%), appendiculate, 2453 individuals (9.19%) and polychaetes, 2988 individuals (11.20%). The order of dominance was represented by Crustacean copepods > Cladocera > Pices Larvae/fish eggs > Polychaete larvae > Rotifera > Appendicular > Crustacean decapods > Mollusca Larvae > Chaetognatha. The crustacean copepods were generally the most diverse and abundant in the area, an indication of clean and unpolluted environment. Common zooplankton groups encountered within OML 79 Field are presented below.

		
<b>Fish egg</b>	<i>Oithonahal gollandica</i>	<i>Microsetella norvegica</i>

The presence of fish eggs in the zooplankton of the area is a signal of fish production capacity of the area with corresponding significant numbers of fish larvae recorded in the zooplankton.

Table 4.6b: Ecological indices of zooplankton within the OML 79 Field during the study

S/N	Parameter (Index)	Mean	Range
1	Number of species (S)	4.44	18 – 22
2	Number of individuals (N)	2,964.44	1112 – 7044
3	Shannon-Wiener Index (H)	1.84	0.93 – 2.74
4	Margalef's Index (d)	4.47	2.60 – 6.34
5	Pielov's Evenness Index (E)	0.16	0.12 – 0.20

The high abundance and diversity of copepod crustaceans in the water column of the OML 79 Field as evident in the Marglaef's index, is an indication of clean environment. Considering the ecological indices values of 2.60 – 6.34 with a mean of 4.47 for Margalef's Index (d), 0.93 – 2.74 with a mean of 1.84 for Shannon-Wiener Index (H) and 0.12 – 0.20 with a mean of 0.16 for Pielou's Evenness Index (E) the ecological status of the OML 79 Field may be said to vary between clean and moderately polluted.

Margalef's Index values ranging between 1 and 3, indicate moderately polluted environment, while values greater than 3 indicate clean environment and values less than 1 are known to characterize heavily polluted conditions (Ali et al, 2003); Mason, 1998; Salam *et al*, 2005). In Shannon Wiener legislation, the aquatic environment (soil/water) is classified as – very good when H' is > 4, good quality 4- 3, moderate quality 3-2, poor quality 2-1 and very poor quality <1. A community becomes more dissimilar as the stress increases and accordingly species diversity decreases with poor water quality. A community dominated by relatively few species indicates environmental stress (Plafkin *et al.*, 1989). The value of 2.3 to 2.65 obtained during the study represents a system with moderate quality or moderately stressed environment (low pollution level).

### ***Zooplankton Trend***

Zooplankton trending in the area was carried out using data from 2001 to 2018 (Table 4.6c). Trending parameters were total count of zooplankton, number of major taxa, total number of species, major taxa and dominant taxon. Zooplankton species and density recorded marked increasing trend from 2001 to 2015. While species diversity decreased in 2018, zooplankton density increased almost ten-fold in 2018 compared to 2015. Decreasing diversity combined with increasing density of organisms usually point to a stressed system. The presence of polychaetes in the plankton of 2018 is also a pointer to the subtle pollution of the system as polychaetes are usually associated with polluted/organically enriched environments. Generally, Copepoda dominated the zooplankton community during all studies, reflecting the typical community structure in the tropical oceans and showing the relative stability in the area.

Table 4.6c: Comparing Zooplankton in the present study and previous (2001 and 2011) EIA reports

Parameter	EIA report	EIA 2011		EER/EES 2015	2018
Parameter		Wet Season	Dry Season		
No. of species	10 - 15	19 - 33	19 - 32	23 - 40	18 – 22
Total count	16 - 31	142 - 538	241 - 523	176 - 807	1112 – 7044
Major Families	-	Crustaceans (copepods and decapods, Cladocera, Euphausicea), rotifers, the larvae of molluscs and Pisces.	Crustaceans (copepods and decapods, Cladocera, Euphausicea), rotifers, the larvae of molluscs and Pisces.	Rotifers, cladocera, molluscan larvae, decapod and copepod crustaceans, euphausiacea and pisces	Crustacean (Copepods, decapods, Cladocera), rotifers, chaetognatha, Mollusca, pieces Appendiculata and polychaeta,
Dominant Division	Copepods	Copepods	Copepods	Copepods	Copepods
	Increasing		Decreasing trend		

### ***Benthic fauna***

A total of 23,509 macrobenthos comprising 37 taxa from the 9 major groups during the study (Appendix 3c). Gastropod Molluscs were the most abundant with 10,650 individuals forming 45.32% of the macrobenthos during the survey. This was followed by Bivalve Molluscs with 5,358 individuals making 22.80% of the population. The third most abundant macrobenthos were the Bryozoans with 2673 individuals making 11.37% of the population followed by Echinodermata with 2386 individuals forming 10.15% of the macrobenthos. Others in order of abundance were the Scaphopoda with 2045 individuals (8.70%), Polychaeta (Annelids) with 187 (0.80%), Sponges with 87 individuals (0.37%), Crustacea, 58 individuals (0.25%) and chordates with 57 individuals comprising 0.24% of the total population of the macrobenthos in the area. The general pattern of distribution by number of individuals and relative abundance was in the following order: Gastropod molluscs> Bivalve Molluscs> Bryozoans> Echinodermata> Scaphopoda> Polychaeta (Annelids) > Sponges> Crustacea> Chordata (Fig. 4.2)

All species reported are normal residents of unpolluted marine environment. The only species of the Scaphopoda (*Dentalium vulgare*) was observed at all the stations within the Field. This

is also a non pollution indicator species. In term of species richness, the Gastropod molluscs were the most diverse with 4 species, although the 4<sup>th</sup> species (*Lanthina fragilis*), was rare occurring only at 4 stations (EA88, EA94, EA80 and EA4).

The most widely reported bio-indicator macrobenthic group, the Polychaeta- were generally scanty within the field. Polychaetes are known to thrive well in oil polluted or organically enriched environment. The scanty occurrence of polychaetes as compared with the mollusc particularly the Scaphopods (*Dentilium vulgare*) is an indication of the ecological stability of the OML 79 Field.

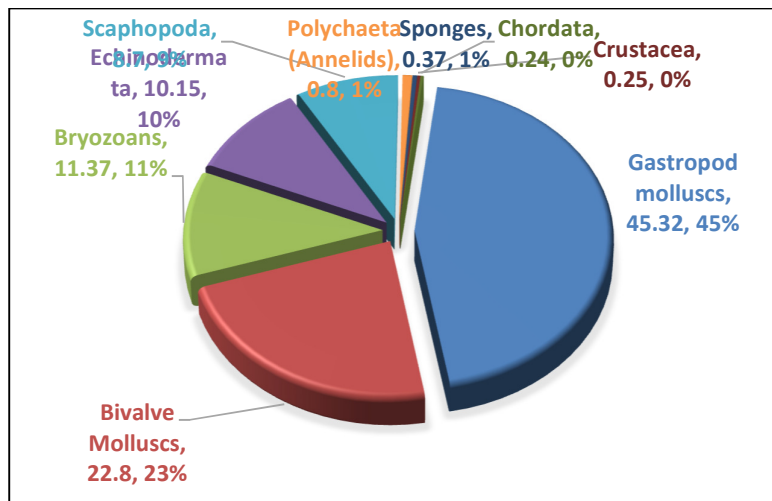





Figure 4.2: Relative abundance of macrobenthos in the OML 79 field during the study

The commonly occurring species of macrobenthos within OML 79 Field are presented below:

		
<i>Clibanarius Africana</i> (Crustacea)	<i>Syllisrolifera</i> sp. (Crustacea)	<i>Ophelia</i> sp (Polychaeta)
		
<i>Erichelycore nigricans</i>	<i>Sabella meranostigma</i>	<i>Amoria zebra</i> (molluca)



(Chordata)	(Polychaeta)	
		
<i>Palices</i> sp Mollusca: (Gastropod)	<i>Asterias rubbens</i> (Echinodermata)	<i>Dentalium vulgare</i> (scaphopoda)

### ***Benthic fauna trends***

**Table 4.7** shows the trending of benthos data within Sea Eagle FPSO. Data for the trending were obtained from studies from 2001 to 2018. Parameters for trending included total number of species, density, major taxa and dominant taxon. A marked increasing trend was recorded in benthos density and species number from 2001 to 2011 with a reduction in 2015 followed by increase in 2018 with the benthos density increasing by over 20-fold. Such variation may be linked to sediment quality and overlying water hydrodynamics. The stability of the area over the years is apparent from the dominance of the benthos by Molluscs. The occurrence of Polychaetes from 2001 is a further support to the stability of the ecosystem. The Table shows the number of species of benthos has declined from 16 – 34 in 2011 to 12 – 20 in 2015 (present study). Similarly, the total number of benthos has also declined over the time frame.

Table 4.7: Benthic fauna trends (2001 to 2018)

Parameter	EIA report 2001	EIA 2011		EER 2015	2018
		Wet Season	Dry Season		
No. of Major groups	6	9	9	6	9
No. of species	23	16-32	21-34	12 - 20	21-28
Total count	1,973	2544	2771	626	23509
Major Families	Porifers, Coelenterates, Annelids, Molluscs and Pisces.	Sponges, Holothuroidea, Polychaetes, Echinoderms, Molluscs (Gastropods, Bivalves), Athropods, Coelenterates, and	Sponges, Holothuroidea, Polychaetes, Echinoderms, molluscs (Gastropods, Bivalves), Arthropods, Coelenterates, and	Polychaetes Crustaceans Bivalve Gastropods Insects (Arthropods) Pisces	Molluscs (Gastropods, Bivalves), Bryozoans, Echinoderms, Scaphopods, Polychaetes (Annelids), Sponges, Crustaceans
Dominant Division	Molluscs	Molluscs	Molluscs	Molluscs	Molluscs
	Increasing trend			Decreasing trend	

### ***Fish And Fisheries***

A checklist of the fish species that were sighted in the catch of artisanal fishers and fish mongers during the survey are listed in Table 4.9a. Thirteen (13) species of fish were identified belonging to 11 families. Available literature also shows that four (4) more species can also be found in the locality (Schneider, 1990).

Table 4,8a: Fish composition in catch of artisanal fishers in EA/EJA field OML 79

<b>FAMILY</b>	<b>SPECIES</b>	<b>COMMON NAME</b>	<b>Sighted during Field work</b>	<b>Literature</b>
ARIDAE	<i>Arius gigas, A. heudeloti</i>	Sea Catfish	√	√
CARANGIDAE	<i>Trachinotus sp., Caranx africanus, C. hippos.</i>	Jack Fish		√
CLUPEIDAE	<i>Ethmalosa fimbriata</i>	Bonga fish	√√	
	<i>Ilisha africana,</i>	Shad	√√√	
	<i>Sardinella</i>	Sardines		
	<i>Pellonula spp.</i>			
CYNOGLOSSIADAE	<i>Cynoglossus monodi</i>	Sole	√	√
DASYATIDAE	<i>Dasyatis sp.</i>	Ray		√
HAEMULIDAE	<i>Pomadasys jubelini</i>	Grunts	√	√
LUTJANIDAE	<i>Lutjanus dentatus</i>	Snapper		
MUGILIDAE	<i>Liza sp., Mugil sp.</i>	Mulletts		
MURAENIDAE	<i>Muraena sp.</i>		√	√
SCIAENIDAE	<i>Pseudotolithus sp.</i>	Croaker	√	
POLYNEMIDAE	<i>Polydactylus quadrifilis</i>	Shiny nose	√	√
SCROMBRIDAE	<i>Thunus sp., Scomber japonic</i>	Mackerel		√
SERANIDAE	<i>Anthias anthias; Ephinephelus</i>	Grouper	√	
SOLEIDAE	<i>Pegusa sp., Dicologlossa sp.</i>			
SPARIDAE	<i>Dentex angolensis; Diplodus sp.</i>	Breams	√	√
	<i>Oblada; Pagellus sp., Pagrus sp.</i>		√	
SPHYRAENIDAE	<i>Sphyraena barracuda</i>	Barracuda		√
	<i>S. guachancho; S. sphyraena</i>			√
TRICHIURIDAE	<i>Trichiorus lepturus</i>	Silver Fish		
DASYATIDAE	<i>Dasyatis sp.</i>	Ray		
Penaeidae	<i>Penaeus notialis</i>	Southern Pink Shrimp		√
	<i>Parapenaeopsis atlantica</i>		√	√
Palaemonidae	<i>Nematopalaemon hastatus</i>	Estuarine prawn	√	

**Note:** √Recorded

### ***Fish Abundance/Density***

Clupeid fishes namely *Pseudotolithus elongates*, *Ethmalosa fimbriata*, *Ilisha africana*, *Sardinella* and *Pellonula*, were the most abundant fish and constitute about 25% of the fish in terms of number.

### **Artisanal Fisheries**

The coastal inshore artisanal fishery is mainly confined in waters of less than 40 m depth. Local artisanal fisher folks operate in large wooden motorized “Ghana-type” canoes which are more durable on this surf-beaten coast. Canoe sizes range from 7-9 m in length. The fish stocks in EA/EJA field are exploited with a wide variety of artisanal gears: set gillnets, beach seines, large meshed shark drift nets, hooks on long line/hand lines and various traps.

### **Artisanal Fishing Techniques**

Common fishing techniques observed and reported within the study area include:

- basket trap fishing
- cast-net/dragnet fishing
- commercial trawling
- hook and line fishing
- ring gillnet fishing
- set-net fishing

Cast net and set net fishing are reported to be most common fishing methods during the rainy season whilst beach seining and the use of traps are common in dry season. The choice of fishing technique depended on the size, type and the availability of fish during each season.

### **Ecological Indices**

The health performance indicators of *Pseudotolithus typus* (the longneck croaker) used for the study is presented in Table 4.8b.

Table 4.8b: Log – log transformation of the raw data of *Pseudotolithus typus* caught within the OML 79 field during the survey (Nov. 2018)

S/N	Weight W(g)	Standard length (SL) (cm)	Gonad weight (G) (g)	Fecundity (F)	Log W	Log SL	Log G	Log F	GSI (%)	K	Gond-free weight (g)
1	198.0	20.6	56.34	37684	2.30	1.31	1.75	4.51	39.77	2.26	141.66
2	198.2	20.9	56.48	30437	1.28	1.32	1.75	4.48	39.85	2.17	141.72
3	197.8	20.3	56.31	29844	2.30	1.31	1.75	4.47	39.78	2.36	141.49
4	198.3	20.9	57.04	31328	2.30	1.32	1.76	4.50	40.38	2.17	141.26
5	196.4	19.5	55.27	30473	2.29	1.29	1.74	4.48	39.16	2.70	141.13
6	194.2	19.8	55.29	29684	2.29	1.30	1.74	4.47	39.80	2.50	138.91
7	174.2	16.5	48.78	28478	2.24	1.22	1.69	4.45	38.27	3.89	125.42
8	174.5	16.8	49.22	28484	2.24	1.23	1.69	4.45	39.28	3.68	125.28

9	199.4	20.5	56.28	32863	2.30	1.31	1.75	4.52	39.32	2.31	143.12
10	204.6	20.9	58.02	34387	2.31	1.32	1.76	4.54	39.58	2..24	146.60

\*Log F = Log – transformed values of fecundity; Log W = Log- transformed values of fish weight; Log SL=Log–transformed values of standard length of fish; Log G=Log transformed values of Gonad weight; GSI = Gonadosomatic index values and K= Condition factor

### **Fecundity**

The fecundity of *Pseudotolithus typus* (the longneck croaker) which was observed to be the most commercially important fish species in the artisanal fisheries within the OML79 field during the October/ November, 2018 studies of the Field is reported. It was chosen as it was observed to be with matured eggs. The fecundity of the species was observed to fall between 30437 – 34, 387. The fish fecundity was generally high within the field. Fecundity, was observed to be high in individuals with higher weights than those with higher standard lengths. In general, there was positive high correlation between fecundity/ fish length ( $r=1.0$ ) and fecundity/ fish weight ( $r=1.0$ ).

Similar records were presented by Sossoukpe *et al.*, (2013) on the same species from the nearshore waters of Benin (West Africa) when investigating the population structure and reproductive parameters and their implication for management. Emmanuel, *et al.*, (2010) also observed that the gonad weights of *Galeoides decadactylus* off Nigerian coast were related to the length and weight of the fish. Hunter, *et al.*, (1992), Shield (1992), Hartholl (1985) and Campell & Eagle (1983) have also reported similar trends in gonad weight in relation to fish length and weight in female Dover fish (*Microstomus paeificus*) and cancer crab (*Neptunus hastatus*), in crustaceans community in Rotterdam waters and the rock crab (*Maja squinado*) from the Bay of Funday and South Western Nova Scotia, Canada respectively.

Apart from the high fecundity, the authors also reported, high gonadosomatic index (GSI) (35-75-40.88%), condition factor (K) (2.28-3.69) and Gonad – free weight (128.90-147.34g) in the respective species which were attributed to stable and unpolluted nature of the environment. Consequently, from similar parameters on the longneck croaker (*P. typus*) used in this study, it can be concluded that the OML 79 Field is ecologically healthy and unpolluted. This supported by the observed intensity of artisanal fisheries activities in the area. This is also supported by conclusion drawn from results of species diversity of plankton in the field.

### **Length and Weight**

The standard length of the fish fell between 16.5 – 20.9 cm with a weight range of between 174.20 – 204.62 g.

### **Gonad weight**

Gonad (ovary) weight was observed to range between 48.78 – 58.02g. The gonad weight showed an impressive range for each of the fecund individuals. They were all observed to increase in relation to the fish length and weight. Individuals with higher lengths and weights had corresponding higher ovary (gonad) weights.

**GSI and K values**

The range of Gonadosomatic index values fell between 38.27–40.38%, while the condition factor of the species ranged between 2.17-3.8. Condition factor (K) was generally high in the fish within the OML 79 field.

**Tissue analysis**

**Heavy metals**

Heavy metals are generally found at very low concentrations, while high concentrations are commonly associated with pollution from anthropogenic activities (Forstner & Wittman, 1981; Obasohan & Eguavo, 2008). Discharged pollutants especially at the sub-lethal level, results in chronic stress conditions with the attendant negative effects on aquatic life (Obasohan & Eguavo, 2008). Marine organisms such as fishes have been recognized as a useful tool for the monitoring of the environment. The fish species used in this study, *Pseudotolithus typus* is a bottom dwelling species found at depth upto 150 m (Schneider, 1990) and feeds voraciously on benthic organisms (Job, 1992; Sossoukpe, 2011).

Tissue levels of heavy metals measured in the fish species during the present study is shown in Table 4.8c. The heavy metals in the Gills ranged from 0.12 ± 0.2 ppm (Pb) to 0.46 ± 1.21 ppm (Co), while a range of between 0.01±0.10 ppm (Pb) to 0.37±0.22 ppm (Co) was obtained from the fish stomach and a range of 0.00 ± 0.00 ppm (Pb) to 0.34.06 ppm (Co) was obtained from the muscle. The trend of heavy metal concentration in fish organs was Gills>Stomach>Muscles. The concentration of the heavy metals in the fish tissues (Gills, Stomach and Muscle) was in the following order: Co > Cr > Cd/Ni > Pb.

Table 4.8c: Mean concentration (ppm) of heavy metals in the tissue (Gills, Stomach and Muscle) of *Pseudotolithus typus* (Longneck croaker) within the OML 79 Field

<b>Fish tissue</b>	<b>Cd</b>	<b>Ni</b>	<b>Cr</b>	<b>Co</b>	<b>Pb</b>
Gills	0.34±0.07	0.23±1.21	0.38±0.02	0.46±0.22	0.12±0.20
Stomach	0.16±0.06	0.04±0.01	0.27±0.08	0.037±0.22	0.01±0.10
Muscle	0.26±0.04	0.22±0.14	0.35±0.03	0.34±0.06	0.00±0.00
WHO (1985)/ FEPA (2003)/ FAO (1983) limits in fish and fish products (ppm)	2.00	0.5-0.6	0.15-1.0	Not provided	2.00

Source: Field Work, October/November, 2018.

Pollutants accumulated in marine organism are transferred to man through the food chain (Cogun *et al.*, 2006; Farkas *et al.*, 2000; and Uluozu *et al.*, 2007). However, the heavy metals levels were generally below the stipulated WHO, FEPA and FAO limits for seafood. From the observed concentrations of the heavy metal in the tissues of the OML 79 field, heavy

metals were not accumulated in the fish to any significantly extent that would be detrimental to the ecosystem. Low values of heavy metals in fish species are commonly reported for the Niger Delta (Murtala *et al.*, 2012; Edem *et al.*, 2009; Eneji *et al.*, 2011).

The variability in heavy metal concentrations of marine organisms depends on the interplay of many factors which may include the position of the fish in the food chain, size, age and characteristic kinetics for elements and their biological halftime (Bolava & Gbenle, 2010). The low levels of the heavy metals recorded in the fish tissue may their low levels in the environment of OML 79. Although varying concentrations of trace metals including Cd, Ni, Cr, and Pd have been implicated in crude oils and waste generated from production operations within the Niger Delta Region (Nwadinigwe & Nwaorgu, 1999; DPR, 2002), heavy metals in water in sediment were generally low and most were below the detection limits of the analyses during the present studies.

#### **Total petroleum hydrocarbons (TPH)**

The results of the TPH analysis of the fish tissues are presented in Table 4.8d. In the gills, TPH ranged between 3.64-3.84 mg/kg with a mean of  $3.72 \pm 0.085$ , TPH ranged between 2.46-2.80 mg/kg with a mean value of  $2.61 \pm 0.140$  in the gut and between 2.66 – 2.82 mg/kg with a mean of  $2.72 \pm 0.071$  mg/kg in the muscle. All TPH values were far below the UNESCO/WHO/UNEP (1992) maximum permissible limit of 100.0 mg/kg indicating that the environment was not polluted with petroleum hydrocarbons and that the fish species were safe for human consumption.

Table 4.8d: Summary of TPH in the fish tissue (mg/kg)

<b>Fish Tissue</b>	<b>First Reading (mg/kg)</b>	<b>Second Reading (mg/kg)</b>	<b>Third Reading (mg/kg)</b>	<b>Mean value <math>\pm</math> SD (mg/kg)</b>	<b>UNESCO/WHO/UNEP (1992) Permissible limit (mg/kg)</b>
Gills	3.64	3.69	3.84	$3.72 \pm 0.085$	100.0
Gut	2.46	2.80	2.58	$2.61 \pm 0.140$	100.0
Muscle	2.66	2.82	2.68	$2.72 \pm 0.071$	100.0

Source: Field Work, October/November, 2018.

#### ***Food and feeding habit of fishes***

##### **Diet composition of *P. typus***

The diet composition of the longneck croaker (*P. typus*) studied are presented in Table 4.8e. The diet of was observed to consist of 9 major food components namely shrimps, crustacean parts/remains, crabs, fish bones, fish scales, bivalves, juvenile fishes (mainly croaker), crab parts and polychaete worms. Mud/particles and detritus were also found in the gut of the fish. There was no empty gut as the guts were observed to contain one food type or the other.

Table 4.8e: Diet composition of *P. typus* caught within the OML 79 filed during the survey (October-November, 2018)

SN	Fish	Fish standard	Diet Components
----	------	---------------	-----------------

	weight (g)	length (cm)	
1	198.0	20.6	2 shriups 8 crusatcean parts, 3 small crabs, 5 fish bones, detritus, mudparticles, 8 fish scales
2	198.2	20.9	3 small crabs, 5 shrimps, I bivalve, detritus 7 fish scales, mud/sand particles, 9 fish bones
3	197.8	20.3	6 crustacean parts, 3 shrimps, 1 crab, 4 crab parts, detritus
4	198.3	20.9	2 fish juvenile (Croaher), 5 folychaete worws, mud particles, detritus
5	196.4	19.5	7 crustacean remains, 6 fish scales, 9 fish bones, detritus
6	194.2	19.8	3 shrimps, 2 crbas, 10 fish scales, 4 fish bones, detritus
7	174.2	16.5	2 crabs 5 shrimps, detritus, mud particles
8	174.5	16.8	4 polychaete worms, 1 crab, mud particles, 3 juvenile fishes (croaker)
9	199.4	20.5	3 shrimps, I bivalves, 2 crabs, Detritus
10	204.6	20.9	1 crab, 1 shrimp, 8 fish scales, 11 fish bones, 4 juvenile fisher

Source: Field work (October – November, 2018).

The frequency of occurrence (FO) of the various diet components and their relative importance in the diet of the species is presented in Table 4.8f.

Table 4.8f: Summary of the diet components extracted from the gut of the longneck croaker (*P. typus*) investigated

SN	Diet components	FO*	Numerical abundance (n)	%n
1.	Shrimps	7	22	13.84%
2.	Crustacean parts / remains	3	21	13.21%
3.	Crabs	8	15	9.43%
4.	Fish bones	5	38	23.89%
5.	Fish scales	5	39	24.53%
6.	Bivalves	2	2	1.26%
7.	Juvenile fishes	3	9	5.66%
8.	Crab parts	1	4	2.525
9.	Polychaete worms	2	9	5.66%
10.	Mud particle/second	6	NNP*	-
11.	Detritus	7	NNP*	-
			159	100.0

NNP\* = Numeration not practicable. FO\* - frequency of occurrence of the diet components  
Source: Field Work (October – November, 2018)

Out of 10 guts analyzed, 7 had shrimps and detritus while 1 contained crab parts. In general, fish scales formed the greater part of the fish diet, with 39 individuals which formed 24.53% of the total diet component of the fish followed by fish bones with 38 individuals constituting 23.89% of the diet of the fish. The least consumed diet was bivalves with individual forming 1.26% of the diet of the fish. The mud/sand particles in the gut of the fish may be considered

incidental components, as these might have been picked up alongside the main food items while feeding. Polychaete worms and juvenile fishes (namely croaker) had same numerical abundance (9 individuals) each forming 5.66% of the diet of the fish. There was no empty stomach as all the stomachs were found to contain one or the other food item. The general spectrum of the diet of the fish portrays the fish to be a voracious benthic species feeding on both sessile and motile organisms.

From the diet composition of the longneck croaker (*P. typus*), it is clear that the OML 79 Field where the fish was caught, has a rich array of food items which points to high trophic stable. Nature generally provide a wide array of organisms as food for fish in the aquatic environment (Olojo *et al.*, 2003). However, when there is alternation of these dietary components due to the influence of pollution the classic food web is disrupted and the food chain (primary producers, secondary consumers and tertiary consumers) links may also become disrupted (Odum & Heald, 1972; Costal *et al.*, 1992; Job, 2006). Crustaceans, generally are benthos in the adult stage and respond rapidly to the influence of pollution (Ezemonye & Egborge 1992; Cogun *et al.*, 2006). The high number of the Crustaceans (shrimps/crabs) in the diet of the fish during the period of study, is in support of the ecological and trophic stability of the OML 79 Field.

### ***Marine Wildlife***

Wildlife reported in Nigeria's near-coast waters include marine mammals and sea turtles. Dublin-Green and Tobor (1992) reported the occurrence of members of the toothed whales, the *Odontocedi* in Nigerian coastal and offshore waters. The common dolphin (*Dolphinus delphis*) is also believed to occur in the Nigerian coastal waters. The presence of other whales such as *Dolphinus and Steno* in the Gulf of Guinea off the West African coast has also been reported. The manatee belonging to the genus *Tricheus* has also been observed in Nigerian coastal waters. Among the marine reptiles, the sea turtles occur in small numbers in Nigeria waters. The turtles belong to two families (Chenolidae and Dormochelidae) and consist of five genera and six species (Dublin-Green and Tobor, 1992). Some of the documented sea turtle species and their IUCN status include:

- Green sea turtle (*Chelonia mydas*) = EN (endangered)
- Hawksbill sea turtle (*Eretmochelys imbricata*) = CR (critically endangered)
- Leatherback sea turtle (*Dermochelys coriacea*) = CR (critically endangered)
- Loggerhead turtle (*Caretta caretta*) = EN (endangered)
- Olive ridley (*Lepidochelys olivacea*) = EN (endangered)

The area covering the beaches of Brass River, St Nicholas, Sangana River, Fishtown River, and Akassa River (Nun River) are listed as nesting sites for a variety of marine turtles belonging to the five species. The FAO Species ID Sheets (1981) also gave the following periods as breeding seasons for the different turtle species;

- Leatherback - September to February
- Olive Ridley - August to December
- Green turtle - July to November
- Hawksbill - September to February



- Loggerhead - April to September

Nigeria is also a signatory to two International Conventions regulating the protection of sea turtles and other endangered species; Convention on the International Trade in Endangered Species (CITES) and the Bonn Convention on Migratory Species (CMS). Within the African sub-region, a network called PROTOMAC (Protection of Marine Turtles in Central Africa) working in coastal countries from Cameroon to South Africa, and its corresponding branch covering areas northwards as far as Morocco, was created in 1998 to attempt to coordinate and network between local initiatives working for the protection of sea turtles. PROTOMAC was established in line with a Memorandum of Understanding by 25 Coastal African States under UNEP (1999 and 2002) to declare marine turtles in the region endangered. The International Union for Conservation of Nature (IUCN) has also established a Marine Turtle Specialist Group that is responsible for tracking the status of sea turtle populations around the world (IUCN Global Action Plan for Sea Turtles).

#### **4.2.8: Social Profile**

##### **Project Area and Historical Perspective**

The EA/EJA-FOD proposed project is contiguous to about twelve major coastal settlements and immediate hinterlands that are likely to be exposed to the potential impacts of the project. These include Ezetu, Ekeni, Bisangbene, Amatu I, Amatu II, Letugbene, Orobiri, Azamabiri, Agge, Bilabiri I, Bilabiri II and Ogbeintu. Ezetu and Ekeni communities located in the Southern Ijaw Local Government Area while the remaining 10 communities are located in Ekeremor Local Government Area (LGA) of Bayelsa State. These communities are located geographically to the north at distance of about 15 km away from the project site. Each of the “parent” communities has numerous fishing/farming settlements along the coastal strip and along the main water-ways. Principally, these communities lie between the Ramos and Pennington Rivers.

Historical and sociological studies have shown that these communities, as other Niger Delta communities have strong tribal and cultural affinities that override community boundaries, except in the area of political and local governance arrangements. Thus, these communities are traditionally grouped under different clans; the dominant clans in the area being the Khou Clan and the Iduwini Clan.

The indigenes have a common migration story, and this is tied to their common language, festivals and taboos. All the communities within the area are homogeneously Ijaw (Izon), a major ethnic group in the Niger Delta region of Southern Nigeria. The Ijaws, whose settlements are mainly around the coastal belt, claim to have descended from a common ancestor who migrated from ‘Benin-Aboh’ in the hinterland. The indigenes have close historical and kinship ties with the Oporoma, Eastern Olodiana and Ogbe tribes. Historically, the indigenes settled in the area several thousand years before the arrival of the Portuguese on the coast of the Niger Delta in the 15<sup>th</sup> century (Alagoa, 2005).

All the communities in both Local Government Areas are oil producing. This is manifested in the oil exploration related activities that are seen daily all over the locality. The area is believed to have the highest number of oil wells in the Niger Delta. This includes both onshore and offshore locations. Major oil companies that operate here includes; Shell Petroleum Development Company, Chevron Nigeria Limited, and Nigeria Agip Oil Company Limited.

### **Religion, Cultural/Archaeological Properties, Customs, Belief Systems and Values**

The general belief/value system of the indigenes in EA/EJA FOD neighbouring communities does not differ significantly from that of the neighbouring tribes. Christianity predominates as evidenced in the presence of different denominations of churches in the communities. This suggests reducing African Traditional Religion (ATR) adherence in the communities over the years. The reality on ground is that traditional worship is rooted in the communities' culture and even acclaimed Christians participate in the festivals at different levels of commitment.

The people are both patrilineal and matrilineal, depending on the degree of marriage. Inheritance rights are biased towards biological offsprings especially male household members. It is rich in cultural diversity. Some of the best cultural troupes and traditional festivals can be found in the area. One of the renowned cultural troupes popularly known as the "egbelegebe" dance troupe is a common phenomenon within this locality. The area is also known for its prowess in wrestling. The likes of Jackson Bidei and other great wrestlers that have represented Nigeria in international competitions are from this area. The coastal area is rich in natural splendour and a very good tourist destination for people that want to see the exotic aquatic beauty and other numerous tourist attractions.

Generally, to promote pro-environmental behaviour, order and social cohesion among the residents there are standard social norms that are common in the communities. Some of these include respect to the elders by the youth/children, wives and husbands and relational social capital. There are other belief systems, which revolve around common taboos. Typical prohibitions include killing of tortoise, python and the pure white coloured bird. Because of the cultural significance attached to these animals, the indigenes have been ensuring that their habitats are protected. Apart from these, the people really do not have so many forbidden food or cultural/traditional taboos. Non-indigenes, therefore, find it easy to mix freely with the indigenes leading to considerable population of other ethnic groups residing in the area, including Urhobo, Isoko, Igbo, Yoruba, Ibibios and Efiks. These mixed groups are particularly concentrated in the satellite settlements and outposts, stretched between Agee and Obiri Creek. Emotional and religious attachments forbid open discussions about some deities, their activities and abodes. Their systems of traditional administration are similar, so are the folklore, dances, arts, crafts and mode of dressing. As in any evolving and developing community where there is influx of people, there are noticeable signs of alteration in the socio-cultural system of the communities.

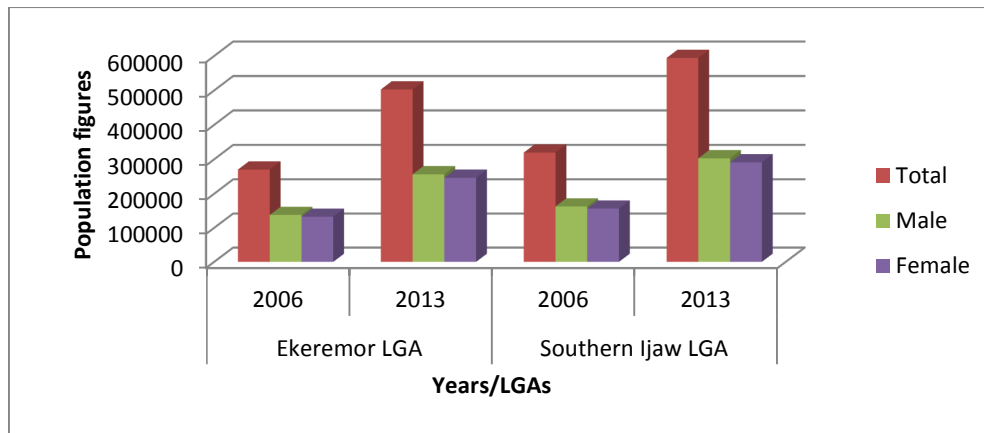
The high humidity of the climate does not allow for preservation of archaeological artefacts in the area. Moreover, termites and other insects would not permit preservation of wooden

artefacts. Stone objects are rare in the area because rocky formations are not part of the geological heritage. Sacred sites are routinely out of bounds to strangers and some indigenous elements alike.

**Demographic Studies**

**Population Description**

Ekeremor and Southern Ijaw Local Government Areas occupy land size of 1,810 km<sup>2</sup> and 2,682 km<sup>2</sup> respectively. The Nigeria 2006 Census estimates the population of the Ekeremor LGA at 270,257 with males constituting 51% (137,831) and females 49% (132,425), but with a population growth rate of 2.5% the population figure is estimated to be 502,758 comprising (256,406) males and (246,351) females as at 2013. For Southern Ijaw LGA, the 2006 figure stood at 319,413 comprising 256,406 males and 246,351 females, which increased to about 594,202 with males comprising 303,043 persons and females 291,159 persons in 2013 (Fig. 4.9a). This suggests an increase in population of the study area with implications on increased demand on social amenities.



**Fig. 4.3a: Population of Ekeremor and Southern Ijaw LGAs of Bayelsa State**

In the Niger Delta region, it is noted that there are slightly more males than females. The coastal area from the Pennington River to the Ramos River is home to numerous communities. A realistic appraisal of the population of the communities will in all cases include the population of the primary community with the satellite settlements. As in the case of macro population of the entire LGAs, the population in the communities has been on the increased. **Table 4.9a** shows the estimated population of some of the communities as at 2003 and the 2013.

Table 4.9a: Estimated population in some of the coastal communities

s/no	Community	Population (2003)	Population (2013)*
1	Letugbene	5000	6720
2	Ekenie	4040	5429
3	Agge	4000	5376

4	Bisagbene	3000	4032
5	Ezeati	3000	4032
6	Bilabri (1&2)	2500	3360
7	Azamabiri	2000	2688
8	Orobiri	2000	2688

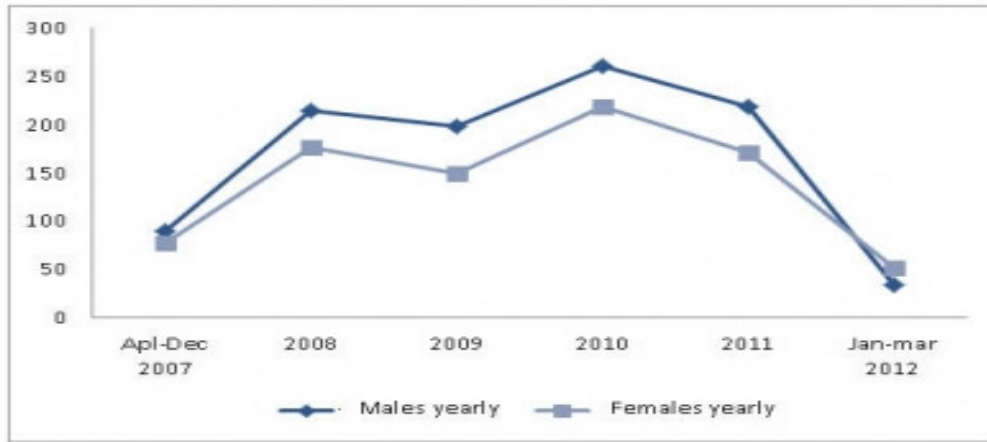
\* based on growth rate of 3%

As shown in **Table 4.9a**, the population of the area has increased following the natural factors that influence population dynamics, which are birth rate, death rate and migration. In most Niger Delta communities, the high birth rate is kept in check by a high mortality rate especially among infants and the elderly who are vulnerable to premature death due to lack of basic health care facilities.

### ***Sex ratio structure***

Sex ratio is the ratio of males to females in a given population, usually expressed as the number of males for every 100 females (Haupt and Kane, 2004). Information on secondary sex ratio in Niger Delta region of Nigeria is limited. Certain factors like cultural practices, seasonal variation, small-family size policy and sex selective technology have been known to influence sex ratio structure (Eneni *et al.*, 2013). As usual in the Niger Delta region it is noted that there are slightly more males than females in the states, LGAs and the communities, based on the NPC census of 2006. Surveys carried out in the course of the Niger Delta Master Plan development process show that there are actually more males (54%) than females (46%) in the Region.

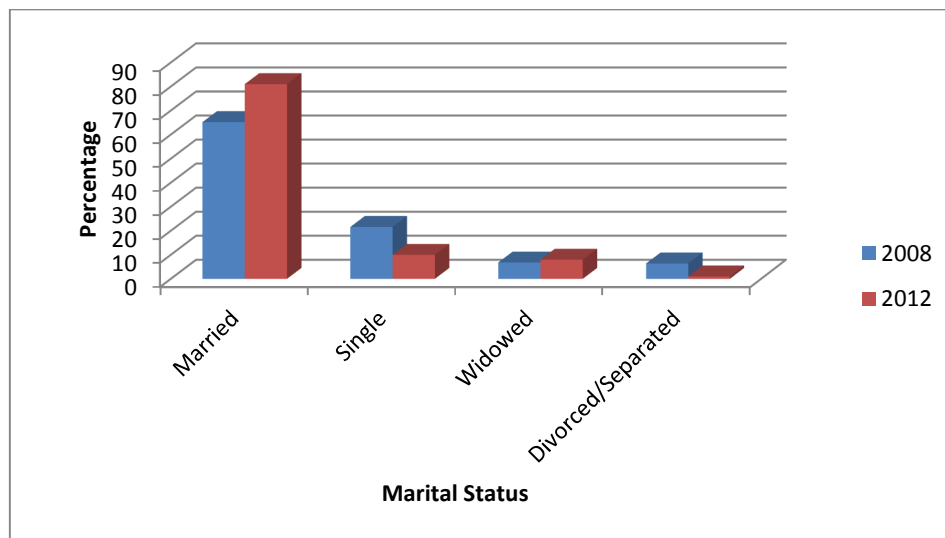
Sex distribution of the population in the study environment reveals a slightly male dominant structure in the ratio of approximately 1.13:1. In a recent work carried out by Eneni *et al.* (2013), it was revealed that between April 2007 and March 2012 the annual average male to female sex ratios were 1.24, 1.89, 1.3 and 1.34 for 2008, 2009, 2010, and 2011 respectively in Bayelsa State (**Fig. 4.3b**). When pooled together, the average ratio was 120:100. This shows some bias for male births and the difference shown to be statistically insignificant ( $P > 0.05$ ). Data also indicates less male birth in the peak period of rainy season and the highest male to female ratio in harmattan season, suggesting a seasonal variation of sex ratio. These findings further confirmed that male –female sex ratio is higher in South-south when compared to those of southwest Nigeria or other regions in Nigeria as well as other populations of African origin.



**Fig. 4.3b: Sex ratio structure in Bayelsa State (2007-2013)**

***Marital status, household size and Household Composition***

**Fig. 4.3c** reveals increase in the number of married persons in the neighbouring communities between 2008 and 2012. About 65.2% of the communities’ members were married in 2008 which increased to about 81% in 2012. For the married, polygamy is preponderant in the area accounting for 71.4% and 65.8% in 2008 and 2012 respectively with one man having 2-4 wives. The declined rate of divorced household heads in the area between 2008 (6.4%) and 2012 (1%) is an indication that the indigenes valued marriage.



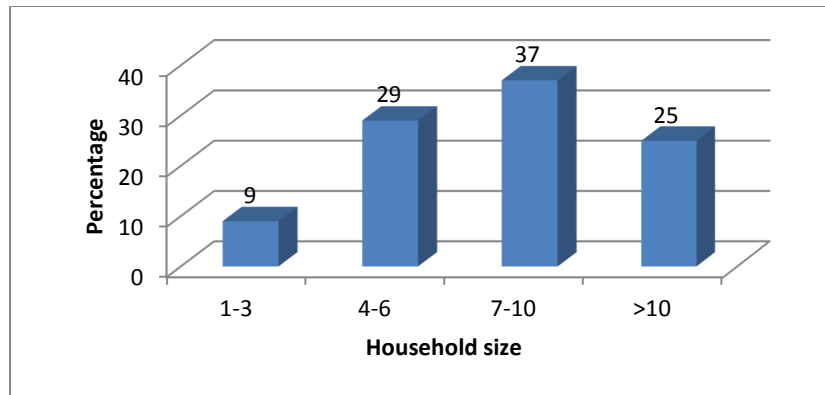
**Fig. 4.3c: Marital status of the Households in the project neighbouring communities**

***Household size Structure***

The size of families differs from community to community, influenced largely by the cultural attitude of the people, economy of the settlement and educational status/awareness of the resident population amongst other factors. The 2012 field survey showed an average of 6-8 persons per dwelling unit with about 37% households having between 7 and 10 persons in a family as against 46.2% of households in 2008 having 7-10 persons (**Fig. 4.3d**). The results

suggest that the communities are largely dominated by youths and agree with findings of EIA of SSAGGP (2003).

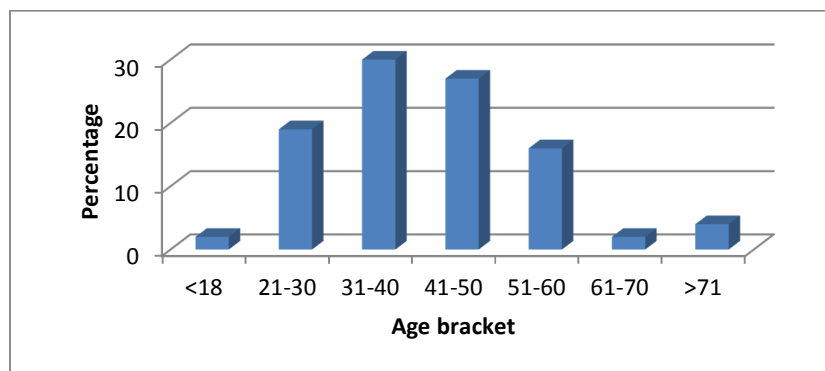
A total of 3,919,364 households were enumerated during the preparation of the Niger Delta Regional Master Plan Development with an average household size of 7.4, but with more than 70% of them having an average of 8 occupants. Large households were found more prevalent in the rural areas (NDDC, 2006).



**Fig. 4.3d: Family size in typical coastal communities**

***Age Distribution structure***

The household age structure and distribution in Bayelsa State conforms to the overall Nigeria’s pyramidal structure. The Niger Delta population is rather overwhelmingly loaded from the lower age-cohorts. The socioeconomic sample survey of the most coastal communities and settlements showed that persons below the 26 years age bracket constitute an overwhelming percentage of approximately 63 percent (**Fig. 4.3e**). In all, children are proportionately more while the aged (>60 years) are fewest in the population. A comparatively high proportion of people below the working age also tend to reduce labour input per capita and income per capita (UNDP, 2006). The active age involved in economic activities contributing to family income is 35%. The rest are either children of school age or very old people. The overall implications of the age profile is that the population is young and growing and places a heavy burden on the adult population, a high dependency ratio, as well as huge unemployed human number. More importantly, the provision of educational facilities and health care services are paramount in the study affected area to accommodate this young population.



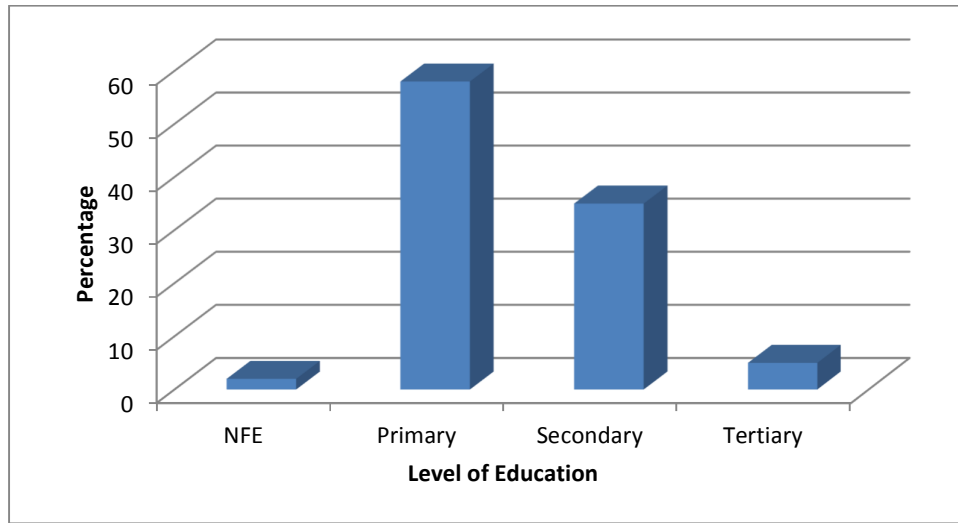
**Fig. 4.3e: Age Structure of sampled respondents at project neighbouring Communities**

### *Educational structure*

An overview of the current state of education in Bayelsa State reveals, there are 537 primary schools in Bayelsa, with Ekeremor and Southern-Ijaw LGAs having 86 and 131 schools respectively. Over the years, these schools are characterized by low completion rate, and high dropout rate arising from inadequate teaching staff both in quality and quantity, dearth of educational inputs and the peculiar riverine terrain which makes the deployment of teachers in rural schools very difficult. Besides, whereas the schools for migrant fishermen only exist in the statute books, they are non-functional. The same ugly fate has befallen the vocational and adult schools in the State.

These challenges have reduced the morale of teachers, attenuated educational standards and consequently increased the illiteracy rate. The teacher's population in the State totals 3031 qualified in the primary school level, with Ekeremor and Southern Ijaw LGAs having had 261 and 519 teachers respectively as at 2009. From the above data, there is significant manpower gap; this lacuna requires training and retraining the teachers.

Bayelsa State has the lowest educational attainment and literacy level, especially among the female gender in the South South States of Nigeria. Africa Health, Human and Social Development Services Report recently released, placed the State among the educationally disadvantaged states in the federation and having high incidence of both under age marriage and under age child bearing. Irrespective of the dismal literacy level in the state an appreciable proportion of the population in the coastal communities has received some formal educational training. The modal educational attainment amongst the population in the communities is primary educational level. Result from the 2005 field survey showed that about 58% of the total respondents claimed to possess primary education, 35% secondary education and 5% tertiary education. Only about 2% of the sampled population claimed to have no form of formal education (**Fig. 4.3f**). However, the low level of those with tertiary/post-secondary education may be because of limited job opportunities in the past, coupled with limited access to the creeks due to water transportation problem and predominantly fishing occupation of the indigenes. This is commendable considering that educational facilities are relatively absent and not within easy reach of those desirous of this necessary service.



**Fig. 4.3f: Educational attainment in the project neighbouring communities of Bayelsa state**

In 2012, the government declared free primary and secondary education in Bayelsa State. This is the first time an all-inclusive pronouncement of free education was proclaimed in Bayelsa State since its creation 15 years ago. The pronouncement was predicated on the fact that Bayelsa State has remained acutely disadvantaged since creation. It is expected that the fortune of educational level and literacy level would have changed with attendant positive impacts.

**Economic characteristics and livelihood**

***Occupation and Employment Status***

Agriculture is the main source of livelihood in the area. The people are predominantly fishermen and farmers although others engage in trading and civil service employment (**Plate. 4.1a**). Some are into Oil and Gas services as contractors to SPDC, Chevron and other operators in the area in providing services such as surveillance, Right of Way maintenance, civil and mechanical works. The competition for Oil and Gas contracts is very fierce because there are limited livelihood opportunities.

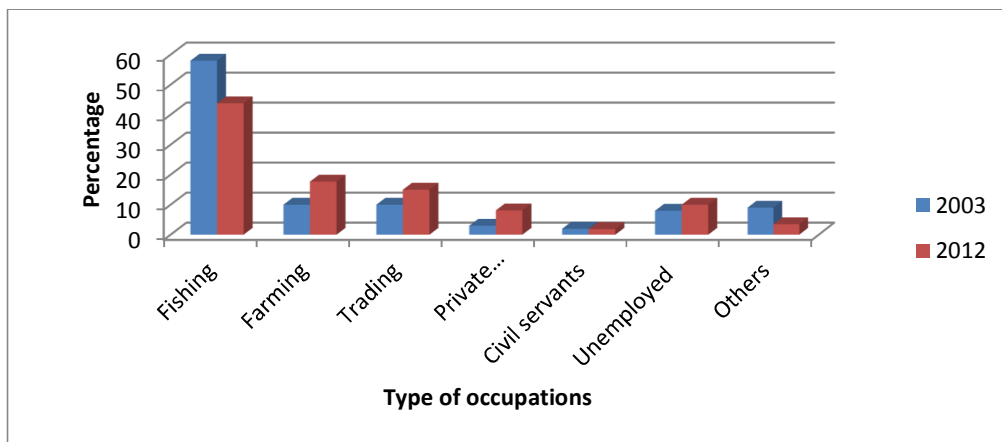




Plate 4.1a: Livelihood earning activities in the project neighbouring communities

The occupational distribution (**Fig. 4.3g**) suggests different occupations or income generating activities exist in the communities. Based on the 2012 field survey majority (43.8%) were fisher folks, 17.7% and 15% were into both crop farming and trading as major occupations as against 58%, 10% and 10% in fishing, trading and farming respectively as at 2003. Though there is reduction in the number of fisher folks between 2008 and 2012, fishing is still the dominant primary source of income for the residents of the coastal communities. There is virtually no single person in the communities who is not knowledgeable in the art of fishing; even the children of primary school ages have considerable experiences in fisheries activities. Fishing is conducted along the surrounding creeks, rivers, slots/canals and deep into the Atlantic Ocean. Fishing techniques employed remains largely unchanged from the baseline condition and includes hooks, lines, cast nets, drag nets, sweep nets, fish traps and conical baskets. Trading is largely undertaken by women and trading items include fish in fresh and roasted forms, foodstuffs, confectionaries, etc. In the recent times, there has been increased demand for exotic ice fish in the communities with concomitant increase in the supply/sale.

The traders sourced these iced fishes from Warri and Yenagoa towns and market them in the local markets.



**Fig. 4.3g: Major occupation structure**

Mixed cropping is a dominant feature of the farming system of the area. Common crops grown include maize, cassava, yam, plantain, banana, and vegetables such as okra and fluted pumpkin. Simple farm tools, such as cutlasses and hoes characterize the crop farming system in the area.

The observed level (10% of the studied sample) of unemployment rate may account for a high level of youth restiveness and continued illegal bunkering activities observed in the area. Some factors contributing to youth unemployment include:

- Lack of local industries to create employment;
- Lack of marketable skills due to non-availability of vocational skill development programmes;
- Inadequate mobilization, support and incentives for self-employment through Small and Medium Enterprises (SMEs);
- Lack of poverty-reduction programmes such as micro-credit schemes in the region;
- Abandonment of traditional occupations, which are low yielding, fraught with hardship and no longer command respect;
- Attraction for better paying and more dignifying jobs in the oil sector;
- Limited job opportunities provided by oil and gas sector; and
- The boom and bust patterns of oil company temporary contract jobs, resulting in long periods of prospecting in between short spells of work.

Respondents appeared to be quite experienced in their occupation as shown in **Table 4.9b**. About 51% had more than one decade experience in their jobs while about 11% had between 1 and 5 years of working experience. An interesting implication of this is that the individuals would be quite familiar with the challenges associated with their current economic activities.

Table 4.9b: Working experience of respondents

s/n	Experience (Years)	Percentage
1	Unemployed	10
2	1-5	11.0
3	6-10	28.0
4	11-20	31.0
5	21-30	18.7
6	>30	1.3
Total		100

The community does not enjoy the abundance of skilled labour as obtainable in the local government headquarters and other large settlements. Skilled labour does not abound and most of the tertiary graduates seek employment in other communities and towns. The artisans who exist are mostly in the areas of carpentry, welding, hand crafts, tailoring, commercial boat driving, and hair dressing. Unskilled labours abound and are mostly engaged by NGOs and companies as helpers. There was a general concern for the lack of skill development centres.

### Quality of Life

#### *Income and Expenditure Levels*

Personal income levels of self-employed rural households is always difficult to assess because many local people do not keep records and are therefore uncertain of the gross or net amount actually earned from self-endeavours. Some who may have information about their earnings are also not willing to divulge such sensitive data, fearing the effects of taxation. The consequence is that incomes of rural householders are very unreliable. The non-existence of income and expenditure receipts among households made some respondents to over-exaggerate their income while others under-estimated theirs depending on how they perceived the implications of the questions. Those who believed that the figures might be used as a basis for the payment of compensation in the future normally over-exaggerated their income while others thought it was better to paint a pathetic condition of abject poverty.

In most riverine communities of Niger Delta, incomes range for a weekly mean catch of “small fishing” is between ₦4,000.00 and ₦10,000.00, using hand-pulled canoes, with a monthly average income of about ₦80, 000.00 (SPDC, 2001; SPDC, 2011). However, in the project neighbouring communities, an examination of the income level (**Fig. 4.3h**) reveals that majority 13.5% earned ₦5000 and below weekly, about 30.8% earned ₦5000-10,000 while 16.9% earned ₦11, 000 -15,000, but the average weekly income is estimated to be about ₦15,450.00. Respondents however noted that the income range is not consistent throughout the years as it changes with the seasons and festivities.

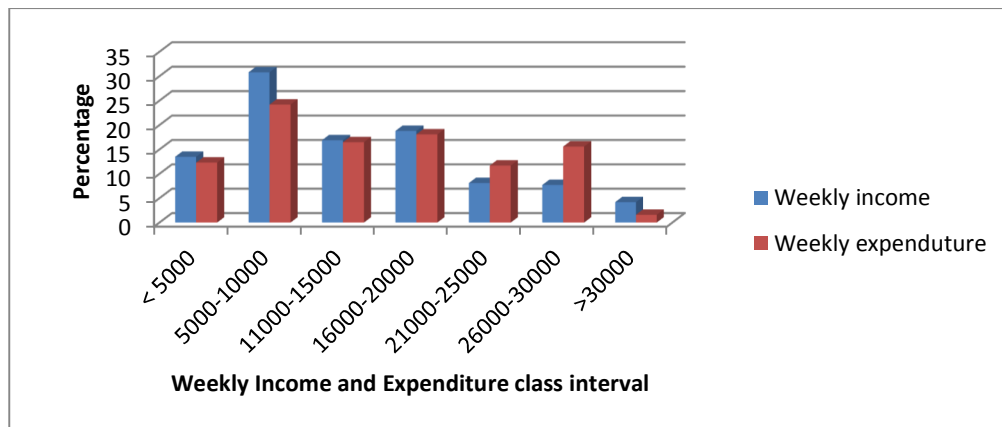
Household expenditure followed the distribution of income level as shown in Fig. 4.9h in the study area. About 24.2% households spend between ₦5,000.00 and ₦10,000.00 weekly while about 12.3% spend less than ₦5,000.00 weekly. Only 1.6% of the households spend over

₦30,000.00 in a week and the average expenses per household amounts to about ₦13,971.00. The observed expenditure profile in **Table 4.9c** clearly shows that over 50% of household income is spent on food for the family, 20% spent on transportation/communication and less than 20% for human development. This distribution pattern is common for households that are considered to be living below acceptable poverty threshold. The EIA SSAGG of 2003 noted that most community residents were subsistence in their livelihood pursuits i.e. producing largely for themselves and selling only the little surplus they had from their fishing and farming activities.

Table 4.9c: Expenditure Profile of households in the area

S/N	Expenditure Profile	Percentage
1	Feeding	51.0
2	Clothings	5.4
3	Medicare	4.3
4	Education	11.1
5	Social/transfer	8.1
6	Communication/Transport	20.1
<b>Total</b>		100

The pattern of both income and expenditure distribution provides insight into the standard of living/quality of life of the project neighbouring communities’ residents. Given that the average household size in the area is about 8 persons per family, it therefore implies that in a week per capita income and expenditure is about N1, 927.50 and N1, 746.37 respectively. Therefore, on the bases of one dollar or N360.00 per day poverty line thresholds, it can be inferred that majority of the residents are relatively poor. When asked to self-evaluate their poverty status most ranked themselves as very poor (71.9%) while 28.1% saw themselves as being averagely poor. Interestingly none perceived themselves as being non-poor. This self-evaluation by the respondents and the proportion of income spent daily, gives an insight into the high rate of poverty prevalent in the communities studied.



**Fig. 4.3h: Weekly Income and Expenditure distributions**

Source: EER Sea Eagle, 2012

***Household Asset Ownership***

A typical household in the communities lacks modern home assets probably because of low household purchasing power and temporary nature of settlement. Besides dug-out canoe, which is virtually owned by all the households, about over 69 % of the households possess sets of Radio. Also, according to **Table 4.9d** few members of the community possess valuable household items such as television (4.6%), Engine boats (3.1%) and generating sets (2.7%). Only about 5.2% of the respondents claimed to have purchased and have titled ownership to farmland.

Table 4.9d: Household Assets ownership structure

s/no	Household Assets	Percentage of ownership
1	Beddings (mattress, pillow, etc)	43.6
2	Radio/ CD Players	69.2
3	Television	34.6
4	Freezer/Fridge	3.8
5	Cushion Chairs	1.3
6	Generating set	2.7
8	Dug-out canoe	96.9
9	Engine boat	3.1
10	Land	5.2

***Energy for Cooking***

Energy for cooking is mainly from firewood cut from the mangrove forest. The modal fuel or primary energy source in the communities is firewood (a mean of 73%), followed by kerosene (24.8%) and gas (1.2%). This has led to the gradual depletion and destruction of the mangrove with its environmental and economic costs. Therefore, the general sources of household fuel are firewood, charcoal, kerosene, gas, electricity, crop residues, animal waste and others.

***Housing Types, Pattern and Quality***

Qualitatively, rural and urban housing in Niger Delta falls below minimum standards in all aspects, especially in the swamps and creeks where dwellings are made up largely of mud walls, and stilt or strip foundations (UNDP, 2006). There are several factors, which may be used in assessing the quality of housing, including liveability, level of comfort afforded, safety, and ease of maintenance. These factors include wall and roofing materials, as well as household facilities.

Traditionally, most Nigerians (about 80%) live in their own houses, which are constructed of locally available materials (NEST, 1991). These include mud walls and bamboo and thatch roofs particularly in the rural areas and cement blocks and corrugated iron sheets/zinc roofs in the urban areas. The settlements exhibited similar housing patterns and local architecture. There are very few houses depicting modern architectural design and these houses are known to be owned by one single person. Settlement pattern observed in the communities is predominantly linear. The housing quality is generally poor. Most of the houses are built of ephemeral materials such as reeds and thatch (**Plate 4.1b**). Along the shoreline, the houses are built on stilts, which although fairly durable, are physically very fragile and aesthetically unattractive. Eighty six percent of the community members live in their own houses, while 13.4% live in rented accommodation. Most of the houses are built with blocks with either zinc or asbestos roofing. However, there are several communities where the majority of the houses are made of mud, bamboo and thatched roofs.



Plate 4.1b: Typical Residential housing in the coastal communities

With regards to sanitary condition of the communities, drawing from data from the National Bureau of Statistics (2009), the most widespread methods of waste or refuse disposal are disposal within household compounds and disposal in unauthorized heaps. Domestic wastes are disposed of indiscriminately in and around the communities in bushes, water bodies (rivers streams and creeks). Human sewage disposal is mostly by pit latrines and in the open, in nearby bushes or directly into the water bodies for most communities living along watercourses. Thus, the commonest toilet disposal system is the pier system (**Plate 4.1c**).



Plate 4.1c: A typical overhung toilet in Ezetu community

### **Social and Infrastructural facilities**

The level of infrastructure and amenities available and functional in any area or community has direct implications on the quality of life in that area, and therefore the willingness of people to live and remain there. The availability, accessibility and functionality of social infrastructure explain the extent of socio-economic development of the people. It is a well-known fact that the available social infrastructures and services in the Niger Delta communities are inadequate and of poor quality.

### ***School and Educational Facilities***

Most project communities have primary and secondary schools, many of which were government owned while few are private owned. There are 12 primary schools distributed evenly in the communities and 2 secondary schools located in Letugbene and Ezetu (**Plate 4.1d**). Regardless of the school ownership, these schools suffer from inadequate staff and facilities such as tables and chairs. Across the communities, the inventory of educational facilities is far from adequate and nearly all school facilities are in different states of disrepair, requiring major rehabilitation. None of the schools had a functional staff quarters for teachers.



Plate 4.1d: Community Comprehensive Secondary School in Ezetu

### ***Potable Water Sources and Facilities***

Most communities lacked potable water. Thus, most communities have to depend on river water as their major water source, which has implication for health as it is not uncommon to see the same river being used for waste disposal. Some communities noted that a reason for their lack of borehole water was because past attempts to drill bore-hole water in the community only produced salty water which is unfit for human consumption. They believed if the bore-hole is drilled to the proper depth they would get fresh water.

Data from the Federal Office of Statistics, (now the National Bureau of Statistics), reveals that water in the majority of Niger Delta States comes from unsafe supply facilities, including rivers, lakes or ponds, unprotected wells and boreholes. The Bureau classifies available sources of potable water for household consumption as: pipe borne, untreated pipe, borehole, protected well, unprotected well, river/lake/pond, vendor trucks and other categories. A safe and reliable water supply is currently available to only a small fraction of the population in the Niger Delta Region. In the supply systems surveyed and reported in the NDRDMP Report (NDDC, 2006), approximately 8% of the population actually enjoys water supply in urban and rural centres, while only 3% of the population in rural villages were actually served by the supply.

### ***Electricity and Power Sources***

Few communities like Bilabiri (1 and 2) with electricity claim supply is irregular. Available electricity infrastructures in some communities remain in poor condition either due to vandalization or breakdown. It is pertinent to note that none of the communities with electricity is serviced by regular public power provider or PHCN. Rather electricity is supplied by oil companies operating in the areas through the giant generating sets donated to the communities, especially Chevron. However, the twin problems of frequent break down of the generating sets and lack of diesel make it difficult to have regular power supply from these facilities. According to the NBS (2009), on average, only 34% of people living in Niger Delta communities use electrical lighting; 61% use kerosene or a lantern. Less popular sources of lighting are gas (1.2% on average), a generator (1.5%), batteries (0.2%), candles (0.6%), firewood (1.8%) and others (1.2%). However, due to the increasing influence of urbanization, the usage rate of generator is increasing.

### ***Transportation and Communication***

Located by the water side and surrounded by water, these communities are accessible only through water using hand-dug canoes and the popular fibre or outboard engine boats usually fitted with various grade of HP engines. Marine transport to the coastal and riverine settlements can be cumbersome, risky, and costly. For instance, a 20-litre fuel that cost about N3000 in other states in the south cost about N4000-4500 in the project area. The rough water is a cause for concern; while low tide constrains attempts to access some of the settlements via the creeks since these are influenced by the tidal regimen of the ocean. There are no concrete landing jetties in the villages. Cargo boats used by the women for trading navigate the rivers and creeks during high tide.



Communication via telephoning is grossly difficult even though different GSM providers' masts are located in the area. Telephone networks are weak and erratic, and signals are mostly received when GSM users either climb trees or stay at specific locations.

### ***Waste Management***

In many coastal communities, there are no organized and sanitary waste management systems. Most houses in the study area lack modern convenience or waste disposal facilities. The usual waste disposal method is in the bushes behind homes and/or directly into the river. This applies to both human and other domestic waste. No doubt this constitute a serious health hazard considering the fact that the river remains largely the source of water for drinking and other domestic purposes such as bathing, washing etc. SPDC had assisted to some extent in this regard by providing public toilet facilities in communities like Bilabiri.

### ***Other infrastructures***

The presence of financial institutions, markets, agro-allied processing facilities, cooperative organization, police post/stations in these communities is rather inadequate and poorly established. Based on the field visits reports for 2012, none of the settlements was found to be serviced by a bank, police posts/stations, agricultural extension facilities and research institutes. Local markets are common in the area where buyers and sellers meet periodically to engage in commercial activities, but the shops are in deplorable stages (**Plate 4.1e**). The most common processing facilities are family owned fish processing facilities. To strengthen social capital, fisher folks and farmers have formed co-operative societies, mostly along family ties.



Plate 4.1e: Ezetu Central Market

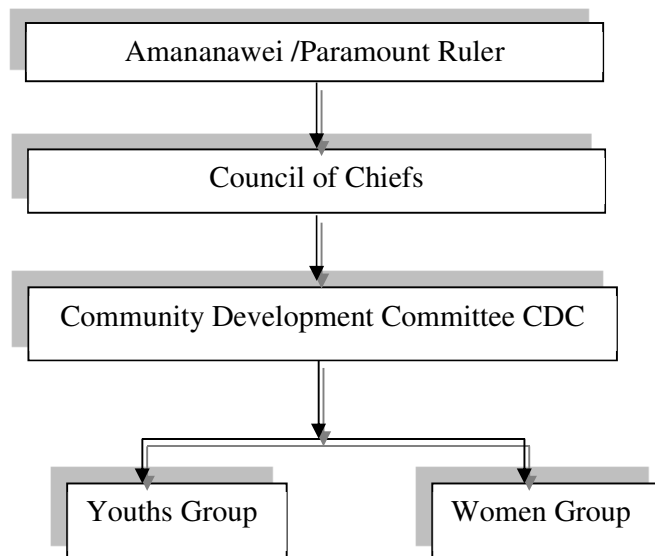
### **Local Governance and Social Structure**

#### ***Leadership structure***

There are two levels of political organizations, the first being formal governmental and the local/traditional administration. The second level of political organization consists of three tiers of authority- the traditional ruler and his Chiefs, Community Development Committee (CDC) executives headed by a chairman, and the youths. The pattern of traditional institutions and local governance observed in the area are ideologically uniform in all the communities. The power structure of each community has at the apex a (traditional) paramount ruler, who is assisted by Council of Chiefs, Elders, Community Development Committee CDC and Youth Executives in ensuring effective local governance and decision-making process. Women groups have since been integrated into the power structure of these communities and is known to have remarkable socio-cultural influences on the society.

There exists a strong leadership structure at the community level in the study area. The political administration is well structured. The CDC, youth and women leaders report to the traditional leader/chief council. It should be borne in mind that the CDC and/youth chairman wields great authority at the community level. Every project activity must of necessity get the approval of this leadership arms if it is to be successfully implemented. These positions are considered financially lucrative and have constituted a source of clash at the community level especially in deciding the next leadership. Fortunately, some communities have evolved a tenural arrangement especially for the position of Youth Chairman by pegging the leadership duration at one year without option of re-contesting. This, no doubt, has greatly contributed to the existence of peaceful transition from one leadership to the next. These tiers of leadership structure align with other studies (EIA of SSAGG of 2003 and EIA of Benisede Catchment Area Phase I 2004) in the area suggesting no change in community leadership structure over the years. This implies a sense of leadership stability at the community level.

The paramount ruler is called or addressed as the Amananawei or king appointed by the Royal House. He is assisted by the council of chiefs Council of elders, Community Development Committees (CDC), the youth council and women council. The power flow of the study area is presented in **Fig. 4.1i**. The Council of Chiefs consists of traditional chiefs among whom a chairman is elected. Their responsibility is to ensure peace, progress and stability. The elder's council are made up/drawn for the oldest members of individual families; old men of proven integrity and impeccable character.



**Fig. 4.3i: Power Flow in the Study Area**

***The role of Youth and Women Group/Association***

The youths of the area are quite active and their most significant role is in the mobilization of the youths for development and in the sensitization of the community about political issues and government projects. They are more vigilant and appear to be in control over information input and dissemination. They are responsible for swift coordination of activities and alertness in the event of day to day running of the community affairs especially when confrontational actions are involved. Like the CDC, the youths are formidable pressure group. They maintain law, order and security in their communities.

In the study area, there exist a number of women groups. Their associations are usually welfare oriented; they render financial and moral assistance to members that are in need. They pursue peace in the land and also carry out sanitation exercises to keep the environments clean. Women also play major role during ceremonial functions such as festivals, marriage ceremonies and burials.

Joint meetings between the various bodies are held from time to time to discuss various issues affecting the communities. It can therefore be stated that the political administration and local level of governance in the coastal communities is basically traditional, title holding, executive committees and group association, local power authority and the direction of flow of power is clearly exhibited, in general the traditional authority is valued with utmost significance. The basis of social stratification is the age of the individual, education and social attainment.

***Conflict Management and Resolution Mechanism***

As in any social environment and in oil producing communities, there are various cases of both internal and external conflicts that have exerted influence on the social structure and

relationship among individuals as well as between the community and oil producing companies, especially SPDC. Internal conflicts are mostly related to domestic issues, land disputes, election of youth executives, compensation matters, and occasional chieftaincy disputes. However, the major party of external conflict that the community has is with SPDC. The major causes of conflict between the communities and SPDC includes the following:

- Non-recognition of communities,
- Oil spills,
- Border/land disputes,
- Agitation for employment,
- Non-payment of compensation.

Others include non-compliance with court rulings and orders, failure to honour MOUs, perceived intimidation of the communities, perceived “divide and rule tactics” and ineffective communication channels (SPDC, 2008). The remoteness of the swamp location and inadequate transport infrastructure means that opportunities for other rewarding enterprises are rare. There is high level of youth unemployment and reasonably high tendencies for restiveness in the area. The perceived injustice in the allocation of national revenue, long-standing marginalization of the Niger Delta and the resource control agitation provide the ingredients for youth restiveness and insecurity. Strategies used in resolving these conflicts in the communities include community meetings, elders-in-council, dialogue, oath taking, appeals and summons, youth council, women councils, the police and courts. There are procedural guidelines for conflict resolution and management in these communities. These include:

- Adjudication by the traditional customary process
- Dialogue
- Reaching of consensus
- Proclamation of sanctions
- Administration of fines such as payment of fines with such things like wines/drink, goat and of cash depending on the adjudged magnitude of the offence
- Administration of oath of sincerity and allegiance to the interest of the community
- Use of law enforcement agents e.g. Police, local police or vigilante.
- Use of court
- Banishment of the culprit for a specified period of time

In the event that a matter is not resolved on the spot when the community member runs foul of the law, the matter is handed over to the lower organ (youth and women) i.e. action group and the deviant are punished according to the gravity of the offence. Serious cases therefore involve meting out serious punishments including ostracism or handing over the criminal to the police. In most cases or more often than not, cases/disputes were amicably settled without resort to the police or court proceedings.

### ***Social Grouping***

The need to have institution, relationships, and norms that shape the quality and quantity of the communities' social interactions have been the propelling factor for formation of social groupings. There are social groups/clubs in the communities e.g. cooperative societies, women club, fishing club and credit groups. These clubs/groups are organized on the basis of common interest and affiliations and also mostly on gender basis. The women with common social identity like marriage or visions such as fostering, friendship and solidarity within their community can form their own social clubs.

Typical women social clubs have lots of cultural trappings which are usually indicated in their names and strict adherence to traditional dresses at public functions. Entertainment through dances at social functions is another area of culture which is commonly practiced by the social clubs. The social clubs provide mutual support for their members in times of child birth, marriage, bereavement and other festive occasions. They also provide common fronts for support of community development programmes, donations of equipment, physical infrastructures and other items for public use. Women are also known to intercede for peace during inter/intra community crises.

As is the case in other Niger Delta communities, there are also age groups in the study communities and each age group embraces children born within a period of three years. The contributions of age groups are generally recognized but their direct roles/responsibilities and involvements in developments differ from community to community. In some communities, they have contributed to the development of physical infrastructures. Generally, they are effective vehicles for social mobilizations and they also offer mutual support for their members during times of bereavement and festivities.

### ***Local Security Arrangement/Management***

The youths of oil producing communities are vibrant and militant and are in-charge of labour, security and protection of their environment, swift co-ordination of activities and alertness in the events of the day to day running of the villages/communities especially when confrontational and security issues are involved. They were solely in-charge of security and defence of their communities prior to the militancy period but with the upsurge and escalation of militancy in the region, the region has been militarized with the Joint Task Force (JTF) taking over the security and defence of the Niger Delta to protect life and property especially multi-national oil workers and installations in the rich oil and gas region of the Niger Delta.

Historically, the study area was generally very peaceful until the problems of militancy in the 1990's and 2000s. In the recent years normalcy has returned to the communities, though occasional fears are still being entertained because of the sporadic nature of attack in the Niger Delta. The reported social vice in the area include: piracy, pipeline vandalization, petty stealing and prostitution which are fast becoming routine activities.

## **Natural Resource Acquisition, Ownership and Management**

### ***Land Ownership/Access and Tenure System***

By providence, in and around the communities and settlements, land resource availability is very limited because of the overwhelming influence of hydrology; myriads of rivers, creeks and creeklets criss-cross the terrain, leaving very limited land space either for habitation or cultivation. Consequently, the little land available is held in very high value, especially since lands on which oil wells and facilities are located confer additional advantages on the land-owning individual, family or community. Two forms of land-ownership are common in the study area under study, namely, *family* and *communal land ownership*. In most communities land is not available for sale, as it is communally owned. Inter community strife over land rights is uncommon in the area. The only significant dispute over land was between the people of Letugbene and Agelabiri over ownership of the land where the SPDC Tunu flowstation is sited but this was since resolved. Responses from 2012 survey carried out in coastal communities in the area affirmed that the structure of landownership as observed in 2012 has not changed significantly from what was tenable in 2008. Result confirmed nature of landownership to be mainly through family inheritance; approximately 96% claimed to have personal land as opposed to 4% that claimed communal landownership.

### ***Forest and wildlife exploitation***

The primary source of energy for cooking in the community is fuel wood which is sourced from the mangrove swamps. The red mangrove is very good for making fire and is especially important to fish smoking and for canoe carving. More than 90% of community members use firewood as energy source, only about 10% use kerosene for cooking. Some members of the communities are engaged in hunting as a source of livelihood, a few others as past time. The wildlife provides the much-needed proteins, vitamins and mineral salts and also income for the people.

### ***Local conservation practices***

As already noted, members of some communities do not kill or eat python, tortoise and white birds, rather their habitats are protected. Equally, sharks are neither killed nor eaten but worshipped as a god. Even though the community members are not doing this as conservation practice per say, it constitutes or serves as a means of conservation of the natural resource base.

## **Lifestyle and Social Vices**

### ***Alcohol and Drug Use***

Based on the opinion of key informants, the level of use and abuse of alcohol and drugs have increased in Niger Delta communities over the years, as more young persons are involved in alcoholism and drug use. About 87% of the community members drink alcohol especially local dry gin and about 55% of the young male smoke cigarettes. Alcoholism is becoming a lifestyle in the coastal communities as well as smoking of cigarettes and Indian hemp especially among the youths. It is common to see youths smoking and drinking strong beverages openly in the public places.

### ***Discrimination against Women***

There appears to be some level of discrimination against women. For example, they have no inheritance rights to land/buildings. However, they are allowed to contest or hold some political positions. The observation at the community level was that women leadership role is expressed within women groups. Only few respondents agreed (25.4%) that women are indeed given the freedom to contest political positions. Some community members interviewed noted that women do not wield real power at the community level.

### ***Child Labour***

Child work as an aspect of child entrepreneurship instead of child labour was a common feature in the communities as children are known to assist parents in their economic activities. Children were seen to help their parents in fish catching, processing and in cutting firewood required for fish processing and this did not affect the school enrolment, retention and completion of the children. This was not perceived as an abuse; though parents succinctly accepted the responsible of caring for their wards, but current realities suggest that assistance of all household members is required to sustain the home economically.

### ***Crime Rate***

The level of crime is moderate. The commonest crime in the area is crude oil theft. Across the coastal communities, the lack of employment opportunities for the teeming youth members is a constant complaint. Statistically, approximately 90% of respondents interviewed in many previous field surveys confirmed this as the most challenging social problems in the area. The number of youths observed hanging around the oil facilities attested to the prevalence of the problem. Lack of gainful employment can effectively account for youth delinquency and other anti-social activities such as the rampant stealing and illegal bunkering activities in the area. It was, therefore, not surprising that some youth members are always very aggressive and are always suspicious toward visitors.

### ***Physically Challenged People***

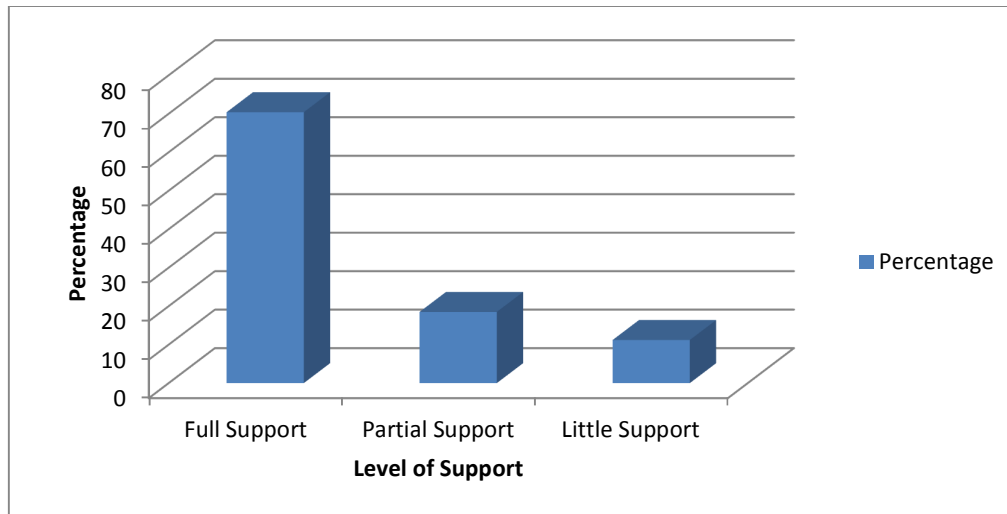
The study examined the status of the physically challenged in the communities. Although physically challenged persons are fully assimilated into the communities, no designed programs are in place to assist them. These people are often left to fend for themselves and can only expect support from family, but all are completely absorbed/ assimilated into the system in the communities, nevertheless there are no programmes specifically designed to assist them. According to the elders, the foundation of the communities is built on justice, equity and fair play.

## **Perceptions, concerns and social needs/expectations of the population**

### ***People's Support for SPDC Project***

The general populace in the Niger Delta communities have a mixed outlook on the presence of the SPDC facilities. Responses from the community members (elders, women and youth respectively) affirmed varying perceptions with respect to positive and negative impacts the SPDC project have on the communities, resulting in respective degrees of support. Field

survey revealed a generally wide support for the project (**Fig. 4.3j**) due to its envisaged benefits. About 70% gave their full support while 18.5% said their support was with reservations. Similarly, 11.5% had little support for the SPDC project. Their lack of full support was borne out of fear that the project usually ends up benefiting few individuals in the community. Equally of concern was that the proposed benefits of SPDC project are mostly hijacked or diverted away by the community leadership who may take the funds and fail to apply such to development projects.



**Fig.4.3j: Support for SPDC projects**

Source: SPDC EER, 2012

***Perceptions of impacts of existing EA/EJA facility on human environment***

Interaction with the population in the EA/EJA FOD project environment revealed a mix of perceptions on how the operations of SPDC have impacted the human and physical environments. Specifically, the general opinion of the youth, adult male and female was that the communities have received more of diseconomies (negative impacts) than economies (positive impacts) as showed in **Table 4.9e**. The people perceived that the negative impacts have occurred since oil and gas development activities intensified in the area.

Table 4.9e: Perceived impacts on the communities from the existing SPDC facilities

<b>Physical environment/Health related issues</b>	<b>Socio-economic issues</b>
Oil spills	Decrease in fish catch
Water pollution due to oil spillage	Harassment by JTF personals
Noise from operations	Acid rain phenomenon
Noise from chopper	Reduction in farm harvest
Destruction of the environmental beauty of the area	Lack of basic amenities
Contamination of local water supplies	Low number of employment of indigenes.
	Increased incidence of oil theft
	Disruption of fishing and other businesses



<b>Physical environment/Health related issues</b>	<b>Socio-economic issues</b>
	of community member

It was the opinion of the people that environmental pollution and hazards particularly from oil spills has effects on fisheries and farm harvests. Also, the emissions and gas flared have caused deterioration in rain water quality (acid rain phenomenon) and thus makes rain water undrinkable. Harassment of inhabitants by the military was mostly reported. Noise pollution resulting from operations and constant chopper flights were reported during the FGD sessions. The people, especially the youth believed that the number of employment opportunities for indigenes were very low and unacceptable.

***Perceptions of impacts of proposed EA/EJA FOD Project activities***

The general population in the EA/EJA FOD neighbouring communities has a mixed outlook on the proposed project. While many perceived the potential impacts of the project in the negative light, a few were hopeful that increased employment opportunities and social infrastructural development could accrue from the increased development activities if properly executed and these will more than compensate for the negative impacts.

Majority of the population (85%) in the project area fear that the proposed project activities shall impact on the livelihood system in more ways than one. These shall include further disruption of fishing activities (31%), pollution of fishing grounds (28%) and blockage of transportation routes (26%). About one-tenth (14%) also fear that crime and other social vices shall increase during project implementation and further impact on their social lives (**Table 4.9f**).

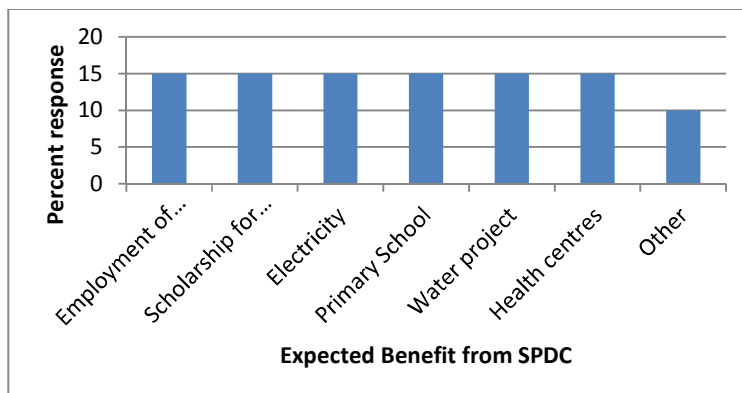
Table 4.9f: Perceived Fears of the people

<b>People’s perceived fears</b>	<b>Percentage of response</b>
Further disruption of fishing activities	31.0
Pollution of fishing grounds	28.0
Blockage of transportation routes	26.0
Increased crime and other social vices	14.0
Damage to cultural properties	1.0
Total	100

***Community Expectations and needs***

Community members in the EA/EJA area have high expectations regarding the proposed project activities with particular reference to the associated benefits and/or positive effects; overall social issues, including increased and more permanent employment opportunities to indigenes at the skilled, semi-skilled and unskilled levels as company’s operations enlarges and as opportunities emerge, economic empowerment of youth and women group through skills training/acquisition and micro-credit programs; vendor services/minor supplies (contractor), compensation for resource losses, scholarships and provision of infrastructures, e.g., educational, health, electricity, water, among others are expectations of the communities.

Statistically, all of the positive expectations have equal weight by respondents at the coastal communities (**Fig. 4.3k**).



**Fig. 4.3k: Benefits expected from EA/EJA FOD Project**

#### 4.2.9: Community Health Profile

Healthcare is the sum of all resources that individuals require to maintain, retain and promote good health, as well as meet challenges of ill health and diseases. The determinants of human health include; environmental (physico-chemical or biological), socio-economic and genetic factors. The health status of communities in the EA/EJA study area has been considered taking into account these determinants.

#### Disease Pattern in the Communities

The EA/EJA neighbouring communities are in similar ecological environment as those in the Atala, Southern Swamp and Eremor fields. The commonest ailments and diseases in the EA/EJA communities are: malaria, leg ulcers, skin rashes, conjunctivitis, cough, respiratory distress, gastro-enteritis, hernias, sexually transmissible infections (SPDC, 2001; Excel E & P, 2005; SPDC, 2013). The proportional morbidity of diseases encountered in the Atala Field communities are malaria 27.5%, gastroenteritis 18%, cough/ catarrh 13.25%, abdominal pains 12.25%, measles 11.5% (Bayelsa Oil Company, 2008). These show that the infectious or communicable diseases are the commonest diseases in the project communities.

The integrated disease surveillance response data for Bayelsa State, (for both in-patients and out- patients) in 2005 revealed that the top three diseases recorded in the State were infectious diseases: malaria 49.88%, diarrhoea 23.65% and sexually transmissible infections 20.24%. These three account for 93.8% of all diseases recorded for the period. Malaria accounted for half of the proportional morbidity of all the diseases. A community woman with fungal skin infection under the breast is shown in **Plate 4.1f**.



Plate 4.1j: Fungal Breast Skin Infection affecting a Community Member

The 2008 National Disease and Health Survey (NDHS) indicated that fever (mainly due to malaria) remains an important cause of illness among children under five. As shown in **Table 4.9g**, 18.1% and 20.6% of under-five children recorded a febrile illness in the two weeks preceding the survey in Bayelsa State and in South-South zone – both being higher than the national median of 15.9%. The Nigeria Malaria Indicator Survey of 2010 reported a malaria slide positive rate of 32.2% among children 6-59 months old in Bayelsa, showing the relative importance of malaria as a cause of febrile illness in the area.

Table 4.9g: Morbidity Pattern among Children in Project State/ Region

	Proportion of children under age five who had a fever in the two weeks preceding the survey	Proportion of children under age five who had diarrhoea in the two weeks preceding the survey	Proportion of children under age five who had ARI in the two weeks preceding the survey
Bayelsa State	18.1%	3.2%	n.a.
South-South Zone	20.6%	3.8%	3.5%
National	15.9%	10.1%	2.8%

Source: NPC and ICF Macro, 2009

Non-communicable diseases have also been documented as important causes of ill health in Bayelsa State where the project is located. Oni *et al.* (2009) reported that stroke patients constituted 2.3% of the total hospital admissions and 9.3% of medical admissions at the Niger Delta University Teaching Hospital, Okolobiri. Hypertension was found in 89% of these individuals that had stroke.

Mortality (deaths) among the most vulnerable population groups, children under-five and women of child-bearing age, have been reported to be high in Bayelsa State. The Multiple Indicator Cluster Survey of 2011 reported that infants (under-1-year-old) died at a rate of 107/1000 live births, which was higher than the average rates in the South-South zone and Nigeria as a whole (**Table 4.9h**). Similarly, the death rate in children under-5 was also relatively higher in Bayelsa State.

Table 4.9h: Mortality Rates in the Project State

	Infant Mortality Rate* (per 1000 live births)	Under-Five Mortality Rate* (per 1000 live births)
Bayelsa State	107	178
South South Zone	75	118
National	97	158

*\*Using North Model*

*Source: Nigeria Multiple Cluster Indicator Survey 2011 (NBS, UNICEF and UNFPA, 2013)*

### Healthcare Facilities and Services

A major deficiency in the EA/EJA area is the lack of healthcare facilities. None of the communities have a doctor, nurse or any other trained medical staff. There are no hospitals, clinics, maternity facilities, or any formal drug-dispensing outlet. There are non-functional healthcare centres at Agge and Ezetu (Plate 4.1k). The main sources of healthcare delivery in the area include:

- The patent medicine stores in these communities. They stocked drugs ranging from painkillers to anti-malarial and antibiotics (Plate 4.1l)
- Traditional healers play a prominent role in providing health care in these communities including fracture bone treatment (Plate 4.1m).
- The Traditional Birth Attendants (TBA) receives a high level of patronage from the pregnant women.

To treat the severely sick from Agge, Letugbeneetc, people have to travel to Burutu in Delta State. Communities in Ekenie and Ezota have to travel to Yenagoa, Bayelsa State Capital, which takes about four hours by speedboat for such treatments.



Plate 4.1k: Non-functional Community healthcare center at Ezetu



Plate 4.1l: A Typical Drug Store in the Community.



Plate 4.1m: Traditional Bone Healer and his Patient in Ezetu Community

### **Nutritional Status and Immunization**

The nutritional pattern in the community follows the general trend in several parts of the country in which starchy food constitute a large part of the family diet. These starchy foods include cassava, rice, yam, garri and dried cassava chaff (kpokpo garri). Other less starchy foods consumed include plantain and beans.

Fish is the chief source of proteins. Seafoods such as, shrimps, crayfish, oysters are the other sources. Vegetables and fruits were consumed but not in large quantities. Basic staples (rice, flour) items are very costly because most of them have to be brought in from Warri, Yenagoa and other inland communities of the Niger Delta. The people however appear strong and healthy and do not show visible signs of malnutrition.

The 2011 Multiple Indicator Cluster Survey reported a prevalence of chronic and acute malnutrition as 15.9% and 7.3%, respectively in Bayelsa State where the project is located. However, these figures represent a decrease in the rates from the 2008 NDHS findings, and are lower than the South-South and national averages. Nonetheless, qualitative information gathered during the fieldwork indicate that the local populace reported health concerns

regarding a declining state of household food security, which they attributed to the lull in economic activities. Regarding the immunization status of children under-five in the communities, Bayelsa State figures for percentage of DPT3 coverage have remained below the averages for South-South zone and Nigeria. This is in spite of the increase observed between 2008 and 2011 as shown in **Table 4.9i**.

Table 4.9i: Nutritional status and immunization status of under-five children in the Projects Region

Variable	Bayelsa State		South-South Zone		National	
	2008*	2011‡	2008*	2011‡	2008*	2011‡
Proportion of children under age five with <b>Height-for-Age</b> below -2 SD of reference value ( <b>Stunting</b> )	28.7%	15.9 %	31.1%	19.5%	40.6%	35.8%
Proportion of children under age five having <b>Weight-for-Height</b> below -2 SD of reference value ( <b>Wasting</b> )	7.4%	7.3%	7.5%	6.5%	13.9%	10.2%
Proportion of children under age five with <b>Weight-for-Age</b> below -2 SD of reference value ( <b>Under-nutrition</b> )	8.0%	12.9%	12.8%	12.1%	23.1%	24.2%
Proportion of children aged 12-23 months who had received <b>DPT3 vaccination</b>	27.6%	38.3%	54.2%	60.2%	35.4%	70.5%

\*National Demographic and Health Survey 2008 (NPC and ICF Macro, 2009)

‡Nigeria Multiple Cluster Indicator Survey 2011 (NBS, UNICEF and UNFPA, 2013)

### **Knowledge, Attitude, Practices and Behaviour on Sexually Transmissible Infections (STI)**

The knowledge, attitude, practices and behaviours of the people on sexually transmissible infections were evaluated because of its public health importance. The awareness of the existence of STI in the communities was high (73.7% of respondents). The males at 41.4% had more awareness than females, 32.3%. About 26.3% of respondents are unaware of the existence of STI. The level of awareness of HIV/AIDS at 81.2% is higher than that of STI even though HIV/AIDS is an STI. This could be due to the high publicity that HIV/AIDS enjoy over the other STIs both locally and internationally. Despite the high awareness of the existence of HIV/AIDS, only 28.7% of the respondents have knowledge of the mode of its transmission in 2005.

According to the 2008 NDHS Report, the proportion of women and men with comprehensive knowledge of HIV/AIDS in Bayelsa State was found to be higher, at 41.7% and 76.2%,

respectively, than figures for South-South zone and Nigeria. However, it appeared that this level of knowledge did not translate into lower risk behaviours in Bayelsa State as higher rates of multiple sex partners were also found among women and men (2.7% and 22.1%) than the average rates for South-South zone and Nigeria (**Table 4.9j**).

Qualitative information obtained from key informants in the communities in 2012 indicated that many of them had heard of HIV/AIDS; that polygamy was common; and there were allusions to preponderance of male infidelity. Due to the importance of tuberculosis (TB) in public health and as an opportunistic infection, the prevalence in the community was assessed. About 19% are aware of current or former cases of infection in the community based on relations diagnosed in hospitals as having the disease and receiving treatment. Use of alcohol and tobacco was also reported in the SSAGG+ EIA Report of 2013, from qualitative assessments. It was noted that, “alcoholic beverages were freely available and at all times in the communities, while about 20% of the adult males in the communities smoke cigarette”.

Table 4.9j: Sexual Behaviour and HIV/AIDS Knowledge in Project Area

	Proportion of women aged 15-49 with comprehensive knowledge of HIV/AIDS	Proportion of men aged 15-49 with comprehensive knowledge of HIV/AIDS	Proportion of women aged 15-49 who had 2+ sex partners in past 12 months	Proportion of men aged 15-49 who had 2+ sex partners in past 12 months
Bayelsa State	41.7%	76.2%	2.7%	22.1%
South South Zone	26.0%	37.0%	2.2%	18.4%
National	23.4%	44.9%	1.0%	9.9%

Source: NPC and ICF Macro, 2009

## Environmental Health

### *Access to Safe Drinking Water*

Access to potable water is a major problem in the EA/EJA neighbouring communities. Water for drinking and sundry domestic needs is obtained from hand dug wells (often of high salinity), creeks (**Plate 4.2a**) and rainwater. Boreholes in Agge, Letugbene and a ringwell in Ekenie are unserviceable. In most cases the water is unfit for human consumption and not even for general domestic use. The reliance on creek and local well water makes these communities very vulnerable to the effects of pollution from oil or chemical spills.



Plate 4.2a: Fetching Water from Creek for Domestic Use in Ezetu Community

Likely sources of potable water include, pipe borne well or borehole, and protected well. Data from the 2011 Multiple Indicator Cluster Survey showed that less than one-third (27.5%) of households in Bayelsa State have access to improved drinking water sources (**Table 4.10a**). Though this represents a slight increase from the 26.6% reported in the 2008 NDHS, the figure is lower than the zonal and national averages.

Table 4.10a: Access to Improved Drinking Water Sources and Sanitation Facilities

<b>Proportion (%) of Households having:</b>	<b>Bayelsa</b>	<b>South-South</b>	<b>National</b>
<b>Improved drinking water</b>			
Piped into dwelling, plot or yard	1.3	4.1	4.7
Other improved	26.2	66.4	53.9
<b>Unimproved drinking water</b>	72.5	29.5	41.5
<b>Total</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
<b>Improved Sanitation</b>	8.4	30.4	31.0
<b>Unimproved Sanitation</b>			
Shared improved facilities	8.7	25.3	20.3
Unimproved facilities	50.8	21.7	20.2
Open defecation	32.1	22.6	28.5
<b>Total</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>
<b>Improved drinking water sources and improved sanitation</b>	<b>4.3</b>	<b>25.4</b>	<b>21.6</b>

Source: Adapted from National Bureau of Statistics (NBS) [Nigeria], UNICEF and UNFPA. Nigeria Multiple Indicator Cluster Survey 2011: Main Report. Abuja, Nigeria: National Bureau of Statistics. April 2013.

#### ***Household Wastes and Access to Sanitation Facility***

The wastes generated in the area were from domestic, agricultural and fishing activities. The domestic wastes include ashes, cassava peels, food remains, kitchen wastewater, vegetable,



and fish parts including human/animal faeces. These wastes are disposed by open dumping on land (**Plate 4.2b**), into the water bodies and at times used as manure in the farms. The human wastes are disposed via direct defecation into the water bodies, on land and pit latrine. There is no waste recycling.



Plate 4.2b: Open Dumping of Refuse on Land

Sanitation facility is defined as a private excreta disposal facility that is either a toilet or a latrine, but not an overhung toilet, or a flush toilet without septic tanks that channels its effluents directly into the river (NBS, UNICEF and UNFPA, 2013). A household is classified as having an improved toilet if the toilet is used only by members of one household (i.e. it is not shared with other households) and if the facility used by the household separates the waste from human contact (WHO/UNICEF, 2004).

Data from the 2011 Multiple Indicator Cluster Survey showed that only 8.4% of households in Bayelsa State have access to improved sanitation facilities (**Table 4.11a**). This represents a slight increase from the 6.1% reported in the 2008 NDHS. This figure is far lower than the zonal and national averages of 30.4% and 31.0% respectively. Among those that use unimproved sanitation facilities, over-hung toilets and open defecation were pronounced. Open defecations were reported as high as 32.1% of households in Bayelsa State. Qualitative assessments conducted in 2012 among members of the project communities corroborated the widespread use of over-hung (jetty-type) toilet (**Plate 4.2c**). The use of overhung toilet not only contaminates the receiving water body with fresh faeces, but also has been linked to several excreta-related diseases, including diarrhoea and typhoid.



Plate 4.2c: An Over-hung toilet in a Riverine Community in Bayelsa State

### *Housing Conditions*

The quality of housing contributes to health problems in the area. Overcrowding and poor ventilation are major problems. The houses are mainly small huts (**Plate 4.2d**) with inadequate ventilation. There are on the average 6 to 7 persons per hut and a consequence of this is the high rate of spread of skin and airborne diseases. In most houses there is one communal living/cooking room. Fish and other seafood are smoked in the huts exposing inhabitants to high levels of air pollution, respiratory conditions are caused and exacerbated by the smoky atmosphere.

The 2008 NDHS Report showed that not many households in Bayelsa State own insecticide-treated mosquito nets (ITNs) or reported that household members sleep under them (**Table 4.10b**). This figure increased from 2.4% to 19.0% following the mass distribution of 576,192 Long-Lasting Insecticide-treated Nets by the national and Bayelsa State Malaria Control Programmes in 2011. However, the nets utilization rate reduced from 8.1% to 6.7% and this was lower than rates reported for the South-South zone and the national average.



Plate 4.2d: A thatch house at a fishing port in the Community

Table 4.10b: Ownership and Use of Mosquito Nets in Project Region

Variable	Bayelsa State		South-South Zone		National	
	2008*	2011‡	2008*	2011‡	2008*	2011‡
Proportion of households with at least 1 Insecticide-Treated Net (ITN)	2.4%	19.0%	10.3%	39.6%	8.0%	38.6%
Proportion of under-five children who slept under an ITN	8.1%	6.7%	9.4%	21.5%	5.5%	16.4%

## Consultations

### Consultation/ Stakeholder Engagement

In the EIA process, consultation is accorded high priority so as to capture and address issues and concerns of the stakeholders. Consultation with the identified stakeholders for the EA/ELA FOD Project is designed to be a continuous process throughout the development and operation of the facilities. The principal objective is to acquire and disseminate information, identify and address legislative, community, and environmental concerns, proffer appropriate mitigation options for all the negative impacts, and enhance the positive impacts.

The scoping workshop held on Thursday September 05, 2013 at the conference hall of Matho-Crystal hotel, Yenagoa served as the first contact between SPDC and the various stakeholders and the neighbouring communities involved with the project. Relevant stakeholders were identified and engaged during the scoping exercise (**Plate 4.2e**). Consultation is a continuous process that spans through the life cycle of the project. Stake holders invited include:

- Regulators – DPR, FMEnv, NIWA, Bayelsa State Ministry of Environment.
- Southern Ijaw Local Government Area and Ekeremor Local Government Area Chairmen (Bayelsa State)
- SPDC team (including community Relation Team (CLOs), Impact Assessment team and EA/EJA Project team).
- Non-Governmental Organizations (NGOs) – Niger Delta Peace Coalition (NDPC).
- EIA Consultants.
- Representatives of twelve (12) Stakeholders communities within the proposed project area.

### Scoping Workshop Aims and Objectives

The EIA Act requires an EIA reports on all proposed projects and significant modifications to existing facilities or projects. In line with the new SPDC EIA Process Manual, consultations are part of all EIA reports and hence the present consultation initiative which is intended to carry along all the stakeholders in this project. The consultation process for the EIA is undertaken at an early stage to help develop a scope of issues to be addressed and to identify the significant issues relating to the project activities. Stakeholders were made to express

their perceptions and expectations, identify potential impacts (adverse and beneficial), propose measures to mitigate the negative impacts and enhance the positive impacts. The Terms of Reference (ToR) was developed after the Scoping Workshop. It was developed in an integrated manner to include the Scope of Work for Biophysical, Social and Health Impact Assessments.

### **Issues and Concerns**

Interaction with the community was positive and there was widespread appreciation of the consultation process undertaken. The summary of concerns expressed by the major stakeholders, especially the 12 neighbouring communities during the scoping workshop include the under listed:

- The dredging activity proposed as part of the project may close up the Dodo River mouth. (Dredging has however, been expunged from the project activities).
- Fishing which is the main occupation of the people may be a thing of the past due to the project impacts.
- There should be full implementation of community content.
- Loss of fishing may lead to low income and unemployment.
- Dredging may cause more erosion problems due to heavy duty equipment and tidal waves. (Dredging has however, been expunged from the project activities).
- Emission of gaseous substances will cause heavy corrosion which is already experienced in the communities due to continuous gas flaring.
- Provide health facilities and make existing facilities functional.
- In course of this project, comply strictly with employment acts and regulations.
- Increase funding level of the GMOU to enable the execution of more projects in the communities.
- There may be increase in piracy, so increase number of surveillance in the communities.
- There will be noisy operations and other construction impacts. Gaseous emission, spill, etc due to construction activities.
- Water pollution will lead to the scaring away of fishes in the area.
- Sudden pollution due to oil spill may lead to destruction of economic trees.
- There will likely be change in the quality of sea water as a result of the projects activities.
- The project activities will negatively affect aquatic life.
- Oil spillage most likely due to oil field operations will affect livelihood.
- Social and economic lives will drastically be affected.
- There may be landslide, shore cuts, depression and collapse of lands and coastline communities.
- The project will definitely bring waste deposits on coastline communities and oil emission that will impact water flora and fauna
- Flooding and overflow of tide due to oil field operations.

- Project will bring more development and infrastructure to the communities that will help curb youth restiveness.
- Project community content will boast socio-economic activities in the communities.
- Chemical pollution- e.g. radioactive materials may bio-accumulate in marine organisms. Materials like drilling mud, effluents, sewage, radioactive isotopes used in agitating oil wells might affect the environment negatively.
- Flares- from oil wells (i.e gas wells) might trigger acid rain.
- Construction of underwater pipelines and associated structures will lead to the formation of an entirely new ecosystem. Invasive species might prey on the native species leading to extinction and loss of livelihood on the part of fishermen.
- Though the economy of the impacted communities will improve, the health effects might be challenging due to incidence of diseases like HIV/AIDS.
- There may be serious agitation due to limited job slots.
- Groundwater in the neighbouring communities should be studied to ascertain possible interactions and seepages.
- There will be littering of domestic wastes from drilling operations, health risks like sight problems. Desecrating of native culture and tradition by job seekers flooding the area in search of jobs.

In response SPDC advised the communities to include areas of concerns relating to the provision of infrastructure in their Participatory Rural Appraisal Programmes for greater attention by SPDC. In addition, SPDC reiterated that:

- All complaints/issues raised outside the context of the project shall be sent to appropriate authorities
- Terms of reference (TOR)/scope of work from the workshop will form the basis of the EIA study
- Consultation will be continuous and all mitigation measures shall be implemented.

The requests made by the various communities are summarized as follows:

- Creation of job opportunities for the host communities during the project execution phase.
- Provision of potable water, electricity, cottage hospitals and river transportation.
- Involvement of the communities in the EIA study
- Implementation of appropriate mitigation measures

### **Future consultations**

SPDC, contractors and subcontractors would continue to consult with all relevant parties (host communities, Ekeremor and Southern Ijaw LGAs, Bayelsa state government, the Federal Ministry of Environment, DPR) and all parties concerned with or are likely to be affected by the project, at all stages of the project development.



Plate 4.2e: Cross section of the EA FOD communities at the scoping workshop

## **CHAPTER FIVE**

### **POTENTIAL, EXISTING, ASSOCIATED AND CUMULATIVE IMPACTS**

#### **5.1: Introduction**

This chapter presents findings from the assessment of impacts of the proposed SPDC EA/EJA further oil development activities. It includes consideration of potential impacts on the bio-physical and socio-economic environment as well as human health and safety; related to normal project activities in addition to those that might result from abnormal occurrences. The impacts identified were subsequently characterized, evaluated and ranked. The analysis of impacts would ensure sound environment and social management of the project during its lifespan.

Mitigation measures to ensure that the potential negative impacts of the project on the environment are eliminated or reduced to as low as reasonably practicable (ALARP) are documented in **chapter six** of this report. Thereafter, an Environmental Management Plan was developed for the effective functioning and implementation of measures to cover the entire life cycle of the proposed project as documented **chapter seven**.

#### **5.2: Assessment of Potential Impacts using ISO 14001 and RAM Method**

In assessing and evaluating the project's potential and associated impacts, ISO 14001 and risk assessment matrix method (RAM) was used. The method is simple to apply and provides a high level of detail that can be both subjective and objective. In line with general guidelines for an Environmental Impact Assessment (EIA) process, the following were the basic steps adopted for identification and evaluation of impacts:

- Impact identification
- Impact description
- Impact qualification
- Impact risk and severity rating

##### **5.2.1: Potential Impact Identification**

The aim of impact identification is to account for the entire potential and associated bio-physical, social and health impacts making sure that both significant and insignificant impacts are accounted for. The anticipated impacts were determined based on the interaction between project activities and environmental sensitivities. The identified existing, associated, potential and cumulative impacts of the project are listed in **Table 5.1**.

##### **5.2.2: Impact Description and Qualification**

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

- Positive or negative
- Direct or indirect

Negative impacts are those that adversely affect the biophysical environments while positive impacts are those which enhance the quality of the environment. Direct impacts refer to those

impacts that are caused by the project activity and occur at the same time and place. Indirect impacts are impacts caused by a project activity but would occur in the future or outside the project area and are reasonably foreseeable. Impacts are qualified either as:

- Short term < 3 months (S) or Long term > 3 months (L), or
- Reversible (R) or Irreversible (I).

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. Reversible means the environment can revert to its previous conditions, while irreversible means the impacts remain permanent even after the activity causing the impact is terminated.



Table 5.1: Associated and Potential Impacts of Proposed EA/EJA Further Oil Development Project

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
<b>PRE-CONSTRUCTION</b>	Survey	<ul style="list-style-type: none"> <li>• Measurements (access, geotechnical/geomechanical, pipeline route)</li> <li>• Transportation</li> </ul>	<ul style="list-style-type: none"> <li>• Risk of accident</li> <li>• Risk of Piracy &amp; kidnapping</li> </ul>
	Mobilization of Equipment and Personnel to Site	<ul style="list-style-type: none"> <li>• Transportation of personnel, materials, equipment and Rig to site by road and water;</li> <li>• Employment of local labor and award of contracts;</li> </ul>	<ul style="list-style-type: none"> <li>• Impairment of air quality from emissions of air pollutants including greenhouse gases</li> <li>• Increase in noise and vibration/levels</li> <li>• Increase potential for water traffic volume and accidents from movement of heavy equipment to worksites</li> <li>• Interference of water transport and fishing activities</li> <li>• Kidnappings</li> <li>• Third party agitations</li> <li>• Increase in income to local hired labor hands</li> </ul>
<b>CONSTRUCTION</b>	Pipeline laying	<ul style="list-style-type: none"> <li>• Excavation, welding, stringing, hydro-testing back filing</li> <li>• Abstraction and Disposal of hydrotest water</li> <li>• Maintenance and use of radiological materials</li> </ul>	<ul style="list-style-type: none"> <li>• Impairment of air quality by emissions of air pollutants including greenhouse gases</li> <li>• Noise and vibration nuisance</li> <li>• Impairment of health by ionizing radiations from radiological materials</li> <li>• Risk of inhalation of welding fumes</li> <li>• Soft tissues damage from welding sparks</li> <li>• Risk of loss or damage to eyes from welding flash</li> <li>• Opportunities for business and employment</li> <li>• Third party agitation</li> <li>• Risk of Accidents and injuries</li> <li>• Contamination of the surface water and sediment by wastes and turbidity</li> <li>• Impacts on water and benthic organisms</li> </ul>
	Drilling (Rig positioning, Casing, Logging, Cementation, Production (well Testing), Production (operations))	<ul style="list-style-type: none"> <li>• Boring into the earth crust to get to the Oil &amp; Gas Reservoir</li> <li>• Employment of local labour and award of contracts to members of the communities</li> <li>• Waste generation and disposal</li> <li>• Movement of supply vessels</li> </ul>	<ul style="list-style-type: none"> <li>• Impairment of air quality by emissions of air pollutants including greenhouse gases</li> <li>• Noise and vibration nuisance</li> <li>• Danger of explosion and fire</li> <li>• Continuous glare from rig operation</li> <li>• Opportunities for business and employment</li> <li>• Water pollution from chemicals, drill cuttings and mud</li> <li>• Third party agitation</li> </ul>

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
			<ul style="list-style-type: none"> <li>• Accidents and injuries</li> <li>• Contamination of the surface water and sediment by wastes</li> <li>• Smothering of benthic habitats and organisms</li> <li>• Destruction of breeding grounds</li> <li>• Threats to marine wild life</li> <li>• Interference of water transport and fishing activities</li> </ul>
<b>DEMOBILIZATION</b>	Mobilization of Equipment and Construction workers out of the project site	<ul style="list-style-type: none"> <li>• Transportation of personnel, materials, equipment and Rig from site by water and air</li> <li>• Downscaling of local labour and community contracts</li> <li>• Emigration of workers and followers (dependents, bounty seekers) from the host Communities</li> <li>• Movement of supply Vessels on water</li> <li>• Clearing and Disposal of wastes</li> </ul>	<ul style="list-style-type: none"> <li>• Impairment of air quality by emissions of air pollutants including greenhouse gases</li> <li>• Water traffic incidents</li> <li>• Improper disposal of materials removed from site</li> <li>• Increase in noise and vibration level</li> <li>• Loss of employment/ income</li> </ul>
<b>OPERATIONS AND MAINTENANCE</b>	Operation of well clusters	<ul style="list-style-type: none"> <li>• Oil and gas production and sales</li> <li>• Waste production and disposal</li> <li>• Disposal of Domestic effluents and Produce water</li> <li>• Movement of supply vessels and chopper</li> </ul>	<ul style="list-style-type: none"> <li>• Impairment of air quality by emissions of air pollutants including greenhouse gases</li> <li>• Environmental pollution arising from improper disposal of lubricants and oily debris</li> <li>• Water and sediment degradation from wastes and effluents disposal</li> <li>• Equipment failure and damage leading to injuries/fatality</li> <li>• Revenue generation to government and company</li> <li>• Increase in noise and vibration levels</li> <li>• Oil and Gas leaks</li> <li>• Danger of explosion and fire</li> <li>• Skills training and acquisition</li> </ul>
<b>DECOMMISSIONING &amp; ABANDONMENT</b>	Demolition of structures and removal of well casings	<ul style="list-style-type: none"> <li>• Transportation of personnel, materials, equipment and wastes from site by water</li> <li>• Disengagement of local labour and</li> </ul>	<ul style="list-style-type: none"> <li>• Increase in noise and vibration/levels</li> <li>• Interference with water transport and fishing activities</li> <li>• Kidnappings</li> <li>• Impairment of air quality from fumes, dust, including</li> </ul>

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Project Activity	Project Activities/ Environmental Aspects	Potential and Associated Impacts
	Demobilization of Equipment, Materials and Wastes out of the project site	community contractors <ul style="list-style-type: none"> <li>• Excavation of pipelines and well head and umbilicals</li> <li>• Clearing and Disposal of solid wastes</li> </ul>	greenhouse gases <ul style="list-style-type: none"> <li>• Employment and income generating opportunity</li> <li>• Potential for conflicts arising from labor issues</li> <li>• Third party agitations</li> <li>• Increase potential for road traffic volume and accidents from movement of heavy equipment from project sites</li> <li>• Increase potential for water traffic accidents/injury</li> <li>• Potential for inhalation of welding fumes</li> <li>• Oil and Gas leaks</li> <li>• Impairment of surface water and sediment quality from excavation of well head and pipelines</li> <li>• Degradation of sediments and surface water by spills and leaks</li> <li>• Danger of explosion and fire</li> <li>• Injury/fatalities in workforce</li> <li>• Destruction of benthic flora and fauna</li> <li>• Interference with marine wild life</li> </ul>

### 5.3: Impact Risk Assessment

The risk that an impact poses is determined using the Risk Assessment (RAM) tool shown in **Figure 5.1**. The environmental consequences arising from use of the RAM is defined in **Table 5.2**. The impact risk is rated as:

- 1= Low risk
- 3 = Medium/intermediate risk
- 5 = High risk

Consequences					Increasing Likelihood				
					A	B	C	D	E
Severity	People	Assets	Environment	Reputation	Never heard of in the industry	Heard of in the industry	Has happened in the Organization or more than once per year in the industry	Has happened at the location or more than once per year in the Organization	Has happened more than once per year at the Location
0	No injury or health	No damage	No effect	No impact					
1	Slight injury or	Slight damage	Slight effect	Slight impact		<b>Low</b>			
2	Minor Injury or	Minor damage	Minor effect	Minor impact		<b>Risk</b>			
3	Major Injury or health	Moderate damage	Moderate effect	Moderate impact			<b>Medium</b>		
4	PTD or up to 3	Major damage	Major effect	Major impact			<b>Risk</b>	<b>High</b>	
5	More than 3	Massive damage	Massive effect	Massive impact				<b>Risk</b>	

**Fig. 5.1: Risk Assessment Matrix**

Table 5.2: Definition of Consequence in the Risk Matrix (RAM)

Severity	Potential Impact	Definition
0	Zero effect	No environmental damage. No change in the environment. No financial consequences.
1	Slight effect	Local environmental damage within the fence and within systems. Negligible financial consequences.
2	Minor effect	Contamination, damage sufficiently large to affect the environment. Single exceedance of statutory or prescribed criteria, single complaint. No permanent effect on the environment
3	Localized effect	Limited loss of discharges of known toxicity. Repeated

Severity	Potential Impact	Definition
		exceedance of statutory or prescribed limit. Affecting neighborhood
4	Major effect	Severe environmental damage. The company is required to take extensive measures to restore the contaminated environment to its original state. Extended exceedance of statutory or prescribed limits
5	Massive effect	Persistent severe environmental damage or severe nuisance extending over a large area. In terms of commercial or recreational use or nature conservancy, a major economic loss for the company. Constant high exceedance of statutory or prescribed limits.

Source: SIEP (1996).

#### 5.4: Determination of Impact Rating and Significance

The ISO 14001 methodology, for determining potential impact rating and significance, is adopted in this study. The criteria employed in evaluating the potential impacts are:

- 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).

Each of the criteria is weighted on a scale of 0, 1, 3 and 5 depending on the perceived significance of the impact under consideration. This is a modification of the arbitrary scale proposed by Vesilind, *et al.* (1994). The weightings are 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 (RAM)?**

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

- **Frequency of Impact (F) – What is the frequency rating of impact?**

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

- The frequency of occurrence of each impact was determined from historic records and consensus of experts' opinion.

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

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

The perception of the general public on each potential impact were determined through consultation and consensus of opinions of environmental professionals.

- **Importance of affected environmental components and impacts (I) – What is the rating of importance based on consensus of opinions? Will the impact be localized or spread to cover greater areas of the environmental component?**

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

The importance of affected environmental component was determined through consultation and consensus of opinions.

This approach combines the following factors in assessing the overall rating of the potential impacts of the proposed 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 overall impact significance rating is determined as shown in **Table 5.3**. The potential and associated impacts of the project are presented in **Table 5.4**. All impacts with the Medium and

High Ranking are considered significant and will require mitigation measures. Impacts with Low ranking will be addressed by application of the SPDC HSE Policy. Impacts rated as positive do not require mitigation and are considered Beneficial. Significant and beneficial impacts are discussed in the proceeding paragraphs.

Table 5.3: Impact Value and Rating

<b>Impact value</b>	<b>Cut off values</b>	<b>Impact Rating</b>	<b>Impact Significance</b>
L+R+F+I+P	<8	Low	<b>Not Significant</b>
	≥8 but <15	Medium	<b>Significant</b>
	≥15	High	
F + I	≥6		High
P	= 5		
Positive		Positive	<b>Beneficial</b>

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Table 5.4: Ranking of Potential and Associated Impacts of Proposed EA Further Oil Development Project

Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification						Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total		F+I
Pre-construction (survey)	Risk of accident from vessel collision,		√	√		√	√	√	√	0	3	3	3	3	12	6	H
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
Mobilization (equipment & personnel), and Rig Movement	Impairment of air quality from equipment		√	√		√		√		3	1	3	1	1	9	2	M
	Increase in noise and vibration		√	√		√		√		3	1	1	3	1	9	2	M
	Interference with fishing activities		√	√		√		√		0	1	1	3	1	6	4	L
	Interference with water transport		√	√		√		√		0	1	3	1	1	6	4	L
	Risk of accident from marine collision		√	√		√	√	√	√	0	3	3	3	3	12	6	H
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
Site preparation (piling)	Increase in noise and vibration from heavy machineries		√	√		√	√	√		5	3	3	3	1	15	6	H
	Interference with fishing activities		√	√		√		√		0	1	1	3	1	7	4	L
	Risk of accident from dropped objects and structural failures		√	√		√	√	√	√	0	3	3	3	3	12	6	H
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
	Fish-kills		√	√			√		√	0	3	3	3	1	10	6	H
	Aggregation of bottom sediments		√	√			√		√	0	3	3	3	1	10	6	H
	Impairment of water quality (turbidity and		√	√			√		√	0	3	3	3	1	10	6	H



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Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification							Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I		
	suspended solids)																	
<b>Installation and positioning of Wellhead Platform</b>	Increase in noise and vibration		√	√		√	√	√	√	3	3	3	3	1	15	6	H	
	Interference with fishing activities		√	√		√		√		0	1	3	3	1	8	6	M	
	Risk of accident from lifting and hoisting activities		√	√		√	√	√	√	0	3	3	3	3	12	6	H	
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H	
	Impacts of Wastes (metal scrap)		√	√		√		√		3	1	3	3	3	13	6	H	
	Impairment of air quality from emissions		√	√		√		√		3	1	1	1	1	7	2	L	
	Duty of care extended to Contractor yard	√		√		√	√	√									P	
<b>Drilling</b>	Impairment of air quality		√	√		√		√		3	1	3	1	1	9	4	M	
	Noise and vibration nuisance		√	√		√		√		3	1	3	1	3	11	4	M	
	Injuries and death from failure of BOP		√	√		√	√	√	√	0	5	1	5	5	16	6	H	
	Explosion from Well blowout		√	√		√	√	√	√	0	5	1	5	5	16	6	H	
	Continuous glare from rig operations		√	√		√		√		0	1	3	1	1	6	4	L	
	Opportunities for business and employment	√		√		√	√	√									P	
	Increased oil production	√		√		√	√	√									P	
	Increased revenue	√		√		√	√	√									P	

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Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification							Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Impairment of water and sediment quality from accidental release of hydrocarbons, drill cuttings		√	√		√		√		3	3	3	3	3	15	6	H
	Increased waste volumes - drilling cuttings and muds		√	√		√		√		5	3	3	3	3	17	6	H
	Smothering of benthic flora and fauna		√	√		√		√		0	1	1	3	1	6	4	L
	Interference with marine wildlife		√	√		√		√		0	1	1	3	1	6	4	L
	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure , dropped objects		√	√		√	√	√	√	0	5	3	5	5	18	8	H
	Accidental ignition of released hydrocarbons		√	√		√	√	√	√	0	5	3	5	5	18	8	H
	Structural failures due to fatigue – Derrick collapse, crane collapse,		√	√		√	√	√	√	0	5	1	5	5	16	6	H
	Risk of dropped objects during lifting and hoisting activities		√	√		√	√	√	√	0	5	1	5	5	16	6	H
	Accidents from naked flame jobs within existing live facilities		√	√		√	√	√	√	0	5	1	5	5	16	6	H
	Drop in production due to risk of		√	√		√	√	√	√	0	5	1	5	5	16	6	H

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification							Impact Rating	
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I		
	unplanned shutdown during SIMOPS																	
<b>Pipeline construction (Piping/ flowlines, well hook-up)</b>	Increase in income generating activities	√		√		√	√	√										P
	Disruption of spawning and migratory routes for marine mammals		√	√		√		√		0	1	1	3	1	6	4	L	
	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure		√	√		√	√	√	√	0	3	3	3	3	12	6	H	
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H	
	Impairment of air quality		√	√		√		√		5	3	3	1	1	13	4	M	
	Increase in noise and vibration levels		√	√		√		√		3	3	1	3	1	11	4	M	
	Impairment of water quality (turbidity and suspended solids)		√	√		√	√	√		3	3	1	3	5	15	4	H	
	Exposure to radiation during pipeline welding and stringing		√	√			√		√	3	3	1	3	5	15	4	H	
	inhalation of welding fumes		√	√		√		√		3	3	1	3	3	13	4	M	
	Soft tissues damage from welding sparks		√	√		√		√		3	3	1	3	3	13	4	M	
	Corneal flash burns (photokeratosis) from welding		√	√		√		√		3	3	1	3	3	13	4	M	

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification							Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Potential for conflicts arising from labour issues		√	√		√		√		3	5	3	3	3	17	6	H
	Stress on existing security structures		√	√		√	√	√	√	0	5	3	5	5	18	10	H
	Contamination of water from inhibited hydrotest water		√	√		√		√		3	1	1	1	1	7	2	L
	Interference with water transport and fishing activities		√	√		√		√		0	1	1	1	3	6	2	L
<b>Demobilization</b>	Impairment of air quality		√	√		√		√		3	1	1	3	5	13	4	M
	Water traffic incidents		√	√		√	√	√	√	0	3	3	3	3	12	6	H
	Improper disposal of materials removed from site		√	√		√	√	√		3	3	1	3	3	13	4	M
	Increase in noise and vibration level		√	√		√		√		3	3	1	3	1	11	4	M
	Loss of employment/income		√	√		√	√	√	√	0	5	3	3	5	16	6	H
	Risk of accident from vessel collision		√	√		√	√	√	√	0	3	3	3	3	12	6	H
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
	Interference with water transport and fishing activities		√	√		√		√		0	1	1	1	3	6	2	L
<b>Commissioning</b>																	
<b>Operations and Maintenance</b>	Improper disposal of materials		√	√		√	√	√	√	3	3	3	3	3	15	6	H

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification							Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Revenue generation to government and company	√		√			√	√		-	-	-	-	-	-	-	P
	Increase in noise levels		√	√			√	√		3	1	1	1	1	7	2	L
	Air quality impairment from Well flare/vent		√	√		√	√	√		5	3	5	5	3	21	10	H
	Impairment of water quality from produced water discharges and leaks		√	√		√	√	√		5	3	5	3	3	19	8	H
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H
	Leaks from process pipes, Well head equipment, flanges, subsea lines etc.		√	√		√	√	√	√	0	5	3	5	5	18	8	H
<b>Decommissioning and Abandonment</b>	Employment and income generating opportunity	√		√		√		√									P
	Increase in noise and vibration		√	√		√		√		3	3	1	3	1	11	4	M
	Interference with water transport and fishing activities		√	√		√		√		0	1	1	1	3	6	2	L
	Impairment of air quality from emission of HWR		√	√		√		√		3	1	1	1	1	8	2	M
	Risk of accident from well blowout during decommissioning		√	√		√	√	√	√	0	3	3	3	3	12	6	H
	Risk of Piracy & kidnapping		√	√		√	√	√	√	0	5	3	5	5	18	8	H

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Activity	Impacts	Impact Description				Impact Qualification				Impact Quantification							Impact Rating
		Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Increase potential for water traffic accidents/ injury		√	√		√	√	√	√	3	1	1	3	1	9	4	M
	Potential for conflicts arising from labour issues		√	√		√		√		0	1	3	5	5	16	8	H
	Impairment of surface water and sediment quality from complete decommissioning activities		√	√		√		√		3	3	1	3	3	13	4	M
	Disruption of aquatic fauna community		√	√		√		√		0	3	1	3	1	8	4	M
	Interference with marine wildlife		√	√		√		√		0	1	1	1	1	4	2	L
	Injury/fatalities in workforce		√	√		√	√	√	√	3	3	1	3	3	13	4	H

## **5.5: Potential Impacts**

**Table 5.4** present the potential impacts of the proposed EA further oil development project. Only the medium and high impacts are described in this subsection. The impacts rated low were not described and could be effectively addressed by routine SPDC procedures and would therefore not require mitigation.

### **Premobilization (pipeline route survey)**

#### ***Risk of accident***

There is potential risk of accident particularly drowning during the pipeline and flowline survey. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

#### ***Risk of Piracy & kidnapping***

Piracy and kidnapping could occur during hydro-surveys. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

### **Mobilization (equipment & personnel) and Rig Movement**

#### ***Impairment of air quality***

Transportation of equipment, materials and personnel via road, air and water to site could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO<sub>2</sub>, NO<sub>2</sub>, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

#### ***Increase in noise and vibration***

Noise and vibrations could increase during mobilization to site. Current noise levels at site were 45.56±1.18 dB (A), which is far lower than the regulatory limits of 85 dB (A). However, this impact was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

#### ***Risk of accident***

There is potential risk of accident particularly drowning during mobilization to site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

***Risk of Piracy & kidnapping***

Piracy and kidnapping could occur during mobilization to site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

**Site preparation (piling)**

***Increase in noise and vibration***

Noise and vibrations could increase during site preparation particularly piling. Current noise levels at site were  $45.56 \pm 1.18$  dB (A), which is by far lower than the regulatory limits of 85 dB (A). But during piling, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the piling period, reversible and was rated as high impact.

***Interference with fishing activities***

Piling could affect fishing activities especially at the continental shelf. The impact was described as negative, direct, short-term, reversible and was rated medium.

***Risk of accident***

There is potential risk of accident particularly drowning during site preparation. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

***Risk of Piracy & kidnapping***

Piracy and kidnapping could occur during site preparation. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

**Fabrication, positioning and Installation of Wellhead Platform**

***Increase in noise and vibration***

Noise and vibrations could increase during fabrication, positioning and installation of well platforms. Current noise levels at site were  $45.56 \pm 1.18$  dB (A), which is by far lower than the regulatory limits of 85 dB(A). But during construction, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the piling period, reversible and was rated as high impact.

***Interference with fishing activities***

Installation of the well head could affect fishing activities especially at the continental shelf. The impact was described as negative, direct, short-term, reversible and was rated medium.



### ***Risk of accident***

There is potential risk of accident particularly during site construction. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

### ***Risk of Piracy & kidnapping***

Piracy and kidnapping could occur during site construction. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

### ***Impacts of Wastes***

Various streams of wastes could be generated during site construction including liquid (oily wastewater, sewage and effluents from barges and houseboats), air emissions (fumes from welding activities and generators) and solid wastes (wood wastes, iron offcuts, plastics, cement and concrete wastes). Waste generation during construction activities could mount pressure on existing waste management infrastructure on Sea Eagle. On the other hand, poor waste management could impact the environment negatively. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the construction period, reversible and was rated as high impact.

### ***Impairment of air quality***

Site construction could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO<sub>x</sub>, NO<sub>x</sub>, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

## **Drilling**

### ***Impairment of air quality***

Drilling could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO<sub>2</sub>, NO<sub>2</sub>, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

### ***Increase in noise and vibration***

Noise and vibrations could increase during drilling. Current noise levels at site were 45.56±1.18 dB(A), which is by far lower than the regulatory limits of 90 dB (A). But during drilling, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term or long-term depending on the length of the piling period, reversible and was rated as high impact.

***Injuries and death from blowouts***

Blowouts could occur during drilling. Today, only a few blowouts have occurred in Nigeria while drilling, but none in SPDC. Notwithstanding, injuries and death from blowouts was described as negative, direct and it could either be short- or long-term, reversible or irreversible depending on the scale and severity, hence this impact was rated high.

***Opportunities for business and employment***

Drilling activities in EA/EJA field could create opportunities for business, contracting and employment. Though, this is a positive impact, it can be enhanced by using local and indigenous contractors and personnel, otherwise, it could lead to agitation and conflicts. The impact was rated Positive.

***Increased oil production***

Existing wells in the EA/EJA field are depleting with high water production. Drilling of additional 20 wells in the EA/EJA field could boost oil production in Nigeria and increase capacity utilization of the Sea Eagle FPSO. This impacted was ranked Positive.

***Increased revenue***

Increased oil production could result in increased revenue for SPDC and the Nigerian Government. This impacted was ranked Positive as well.

***Surface water and sediment pollution from chemicals, drill cuttings, and mud***

Surface water and sediment pollution from chemicals, drill cuttings, and drilling mud could occur as a result of drilling activities. Several chemicals are used during drilling and completion such as drilling mud (consisting of several additives such as barite, bentonite, potassium chloride, calcium carbonates, base oil or pseudo-oil etc), cement etc. Large volumes of wastes could be generated from the use of these chemicals. In addition, other types of wastes could be generated including effluent, sewage, food wastes and other solid wastes particularly packaging materials such as plastics. This impact was therefore described as negative, direct, short-term, reversible and was rated major.

***Accidents and injuries***

Accidents and injuries could arise from drilling operations. This impact was described as negative, direct, short-term, reversible and was rated major.

***Pipeline construction (Piping/ flowlines, well hook-up)***

***Increase in income generating activities***

Income generating activities (business/contracting) could increase during pipeline construction. This impact was ranked positive.

***Risk of accident***

Accidents and injuries could arise from pipeline construction such as explosion, fire and drowning. This impact was described as negative, direct, short-term, reversible and was rated major.

***Risk of Piracy & kidnapping***

Piracy and kidnapping could occur during pipeline construction. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

***Impairment of air quality***

Pipeline construction could result in the release of emissions into the environment. Despite being a brown field, all the priority air quality parameters tested (SO<sub>x</sub>, NO<sub>x</sub>, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

***Increase in noise and vibration***

Noise and vibrations could increase during pipeline construction. Current noise levels at site were 45.56±1.18 dB(a), which is far lower than the regulatory limits of 85 dB(A). But during drilling, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term, reversible and was rated as medium.

***Contamination of surface water bodies***

Surface water and sediment pollution could arise from pipeline construction activities. In addition, wastes could be generated including effluent, sewage, food wastes and other solid wastes particularly packaging materials such as plastics. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

***Exposure to radiation***

Personnel could be exposed to radiation during pipeline construction activities especially during arc welding and NDT. Some ionizing radiations may lead to cancer. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

***Inhalation of welding fumes***

Fumes are released during welding, which could be inhaled by welders. This impact was therefore described as negative, direct, short-term, reversible and was rated medium.

***Soft tissues damage from welding sparks***

Welding sparks could cause tissue damage. This impact was therefore described as negative, direct, short-term, reversible and was rated medium.

***Conjunctivitis from welding flash***

Conjunctivitis could result from welding flash. This impact was therefore described as negative, direct, short-term, reversible and was rated medium.

***Potential for conflicts arising from labour issues***

Conflicts could arise from labour related issues during pipeline construction. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

***Stress on existing security structures***

Stress on existing security structures could arise during pipeline construction activities. Kidnapping and hostage taking is common in the Niger Delta. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

**Demobilization**

***Impairment of air quality***

Emissions into the environment can occur during demobilization of equipment and personnel. Despite being a brown field, all the priority air quality parameters tested (SO<sub>x</sub>, NO<sub>x</sub>, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium i.e. moderate impact.

***Water traffic incidents***

Water traffic incidents can occur during demobilization of equipment and personnel. This impact was described as negative, direct and it could either be short- or long-term, reversible or irreversible depending on the scale and severity, hence this impact was rated high.

***Improper disposal of materials removed from site***

Wastes could be generated from materials removed from site during demobilization. If not well managed, these wastes could cause environmental pollution. This impact was assessed and described as negative, direct, short-term, reversible and was rated as medium

***Increase in noise and vibration***

Noise and vibrations could increase during demobilization. Current noise levels at site were 45.56±1.18 dB(A), which is by far lower than the regulatory limits of 85 dB(A). But during

construction, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term and was rated as high impact.

***Loss of employment/ income***

Employment and income could be loss due to demobilization. Conflict could arise from the poor management of demobilization. This impact was assessed and described as negative, direct, short-term and was rated as high impact.

***Risk of accident***

There is potential risk of accident particularly drowning during demobilization from site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

***Risk of Piracy & kidnapping***

Piracy and kidnapping could occur during demobilization from site. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

**Commissioning, Operations and Maintenance**

***Improper Disposal of Materials***

Several waste streams could be generated during commissioning, routine operations and maintenance. If not well managed, these wastes could cause environmental pollution. This impact was assessed and described as negative, direct, short-term, reversible and was rated high.

***Equipment Failure and Damage Leading to Injuries/Fatality***

Equipment failure could result to damage leading to injuries and fatality. This impact was assessed and described as negative, direct, short-term, reversible and was rated medium.

***Revenue Generation to Government and Company***

Operations of the production facilities could result in increased production and revenue generation for the government and SPDC. The impact was ranked positive.

***Gas Flaring***

Associated gas is typically produced along with the crude oil. Therefore, increased production arising from the EA/EJA FOD project has the potential of increased gas flaring in the area, which is a negative impact. This impact of gas flaring was assessed and described as negative, direct, short-or long-term, reversible and was rated high.

***Produced Water***

Produced water is associated with crude oil production. Increased oil production arising from the EA/EJA FOD project has the potential of increased produced water discharge, which is a negative impact. This impact of produce water disposal was assessed and described as negative, direct, short-or long-term, reversible and was rated high.

***Risk of Accident***

There is potential risk of accident particularly drowning during operations. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

***Risk of Piracy and Kidnapping***

Piracy and kidnapping could occur during operations. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

**Decommissioning and Abandonment**

***Employment and Income Generating Opportunity***

Decommissioning can create opportunity for business and employment. This impact was ranked positive.

***Increase in Noise and Vibration***

Noise and vibrations could increase during decommissioning of equipment. Current noise levels at site were  $45.56 \pm 1.18$  dB(A), which is by far lower than the regulatory limits of 85 dB(A). But during decommissioning, high noise and vibrations beyond regulatory limits could be released. However, this impact was assessed and described as negative, direct, short-term and was rated as high impact.

***Impairment of Air Quality***

Emissions into the environment can occur during decommissioning of equipment. Despite being a brown field, all the priority air quality parameters tested (SO<sub>x</sub>, NO<sub>x</sub>, VOC, SPM) were within regulatory limits. However, the impairment of air quality was assessed and described as negative, direct, short-term, reversible and was rated as medium.

***Risk of Accident***

There is potential risk of accident particularly drowning during decommissioning. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the severity of the accident. The risk of accident was rated high i.e. major.

### ***Risk of Piracy and Kidnapping***

Piracy and kidnapping could occur during decommissioning. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity and length of time and was rated high.

### ***Increase Potential for Water Traffic Accidents/ Injury***

Water traffic accidents such as boat accidents and drowning could occur as a result of increased transportation during decommissioning, which could result in injury or death. The risk was described as negative, direct and could either be short- or long-term, reversible or irreversible depending on the scale, severity of the accident and was rated medium.

### ***Potential for Conflicts Arising from Labour Issues***

Conflicts could arise from labour related issues during decommissioning. This impact was therefore described as negative, direct, short-term, reversible and was rated high.

### ***Accidents/Injury/Fatalities of Workforce***

Improper use of personal protective equipment (PPE), non-adherence to HSE policies and regulatory standards, system/equipment failure and human errors during decommissioning could result in injuries and fatalities. This impact was described as direct, negative, short- or long-term and reversible or irreversible and was ranked high.

## **5.6: Assessment of Existing Impacts**

### ***Air Quality and Noise***

Although air quality and noise parameters were not analyzed in 2001 (baseline benchmark), values for 2018 were higher than or similar to values obtained in 2011 and 2015 as indicated below (**Table 5.5**). Increased concentration observed in VOCs, SPM and Noise level may be associated with activities going on in the field as at time of studies such as gas flaring and power generation. However, all concentrations recorded were below regulatory stipulated limits.

Table 5.5: Comparison of Air Quality and Noise Values

<b>Parameters</b>		<b>2011</b>	<b>2015</b>	<b>2018</b>	<b>DPR Limit</b>
		<b>Mean</b>	<b>Mean</b>	<b>Mean</b>	
Air Quality	SO <sub>x</sub> (as SO <sub>2</sub> ) µg/m <sup>3</sup>	<0.01	<0.01	<19.9	125
	NO <sub>x</sub> (as NO), µg/m <sup>3</sup>	<0.01	<0.01	<14.2	200
	VOC, µg/m <sup>3</sup>	<0.01	0.98	-	-
	SPM, µg/m <sup>3</sup>	0.15	10.3	25.1	-
Noise	Noise Level, dB(A)	45.6	71.1	72.8	85

### ***Surface Water Quality***

Seawater heavy metal concentrations were generally higher in the sampling stations than the control. A significant increase in seawater heavy metal and TPH concentrations with decreasing distance from FPSO suggested the facility as a possible source. Polycyclic Aromatic Hydrocarbons and BTEX were not detected in the seawater. Oil and Grease and TPH were generally below 10 mg/l which are well below the DPR effluent discharge limit of 20 mg/l.

Surface water trend analysis from 2001 showed increasing concentrations of most parameters attributed mainly to increasing impacts of land-based and maritime human activities including coastal waste discharges and crude oil operations. In terms of microbiology analysis, there were generally no significant horizontal variation in the population of microbial parameters (THB, TF HUB and HUF) between sampling stations and control stations i.e. impact of facilities (FPSO and platforms) on some microbial parameters was insignificant.

### ***Sediment Quality***

The sediments were moderately reducing (negative redox potentials) but considered normal for clay dominated environments. Sediment TOC was generally low suggesting absence of organic pollution. Sediment heavy metals were mostly below detection limits but chromium and cobalt showed values that were higher than those of the controls while all other metals detected including nickel, iron, lead, zinc, cadmium and barium were similar to those of the control levels. PAH and BTEX were not detected in the sediments. Oil and grease and TPH varied generally with no apparent trend compared to control. Sediment TPH levels were however generally low compared to the DPR target limit of 50 mg/kg indicating absence of any significant oil pollution in the area. The absence of PAH and BTEX compounds in the sediment were indicative of the absence of any significant fresh and residual petroleum hydrocarbon contamination in the area.

The possible impact of the existing facilities on sediment quality was assessed by comparing average values of results obtained during the Sea Eagle EIA (2001), FOD-EIA (2011), and EE study (2015) as well as EIA 2018. Apart from reduction observed in Redox, measurements in 2018 were characterized by increases in iron, copper, zinc, chromium, cobalt and cadmium. Although some parameters measured at the FPSO showed a decreasing trend with distance from the facility, the apparent increases observed in this trending may be attributed to both crude oil related operations and other marine and land-based inputs of contaminants. The hydrocarbonoclastics were not identified in the sediments including the control stations at the various receptor distances. The absence of the hydrocarbon utilizing organisms corroborates with the non-detection of BTEX and PAH in the sediments. SRBs were also not identified across the receptor distances including the control station and indicate unlikelihood of biogenic souring during the operation phase of the project.



### ***Phytoplankton trends***

The order of dominance of phytoplankton in the area was Bacillariophyceae> Chlorophyceae> Cyanophyceae> Dinophyceae. A comparison of Phytoplankton indices from 2001 to 2018 showed increasing trend in the phytoplankton species number from 19 species in 2001 to over 80 species in 2011 and 2015 followed by a decrease was observed in 2018 (max 44 species). In contrast, an over 6-fold increase occurred in the density of phytoplankton in 2018 compared to 2015. A decrease in phytoplankton diversity with concomitant increase in density shows a tendency towards eutrophic conditions. Irrespective of the year of study, Bacillariophyceae (Diatoms) remained the most dominant phytoplankton around Sea Eagle FPSO showing the high stability in the system with minimal environmental stress. Diatoms are widely reported as the most abundant and dominant phytoplankton taxa in unpolluted tropical coastal waters.

### ***Zooplankton Trends***

The order of dominance of zooplankton was represented by Crustacean copepods > Cladocera > Pices Larvae/fish eggs > Polychaete larvae > Rotifera> Appendicular > Crustacean decapods > Mollusca Larvae > Chaetognatha. Zooplankton was characterized by marked increasing trend in species diversity and density from 2001 to 2015. While species diversity decreased in 2018, zooplankton density increased almost 10-fold in 2018 compared to 2015. Decreasing diversity combined with increasing density of organisms usually point to a stressed system. The presence of polychaetes in the plankton of 2018 is also a pointer to the subtle pollution of the system as polychaetes are usually associated with polluted/organically enriched environments. Generally, Copepoda dominated the zooplankton community during all studies, reflecting the typical community structure in the tropical oceans and showing the relative stability in the area.

### ***Benthic fauna trends***

The general pattern benthos in the area was in the following order: Gastropod molluscs> Bivalve Molluscs> Bryozoans> Echinodermata> Scaphopoda> Polychaeta (Annelids) > Sponges> Crustacea> Chordata. Trending of benthos data within Sea Eagle FPSO showed a marked increasing trend in benthos density and species numbers from 2001 to 2011 with a reduction in 2015 followed by over 20-fold increase in 2018. Such variation may be linked to sediment quality and overlying water hydrodynamics. The stability of the area over the years is apparent from the dominance of the benthos by molluscs. The occurrence of Polychaetes from 2001 is a further support to the stability of the ecosystem.

### ***Fish and Fisheries***

Thirteen (13) species of fish were identified belonging to 11 families. Available literature also shows that four (4) more species can also be found in the locality (Schneider, 1990). The fecundity of *Pseudotolithus typus* (the longneck croaker) which was observed to be the most commercially important fish species in the artisanal fisheries within the OML79 field during the

2018 studies was generally high. Apart from the high fecundity, other parameters of fish condition such as gonadosomatic index (GSI), condition factor (K) and Gonad – free weight, were high which could be attributed to a stable and unpolluted environment. This was supported by the observed intensity of artisanal fisheries activities in the area.

Tissue levels of heavy metals measured in the fish species (Gills, Stomach and Muscle) was in the following order: Co > Cr > Cd/Ni > Pb. The heavy metals levels were generally below the stipulated WHO, FEPA and FAO limits for seafood. From the observed concentrations of the heavy metal in the tissues, heavy metals were not accumulated in the fish to any significantly extent that would be detrimental to the ecosystem. Similarly, the results of the TPH analysis of the fish tissues showed that the TPH values were far below the UNESCO/WHO/UNEP (1992) maximum permissible limit of 100.0 mg/kg indicating that the environment was not polluted with petroleum hydrocarbons and that the fish species were safe for human consumption.

### ***Marine wildlife***

Wildlife reported in Nigeria’s near-coast waters include marine mammals and sea turtles. The mamals include members of the toothed whales, the *Odontocedi* and the common dolphin (*Dolphinus delphis*). Other whales such as *Dolphinus and Steno* and the manatee belonging to the genus *Tricheus* have also been observed in Nigerian coastal waters and the wider Gulf of Guinea. Among the marine reptiles, the sea turtles belonging to the Chenolidae and Dormochelidae and consisting of five genera and six species (Dublin-Green and Tobor, 1992) have been reported. Some of the documented sea turtle species and their IUCN status include:

- Green sea turtle (*Chelonia mydas*) = EN (endangered)
- Hawksbill sea turtle (*Eretmochelys imbricata*) = CR (critically endangered)
- Leatherback sea turtle (*Dermochelys coriacea*) = CR (critically endangered)
- Loggerhead turtle (*Caretta caretta*) = EN (endangered)
- Olive ridley (*Lepidochelys olivacea*) = EN (endangered)

The FAO Species ID Sheets (1981) also gave the following periods as breeding seasons for the different turtle species;

- Leatherback - September to February
- Olive Ridley - August to December
- Green turtle - July to November
- Hawksbill - September to February
- Loggerhead - April to September

Offshore drilling including oil rig operations are know to negatively impact marine wildlide in multiple ways.

### **5.6: Cumulative Impacts**

Cumulative impact includes the combination of existing impacts derived from operations and maintenance of the existing facilities/potential and associated impacts from the proposed project activities. **Table 5.6** present cumulative effects.

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Table 5.6: Cumulative Effect of Existing and New Project

	Potential impacts		Existing impacts			Cumulative impacts
			2001 vs 2011	2001 vs 2015	2015vs 2018	
Pre-construction (survey)	Risk of accident from vessel collision	H	NA	NA	NA	H
	Risk of Piracy & kidnapping	H	NA	NA	NA	H
Mobilization (equipment & personnel), and Rig Move	Impairment of air quality from equipment	M	NA	NA	NA	M
	Increase in noise and vibration	M	NA	NA	NA	M
	Interference with fishing activities	L	NA	NA	NA	L
	Interference with water transport	L	NA	NA	NA	L
	Risk of accident from marine collision	H	NA	NA	NA	H
	Risk of Piracy & kidnapping	H	NA	NA	NA	H
Site preparation (piling)	Increase in noise and vibration	H	NA	NA	NA	H
	Interference with fishing activities	M	NA	NA	NA	M
	Risk of accident	H	NA	NA	NA	H
	Risk of Piracy & kidnapping	H	NA	NA	NA	H
	Risk of accident from dropped objects and structural failures	H	NA	NA	NA	H
	Fish-kills during piling activity	H	NA	NA	NA	H
	Aggregation of bottom sediments	H	NA	NA	NA	H
	Impairment of water quality (turbidity and suspended solids)	H	NA	NA	NA	H
Installation and positioning of Wellhead Platforms	Increase in noise and vibration	H	NA	NA	NA	H
	Interference with fishing activities	M	NA	NA	NA	M
	Risk of accident from lifting and hoisting activities	H	NA	NA	NA	H
	Risk of Piracy & kidnapping	H	NA	NA	NA	H
	Impacts of Wastes (metal scrap)	H	NA	NA	NA	H
	Impairment of air quality from emissions	M	NA	NA	NA	M
Drilling	Impairment of air quality	M	NA	NA	VOC, SPM	M
	Noise and vibration nuisance	M	NA	NA	NA	M
	Injuries and death from failure of BOP and Well blowout	H	NA	NA	NA	H
	Continuous glare from rig operations	L	NA	NA	NA	L
	Opportunities for business and employment	P	NA	NA	NA	P

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	Potential impacts		Existing impacts			Cumulative impacts
			2001 vs 2011	2001 vs 2015	2015vs 2018	
	Increased oil production	P	NA	NA	NA	P
	Increased revenue	P	NA	NA	NA	P
	Impairment of water and sediment quality from accidental release of hydrocarbons, drill cuttings	H	N, P, Zn, Fe and Cu	Pb, Fe, Zn, Cr, Ni	Pb, Fe, Cr, Ni, Cd, TPH,	Pb, Fe, Cr, Cu, Ni, Cd, Z, Ni, N, P, TPH,
	Increased waste volumes - drilling cuttings and muds	H	NA	NA	NA	H
	Smothering of benthic flora and fauna	H	NA	NA	NA	H
	Interference with marine wildlife	H	NA	NA	NA	H
	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure , dropped objects	H	NA	NA	NA	H
	Accidental ignition of released hydrocarbons	H	NA	NA	NA	H
	Structural failures due to fatigue – Derrick collapse, crane collapse,	H	NA	NA	NA	H
	Risk of dropped objects during lifting and hoisting activities	H	NA	NA	NA	H
	Accidents from naked flame jobs within existing live facilities	H	NA	NA	NA	H
	Drop in production due to risk of unplanned shutdown during SIMOPS	H	NA	NA	NA	H
Pipeline construction (Piping/ flowlines, well hook-up)	Increase in income generating activities	P	NA	NA	NA	P
	Disruption of spawning and migratory routes for marine mammals	L	NA	NA	NA	L
	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure	H	NA	NA	NA	H
	Risk of Piracy & kidnapping	H	NA	NA	NA	M
	Impairment of air quality	H	NA	NA	NA	H
	Increase in noise and vibration levels	L	NA	NA	NA	L
	Impairment of water quality (turbidity and suspended solids)	H	NA	NA	NA	H
	Exposure to radiation during pipeline welding	H	NA	NA	NA	H

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	Potential impacts	Existing impacts			Cumulative impacts
		2001 vs 2011	2001 vs 2015	2015vs 2018	
	and stringing				
	inhalation of welding fumes	M	NA	NA	L
	Soft tissues damage from welding sparks	M	NA	NA	L
	Corneal flash burns (photokeratosis) from welding	M	NA	NA	L
	Potential for conflicts arising from labour issues	H	NA	NA	H
	Stress on existing security structures	H	NA	NA	H
	Contamination of water from inhibited hydrotest water	L	NA	NA	L
	Interference with water transport and fishing activities	L	NA	NA	L
<b>Demobilization</b>	Impairment of air quality	M	NA	NA	VOC, SPM L
	Water traffic incidents	H	NA	NA	NA H
	Improper disposal of materials removed from site	M	NA	NA	NA M
	Increase in noise and vibration level	M	NA	NA	NA M
	Loss of employment/ income	H	NA	NA	NA H
	Risk of accident from vessel collision	H	NA	NA	NA H
	Risk of Piracy & kidnapping	H	NA	NA	NA H
	Interference with water fishing activities	L	NA	NA	NA L
Commissioning Operations and Maintenance	Improper disposal of materials	H	NA	NA	NA H
	Equipment failure and damage leading to injuries/fatality	M	NA	NA	NA M
	Revenue generation to government and company	P	NA	NA	NA P
	Increase in noise levels	L	NA	NA	NA L
	Air quality impairment from Well flare/vent	H	NA	NA	NA H

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	Potential impacts		Existing impacts			Cumulative impacts
			2001 vs 2011	2001 vs 2015	2015vs 2018	
	Impairment of water quality from produced water discharges and leaks	H	NA	NA	NA	H
	Risk of Piracy & kidnapping	H	NA	NA	NA	H
	Leaks from process pipes, Well head equipment, flanges, subsea lines etc.	H	NA	NA	NA	H
<b>Decommissioning and Abandonment</b>	Employment and income generating opportunity	P	NA	NA	NA	P
	Increase in noise and vibration	M	NA	NA	NA	M
	Interference with water transport and fishing activities	L	NA	NA	NA	L
	Impairment of air quality from emission of HWR	M	NA	NA		M
	Risk of Piracy & kidnapping	H	NA	NA	NA	H
	Increase potential for water traffic accidents/ injury	M	NA	NA	NA	M
	Potential for conflicts arising from labour issues	H	NA	NA	NA	H
	Impairment of surface water and sediment quality from complete decommissioning activities	M	NA	NA	NA	M
	Disruption of aquatic fauna community	L	NA	NA	NA	L
	Interference with marine wildlife	L	NA	NA	NA	L
	Injury/fatalities in workforce	H	NA	NA	NA	H

## CHAPTER SIX MITIGATION MEASURES

### 6.1: Introduction

The action plans and measures SPDC propose to take to reduce (or eliminate) negative impacts and promote positive impacts of the proposed Project are presented in this chapter. In proffering mitigation measures, emphases are placed on those negative impacts rated as significant (medium and high impacts). The measures are aimed at reducing potential impacts to As Low As Reasonably Practicable (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. None significant impacts are expected to be mitigated through effective implementation of Health, Safety and Environment (HSE) plans that will be put in place during the different phases of the project.

The mitigation measures proposed are in consonance with the following:

- Department of Petroleum Resources guidelines and standards,
- National, regional and international Environmental laws,
- Best Available Technology for Sustainable Development;
- Social wellbeing and
- Concerns of stakeholders.

The following criteria were used to define mitigation measures for the identified impacts:

- Prevention - Exclude significant potential impacts and risks by design and management Measures.
- Reduction - Minimize the effects or consequences of those significant associated and potential impacts that cannot be prevented, to a level as low as reasonably practicable by implementing operational and management measures.
- Control - Implement operational and management measures to ensure that residual associated impacts are reduced to a level as low as reasonably practicable.

### 6.2: Mitigation Measures

A summary of the mitigation measures for the potential, associated and existing impacts is presented in Table 6.1. These measures are recommended to ameliorate all the significant impacts of existing facilities and significant associated and potential impacts for the proposed Project.

Table 6.1: Mitigation Measures for Significant Project Impacts

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
Pre-mobilization (pipeline route survey)	Risk of accident from vessel collision	H	SPDC shall ensure <ul style="list-style-type: none"> <li>• Compliance with journey management policy marine transport</li> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Daily pep talk shall be conducted</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> <li>• Use of appropriate PFDs by the survey team.</li> </ul>	L
	Risk of Piracy and kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Proper identification and management for all security threats and risk are highlighted</li> <li>• Develop adequate security strategy, plan and procedure for the project.</li> <li>• Ensure that security orientation and awareness/drills are conducted for the workforce</li> <li>• Make all necessary arrangements with Government security agents to improve security.</li> <li>• Develop security management plan for the project before mobilization.</li> </ul>	M



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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<ul style="list-style-type: none"> <li>• Ensure all countermeasures to mitigate identified threats are in place.</li> <li>• Ensure project non productive time are reduced to the barest minimum.</li> <li>• Regular drills are conducted.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• Movement shall be under a GSA armed escort.</li> </ul>	
Mobilization (equipment and personnel), and Rig Movement	Impairment of air quality (VOC & SPM)	M	SPDC shall: <ul style="list-style-type: none"> <li>• Use only pre-mobbed and regularly maintained vessels, generators and other machines.</li> <li>• Use only low sulphur containing fuels and low NOx burners in large generators and turbines.</li> <li>• Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems</li> </ul>	L
	Increase in noise and vibration	M	SPDC shall <ul style="list-style-type: none"> <li>• use only pre-mobbed and regularly maintained equipment and water crafts.</li> <li>• Ensure availability and use of proper PPE by workforce</li> <li>• Provide acoustic mufflers for heavy engines with noise level above acceptable limits</li> <li>• Daily pep talk is carried out for workforce</li> </ul>	L
	Risk of accident	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> </ul>	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<ul style="list-style-type: none"> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>	
	Risk of Piracy and kidnapping	H	<p>SPDC shall:</p> <ul style="list-style-type: none"> <li>• Proper identification and management for all security threats and risk are highlighted</li> <li>• Develop adequate security strategy, plan and procedure for the project.</li> <li>• Ensure that security orientation and awareness/drills are conducted for the workforce</li> <li>• Make all necessary arrangements with Government security agents to improve security.</li> <li>• Develop security management plan for the project before mobilization.</li> <li>• Ensure all countermeasures to mitigate identified threats are in place.</li> <li>• Ensure project non productive time are reduced to the barest minimum.</li> </ul>	M

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<ul style="list-style-type: none"> <li>Regular drills are conducted.</li> <li>All movements shall be undertaken only with Security Single Point Approval</li> <li>Movement shall be under a GSA armed escort.</li> </ul>	
Site preparation (piling)	Increase in noise and vibration	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>Appropriate pile techniques are used to minimize noise and vibration effects and disturbance of marine life.</li> <li>Pre-mob of all equipment before they are deployed to site.</li> <li>Only Generators with noise levels within acceptable limits of (85 - 90 dB (A) are used.</li> <li>Appropriate abatement techniques are adopted including the use of acoustic mufflers for heavy engines with noise level above acceptable limits.</li> <li>Enclosure of high sound energy equipment in noise insulators in line with SPDC policy.</li> <li>SPDC HSE policy of wearing ear muffs/ plugs shall be applied during piling activities.</li> <li>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</li> <li>Workers with existing hearing impairment shall not be deployed to site.</li> </ul>	L
	Fish-kills during piling activity	H	SPDC shall: <ul style="list-style-type: none"> <li>Ensure the use of Best Practical Environmental Option shall be adopted to</li> </ul>	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			minimize disturbance of fish and other marine fauna <ul style="list-style-type: none"> <li>• Ensure pile driving activities commence slowly to provide opportunities for migration of marine fauna.</li> <li>• Mobilise to site during off season to avoid disruption of some marine organisms` reproduction cycle and migratory routes.</li> </ul>	
	Risk of accident from dropped objects and structural failures	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Enforce the prohibition of untethered tools, uncertified lifing equipment, bolt secured with a double nut arrangements etc.</li> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• Effective housekeeping practices are implemented and maintained.</li> <li>• Working at height procedures shall be implemented.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during piling activities</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place.</li> </ul>	L
	Risk of Piracy and kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only</li> </ul>	M

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			with Security Single Point Approval <ul style="list-style-type: none"> <li>All piling activities are executed under a GSA armed escort.</li> </ul>	
	Fish-kills		SPDC shall: <ul style="list-style-type: none"> <li>Ensure the use of Best Practical Environmental Option shall be adopted to minimize disturbance of fish and other marine fauna</li> <li>Ensure pile driving activities commence slowly to provide opportunities for migration of marine fauna.</li> <li>Mobilise to site during off season to avoid disruption of some marine organisms` reproduction cycle and migratory routes.</li> </ul>	
	Aggregation of bottom sediments		SPDC shall use the best available technology to minimize disturbance of bottom sediments	
	Impairment of water quality (turbidity and suspended solids)		<ul style="list-style-type: none"> <li>Deploy best in class pile driving technique to reduce impact of turbidity</li> </ul>	
Installation and positioning of Wellhead Platform	Increase in noise and vibration	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits</li> <li>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</li> <li>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</li> <li>Sufficient separation distances shall be provided for sources of high-energy sound</li> </ul>	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			to reduce noise levels.	
	Interference with fishing activities	M	SPDC shall: <ul style="list-style-type: none"> <li>• 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.</li> </ul>	L
	Risk of accident from lifting and hoisting activities	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the certification of lifting equipment</li> <li>• Conduct strength test for lifting slings</li> <li>• Dynamic Risk assessment conducted for SIMOPS.</li> <li>• Enforce the prohibition of untethered tools, uncertified lifting equipment, bolt secured with a double nut arrangements etc.</li> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• Effective housekeeping practices are implemented and maintained.</li> <li>• Working at height procedures shall be implemented.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during installation of Well head platforms</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place</li> </ul>	L
	Risk of Piracy and kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> </ul>	M

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<ul style="list-style-type: none"> <li>Ensure project non productive time is reduced to the barest minimum.</li> <li>All movements shall be undertaken only with Security Single Point Approval</li> <li>All installation activities are executed under a GSA armed escort.</li> </ul>	
	Impacts of Wastes (metal scrap)	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>Wastes are segregated at source inline with the SPDC Waste Management Plan.</li> <li>Scrap metal/pipe off-cuts are transported to Shell Kidney Island (KI) scrap yard, Port Harcourt, for onward delivery to SPDC approved metal recycling vendor(s).</li> </ul>	L
	Duty of care extended to Contractor yard	P	SPDC shall occasionally visit contractor`s yard during fabrication activities	P
Drilling	Impairment of air quality	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>generators and engines are maintained in accordance with written procedures based on the manufacturers` guidelines or applicable industry code or engineering standards to ensure efficient and reliable operation.</li> <li>Regular audits of drilling operation.</li> </ul>	L
	Noise and vibration nuisance	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>Appropriate technology (Big Air Bubble Curtain, Noise Mitigation Screen, Acoustic decoupling (vibration absorber) to minimize the impact of noise and vibration.</li> <li>Soft start protocols are adopted for drilling activities (Noise emissions shall begin at low power, increasing gradually until full power is reached).</li> <li>Acoustic Mitigation devices shall be used to</li> </ul>	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			drive away marine mammals <ul style="list-style-type: none"> <li>• SPDC HSE policy of wearing ear muffs/plugs is applied in all construction and operational sites where high noise is produced.</li> </ul>	
	Injuries and death from failure of BOP	H	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Well design approach incorporates protection against credible risks associated with the drilling and completion processes.</li> <li>• All primary cemented barriers to flow shall be tested to verify quality, quantity and location of cement.</li> <li>• The integrity of primary mechanical barriers (such as the float equipment, liner tops and wellhead seals) shall be verified by using best available test procedures.</li> <li>• BOP systems shall be designed to provide a robust and reliable cutting, sealing and separation capabilities for the drilling environment.</li> <li>• Test and maintenance procedures shall be established to ensure operability and reliability to their environment of application.</li> <li>• Instrumentation and expert system decision aids shall be used to provide timely warning of loss of well control to drillers on the rig.</li> <li>• Use appropriate blowout prevention fluids.</li> <li>• Use appropriate mud density.</li> <li>• Ensure emergency response procedures are in place.</li> </ul>	M



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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	Impairment of water and sediment quality from accidental release of hydrocarbons, drill cuttings	H	<ul style="list-style-type: none"> <li>SPDC shall continue to encourage the use of WBM in her drilling programme.</li> <li>In the event that large quantities of hydrocarbon are produced during the proposed well and reservoir test, the hydrocarbons will be evacuated to the FPSO.</li> </ul>	L
	Increased waste volumes - drilling cuttings and muds	H	<ul style="list-style-type: none"> <li>Cuttings and the associated fluids shall be collected and transported for treatment if necessary and final disposal.</li> <li>SPDC shall encourage waste-to-shore programme for treatment and disposal.</li> </ul>	L
	Smothering of benthic flora and fauna	H	<ul style="list-style-type: none"> <li>SPDC shall encourage waste-to-shore programme for treatment and disposal of drilling mud and cuttings.</li> </ul>	L
	Interference with marine wildlife	H	<ul style="list-style-type: none"> <li>Soft start protocols are adopted for drilling activities (Noise emissions shall begin at low power, increasing gradually until full power is reached).</li> <li>Acoustic Mitigation devices shall be used to drive away marine mammals</li> </ul>	L
	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure,	H	<p>SPDC shall ensure:</p> <ul style="list-style-type: none"> <li>All rotating parts of the mooring equipment shall be free running and the grease nipples should be clearly marked so they are not missed during greasing rounds</li> <li>The crew members are competent</li> <li>Enforce the use of appropriate PPEs</li> <li>Lines/machinery are inspected regularly, paying attention to wear and tear, thermal damage and dirt.</li> </ul>	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	Accidental ignition of released hydrocarbons		SPDC shall: <ul style="list-style-type: none"> <li>• Activate emergency response plan</li> <li>• use of water deluge system to control pool fires and reduce the risk of escalation, provide cooling of equipment not impinged by jet fires, and limit the effects of fires to make evacuation possible.</li> </ul>	
	Structural failures due to fatigue – Derrick collapse, crane collapse,		SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the certification of lifting equipment</li> <li>• Conduct strength test for lifting slings</li> <li>• Regular maintenance of equipment to prevent corrosion either by selection of corrosion resistant materials or by application of suitable protective techniques or coatings in accordance to international best practices and manufacturers guidelines.</li> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during drilling phase.</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place</li> </ul>	
	Risk of dropped objects during lifting and hoisting activities		SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the certification of lifting equipment</li> <li>• Conduct strength test for lifting slings</li> <li>• Dynamic Risk assessment conducted for SIMOPS.</li> <li>• Enforce the prohibition of untethered tools,</li> </ul>	

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			uncertified lifing equipment, bolt secured with a double nut arrangements etc. <ul style="list-style-type: none"> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• Effective housekeeping practices are implemented and maintained.</li> <li>• Working at height procedures shall be implemented.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during installation of Well head platforms</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place</li> </ul>	
	Accidents from naked flame jobs within existing live facilities		SPDC shall: <ul style="list-style-type: none"> <li>• Activate mergency response plan</li> <li>• use of water deluge system to control pool fires and reduce the risk of escalation, provide cooling of equipment not impinged by jet fires, and limit the effects of fires to make evacuation possible.</li> </ul>	
	Drop in production due to risk of unplanned shutdown during SIMOPS			

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
Pipeline construction (Piping/ flowlines, well hook-up)	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• All rotating parts of the mooring equipment shall be free running and the grease nipples should be clearly marked so they are not missed during greasing rounds</li> <li>• The crew members are competent</li> <li>• Enforce the use of appropriate PPEs</li> <li>• Lines/machinery are inspected regularly, paying attention to wear and tear, thermal damage and dirt.</li> </ul>	L
	Disruption of spawning and migratory routes for marine mammals	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the use of Best Practical Environmental Option shall be adopted to minimize disturbance of fish and other marine fauna</li> <li>• Ensure pipeline activities commence slowly to provide opportunities for migration of marine fauna.</li> <li>• Mobilise to site during off season to avoid disruption of some marine organisms` reproduction cycle and migratory routes.</li> </ul>	L
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>	M

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	Impairment of air quality	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>generators and engines are maintained in accordance with written procedures based on the manufacturers' guidelines or applicable industry code or engineering standards to ensure efficient and reliable operation.</li> </ul>	L
	Impairment of water quality (turbidity and suspended solids)	H	<ul style="list-style-type: none"> <li>Deploy best in class pipelaying method for pipelaying to reduce impact of turbidity</li> <li>Dispose all wastes in line with regulatory requirements.</li> </ul>	M
	Agitation of sediment that will impact benthic community	H	<ul style="list-style-type: none"> <li>Deploy best in class pipelaying method for pipelaying to reduce impact of turbidity and sediment agitation</li> <li>Dispose all wastes in line with regulatory requirements.</li> <li>Treat all effluents to regulatory limits before discharging into the environment</li> </ul>	M
	Exposure to radiation materials	H	SPDC shall ensure that: <ul style="list-style-type: none"> <li>Health awareness training is conducted prior to commencement of activities.</li> <li>Staff undergo routine medical check-ups for radiation exposure.</li> <li>Radiation monitors are provided to monitor radiation levels at site.</li> <li>The use of radiography aprons to protect the body from radiation is enforced.</li> <li>Warning signs are provided during radiation emitting activities to prevent trespass into such areas.</li> <li>The radiation emitting activity is carried out in accordance with standard construction</li> </ul>	L

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			specifications and Regulatory guidelines.	
	Inhalation of welding fumes	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>Awareness sessions on health risks and safety precautions of welding operations are carried out for workers.</li> <li>The use of PPEs (welder's mask, jacket, gloves, boots and coveralls), by welders during welding is enforced.</li> </ul>	L
	Soft tissues damage from welding sparks	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>Awareness sessions on health risks and safety precautions of welding operations are carried out for workers.</li> <li>the use of PPEs (welder's mask, jacket, gloves, boots and coveralls), by welders during welding is enforced.</li> <li>A functional site clinic approved by SPDC is provided by the contractor.</li> </ul>	L
	Corneal flash burns (photokeratosis) from welding	M	SPDC shall ensure that <ul style="list-style-type: none"> <li>Awareness sessions on health risks and safety precautions of welding operations for workers are carried out.</li> <li>Pre-employment medical certification the welders is carried out.</li> <li>PPEs (welder's mask, earmuffs, jacket, gloves, boots and coveralls), by welders during welding is enforced.</li> </ul>	L
	Potential for conflicts arising from labour issues	H	SPDC & her contractors shall: <ul style="list-style-type: none"> <li>Respond to complaints by locals on the activities of her workers</li> <li>Deploy GMOU provisions on community labour issues.</li> </ul>	L

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	Stress on existing security structures	H	SPDC shall: <ul style="list-style-type: none"> <li>• Make all necessary arrangements with Government security agents (Navy) to improve security.</li> <li>• SPDC shall continue to engage stakeholders in order to minimize resentment.</li> <li>• Workers are made aware to be security conscious</li> </ul>	M
Demobilization	Impairment of air quality (VOC & SPM)	M	SPDC shall: <ul style="list-style-type: none"> <li>• Use only pre-mobbed and regularly maintained vessels, generators and other machines.</li> <li>• Use only low sulphur containing fuels and low NOx burners in large generators and turbines.</li> <li>• Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems</li> </ul>	L
	Water traffic incidents	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> </ul>	L

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<ul style="list-style-type: none"> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>	
	Improper disposal of materials removed from site	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>• All removed materials shall be properly disposed of and monitored from cradle to grave in line with the waste management plan</li> <li>• Scrap metals shall be collected, segregated and subjected to SPDC's waste management guidelines.</li> <li>• Plastic wastes shall be sent to an approved Recycling Waste Depot (RWD).</li> <li>• Radioactive wastes/materials shall be managed according to Nigerian Nuclear Regulatory Authority (NNRA) approved procedure.</li> <li>• SPDC waste management policy shall be enforced.</li> </ul>	L
	Increase in noise and vibration level	M	SPDC shall: Use only pre-mobbed and regularly maintained equipment and water crafts	L
	Loss of employment/ income	H	SPDC Shall: <ul style="list-style-type: none"> <li>• Strengthen existing cooperation of the neighbouring communities via the existing Global Memorandum of Association interface.</li> <li>• Require contractors to prepare and implement workers disengagement plans</li> <li>• Encourage and support skill acquisition</li> </ul>	L



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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			programmes of Government, NGOs and CBOs	
	Risk of accident from vessel collision	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>	L
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>	M
Commissioning	Discharge of hydrotest water to the environment during pre-commissioning.	M	SPDC shall barge hydrotest water to onshore for treatment.	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
	Spill due to damaged pipe or valve.	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure adequate testing of pipes and valves for leakages prior to introduction of hydrocarbon.</li> <li>• Installation of Emergency Shut down Valve (ESDV) to control excessive well pressure.</li> </ul>	L
Operations and Maintenance	Improper disposal of materials removed from site	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure all oily wastes are properly segregated and contained before disposal.</li> <li>• Ensure all oily wastes are properly disposed of and monitored from cradle to grave.</li> <li>• Ensure regular clean-up of equipment at site.</li> <li>• Provide containment for chemicals and liquid discharges.</li> <li>• Ensure the enforcement of waste management policy.</li> <li>• Ensure that a controlled fuelling, maintenance and servicing protocol for machinery at worksite is established and followed to minimize leaks and spills.</li> <li>• Ensure Spent chemicals, lube oil, grease, waste oil and detergent solutions are properly disposed of.</li> <li>• Ensure used chemical drums and containers are sent to an approved recyclable waste dump (RWD).</li> <li>• Ensure that Small chemicals spills, crude oil and aqueous effluents shall be cleaned up promptly.</li> </ul>	L
	Equipment failure and damage leading to injuries/fatality	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Only skilled personnel and certified</li> </ul>	L

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<p>equipment are used.</p> <ul style="list-style-type: none"> <li>• Certified first aiders shall be available at every site.</li> <li>• First aid boxes and emergency response procedures are in place.</li> <li>• Hazard assessment has been conducted.</li> <li>• Emergency response procedures are in place.</li> <li>• HSE standards are strictly adhered to.</li> <li>• Permit to work and proper briefing is giving before any work can commence.</li> </ul>	
	Air quality impairment from Well flare/vent	H	SPDC shall ensure: No routine flaring of associated gas.	L
	Impairment of water quality from produced water discharges and leaks	H	SPDC shall ensure that: Produced water shall be treated at the Sea Eagle FPSO to regulatory standards before discharge.	M
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>	M
	Leaks from process pipes, Well head equipment, flanges, subsea lines etc.		SPDC shall: <ul style="list-style-type: none"> <li>• Ensure adequate testing of pipes and valves for leakages prior to introduction of hydrocarbon.</li> <li>• Installation of Emergency Shut down Valve (ESDV) to control excessive well pressure.</li> </ul>	

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
Decommissioning and Abandonment	Increase in noise and vibration	M	SPDC shall <ul style="list-style-type: none"> <li>• Use only pre-mobbed and regularly maintained equipment and water crafts</li> </ul>	L
	Impairment of air quality from emission of HWR	M	SPDC shall: <ul style="list-style-type: none"> <li>• Use only pre-mobbed crafts</li> <li>• Regular maintenance of water crafts, vessels, generators and other machines.</li> <li>• Use low sulphur containing fuel and low NOx burners</li> </ul>	L
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non-productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>	M
	Increase potential for water traffic accidents/ injury	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> </ul>	L

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation
			<ul style="list-style-type: none"> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>	
	Potential for conflicts arising from labour issues	H	SPDC and her contractors shall: <ul style="list-style-type: none"> <li>• Respond to complaints by locals on the activities of her workers.</li> <li>• Deploy GMOU provisions on community employment.</li> </ul>	L
	Injury/fatalities in workforce	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Daily pep talk is carried out for marine transportation</li> <li>• Safety signage shall be deployed at strategic locations.</li> <li>• Provide first aid boxes in operational water crafts.</li> <li>• Emergency response plan shall be in place.</li> </ul>	L
	Impairment of surface water and sediment quality from complete decommissioning activities	H	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Effluents from decommissioning activities are treated to regulatory standards before discharge.</li> </ul>	L

## **CHAPTER SEVEN ENVIRONMENTAL MANAGEMENT PLAN**

### **7.1: Introduction**

Environmental management is concerned with a planned and integrated program aimed at ensuring that unforeseen and unidentified impacts of a proposed project are contained and brought to acceptable minimum levels. 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 development, from mobilization to abandonment. In keeping with Shell policy on the environment, considerations of environmental implications of this project began from feasibility study, conceptual design, up to the present stage of EIA and will continue throughout the project life cycle. This EIA report is part of the environmental management program and is intended to provide an environmental input into the planning and execution of the project. The project's HSE-MS addresses the overall approach adopted for management of HSE risks through the project development phases by the project management team. The project 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 ALARP.

### **7.2: Objectives of EMP**

Good environmental management, which is part of SPDC 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 in this environmental impact assessment are implemented, a comprehensive EMP was developed (Table 7.1). The EMP takes cognisance of the technical implementation of the EIA findings in the design phase of project development, such that a plan of action for managing residual environmental impacts can then be evolved.

### **7.3: Monitoring Objectives**

The following monitoring objectives are established:

- to create local data bank on the impacts of project activities on the aquatic ecosystem, for future development of predictive models;
- to compare effluent quality and quantity with design specifications, impact predictions and regulatory standards;
- to monitor emissions and discharges at all stages of project development to ensure they meet national standards;

- to determine whether environmental changes are results of development or a result of natural variations;
- to determine the effectiveness of the mitigation measures;
- to determine long term impacts.
- to determine the duration of return to normalcy of the environmental components of the project area

#### **7.4: Environmental Audits Programme**

SPDC has instituted 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. The audits are focused on areas of project perceived as having the highest environmental impacts. They are carried out annually and reviewed by SPDC environmental audit committee. 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.

#### **7.5: Training and Awareness Campaign**

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 will be made aware of their responsibilities through induction and training courses as outlined in the projects' HSE-MS document. In addition, procedures, guidelines and notices will advise staff on how to respond in the event of an environmental emergency. The Shell Corporate Environment Department is responsible for monitoring and auditing the environmental activities of this project.

#### **7.6: Emergency Response Programme**

The SPDC strategy for the Offshore Oil Spill Contingency Plan and Emergency response are detailed in the company Emergency Response (ER) Procedure, HSEM-2000-0012. This section discusses the operational controls in place and the monitoring plan. The ER document addresses the response activities to all Tier 1, 2 and 3 spills within the Field. Also, it covers the initial response to all oil spills sighted within the Field regardless of whether or not the oil spill is known to have come from SPDC operated facilities. This is a statutory requirement under the Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) Appendix VIII B Clause 4.0.

Oil spill incidents are classified in the same way as other emergencies and the response is appropriate to this risk-based classification. In developing their Health, Safety and Environment

(HSE) Management Systems with respect to spills of oil and chemicals on land and water, Shell Companies and Business Units (BUs) are committed to compliance with the relevant legislations and the prevention of spills. Shell strives to be a leader in oil and chemical spill preparedness and response capability.

In order to achieve this, SPDC shall:

- Recognize the priority of preventing oil and chemical spills, and promote the high standards this demands among employees, contractors and others associated with handling these products.
- Seek to maintain and continuously improve their ability to minimize the impact of oil and chemical spills on the environment.
- For spills on water, SPDC shall promote the tiered response concept of the International Petroleum Industry Environmental Conservation Association (IPIECA), which classifies the need for response capabilities in terms of the size of spill and its proximity to a company's operating facilities.

Spills that are contained on a facility or vessel will be managed in accordance with the particular facility or vessel procedures. All contaminated clean-up material will be placed in suitable bags or skips and will be shipped to the onshore supply base for disposal in accordance with SPDC requirements. If onshore support is not available, then the facility or vessel OIM or Master will report the spill in accordance with the SPDC procedure (HSEM-2000-0017) for Accident and Incident Reporting, Investigation and Follow-up, after the spill has been controlled and cleaned up.

### **SPDC Oil Spill Policy**

It is SPDC policy to:

- Clean up all hydrocarbon and chemical spills emanating from the Company's operations in a timely and efficient manner.
- Draw up contingency plans and provide resources for prevention and timely response to spills.
- Effect clean-up where the cause of the spill or the party responsible is unknown and seek to recoup costs for such services.

This plan aims to demonstrate how this policy is to be implemented for the offshore operation.

### **Waste management**

Wastes shall be managed in line with Shell EA/EJA field waste management guideline summarized as follows:

- Synthetic Based Mud (SBM) cuttings are treated to  $\leq 5\%$  oil on cuttings and discharged offshore as per DPR environmental waste discharge permits



- Water based mud cuttings are discharged offshore as per DPR environmental waste discharge permits
- Oily rags and oil filters (collected in dedicated containers), Filters crushed on the rig and together with the rags are manifested and transported to land for incineration.
- Oily waste, used lubricants and hydraulic oil, will be collected in drums, with plastic lids, sealed and sent to town for re-conditioning / re-use
- Spent fluorescent tubes will be crushed using the tube eater on the rig and when filled, sealed and sent to Onne for incineration.
- Batteries – sent to land for appropriate disposal.
- Medical wastes - stored and transported in puncture proof plastic drums / sealed boxes and transported to land for incineration.
- Empty oil and chemical drums – Back loaded to land to the chemical companies.
- Sewage: In compliance with regulatory requirements (sewage treatment and chlorination before discharge) and proper measures to be put in place to check increase in coliforms levels.

Table 7.1: Environmental Management Plan

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
Pre-mobilization (pipeline route survey)	Risk of accident from vessel collision	H	SPDC shall ensure <ul style="list-style-type: none"> <li>Compliance with journey management policy marine transport</li> <li>Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>Regular drills on abandon ship procedures shall be enforced</li> <li>Daily pep talk shall be conducted</li> <li>Safety signages shall be deployed at strategic locations.</li> <li>Activate Emergency response plan inline with SOLAS</li> <li>Use of appropriate PFDs by the survey team.</li> </ul>	L	Journey management records Pre-mob certificates of vessels Pep-talk records Accident records	Monthly during premob	Project manager
	Risk of Piracy and kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>Proper identification and management for all security threats and risk</li> </ul>	M	Security Management procedure Journey management	Monthly during premob	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<p>are highlighted</p> <ul style="list-style-type: none"> <li>• Develop adequate security strategy, plan and procedure for the project.</li> <li>• Ensure that security orientation and awareness/drills are conducted for the workforce</li> <li>• Make all necessary arrangements with Government security agents to improve security.</li> <li>• Develop security management plan for the project before mobilization.</li> <li>• Ensure all countermeasures to mitigate identified threats are in place.</li> <li>• Ensure project non productive time are reduced to the barest minimum.</li> <li>• Regular drills are conducted.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• Movement shall be under a GSA armed escort.</li> </ul>		<p>procedure Record of security situation/ updates Site Inspection records</p>		

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
Mobilization (equipment and personnel), and Rig Movement	Impairment of air quality (VOC & SPM)	M	SPDC shall: <ul style="list-style-type: none"> <li>• Use only pre-mobbed and regularly maintained vessels, generators and other machines.</li> <li>• Use only low sulphur containing fuels and low NOx burners in large generators and turbines.</li> <li>• Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager
	Increase in noise and vibration	M	SPDC shall <ul style="list-style-type: none"> <li>• use only pre-mobbed and regularly maintained equipment and water crafts.</li> <li>• Ensure availability and use of proper PPE by workforce</li> <li>• Provide acoustic mufflers for heavy engines with noise level above acceptable limits</li> <li>• Daily pep talk is carried out for workforce</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager
	Risk of accident	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby</li> </ul>	L	Journey management records Premob certificates Pep-talk records Accident records	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<p>vessels</p> <ul style="list-style-type: none"> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>				
	Risk of Piracy and kidnapping	H	<p>SPDC shall:</p> <ul style="list-style-type: none"> <li>• Proper identification and management for all security threats and risk are highlighted</li> <li>• Develop adequate security strategy, plan and procedure for the project.</li> <li>• Ensure that security</li> </ul>	M	<p>Security Management procedure Record of security situation/ updates Site Inspection records</p>	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			orientation and awareness/drills are conducted for the workforce <ul style="list-style-type: none"> <li>• Make all necessary arrangements with Government security agents to improve security.</li> <li>• Develop security management plan for the project before mobilization.</li> <li>• Ensure all countermeasures to mitigate identified threats are in place.</li> <li>• Ensure project non productive time are reduced to the barest minimum.</li> <li>• Regular drills are conducted.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• Movement shall be under a GSA armed escort.</li> </ul>				
Site preparation (piling)	Increase in noise and vibration	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Appropriate pile techniques are used to minimize noise and vibration effects and disturbance of marine</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			life. <ul style="list-style-type: none"> <li>• Only pre-mob of all equipment before they are deployed to site.</li> <li>• Use Generators with noise levels within acceptable limits of (85 - 90 dB (A)).</li> <li>• Appropriate abatement techniques are adopted including the use of acoustic mufflers for heavy engines with noise level above acceptable limits.</li> <li>• Enclose high sound energy equipment in noise insulators in line with SPDC policy.</li> <li>• SPDC HSE policy of wearing ear muffs/ plugs shall be applied during piling activities.</li> <li>• Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</li> <li>• Workers with existing hearing impairment shall not be deployed to site.</li> </ul>				
	Fish-kills during piling activity	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the use of Best Practical Environmental Option shall be adopted</li> </ul>	L	Site inspection report	Once during piling activity	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<p>to minimize disturbance of fish and other marine fauna</p> <ul style="list-style-type: none"> <li>• Ensure pile driving activities commence slowly to provide opportunities for migration of marine fauna.</li> <li>• Mobilise to site during off season to avoid disruption of some marine organisms` reproduction cycle and migratory routes.</li> </ul>				
	Risk of accident from dropped objects and structural failures	H	<p>SPDC shall ensure:</p> <ul style="list-style-type: none"> <li>• Enforce the prohibition of untethered tools, uncertified lifing equipment, bolt secured with a double nut arrangements etc.</li> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• Effective housekeeping practices are implemented and maintained.</li> <li>• Working at height procedures shall be implemented.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> </ul>	L	<p>Premob certificates Pep-talk records Accident records</p>	Monthly	Project manager



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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<ul style="list-style-type: none"> <li>The use of appropriate PPEs during piling activities</li> <li>Safety signages are deployed at strategic locations.</li> <li>Emergency response plan are in place.</li> </ul>				
	Risk of Piracy and kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>Ensure project non productive time is reduced to the barest minimum.</li> <li>All movements shall be undertaken only with Security Single Point Approval</li> <li>All piling activities are executed under a GSA armed escort.</li> </ul>	M	Security Management procedure Record of security situation/ updates Site Inspection records	Monthly	Project manager
	Aggregation of bottom sediments		SPDC shall use the best available technology to minimize disturbance of bottom sediments		Site inspection report	Once during piling activity	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	Impairment of water quality (turbidity and suspended solids)		<ul style="list-style-type: none"> <li>Deploy best in class pile driving technique to reduce impact of turbidity</li> </ul>		Site inspection report	Monthly	Project manager
Installation and positioning of Wellhead Platform	Increase in noise and vibration	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits</li> <li>High sound energy equipment shall be enclosed in noise insulators in line with SPDC policy</li> <li>SPDC HSE policy of wearing ear muffs/ plugs shall be applied in all construction and operational sites where high noise is produced.</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<ul style="list-style-type: none"> <li>Sufficient separation distances shall be provided for sources of high-energy sound to reduce noise levels.</li> </ul>				
	Interference with fishing activities	M	SPDC shall: <ul style="list-style-type: none"> <li>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.</li> </ul>	L	Records of engagement sessions,	Once during piling activity	Project manager
	Risk of accident from lifting and hoisting activities	H	SPDC shall: <ul style="list-style-type: none"> <li>Ensure the certification of lifting equipment</li> <li>Conduct strength test for lifting slings</li> <li>Dynamic Risk assessment conducted for SIMOPS.</li> <li>Enforce the prohibition of untethered tools, uncertified lifting equipment, bolt secured with a double nut arrangements etc.</li> </ul>	L	Journey management records Premob certificates Pep-talk records Accident records	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<ul style="list-style-type: none"> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• Effective housekeeping practices are implemented and maintained.</li> <li>• Working at height procedures shall be implemented.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during installation of Well head platforms</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place</li> </ul>				
	Risk of Piracy and kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation</li> </ul>	M	Security Management procedure Record of security situation/ updates Site Inspection records	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			activities are executed under a GSA armed escort.				
	Impacts of Wastes (metal scrap)	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>Wastes are segregated at source inline with the SPDC Waste Management Plan.</li> <li>Scrap metal/pipe off-cuts are transported to Shell Kidney Island (KI) scrap yard, Port Harcourt, for onward delivery to SPDC approved metal recycling vendor(s).</li> </ul>	L	SPDC Waste management plan Waste consignment note Environmental Compliance Monitoring Reports Site inspection Reports	Weekly	Project manager
	Duty of care extended to Contractor yard	P	SPDC shall occasionally visit contractor's yard during fabrication activities	P	Safe system of work JHA Tool Box meeting Work processes	Bi--monthly	Project manager
Drilling	Impairment of air quality	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>generators and engines are maintained in accordance with written procedures based on the manufacturers' guidelines or applicable industry code or engineering standards to ensure efficient and reliable operation.</li> <li>Regular audits of drilling operation.</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager
	Noise and vibration nuisance	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>Appropriate technology (Big Air Bubble</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<p>Curtain, Noise Mitigation Screen, Acoustic decoupling (vibration absorber) to minimize the impact of noise and vibration.</p> <ul style="list-style-type: none"> <li>• Soft start protocols are adopted for drilling activities (Noise emissions shall begin at low power, increasing gradually until full power is reached).</li> <li>• Acoustic Mitigation devices shall be used to drive away marine mammals</li> <li>• SPDC HSE policy of wearing ear muffs/ plugs is applied in all construction and operational sites where high noise is produced.</li> </ul>				
	Injuries and death from failure of BOP and explosion	H	<p>SPDC shall ensure that:</p> <ul style="list-style-type: none"> <li>• Well design approach incorporates protection against credible risks associated with the drilling and completion processes.</li> <li>• All primary cemented barriers to flow shall be tested to verify quality, quantity and location of cement.</li> <li>• The integrity of primary</li> </ul>	M	<p>Evidence of Equipment certification Evidence of Cable and wire strength testing Evidence of operator's competency Issuance of PTW prior to the commencement of any activity on site.</p>	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<p>mechanical barriers (such as the float equipment, liner tops and wellhead seals) shall be verified by using best available test procedures.</p> <ul style="list-style-type: none"> <li>• BOP systems shall be designed to provide a robust and reliable cutting, sealing and separation capabilities for the drilling environment.</li> <li>• Test and maintenance procedures shall be established to ensure operability and reliability to their environment of application.</li> <li>• Instrumentation and expert system decision aids shall be used to provide timely warning of loss of well control to drillers on the rig.</li> <li>• Use appropriate blowout prevention fluids.</li> <li>• Use appropriate mud density.</li> <li>• Ensure emergency response procedures are in place.</li> </ul>				

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	Impairment of water and sediment quality from accidental release of hydrocarbons, drill cuttings	H	<ul style="list-style-type: none"> <li>SPDC shall continue to encourage the use of WBM in her drilling programme.</li> <li>In the event that large quantities of hydrocarbon are produced during the proposed well and reservoir test, the hydrocarbons will be evacuated to the FPSO.</li> </ul>	L	Drill cutting treatment records Drilling mud recovery record  Waste consignment note	Monthly	Project manager
	Increased waste volumes - drilling cuttings and muds		<ul style="list-style-type: none"> <li>Cuttings and the associated fluids shall be collected and transported for treatment if necessary and final disposal.</li> <li>SPDC shall encourage waste-to-shore programme for treatment and disposal.</li> </ul>		SPDC Waste management plan Waste consignment note Reports Site inspection Reports	Weekly	Project manager
	Smothering of benthic flora and fauna	H	<ul style="list-style-type: none"> <li>SPDC shall encourage waste-to-shore programme for treatment and disposal of drilling mud and cuttings.</li> </ul>		Drill cutting treatment records Drilling mud recovery record	Monthly	Project manager
	Interference with marine wildlife	H	<ul style="list-style-type: none"> <li>Soft start protocols are adopted for drilling activities (Noise emissions shall begin at low power, increasing gradually until full power is reached).</li> <li>Acoustic Mitigation</li> </ul>		Site inspection report	Once during piling activity	Project manager



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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			devices shall be used to drive away marine mammals				
	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure,	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>All rotating parts of the mooring equipment shall be free running and the grease nipples should be clearly marked so they are not missed during greasing rounds</li> <li>The crew members are competent</li> <li>Enforce the use of appropriate PPEs</li> <li>Lines/machinery are inspected regularly, paying attention to wear and tear, thermal damage and dirt.</li> </ul>	L	Certification of workforce MSDS and Technical specification Emergency response plan HAZID register. Pep-talk records Site inspection Reports	Weekly	Project manager
	Accidental ignition of released hydrocarbons		SPDC shall: <ul style="list-style-type: none"> <li>Activate emergency response plan</li> <li>use of water deluge system to control pool fires and reduce the risk of escalation, provide cooling of equipment not impinged by jet</li> </ul>		Certification of workforce MSDS and Technical specification Emergency response plan HAZID register. Pep-talk records	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			fires, and limit the effects of fires to make evacuation possible.		Site inspection Reports		
	Structural failures due to fatigue – Derrick collapse, crane collapse,		SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the certification of lifting equipment</li> <li>• Conduct strength test for lifting slings</li> <li>• Regular maintenance of equipment to prevent corrosion either by selection of corrosion resistant materials or by application of suitable protective techniques or coatings in accordance to international best practices and manufacturers guidelines.</li> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during drilling phase.</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place</li> </ul>		Certification of workforce MSDS and Technical specification Emergency response plan HAZID register. Pep-talk records Site inspection Reports	Weekly	Project manager
	Risk of dropped objects		SPDC shall:		Certification of	Weekly	Project

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	during lifting and hoisting activities		<ul style="list-style-type: none"> <li>• Ensure the certification of lifting equipment</li> <li>• Conduct strength test for lifting slings</li> <li>• Dynamic Risk assessment conducted for SIMOPS.</li> <li>• Enforce the prohibition of untethered tools, uncertified lifting equipment, bolt secured with a double nut arrangements etc.</li> <li>• Effective inspection and audit of drop object prevention programme.</li> <li>• Effective housekeeping practices are implemented and maintained.</li> <li>• Working at height procedures shall be implemented.</li> <li>• All designated dropped object risk control zones are to be access controlled.</li> <li>• The use of appropriate PPEs during installation of Well head platforms</li> <li>• Safety signages are deployed at strategic locations.</li> <li>• Emergency response plan are in place</li> </ul>		workforce MSDS and Technical specification Emergency response plan HAZID register. Pep-talk records Site inspection Reports		manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	Accidents from naked flame jobs within existing live facilities		SPDC shall: <ul style="list-style-type: none"> <li>• Activate emergency response plan</li> <li>• use of water deluge system to control pool fires and reduce the risk of escalation, provide cooling of equipment not impinged by jet fires, and limit the effects of fires to make evacuation possible.</li> </ul>		Certification of workforce MSDS and Technical specification Emergency response plan HAZID register. Pep-talk records Site inspection Reports	Weekly	Project manager
Pipeline construction (Piping/ flowlines, well hook-up)	Accidents and injuries from anchor and mooring failures, crane accidents, machinery/propulsion failure	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• All rotating parts of the mooring equipment shall be free running and the grease nipples should be clearly marked so they are not missed during greasing rounds</li> <li>• The crew members are competent</li> <li>• Enforce the use of appropriate PPEs</li> <li>• Lines/machinery are inspected regularly, paying attention to wear and tear, thermal damage and dirt.</li> </ul>	L	Certification of workforce Technical specification Emergency response plan HAZID register. Pep-talk records Site inspection Reports	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	Disruption of spawning and migratory routes for marine mammals	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure the use of Best Practical Environmental Option shall be adopted to minimize disturbance of fish and other marine fauna</li> <li>• Ensure pipeline activities commence slowly to provide opportunities for migration of marine fauna.</li> <li>• Mobilise to site during off season to avoid disruption of some marine organisms` reproduction cycle and migratory routes.</li> </ul>	L	Site inspection report	Once during pipeline construction activity	Project manager
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>	M	Security Management procedure Journey management procedure Record of security situation/ updates Site Inspection records	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	Impairment of air quality	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>generators and engines are maintained in accordance with written procedures based on the manufacturers' guidelines or applicable industry code or engineering standards to ensure efficient and reliable operation.</li> </ul>	L	Premob certificates Maintenance records Compliance Monitoring Reports	Weekly	Project manager
	Impairment of water quality (turbidity and suspended solids)	H	<ul style="list-style-type: none"> <li>Deploy best in class pipelaying method for pipelaying to reduce impact of turbidity</li> <li>Dispose all wastes in line with regulatory requirements.</li> </ul>	M	Waste Consignment note	Monthly	Project manager
	Agitation of sediment that will impact benthic community	H	<ul style="list-style-type: none"> <li>Deploy best in class pipelaying method for pipelaying to reduce impact of turbidity and sediment agitation</li> <li>Dispose all wastes in line with regulatory requirements.</li> <li>Treat all effluents to regulatory limits before discharging into the environment</li> </ul>	M	Site Report Waste	Monthly	Project manager
	Exposure to radiation materials	H	SPDC shall ensure that: <ul style="list-style-type: none"> <li>Health awareness training is conducted prior to commencement of activities.</li> <li>Staff undergo routine</li> </ul>	L	Minutes of toolbox meetings/safety briefings. Site inspection reports. Radiation levels	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			medical check-ups for radiation exposure. <ul style="list-style-type: none"> <li>• Radiation monitors are provided to monitor radiation levels at site.</li> <li>• The use of radiography aprons to protect the body from radiation is enforced.</li> <li>• Warning signs are provided during radiation emitting activities to prevent trespass into such areas.</li> <li>• The radiation emitting activity is carried out in accordance with standard construction specifications and Regulatory guidelines.</li> </ul>		record at work site Records of medical checks.		
	Inhalation of welding fumes	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Awareness sessions on health risks and safety precautions of welding operations are carried out for workers.</li> <li>• The use of PPEs (welder’s mask, jacket, gloves, boots and coveralls), by welders during welding is enforced.</li> </ul>	L	Records of PPEs issuance and usage Records of awareness sessions Site clinic records	Weekly	Project manager
	Soft tissues damage from welding sparks	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Awareness sessions on health risks and safety precautions of welding</li> </ul>	L	Records of PPEs issuance and usage Records of awareness sessions	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<p>operations are carried out for workers.</p> <ul style="list-style-type: none"> <li>the use of PPEs (welder’s mask, jacket, gloves, boots and coveralls), by welders during welding is enforced.</li> <li>A functional site clinic approved by SPDC is provided by the contractor.</li> </ul>		Site clinic records		
	Corneal flash burns (photokeratosis) from welding	M	<p>SPDC shall ensure that</p> <ul style="list-style-type: none"> <li>Awareness sessions on health risks and safety precautions of welding operations for workers are carried out.</li> <li>Pre-employment medical certification the welders is carried out.</li> <li>PPEs (welder’s mask, earmuffs, jacket, gloves, boots and coveralls), by welders during welding is enforced.</li> </ul>	L	Records of PPEs issuance and usage Records of awareness sessions Site clinic records	Weekly	Project manager
	Potential for conflicts arising from labour issues	H	<p>SPDC &amp; her contractors shall:</p> <ul style="list-style-type: none"> <li>Respond to complaints by locals on the activities of her workers</li> <li>Deploy GMOU provisions on community labour issues.</li> </ul>	L	Records of employment Records of issues settled	Monthly	Project manager



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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	Stress on existing security structures	H	SPDC shall: <ul style="list-style-type: none"> <li>• Make all necessary arrangements with Government security agents (Navy) to improve security.</li> <li>• SPDC shall continue to engage stakeholders in order to minimize resentment.</li> <li>• Workers are made aware to be security conscious</li> </ul>	M	Security Management procedure Journey management procedure Record of security situation/ updates Site Inspection records	Weekly	Project manager
Demobilization	Impairment of air quality (VOC & SPM)	M	SPDC shall: <ul style="list-style-type: none"> <li>• Use only pre-mobbed and regularly maintained vessels, generators and other machines.</li> <li>• Use only low sulphur containing fuels and low NOx burners in large generators and turbines.</li> <li>• Ensure wet scrubbers and venturi techniques are fitted at the end of pipe for generators and vessel exhaust systems</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager
	Water traffic incidents	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> </ul>	L	Journey management records Premob certificates Pep-talk records Accident records	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<ul style="list-style-type: none"> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>				
	Improper disposal of materials removed from site	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>• All removed materials shall be properly disposed of and monitored from cradle to grave in line with the waste management plan</li> <li>• Scrap metals shall be collected, segregated and subjected to SPDC's waste</li> </ul>	L	SPDC Waste management plan Waste consignment note Reports Site inspection Reports	Weekly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			management guidelines. <ul style="list-style-type: none"> <li>Plastic wastes shall be sent to an approved Recycling Waste Depot (RWD).</li> <li>Radioactive wastes/materials shall be managed according to Nigerian Nuclear Regulatory Authority (NNRA) approved procedure.</li> <li>SPDC waste management policy shall be enforced.</li> </ul>				
	Increase in noise and vibration level	M	SPDC shall: Use only pre-mobbed and regularly maintained equipment and water crafts	L	Premob certificates Maintenance records	Weekly	Project manager
	Loss of employment/ income	H	SPDC Shall: <ul style="list-style-type: none"> <li>Strengthen existing cooperation of the neighbouring communities via the existing Global Memorandum of Association interface.</li> <li>Require contractors to prepare and implement workers disengagement plans</li> <li>Encourage and support skill acquisition programmes of Government, NGOs</li> </ul>	L	Evidences of workers disengagement plans, Records of skill acquisition, Evidence of support for micro-credits	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			and CBOs				
	Risk of accident from vessel collision	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency response plan inline with SOLAS</li> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>	L	Journey management records Premob certificates Pep-talk records Accident records	As required	Project manager
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>• Activate countermeasures to</li> </ul>	M	Security Management procedure	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			mitigate the threats of piracy and kidnapping. <ul style="list-style-type: none"> <li>• Ensure project non productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>		Journey management procedure Record of security situation/ updates Site Inspection records		
Commissioning	Discharge of hydrotest water to the environment during pre-commissioning.	M	SPDC shall barge hydrotest water to onshore for treatment.	L	Consignment Note/ Evidence of Hydrotest water barging to shore	Monthly	Project manager
	Spill due to damaged pipe or valve.	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure adequate testing of pipes and valves for leakages prior to introduction of hydrocarbon.</li> <li>• Installation of Emergency Shut down Valve (ESDV) to control excessive well pressure.</li> </ul>	L	Record of spill	During Pre-commissioning	Project manager
Operations and Maintenance	Improper disposal of materials removed from site	H	SPDC shall: <ul style="list-style-type: none"> <li>• Ensure all oily wastes are properly segregated and contained before disposal.</li> <li>• Ensure all oily wastes are properly disposed of</li> </ul>	L	Waste consignment note Site Inspection reports Maintenance reports	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			and monitored from cradle to grave. <ul style="list-style-type: none"> <li>• Ensure regular clean-up of equipment at site.</li> <li>• Provide containment for chemicals and liquid discharges.</li> <li>• Ensure the enforcement of waste management policy.</li> <li>• Ensure that a controlled fuelling, maintenance and servicing protocol for machinery at worksite is established and followed to minimize leaks and spills.</li> <li>• Ensure Spent chemicals, lube oil, grease, waste oil and detergent solutions are properly disposed of.</li> <li>• Ensure used chemical drums and containers are sent to an approved recyclable waste dump (RWD).</li> <li>• Ensure that Small chemicals spills, crude oil and aqueous effluents shall be cleaned up promptly.</li> </ul>				
	Equipment failure and damage leading to injuries/fatality	M	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Only skilled personnel and certified equipment</li> </ul>	L	Premob certificates Maintenance records.	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<ul style="list-style-type: none"> <li>are used.</li> <li>Certified first aiders shall be available at every site.</li> <li>First aid boxes and emergency response procedures are in place.</li> <li>Hazard assessment has been conducted.</li> <li>Emergency response procedures are in place.</li> <li>HSE standards are strictly adhered to.</li> <li>Permit to work and proper briefing is given before any work can commence.</li> </ul>		Certification of work force First Aid box inventory  HAZID register Records Tool box meeting HSE inspection records.  Emergency response procedure.		
	Air quality impairment from Well flare/vent	H	SPDC shall ensure: No routine flaring of associated gas.	L	Records of gas produced, Records of gas flared,	Quarterly	Project manager
	Impairment of water quality from produced water discharges and leaks	H	SPDC shall ensure that: Produced water shall be treated at the Sea Eagle FPSO to regulatory standards before discharge.	M	Site inspection report	Monthly	Project manager
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>Activate countermeasures to mitigate the threats of piracy and kidnapping.</li> <li>Ensure project non productive time is reduced to the barest minimum.</li> </ul>	M	Journey management records Premob certificates Pep-talk records Accident records	Monthly	Project manager

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			<ul style="list-style-type: none"> <li>All movements shall be undertaken only with Security Single Point Approval</li> <li>All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>				
	Leaks from process pipes, Well head equipment, flanges, subsea lines etc.		SPDC shall: <ul style="list-style-type: none"> <li>Ensure adequate testing of pipes and valves for leakages prior to introduction of hydrocarbon.</li> <li>Installation of Emergency Shut down Valve (ESDV) to control excessive well pressure.</li> </ul>		Site inspection report	Monthly	Project manager
Decommissioning and Abandonment	Increase in noise and vibration	M	SPDC shall <ul style="list-style-type: none"> <li>Use only pre-mobbed and regularly maintained equipment and water crafts</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager
	Impairment of air quality from emission of HWR	M	SPDC shall: <ul style="list-style-type: none"> <li>Use only pre-mobbed crafts</li> <li>Regular maintenance of water crafts, vessels, generators and other machines.</li> <li>Use low sulphur containing fuel and low NOx burners</li> </ul>	L	Premob certificates Maintenance records	Weekly	Project manager
	Risk of Piracy & kidnapping	H	SPDC shall: <ul style="list-style-type: none"> <li>Activate</li> </ul>	M	Journey management records	Monthly	Project manager



Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			countermeasures to mitigate the threats of piracy and kidnapping. <ul style="list-style-type: none"> <li>• Ensure project non-productive time is reduced to the barest minimum.</li> <li>• All movements shall be undertaken only with Security Single Point Approval</li> <li>• All installation activities are executed under the supervision of a GSA armed escort.</li> </ul>		Premob certificates Pep-talk records Accident records		
	Increase potential for water traffic accidents/ injury	M	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Adequate radio communication between offshore installations, merchant ships and standby vessels</li> <li>• Communication hardwares and agreed Global Maritime Distress and Safety System (GMDSS) procedures are effective</li> <li>• Regular drills on abandon ship procedures shall be enforced</li> <li>• Safety signages shall be deployed at strategic locations.</li> <li>• Activate Emergency</li> </ul>	L	Journey management records Pre-mob certificates Pep-talk records Accident records	monthly	Project manager

Environmental Impact Assessment of EA/EJA Further Oil Development Project

Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
			response plan inline with SOLAS <ul style="list-style-type: none"> <li>• Strict adherence to weather forecast information from the synoptic stations.</li> <li>• Only competent and experienced vessel crew with appropriate certification shall be used.</li> </ul>				
	Potential for conflicts arising from labour issues	H	SPDC and her contractors shall: <ul style="list-style-type: none"> <li>• Respond to complaints by locals on the activities of her workers.</li> <li>• Deploy GMOU provisions on community employment.</li> </ul>	L	Records of employment	Monthly	Project manager
	Injury/fatalities in workforce	H	SPDC shall ensure: <ul style="list-style-type: none"> <li>• Daily pep talk is carried out for marine transportation</li> <li>• Safety signage shall be deployed at strategic locations.</li> <li>• Provide first aid boxes in operational water crafts.</li> <li>• Emergency response plan shall be in place.</li> </ul>	L	Certification of workforce Emergency response plan MSDS and Technical specification HAZID register. Pep-talk records	Monthly	Project manager
	Impairment of surface water and sediment quality from complete decommissioning	H	SPDC shall ensure that: <ul style="list-style-type: none"> <li>• Effluents from decommissioning activities are treated to</li> </ul>	L	Site inspection report	Monthly	Project manager

Environmental Impact Assessment of EA/EJA Further Oil Development Project

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Project Phase	Description of Impacts	Impact Rating Before Mitigation	Mitigation Measures	Impact Rating After Mitigation	Parameter for Monitoring	Frequency of Monitoring/ Formal Reporting	Responsible/ Action Party
	activities		regulatory standards before discharge.				

### **CHAPTER EIGHT CONCLUSION**

The Environmental Impact Assessment study of the EA/EJA FOD Project has attempted to evaluate and described the environmental impacts that may arise from the planned project execution. The environmental components description was based on recent data obtained from the Field Data Gathering (FDG) of the EA FOD areas carried out in November 2018 as well as from comparison with past studies.

The area of influence of the proposed project (drilling of wells, platforms and pipeline construction activities) were also covered during the FDG. The environmental components covered includes; air quality and noise, surface water, sediment, hydrobiology, fisheries, social and health profile. The results showed that air quality and noise levels were general within the DPR limits of daily average values and compared favourably with the control stations. A significant increase in seawater heavy metal and TPH concentrations with decreasing distance from FPSO suggested the facility as a possible source. However, other anthropogenic sources such as effluents from water crafts cannot be ruled out. Similarly, the concentration of heavy metals and organics were generally within the DPR target and intervention values for micro pollutants in sediments.

The EIA identified and addressed environmental issues/risks concerned with the various execution phases, and proffered mitigation measures to reduce negative impacts identified.

An Environmental Management Plan (EMP) has been developed to be implemented and monitored for the duration of the project lifecycle, Also, SPDC conducts weekly environmental compliance monitoring in the EA/EJA field and has a robust waste management system for existing facilities in the field. It is SPDC's resolve to maintain and sustain a mechanism for internationally acceptable environmental management practice.

In the light of the above, having evaluated all potential, associated and cumulative impacts of the existing facilities and the proposed project in the EA/EJA field, proffered mitigation measures and developed an EMP in line with international best practises, we hope that approval/permit for the commencement of the project is granted.

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**Appendix 1a**  
**DPR Approved Terms of Reference**



# MINISTRY OF PETROLEUM RESOURCES

## DEPARTMENT OF PETROLEUM RESOURCES

7, KOFO ABAYOMI STREET, VICTORIA ISLAND, LAGOS

P.M.B. No: 12650

Telephone: 01-2790000

Website: [www.dpr.gov.ng](http://www.dpr.gov.ng)



Ref. No: DPR/HSE.02/001.102/2018/039

Date: 19<sup>th</sup> July 2018

The Managing Director  
Shell Petroleum Development Company (Nig.) Limited  
Freeman House  
21/22 Marina  
Lagos



Dear Sir,

### APPROVAL OF TERMS OF REFERENCE (TOR) / SCOPE OF WORK (SOW) FOR THE ENVIRONMENTAL EVALUATION STUDY (EES) AND BIOLOGICAL MONITORING (BM) OF EA/EJA FIELD (OML 79)

We refer to your letter of July 5, 2018 referenced SPDC-HSE-2018-0352L transmitting the TOR/SOW for the Environmental Evaluation and Biological Monitoring studies of the above fields as well as your additional request to include your further oil development scope to this study.

2. Consequent upon your admission of error in the number of surface water samples stated in your TOR/SOW submission and your request to collect the same number of samples as in the 2015 study for the purposes of trending/revalidation, we hereby accede to your request but however posit as follows:

- i. The field data gathering shall be for one season but the sampling exercise should be carried out in the same period as the previous study to allow for proper evaluation based on seasonality.
- ii. The number of surface water samples shall be increased to be in tandem with the proposed sediment samples.
- iii. Trend analysis shall be carried out by leveraging the following data sets:
  - EIA Approval for the EA/Eja Field Further Oil Development (FOD), November 21, 2016
  - EE/BM Studies Approval of EA/Eja Fields, November 21, 2016

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

- Environmental compliance monitoring data, 2016-2018

iv. The collected samples shall be analysed for the following parameters:

S/N	Sample	Analysis	Parameters	Remarks
1.	Sediment 102 + 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, Ag, Co and Zn), etc.	<p>Sediment samples for BTEX shall be collected in glass bottles preserved in methanol.</p> <p>GC with a purge &amp; trap system or GC-FID with headspace shall be used for the analysis of BTEX.</p> <p>Samples for PAH analysis shall be conducted with a GC-MS.</p> <p>Oil &amp; grease/TPH shall be analysed using infrared spectrophotometer.</p> <p>Control samples shall be collected from pristine environments.</p>
		Microbiology	THB, THF, THUB, THUF, SRB and Fecal 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 102 + 3 controls  40 Water Profiles	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 <sub>5</sub> , COD, anions/cations, $NH_4^+$ , $NO_3^-$ , $NO_2^-$ , $PO_4^{3-}$ , $SO_4^{2-}$ ,	<p>Samples for BTEX samples shall be taken with vials.</p> <p>Analyses for BTEX, PAH, THC/Oil &amp; grease shall be as stated above.</p>

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

			SiO <sub>2</sub> , Na, K, Ca, Mn, Mg, Heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Ba, Hg), etc.	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 (chlorophyll concentration)	Same as macro benthos above.
		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, gonad ratio, etc. shall be reported as part of this study.
		Hydrodynamics	Water depth and width, flow direction and flow rate.	
3.	<b>Air Quality/Noise (16 + 3 Controls)</b>	Ambient	VOCS, SO <sub>2</sub> , NO <sub>2</sub> , CH <sub>4</sub> , CO, CO <sub>2</sub> , temperature, Noise Levels, SPM, PM <sub>2.5</sub> , PM <sub>10</sub> , wind speed and direction.	One (1) hour mean for each of the air quality parameters shall be taken per station. A total of four (4) data sets should be collected within 1 hr.
4.	<b>Social &amp; Health Impact Assessment</b>		Enumerate and evaluate the impact of social interventions on communities, Vital health statistics, disease prevalence, predisposing factors, existing health	



## Environmental Impact Assessment of EA/EJA Further Oil Development Project

			institutions/facilities in the area, identification of communities in the study area, social organisations/institutions, population distribution & density, birth rate, land use, water use, life expectancy, employment status, archaeological sites, cultural and religious practices, restricted areas, occupation, etc.	
5.	Effluent Characterization (Waste water/produced water)	Physico-chemical	pH, DO, salinity, conductivity, alkalinity, BTEX, TPH, TDS, TSS, Turbidity, TOC, THC, BOD <sub>5</sub> , COD, phenols, sulphate, nitrate, calcium, sodium, potassium, magnesium, heavy metals (Fe, Cd, Cr, Ni, V, Pb, Zn, Ba, Hg), etc.	Sampling/analyses shall be as prescribed for surface water above.
6.	Effluent Bioassay (Waste water/produced water)	Biological	<p>Toxicity tests shall be conducted using the following multi-trophic level species.</p> <ul style="list-style-type: none"> <li>-Bacteria (<i>Vibrio fischeri</i>)</li> <li>-Microalgae (<i>Skeletonema costatum</i>)</li> <li>-Copepod (<i>Acartia tonsa</i>)</li> <li>-Fish (<i>Tilapia guineensis</i>)</li> </ul> <p>Bioaccumulation and Biomagnification test using <i>Clibanarius africanus</i> (Hermit crab) &amp; <i>Palaemonetes africanus</i> (Shrimp)</p>	Kindly note that the holding time of effluent for ecotoxicity test is 72 hours.
7.	Effluent Receiving Water (Recipient Environment)	Biological	Toxicity tests shall be conducted using the same four trophic level species above.	<p>Samples shall be collected at the mixing zone (the point the effluent had first contact with the receiving water)</p> <p>Characterization of the effluent receiving</p>

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

				water shall be done as prescribed in item (4) above.
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4. As listed on the table above, you are to investigate toxicity at four trophic levels using procedures entrenched in Part VIII E.2.3.3 of Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2002) and the Whole Effluent Toxicity (WET) testing methodology, USEPA, 2002 at Funiwa/North Apoi where produced water is currently being discharged. Please note that, whilst the plant (microalgae), invertebrate (Copepod) and vertebrate (fish) are invivo tests, the bacteria (*Vibrio fischeri*) is an invitro test using Microtox microbial toxicity screening procedure. The results of the test for each of the individual species shall be used for the derivation of the following endpoints- **LC50, EC50, IC50, NOEC, LOEC** and **TUa** (acute toxic unit) while for the bioaccumulation and biomagnification tests, the expected end points are the bioaccumulation factor (**BAF**) and biomagnification factor (**BMF**).
5. The results of this study shall be used for comparative and trend analysis of the afore listed environmental data sets in this field or other proximal fields. Statistical analyses shall be used to draw inferences and necessary deductions.
6. Should you require to change any of the test organisms based on availability or any other cogent reason, please do not hesitate to contact this office.
7. On conclusion of this study, you are to submit two separate draft reports, an EIA for the FOD studies and the EE/BM studies 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.
8. You are required to liaise with this Office in good time to ensure our adequate participation in the field data gathering exercise and subsequent laboratory analyses.
9. Finally, please note that this TOR/SOW approval supersedes the former that was issued to you earlier.

Yours faithfully,



**Abdurrahman A. S.**

for: Director, Petroleum Resources

**Appendix 1b**

**Evidence of DPR participation during the October/November, 2018 EIA Studies**



**ATTENDANCE SHEET**

**JOINT DPR/SPDC QA/QC LABORATORY INSPECTION FOR THE ENVIRONMENTAL SAMPLES OF OML 77174  
SEISMIC DATA ACQUISITION AND JK EXPLORATION AND APPRAISAL WELLS PROJECTS** *EA EJA FEEDS FOR FE*

**ATTENDANCE SHEET**

Date: *21/11/2018*

S/N	Name	Designation	Phone number	Signature
1	<i>MUSA OYINMI</i>	<i>SPDC</i>	<i>0808670900</i>	<i>[Signature]</i>
2	<i>Al. Mala</i>	<i>DPR</i>	<i>07032205522</i>	<i>[Signature]</i>
3	<i>Obua Uche</i>	<i>ESL</i>	<i>07065431192</i>	<i>[Signature]</i>
4	<i>Nwanya Kingsley</i>	<i>ESL</i>	<i>07039515980</i>	<i>[Signature]</i>
5	<i>Epeni Vivan</i>	<i>ESL</i>	<i>08032750664</i>	<i>[Signature]</i>
6	<i>Ebere Chinyere</i>	<i>ESL</i>	<i>08237751957</i>	<i>[Signature]</i>
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8	<i>Ozumba Benita</i>	<i>ESL</i>	<i>08032310366</i>	<i>[Signature]</i>
9	<i>Kingsley Eze</i>	<i>ESL</i>	<i>08037481142</i>	<i>[Signature]</i>
10	<i>Alexander Aselamin</i>	<i>ESL</i>	<i>07030707373</i>	<i>[Signature]</i>
11	<i>OLAAUN BOAE</i>	<i>ESL</i>	<i>08166470280</i>	<i>[Signature]</i>
12	<i>Williams Bell A</i>	<i>ESL</i>	<i>08060356086</i>	<i>[Signature]</i>
13	<i>AKOTOHWO EKENNAY</i>	<i>DPR</i>	<i>08036460323</i>	<i>[Signature]</i>
14	<i>Michael Richard</i>	<i>SPDC</i>	<i>08070324034</i>	<i>[Signature]</i>

**Appendix 1c**  
**Sampling Map and Coordinates**



**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 2  
Analytical results for Sea Eagle during the October/November, 2018 EIA Studies**

**Appendix 2a: Meteorological/Gaseous Emission Field Measurement for Sea Eagle during the October/November, 2018 EIA Studies**

Field Air Quality Measurements: In-situ Measurements									
S/N	Parameter	Unit	DPR Limits (1hr)	EA 50 1/11/18	EA 53 1/11/18	EA 56 2/11/18	EA 38 2/11/18	EA 40 2/11/18	EA CONTL 1 3/11/18
1	SOX	µg/m <sup>3</sup>	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NOX	µg/m <sup>3</sup>	400	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2
3	COx	µg/m <sup>3</sup>	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H <sub>2</sub> S	µg/m <sup>3</sup>		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	CXHY	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	SW	SW	SW	SW	SW	SW
8	Wind Speed	m/s	N/A	2.2	1.3	2.4	1.7	1.6	2.3
9	Amb. Temperature	OC	N/A	30.9	34.9	28.4	30.5	30.9	34.5
10	Relative Humidity	%	N/A	75.3	63.8	77.3	63.2	63.4	58.7
11	Atm. Pressure	Pa	N/A	1006	1005	1009	1006	1006	1005
12	Noise Level	dBA	80-100	77.8	70.6	70.9	74.2	79.7	70.9
13	SPM10	µg/m <sup>3</sup>	60-90	32.0	38.0	27.0	29.0	26.0	28.0

**Appendix 2a Continued: Meteorological/Gaseous Emission Field Measurement for Sea Eagle during the October/November, 2018 EIA**

Field Air Quality Measurements:									
S/N	Parameter	Unit	DPR Limits (1hr)	EA CONTL 3 4/11/18	EA 29 4/11/18	EA 26 4/11/18	EA CONTL 2 4/11/18	EA 92 5/11/18	EA 93 5/11/18
1	SOX	µg/m <sup>3</sup>	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NOX	µg/m <sup>3</sup>	400	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2
3	COx	µg/m <sup>3</sup>	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H <sub>2</sub> S	µg/m <sup>3</sup>		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	CXHY	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	SW	SW	SW	SW	SW	SW
8	Wind Speed	m/s	N/A	1.4	1.3	3.3	2.9	1.2	1.1
9	Amb. Temperature	OC	N/A	29.4	33.1	33.3	35.8	30.9	33.4
10	Relative Humidity	%	N/A	76.2	63.7	63.4	60.2	74.8	68.5
11	Atm. Pressure	Pa	N/A	1007	1009	1009	1009	1006	1006

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

12	Noise Level	dBA	80-100	73.2	76.8	75.2	70.9	74.8	74.9
13	SPM10	µg/m3	60-90	31.0	27.0	38.0	30.0	27.0	26.0

**Appendix 2a Continued: Meteorological/Gaseous Emission Field Measurement for Sea Eagle during the October/November, 2018 EIA**

Field Air Quality Measurements:									
S/N	Parameter	Unit	DPR Limits (1hr)	EA 82 6/11/18	EA 78 6/11/18	EA 67 7/11/18	EA 61 7/11/18	EA 72 7/11/18	EA 63 8/11/18
1	SOX	µg/m3	350	<19.9	<19.9	<19.9	<19.9	<19.9	<19.9
2	NOX	µg/m3	400	<14.2	<14.2	<14.2	<14.2	<14.2	<14.2
3	COx	µg/m3	30	<8.7	<8.7	<8.7	<8.7	<8.7	<8.7
4	H2S	µg/m3		<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
5	CXHY	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	SW	SW	SW	SW	SW	SW
8	Wind Speed	m/s	N/A	2.6	1.4	3.6	6.1	4.8	2.6
9	Amb. Temperature	OC	N/A	27.6	27.2	28.8	28.9	27.9	28.2
10	Relative Humidity	%	N/A	80.3	84.2	77.6	77.5	83.6	85.1
11	Atm. Pressure	Pa	N/A	1007	1005	1010	1010	1006	1011
12	Noise Level	dBA	80-100	70.0	71.3	70.1	68.9	71.2	68.9
13	SPM10	µg/m3	60-90	42.0	30.0	35.0	6.0	5.0	20.0

**Appendix 2a Continued: Meteorological/Gaseous Emission Field Measurement for Sea Eagle during the October/November, 2018 EIA**

Field Air Quality Measurements:							
S/N	Parameter	Unit	DPR Limits (1hr)	EA 4 8/11/18	EA 8 8/11/18	EA 13 9/11/18	EA 20 9/11/18
1	SOX	µg/m3	350	<19.9	<19.9	<19.9	<19.9
2	NOX	µg/m3	400	<14.2	<14.2	<14.2	<14.2
3	COx	µg/m3	30	<8.7	<8.7	<8.7	<8.7
4	H2S	µg/m3		<1.1	<1.1	<1.1	<1.1
5	CXHY	ppm		<1.0	<1.0	<1.0	<1.0
6	Smoke Density	Ringlemann	2.0	N/A	N/A	N/A	N/A
7	Wind Direction	N/A	N/A	SW	SW	SW	SW
8	Wind Speed	m/s	N/A	0.9	4.0	3.2	1.9
9	Amb. Temperature	OC	N/A	39.3	31.1	29.6	29.0
10	Relative Humidity	%	N/A	52.8	73.7	80.1	80.9
11	Atm. Pressure	Pa	N/A	1010	1007	1010	1010
12	Noise Level	dBA	80-100	75.4	72.8	70.0	72.4
13	SPM10	µg/m3	60-90	39.0	5.0	16.0	14.0

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

**Appendix 2b: Physico-Chemistry Results for Water Samples for the Sea Eagle during the October/November, 2018 EIA Studies**

Sample ID	TEMP (°C)	PH	COND	TURB	DO	TDS	CL	AL	CO	TSS	COD	BOD	SO4	PO4	NO3	NH4	N02-	O/G	THC	TPH	PAH	BTE
		APH	APH		APH	APH	APH	K	L	AST	APH	APH	APH	APH	APH	APH	APH	AST	AST	AST	AST	X
		A	A		A	A	A			M	A	A	A	A	A	A	A	M	M	M	M	AST
		4500	2510		4500	1030	4500			1868	5220	9210	4500	4500	4500	4500	4500	D3921	D3921	D3921	D4657	M
			A			mg/l	mg/l			mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	mg/l	D2600
			μS/cm																			mg/l
EA 1 TOP	28.3	8.54	37100	0	5.9	25971	13397	12.0	0.01	52	160	0.1	887	0.48	1.9	0.88	6.24	<0.001	<0.001	<0.001	<0.001	<0.001
EA 1 MID	27.9	8.51	37500	0	4.9	26257	13542	8.0	0.02	56	154	0.1	982	0.72	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001
EA 1 BOT	27.6	8.51	38400	0	3.0	26890	13867	12.0	0.00	48	187	0.3	899	0.51	2.1	0.97	6.89	<0.001	<0.001	<0.001	<0.001	<0.001
EA 2 TOP	27.5	8.41	33300	0	5.9	23319	12025	12.0	0.00	50	187	0.1	996	0.26	2.3	1.06	7.55	<0.001	<0.001	<0.001	<0.001	<0.001
EA 2 MID	27.3	8.47	39200	0	4.3	27448	14156	16.0	0.00	54	193	0.1	860	0.81	2.2	1.02	7.23	<0.001	<0.001	<0.001	<0.001	<0.001
EA 2 BOT	27.1	8.45	43600	0	3.1	30527	15744	12.0	0.01	58	197	0.1	882	0.27	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001
EA 3 TOP	28.1	8.44	33900	0	5.8	23731	12242	16.0	0.00	46	195	0.3	926	0.30	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001
EA 3 MID	27.4	8.44	44900	0	4.4	31433	16214	12.0	0.00	50	190	0.2	810	0.41	1.2	0.55	3.94	<0.001	<0.001	<0.001	<0.001	<0.001
EA 3 BOT	27.1	8.44	46600	0	3.0	32624	16828	12.0	0.00	48	193	0.1	855	0.31	0.8	0.37	2.63	<0.001	<0.001	<0.001	<0.001	<0.001
EA 4 TOP	29.9	8.43	34500	0	5.8	24155	12458	12.0	0.01	52	221	0.2	930	0.22	1.7	0.79	5.58	<0.001	<0.001	<0.001	<0.001	<0.001
EA 4 MID	28.7	8.47	45100	0	4.3	31573	16286	16.0	0.00	56	205	0.1	980	0.61	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Samp le ID	TEM P (°C)	PH APH A 4500	CON D APH A 2510 A μS/c m	TUR B	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	AL K	CO L	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02- APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTE X AST M D260 0 mg/l
EA 4 BOT	28.3	8.45	4640 0	0	3.0	3249 1	1675 6	16. 0	0.0 0	48	219	0.2	838	0.40	1.4	0.65	4.59	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 5 TOP	30.1	8.48	3440 0	0	5.9	2408 1	1242 2	12. 0	0.0 0	50	231	0.1	995	0.50	2.2	1.02	7.23	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 5 MID	29.3	8.50	3970 0	0	4.3	2779 4	1433 6	16. 0	0.0 1	54	198	0.3	855	0.31	1.2	1.02	3.94	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 5 BOT	28.9	8.49	4180 0	0	3.2	2926 2	1509 6	12. 0	0.0 0	58	187	0.3	801	0.46	1.3	0.60	4.27	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 6 TOP	29.5	8.48	3450 0	0	5.8	2415 1	1245 8	16. 0	0.0 0	60	205	0.2	836	0.26	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 6 MID	29.0	8.49	4160 0	0	4.1	2912 4	1502 2	12. 0	0.0 0	56	201	0.1	841	0.60	1.2	0.55	3.94	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 6 BOT	28.1	8.48	4240 0	0	3.0	2968 3	1531 1	12. 0	0.0 1	62	208	0.3	948	0.40	1.4	0.65	4.59	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 7 TOP	29.7	8.51	3520 0	0	5.8	2464 1	1271 1	12. 0	0.0 1	60	195	0.3	715	0.20	1.3	0.60	4.27	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 7 MID	28.4	8.51	3940 0	0	4.4	2758 0	1422 4	12. 0	0.0 2	56	199	0.2	973	0.44	1.7	0.79	5.58	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 7 BOT	27.9	8.51	3960 0	0	3.2	2772 1	1430 0	16. 0	0.0 0	52	200	0.2	845	0.88	1.3	0.60	4.27	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 8 TOP	29.3	8.54	3380 0	0	5.8	2366 7	1220 6	12. 0	0.0 0	70	203	0.3	890	0.33	1.4	0.65	4.59	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 8 MID	28.7	8.52	3680 0	0	4.2	2576 3	1328 9	12. 0	0.0 0	66	201	0.3	835	0.20	1.3	0.60	4.27	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 8 BOT	28.4	8.52	3910 0	0	3.0	2737 2	1411 9	12. 0	0.0 1	68	197	0.1	871	0.38	1.6	0.74	5.25	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 9 TOP	31.1	8.48	3160 0	0	5.9	2212 0	1141 1	16. 0	0.0 1	62	225	0.4	910	0.12	1.8	0.83	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 9 MID	29.8	8.51	3970 0	0	4.6	2779 0	1433 6	12. 0	0.0 1	54	217	0.4	780	0.66	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 9 BOT	29.7	8.50	4050 0	0	3.2	2835 2	1462 5	16. 0	0.0 0	58	219	0.3	951	0.22	1.1	0.51	3.61	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 10	29.2	8.57	3020 0	0	5.9	2114 7	1090 6	12. 0	0.0 0	54	202	0.1	838	0.77	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1

### Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	COL	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02-APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTEX AST M D260 0 mg/l	
TOP																							
EA 10 MID	28.8	8.52	39500	0	4.3	27650	14264	16.0	0.02	50	207	0.1	941	0.66	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 10 BOT	28.5	8.54	40000	0	3.1	28000	14444	16.0	0.00	48	219	0.1	954	0.44	1.3	0.60	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 11 TOP	27.9	8.51	42400	0	5.8	29680	15311	12.0	0.00	48	163	0.2	800	0.38	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 11 MID	27.1	8.50	43800	0	5.3	30660	15817	12.0	0.02	50	167	0.3	870	0.13	0.8	0.37	2.63	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 11 BOT	26.9	8.50	44200	0	3.1	30940	15961	8.0	0.02	54	156	0.1	982	0.41	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 12 TOP	27.8	8.56	38800	0	5.9	27160	14011	12.0	0.00	60	205	0.5	841	0.36	1.3	0.60	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 12 MID	27.4	8.56	40300	0	4.4	28214	14553	12.0	0.00	54	201	0.3	839	0.81	2.1	0.97	6.89	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 12 BOT	26.2	8.56	42000	0	3.1	29400	15167	12.0	0.00	58	203	0.2	910	0.56	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 13 TOP	27.9	8.56	39700	0	5.8	27793	14336	12.0	0.00	56	295	0.6	997	0.11	1.7	0.79	5.58	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 13 MID	27.5	8.55	40800	0	4.3	28563	14733	12.0	0.01	52	195	0.3	831	0.51	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 13 BOT	26.4	8.55	42000	0	3.1	29400	15167	8.0	0.00	58	193	0.2	974	0.72	1.9	0.88	6.24	<0.001	<0.001	<0.001	<0.001	<0.001	

### Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	COL	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02-APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTEX AST M D260 0 mg/l
EA 14 TOP	27.9	8.56	3870 0	0	6.0	2709 4	1397 5	12.0	0.0 1	60	177	0.3	991	0.90	2.3	1.06	7.55	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 14 MID	27.3	8.56	3910 0	0	4.5	2737 0	1411 9	12.0	0.0 1	50	185	0.1	962	0.20	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 14 BOT	26.4	8.52	4400 0	0	3.2	3080 1	1588 9	16.0	0.0 0	48	194	0.3	837	0.41	1.9	0.88	6.24	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 15 TOP	28.1	8.56	3860 0	0	5.9	2702 0	1393 9	16.0	0.0 1	60	204	0.2	892	0.62	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 15 MID	27.5	8.56	4140 0	0	4.6	2898 1	1495 0	16.0	0.0 1	56	218	0.4	825	0.51	1.9	0.88	6.24	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 15 BOT	26.9	8.55	4200 0	0	3.2	2940 2	1516 7	12.0	0.0 0	54	209	0.2	846	0.22	1.7	0.79	5.58	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 16 TOP	28.3	8.56	3870 0	0	5.9	2709 2	1397 5	16.0	0.0 0	48	186	0.4	930	0.19	1.5	0.69	4.93	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 16 MID	27.8	8.55	4100 0	0	4.6	2870 2	1480 6	12.0	0.0 2	52	181	0.1	875	0.81	1.1	0.51	3.61	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 16 BOT	27.2	8.56	4220 0	0	3.1	2954 0	1523 9	12.0	0.0 2	54	187	0.2	945	0.30	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 17 TOP	27.8	8.56	4040 0	0	5.8	2828 6	1458 9	16.0	0.0 0	40	184	0.1	849	0.74	2.3	1.06	7.55	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 17 MID	27.1	8.56	4350 0	0	4.5	3045 0	1570 8	12.0	0.0 0	46	188	0.2	851	0.34	1.2	0.55	3.94	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA	26.3	8.55	4520	0	3.0	3164	1632	12.0	0.0	48	192	0.1	800	0.27	1.4	0.65	4.59	<0.00	<0.00	<0.00	<0.00	<0.00

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Samp le ID	TEM P (°C)	PH APH A 4500	CON D APH A 2510 A μS/cm	TUR B	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	AL K	CO L	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02- APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTE X AST M D260 0 mg/l
17 BOT			0			3	2	0	1									1	1	1	1	1
EA 18 TOP	29.9	8.50	3690 0	0	5.9	2583 0	1332 5	12. 0	0.0 1	68	204	0.3	838	0.22	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 18 MID	29.2	8.5	4230 0	0	4.5	2961 2	1527 3	12. 0	0.0 0	60	201	0.2	837	0.46	1.6	0.74	5.25	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 18 BOT	28.6	8.49	4290 0	0	3.2	3003 9	1549 2	12. 0	0.0 1	64	203	0.5	907	0.83	2.2	1.02	7.23	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 19 TOP	27.9	8.56	3960 0	0	5.9	2772 1	1430 0	16. 0	0.0 0	64	158	0.1	810	0.33	1.9	0.88	6.24	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 19 MID	27.6	8.55	4240 0	0	4.3	2968 0	1531 1	16. 0	0.0 1	68	162	0.6	840	0.74	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 19 BOT	26.4	8.52	4400 0	0	3.2	3080 1	1588 9	12. 0	0.0 0	70	155	0.7	848	0.58	1.2	0.55	3.94	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 20 TOP	28.1	8.56	3870 0	0	5.9	2709 2	1397 5	12. 0	0.0 1	42	197	0.3	911	0.55	1.3	0.60	4.27	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 20 MID	27.9	8.56	4040 0	0	4.3	2828 0	1458 9	12. 0	0.0 1	44	185	0.2	823	0.68	1.0	0.46	3.28	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 20 BOT	27.6	8.54	4320 0	0	3.2	3024 1	1560 0	12. 0	0.0 2	50	179	0.3	843	0.41	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 21 TOP	28.1	8.56	3860 0	0	5.9	2702 2	1393 9	8.0	0.0 0	92	199	0.2	870	0.81	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 21	27.9	8.54	4080 0	0	4.6	2856 0	1473 3	8.0	0.0 0	56	188	0.3	935	0.33	1.9	0.88	6.24	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APH A 5220 mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02-APH A 4500 mg/l	O/G AST M D3921 mg/l	THC AST M D3921 mg/l	TPH AST M D3921 mg/l	PAH AST M D4657 mg/l	BTEX AST M D2600 mg/l	
MID																							
EA 21 BOT	27.3	8.52	43200	0	3.1	30241	15600	8.0	0.01	96	195	0.5	980	0.35	1.7	0.79	5.58	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 22 TOP	28.2	8.55	38900	0	6.1	27230	14047	12.0	0.00	62	198	0.4	990	0.72	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 22 MID	27.8	8.55	39300	0	4.8	27512	14192	12.0	0.00	68	192	0.1	815	0.49	2.4	1.11	7.88	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 22 BOT	27.6	8.54	40900	0	3.5	28637	14769	12.0	0.01	48	197	0.9	946	0.81	2.3	1.60	7.55	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 23 TOP	28.7	8.47	41400	0	5.9	28980	14950	12.0	0.01	70	195	0.1	970	0.51	1.4	0.64	4.59	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 23 MID	28.1	8.44	41600	0	5.6	29120	15022	12.0	0.01	92	170	0.6	930	0.26	0.9	0.42	2.96	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 23 BOT	27.3	8.39	44600	0	3.2	31221	16106	8.0	0.00	96	187	0.6	881	0.41	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 24 TOP	28.9	8.50	44100	0	5.7	30874	14842	12.0	0.00	88	184	0.1	871	0.21	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 25 TOP	27.8	8.50	41300	0	5.8	28913	14914	12.0	0.01	90	168	0.1	873	0.59	1.1	0.52	3.61	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 26 TOP	27.8	8.47	42700	0	5.9	29890	15419	12.0	0.01	86	155	0.1	963	0.32	0.8	0.37	2.63	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 26 MID	27.5	8.50	46400	0	5.4	32480	16756	16.0	0.00	90	161	0.3	845	0.38	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	



## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APHA 4500	COND APHA 2510 A μS/cm	TURB	DO APHA 4500 mg/l	TDS APHA 1030 mg/l	CL APHA 4500 mg/l	ALK	CO L	TSS AST M D186 8 mg/l	COD APHA 5220 D mg/l	BOD APHA 9210 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NO3 APHA 4500 mg/l	NH4 APHA 4500 mg/l	N02- APHA 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTEX AST M D260 0 mg/l
EA 26 BOT	26.9	8.48	46700	0	3.0	32690	16864	16.0	0.0	84	195	0.2	930	0.11	0.8	0.37	2.63	<0.001	<0.001	<0.001	<0.001	<0.001
EA 27 TOP	28.7	8.49	41300	0	5.8	28910	14914	12.0	0.0	90	181	0.1	811	0.81	0.6	0.28	1.97	<0.001	<0.001	<0.001	<0.001	<0.001
EA 28 TOP	27.5	8.44	42700	0	5.8	29891	15419	16.0	0.0	86	187	0.2	841	0.31	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001
EA 28 MID	27.1	8.44	44500	0	5.3	31151	16069	12.0	0.0	80	182	0.3	857	0.11	0.9	0.42	2.96	<0.001	<0.001	<0.001	<0.001	<0.001
EA 28 BOT	26.7	8.47	45200	0	3.2	31640	16322	16.0	0.0	78	153	0.2	877	0.32	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001
EA 29 TOP	29.1	8.44	42200	0	5.9	29540	15239	12.0	0.0	80	149	0.1	932	0.41	1.3	0.62	4.27	<0.001	<0.001	<0.001	<0.001	<0.001
EA 30 TOP	27.9	8.54	38440	0	5.8	26908	13881	8.0	0.0	88	184	0.1	892	0.41	1.5	0.70	4.93	<0.001	<0.001	<0.001	<0.001	<0.001
EA 31 TOP	28.5	8.49	39700	0	5.7	27793	14336	12.0	0.0	78	165	0.1	887	0.41	1.9	0.88	6.24	<0.001	<0.001	<0.001	<0.001	<0.001
EA 32 TOP	28.8	8.48	39700	0	5.8	27790	14336	8.0	0.0	74	193	0.9	910	0.32	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001
EA 33 TOP	28.5	8.47	40000	0	5.9	28000	14444	8.0	0.0	70	187	0.4	920	0.38	1.0	0.47	3.28	<0.001	<0.001	<0.001	<0.001	<0.001
EA 34 TOP	29.4	8.43	40100	0	5.8	28070	14481	12.0	0.0	76	163	0.3	839	0.71	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001
EA	27.5	8.49	3770	0	5.9	2639	1361	8.0	0.0	80	171	0.4	842	0.32	2.3	1.07	7.55	<0.001	<0.001	<0.001	<0.001	<0.001

### Environmental Impact Assessment of EA/EJA Further Oil Development Project

Samp le ID	TEM P (°C)	PH APH A 4500	CON D APH A 2510 A μS/cm	TUR B	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	AL K	CO L	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02- APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTE X AST M D260 0 mg/l
35 TOP			0			0	4		0									1	1	1	1	1
EA 36 TOP	29.2	8.46	4240 0	0	5.8	2968 1	1531 1	12. 0	0.0 0	70	100	0.2	880	0.70	1.4	0.65	4.59	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 37 TOP	28.4	8.49	4130 0	0	5.5	2891 0	1491 5	8.0	0.0 1	68	197	0.3	790	0.65	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 38 TOP	28.2	8.47	3990 0	0	5.9	2793 0	1440 8	8.0	0.0 2	74	178	0.2	809	0.51	1.1	0.51	3.61	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 39 TOP	28.6	8.45	4050 0	0	5.9	2835 0	1462 5	8.0	0.0 0	70	173	0.7	998	0.63	1.8	0.84	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 40 TOP	29.6	8.45	4000 0	0	5.8	2800 0	1444 4	12. 0	0.0 1	72	186	0.5	870	0.50	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 41 TOP	27.9	8.47	4220 0	0	5.8	2954 0	1523 9	16. 0	0.0 1	64	192	0.7	998	0.81	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 42 TOP	28.2	8.45	4110 0	0	5.9	2877 1	1484 2	12. 0	0.0 1	66	198	0.6	875	0.21	1.1	0.51	3.61	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 43 TOP	27.8	8.45	4030 0	0	5.7	2821 0	1455 3	12. 0	0.0 1	66	196	0.6	941	0.71	2.2	1.02	7.23	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 44 TOP	27.3	8.45	4030 0	0	5.9	2821 0	1455 3	8.0	0.0 1	62	183	0.1	973	0.21	1.2	0.56	3.94	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 45 TOP	25.6	7.92	2710 0	0	5.4	1897 4	9786	16. 0	0.0 1	70	209	0.2	460	0.16	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 46	28.5	8.40	3840 0	0	5.7	2689 0	1386 7	8.0	0.0 0	68	149	0.2	782	0.32	1.3	0.61	4.27	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1

### Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APH A 5220 mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02-APH A 4500 mg/l	O/G AST M D3921 mg/l	THC AST M D3921 mg/l	TPH AST M D3921 mg/l	PAH AST M D4657 mg/l	BTEX AST M D2600 mg/l	
TOP																							
EA 47 TOP	28.1	8.41	34800	0	5.9	24362	12567	12.0	0.0	60	151	0.3	601	0.27	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 48 TOP	26.4	8.43	32600	0	5.7	22824	11772	12.0	0.02	64	151	0.9	562	0.31	1.5	0.70	4.93	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 49 TOP	26.7	8.47	33600	0	5.7	23523	12133	16.0	0.0	68	164	1.2	672	0.37	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 50 TOP	29.5	8.40	37100	0	5.6	25980	13397	16.0	0.01	70	162	0.7	742	0.21	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 51 TOP	28.4	8.43	39600	0	5.8	27721	14300	16.0	0.01	62	181	0.2	995	0.11	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 52 TOP	29.2	8.46	40300	0	5.9	28220	14553	12.0	0.0	74	183	0.6	849	0.70	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 53 TOP	28.7	8.41	39200	0	5.8	27442	14156	12.0	0.0	70	177	0.2	821	0.41	0.8	0.37	2.63	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 53 MID	27.3	8.41	39620	0	5.7	27738	14307	12.0	0.01	76	194	0.4	839	0.32	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 53 BOT	26.1	8.40	39800	0	3.6	27863	14372	16.0	0.0	74	187	0.2	856	0.38	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 54 TOP	25.7	8.38	28700	0	5.7	20090	10364	16.0	0.0	74	137	0.6	471	0.15	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 54 MID	24.4	8.36	29100	0	5.6	20373	10508	12.0	0.01	78	141	0.5	549	0.12	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001	

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APHA 4500	COND APHA 2510 A 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 5220 D mg/l	BOD APHA 9210 mg/l	SO4 APHA 4500 mg/l	PO4 APHA 4500 mg/l	NO3 APHA 4500 mg/l	NH4 APHA 4500 mg/l	N02- 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
EA 54 BOT	25.1	8.34	29800	0	3.3	20861	10761	12.0	0.00	70	145	0.7	568	0.25	1.9	0.88	6.24	<0.001	<0.001	<0.001	<0.001	<0.001
EA 55 TOP	27.2	8.43	34900	0	5.8	34430	12603	12.0	0.01	68	153	0.8	605	0.22	0.9	0.42	2.96	<0.001	<0.001	<0.001	<0.001	<0.001
EA 56 TOP	28.4	8.49	39600	0	5.9	27721	14300	16.0	0.00	58	198	0.5	805	0.35	1.8	0.84	5.91	<0.001	<0.001	<0.001	<0.001	<0.001
EA 56 MID	28.2	8.47	39800	0	5.7	27862	14372	12.0	0.00	50	191	0.3	933	0.41	1.5	0.70	4.93	<0.001	<0.001	<0.001	<0.001	<0.001
EA 56 BOT	27.8	8.39	40000	0	3.6	28002	14444	12.0	0.01	54	185	0.2	994	0.37	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001
EA 57 TOP	29.5	8.40	40300	0	5.8	28210	14553	12.0	0.00	60	199	0.3	838	0.11	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001
EA 57 MID	28.8	8.36	40600	0	5.7	28421	14661	12.0	0.01	56	187	0.1	899	0.21	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001
EA 57 BOT	27.9	8.39	40700	0	3.5	28492	14697	12.0	0.00	62	198	0.3	877	0.81	1.0	0.47	3.28	<0.001	<0.001	<0.001	<0.001	<0.001
EA 58 TOP	27.2	8.48	39400	0	5.9	27590	14228	12.0	0.00	80	194	0.3	910	0.50	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001
EA 59 TOP	27.6	8.37	38400	0	5.2	26890	13867	12.0	0.01	68	187	0.5	887	0.42	1.5	0.70	4.93	<0.001	<0.001	<0.001	<0.001	<0.001
EA 60 TOP	28.5	8.52	39100	0	6.0	27371	14119	16.0	0.02	70	185	0.2	844	0.51	1.3	0.60	4.27	<0.001	<0.001	<0.001	<0.001	<0.001
EA	28.1	8.51	4070	0	4.8	2849	1469	12.	0.0	64	187	0.2	889	0.39	1.9	0.88	6.24	<0.00	<0.00	<0.00	<0.00	<0.00

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Samp le ID	TEM P (°C)	PH APH A 4500	CON D APH A 2510 A μS/c m	TUR B	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	AL K	CO L	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02- APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTE X AST M D260 0 mg/l
60 MID			0			3	7	0	0									1	1	1	1	1
EA 60 BOT	28.0	8.50	4380 0	0	3.1	3070 1	1581 7	12. 0	0.0 0	60	181	0.1	886	0.27	2.2	1.02	7.23	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 61 TOP	28.7	8.52	3920 0	0	5.9	2744 2	1415 6	12. 0	0.0 1	78	192	0.2	862	0.33	1.8	0.83	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 62 TOP	27.9	8.54	3840 0	0	6.0	2689 0	1386 7	12. 0	0.0 0	80	190	0.2	993	0.30	1.7	0.79	5.58	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 62 MID	27.7	8.53	4050 0	0	4.9	2840 1	1462 5	12. 0	0.0 1	72	187	0.1	942	0.14	1.2	0.55	3.94	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 62 BOT	27.6	8.53	4070 0	0	3.0	2849 3	1469 7	16. 0	0.0 1	76	189	0.1	956	0.60	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 63 TOP	27.9	8.44	3270 0	0	5.9	2289 7	1180 8	12. 0	0.0 0	84	198	0.1	864	0.73	1.7	0.79	5.58	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 63 MID	27.6	8.47	3770 0	0	4.2	2639 0	1361 4	16. 0	0.0 0	90	185	0.2	830	0.55	1.8	0.83	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 63 BOT	27.1	8.44	4140 0	0	3.0	2898 7	1495 0	12. 0	0.0 1	88	189	0.2	880	0.38	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 64 TOP	27.3	8.43	3360 0	0	5.8	2352 8	1213 3	12. 0	0.0 1	96	182	0.3	846	0.44	2.3	1.06	7.55	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 65 TOP	27.0	8.45	3370 0	0	5.9	2359 4	1216 9	16. 0	0.0 0	88	194	0.1	802	0.22	2.2	1.02	7.23	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 66	28.0	8.52	3890 0	0	5.9	2723 3	1404 7	12. 0	0.0 0	90	187	0.2	809	0.18	2.1	0.97	6.89	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1

### Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APH A 5220 mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02-APH A 4500 mg/l	O/G AST M D3921 mg/l	THC AST M D3921 mg/l	TPH AST M D3921 mg/l	PAH AST M D4657 mg/l	BTEX AST M D2600 mg/l	
TOP																							
EA 67 TOP	28.2	8.55	38000	0	5.9	26640	13722	12.0	0.0	94	194	0.2	860	0.44	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 68 TOP	28.1	8.55	39800	0	6.0	27871	14372	16.0	0.0	92	188	0.1	992	0.84	1.5	0.69	4.93	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 69 TOP	28.8	8.53	41500	0	6.1	29058	14986	12.0	0.0	70	183	0.2	840	0.48	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 69 MID	28.5	8.51	42600	0	4.9	29829	15383	12.0	0.0	64	181	0.2	896	0.72	1.5	0.69	4.93	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 69 BOT	28.4	8.50	43200	0	3.2	30241	15600	16.0	0.0	68	187	0.2	838	0.51	2.3	1.06	7.55	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 70 TOP	28.4	8.52	40100	0	5.9	28071	14481	12.0	0.0	78	189	0.2	868	0.14	2.4	1.11	7.88	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 71 TOP	26.9	8.44	33200	0	5.8	23247	11989	12.0	0.0	74	199	0.1	840	0.90	2.2	1.02	7.23	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 72 TOP	28.1	8.46	40300	0	6.1	28211	14556	12.0	0.0	80	190	0.1	863	0.26	1.8	0.83	5.91	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 73 TOP	28.1	8.51	40100	0	5.9	28073	14481	12.0	0.0	80	189	0.2	901	0.30	1.5	0.69	4.93	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 74 TOP	28.4	8.52	40500	0	6.0	28350	14625	16.0	0.0	84	89	0.1	842	0.44	1.3	0.60	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 75 TOP	27.1	8.44	34200	0	5.9	23940	12350	12.0	0.0	86	193	0.2	900	0.38	1.3	0.60	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH	COND	TURB	DO	TDS	CL	AL	CO	TSS	COD	BOD	SO4	PO4	NO3	NH4	N02-	O/G	THC	TPH	PAH	BTEX
		APHA 4500	APHA 2510 μS/cm		APHA 4500 mg/l	APHA 1030 mg/l	APHA 4500 mg/l	K	L	ASTM D1868 mg/l	APHA 5220 D mg/l	APHA 9210 mg/l	APHA 4500 mg/l	APHA 4500 mg/l	APHA 4500 mg/l	APHA 4500 mg/l	APHA 4500 mg/l	ASTM D3921 mg/l	ASTM D3921 mg/l	ASTM D3921 mg/l	ASTM D4657 mg/l	ASTM D2600 mg/l
EA 76 TOP	28.3	8.48	41100	0	5.8	28771	14842	12.0	0.0	72	191	0.4	828	0.21	1.8	0.84	5.91	<0.001	<0.001	<0.001	<0.001	<0.001
EA 77 TOP	27.8	8.51	33810	0	5.9	20100	12209	12.0	0.0	80	181	0.1	921	0.27	2.1	0.98	6.89	<0.001	<0.001	<0.001	<0.001	<0.001
EA 78 TOP	27.6	8.52	36580	0	5.9	25603	13209	16.0	0.0	78	175	0.1	850	0.51	1.8	0.84	5.91	<0.001	<0.001	<0.001	<0.001	<0.001
EA 79 TOP	28.1	8.55	36700	0	5.9	25690	13253	16.0	0.0	90	179	0.2	850	0.33	1.8	0.83	5.91	<0.001	<0.001	<0.001	<0.001	<0.001
EA 79 MID	27.8	8.54	36900	0	5.1	25832	13325	12.0	0.0	86	186	0.2	998	0.84	1.0	0.46	3.28	<0.001	<0.001	<0.001	<0.001	<0.001
EA 79 BOT	27.1	8.53	38800	0	3.0	27163	14011	12.0	0.0	82	181	0.3	844	0.26	1.3	0.60	4.27	<0.001	<0.001	<0.001	<0.001	<0.001
EA 80 TOP	28.4	8.52	34650	0	5.8	24256	12513	8.0	0.0	90	198	0.2	841	0.81	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001
EA 80 MID	27.8	8.48	41200	0	5.1	28840	14878	8.0	0.0	84	168	0.2	851	0.14	0.7	0.33	2.29	<0.001	<0.001	<0.001	<0.001	<0.001
EA 80 BOT	27.3	8.44	43300	0	3.1	30310	15636	8.0	0.0	86	171	0.1	871	0.60	0.9	0.42	2.96	<0.001	<0.001	<0.001	<0.001	<0.001
EA 81 TOP	27.1	8.54	34440	0	5.9	24109	12437	12.0	0.0	88	183	0.1	846	0.18	1.4	0.65	4.59	<0.001	<0.001	<0.001	<0.001	<0.001
EA 82 TOP	27.8	8.55	36400	0	5.8	25483	13144	8.0	0.0	70	195	0.2	880	0.11	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001
EA	27.9	8.54	4140	0	5.8	2898	1495	12.0	0.0	82	190	0.2	860	0.38	1.2	0.56	3.94	<0.001	<0.001	<0.001	<0.001	<0.001

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

Samp le ID	TEM P (°C)	PH APH A 4500	CON D APH A 2510 A μS/cm	TUR B	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	AL K	CO L	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02- APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTE X AST M D260 0 mg/l
83 TOP			0			1	0	0	1									1	1	1	1	1
EA 84 TOP	28.0	8.54	4120 0	0	5.8	2884 0	1487 8	12. 0	0.0 1	90	188	0.1	903	0.32	1.8	0.84	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 85 TOP	27.7	8.54	3497 0	0	5.9	2447 9	1262 8	8.0	0.0 2	92	178	0.1	850	0.32	1.9	0.88	6.24	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 86 TOP	27.9	8.56	3410 0	0	5.9	2387 2	1231 4	12. 0	0.0 0	82	181	0.2	900	0.11	1.8	0.84	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 87 TOP	28.7	8.52	4340 0	0	5.9	3038 0	1567 2	12. 0	0.0 2	96	179	0.2	950	0.31	2.0	0.93	6.57	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 88 TOP	27.5	8.53	4040 0	0	5.7	2828 0	1458 9	12. 0	0.0 0	88	195	0.1	829	0.21	1.6	0.74	5.25	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 89 TOP	27.7	8.52	4080 0	0	5.8	2856 0	1473 3	12. 0	0.0 1	92	173	0.2	868	0.61	1.0	0.47	3.28	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 90 TOP	29.0	8.53	4000 0	0	5.7	2800 0	1444 4	12. 0	0.0 0	80	186	0.2	910	0.71	1.1	0.51	3.61	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 91 TOP	27.9	8.54	3990 0	0	5.9	2793 0	1440 8	8.0	0.0 1	80	176	0.1	998	0.45	0.9	0.42	2.96	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 91 MID	27.5	8.53	4000 0	0	5.2	2800 0	1444 4	12. 0	0.0 0	84	182	0.2	902	0.38	1.0	0.47	3.28	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 91 BOT	27.1	8.53	4100 0	0	3.2	2870 0	1480 6	8.0	0.0 1	86	176	0.2	840	0.13	1.1	0.51	3.61	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1
EA 92	28.8	8.54	4010 0	0	5.8	2807 1	1448 1	8.0	0.0 0	94	192	0.2	838	0.37	1.8	0.84	5.91	<0.00 1	<0.00 1	<0.00 1	<0.00 1	<0.00 1



## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	COL	TSS ASTM D1868 mg/l	COD APH A 5220 mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02-APH A 4500 mg/l	O/G AST M D3921 mg/l	THC AST M D3921 mg/l	TPH AST M D3921 mg/l	PAH AST M D4657 mg/l	BTEX AST M D2600 mg/l	
TOP																							
EA 93 TOP	27.5	8.52	41100	0	5.8	28770	14842	8.0	0.00	88	189	0.3	866	0.35	1.7	0.79	5.58	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 94 TOP	28.3	8.52	40700	0	5.7	28490	14697	12.0	0.01	78	189	0.4	856	0.63	1.7	0.79	5.58	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 95 TOP	27.8	8.51	40500	0	5.7	28350	14625	12.0	0.01	90	164	0.2	899	0.41	2.0	0.93	6.57	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 96 TOP	28.3	8.54	39800	0	5.9	27860	14372	12.0	0.00	88	187	0.3	820	0.41	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 97 TOP	2.8	8.50	41100	0	5.7	28770	14842	8.0	0.01	90	197	0.3	910	0.21	1.9	0.88	6.24	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 98 TOP	28.7	8.50	40900	0	5.7	28630	14769	12.0	0.00	82	183	0.3	850	0.51	1.0	0.47	3.28	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 98 MID	28.1	8.50	41000	0	5.3	28700	14806	8.0	0.00	86	198	0.2	900	0.71	1.3	0.62	4.27	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 98 BOT	27.9	8.49	41200	0	3.5	28840	14878	12.0	0.02	90	195	0.2	907	0.41	2.1	0.98	6.89	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 99 TOP	28.7	8.52	41300	0	5.8	28910	14914	12.0	0.00	82	170	0.1	839	0.59	2.1	0.98	6.89	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 100 TOP	27.9	8.52	39700	0	5.8	27791	14366	12.0	0.01	84	179	0.2	871	0.35	1.0	0.47	3.28	<0.001	<0.001	<0.001	<0.001	<0.001	
EA 101 TOP	27.6	8.53	33530	0	5.9	23471	12108	16.0	0.01	74	173	0.2	866	0.39	1.5	0.70	4.93	<0.001	<0.001	<0.001	<0.001	<0.001	

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID	TEMP (°C)	PH APH A 4500	COND APH A 2510 A μS/cm	TURB	DO APH A 4500 mg/l	TDS APH A 1030 mg/l	CL APH A 4500 mg/l	ALK	CO L	TSS AST M D186 8 mg/l	COD APH A 5220 D mg/l	BOD APH A 9210 mg/l	SO4 APH A 4500 mg/l	PO4 APH A 4500 mg/l	NO3 APH A 4500 mg/l	NH4 APH A 4500 mg/l	N02- APH A 4500 mg/l	O/G AST M D392 1 mg/l	THC AST M D392 1 mg/l	TPH AST M D392 1 mg/l	PAH AST M D465 7 mg/l	BTEX AST M D260 0 mg/l
EA 102 TOP	27.9	8.53	34720	0	5.9	24304	12538	16.0	0.00	86	193	0.2	892	0.21	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 1 TOP	28.1	8.47	40300	0	5.9	28210	14553	12.0	0.00	50	192	0.2	922	0.50	2.1	0.98	6.89	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 1 MID	27.3	8.46	41200	0	5.7	28840	14878	8.0	0.00	48	187	0.3	851	0.11	1.7	0.79	5.58	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 1 BOT	26.8	8.41	42600	0	3.0	29820	15383	8.0	0.00	44	189	0.3	948	0.26	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 2 TOP	27.7	8.49	42900	0	5.9	30032	15492	12.0	0.00	46	192	0.4	921	0.70	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 2 MID	27.5	8.48	43400	0	5.1	30384	15672	8.0	0.00	50	188	0.3	890	0.50	1.1	0.51	3.61	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 2 BOT	27.1	8.48	44000	0	3.6	30801	15889	8.0	0.00	52	184	0.2	842	0.11	0.8	0.37	2.63	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 3 TOP	28.1	8.54	43900	0	5.9	30730	15853	8.0	0.00	46	189	0.2	841	0.35	1.6	0.74	5.25	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 3 MID	27.1	8.53	44300	0	5.6	31012	15997	8.0	0.00	50	165	0.2	843	0.61	2.1	0.98	6.89	<0.001	<0.001	<0.001	<0.001	<0.001
CTL 3 BOT	26.9	8.53	44600	0	3.2	31220	16106	8.0	0.01	48	155	0.2	961	0.45	1.3	0.61	4.27	<0.001	<0.001	<0.001	<0.001	<0.001

**Appendix 2c: Heavy Metal Results for Water Samples for the Sea Eagle during the October/November, 2018 EIA Studies**

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Ag 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/l
EA 1 TOP										<0.001	<0.001				
EA 1 MID										<0.001	<0.001				
EA 1 BOT										<0.001	<0.001				
EA 2 TOP										<0.001	<0.001				
EA 2 MID										<0.001	<0.001				
EA 2 BOT										<0.001	<0.001				
EA 3 TOP										<0.001	<0.001				
EA 3 MID										<0.001	<0.001				
EA 3 BOT										<0.001	<0.001				
EA 4 TOP										<0.001	<0.001				
EA 4 MID										<0.001	<0.001				
EA 4 BOT										<0.001	<0.001				
EA 5 TOP										<0.001	<0.001				
EA 5 MID										<0.001	<0.001				
EA 5 BOT										<0.001	<0.001				
EA 6 TOP										<0.001	<0.001				
EA 6 MID										<0.001	<0.001				
EA 6 BOT										<0.001	<0.001				
EA 7 TOP										<0.001	<0.001				
EA 7 MID										<0.001	<0.001				
EA 7 BOT										<0.001	<0.001				
EA 8 TOP										<0.001	<0.001				
EA 8 MID										<0.001	<0.001				
EA 8 BOT										<0.001	<0.001				
EA 9 TOP										<0.001	<0.001				
EA 9 MID										<0.001	<0.001				
EA 9 BOT										<0.001	<0.001				
EA 10 TOP										<0.001	<0.001				
EA 10 MID										<0.001	<0.001				
EA 10 BOT										<0.001	<0.001				
EA 11 TOP										<0.001	<0.001				
EA 11 MID										<0.001	<0.001				
EA 11 BOT										<0.001	<0.001				
EA 12 TOP										<0.001	<0.001				
EA 12 MID										<0.001	<0.001				
EA 12 BOT										<0.001	<0.001				
EA 13 TOP										<0.001	<0.001				

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Ag 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/l
EA 13 MID										<0.001	<0.001				
EA 13 BOT										<0.001	<0.001				
EA 14 TOP										<0.001	<0.001				
EA 14 MID										<0.001	<0.001				
EA 14 BOT										<0.001	<0.001				
EA 15 TOP										<0.001	<0.001				
EA 15 MID										<0.001	<0.001				
EA 15 BOT										<0.001	<0.001				
EA 16 TOP										<0.001	<0.001				
EA 16 MID										<0.001	<0.001				
EA 16 BOT										<0.001	<0.001				
EA 17 TOP										<0.001	<0.001				
EA 17 MID										<0.001	<0.001				
EA 17 BOT										<0.001	<0.001				
EA 18 TOP										<0.001	<0.001				
EA 18 MID										<0.001	<0.001				
EA 18 BOT										<0.001	<0.001				
EA 19 TOP										<0.001	<0.001				
EA 19 MID										<0.001	<0.001				
EA 19 BOT										<0.001	<0.001				
EA 20 TOP										<0.001	<0.001				
EA 20 MID										<0.001	<0.001				
EA 20 BOT										<0.001	<0.001				
EA 21 TOP										<0.001	<0.001				
EA 21 MID										<0.001	<0.001				
EA 21 BOT										<0.001	<0.001				
EA 22 TOP										<0.001	<0.001				
EA 22 MID										<0.001	<0.001				
EA 22 BOT										<0.001	<0.001				
EA 23 TOP										<0.001	<0.001				
EA 23 MID										<0.001	<0.001				
EA 23 BOT										<0.001	<0.001				
EA 24 TOP										<0.001	<0.001				
EA 25 TOP										<0.001	<0.001				
EA 26 TOP										<0.001	<0.001				
EA 26 MID										<0.001	<0.001				

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Ag 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/l
EA 26 BOT										<0.001	<0.001				
EA 27 TOP										<0.001	<0.001				
EA 28 TOP										<0.001	<0.001				
EA 28 MID										<0.001	<0.001				
EA 28 BOT										<0.001	<0.001				
EA 29 TOP										<0.001	<0.001				
EA 30 TOP										<0.001	<0.001				
EA 31 TOP										<0.001	<0.001				
EA 32 TOP										<0.001	<0.001				
EA 33 TOP										<0.001	<0.001				
EA 34 TOP										<0.001	<0.001				
EA 35 TOP										<0.001	<0.001				
EA 36 TOP										<0.001	<0.001				
EA 37 TOP										<0.001	<0.001				
EA 38 TOP										<0.001	<0.001				
EA 39 TOP										<0.001	<0.001				
EA 40 TOP										<0.001	<0.001				
EA 41 TOP										<0.001	<0.001				
EA 42 TOP										<0.001	<0.001				
EA 43 TOP										<0.001	<0.001				
EA 44 TOP										<0.001	<0.001				
EA 45 TOP										<0.001	<0.001				
EA 46 TOP										<0.001	<0.001				
EA 47 TOP										<0.001	<0.001				
EA 48 TOP										<0.001	<0.001				
EA 49 TOP										<0.001	<0.001				
EA 50 TOP										<0.001	<0.001				
EA 51 TOP										<0.001	<0.001				
EA 52 TOP										<0.001	<0.001				
EA 53 TOP										<0.001	<0.001				
EA 53 MID										<0.001	<0.001				
EA 53 BOT										<0.001	<0.001				
EA 54 TOP										<0.001	<0.001				
EA 54 MID										<0.001	<0.001				
EA 54 BOT										<0.001	<0.001				
EA 55 TOP										<0.001	<0.001				

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Ag 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/l
EA 56 TOP										<0.001	<0.001				
EA 56 MID										<0.001	<0.001				
EA 56 BOT										<0.001	<0.001				
EA 57 TOP										<0.001	<0.001				
EA 57 MID										<0.001	<0.001				
EA 57 BOT										<0.001	<0.001				
EA 58 TOP										<0.001	<0.001				
EA 59 TOP										<0.001	<0.001				
EA 60 TOP										<0.001	<0.001				
EA 60 MID										<0.001	<0.001				
EA 60 BOT										<0.001	<0.001				
EA 61 TOP										<0.001	<0.001				
EA 62 TOP										<0.001	<0.001				
EA 62 MID										<0.001	<0.001				
EA 62 BOT										<0.001	<0.001				
EA 63 TOP										<0.001	<0.001				
EA 63 MID										<0.001	<0.001				
EA 63 BOT										<0.001	<0.001				
EA 64 TOP										<0.001	<0.001				
EA 65 TOP										<0.001	<0.001				
EA 66 TOP										<0.001	<0.001				
EA 67 TOP										<0.001	<0.001				
EA 68 TOP										<0.001	<0.001				
EA 69 TOP										<0.001	<0.001				
EA 69 MID										<0.001	<0.001				
EA 69 BOT										<0.001	<0.001				
EA 70 TOP										<0.001	<0.001				
EA 71 TOP										<0.001	<0.001				
EA 72 TOP										<0.001	<0.001				
EA 73 TOP										<0.001	<0.001				
EA 74 TOP										<0.001	<0.001				
EA 75 TOP										<0.001	<0.001				
EA 76 TOP										<0.001	<0.001				
EA 77 TOP										<0.001	<0.001				
EA 78 TOP										<0.001	<0.001				
EA 79 TOP										<0.001	<0.001				
EA 79 MID										<0.001	<0.001				

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Ag 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/l
EA 79 BOT										<0.001	<0.001				
EA 80 TOP										<0.001	<0.001				
EA 80 MID										<0.001	<0.001				
EA 80 BOT										<0.001	<0.001				
EA 81 TOP										<0.001	<0.001				
EA 82 TOP										<0.001	<0.001				
EA 83 TOP										<0.001	<0.001				
EA 84 TOP										<0.001	<0.001				
EA 85 TOP										<0.001	<0.001				
EA 86 TOP										<0.001	<0.001				
EA 87 TOP										<0.001	<0.001				
EA 88 TOP										<0.001	<0.001				
EA 89 TOP										<0.001	<0.001				
EA 90 TOP										<0.001	<0.001				
EA 91 TOP										<0.001	<0.001				
EA 91 MID										<0.001	<0.001				
EA 91 BOT										<0.001	<0.001				
EA 92 TOP										<0.001	<0.001				
EA 93 TOP										<0.001	<0.001				
EA 94 TOP										<0.001	<0.001				
EA 95 TOP										<0.001	<0.001				
EA 96 TOP										<0.001	<0.001				
EA 97 TOP										<0.001	<0.001				
EA 98 TOP										<0.001	<0.001				
EA 98 MID										<0.001	<0.001				
EA 98 BOT										<0.001	<0.001				
EA 99 TOP										<0.001	<0.001				
EA 100 TOP										<0.001	<0.001				
EA 101 TOP										<0.001	<0.001				
EA 102 TOP										<0.001	<0.001				
CTL 1 TOP										<0.001	<0.001				
CTL 1 MID										<0.001	<0.001				
CTL 1 BOT										<0.001	<0.001				
CTL 2 TOP										<0.001	<0.001				
CTL 2 MID										<0.001	<0.001				
CTL 2 BOT										<0.001	<0.001				
CTL 3 TOP										<0.001	<0.001				

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

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	Ba ASTM D4382 mg/l	Co ASTM D3558 mg/l	Ag 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/l
CTL 3 MID										<0.001	<0.001				
CTL 3 BOT										<0.001	<0.001				

**Appendix 2d: Microbiology Results for Water Samples for the Sea Eagle during the October/November, 2018 EIA Studies**

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	FAECAL COLIFORM APHA 9222D (cfu/ml)	SRB
EA 1 TOP	NIL	NIL	2.73x102	1.03x102	0	NA
EA 1 MID	NIL	NIL	2.14x102	1.10x101	0	NA
EA 1 BOT	NIL	NIL	2.02x102	1.24x102	0	NA
EA 2 TOP	NIL	NIL	2.32x102	1.17x102	0	NA
EA 2 MID	NIL	NIL	2.19x102	1.33x102	0	NA
EA 2 BOT	NIL	NIL	1.88x102	1.39x102	0	NA
EA 3 TOP	NIL	NIL	2.39x102	1.42x102	0	NA
EA 3 MID	NIL	NIL	2.81x102	1.27x102	0	NA
EA 3 BOT	NIL	NIL	2.92x102	1.40x102	0	NA
EA 4 TOP	NIL	NIL	2.63x102	1.32x102	0	NA
EA 4 MID	NIL	NIL	2.31x102	1.14x102	0	NA
EA 4 BOT	NIL	NIL	2.52x102	1.17x102	0	NA
EA 5 TOP	NIL	NIL	2.11x102	1.08x102	0	NA
EA 5 MID	NIL	NIL	2.19x102	1.31x102	0	NA
EA 5 BOT	NIL	NIL	2.37x102	1.18x102	0	NA
EA 6 TOP	NIL	NIL	2.64x102	1.22x102	0	NA
EA 6 MID	NIL	NIL	1.82x102	1.13x102	0	NA
EA 6 BOT	NIL	NIL	2.07x102	1.28x102	0	NA
EA 7 TOP	NIL	NIL	2.19x102	1.02x102	0	NA
EA 7 MID	NIL	NIL	2.12x102	1.32x102	0	NA
EA 7 BOT	NIL	NIL	2.47x102	1.11x102	0	NA
EA 8 TOP	NIL	NIL	2.53x102	1.17x102	0	NA
EA 8 MID	NIL	NIL	2.09x102	1.06x102	0	NA
EA 8 BOT	NIL	NIL	1.38x102	6.20x101	0	NA
EA 9 TOP	NIL	NIL	2.72x102	1.13x102	0	NA
EA 9 MID	NIL	NIL	2.13x102	1.01x102	0	NA
EA 9 BOT	NIL	NIL	1.72x102	1.21x102	0	NA



## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	FAECAL COLIFORM APHA 9222D (cfu/ml)	SRB
EA 10 TOP	NIL	NIL	2.62x10 <sup>2</sup>	1.28x10 <sup>2</sup>	0	NA
EA 10 MID	NIL	NIL	1.89x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 10 BOT	NIL	NIL	1.58x10 <sup>2</sup>	9.20x10 <sup>1</sup>	0	NA
EA 11 TOP	NIL	NIL	2.18x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 11 MID	NIL	NIL	1.73x10 <sup>2</sup>	8.20x10 <sup>1</sup>	0	NA
EA 11 BOT	NIL	NIL	1.42x10 <sup>2</sup>	9.30x10 <sup>1</sup>	0	NA
EA 12 TOP	NIL	NIL	2.43x10 <sup>2</sup>	1.16x10 <sup>2</sup>	0	NA
EA 12 MID	NIL	NIL	2.12x10 <sup>2</sup>	1.07x10 <sup>2</sup>	0	NA
EA 12 BOT	NIL	NIL	2.09x10 <sup>2</sup>	1.31x10 <sup>2</sup>	0	NA
EA 13 TOP	NIL	NIL	2.77x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 13 MID	NIL	NIL	2.31x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 13 BOT	NIL	NIL	2.01x10 <sup>2</sup>	1.06x10 <sup>2</sup>	0	NA
EA 14 TOP	NIL	NIL	2.31x10 <sup>2</sup>	1.04x10 <sup>2</sup>	0	NA
EA 14 MID	NIL	NIL	2.11x10 <sup>2</sup>	9.80x10 <sup>1</sup>	0	NA
EA 14 BOT	NIL	NIL	1.94x10 <sup>2</sup>	9.20x10 <sup>1</sup>	0	NA
EA 15 TOP	NIL	NIL	2.71x10 <sup>2</sup>	1.34x10 <sup>2</sup>	0	NA
EA 15 MID	NIL	NIL	2.32x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 15 BOT	NIL	NIL	2.17x10 <sup>2</sup>	8.20x10 <sup>1</sup>	0	NA
EA 16 TOP	NIL	NIL	2.63x10 <sup>2</sup>	1.09x10 <sup>2</sup>	0	NA
EA 16 MID	NIL	NIL	2.06x10 <sup>2</sup>	1.03x10 <sup>2</sup>	0	NA
EA 16 BOT	NIL	NIL	1.98x10 <sup>2</sup>	1.04x10 <sup>2</sup>	0	NA
EA 17 TOP	NIL	NIL	2.81x10 <sup>2</sup>	1.31x10 <sup>2</sup>	0	NA
EA 17 MID	NIL	NIL	2.17x10 <sup>2</sup>	1.01x10 <sup>2</sup>	0	NA
EA 17 BOT	NIL	NIL	2.54x10 <sup>2</sup>	1.20x10 <sup>2</sup>	0	NA
EA 18 TOP	NIL	NIL	2.19x10 <sup>2</sup>	1.12x10 <sup>2</sup>	0	NA
EA 18 MID	NIL	NIL	2.58x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 18 BOT	NIL	NIL	2.72x10 <sup>2</sup>	1.31x10 <sup>2</sup>	0	NA
EA 19 TOP	NIL	NIL	2.31x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 19 MID	NIL	NIL	2.19x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 19 BOT	NIL	NIL	2.51x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 20 TOP	NIL	NIL	2.53x10 <sup>2</sup>	1.27x10 <sup>1</sup>	0	NA
EA 20 MID	NIL	NIL	2.15x10 <sup>2</sup>	1.11x10 <sup>2</sup>	0	NA
EA 20 BOT	NIL	NIL	1.93x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 21 TOP	NIL	NIL	2.47x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 21 MID	NIL	NIL	1.83x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 21 BOT	NIL	NIL	2.07x10 <sup>2</sup>	1.29x10 <sup>2</sup>	0	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	FAECAL COLIFORM APHA 9222D (cfu/ml)	SRB
EA 22 TOP	NIL	NIL	2.33x10 <sup>2</sup>	1.12x10 <sup>2</sup>	5	NA
EA 22 MID	NIL	NIL	2.18x10 <sup>2</sup>	1.06x10 <sup>2</sup>	5	NA
EA 22 BOT	NIL	NIL	2.12x10 <sup>2</sup>	1.13x10 <sup>2</sup>	5	NA
EA 23 TOP	NIL	NIL	2.38x10 <sup>2</sup>	1.06x10 <sup>2</sup>	0	NA
EA 23 MID	NIL	NIL	1.34x10 <sup>2</sup>	1.12x10 <sup>2</sup>	0	NA
EA 23 BOT	NIL	NIL	1.43x10 <sup>2</sup>	1.01x10 <sup>2</sup>	0	NA
EA 24 TOP	NIL	NIL	2.48x10 <sup>2</sup>	1.06x10 <sup>2</sup>	0	NA
EA 25 TOP	NIL	NIL	1.58x10 <sup>2</sup>	8.70x10 <sup>1</sup>	0	NA
EA 26 TOP	NIL	NIL	2.81x10 <sup>2</sup>	1.28x10 <sup>2</sup>	0	NA
EA 26 MID	NIL	NIL	2.41x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 26 BOT	NIL	NIL	1.81x10 <sup>2</sup>	1.29x10 <sup>2</sup>	0	NA
EA 27 TOP	NIL	NIL	2.53x10 <sup>2</sup>	1.01x10 <sup>2</sup>	0	NA
EA 28 TOP	NIL	NIL	2.18x10 <sup>2</sup>	1.27x10 <sup>1</sup>	0	NA
EA 28 MID	NIL	NIL	2.01x10 <sup>2</sup>	1.14x10 <sup>1</sup>	0	NA
EA 28 BOT	NIL	NIL	1.19x10 <sup>2</sup>	8.20x10 <sup>1</sup>	0	NA
EA 29 TOP	NIL	NIL	2.75x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 30 TOP	NIL	NIL	2.21x10 <sup>2</sup>	1.12x10 <sup>2</sup>	0	NA
EA 31 TOP	NIL	NIL	2.36x10 <sup>2</sup>	1.11x10 <sup>2</sup>	0	NA
EA 32 TOP	NIL	NIL	2.44x10 <sup>2</sup>	1.23x10 <sup>2</sup>	0	NA
EA 33 TOP	NIL	NIL	1.87x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 34 TOP	NIL	NIL	1.89x10 <sup>2</sup>	1.12x10 <sup>2</sup>	0	NA
EA 35 TOP	NIL	NIL	1.68x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 36 TOP	NIL	NIL	1.78x10 <sup>2</sup>	1.23x10 <sup>2</sup>	0	NA
EA 37 TOP	NIL	NIL	1.93x10 <sup>2</sup>	1.08x10 <sup>2</sup>	0	NA
EA 38 TOP	NIL	NIL	1.71x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 39 TOP	NIL	NIL	2.28x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 40 TOP	NIL	NIL	2.32x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 41 TOP	NIL	NIL	2.14x10 <sup>2</sup>	1.01x10 <sup>2</sup>	2	NA
EA 42 TOP	NIL	NIL	2.31x10 <sup>2</sup>	1.11x10 <sup>2</sup>	0	NA
EA 43 TOP	NIL	NIL	2.59x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 44 TOP	NIL	NIL	2.36x10 <sup>2</sup>	1.19x10 <sup>2</sup>	1	NA
EA 45 TOP	NIL	NIL	1.57x10 <sup>2</sup>	1.12x10 <sup>2</sup>	0	NA
EA 46 TOP	NIL	NIL	2.72x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 47 TOP	NIL	NIL	2.68x10 <sup>2</sup>	1.09x10 <sup>2</sup>	0	NA
EA 48 TOP	NIL	NIL	2.57x10 <sup>2</sup>	1.27x10 <sup>2</sup>	0	NA
EA 49 TOP	NIL	NIL	1.87x10 <sup>2</sup>	1.03x10 <sup>2</sup>	0	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	FAECAL COLIFORM APHA 9222D (cfu/ml)	SRB
EA 50 TOP	NIL	NIL	2.47×10 <sup>2</sup>	1.01×10 <sup>2</sup>	0	NA
EA 51 TOP	NIL	NIL	1.83×10 <sup>2</sup>	1.06×10 <sup>2</sup>	0	NA
EA 52 TOP	NIL	NIL	2.19×10 <sup>2</sup>	1.01×10 <sup>2</sup>	0	NA
EA 53 TOP	NIL	NIL	2.61×10 <sup>2</sup>	1.09×10 <sup>2</sup>	0	NA
EA 53 MID	NIL	NIL	1.43×10 <sup>2</sup>	1.02×10 <sup>2</sup>	0	NA
EA 53 BOT	NIL	NIL	2.18×10 <sup>2</sup>	1.22×10 <sup>2</sup>	0	NA
EA 54 TOP	NIL	NIL	2.71×10 <sup>2</sup>	1.41×10 <sup>2</sup>	1	NA
EA 54 MID	NIL	NIL	2.43×10 <sup>2</sup>	1.21×10 <sup>2</sup>	1	NA
EA 54 BOT	NIL	NIL	1.32×10 <sup>2</sup>	1.07×10 <sup>2</sup>	0	NA
EA 55 TOP	NIL	NIL	2.49×10 <sup>2</sup>	1.18×10 <sup>2</sup>	0	NA
EA 56 TOP	NIL	NIL	2.42×10 <sup>2</sup>	1.17×10 <sup>2</sup>	0	NA
EA 56 MID	NIL	NIL	2.07×10 <sup>2</sup>	1.03×10 <sup>2</sup>	0	NA
EA 56 BOT	NIL	NIL	1.82×10 <sup>2</sup>	1.07×10 <sup>2</sup>	0	NA
EA 57 TOP	NIL	NIL	2.48×10 <sup>2</sup>	1.17×10 <sup>2</sup>	0	NA
EA 57 MID	NIL	NIL	2.19×10 <sup>2</sup>	1.08×10 <sup>2</sup>	0	NA
EA 57 BOT	NIL	NIL	2.52×10 <sup>2</sup>	1.31×10 <sup>2</sup>	0	NA
EA 58 TOP	NIL	NIL	2.38×10 <sup>2</sup>	1.14×10 <sup>2</sup>	0	NA
EA 59 TOP	NIL	NIL	2.52×10 <sup>2</sup>	1.33×10 <sup>2</sup>	0	NA
EA 60 TOP	NIL	NIL	2.39×10 <sup>2</sup>	1.28×10 <sup>2</sup>	5	NA
EA 60 MID	NIL	NIL	2.07×10 <sup>2</sup>	1.13×10 <sup>2</sup>	2	NA
EA 60 BOT	NIL	NIL	2.19×10 <sup>2</sup>	1.01×10 <sup>2</sup>	0	NA
EA 61 TOP	NIL	NIL	2.81×10 <sup>2</sup>	1.42×10 <sup>2</sup>	0	NA
EA 62 TOP	NIL	NIL	2.46×10 <sup>2</sup>	1.05×10 <sup>2</sup>	0	NA
EA 62 MID	NIL	NIL	2.18×10 <sup>2</sup>	1.21×10 <sup>2</sup>	0	NA
EA 62 BOT	NIL	NIL	1.92×10 <sup>2</sup>	1.20×10 <sup>2</sup>	0	NA
EA 63 TOP	NIL	NIL	2.51×10 <sup>2</sup>	1.14×10 <sup>2</sup>	0	NA
EA 63 MID	NIL	NIL	2.18×10 <sup>2</sup>	1.23×10 <sup>2</sup>	0	NA
EA 63 BOT	NIL	NIL	2.26×10 <sup>2</sup>	1.41×10 <sup>2</sup>	0	NA
EA 64 TOP	NIL	NIL	2.47×10 <sup>2</sup>	1.09×10 <sup>2</sup>	0	NA
EA 65 TOP	NIL	NIL	2.24×10 <sup>2</sup>	1.02×10 <sup>2</sup>	0	NA
EA 66 TOP	NIL	NIL	2.45×10 <sup>2</sup>	1.32×10 <sup>2</sup>	0	NA
EA 67 TOP	NIL	NIL	2.37×10 <sup>2</sup>	1.19×10 <sup>2</sup>	0	NA
EA 68 TOP	NIL	NIL	2.12×10 <sup>2</sup>	1.03×10 <sup>2</sup>	0	NA
EA 69 TOP	NIL	NIL	2.08×10 <sup>2</sup>	1.29×10 <sup>2</sup>	0	NA
EA 69 MID	NIL	NIL	2.31×10 <sup>2</sup>	1.13×10 <sup>2</sup>	0	NA
EA 69 BOT	NIL	NIL	2.09×10 <sup>2</sup>	1.06×10 <sup>2</sup>	0	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	FAECAL COLIFORM APHA 9222D (cfu/ml)	SRB
EA 70 TOP	NIL	NIL	2.22x10 <sup>2</sup>	1.11x10 <sup>2</sup>	0	NA
EA 71 TOP	NIL	NIL	2.63x10 <sup>2</sup>	1.28x10 <sup>2</sup>	0	NA
EA 72 TOP	NIL	NIL	2.17x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 73 TOP	NIL	NIL	2.71x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 74 TOP	NIL	NIL	2.42x10 <sup>2</sup>	1.18x10 <sup>2</sup>	0	NA
EA 75 TOP	NIL	NIL	2.59x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 76 TOP	NIL	NIL	1.86x10 <sup>2</sup>	1.13x10 <sup>2</sup>	0	NA
EA 77 TOP	NIL	NIL	2.63x10 <sup>2</sup>	1.12x10 <sup>2</sup>	0	NA
EA 78 TOP	NIL	NIL	2.38x10 <sup>2</sup>	1.09x10 <sup>2</sup>	0	NA
EA 79 TOP	NIL	NIL	2.66x10 <sup>2</sup>	1.36x10 <sup>2</sup>	0	NA
EA 79 MID	NIL	NIL	1.93x10 <sup>2</sup>	9.10x10 <sup>1</sup>	0	NA
EA 79 BOT	NIL	NIL	2.41x10 <sup>2</sup>	1.31x10 <sup>2</sup>	0	NA
EA 80 TOP	NIL	NIL	2.18x10 <sup>2</sup>	1.07x10 <sup>2</sup>	5	NA
EA 80 MID	NIL	NIL	1.79x10 <sup>2</sup>	1.27x10 <sup>2</sup>	25	NA
EA 80 BOT	NIL	NIL	2.34x10 <sup>2</sup>	1.01x10 <sup>2</sup>	5	NA
EA 81 TOP	NIL	NIL	2.48x10 <sup>1</sup>	1.26x10 <sup>1</sup>	0	NA
EA 82 TOP	NIL	NIL	2.43x10 <sup>2</sup>	1.26x10 <sup>2</sup>	0	NA
EA 83 TOP	NIL	NIL	1.52x10 <sup>2</sup>	6.70x10 <sup>2</sup>	0	NA
EA 84 TOP	NIL	NIL	2.09x10 <sup>2</sup>	1.07x10 <sup>2</sup>	0	NA
EA 85 TOP	NIL	NIL	2.81x10 <sup>2</sup>	1.28x10 <sup>2</sup>	0	NA
EA 86 TOP	NIL	NIL	2.71x10 <sup>2</sup>	1.16x10 <sup>2</sup>	0	NA
EA 87 TOP	NIL	NIL	2.66x10 <sup>2</sup>	1.17x10 <sup>2</sup>	0	NA
EA 88 TOP	NIL	NIL	2.71x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 89 TOP	NIL	NIL	2.42x10 <sup>2</sup>	1.03x10 <sup>2</sup>	0	NA
EA 90 TOP	NIL	NIL	2.63x10 <sup>2</sup>	1.16x10 <sup>2</sup>	0	NA
EA 91 TOP	NIL	NIL	2.58x10 <sup>2</sup>	1.14x10 <sup>2</sup>	0	NA
EA 91 MID	NIL	NIL	1.83x10 <sup>2</sup>	1.02x10 <sup>2</sup>	0	NA
EA 91 BOT	NIL	NIL	1.42x10 <sup>2</sup>	1.18x10 <sup>2</sup>	0	NA
EA 92 TOP	NIL	NIL	2.66x10 <sup>2</sup>	1.13x10 <sup>2</sup>	0	NA
EA 93 TOP	NIL	NIL	2.67x10 <sup>2</sup>	1.16x10 <sup>2</sup>	0	NA
EA 94 TOP	NIL	NIL	2.41x10 <sup>2</sup>	1.27x10 <sup>2</sup>	0	NA
EA 95 TOP	NIL	NIL	2.37x10 <sup>2</sup>	1.21x10 <sup>2</sup>	0	NA
EA 96 TOP	NIL	NIL	2.72x10 <sup>2</sup>	1.22x10 <sup>2</sup>	0	NA
EA 97 TOP	NIL	NIL	2.47x10 <sup>2</sup>	1.01x10 <sup>2</sup>	0	NA
EA 98 TOP	NIL	NIL	2.52x10 <sup>2</sup>	1.11x10 <sup>2</sup>	0	NA
EA 98 MID	NIL	NIL	1.83x10 <sup>2</sup>	1.09x10 <sup>2</sup>	0	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	FAECAL COLIFORM APHA 9222D (cfu/ml)	SRB
EA 98 BOT	NIL	NIL	1.48×10 <sup>2</sup>	1.22×10 <sup>2</sup>	0	NA
EA 99 TOP	NIL	NIL	2.52×10 <sup>2</sup>	1.22×10 <sup>2</sup>	0	NA
EA 100 TOP	NIL	NIL	2.68×10 <sup>2</sup>	1.31×10 <sup>2</sup>	0	NA
EA 101 TOP	NIL	NIL	2.41×10 <sup>2</sup>	1.31×10 <sup>2</sup>	0	NA
EA 102 TOP	NIL	NIL	2.15×10 <sup>2</sup>	1.23×10 <sup>2</sup>	0	NA
CTL 1 TOP	NIL	NIL	2.19×10 <sup>2</sup>	1.16×10 <sup>2</sup>	0	NA
CTL 1 MID	NIL	NIL	1.83×10 <sup>2</sup>	1.22×10 <sup>2</sup>	1	NA
CTL 1 BOT	NIL	NIL	2.13×10 <sup>2</sup>	1.17×10 <sup>2</sup>	5	NA
CTL 2 TOP	NIL	NIL	1.63×10 <sup>2</sup>	1.19×10 <sup>2</sup>	0	NA
CTL 2 MID	NIL	NIL	2.31×10 <sup>2</sup>	1.21×10 <sup>2</sup>	0	NA
CTL 2 BOT	NIL	NIL	1.47×10 <sup>2</sup>	9.90×10 <sup>1</sup>	0	NA
CTL 3 TOP	NIL	NIL	2.81×10 <sup>2</sup>	1.24×10 <sup>2</sup>	0	NA
CTL 3 MID	NIL	NIL	1.88×10 <sup>2</sup>	1.13×10 <sup>2</sup>	0	NA
CTL 3 BOT	NIL	NIL	1.17×10 <sup>2</sup>	9.10×10 <sup>1</sup>	0	NA

### Appendix 2e: Physicochemistry Results for Sediment Samples for the Sea Eagle during the October/November, 2018 EIA Studies

Sample Point ID.	pH APHA 4500-H	TEMP	colour	Redox ASTM D1498 mV	CL APHA 2510A mg/kg	TOC APHA 5310 %	PO4 APHA 4500 mg/kg	NO3 APHA 4500 mg/kg	NH4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			O & G ASTM D 3921 mg/kg	ALIPH ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %					
EA 1	7.46	9.0	GREY	-20.3	16186	1.51	0.17	1.9	0.88	-	4.61	95.30	18.0	1.0	12.0	<0.001	<0.001
EA 2	7.31	8.6	GREY	-27.6	17356	1.24	0.22	1.1	0.51	-	5.11	94.78	6.0	<0.001	0.0	<0.001	<0.001
EA 3	8.01	8.1	GREY	-55.0	17095	0.41	0.29	0.9	0.42	-	4.89	95.04	12.0	0.5	6.0	<0.001	<0.001
EA 4	7.92	8.5	GREY	-43.3	17679	0.97	0.21	0.9	0.43	-	4.82	95.10	6.0	<0.001	0.0	<0.001	<0.001
EA 5	7.21	8.0	GREY	-18.4	16706	0.94	0.28	1.5	0.70	-	4.74	95.20	12.0	<0.001	6.0	<0.001	<0.001
EA 6	7.41	8.2	GREY	-29.9	16186	0.66	0.19	0.8	0.37	-	4.34	95.57	6.0	<0.001	0.0	<0.001	<0.001
EA 7	7.47	8.1	GREY	-30.9	17550	0.53	0.31	0.8	0.37	-	4.80	95.17	0.0	<0.001	0.0	<0.001	<0.001
EA 8	7.21	9.2	GREY	-19.8	17291	0.73	0.14	0.9	0.42	-	4.35	95.58	30.0	1.4	18.0	<0.001	<0.001
EA 9	7.63	9.0	GREY	-32.4	16835	0.88	0.18	0.8	0.38	-	4.38	95.58	6.0	<0.001	0.0	<0.001	<0.001
EA 10	7.61	8.7	GREY	-31.6	16900	1.21	0.21	1.3	0.61	-	4.23	95.64	6.0	<0.001	0.0	<0.001	<0.001
EA 11	7.46	8.5	GREY	-26.9	15859	1.73	0.09	2.1	0.98	-	5.30	94.54	6.0	<0.001	0.0	<0.001	<0.001
EA 12	7.34	8.9	GREY	-25.8	14389	1.51	0.22	0.6	0.28	-	4.34	95.57	0.0	<0.001	0.0	<0.001	<0.001

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample Point ID.	pH APHA 4500-H	TEMP	colour	Redox ASTM D1498 mV	CL APHA 2510A mg/kg	TOC APHA 5310 %	PO4 APHA 4500 mg/kg	NO3 APHA 4500 mg/kg	NH4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			O & G ASTM D 3921 mg/kg	ALIPH ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %					
EA 13	7.31	8.7	GREY	-23.7	16900	1.24	0.16	2.0	0.93	-	4.42	95.49	6.0	<0.001	0.0	<0.001	<0.001
EA 14	7.34	8.8	GREY	-24.9	18070	1.04	0.12	1.5	0.70	-	5.19	94.71	0.0	<0.001	0.0	<0.001	<0.001
EA 15	7.18	9.3	GREY	-14.5	18461	1.30	0.35	1.1	0.51	-	4.11	95.78	0.0	<0.001	0.0	<0.001	<0.001
EA 16	7.30	9.1	GREY	-23.9	18199	1.44	0.27	0.6	0.29	-	4.56	95.36	0.0	<0.001	0.0	<0.001	<0.001
EA 17	7.51	8.5	GREY	-34.1	17876	1.65	0.20	1.2	0.59	-	5.15	94.76	12.0	0.4	6.0	<0.001	<0.001
EA 18	7.37	8.5	GREY	-26.7	16121	3.12	0.21	0.7	0.33	-	4.57	95.36	12.0	0.5	6.0	<0.001	<0.001
EA 19	7.30	9.5	GREY	-23.3	17744	1.35	0.25	1.7	0.79	-	4.38	94.89	30.0	1.5	18.0	<0.001	<0.001
EA 20	7.42	8.9	GREY	-29.9	18655	0.94	0.11	0.9	0.42	-	4.39	95.53	12.0	0.4	6.0	<0.001	<0.001
EA 21	7.39	9.3	GREY	-29.2	17355	1.10	0.14	1.2	0.59	-	4.55	95.39	78.0	4.4	54.0	<0.001	<0.001
EA 22	8.13	9.1	GREY	-66.2	17615	0.93	0.29	1.1	0.51	-	5.55	94.38	12.0	<0.001	6.0	<0.001	<0.001
EA 23	7.51	9.5	GREY	-28.8	15989	2.79	0.21	1.6	0.74	-	4.23	95.63	18.0	0.5	6.0	<0.001	<0.001
EA 24	7.50	8.0	GREY	-28.6	16121	1.68	0.17	0.7	0.33	-	4.75	95.25	6.0	<0.001	0.0	<0.001	<0.001
EA 25	7.43	9.5	GREY	-25.1	17224	1.09	0.37	2.1	0.98	-	4.98	94.92	12.0	<0.001	6.0	<0.001	<0.001
EA 26	7.49	7.9	GREY	-28.1	148/84	1.59	0.22	0.9	0.42	-	5.17	94.65	6.0	<0.001	0.0	<0.001	<0.001
EA 27	7.42	8.4	GREY	-24.5	17615	1.17	0.19	0.8	0.37	-	5.50	94.44	24.0	0.9	12.0	<0.001	<0.001
EA 28	7.35	8.9	GREY	-19.4	15404	1.52	0.16	1.3	0.61	-	5.03	94.87	48.0	2.9	36.0	<0.001	<0.001
EA 29	7.46	8.5	GREY	-27.0	16706	1.29	0.23	0.4	0.19	-	5.35	94.52	6.0	<0.001	0.0	<0.001	<0.001
EA 30	7.54	8.9	GREY	-33.5	15795	0.95	0.11	0.9	0.42	-	5.28	94.63	6.0	<0.001	0.0	<0.001	<0.001
EA 31	7.34	9.8	GREY	-19.3	16542	1.52	0.33	1.3	0.61	-	4.69	95.11	0.0	<0.001	0.0	<0.001	<0.001
EA 32	7.37	9.5	GREY	-20.9	15339	2.09	0.25	0.9	0.42	-	3.83	96.16	6.0	<0.001	0.0	<0.001	<0.001
EA 33	7.56	9.6	GREY	-32.7	19499	2.91	0.19	0.8	0.37	-	4.17	95.31	6.0	<0.001	0.0	<0.001	<0.001
EA 34	7.47	8.4	GREY	-27.1	15859	1.51	0.41	2.1	0.98	-	4.35	95.63	6.0	<0.001	0.0	<0.001	<0.001
EA 35	7.32	8.6	GREY	-23.5	17029	0.44	0.32	0.9	0.42	-	5.47	93.75	0.0	<0.001	0.0	<0.001	<0.001
EA 36	7.42	9.4	GREY	-23.5	18461	1.97	0.23	0.6	0.29	-	4.72	95.19	12.0	0.5	6.0	<0.001	<0.001
EA 37	7.49	9.1	GREY	-24.1	18265	2.91	0.18	0.8	0.37	-	4.62	94.41	6.0	<0.001	0.0	<0.001	<0.001
EA 38	7.59	8.7	GREY	-33.8	16445	0.87	0.19	0.6	0.29	-	4.62	95.2	15.0	0.8	10.0	<0.001	<0.001
EA 39	7.44	8.5	GREY	-25.2	17086	0.63	0.24	1.2	0.59	-	4.84	95.06	6.0	<0.001	0.0	<0.001	<0.001
EA 40	7.52	8.9	GREY	-29.7	15536	1.61	0.36	1.5	0.70	-	5.34	94.42	0.0	<0.001	0.0	<0.001	<0.001
EA 41	7.40	8.9	GREY	-22.2	19240	0.73	0.28	1.0	0.47	-	4.31	95.57	0.0	<0.001	0.0	<0.001	<0.001
EA 42	7.46	8.7	GREY	-27.8	16706	0.42	0.42	0.6	0.29	-	4.89	94.20	0.0	<0.001	0.0	<0.001	<0.001
EA 43	7.46	9.6	GREY	-26.4	17615	0.73	0.31	1.4	0.65	-	4.41	95.39	<0.001	<0.001	<0.001	<0.001	<0.001
EA 44	7.32	9.4	GREY	-18.5	15989	1.26	0.27	1.1	0.51	-	4.84	94.84	6.0	<0.001	0.0	<0.001	<0.001
EA 45	7.45	9.2	GREY	-23.6	14755	0.29	0.38	0.9	0.42	-	4.0	95.81	18.0	0.7	9.0	<0.001	<0.001
EA 46	7.17	9.5	GREY	-12.0	16121	1.76	0.25	1.2	0.59	-	5.19	94.81	6.0	<0.001	0.0	<0.001	<0.001
EA 47	7.27	8.5	GREY	-17.7	15536	<0.10	0.31	0.7	0.33	-	4.43	94.91	6.0	<0.001	0.0	<0.001	<0.001
EA 48	7.81	8.6	GREY	-23.4	16198	0.63	0.21	0.9	0.42	-	4.55	95.04	6.0	<0.001	0.0	<0.001	<0.001
EA 49	7.39	8.5	GREY	-22.2	18005	1.16	0.23	0.4	0.20	-	3.77	96.20	24.0	1.0	12.0	<0.001	<0.001

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample Point ID.	pH APHA 4500-H	TEMP	colour	Redox ASTM D1498 mV	CL APHA 2510A mg/kg	TOC APHA 5310 %	PO4 APHA 4500 mg/kg	NO3 APHA 4500 mg/kg	NH4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			O & G ASTM D 3921 mg/kg	ALIPH ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %					
EA 50	7.29	8.4	GREY	-16.9	17029	2.41	0.14	1.2	0.59	-	4.49	95.38	6.0	<0.001	0.0	<0.001	<0.001
EA 51	7.39	9.6	GREY	-22.7	16835	3.05	0.19	1.0	0.47	-	4.39	94.74	18.0	0.5	6.0	<0.001	<0.001
EA 52	7.42	9.3	GREY	-24.0	18914	0.28	0.23	1.2	0.59	-	4.58	95.10	6.0	<0.001	0.0	<0.001	<0.001
EA 53	0.7.41	9.3	GREY	-23.3	16243	1.16	0.41	1.7	0.79	-	5.30	94.04	6.0	<0.001	0.0	<0.001	<0.001
EA 54	7.55	8.0	GREY	-31.1	15275	0.14	0.38	2.1	0.98	-	4.48	95.50	6.0	<0.001	0.0	<0.001	<0.001
EA 55	7.34	9.0	GREY	-23.5	16509	0.92	0.42	1.6	0.74	-	4.39	94.74	6.0	<0.001	0.0	<0.001	<0.001
EA 56	7.43	9.4	GREY	-25.2	18199	2.12	0.09	1.2	0.59	-	5.20	94.60	6.0	<0.001	0.0	<0.001	<0.001
EA 57	7.48	9.5	GREY	-28.3	17550	0.85	0.15	0.8	0.37	-	5.17	94.73	6.0	<0.001	0.0	<0.001	<0.001
EA 58	7.44	9.9	GREY	-26.3	16706	<0.10	0.12	0.7	0.33	-	4.11	95.86	54.0	3.4	42.0	<0.001	<0.001
EA 59	7.61	8.1	GREY	-23.7	14884	0.69	0.40	0.9	0.42	-	4.29	94.70	<0.001	<0.001	<0.001	<0.001	<0.001
EA 60	7.43	8.8	GREY	-28.3	17744	0.88	0.09	1.2	0.59	-	5.24	94.66	6.0	<0.001	0.0	<0.001	<0.001
EA 61	7.45	8.3	GREY	-26.1	17420	<0.10	0.12	1.8	0.84	-	4.62	95.23	18.0	1.0	12.0	<0.001	<0.001
EA 62	7.63	9.6	GREY	-34.3	17291	1.12	0.07	1.1	0.51	-	5.25	94.68	0.0	<0.001	0.0	<0.001	<0.001
EA 63	7.42	8.1	GREY	-31.2	15275	106.9	0.23	1.3	0.61	-	5.97	93.94	6.0	<0.001	0.0	<0.001	<0.001
EA 64	7.34	8.5	GREY	-24.3	16380	1.11	0.11	0.7	0.33	-	5.48	94.45	12.0	0.4	6.0	<0.001	<0.001
EA 65	7.47	8.9	GREY	-32.6	16250	1.43	0.31	0.9	0.42	-	6.52	95.37	12.0	<0.001	0.0	<0.001	<0.001
EA 66	7.41	8.4	GREY	-28.1	16186	0.28	0.15	0.9	0.44	-	5.54	94.37	0.0	<0.001	0.0	<0.001	<0.001
EA 67	7.46	9.1	GREY	-28.3	16054	<0.10	0.24	1.6	0.74	-	5.12	94.74	0.0	<0.001	0.0	<0.001	<0.001
EA 68	7.36	8.2	GREY	-27.8	14884	<0.10	0.28	1.2	0.59	-	4.48	94.78	6.0	<0.001	0.0	<0.001	<0.001
EA 69	7.34	8.1	GREY	-21.2	15339	0.92	0.12	1.5	0.70	-	4.92	95.08	0.0	<0.001	0.0	<0.001	<0.001
EA 70	7.29	8.6	GREY	-22.3	16054	0.99	0.23	1.1	0.51	-	4.39	95.53	0.0	<0.001	0.0	<0.001	<0.001
EA 71	7.39	8.4	GREY	-18.4	15339	0.78	0.24	1.6	0.74	-	5.78	94.11	6.0	<0.001	0.0	<0.001	<0.001
EA 72	7.36	8.6	GREY	-22.4	16121	0.67	0.19	0.8	0.37	-	4.78	95.07	6.0	<0.001	0.0	<0.001	<0.001
EA 73	7.47	8.2	GREY	-31.1	14819	<0.10	0.23	1.0	0.47	-	4.84	94.16	30.0	1.4	18.0	<0.001	<0.001
EA 74	7.60	8.7	GREY	-26.3	16380	<0.10	0.29	1.4	0.65	-	5.88	94.12	0.0	<0.001	0.0	<0.001	<0.001
EA 75	7.36	8.3	GREY	-27.8	14884	0.44	0.21	0.5	0.23	-	4.50	95.43	6.0	<0.001	0.0	<0.001	<0.001
EA 76	7.33	9.7	GREY	-19.4	15404	46.51	0.08	1.3	0.61	-	4.03	95.89	6.0	<0.001	0.0	<0.001	<0.001
EA 77	7.36	9.3	GREY	-23.7	17159	0.98	0.12	0.8	0.37	-	4.50	95.39	0.0	<0.001	0.0	<0.001	<0.001
EA 78	7.28	8.1	GREY	-18.9	15536	0.29	0.15	0.5	0.23	-	4.41	95.53	0.0	<0.001	0.0	<0.001	<0.001
EA 79	7.54	8.6	GREY	-28.9	16509	<0.10	0.29	0.9	0.42	-	4.68	95.23	0.0	<0.001	0.0	<0.001	<0.001
EA 80	7.55	8.6	GREY	-34.3	16706	0.59	0.21	1.6	0.74	-	5.23	94.71	0.0	<0.001	0.0	<0.001	<0.001
EA 81	7.39	8.4	GREY	-25.4	15469	0.26	0.13	1.4	0.65	-	4.40	95.55	12.0	0.5	6.0	<0.001	<0.001
EA 82	7.46	9.3	GREY	-29.7	15989	0.46	0.24	1.2	0.59	-	5.08	94.87	60.0	3.9	48.0	<0.001	<0.001
EA 83	7.38	8.5	GREY	-24.6	16574	0.19	0.22	1.8	0.84	-	5.44	94.43	6.0	<0.001	0.0	<0.001	<0.001
EA 84	7.63	8.7	GREY	-39.2	15536	<0.10	0.09	1.3	0.61	-	5.41	94.51	6.0	<0.001	0.0	<0.001	<0.001
EA 85	7.56	8.4	GREY	-34.5	16380	0.06	0.08	1.6	0.74	-	4.67	95.25	6.0	<0.001	0.0	<0.001	<0.001
EA 86	7.67	8.0	GREY	-41.4	17876	0.26	0.22	0.8	0.37	-	5.03	94.90	12.0	0.4	6.0	<0.001	<0.001

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample Point ID.	pH APHA 4500-H	TEMP	colour	Redox ASTM D1498 mV	CL APHA 2510A mg/kg	TOC APHA 5310 %	PO4 APHA 4500 mg/kg	NO3 APHA 4500 mg/kg	NH4 APHA 4500 mg/kg	PARTICLE SIZE ASTM P 2487 – 92			O & G ASTM D 3921 mg/kg	ALIPH ASTM D 3921 mg/kg	TPH ASTM D3921 mg/kg	PAH ASTM D4657 mg/kg	BTEX ASTM D2600 mg/kg
										Sand %	Silt %	Clay %					
EA 87	7.57	9.2	GREY	-35.8	15339	0.54	0.15	0.6	0.28	-	5.22	94.70	6.0	<0.001	0.0	<0.001	<0.001
EA 88	7.45	8.2	GREY	-26.2	16771	0.45	0.19	1.1	0.51	-	4.84	95.16	12.0	0.5	6.0	<0.001	<0.001
EA 89	7.30	9.1	GREY	-16.9	15339	0.31	0.12	1.3	0.61	-	5.26	94.63	0.0	<0.001	0.0	<0.001	<0.001
EA 90	7.37	8.5	GREY	-21.6	17744	1.12	0.33	1.0	0.47	-	4.93	94.37	6.0	<0.001	0.0	<0.001	<0.001
EA 91	7.49	8.6	GREY	-30.8	17029	<0.10	0.17	0.8	0.37	-	5.37	93.96	54.0	3.9	48.0	<0.001	<0.001
EA 92	7.55	8.7	GREY	-32.2	14560	0.01	0.25	0.7	0.33	-	4.69	95.31	6.0	<0.001	0.0	<0.001	<0.001
EA 93	7.41	9.4	GREY	-23.9	16186	<0.10	0.07	0.9	0.42	-	5.14	94.78	18.0	0.4	6.0	<0.001	<0.001
EA 94	7.34	8.2	GREY	-19.8	16509	0.74	0.21	0.7	0.33	-	5.22	94.03	18.0	1.0	12.0	<0.001	<0.001
EA 95	7.23	8.4	GREY	-15.3	16706	<0.10	0.24	1.1	0.51	-	4.87	95.04	0.0	<0.001	0.0	<0.001	<0.001
EA 96	7.34	8.2	GREY	-20.5	15404	0.33	0.06	1.6	0.74	-	4.62	95.34	12.0	0.4	6.0	<0.001	<0.001
EA 97	7.29	9.1	GREY	-17.8	14755	0.19	0.14	1.4	0.65	-	4.96	94.90	12.0	0.5	6.0	<0.001	<0.001
EA 98	7.43	8.7	GREY	-24.3	15989	<0.10	0.23	1.1	0.51	-	4.05	95.27	6.0	<0.001	0.0	<0.001	<0.001
EA 99	7.38	8.7	GREY	-25.3	15859	<0.10	0.11	1.3	0.61	-	5.72	94.21	12.0	0.5	6.0	<0.001	<0.001
EA 100	7.49	8.6	GREY	-29.6	14689	1.08	0.23	0.8	0.37	-	4.48	95.52	54.0	3.4	42.0	<0.001	<0.001
EA 101	7.55	9.1	GREY	-34.8	16054	0.64	0.17	1.1	0.51	-	5.98	93.95	0.0	<0.001	0.0	<0.001	<0.001
EA 102	7.40	8.2	GREY	-25.1	17809	0.76	0.21	1.5	0.70	-	4.17	94.80	6.0	<0.001	0.0	<0.001	<0.001
CNTRL 1	7.50	8.8	GREY	-28.9	17291	3.81	0.16	1.2	0.59	-	5.01	94.88	6.0	<0.001	0.0	<0.001	<0.001
CNTRL 2	7.23	7.9	GREY	-14.7	16574	1.32	0.14	1.6	0.74	-	5.06	94.91	6.0	<0.001	0.0	<0.001	<0.001
CNTRL 3	7.59	9.2	GREY	-33.7	19095	0.67	0.19	1.0	0.47	-	4.94	94.92	42.0	2.5	30.0	<0.001	<0.001

### Appendix 2f: Heavy Metal Results for Sediment Samples for the Sea Eagle during the October/November, 2018 EIA Studies

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	Mg ASTM D4192 mg/kg
EA 1										<0.001	<0.001				
EA 2										<0.001	<0.001				
EA 3										<0.001	<0.001				
EA 4										<0.001	<0.001				
EA 5										<0.001	<0.001				
EA 6										<0.001	<0.001				



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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	Mg ASTM D4192 mg/kg
EA 7										<0.001	<0.001				
EA 8										<0.001	<0.001				
EA 9										<0.001	<0.001				
EA 10										<0.001	<0.001				
EA 11										<0.001	<0.001				
EA 12										<0.001	<0.001				
EA 13										<0.001	<0.001				
EA 14										<0.001	<0.001				
EA 15										<0.001	<0.001				
EA 16										<0.001	<0.001				
EA 17										<0.001	<0.001				
EA 18										<0.001	<0.001				
EA 19										<0.001	<0.001				
EA 20										<0.001	<0.001				
EA 21										<0.001	<0.001				
EA 22										<0.001	<0.001				
EA 23										<0.001	<0.001				
EA 24										<0.001	<0.001				
EA 25										<0.001	<0.001				
EA 26										<0.001	<0.001				
EA 27										<0.001	<0.001				
EA 28										<0.001	<0.001				
EA 29										<0.001	<0.001				
EA 30										<0.001	<0.001				
EA 31										<0.001	<0.001				
EA 32										<0.001	<0.001				
EA 33										<0.001	<0.001				
EA 34										<0.001	<0.001				
EA 35										<0.001	<0.001				
EA 36										<0.001	<0.001				
EA 37										<0.001	<0.001				
EA 38										<0.001	<0.001				
EA 39										<0.001	<0.001				
EA 40										<0.001	<0.001				
EA 41										<0.001	<0.001				
EA 42										<0.001	<0.001				
EA 43										<0.001	<0.001				

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Mg ASTM D4192 mg/kg
EA 44										<0.001	<0.001				
EA 45										<0.001	<0.001				
EA 46										<0.001	<0.001				
EA 47										<0.001	<0.001				
EA 48										<0.001	<0.001				
EA 49										<0.001	<0.001				
EA 50										<0.001	<0.001				
EA 51										<0.001	<0.001				
EA 52										<0.001	<0.001				
EA 53										<0.001	<0.001				
EA 54										<0.001	<0.001				
EA 55										<0.001	<0.001				
EA 56										<0.001	<0.001				
EA 57										<0.001	<0.001				
EA 58										<0.001	<0.001				
EA 59										<0.001	<0.001				
EA 60										<0.001	<0.001				
EA 61										<0.001	<0.001				
EA 62										<0.001	<0.001				
EA 63										<0.001	<0.001				
EA 64										<0.001	<0.001				
EA 65										<0.001	<0.001				
EA 66										<0.001	<0.001				
EA 67										<0.001	<0.001				
EA 68										<0.001	<0.001				
EA 69										<0.001	<0.001				
EA 70										<0.001	<0.001				
EA 71										<0.001	<0.001				
EA 72										<0.001	<0.001				
EA 73										<0.001	<0.001				
EA 74										<0.001	<0.001				
EA 75										<0.001	<0.001				
EA 76										<0.001	<0.001				
EA 77										<0.001	<0.001				
EA 78										<0.001	<0.001				
EA 79										<0.001	<0.001				
EA 80										<0.001	<0.001				

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

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	Mg ASTM D4192 mg/kg
EA 81										<0.001	<0.001				
EA 82										<0.001	<0.001				
EA 83										<0.001	<0.001				
EA 84										<0.001	<0.001				
EA 85										<0.001	<0.001				
EA 86										<0.001	<0.001				
EA 87										<0.001	<0.001				
EA 88										<0.001	<0.001				
EA 89										<0.001	<0.001				
EA 90										<0.001	<0.001				
EA 91										<0.001	<0.001				
EA 92										<0.001	<0.001				
EA 93										<0.001	<0.001				
EA 94										<0.001	<0.001				
EA 95										<0.001	<0.001				
EA 96										<0.001	<0.001				
EA 97										<0.001	<0.001				
EA 98										<0.001	<0.001				
EA 99										<0.001	<0.001				
EA 100										<0.001	<0.001				
EA 101										<0.001	<0.001				
EA 102										<0.001	<0.001				
CONTROL 1										<0.001	<0.001				
CONTROL 2										<0.001	<0.001				
CONTROL 3										<0.001	<0.001				

### Appendix 2g: Microbiology Results for Sediment Samples for the Sea Eagle during the October/November, 2018 EIA Studies

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
EA 1	NIL	NIL	1.09X102	6.20X101	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
EA 2	NIL	0.20X101	1.16X102	4.10X102	NA
EA 3	NIL	NIL	1.05X102	3.90X101	NA
EA 4	NIL	NIL	1.12X101	4.80X101	NA
EA 5	NIL	NIL	1.43X102	6.40X101	NA
EA 6	NIL	NIL	1.17X102	5.10X101	NA
EA 7	NIL	NIL	1.53X102	7.20X101	NA
EA 8	NIL	NIL	1.17X102	4.10X101	NA
EA 9	NIL	NIL	1.03X102	6.20X101	NA
EA 10	NIL	NIL	1.77X102	3.80X101	NA
EA 11	NIL	NIL	2.02X102	NIL	NA
EA 12	NIL	NIL	1.50X102	7.00X101	NA
EA 13	NIL	NIL	1.22X102	5.20X101	NA
EA 14	NIL	NIL	1.03X102	6.80X101	NA
EA 15	NIL	NIL	1.84X102	8.30X101	NA
EA 16	NIL	NIL	1.91X102	1.21X102	NA
EA 17	NIL	NIL	2.01X102	1.120X102	NA
EA 18	NIL	NIL	2.06X102	3.80X101	NA
EA 19	NIL	NIL	1.51X102	4.90X101	NA
EA 20	NIL	NIL	1.92X102	1.03X102	NA
EA 21	NIL	NIL	1.32X102	6.20X101	NA
EA 22	NIL	NIL	1.28X102	3.10X101	NA
EA 23	NIL	NIL	1.51X102	4.90X101	NA
EA 24	NIL	NIL	1.32X102	6.40X101	NA
EA 25	NIL	NIL	1.09X102	NIL	NA
EA 26	NIL	NIL	2.01X102	8.20X101	NA
EA 27	NIL	NIL	1.06X102	9.10X101	NA
EA 28	NIL	3.90X101	1.78X102	7.10X101	NA
EA 29	NIL	NIL	1.28X102	1.20X101	NA
EA 30	NIL	NIL	1.48X102	4.20X101	NA
EA 31	NIL	NIL	2.07X102	1.06X102	NA
EA 32	NIL	NIL	1.82X102	1.18X10	NA
EA 33	NIL	NIL	1.34X102	5.20X102	NA
EA 34	NIL	NIL	1.52X102	2.20X101	NA
EA 35	NIL	NIL	1.63X102	6.50X101	NA
EA 36	NIL	NIL	2.01X102	7.60X101	NA
EA 37	NIL	NIL	2.15X102	2.30X101	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
EA 38	NIL	5.30X101	2.03X102	7.30X101	2.10X101
EA 39	NIL	NIL	1.13X102	4.70X101	NA
EA 40	NIL	NIL	1.31X102	5.10X102	NA
EA 41	NIL	NIL	1.12X102	6.30X101	NA
EA 42	NIL	NIL	1.41X102	3.10X101	NA
EA 43	NIL	NIL	2.41X102	5.10X101	NA
EA 44	NIL	NIL	1.36X102	4.10X101	NA
EA 45	NIL	0.20X101	1.30X102	1.20X101	NA
EA 46	NIL	NIL	1.31X102	4.40X101	NA
EA 47	NIL	NIL	1.13X102	8.20X102	NA
EA 48	NIL	NIL	1.31X102	7.20X102	NA
EA 49	NIL	NIL	1.28X10	3.80X101	NA
EA 50	NIL	NIL	1.42X102	5.30X101	NA
EA 51	NIL	NIL	1.31X102	4.30X101	NA
EA 52	NIL	NIL	1.07X102	3.20X101	NA
EA 53	NIL	NIL	1.23X102	2.80X101	NA
EA 54	NIL	NIL	1.22X102	6.40X101	NA
EA 55	NIL	NIL	1.53X102	1.02X102	NA
EA 56	NIL	NIL	1.18X102	5.10X101	NA
EA 57	NIL	NIL	1.19X102	6.10X101	NA
EA 58	NIL	2.20X101	1.62X102	8.20X102	0.90X101
EA 59	NIL	NIL	1.41X102	9.10X102	NA
EA 60	NIL	NIL	1.16X102	9.10X101	NA
EA 61	NIL	NIL	1.62X102	6.70X101	NA
EA 62	NIL	NIL	1.04X102	5.20X101	NA
EA 63	NIL	NIL	1.48X102	4.40X101	NA
EA 64	NIL	NIL	1.58X102	7.70X101	NA
EA 65	NIL	NIL	2.07X102	8.10X101	NA
EA 66	NIL	NIL	2.01X102	7.40X101	NA
EA 67	NIL	NIL	1.11X102	4.20X101	NA
EA 68	NIL	NIL	1.21X102	5.10X101	NA
EA 69	NIL	NIL	2.01X102	8.30X101	NA
EA 70	NIL	NIL	1.16X102	4.10X101	NA
EA 71	NIL	NIL	1.02X102	3.80X101	NA
EA 72	NIL	NIL	1.07X102	3.80X101	NA
EA 73	NIL	NIL	1.03X102	8.20X101	NA

## Environmental Impact Assessment of EA/EJA Further Oil Development Project

Sample ID.	HUF APHA 9215B (cfu/ml)	HUB APHA 9610C (cfu/ml)	THB APHA 9215C (cfu/ml)	THF APHA 9610C (cfu/ml)	SRB
EA 74	NIL	NIL	1.11X10 <sup>2</sup>	3.70X10 <sup>1</sup>	NA
EA 75	NIL	NIL	2.01X10 <sup>2</sup>	9.30X10 <sup>1</sup>	NA
EA 76	NIL	NIL	1.85X10 <sup>2</sup>	3.70X10 <sup>1</sup>	NA
EA 77	NIL	NIL	1.35X10 <sup>2</sup>	4.30X10 <sup>1</sup>	NA
EA 78	NIL	NIL	2.06X10 <sup>2</sup>	6.10X10 <sup>1</sup>	NA
EA 79	NIL	NIL	2.12X10 <sup>2</sup>	9.80X10 <sup>1</sup>	NA
EA 80	0.10x10 <sup>1</sup>	0.20X10 <sup>1</sup>	1.02X10 <sup>2</sup>	5.30X10 <sup>1</sup>	NA
EA 81	NIL	NIL	1.09X10 <sup>2</sup>	3.70X10 <sup>1</sup>	NA
EA 82	NIL	NIL	1.17X10 <sup>2</sup>	8.20X10 <sup>1</sup>	NA
EA 83	NIL	NIL	1.53X10 <sup>2</sup>	7.60X10 <sup>1</sup>	NA
EA 84	NIL	NIL	1.19X10 <sup>2</sup>	6.10X10 <sup>1</sup>	NA
EA 85	NIL	NIL	2.01X10 <sup>2</sup>	5.70X10 <sup>1</sup>	NA
EA 86	NIL	NIL	1.31X10 <sup>2</sup>	8.10X10 <sup>1</sup>	NA
EA 87	NIL	NIL	1.09X10 <sup>2</sup>	7.20X10 <sup>1</sup>	NA
EA 88	NIL	NIL	1.02X10 <sup>2</sup>	5.10X10 <sup>1</sup>	NA
EA 89	NIL	NIL	1.41X10 <sup>2</sup>	5.10X10 <sup>1</sup>	NA
EA 90	NIL	NIL	2.13X10 <sup>2</sup>	3.30X10 <sup>1</sup>	NA
EA 91	2.20X10 <sup>1</sup>	0.30X10 <sup>1</sup>	1.44X10 <sup>2</sup>	4.70X10 <sup>1</sup>	NA
EA 92	NIL	NIL	1.19X10 <sup>2</sup>	4.20X10 <sup>1</sup>	NA
EA 93	NIL	NIL	2.11X10 <sup>2</sup>	9.80X10 <sup>1</sup>	NA
EA 94	NIL	NIL	1.81X10 <sup>2</sup>	4.70X10 <sup>1</sup>	NA
EA 95	NIL	NIL	2.01X10 <sup>2</sup>	4.20X10 <sup>1</sup>	NA
EA 96	NIL	1.12x10 <sup>1</sup>	2.02X10 <sup>2</sup>	3.10X10 <sup>1</sup>	NA
EA 97	0.10x10 <sup>1</sup>	NIL	1.03X10 <sup>2</sup>	6.90X10 <sup>1</sup>	NA
EA 98	NIL	NIL	2.17X10 <sup>2</sup>	1.35X10 <sup>1</sup>	NA
EA 99	NIL	NIL	1.22X10 <sup>2</sup>	3.10X10 <sup>1</sup>	NA
EA 100	0.90X10 <sup>2</sup>	2.10X10 <sup>1</sup>	1.82X10 <sup>2</sup>	6.20X10 <sup>1</sup>	NA
EA 101	NIL	NIL	1.12X10 <sup>2</sup>	5.80X10 <sup>1</sup>	NA
EA 102	NIL	NIL	2.02X10 <sup>2</sup>	9.10X10 <sup>1</sup>	NA
CONTROL 1	NIL	NIL	1.33X10 <sup>2</sup>	7.20X10 <sup>1</sup>	NA
CONTROL 2	NIL	NIL	1.16X10 <sup>2</sup>	4.10X10 <sup>1</sup>	NA
CONTROL 3	NIL	4.20X10 <sup>1</sup>	1.43X10 <sup>2</sup>	8.20X10 <sup>1</sup>	3.40X10 <sup>1</sup>

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**Appendix 3  
Hydrobiology result for Sea Eagle**

**Appendix 3a: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

Taxonomic List	Sample ID/Number of individuals (n) identified													
	EA 45	EA 59	EA 54	EA 48	EA 49	EA 55	EA 47	EA 50	EA 46	EA 53	EA 57	EA 52	EA 58	EA 51
<b>A: BACILLARIOPHYCEAE</b>														
<i>Surrirela elegans</i>	12	13	11	10	12	11	15	14	13	11	8	11	-	10
<i>Shuelta annulata</i>	11	9	8	9	7	9	-	11	10	5	10	10	8	9
<i>Rhizosolenia cylindricus</i>	10	11	9	-	13	8	13	10	15	12	-	10	12	11
<i>Thalassiora decipiens</i>	11	13	13	11	-	10	12	13	-	13	8	8	10	16
<i>Ceratulina pelagic</i>	13	12	11	7	12	9	10	-	9	6	-	7	9	10
<i>Halosphaera viridis</i>	12	8	13	14	9	10	-	12	10	10	11	10	9	12
<i>Eucampia zoodiacus</i>	9	17	11	13	11	-	14	13	10	11	9	12	10	12
<i>Coscinodiscus africanus</i>	10	7	9	9	-	10	11	9	-	9	8	-	9	-
<i>Coscinodiscus curvatus</i>	5	8	8	7	6	9	-	7	6	-	7	8	8	8
<i>Navicula petersenni</i>	12	10	9	-	9	8	14	13	-	7	9	6	-	10
<i>Surrirela ovalis</i>	11	9	-	7	8	9	9	8	7	8	-	7	9	9
<i>Coscinodiscus radiata</i>	13	13	8	8	11	10	7	7	-	9	9	10	10	8
<i>Skeletonema costatum</i>	11	15	9	10	15	13	10	-	9	13	11	10	7	9
<i>Chaetoceros similis</i>	13	13	9	7	14	11	9	7	10	11	10	-	-	12
<i>Chaetoceros decipiens</i>	12	11	10	10	13	10	8	9	11	-	13	14	12	10
<i>Chaetoceros simplex</i>	7	13	-	10	12	-	8	7	9	12	-	10	13	12
<i>Coscinodiscus coincinus</i>	8	7	13	-	11	9	11	10	10	13		9	13	18
<i>Coscinodiscus atlantius</i>	9	7	14	11	16	10	11	-	9	13	-	8	9	10

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<i>Coscinodiscus gracilis</i>	7	-	11	8	-	13	13	13	8	12	10	11	8	12
<i>Nitzschia marina</i>	10	13	11	8	7	11	12	11	13	9	17	12	-	13
<i>Nitzschia longissima</i>	9	12	10	8	9	9	8	9	14	15	12	12	15	-
<b>Abundance per station</b>	<b>215</b>	<b>221</b>	<b>197</b>	<b>167</b>	<b>195</b>	<b>189</b>	<b>191</b>	<b>184</b>	<b>173</b>	<b>196</b>	<b>165</b>	<b>185</b>	<b>171</b>	<b>206</b>
<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	11	15	11	10	14	7	15	12	11	8	9	10	11	9
<i>P. boryanum</i>	13	15	13	10	13	9	13	10	-	9	7	8	12	11
<i>P. Clathratum</i>	9	13	10	12	8	12	11	9	7	8	8	7	10	12
<i>Closterium lineatum</i>	-	10	6	12	9	-	10	7	9	10	-	9	10	-
<i>Danaliella salina</i>	6	8	9	5	-	4	8	9	7	-	6	-	7	8
<i>Caulerpa racemosa</i>	4	4	5	-	7	4	-	7	5	5	5	4	6	7
<i>Cladophora prolifera</i>	9	11	9	-	-	7	9	6	-	7	9	5	10	9
<b>Abundance per station</b>	<b>52</b>	<b>76</b>	<b>63</b>	<b>49</b>	<b>51</b>	<b>43</b>	<b>66</b>	<b>60</b>	<b>39</b>	<b>47</b>	<b>44</b>	<b>43</b>	<b>66</b>	<b>56</b>
<b>C: CYANOPHYCEAE</b>														
<i>Microcystis sp</i>	9	12	5	10	14	10	7	9	9	9	7	10	9	11
<i>M. aeruginosa</i>	11	14	11	9	13	11	9	7	7	8	9	7	9	10
<i>Anabaena spiroides</i>	11	12	7	8	-	9	8	5	6	-	7	8	6	12
<i>A. flosaquae</i>	12	10	9	-	11	8	-	7	5	8	6	9	-	9
<i>Lyngbya Subsalsa</i>	13	15	11	9	9	-	9	-	8	7	-	5	4	-
<i>Spirulina subsalsa</i>	11	13	-	10	10	5	-	5	-	5	8	-	7	10
<i>Phormidium Sp</i>	5	9	-	7	-	8	6	9	3	4	7	8	6	7
<b>Abundance per station</b>	<b>72</b>	<b>85</b>	<b>43</b>	<b>53</b>	<b>57</b>	<b>51</b>	<b>39</b>	<b>42</b>	<b>38</b>	<b>36</b>	<b>44</b>	<b>47</b>	<b>34</b>	<b>59</b>
<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	7	13	9	9	11	8	10	12	10	9	8	8	10	13
<i>Ceratium furca</i>	9	10	10	11	9	8	13	13	9	11	7	6	7	11
<i>Ceratium trichoceros</i>	9	12	9	-	9	10	11	7	5	6	9	-	10	10
<i>Peridium catenatum</i>	7	10	12	12	10	-	8	8	9	10	7	8	11	12
<i>Gymnodinium breve</i>	5	6	11	9	-	10	8	5	7	-	11	10	10	-
<i>Dinophysis acuta</i>	4	7	9	-	9	8	-	7	-	7	8	9	9	7
<i>Tabellaria Sp</i>	5	6	8	5	5	5	4	9	6	7	9	8	-	4
<i>Goniaulax catanella</i>	7	9	5	4	-	-	7	-	5	4	-	8	4	8
<i>Noctiluca seintillans</i>	8	8	7	5	-	4	3	8	-	7	9	3	5	9
<b>Abundance per station</b>	<b>61</b>	<b>81</b>	<b>80</b>	<b>55</b>	<b>53</b>	<b>53</b>	<b>64</b>	<b>72</b>	<b>51</b>	<b>61</b>	<b>68</b>	<b>60</b>	<b>66</b>	<b>74</b>
<b>Overall Abundance (N)</b>	<b>400</b>	<b>463</b>	<b>383</b>	<b>324</b>	<b>356</b>	<b>336</b>	<b>360</b>	<b>358</b>	<b>301</b>	<b>340</b>	<b>321</b>	<b>335</b>	<b>337</b>	<b>395</b>

Source: Field work Oct. – Nov. , 2018.



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**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

Taxonomic List	Sample ID/Number of individuals (n) identified													
	EA 56	EA 44	EA 43	EA 39	EA 38	EA 34	EA 40	EA 35	EA 31	EA 32	EA 33	EA 37	EA 42	EA 41
<b>A: BACILLARIOPHYCEAE</b>														
<i>Surirela elegans</i>	11	11	10	9	8	10	13	6	6	-	10	9	10	13
<i>Shuelta annulate</i>	12	13	8	7	9	11	7	-	10	7	-	10	11	13
<i>Rhizosolenia cylindricus</i>	9	12	11	14	8	8	-	13	11	9	13	11	12	5
<i>Thalassiora decipens</i>	10	10	12	-	10	13	8	9	14	11	15	-	14	8
<i>Cerataulina pelagica</i>	6	-	14	7	-	9	10	11	12	14	13	8	-	11
<i>Halosphaera viridis</i>	13	14	13	-	10	-	8	-	13	13	8	8	10	12
<i>Eucampia zoodiacus</i>	14	13	7	8	8	16	14	12	-	10	10	13	11	15
<i>Coscinodiscus africanus</i>	11	-	10	9	8	9	8	8	7	-	-	7	8	9
<i>Coscinodiscus curvatus</i>	6	8	-	7	7	5	6	-	5	6	6	5	8	6
<i>Navicula petersenni</i>	13	11	10	-	8	6	-	11	-	13	9	10	7	9
<i>Surirela ovalis</i>	10	8	9	9	7	7	6	8	8	9	7	-	8	8
<i>Coscinodiscus radiata</i>	8	12	10	9	11	-	9	8	7	-	9	7	6	10
<i>Skeletonema costatum</i>	12	11	9	11	13	14	-	-	9	8	8	9	-	-
<i>Chaetoceros similis</i>	11	13	13	9	-	11	7	9	13	12	11	10	10	14
<i>Chaetoceros decipiens</i>	-	-	14	12	11	12	10	-	4	8	9	-	7	5
<i>Chaetoceros</i>	7	10	8	-	10	-	11	13	9	7	-	10	11	9

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<i>simplex</i>														
<i>Coscinodiscus coincinus</i>	11	13	10	11	9	8	8	11	10	-0	13	13	9	11
<i>Coscinodiscus atlanticus</i>	14	10	9	13	13	14	10	12	-	13	11	9	4	8
<i>Coscinodiscus gracilis</i>	9	13	-	11	8	8	-	12	13	11	10	-	9	7
<i>Nitzschia marina</i>	11	11	10	-	13	9	6	11	-	8	9	11	8	12
<i>Nitzschia longissima</i>	10	11	12	14	-	8	9	14	15	9	10	-	12	11
<b>Abundance per station</b>	<b>208</b>	<b>204</b>	<b>199</b>	<b>151</b>	<b>171</b>	<b>178</b>	<b>150</b>	<b>168</b>	<b>166</b>	<b>168</b>	<b>181</b>	<b>149</b>	<b>175</b>	<b>205</b>
<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	13	13	11	12	10	-	8	14	10	9	11	13	14	12
<i>P. boryanum</i>	12	14	6	-	15	10	8	7	9	9	10	8	11	-
<i>P. Clathratum</i>	11	10	8	7	9	10	7	-	8	7	11	-	15	17
<i>Closterium lineatum</i>	15	13	12	9	10	-	10	16	11	10	-	13	10	15
<i>Danaliella salina</i>	13	11	-	13	12	11	-	14	-	10	11	10	12	13
<i>Caulerpa racemosa</i>	10	12	14	13	-	12	11	13	15	-	12	12	8	7
<i>Cladophora prolifera</i>	-	16	13	8	9	10	9	-	7	8	9	8	7	11
<b>Abundance per station</b>	<b>74</b>	<b>89</b>	<b>70</b>	<b>62</b>	<b>65</b>	<b>53</b>	<b>53</b>	<b>64</b>	<b>59</b>	<b>53</b>	<b>64</b>	<b>64</b>	<b>77</b>	<b>75</b>
<b>C: CYANOPHYCEAE</b>														
<i>Microcystis sp</i>	11	10	6	7	11	13	9	7	8	9	10	13	10	10
<i>M. aeruginosa</i>	5	6	7	9	6	11	-	5	6	4	7	11	9	7
<i>Anabaena spiroides</i>	13	13	14	13	10	14	13	5	8	9	10	-	8	12
<i>A. flosaquae</i>	11	11	10	12	15	11	10	8	10	-	8	12	10	9
<i>Lyngbya Subsalsa</i>	14	15	18	9	9	11	-	-	6	11	8	5	8	-
<i>Spirulina subsalsa</i>	14	15	19	18	11	6	9	6	-	-	6	11	8	6
<i>Phormidium Sp</i>	7	9	8	10	7	7	8	-	9	11	10	-	5	7
<b>Abundance per station</b>	<b>75</b>	<b>79</b>	<b>82</b>	<b>78</b>	<b>70</b>	<b>62</b>	<b>61</b>	<b>39</b>	<b>53</b>	<b>44</b>	<b>46</b>	<b>65</b>	<b>50</b>	<b>55</b>

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<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	9	11	13	12	11	10	12	10	11	13	8	6	7	13
<i>Ceratium furca</i>	8	15	13	11	9	10	12	8	8	8	9	13	7	11
<i>Ceratium trichoceros</i>	9	12	16	14	8	12	13	17	11	-	13	10	-	10
<i>Peniedium catenatum</i>	8	12	10	-	11	9	12	-	10	9	-	9	8	10
<i>Gymnodinium breve</i>	8	10	-	8	5	-	9	7	8	11	9	-	10	8
<i>Dinophysis acuta</i>	10	-	11	9	9	10	11	10	8	12	9	11	10	14
<i>Tabellaria Sp</i>	7	9	8	8	10	13	9	-	10	11	-	8	9	-
<i>Goniaulax catanella</i>	11	8	6	11	5	14	-	8	12	8	8	7	11	13
<i>Noctiluca seintillans</i>	8	10	7	9	10	7	10	11	-	9	7	10	-	13
<b>Abundance per station</b>	<b>77</b>	<b>87</b>	<b>84</b>	<b>82</b>	<b>78</b>	<b>85</b>	<b>88</b>	<b>71</b>	<b>78</b>	<b>81</b>	<b>62</b>	<b>74</b>	<b>62</b>	<b>92</b>
<b>Overall abundance</b>	<b>434</b>	<b>459</b>	<b>435</b>	<b>373</b>	<b>384</b>	<b>301</b>	<b>352</b>	<b>342</b>	<b>356</b>	<b>346</b>	<b>353</b>	<b>352</b>	<b>364</b>	<b>427</b>

Source: Field work Oct. – Nov. , 2018.

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

Taxonomic List	Sample ID/Number of individuals (n) identified													
	EA 36	EA CTL1	EA 23	EA 76	EA CTL3	EA 11	EA 25	EA 28	EA 29	EA 26	EA 24	EA 27	EA CTL2	EA 100
<b>A: BACILLARIOPHYCEAE</b>														
<i>Surrela elegans</i>	10	14	10	9	12	8	10	13	6	9	10	11	12	8
<i>Shuelta annulata</i>	10	17	9	9	14	9	9	6	9	13	11	7	16	7
<i>Rhizosolenia cylindricus</i>	11	10	8	10	11	13	11	-	13	12	-	8	19	12
<i>Thalassiora decipiens</i>	9	14	10	9	10	11	-	12	12	8	10	6	13	10
<i>Cerataulina pelagica</i>	7	8	6	6	11	-	7	9	6	10	4	10	12	-
<i>Halosphaera viridis</i>	9	13	11	10	16	11	10	12	9	-	10	11	13	12
<i>Eucampia zoodiacus</i>	10	19	13	-	8	11	9	-	13	10	11	-	8	7
<i>Coscinodiscus africanus</i>	5	9	7	8	12	7	10	8	10	11	9	9	11	8
<i>Coscinodiscus curvatus</i>	6	8	8	7	10	8	-	9	-	13	10	7	9	7
<i>Navicula petersenni</i>	10	10	9	11	16	9	10	8	7	-	-	8	15	12
<i>Surrela ovalis</i>	9	11	8	7	8	-	9	5	6	9	8	8	9	7
<i>Coscinodiscus radiata</i>	11	10	6	9	12	9	-	8	7	10	8	11	10	-
<i>Skeletonema costatum</i>	13	16	11	11	18	10	13	-	11	12	9	10	17	13
<i>Chaetoceros similis</i>	9	10	11	12	10	9	7	12	-	10	14	9	13	12
<i>Chaetoceros decipiens</i>	8	12	-	13	14	13	11	13	10	11	13	8	14	12
<i>Chaetoceros simplex</i>	-	13	11	9	10	9	8	-	9	13	9	10	13	11
<i>Coscinodiscus coincinus</i>	9	15	10	12	11	-	10	14	8	-	10	6	13	-
<i>Coscinodiscus atlanticus</i>	9	17	-	10	8	19	8	7	12	11	-	-	18	13
<i>Coscinodiscus gracilis</i>	8	13	7	9	12	11	12	11	8	10	13	9	11	-
<i>Nitzschia marina</i>	11	14	10	-	10	11	10	13	11	9	10	11	14	10
<i>Nitzschia longissima</i>	9	11	10	11	13	-	8	9	10	11	12	10	13	11
<b>Abundance per station</b>	<b>193</b>	<b>264</b>	<b>169</b>	<b>182</b>	<b>214</b>	<b>166</b>	<b>172</b>	<b>169</b>	<b>177</b>	<b>192</b>	<b>175</b>	<b>169</b>	<b>297</b>	<b>172</b>
<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	10	18	13	12	16	9	-	11	11	9	7	10	14	10
<i>P. boryanum</i>	12	17	14	10	16	8	11	9	-	9	6	9	17	11
<i>P. Clathratum</i>	11	16	11	9	12	6	9	8	9	7	8	7	13	9
<i>Closterium lineatum</i>	4	6	5	4	8	7	4	-	7	-	-	7	8	7

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<i>Danaliella salina</i>	5	7	6	5	4	-	9	8	6	7	6	6	9	6
<i>Caulerpa racemosa</i>	3	5	3	4	6	-	5	4	3	5	-	7	8	7
<i>Cladophora prolifera</i>	10	13	10	-	11	9	8	11	-	10	9	10	12	-
<b>Abundance per station</b>	<b>55</b>	<b>82</b>	<b>62</b>	<b>44</b>	<b>73</b>	<b>39</b>	<b>46</b>	<b>51</b>	<b>36</b>	<b>47</b>	<b>36</b>	<b>56</b>	<b>81</b>	<b>50</b>
<b>C; CYANOPHYCEAE</b>														
<i>Microcystis sp</i>	10	14	-	10	16	10	9	7	10	8	8	7	19	10
<i>M. aeruginosa</i>	13	17	13	8	18	13	8	7	9	10	7	8	11	8
<i>Anabaena spiroides</i>	10	14	-	9	14	10	6	-	8	-	11	10	16	13
<i>A. flosqual</i>	10	13	9	-	11	9	-	8	6	10	-	9	13	10
<i>Lyngbya subsala</i>	12	18	10	8	10	-	7	11	5	7	11	-	19	14
<i>Spirulina subsala</i>	8	10	8	7	14	9	8	7	-	7	5	10	13	12
<i>Phormidium sp</i>	7	19	13	-	16	10	-	8	9	-	6	11	18	13
<b>Abundance per station</b>	<b>70</b>	<b>105</b>	<b>53</b>	<b>42</b>	<b>99</b>	<b>61</b>	<b>38</b>	<b>48</b>	<b>47</b>	<b>43</b>	<b>48</b>	<b>55</b>	<b>109</b>	<b>80</b>
<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	9	14	10	9	12	11	13	11	10	14	13	12	13	10
<i>Ceratium furca</i>	10	13	11	8	9	8	10	9	11	12	9	10	12	11
<i>Ceratium trichoceros</i>	9	11	10	9	9	9	11	10	11	9	10	10	12	9
<i>Penedium catenatum</i>	10	13	12	8	11	10	9	-	10	8	-	12	17	14
<i>Gymnodinium breve</i>	8	14	13	11	13	8	9	9	11	-	5	-	13	10
<i>Dinophysis acuta</i>	5	8	7	7	10	6	7	4	8	4	9	6	11	8
<i>Tabellaria sp.</i>	5	8	7	-	6	-	5	5	4	4	-	7	9	-
<i>Goniaulax catanella</i>	4	6	5	4	6	5	6	-	-	5	4	5	7	6
<i>Noctiluca seintillans</i>	8	11	10	3	8	-	9	8	6	-	5	5	13	11
<b>Abundance per station</b>	<b>68</b>	<b>98</b>	<b>85</b>	<b>59</b>	<b>84</b>	<b>57</b>	<b>79</b>	<b>56</b>	<b>71</b>	<b>56</b>	<b>55</b>	<b>67</b>	<b>107</b>	<b>79</b>
<b>Overall Abundance</b>	<b>386</b>	<b>549</b>	<b>375</b>	<b>327</b>	<b>470</b>	<b>335</b>	<b>335</b>	<b>324</b>	<b>298</b>	<b>338</b>	<b>320</b>	<b>347</b>	<b>594</b>	<b>381</b>

Source: Field work Oct. – Nov. , 2018.

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**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

Taxonomic List	Sample ID/Number of individuals (n) identified													
	EA 96	EA 92	EA 88	EA 90	EA 94	EA 98	EA 97	EA 93	EA 89	EA 91	EA 95	EA 99	EA 87	EA 86
<b>A: BACILLARIOPHYCEAE</b>														
<i>Surrirela elegans</i>	10	13	7	11	10	8	13	16	11	9	10	11	7	9
<i>Shuelta annulata</i>	13	11	9	10	7	-	12	12	9	13	8	12	13	11
<i>Rhizosolenia cylindricus</i>	10	8	11	7	14	10	12	10	8	10	12	10	9	10
<i>Thalassiora decipiens</i>	-	13	11	8	7	12	10	10	9	12	9	9	6	10
<i>Ceratulina pelagica</i>	8	11	8	-	8	9	-	8	9	11	8	8	8	11
<i>Halosphaera virididis</i>	8	9	8	9	10	11	14	-	11	8	7	9	8	12
<i>Eucampia zodiacus</i>	13	11	10	12	-	12	11	6	-	8	9	11	-	6
<i>Coscinodiscus curvatus</i>	10	-	15	13	11	9	-	8	9	9	-	14	10	-
<i>Navicula petersenni</i>	-	13	9	8	7	12	7	7	9	11	11	9	13	11
<i>Surrirela ovalis</i>	10	9	12	-	10	12	-	8	10	10	12	-	12	10
<i>Coscinodiscus radiata</i>	16	13	12	7	9	13	10	12	11	12	9	10	8	7
<i>Skeletonema costatum</i>	12	9	10	9	8	10	9	10	10	-	10	17	16	13
<i>Chaetoceros similis</i>	-	11	8	10	13	8	8	10	9	8	12	8	9	8
<i>Chaetoceros decipiens</i>	7	-	13	10	13	9	9	-	-	7	8	11	12	9
<i>Chaetoceros simplex</i>	11	10	-	13	12	-	8	11	-	7	9	12	10	9
<i>Coscinodiscus coincinus</i>	8	12	-	12	8	16	7	9	13	10	-	-	8	8
<i>Coscinodiscus atlanticus</i>	13	12	10	8	-	14	11	12	11	9	8	10	8	9
<i>Coscinodiscus gracilis</i>	9	10	8	-	9	13	12	11	9	13	11	9	11	-
<i>Nitzschia marina</i>	13	-	10	13	11	11	11	8	7	11	10	7	11	9
<i>Nitzschia longissima</i>	10	9	11	12	10	13	8	14	10	9	-	-	13	11
<b>Abundance per station</b>	<b>193</b>	<b>194</b>	<b>195</b>	<b>180</b>	<b>187</b>	<b>210</b>	<b>181</b>	<b>189</b>	<b>173</b>	<b>193</b>	<b>173</b>	<b>187</b>	<b>199</b>	<b>173</b>
<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	7	8	12	11	9	8	7	5	12	8	12	12	10	13
<i>P. boryanum</i>	9	9	10	13	12	10	4	7	9	9	12	10	9	12

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<i>P. Clathratum</i>	6	9	8	9	11	6	4	9	7	8	10	9	6	13
<i>Closterium lineatum</i>	5	8	7	4	7	4	7	7	8	13	-	9	-	13
<i>Caulerpa racemosa</i>	7	13	-	7	9	-	9	6	-	9	5	8	11	10
<i>Cladophora prelifera</i>	-	7	5	7	-	8	8	-	7	-	8	7	7	11
<b>Abundance per station</b>	<b>39</b>	<b>63</b>	<b>47</b>	<b>51</b>	<b>54</b>	<b>42</b>	<b>39</b>	<b>42</b>	<b>52</b>	<b>53</b>	<b>52</b>	<b>63</b>	<b>56</b>	<b>72</b>
<b>C: CYANOPHYCEAE</b>														
<i>Microcystis sp</i>	10	11	8	8	13	7	11	13	13	8	-	14	13	10
<i>M. aeruginosa</i>	8	9	9	8	9	8	9	14	4	9	10	12	8	7
<i>Anabaena spiroides</i>	9	7	11	9	14	6	7	11	5	7	11	12	9	11
<i>A. flosaquae</i>	5	11	10	7	8	7	7	9	7	11	9	10	8	-
<i>Lyngbya Subsalsa</i>	7	10	7	8	10	9	5	10	8	10	9	15	8	10
<i>Spirulina subsalsa</i>	9	5	5	10	-	7	7	12	10	-	11	-	-	10
<i>Phormidium Sp</i>	6	-	9	10	11	-	9	11	-	9	8	14	10	6
<b>Abundance per station</b>	<b>54</b>	<b>53</b>	<b>59</b>	<b>60</b>	<b>65</b>	<b>44</b>	<b>55</b>	<b>70</b>	<b>47</b>	<b>54</b>	<b>58</b>	<b>77</b>	<b>56</b>	<b>54</b>
<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	10	8	9	5	13	9	7	9	10	9	7	10	11	8
<i>Ceratium furca</i>	7	9	9	9	12	6	7	9	10	9	8	10	10	10
<i>Ceratium trichoceros</i>	5	12	11	10	10	8	4	8	12	8	13	7	9	9
<i>Peridium catenatum</i>	5	14	-	11	8	-	13	10	10	9	10	8	-	10
<i>Grymnodinium breve</i>	13	10	11	11	11	13	10	11	8	10	10	13	9	7
<i>Dinophysis acuta</i>	12	-	9	10	-	9	8	10	9	-	8	11	12	11
<i>Tabellaria Sp</i>	9	6	4	9	6	9	-	8	13	8	-	10	11	-
<i>Goniaulax catanella</i>	9	6	10	7	5	-	8	13	-	-	10	-	13	10
<i>Noctiluca seintillans</i>	10	7	8	-	9	7	9	7	9	4	7	9	11	9
<b>Abundance per station</b>	<b>80</b>	<b>72</b>	<b>71</b>	<b>72</b>	<b>74</b>	<b>61</b>	<b>66</b>	<b>85</b>	<b>81</b>	<b>57</b>	<b>73</b>	<b>78</b>	<b>86</b>	<b>74</b>
<b>Overall Abundance (N)</b>	<b>366</b>	<b>382</b>	<b>372</b>	<b>363</b>	<b>380</b>	<b>357</b>	<b>341</b>	<b>386</b>	<b>353</b>	<b>357</b>	<b>356</b>	<b>405</b>	<b>397</b>	<b>373</b>

Source: Field work Oct. – Nov. , 2018.

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

Taxonomic List	Sample ID/Number of individuals (n) identified													
	EA 35	EA 30	EA 84	EA 83	EA 82	EA 102	EA 80	EA 78	EA 101	EA 77	EA 81	EA 79	EA 1	EA 67
<b>A: BACILLARIOPHYCEAE</b>														
<i>Surreirela elegans</i>	13	14	10	8	11	7	5	13	9	10	13	11	-	13
<i>Shuelta annulata</i>	11	9	12	-	11	13	11	9	10	4	-	14	16	17
<i>Rhizosolenia cylindricus</i>	9	10	9	10	9	8	10	8	14	10	-	13	11	9
<i>Thalassiora decipiens</i>	8	12	13	12	7	-	10	8	13	-	8	11	16	16
<i>Ceratulina pelagic</i>	10	10	12	9	9	12	-	10	7	13	12	19	7	13
<i>Halosphaera virdidis</i>	9	10	13	11	12	14	13	10	10	14	13	8	-	14
<i>Eucampia zoodiacus</i>	13	11	10	11	10	11	9	9	9	10	11	-	8	-
<i>Coscinodiscus africanus</i>	11	-	8	7	12	8	11	10	11	-	13	10	12	10
<i>Coscinodiscus curvatus</i>	13	9	8	8	9	13	9	12	18	10	8	11	13	7
<i>Navicula petersenni</i>	-	12	9	10	8	-	10	-	13	13	11	13	11	10
<i>Surreirela ovalis</i>	11	10	11	-	10	12	-	10	-	11	13	6	13	13
<i>Coscinodiscus radiate</i>	10	14	-	8	9	11	11	12	10	9	10	8	12	11
<i>Skeletonema costatum</i>	16	9	7	7	9	13	15	-	18	13	-	8	10	13
<i>Chaetoceros similis</i>	12	-	13	12	-	13	11	10	10	11	10	12	9	-
<i>Chaetoceros decipiens</i>	9	10	9	8	-	10	7	11	13	10	9	11	10	12
<i>Chaetoceros simplex</i>	9	13	8	9	12	9	8	13	13	11	-	13	7	7
<i>Coscinodiscus coincinus</i>	13	9	8	10	13	6	13	7	-	9	12	9	10	8
<i>Coscinodiscus atlanticus</i>	13	11	13	-	10	7	12	1	13	11	13	10	8	12
<i>Coscinodiscus gracilis</i>	11	-	12	13	11	10	17	-	14	9	19	8	-	12
<i>Nitzschia marina</i>	-	7	9	8	9	-	12	13	11	12	16	11	9	10
<i>Nitzschia longissima</i>	15	13	-	11	12	18	14	19	-	10	12	8	13	14



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<b>Abundance per station</b>	<b>216</b>	<b>193</b>	<b>194</b>	<b>172</b>	<b>193</b>	<b>195</b>	<b>208</b>	<b>194</b>	<b>216</b>	<b>200</b>	<b>203</b>	<b>216</b>	<b>195</b>	<b>215</b>
<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	7	12	14	9	11	13	9	11	-	-	8	8	10	-
<i>P. boryanum</i>	8	10	7	7	9	10	-	13	10	10	12	7	11	10
<i>P. Clathratum</i>	12	9	10	9	8	-	10	9	10	13	10	9	9	12
<i>Closterium lineatum</i>	6	6	-	11	5	9	13	14	14	12	-	13	-	9
<i>Danaliella salina</i>	10	4	9	12	-	11	5	11	12	6	14	-	11	12
<i>Caulerpa racemosa</i>	4	10	7	13	14	9	-	12	-	10	11	9	10	6
<i>Cladophora prolifera</i>	-	9	8	-	11	7	8	9	14	11	13	9	9	13
<b>Abundance per station</b>	<b>47</b>	<b>60</b>	<b>55</b>	<b>61</b>	<b>58</b>	<b>59</b>	<b>45</b>	<b>79</b>	<b>60</b>	<b>62</b>	<b>68</b>	<b>55</b>	<b>60</b>	<b>62</b>
<b>C: CYANOPHYCEAE</b>														
<i>Microcystis sp</i>	7	3	8	9	-	7	10	5	12	10	6	5	8	-
<i>M. aeruginosa</i>	9	-	5	6	5	8	14	8	18	6	9	11	-	9
<i>Anabaena spiroides</i>	19	18	10	18	17	14	8	7	10	5	-	12	14	13
<i>A. flosaquae</i>	10	17	18	10	10	11	-	6	11	8	8	-	17	8
<i>Lyngbya Subsalsa</i>	-	7	-	11	8	5	10	-	12	-	9	11	19	14
<i>Spirulina subsalsa</i>	11	9	10	14	-	10	9	9	-	10	9	10	4	7
<i>Phormidium Sp</i>	8	9	8	9	9	11	-	5	7	8	4	8	-	11
<b>Abundance per station</b>	<b>64</b>	<b>63</b>	<b>59</b>	<b>77</b>	<b>49</b>	<b>66</b>	<b>51</b>	<b>40</b>	<b>70</b>	<b>47</b>	<b>45</b>	<b>57</b>	<b>62</b>	<b>62</b>
<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	6	8	11	9	12	11	8	7	-	10	11	12	10	12
<i>Ceratium furca</i>	4	5	-	6	10	6	11	8	-	9	6	10	8	10
<i>Ceratium trichoceros</i>	8	5	9	6	7	8	9	6	4	-	10	13	8	14
<i>Peridium catenatum</i>	-	7	9	8	-	6	8	9	8	6	10	9	11	-
<i>Grymnodinium breve</i>	11	6	11	-	10	9	-	12	5	7	9	5	10	11
<i>Dinophysis acuta</i>	10	10	13	9	8	-	7	-	8	-	5	7	8	11
<i>Tabellaria Sp</i>	11	-	10	8	5	6	10	9	8	7	-	6	8	10
<i>Goniaulax catanella</i>	11	10	6	10	9	8	7	-	10	11	-	10	10	8
<i>Noctiluca seintillans</i>	9	12	9	9	-	11	5	9	8	9	10	7	-	5

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<b>Abundance per station</b>	<b>70</b>	<b>63</b>	<b>78</b>	<b>65</b>	<b>61</b>	<b>65</b>	<b>65</b>	<b>60</b>	<b>51</b>	<b>59</b>	<b>61</b>	<b>79</b>	<b>73</b>	<b>81</b>
<b>Overall Abundance (N)</b>	<b>397</b>	<b>379</b>	<b>386</b>	<b>375</b>	<b>361</b>	<b>385</b>	<b>369</b>	<b>373</b>	<b>397</b>	<b>368</b>	<b>377</b>	<b>407</b>	<b>390</b>	<b>420</b>

Source: Field work Oct. – Nov. , 2018.

**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

<b>Taxonomic List</b>	<b>Sample ID/Number of individuals (n) identified</b>													
	<b>EA 62</b>	<b>EA 60</b>	<b>EA 66</b>	<b>EA 61</b>	<b>EA 68</b>	<b>EA 72</b>	<b>EA 69</b>	<b>EA 74</b>	<b>EA 73</b>	<b>EA 70</b>	<b>EA 71</b>	<b>EA 65</b>	<b>EA 63</b>	<b>EA 64</b>
<b>A:BAELLARIOPHYCEAE</b>														
<i>Surreia elegans</i>	13	11	5	12	14	11	10	9	11	9	8	-	7	13
<i>Shueta annulata</i>	8	10	7	8	6	7	9	-	18	14	10	11	-	7
<i>Rhizosolenia cylindricus</i>	9	11	10	9	13	13	10	15	-	13	12	11	12	10
<i>Thalassiora decipiens</i>	7	10	8	-	8	9	11	13	12	14	13	-	10	9
<i>Ceratulina pelagic</i>	13	8	11	11	10	8	10	9	11	12	7	13	-	10
<i>Halosphaera viridis</i>	10	13	9	7	-	7	10	10	11	-	5	13	12	8
<i>Eucampia zoodiacus</i>	9	14	-		9	8	13	8	16	10	12	-	6	-
<i>Coscinodiscus africanus</i>	-	11	14	10	8	-	9	7	13	8	12	13	9	14
<i>Coscinodiscus curvatus</i>	9	14	-	10	6	9	8	11	14	-	15	13	12	11

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<i>Navicula petersenni</i>	8	13	8	9	5	12	7	-	10	16	8	10	8	-
<i>Surrirela ovalis</i>	14	12	10	13	9	-	11	8	9	13	11	-	13	15
<i>Coscinodiscus radiate</i>	10	9	10	10	-	14	9	7	9	8	8	11	7	17
<i>Skeletonema costatum</i>	9	13	12	8	13	-	7	6	10	-	10	8	11	13
<i>Chaetoceros similis</i>	8	12	13	14	11	14	10	-	7	10	8	14	10	-
<i>Chaetoceros decipiens</i>	-	10	12	13	15	-	9	11	13	9	-	14	13	14
<i>Chaetoceros simplex</i>	7	11	-	10	-	10	-	8	10	7	9	10	-	7
<i>Coscinodiscus atlanticus</i>	9	12	10	-	11	8	-	9	13	11	-	12	11	-
<i>Coscinodiscus gracilis</i>	10	8	9	-	14	11	12	10	-	13	13	11	10	13
<i>Nitzschia marina</i>	7	13	7	11	10	9	14	9	7	-	7	13	8	8
<i>Nitzschia longissima</i>	-	7	8	10	9	8	9	-	6	-	9	10	13	11
<b>Abundance per station</b>	<b>168</b>	<b>228</b>	<b>171</b>	<b>169</b>	<b>169</b>	<b>167</b>	<b>186</b>	<b>160</b>	<b>194</b>	<b>175</b>	<b>183</b>	<b>187</b>	<b>179</b>	<b>189</b>
<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	14	8	10	11	13	14	9	10	8	7	11	13	10	10
<i>P. boryanum</i>	10	-	9	12	10	10	7	10	7	-	10	15	11	13
<i>P. Clathratum</i>	11	7	8	-	10	12	7	-	12	8	14	11	12	8
<i>Closterium lineatum</i>	15	13	11	10	-	13	4	4	-	10	12	7	-	7
<i>Danaliella racemosa</i>	4	4	7	-	7	12	6	9	5	7	-	9	9	12
<i>Caulerpa racemosa</i>	4	7	9	5	6	9	-	6	7	-	10	10	7	9
<i>Cladophora prolifera</i>	5	8	5	5	8	5	9	5	6	9	7	8	6	9
<b>Abundance per station</b>	<b>63</b>	<b>47</b>	<b>59</b>	<b>43</b>	<b>54</b>	<b>75</b>	<b>42</b>	<b>44</b>	<b>45</b>	<b>41</b>	<b>64</b>	<b>73</b>	<b>55</b>	<b>68</b>
<b>C: CYANOPHYCEAE</b>														

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<i>Microcystis sp</i>	10	11	9	11	11	12	13	-	9	11	13	14	10	12
<i>M. aeruginosa</i>	14	9	-	9	13	11	9	12	8	7	12	10	11	13
<i>Anabaena spiroides</i>	12	13	10	7	9	8	9	11	13	9	11	13	-	9
<i>A. flosaquae</i>	-	11	13	13	10	5	13	9	10	7	-	-	11	8
<i>Lyngbya Subsalsa</i>	15	-	19	11	-	8	6	-	8	8	7	6	9	-
<i>Spirulina subsalsa</i>	11	18	7	-	10	9	12	11	13	10	-	8	7	13
<i>Phormidium Sp</i>	10	-	9	10	8	8	6	-	5	7	11	13	15	11
<b>Abundance per station</b>	<b>72</b>	<b>62</b>	<b>67</b>	<b>61</b>	<b>61</b>	<b>61</b>	<b>68</b>	<b>43</b>	<b>66</b>	<b>59</b>	<b>54</b>	<b>61</b>	<b>63</b>	<b>66</b>
<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	11	10	9	-	12	13	11	9	11	10	12	9	9	11
<i>Ceratium furca</i>	9	5	6	11	7	10	11	11	8	6	7	12	-	7
<i>Ceratium trichoceros</i>	8	9	-	9	8	-	10	10	13	7	8	9	11	8
<i>Peridium catenatum</i>	13	12	9	13	13	9	-	8	10	11	-	-	6	7
<i>Gymnodinium breve</i>	10	9	5	6	8	7	7	-	11	8	9	11	10	9
<i>Dinophysis acuta</i>	7	7	10	10	-	9	11	10	7	7	11	8	8	10
<i>Tabellaria Sp</i>	10	12	8	8	10	11	8	10	7	4	8	7	-	12
<i>Goniaulax catanella</i>	-	10	12	12	10	-	9	8	-	9	8	5	9	10
<i>Noctiluca seintillans</i>	12	19	15	10	10	11	-	9	5	6	10	11	10	7
<b>Abundance per station</b>	<b>80</b>	<b>93</b>	<b>74</b>	<b>79</b>	<b>77</b>	<b>70</b>	<b>67</b>	<b>75</b>	<b>72</b>	<b>68</b>	<b>73</b>	<b>72</b>	<b>63</b>	<b>81</b>
<b>Overall Abundance (N)</b>	<b>383</b>	<b>430</b>	<b>371</b>	<b>352</b>	<b>361</b>	<b>373</b>	<b>363</b>	<b>322</b>	<b>377</b>	<b>343</b>	<b>374</b>	<b>393</b>	<b>360</b>	<b>404</b>

Source: Field work Oct. – Nov. , 2018.

**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

Taxonomic List	Sample ID/Number of individuals (n) identified													
	EA 75	EA 2	EA 3	EA 4	EA 5	EA 6	EA 18	EA 7	EA 8	EA 9	EA 10	EA 20	EA 17	EA 16
<b>A:BAELLARIOPHYCEAE</b>														
<i>Surirela elegans</i>	12	-	11	18	9	7	13	14	-	7	9	14	13	11
<i>Shuelta annulata</i>	10	7	-	14	6	7	10	12	16	8	-	15	12	8
<i>Rhizosolenia cylindricus</i>	14	13	-	11	9	7	13	11	10	10	11	9	-	10
<i>Thalassiora decipiens</i>	10	11	11	13	-	8	7	8	11	-	9	8	12	16
<i>Ceratulina pelagic</i>	-	7	11	15	13	11	-	13	9	14	12	15	12	8
<i>Halosphaera virididis</i>	13	8	8	12	10	9	12	9	-	9	13	8	10	10
<i>Eucampia zoodiacus</i>	8	10	9	-	6	10	-	11	7	8	9	14	-	-
<i>Coscinodiscus africanus</i>	9	-	7	15	9	8	10	12	14	7	-	11	14	15
<i>Coscinodiscus curvatus</i>	12	9	10	8	9	12	15	-	-	7	13	9	11	12
<i>Navicula petersenni</i>	-	10	9	10	-	-	12	-	13	-	7	-	9	11
<i>Surirela ovalis</i>	12	12	15	10	9	10	9	11	8	10	10	11	-	13
<i>Coscinodiscus radiate</i>	9	-	13	12	13	8	-	14	10	14	-	15	13	14
<i>Skeletonema costatum</i>	9	12	10	7	11	7	7	12	-	10	12	8	-	14
<i>Chaetoceros similis</i>	8	14	13	11	12	-	10	13	10	8	8	9	7	7
<i>Chaetoceros decipiens</i>	-	7	-	13	-	13	10	9	8	6	14	11	13	-
<i>Chaetoceros simplex</i>	9	9	8	9	8	10	11	-	10	9	11	-	14	10
<i>Coscinodiscus atlanticus</i>	12	-	12	8	13	8	10	13	9	-	10	9	12	-
<i>Coscinodiscus gracilis</i>	10	6	10	7	-	10	15	10	6	7	10	11	13	14
<i>Nitzschia marina</i>	9	13	-	8	11	12	-	13	9	-	13	14	-	10
<i>Nitzschia longissima</i>	-	10	9	7	10	7	9	8	8	10	11	-	12	9
<b>Abundance per station</b>	<b>176</b>	<b>171</b>	<b>179</b>	<b>213</b>	<b>167</b>	<b>172</b>	<b>180</b>	<b>204</b>	<b>168</b>	<b>156</b>	<b>182</b>	<b>204</b>	<b>177</b>	<b>202</b>

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<b>B: CHLOROPHYCEAE</b>														
<i>Pediastrum duplex</i>	13	13	14	7	9	5	10	-	5	7	-	13	11	14
<i>P. boryanum</i>	-	10	12	12	12	7	11	15	-	8	10	11	13	9
<i>P. Clathratum</i>	8	11	-	7	5	9	4	7	9	6	12	9	-	10
<i>Closterium lineatum</i>	12	11	10	-	13	8	-	10	11	-	8	10	11	9
<i>Danaliella racemosa</i>	11	15	13	13	-	-	9	13	12	7	11	-	13	-
<i>Caulerpa racemosa</i>	7	12	-	10	14	7	10	7	8	9	-	10	12	10
<i>Cladophora prolifera</i>	6	-	9	10	7	9	-	8	-	6	9	14	13	14
<b>Abundance per station</b>	<b>57</b>	<b>72</b>	<b>58</b>	<b>59</b>	<b>60</b>	<b>45</b>	<b>44</b>	<b>60</b>	<b>45</b>	<b>43</b>	<b>50</b>	<b>67</b>	<b>73</b>	<b>66</b>
<b>C: CYANOPHYCEAE</b>														
<i>Microcystis sp</i>	11	10	11	8	10	7	11	9	13	15	13	-	-	14
<i>M. aeruginosa</i>	12	10	10	12	8	9	7	10	5	-	11	13	12	15
<i>Anabaena spiroides</i>	10	14	12	10	-	14	12	-	9	11	7	10	9	10
<i>A. flosaquae</i>	13	9	-	7	10	-	10	7	6	9	-	13	7	11
<i>Lyngbya Subsalsa</i>	-	12	7	11	7	5	-	7	6	8	13	8	9	9
<i>Spirulina subsalsa</i>	12	10	7	-	8	7	12	8	-	7	7	-	8	-
<i>Phormidium Sp</i>	13	-	4	10	6	10	-	10	8	12	9	10	-	12
<b>Abundance per station</b>	<b>61</b>	<b>65</b>	<b>51</b>	<b>58</b>	<b>49</b>	<b>52</b>	<b>52</b>	<b>51</b>	<b>47</b>	<b>62</b>	<b>6</b>	<b>54</b>	<b>45</b>	<b>71</b>
<b>D: DINOPHYCEAE</b>														
<i>Ceratium tripos</i>	12	13	6	4	8	9	7	10	10	10	-	11	13	15
<i>Ceratium furca</i>	10	11	-	9	7	-	10	12	8	10	11	-	-	8
<i>Ceratium trichoceros</i>	-	8	8	11	10	11	8	12	13	10	-	11	12	9
<i>Peridium catenatum</i>	15	7	5	12	11	9	-	9	8	-	7	13	8	8
<i>Grymnodinium breve</i>	13	8	10	15	8	6	8	7	-	7	-	12	10	11
<i>Dinophysis acuta</i>	10	13	6	7	-	10	9	6	5	7	8	-	6	9
<i>Tabellaria Sp</i>	8	12	6	8	9	-	5	-	7	-	4	9	11	13
<i>Goniaulax catanella</i>	-	10	6	4	12	8	9	-	5	8	6	-	7	-

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<i>Noctiluca seintillans</i>	13	14	7	9	9	-	11	9	6	5	10	8	-	9
<b>Abundance per station</b>	<b>81</b>	<b>96</b>	<b>54</b>	<b>79</b>	<b>74</b>	<b>53</b>	<b>67</b>	<b>65</b>	<b>62</b>	<b>57</b>	<b>46</b>	<b>64</b>	<b>63</b>	<b>81</b>
<b>Overall Abundance (N)</b>	<b>375</b>	<b>404</b>	<b>342</b>	<b>409</b>	<b>350</b>	<b>322</b>	<b>343</b>	<b>380</b>	<b>322</b>	<b>318</b>	<b>338</b>	<b>389</b>	<b>358</b>	<b>420</b>

Source: Field work Oct. – Nov. , 2018.

**Appendix 3a Continued: Station-by-Station Species composition and abundance of the phytoplankton identified within the OML 79 Field during the October/November, 2018 EIA Studies**

Taxonomic List	Sample ID/Number of individuals (n) identified						
	EA 15	EA 14	EA 13	EA 12	EA 19	EA 21	EA 22
<b>A: BACILLARIOPHYCEAE</b>							
<i>Surrirela elegans</i>	14	18	11	7	8	10	9
<i>Shueta annulata</i>	12	11	7	13	13	14	-
<i>Rhizosolenia cylindricus</i>	13	9	-	10	7	7	12
<i>Thalassiora decipiens</i>	15	7	-	13	10	8	9
<i>Ceratulina pelagic</i>	11	12	10	13	8	10	11
<i>Halosphaera viridis</i>	-	9	12	-	10	10	13
<i>Eucampia zoodiacus</i>	14	11	9	12	-	-	17
<i>Coscinodiscus africanus</i>	9	10	-	15	-	12	13
<i>Coscinodiscus curvatus</i>	13	7	11	9	9	13	14
<i>Navicula petersenni</i>	10	14	10	14	-	8	-
<i>Surrirela ovalis</i>	-	12	10	11	8	10	13
<i>Coscinodiscus radiate</i>	15	10	9	11	12	10	15
<i>Skeletonema costatum</i>	10	-	12	15	10	-	13
<i>Chaetoceros similis</i>	9	11	15	10	6	11	10

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<i>Chaetoceros decipiens</i>	8	10	13	15	9	12	-
<i>Chaetoceros simplex</i>	7	7	14	8	9	11	10
<i>Coscinodiscus coisninus</i>	12	12	-	5	-	9	7
<i>Coscinodiscus atlanticus</i>	10	7	9	13	6	-	10
<i>Coscinodiscus gracilis</i>	15	10	6	-	9	10	-
<i>Nitzschia marina</i>	10	9	13	-	8	5	7
<i>Nitzschia longissima</i>	6	8	-	9	7	5	13
<b>Abundance per station</b>	<b>213</b>	<b>203</b>	<b>101</b>	<b>203</b>	<b>149</b>	<b>175</b>	<b>196</b>
<b>B: CHLOROPHYCEAE</b>							
<i>Pediastrum duplex</i>	9	-	13	8	7	9	12
<i>P. boryanum</i>	11	10	15	7	10	12	10
<i>P. Clathratum</i>	13	14	7	9	5	12	12
<i>Closterium lineatum</i>	13	13	-	13	7	7	8
<i>Danaliella racemosa</i>	10	11	10	12	-	10	9
<i>Caulerpa racemosa</i>	7	12	-	10	14	7	10
<i>Cladophora prolifera</i>	5	4	7	11	15	-	15
<b>Abundance per station</b>	<b>72</b>	<b>62</b>	<b>65</b>	<b>60</b>	<b>57</b>	<b>58</b>	<b>66</b>
<b>C: CYANOPHYCEAE</b>							
<i>Microcystis sp</i>	13	13	11	13	-	12	16
<i>M. aeruginosa</i>	15	10	11	12	13	12	13
<i>Anabaena spiroides</i>	13	9	-	9	15	11	9
<i>A. flosaquae</i>	14	-	7	8	14	13	8
<i>Lyngbya Subsalsa</i>	12	5	10	-	12	-	12
<i>Spirulina subsalsa</i>	11	7	12	8	12	-	10
<i>Phormidium Sp</i>	12	11	7	7	13	7	-
<b>Abundance per station</b>	<b>90</b>	<b>55</b>	<b>58</b>	<b>57</b>	<b>79</b>	<b>55</b>	<b>68</b>



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<b>D: DINOPHYCEAE</b>							
<i>Ceratium tripos</i>	14	10	6	9	13	-	10
<i>Ceratium furca</i>	10	-	10	13	8	9	8
<i>Ceratium trichoceros</i>	11	9	6	11	7	5	8
<i>Peridium catenatum</i>	13	11	9	9	-	11	9
<i>Gymnodinium breve</i>	14	9	7	-	6	-	5
<i>Dinophysis acuta</i>	8	15	-	10	7	9	10
<i>Tabellaria Sp</i>	-	6	7	10	8	8	-
<i>Goniaulax catanella</i>	13	10	8	15	-	13	11
<i>Noctiluca seintillans</i>	13	7	6	11	9	10	7
<b>Abundance per station</b>	<b>96</b>	<b>77</b>	<b>59</b>	<b>88</b>	<b>58</b>	<b>39</b>	<b>68</b>
<b>Overall Abundance (N)</b>	<b>471</b>	<b>397</b>	<b>283</b>	<b>408</b>	<b>343</b>	<b>327</b>	<b>398</b>

Source: Field work Oct. – Nov. , 2018.

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**Appendix 3b: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 45	EA 59	EA 54	EA 48	EA 49	EA 55	EA 47	EA 50	EA 46	EA 53	EA 57	EA 52	EA 58	EA 51
A	CRUSTACEA														
(i)	(COPEPODA)														
1	<i>Calanus finmarchinus</i>	8	6	10	4	8	6	2	4	7	4	4	8	6	7
2	<i>Metridia lucens</i>	4	7	8	9	3	8	8	5	4	6	4	4	10	
3	<i>Parathles triseroni</i>	6	9	9	8	4	6	9	7		4	8	3	2	6
4	<i>Paracalanus parvus</i>	8	6		2	9	9	10		7	9	9	2	4	8
5	<i>Oithonahal gollandica</i>		7	6		4	2	9	6	8		6		6	4

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6	<i>Microsetella norvegica</i>	2	8	9	7	9	3	5	10	10	9	13	8	6	6
7	<i>Temora longicornis</i>	4	6	4	10	10	9		7	6	3		4	10	2
8	<i>Pseudocalanus elongates</i>		2	9	4		4	10	3	7	7	8	7	7	8
9	<i>Cylopina longicornis</i>	9	10	9	12	6	10	10	2		4	7	9	10	
10	<i>Corycaeus anglicus</i>	9	5	6	9	11	10	13	9	10	10	8	9	13	11
	<b>Total abundance (N)</b>	<b>50</b>	<b>66</b>	<b>70</b>	<b>65</b>	<b>64</b>	<b>67</b>	<b>76</b>	<b>53</b>	<b>59</b>	<b>56</b>	<b>67</b>	<b>54</b>	<b>74</b>	<b>52</b>
<b>(ii)</b>	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	4	6	5	6			4	2	6		2	2	4	3
2	<i>Isia sclavipes</i>	2	2	3		4	2	3	2	2	3		2	3	6
3	<i>Centropa gestypieus</i>		4	4	3	8	5	5	3		4	3		4	5
4	<i>Candacia armata</i>	4		3	2	2	4	2		4		5		2	
	<b>Total abundance (N)</b>	<b>10</b>	<b>12</b>	<b>15</b>	<b>11</b>	<b>14</b>	<b>11</b>	<b>14</b>	<b>7</b>	<b>12</b>	<b>7</b>	<b>10</b>	<b>4</b>	<b>13</b>	<b>14</b>
<b>B</b>	<b>CLADOCERA</b>														
1	<i>Podon intermedius</i>	6	4	4	4		4	5	5	7	3	6		5	4
2	<i>Podon leucarti</i>	7	6	8	6	10	4	6	6	4	2	5	6	3	8
3	<i>Conchoecia elegans</i>	9	7	6	7	6	3		5	6	8	6	6	9	4
4	<i>Macrocypridina castanea</i>	4		2	3	3	1	2	3	7	5	8	6	6	5
5	<i>Evadueter gestina</i>	4	5	6		4		8		3	5		4	8	4
6	<i>Penilia avirostric</i>		4	3	6	5	3	2	5		8	6	2	3	8
7	<i>Evadues pinipera</i>	3	3	4		2	7	6	7	4	4		7	4	6
8	<i>Philomedes globosa</i>	4	5	2	5	2	4	3	3	5	4	6	5	6	
	<b>Total abundance (N)</b>	<b>37</b>	<b>34</b>	<b>35</b>	<b>31</b>	<b>32</b>	<b>26</b>	<b>32</b>	<b>34</b>	<b>36</b>	<b>39</b>	<b>37</b>	<b>36</b>	<b>44</b>	<b>39</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 56	EA 44	EA 43	EA 39	EA 38	EA 34	EA 40	EA 35	EA 31	EA 32	EA 33	EA 37	EA 42	EA 41
<b>A</b>	<b>CRUSTACEA</b>														
<b>(i)</b>	<b>(COPEPODA)</b>														
1	<i>Calanus finmarchinus</i>	8	9	9	8	7	4	7	9	7	4	8		9	9
2	<i>Metridia lucens</i>	9	8	10	10	4	4	9	6	5	8	6	4		6
3	<i>Parathles triseroni</i>	10	6	9	4	7	6	6	4	9	6		6	2	8
4	<i>Paracalanus parvus</i>	9	3	6	9		7	5	9	7	4	7	4	7	
5	<i>Oithonahal gollandica</i>	7	9		7	8	7	9	8	12	5	9	9		8
6	<i>Microsetella norvegica</i>		5	7	9	3	8		10	6		11		6	9
7	<i>Temora longieornis</i>	6	8	9	7	8		10	7	10	5	9	4	7	6
8	<i>Pseudocalanus elongates</i>	9	9	8	11	3	7	13	10	11	9	13	5	6	10
9	<i>Cylopina longicornis</i>	11	3		3	7	4	7	8	9	10	11	9	8	
10	<i>Coryaeus anglicus</i>	10	8	7		9	8	10	7		8		8	7	9
	<b>Total abundance (N)</b>	<b>79</b>	<b>68</b>	<b>65</b>	<b>68</b>	<b>56</b>	<b>55</b>	<b>76</b>	<b>78</b>	<b>76</b>	<b>59</b>	<b>74</b>	<b>49</b>	<b>52</b>	<b>65</b>
<b>(ii)</b>	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	5	3	4	5		3	4	2	6			7	6	5
2	<i>Isia sclavipes</i>	3	4	2		4	5	3	3	3	2	5	3	2	7
3	<i>Centropa gestypieus</i>		3	7	5	4	4	4		4	4	3	7	4	3
4	<i>Candacia armata</i>	4	6	5	3	2	5		2	5	5	6			5
	<b>Total abundance (N)</b>	<b>12</b>	<b>16</b>	<b>18</b>	<b>13</b>	<b>10</b>	<b>17</b>	<b>11</b>	<b>7</b>	<b>18</b>	<b>11</b>	<b>14</b>	<b>17</b>	<b>12</b>	<b>20</b>
<b>B</b>	<b>CLADOCERA</b>														
1	<i>Podon intermedius</i>	10	7	8	4	7		8	9	6	9	7		8	7

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2	<i>Podon leucarti</i>	7	4	6		8	6	4		5	7		4	9	7
3	<i>Conchoecia elegans</i>	6	7	8	6	9	2	3	6	5	6	9	10	6	6
4	<i>Macrocypridina castanea</i>	3	8	6	8		5	5	7	6		6	9	5	6
5	<i>Evadueter gestina</i>	4		8	5	7	6	4		7	8	4	5		9
6	<i>Penilia avirostric</i>		6		7	6	5	5	4		7	8		8	
7	<i>Evadues pinipera</i>	4	7	8	4	5	6	3		4	6		6	10	7
8	<i>Philomedes globosa</i>		5	4		6	4	6	7	9	7	7	9	8	
	<b>Total abundance (N)</b>	<b>34</b>	<b>44</b>	<b>48</b>	<b>34</b>	<b>48</b>	<b>34</b>	<b>38</b>	<b>33</b>	<b>42</b>	<b>50</b>	<b>41</b>	<b>43</b>	<b>54</b>	<b>42</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 36	EA CTL 1	EA 23	EA 76	EA CTL 3	EA 11	EA 25	EA 28	EA 29	EA 26	EA 24	EA 27	EA CTL 2	EA 100
<b>A</b>	<b>CRUSTACEA</b>														
(i)	<b>(COPEPODA)</b>														
1	<i>Calanus finmarchinus</i>	9	9	7	8	10	6	9	7	4	4	6	3	8	8
2	<i>Metridia lucens</i>	8	9	7	9	7	–	9	7	5	6	6	5	9	6
3	<i>Parathles triseroni</i>	6	9	–	9	9	10	–	8	7	7	9	7	11	6
4	<i>Paracalanus parvus</i>	2	10	6	7	7	4	9	3	4	–	8	8	10	–
5	<i>Oithonahal gollandica</i>	6	9	9	8	13	–	8	–	6	8	9	10	12	9
6	<i>Microsetella norvegica</i>	4	10	3	–	9	10	6	4	11	–	8	8	8	4
7	<i>Temora longieornis</i>	8	13	9	8	10	–	4	9	–	10	7	9	11	7
8	<i>Pseudocalanus elongates</i>	9	12	–	2	9	10	9	2	7	7	6	7	8	10
9	<i>Cylopina longicornis</i>	–	13	7	6	14	2	12	–	10	9	8	6	7	6
10	<i>Corycaeus anglicus</i>	10	8	–	7	9	10	11	9	8	9	–	5	10	–
	<b>Total abundance (N)</b>	<b>62</b>	<b>102</b>	<b>48</b>	<b>64</b>	<b>97</b>	<b>52</b>	<b>77</b>	<b>49</b>	<b>62</b>	<b>60</b>	<b>67</b>	<b>68</b>	<b>94</b>	<b>56</b>
(ii)	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	5	–	8	4	5	–	3	2	3	6	5	2	–	3
2	<i>Isia sclavipes</i>	3	6	5	–	3	4	2	5	6	2	3	6	5	–
3	<i>Centropa gestypieus</i>	4	4	5	3	–	5	2	–	4	–	5	2	2	4
4	<i>Candacia armata</i>	4	2	–	6	4	3	–	4	–	5	4	3	6	5
	<b>Total abundance (N)</b>	<b>16</b>	<b>12</b>	<b>18</b>	<b>13</b>	<b>12</b>	<b>12</b>	<b>7</b>	<b>11</b>	<b>13</b>	<b>13</b>	<b>17</b>	<b>13</b>	<b>13</b>	<b>12</b>
<b>B</b>	<b>CLADOCERA</b>														

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1	<i>Podon intermedius</i>	7	10	9	5	4	10	6	–	8	7	9	4	–	6
2	<i>Podon leucarti</i>	–	8	6	6	10	–	7	5	7	4	7	10	9	8
3	<i>Conchoecia elegans</i>	8	7	8	9	3	8	4	–	3	7	6	7	8	–
4	<i>Macrocypridina castanea</i>	6	9	–	7	7	7	–	5	7	5	8	–	6	8
5	<i>Evaduator gestina</i>	8	–	5	–	6	7	4	5	9	6	4	9	–	9
6	<i>Penilia avirostric</i>	–	8	10	9	8	6	7	6	6	–	7	–	3	7
7	<i>Evadues pinipera</i>	6	–	7	4	6	–	7	–	8	4	–	8	6	5
8	<i>Philomedes globosa</i>	8	5	3	–	7	6	–	7	10		8	9	6	7
	<b>Total abundance (N)</b>	<b>43</b>	<b>47</b>	<b>48</b>	<b>40</b>	<b>51</b>	<b>44</b>	<b>35</b>	<b>28</b>	<b>58</b>	<b>33</b>	<b>49</b>	<b>47</b>	<b>38</b>	<b>50</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 96	EA 92	EA 88	EA 90	EA 94	EA 98	EA 97	EA 93	EA 89	EA 91	EA 95	EA 99	EA 87	EA 86
<b>A</b>	<b>CRUSTACEA (COPEPODA)</b>														
(i)															
1	<i>Calanus finmarchinus</i>	9	10	10	8	10	12	9	8	–	9	7	9	11	–
2	<i>Metridia lucens</i>	9	–	9	7	7	8	8	9	8	7	13	7	–	9
3	<i>Parathles triseroni</i>	10	8	4	3	9	4	9	7	9	6	–	12	10	8
4	<i>Paracalanus parvus</i>	7	9	4	8	10	–	9	6	7	5	9	9	8	–
5	<i>Oithonahal gollandica</i>	9	10	13	11	–	10	8	9	–	6	9	4	8	9
6	<i>Microsetella norvegica</i>	9	7	7	8	9	9	10	6	10	8	8	7	–	11
7	<i>Temora longicornis</i>	–	–	6	–	10	10	8	5	7	6	–	4	11	10
8	<i>Pseudocalanus elongates</i>	7	4	12	6	9	10	5	10	9	4	10	6	7	9
9	<i>Cylopina longicornis</i>	10	7	11	9	–	10	–	12	10	–	3	9	11	–
10	<i>Corycaeus anglicus</i>	9	8	6	9	8	13	8	–	11	6	9	9	10	7
	<b>Total abundance (N)</b>	<b>79</b>	<b>63</b>	<b>82</b>	<b>69</b>	<b>72</b>	<b>86</b>	<b>74</b>	<b>72</b>	<b>71</b>	<b>57</b>	<b>68</b>	<b>76</b>	<b>76</b>	<b>63</b>
<b>(ii)</b>	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	4	7	6	–	6	2	4	–	6	4	6	2	1	7
2	<i>Isia sclavipes</i>	5	5	5	4	4	7	5	3	5	7	4	4	5	7
3	<i>Centropa gestypieus</i>	3	3	4	5	3	6	8	5	3	6	3	3	2	5
4	<i>Candacia armata</i>	3	4	–	3	7	5	–	5	–	5	–	5	3	10
	<b>Total abundance (N)</b>	<b>15</b>	<b>19</b>	<b>15</b>	<b>12</b>	<b>20</b>	<b>20</b>	<b>17</b>	<b>13</b>	<b>14</b>	<b>22</b>	<b>13</b>	<b>14</b>	<b>11</b>	<b>29</b>
<b>B</b>	<b>CLADOCERA</b>														
1	<i>Podon intermedius</i>	4	7	3	8	7	3	7	6	4	9	–	9	7	6
2	<i>Podon leucarti</i>	6	9	7	9	6	8	5	7	7	7	8	9	4	10
3	<i>Conchoecia elegans</i>	10	4	9	6	8	4	8	6	4	9	9	10	9	8
4	<i>Macrocypridina castanea</i>	8	7	3	9	7	–	8	6	6	6	8	8	7	3
5	<i>Evadueter gestina</i>	9	9	3	7	–	7	–	–	8	7	3	7	10	4
6	<i>Penilia avirostric</i>	3	10	7	8	7	–	7	5	4	5	7	6	9	9
7	<i>Evadues pinipera</i>	–	8	10	4	–	8	5	6	8	7	4	–	8	8



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8	<i>Philomedes globosa</i>	4	–	8	–	6	6	8	10	–	7	6	6	9	–
	<b>Total abundance (N)</b>	<b>44</b>	<b>54</b>	<b>50</b>	<b>51</b>	<b>41</b>	<b>36</b>	<b>48</b>	<b>46</b>	<b>41</b>	<b>57</b>	<b>45</b>	<b>55</b>	<b>63</b>	<b>48</b>

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**Appendix 3b Continued: species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 85	EA 30	EA 84	EA 83	EA 82	EA 102	EA 80	EA 78	EA 101	EA 77	EA 81	EA 79	EA 1	EA 67
<b>A</b>	<b>CRUSTACEA (COPEPODA)</b>														
(i)															
1	<i>Calanus finmarchinus</i>	8	6	8	6	10	9	–	13	15	8	5	6	9	10
2	<i>Metridia lucens</i>	7	6	8	11	–	5	8	4	11	9	6	8	5	10
3	<i>Parathles triseroni</i>	10	10	11	9	13	3	5	8	9	6	9	6	–	7
4	<i>Paracalanus parvus</i>	9	6	–	–	9	5	6	12	5	10	6	11	9	3
5	<i>Oithonahal gollandica</i>	8	5	9	8	9	–	8	–	4	3	11	8	4	7
6	<i>Microsetella norvegica</i>	9	7	7	7	–	8	9	10	4	9	8	10	–	5
7	<i>Temora longicornis</i>	10	4	7	10	8	4	6	6	4	–	7	11	7	9
8	<i>Pseudocalanus elongates</i>	–	11	4	8	7	9	8	8	5	–	10	8	9	11
9	<i>Cylopina longicornis</i>	5	7	3	9	8	6	3	–	5	9	6	6	6	5
10	<i>Coryaeus anglicus</i>	6	8	8	12	–	7	6	8	–	7	8	6	9	10
	<b>Total abundance (N)</b>	<b>72</b>	<b>70</b>	<b>65</b>	<b>80</b>	<b>64</b>	<b>56</b>	<b>59</b>	<b>69</b>	<b>62</b>	<b>61</b>	<b>76</b>	<b>80</b>	<b>58</b>	<b>77</b>
<b>(ii)</b>	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	4	7	5	4	4	–	6	7	6	6	3	7	–	8
2	<i>Isia slavipes</i>	4	2	2	7	7	8	5	7	8	5	–	3	5	4
3	<i>Centropa gestypieus</i>	5	–	5	7	8	5	3	–	4	6	3	5	4	8
4	<i>Candacia armata</i>	7	4	6	5	5	4	5	7	5	4	4	6	7	–
	<b>Total abundance (N)</b>	<b>20</b>	<b>13</b>	<b>18</b>	<b>23</b>	<b>24</b>	<b>17</b>	<b>19</b>	<b>21</b>	<b>23</b>	<b>21</b>	<b>10</b>	<b>21</b>	<b>16</b>	<b>20</b>
<b>B</b>	<b>CLADOCERA</b>														
1	<i>Podon intermedius</i>	9	2	4	4	–	9	7	6	6	–	5	9	7	9
2	<i>Podon leucarti</i>	8	8	4	8	10	5	10	6	5	7	8	4	6	7
3	<i>Conchoecia elegans</i>	4	9	6	9	6	6	8	9	6	9	9	4	7	–
4	<i>Macrocypridina castanea</i>	–	3	3	5	8	–	3	–	9	7	6	8	8	7
5	<i>Evadueter gestina</i>	3	7	–	5	3	7	4	6	–	5	9	10	–	6
6	<i>Penilia avirostric</i>	10	8	4	8	6	5	5	8	9	6	–	7	4	5
7	<i>Evadues pinipera</i>	7	10	8	–	–	7	–	5	11	9	6	5	6	6

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8	<i>Philomedes globosa</i>	4	4	3	6	6	4	8	–	7	7	9	6	8	4
	<b>Total abundance (N)</b>	<b>45</b>	<b>51</b>	<b>32</b>	<b>45</b>	<b>39</b>	<b>43</b>	<b>45</b>	<b>40</b>	<b>53</b>	<b>50</b>	<b>52</b>	<b>53</b>	<b>46</b>	<b>44</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 62	EA 60	EA 66	EA 61	EA 68	EA 72	EA 69	EA 74	EA 73	EA 70	EA 71	EA 65	EA 63	EA 64
<b>A</b>	<b>CRUSTACEA (COPEPODA)</b>														
(i)															
1	<i>Calanus finmarchinus</i>	11	11	10	–	9	7	12	8	8	10	–	10	10	12
2	<i>Metridia lucens</i>	6	9	4	8	7	7	9	5	7	8	9	7	8	9
3	<i>Parathles triseroni</i>	7	13	9	4	9	7	8	7	4	8	9	–	7	8
4	<i>Paracalanus parvus</i>	8	9	7	–	6	6	9	8	7	6	10	12	–	6
5	<i>Oithonahal gollandica</i>	9	8	9	11	9	9	8	7	9	–	7	5	9	–
6	<i>Microsetella norvegica</i>	8	–	10	9	10	–	9	–	5	4	8	7	3	11
7	<i>Temora longicornis</i>	9	4	9	8	8	9	9	10	–	3	9	9	8	10
8	<i>Pseudocalanus elongates</i>	–	9	6	9	–	7	–	9	3	6	–	–	10	6
9	<i>Cylopina longicornis</i>	9	8	9	7	8	9	9	10	–	3	9	9	8	10
10	<i>Corycaeus anglicus</i>	7	6	–	8	5	7	8	–	10	4	6	5	11	9
	<b>Total abundance (N)</b>	<b>74</b>	<b>77</b>	<b>73</b>	<b>64</b>	<b>71</b>	<b>68</b>	<b>81</b>	<b>64</b>	<b>53</b>	<b>52</b>	<b>67</b>	<b>64</b>	<b>74</b>	<b>81</b>
(ii)	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	6	4	6	3	5	–	7	5	6	4	8	–	7	8
2	<i>Isia sclavipes</i>	2	4	8	7	8	5	3	7	5	–	2	5	4	4
3	<i>Centropa gestypieus</i>	4	7	5	–	3	6	5	7	6	2	4	4	6	5
4	<i>Candacia armata</i>	5	–	2	8	2	8	4	–	2	5	3	3	3	–
	<b>Total abundance (N)</b>	<b>17</b>	<b>15</b>	<b>21</b>	<b>18</b>	<b>18</b>	<b>19</b>	<b>19</b>	<b>19</b>	<b>19</b>	<b>11</b>	<b>17</b>	<b>12</b>	<b>20</b>	<b>17</b>
<b>B</b>	<b>CLADOCERA</b>														
1	<i>Podon intermedius</i>	7	9	5	9	5	6	9	7	–	4	8	9	8	10
2	<i>Podon leucarti</i>	8	7	8	7	8	9	8	9	7	6	9	–	7	–
3	<i>Conchoecia elegans</i>	4	9	6	–	4	7	3	3	8	7	–	5	6	5
4	<i>Macrocypridina castanea</i>	7	3	–	8	6	–	4	7	–	6	5	4	–	7
5	<i>Evadueter gestina</i>	8	9	6	10	–	8	5	6	9	8	5	6	10	9
6	<i>Penilia avirostric</i>	7	8	8	3	6	9	7	8	7	–	8	8	8	6
7	<i>Evadues pinipera</i>	7	–	5	7	8	7	–	6	4	8	8	4	10	9

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8	<i>Philomedes globosa</i>	–	6	7	4	5	9	8	–	6	7	4	–	5	8
	<b>Total abundance (N)</b>	<b>48</b>	<b>51</b>	<b>45</b>	<b>48</b>	<b>42</b>	<b>55</b>	<b>44</b>	<b>46</b>	<b>41</b>	<b>46</b>	<b>47</b>	<b>36</b>	<b>54</b>	<b>54</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 75	EA 2	EA 3	EA 4	EA 5	EA 6	EA 18	EA 7	EA 8	EA 9	EA 10	EA 20	EA 17	EA 16
<b>A</b>	<b>CRUSTACEA (COPEPODA)</b>														
(i)															
1	<i>Calanus finmarchinus</i>	9	7	7	8	8	9	9	–	10	9	10	6	11	7
2	<i>Metridia lucens</i>	7	10	9	6	5	9	9	7	10	4	9	–	10	10
3	<i>Parathles triseroni</i>	5	7	4	9	6	7	7	6	14	7	10	4	11	6
4	<i>Paracalanus parvus</i>	9	8	9	8	6	9	5	4	4	–	6	–	10	–
5	<i>Oithonahal gollandica</i>	9	9	6	–	4	7	11	7	–	8	–	10	3	9
6	<i>Microsetella norvegica</i>	8	13	–	12	8	8	8	6	6	8	9	5	10	8
7	<i>Temora longicornis</i>	9	5	8	3	10	12	7	–	9	7	8	6	8	–
8	<i>Pseudocalanus elongates</i>	11	–	10	8	7	–	7	7	8	–	9	5	5	9
9	<i>Cylopina longicornis</i>	3	7	7	–	6	7	9	9	–	6	8	7	4	3
10	<i>Corycaeus anglicus</i>	–	4	9	7	–	9	2	7	9	9	–	9	–	8
	<b>Total abundance (N)</b>	<b>70</b>	<b>70</b>	<b>69</b>	<b>61</b>	<b>60</b>	<b>77</b>	<b>74</b>	<b>53</b>	<b>70</b>	<b>58</b>	<b>69</b>	<b>52</b>	<b>72</b>	<b>60</b>
(ii)	<b>DECAPODA</b>														
1	<i>Enterpina acutirous</i>	–	7	5	4	6	4	3	4	5	3	3	8	6	–
2	<i>Isia sclavipes</i>	6	6	4	–	6	8	5	7	4	–	5	4	5	7
3	<i>Centropa gestypieus</i>	5	6	5	3	5	–	4	–	6	6	4	5	6	5
4	<i>Candacia armata</i>	4	–	3	7	7	2	3	7	3	2	4	–	2	7
	<b>Total abundance (N)</b>	<b>15</b>	<b>19</b>	<b>17</b>	<b>14</b>	<b>24</b>	<b>14</b>	<b>15</b>	<b>18</b>	<b>18</b>	<b>11</b>	<b>16</b>	<b>17</b>	<b>19</b>	<b>19</b>
<b>B</b>	<b>CLADOCERA</b>														
1	<i>Podon intermedius</i>	8	6	8	9	9	–	7	10	8	–	8	9	7	9
2	<i>Podon leucarti</i>	9	4	7	8	3	10	6	8	9	7	9	–	8	7
3	<i>Conchoecia elegans</i>	6	8	10	6	8	6	6	6	9	6	8	2	6	9
4	<i>Macrocypridina castanea</i>	8	8	9	–	7		8	9	–	9	–	6	5	7
5	<i>Evaduetter gestina</i>	6	6	10	6	7	8	9	7	6	–	9	–	6	4
6	<i>Penilia avirostric</i>	8	4	6	9	7	7	–	6	5	8	8	5	4	–
7	<i>Evadues pinipera</i>	–	–	6	7	5	3	6	–	4	5	9	5	9	8

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8	<i>Philomedes globosa</i>	7	7	–	5	–	7	5	4	8	7	–	7	–	8
	<b>Total abundance (N)</b>	<b>52</b>	<b>43</b>	<b>56</b>	<b>50</b>	<b>46</b>	<b>41</b>	<b>47</b>	<b>50</b>	<b>49</b>	<b>42</b>	<b>51</b>	<b>34</b>	<b>45</b>	<b>52</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID												
		EA 15	EA 14	EA 13	EA 12	EA 19	EA 21	EA 22						
<b>A</b>	<b>CRUSTACEA</b>													
<b>(i)</b>	<b>(COPEPODA)</b>													
1	<i>Calanus finmarchinus</i>	9	8	5	9	9	10	7						
2	<i>Metridia lucens</i>	13	12	8	6	9	-	9						
3	<i>Parathles triseroni</i>	10	11	9	9	8	9	-						
4	<i>Paracalanus parvus</i>	7	10	9	8	4	6	8						
5	<i>Oithonahal gollandica</i>	7	8	7	9	3	6	7						
6	<i>Microsetella norvegica</i>	8	8	7	8	9	-	9						
7	<i>Temora longicornis</i>	7	8	4	9	4	9	-						
8	<i>Pseudocalanus elongates</i>	9	9	8	-	7	4	7						
9	<i>Cylopina longicornis</i>	9	10	4	10	4	7	-						
10	<i>Corycaeus anglicus</i>	-	7	9	7	8	7	10						
	<b>Total abundance (N)</b>	<b>79</b>	<b>91</b>	<b>70</b>	<b>75</b>	<b>65</b>	<b>58</b>	<b>57</b>						
<b>(ii)</b>	<b>DECAPODA</b>													
1	<i>Enterpina acutirous</i>	4	5	2	6	6	5	2						
2	<i>Isia sclavipes</i>	5	3	-	2	3	6	6						
3	<i>Centropa gestypieus</i>	3	3	5	3	4	3	-						
4	<i>Candacia armata</i>	4	2	3	4	-	3	5						
	<b>Total abundance (N)</b>	<b>16</b>	<b>13</b>	<b>10</b>	<b>15</b>	<b>13</b>	<b>17</b>	<b>13</b>						
<b>B</b>	<b>CLADOCERA</b>													
1	<i>Podon intermedius</i>	9	2	8	7	-	7	6						
2	<i>Podon leucarti</i>	6	5	6	7	9	3	8						
3	<i>Conchoecia elegans</i>	8	5	7	4	7	4	-						
4	<i>Macrocypridina castanea</i>	2	8	9	7	3	7	5						
5	<i>Evadueter gestina</i>	3	-	-	8	7	6	8						
6	<i>Penilia avirostric</i>	9	10	9	3	7	6	8						
7	<i>Evadues pinipera</i>	8	7	8	-	5	7	-						
8	<i>Philomedes globosa</i>	-	6	-	2	4	9	3						



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	Total abundance (N)	45	43	47	38	42	49	38							
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**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 45	EA 59	EA 54	EA 48	EA 49	EA 55	EA 47	EA 50	EA 46	EA 53	EA 57	EA 52	EA 58	EA 51
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	8	6	5	7	5	–	4	–	6	5	8	5	3	–
2	<i>Belone</i> sp	4	8	3	3	4	–	5	3	6		4	7	4	7
3	<i>Trisoptera minitus</i>	4	5	6	–	4	8	3	5	–	4	5	7	5	5
4	<i>Solea solea</i>	5	3	7	–	2	5	4	3	5	6	8	3	5	
5	<i>Trachinus vipera</i>	3	9	6	4		4	4	5	5	5	5	7	7	4
6	<i>Clopea</i> sp	5	–	5	6	9	–	–	8	–	4	3	–	3	6
7	Fish eggs	7	8	3	5	–	7	4	3	7	7	3	8	4	8
8	<i>Blennius pholis</i>	5	7	9	6	4	–	3	4	4	3	6	–	4	7
	<b>Total abundance (N)</b>	<b>41</b>	<b>46</b>	<b>44</b>	<b>31</b>	<b>28</b>	<b>24</b>	<b>27</b>	<b>31</b>	<b>33</b>	<b>34</b>	<b>42</b>	<b>37</b>	<b>35</b>	<b>37</b>
	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	3	5	3	8	–	3	4	8	9	–	3	2	7	5
2	<i>O. fudiformis</i>	7	–	4	7	5	7	9	4	4	3	7	4	3	
3	<i>O. labradoriensis</i>	4	9	5	4	–	3	3	8	7	4	5	8	–	6
4	<i>Clavelina lepadiformis</i>	5	4	2	–	8	7	–	3	–	1	4	3	3	7
5	<i>Fritillaria pellucida</i>	–	–	2	7	4	–	4	3	3	5	3	2	4	4
6	<i>Fritillaria tenalla</i>	6	5	4	–	5	7	5	4	5	2	–	–	2	5
	<b>Total abundance (N)</b>	<b>25</b>	<b>23</b>	<b>20</b>	<b>26</b>	<b>22</b>	<b>27</b>	<b>25</b>	<b>30</b>	<b>28</b>	<b>15</b>	<b>22</b>	<b>19</b>	<b>19</b>	<b>27</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	9	6	5	5	4	–	3	8	2	1	5	6	–	3
2	<i>Pectinaria koreni</i>	6	3	–	3	5	3	–	4	6	9	3	5	9	1
3	<i>Proterae apicta</i>	5	4	1	3	–	3	7	4	6	–	9	2	3	6
4	<i>Lopadorhynchus uncinatus</i>	–	4	8	4	3	–	6	7	3	4	9	–	2	–
5	<i>Nereid nectochaete</i>	4	–	3	–	2	3	–	3	–	3	6	4	3	4
6	<i>Procerae acornuta</i>	4	2	3	3	6	–	2	2	5	7	4	8	–	2
7	<i>Serpulid trochopore</i>	2	5	2	4	5	2	8	3	–	5	3	–	7	6

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8	<i>Travisopsis lanceolata</i>	6	1	–	2	3	–	2	3	–	3		5	5	3
	<b>Total abundance (N)</b>	<b>36</b>	<b>25</b>	<b>22</b>	<b>24</b>	<b>28</b>	<b>11</b>	<b>28</b>	<b>34</b>	<b>22</b>	<b>32</b>	<b>39</b>	<b>30</b>	<b>29</b>	<b>25</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 56	EA 44	EA 43	EA 39	EA 38	EA 34	EA 40	EA 35	EA 31	EA 32	EA 33	EA 37	EA 42	EA 41
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	5	3	3	5	4	4	8	4	7	–	7	8	–	3
2	<i>Belone</i> sp	7	4	1	8	5	5	3	6	6	3	–	–	3	–
3	<i>Triscoptera minitus</i>	5	6	3	3	7	8	–	7	7	3	6	3	8	5
4	<i>Solea solea</i>	7	7	3	5	–	–	7	3	4	4	3	9	5	4
5	<i>Trachinus vipera</i>	4	5	–	4	5	7	4	8	–	4	8	–	2	7
6	<i>Clopea</i> sp	–	8	3	3	3	4	8	6	–	3	–	7	5	8
7	Fish eggs	8	7	4	–	8	3	3	7	3	–	4	3	9	3
8	<i>Blennius pholis</i>	5	5	3	8	5	4	–	3	6	6	3	–	8	5
	<b>Total abundance (N)</b>	<b>41</b>	<b>45</b>	<b>20</b>	<b>36</b>	<b>37</b>	<b>35</b>	<b>33</b>	<b>44</b>	<b>33</b>	<b>23</b>	<b>31</b>	<b>30</b>	<b>40</b>	<b>35</b>
<b>E</b>	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	6	4	8	4	–	4	7	3	–	5	3	9	5	5
2	<i>O. fudiformis</i>	3	6	7	–	7	7	8	6	4	–	5	3	1	6
3	<i>O. labradoriensis</i>	4	9	7	2	–	8	6	1	3	5	3	7	1	3
4	<i>Clavelina lepadiformis</i>	–	3	–	–	3	–	7	–	3	8	3	4	5	–
5	<i>Fritillaria pellucida</i>	3	9	2	2	9	7	9	–	5	–	3	–	3	5
6	<i>Fritillaria tenalla</i>	5	–	9	2	7	1	–	5	9	3	2	7	–	6
	<b>Total abundance (N)</b>	<b>21</b>	<b>31</b>	<b>33</b>	<b>10</b>	<b>26</b>	<b>27</b>	<b>37</b>	<b>15</b>	<b>24</b>	<b>21</b>	<b>19</b>	<b>30</b>	<b>15</b>	<b>25</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	5	7	4	3	–	5	5	9	2	–	4	3	3	2
2	<i>Pectinaria koreni</i>	3	3	9	4	9	2	3	3	3	–	3	4	–	9
3	<i>Proterae apicta</i>	4	6	2	3	2	–	5	7	8	–	2	6	9	3

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4	<i>Lopadorhynchus uncinatus</i>	6	9	–	9	5	5	3	4	7	4	8	–	4	–
5	<i>Nereid nectochaete</i>	–	3	5	2	3	7	–	4	–	3	2	4	5	–
6	<i>Proceræ acornuta</i>	3	–	3	4	–	8	–	1	2	4	3	4	–	4
7	<i>Serpulid trochopore</i>	2	6	3	2	4	–	4	4	7	5	–	–	3	8
8	<i>Travisiopsis lanceolata</i>	5	4	–	8	3	3	5	–	1	3	4	7	2	4
	<b>Total abundance (N)</b>	<b>28</b>	<b>38</b>	<b>26</b>	<b>35</b>	<b>26</b>	<b>30</b>	<b>25</b>	<b>32</b>	<b>30</b>	<b>19</b>	<b>26</b>	<b>28</b>	<b>26</b>	<b>30</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 36	EA CTL 1	EA 23	EA 76	EA CTL 3	EA 11	EA 25	EA 28	EA 29	EA 26	EA 24	EA 27	EA CTL 2	EA 100
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	3	5	3	4	5	3	7	5	3	4	4	7	9	7
2	<i>Belone</i> sp	4	7	8	8	4	4	6	4	5	4	3	9	8	6
3	<i>Triscoptera minutus</i>	1	3	7	7	7	4	3	7	8	3	1	–	2	5
4	<i>Solea solea</i>	4	8	3	3	–	2	–	7	5	6	–	5	9	9
5	<i>Trachinus vipera</i>	4	7	–	8	6	–	3	5	4	4	3	7	3	9
6	<i>Clopea</i> sp	2	5	3	–	3	3	5	3	9	8	5	5	2	–
7	Fish eggs	5	–	8	7	8	7	4	–	7	5	7	–	3	5
8	<i>Blennius pholis</i>	3	7	5	–	8	2	–	3	4	7	4	3	2	4
	<b>Total abundance (N)</b>	<b>26</b>	<b>42</b>	<b>37</b>	<b>37</b>	<b>41</b>	<b>25</b>	<b>28</b>	<b>34</b>	<b>45</b>	<b>41</b>	<b>27</b>	<b>36</b>	<b>38</b>	<b>45</b>
E	APPENDICULARIA														
1	<i>Oikopleu radioica</i>	–	8	3	4	6	–	7	–	4	3	3	8	8	9
2	<i>O. fudiformis</i>	7	6	–	3	4	2	9	6	3	–	2	9	3	–
3	<i>O. labradoriensis</i>	3	7	2	7	8	4	1	5	3	6	–	4	5	8
4	<i>Clavelina lepadiformis</i>	8	–	9	3	9	–	7	5	5	7	9	–	7	3
5	<i>Fritillaria pellucida</i>	3	9	4	–	3	3	6	–	9	7	3	3	5	5

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6	<i>Fritillaria tenalla</i>	7	8	2	2	2	5	4	3	–	8	–	3	9	4
	<b>Total abundance (N)</b>	<b>28</b>	<b>38</b>	<b>20</b>	<b>19</b>	<b>32</b>	<b>14</b>	<b>34</b>	<b>19</b>	<b>24</b>	<b>31</b>	<b>17</b>	<b>27</b>	<b>37</b>	<b>29</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	7	3	3	1	5	4	7	3	8	–	5	4	–	2
2	<i>Pectinaria koreni</i>	5	5	3	7	1	3	7	1	7	5	1	8	5	3
3	<i>Proterae apicta</i>	1	2	2	1	4	8	4	–	2	3	3	7	4	2
4	<i>Lopadorhynchus uncinatus</i>	4	9	3	9	3	9	3	3	–	1	3	9	8	9
5	<i>Nereid nectochaete</i>	3	–	8	3	4	–	2	3	5	2	4	–	5	4
6	<i>Procerae acornuta</i>	3	2	4	4	9	4	–	2	9	4	3	1	–	2
7	<i>Serpulid trochopore</i>	–	4	3	–	3	2	3	–	7	–	2	7	9	–
8	<i>Travisiopsis lanceolata</i>	4	5	–	5	–	8	2	2	4	3	5	–	5	6
	<b>Total abundance (N)</b>	<b>27</b>	<b>30</b>	<b>26</b>	<b>30</b>	<b>29</b>	<b>38</b>	<b>28</b>	<b>14</b>	<b>42</b>	<b>18</b>	<b>26</b>	<b>36</b>	<b>36</b>	<b>28</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 96	EA 92	EA 88	EA 90	EA 94	EA 98	EA 97	EA 93	EA 89	EA 91	EA 95	EA 99	EA 87	EA 86
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	9	3	3	4	5	3	7	3	7	9	5	7	3	8
2	<i>Belone</i> sp	–	5	8	2	5	4	3	4	3	3	4	5	6	5
3	<i>Triscoptera minutus</i>	–	3	7	4	8	1	–	8	6	3	7	3	7	3
4	<i>Solea solea</i>	4	4	–	1	3	3	8	–	8	–	–	5	–	4
5	<i>Trachinus vipera</i>	5	3	8	5	–	8	7	5	–	7	8	–	3	9
6	<i>Clopea</i> sp	3	8	5	3	8	3	3	3	4	4	5	9	8	–
7	Fish eggs	9	–	3	8	5	9	9	5	8	8	2	–	7	4
8	<i>Blennius pholis</i>	3	7	4	–	4	–	2	7	4	5	3	3	4	3
	<b>Total abundance (N)</b>	<b>33</b>	<b>33</b>	<b>38</b>	<b>27</b>	<b>38</b>	<b>31</b>	<b>39</b>	<b>35</b>	<b>40</b>	<b>39</b>	<b>34</b>	<b>32</b>	<b>38</b>	<b>36</b>
<b>E</b>	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	4	9	6	7	–	9	6	3	–	5	6	5	–	3
2	<i>O. fudiformis</i>	7	–	4	9	3	4	–	2	2	2	1	1	1	3

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3	<i>O. labradoriensis</i>	5	5	–	–	4	7	–	–	4	3	6	2	3	4
4	<i>Clavelina lepadiformis</i>	4	5	5	1	2	5	5	9	3	4	2	4	2	–
5	<i>Fritillaria pellucida</i>	–	4	3	1	3	4	2	3	7	–	–	3	4	5
6	<i>Fritillaria tenalla</i>	7	6	–	3	1	3	3	4	3	4	3	–	4	2
	<b>Total abundance (N)</b>	<b>27</b>	<b>29</b>	<b>18</b>	<b>21</b>	<b>13</b>	<b>32</b>	<b>16</b>	<b>21</b>	<b>19</b>	<b>18</b>	<b>18</b>	<b>15</b>	<b>14</b>	<b>17</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	5	2	3	2	3	5	–	7	1	5	3	2	1	1
2	<i>Pectinaria koreni</i>	1	3	–	5	1	3	3	1	7	1	7	1	3	6
3	<i>Proterae apicta</i>	3	2	3	–	3	–	1	–	6	3	7	3	5	1
4	<i>Lopadorhynchus uncinatus</i>	6	–	5	7	2	3	5	9	3	4	3	3	–	7
5	<i>Nereid nectochaete</i>	2	4	3	–	5	3	5	8	1	8	5	4	1	3
6	<i>Procerae acornuta</i>	6	–	7	5	–	8	3	3	3	3	3	–	6	3
7	<i>Serpulid trochopore</i>	4	2	1	3	2	–	2	4	–	–	5	3	3	2
8	<i>Travisiopsis lanceolata</i>	–	5	2	–	1	4	6	–	4	–	–	4	1	3
	<b>Total abundance (N)</b>	<b>27</b>	<b>13</b>	<b>22</b>	<b>22</b>	<b>16</b>	<b>22</b>	<b>19</b>	<b>32</b>	<b>21</b>	<b>24</b>	<b>33</b>	<b>16</b>	<b>19</b>	<b>23</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 85	EA 30	EA 84	EA 83	EA 82	EA 102	EA 80	EA 78	EA 101	EA 77	EA 81	EA 79	EA 1	EA 67
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	9	7	9	4	1	8	9	7	2	4	9	1	3	2
2	<i>Belone</i> sp	3	3	4	5	4	6	10	8	6	3	9	2	–	4
3	<i>Trisoptera minitus</i>	4	5	4	8	8	3	–	3	5	3	–	2	8	4
4	<i>Solea solea</i>	–	4	5	6	4	8	7	8	9	3	5	9	1	–
5	<i>Trachinus vipera</i>	6	5	4	6	3	8	5	8	–	3	2	6	8	8
6	<i>Clopea</i> sp	4	6	9	–	2	4	3	5	6	9	6	–	9	5
7	Fish eggs	3	2	6	2	4	4	3	–	6	8	3	8	9	–
8	<i>Blennius pholis</i>	–	2	4	–	5	7	4	7	8	–	7	2	7	3
	<b>Total abundance (N)</b>	<b>29</b>	<b>34</b>	<b>45</b>	<b>31</b>	<b>31</b>	<b>48</b>	<b>41</b>	<b>46</b>	<b>42</b>	<b>33</b>	<b>41</b>	<b>30</b>	<b>45</b>	<b>26</b>

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<b>E</b>	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	6	9	6	7	–	3	6	3	–	8	3	7	6	7
2	<i>O. fudiformis</i>	7	5	7	5	3	2	9	7	4	4	7	9	8	2
3	<i>O. labradoriensis</i>	5	7	5	–	9	7	–	2	7	5	6	5	3	3
4	<i>Clavelina lepadiformis</i>	–	3	7	4	5	6	3	6	4	9	–	4	2	6
5	<i>Fritillaria pellucida</i>	3	6	3	4	8	7	8	8	5	9	4	8	–	8
6	<i>Fritillaria tenalla</i>	5	4	–	3	4	6	4	–	4	3	6	–	4	7
	<b>Total abundance (N)</b>	<b>26</b>	<b>34</b>	<b>28</b>	<b>23</b>	<b>29</b>	<b>31</b>	<b>30</b>	<b>26</b>	<b>24</b>	<b>38</b>	<b>26</b>	<b>33</b>	<b>23</b>	<b>33</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	9	6	1	9	7	1	–	5	4	–	5	2	2	6
2	<i>Pectinaria koreni</i>	1	9	6	1	7	3	3	5	–	2	6	3	6	5
3	<i>Proterae apicta</i>	1	5	6	–	2		4	3	3	4	7	4	5	–
4	<i>Lopadorhynchus uncinatus</i>	5	9	1	3	9	4	6	–	4	3	3	2	3	3
5	<i>Nereid nectochaete</i>	6	7	3	–	1	6	–	4	8	7	4	5	–	3
6	<i>Procerae acornuta</i>	1	3	2	2	3	7	4	8	7	4	–	–	7	4
7	<i>Serpulid trochopore</i>	–	7	9	6	–	2	2	–	4	3	–	–	5	1
8	<i>Travisioipsis lanceolata</i>	5	1		3	2	2	1	3	3	1	6	6	3	2
	<b>Total abundance (N)</b>	<b>28</b>	<b>47</b>	<b>28</b>	<b>24</b>	<b>31</b>	<b>25</b>	<b>20</b>	<b>28</b>	<b>33</b>	<b>24</b>	<b>31</b>	<b>22</b>	<b>31</b>	<b>24</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 62	EA 60	EA 66	EA 61	EA 68	EA 72	EA 69	EA 74	EA 73	EA 70	EA 71	EA 65	EA 63	EA 64
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	6	3	5	3	8	7	–	3	7	3	9	3	7	9
2	<i>Belone</i> sp	8	5	7	8	3	4	3	4	9	7	3	8	5	4
3	<i>Triscoptera minitus</i>	8	3	–	–	7	5	7	5	–	4	3	7	–	6
4	<i>Solea solea</i>	4	–	4	4	5	–	3	7	3	7	3	3	8	7
5	<i>Trachinus vipera</i>	–	7	6	3	4	7	5	–	1	4	7	8	3	4
6	<i>Clopea</i> sp	5	4	7	9	–	5	4	3	7	9	7	–	4	4

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7	Fish eggs	7	5	–	5	4	2	–	5	8	7	–	4	3	5
8	<i>Blennius pholis</i>	5	4	–	6	8	5	4	4	3	–	–	3	–	–
	<b>Total abundance (N)</b>	<b>43</b>	<b>31</b>	<b>29</b>	<b>38</b>	<b>39</b>	<b>35</b>	<b>26</b>	<b>31</b>	<b>38</b>	<b>41</b>	<b>32</b>	<b>36</b>	<b>30</b>	<b>39</b>
<b>E</b>	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	4	7	3	5	4	3	3	5	–	2	3	3	4	2
2	<i>O. fudiformis</i>	7	–	4	–	8	3	5	–	7	9	–	6	7	–
3	<i>O. labradoriensis</i>	5	4	–	4	9	8	3	5	4	6	8	3	5	2
4	<i>Clavelina lepadiformis</i>	3	2	5	5	7	9	–	1	3	–	3	8	7	4
5	<i>Fritillaria pellucida</i>	–	2	2	3	2	–	9	7	5	7	–	4	6	7
6	<i>Fritillaria tenalla</i>	3	4	3	2	3	8	–	4	5	3	2	8	–	8
	<b>Total abundance (N)</b>	<b>22</b>	<b>19</b>	<b>17</b>	<b>19</b>	<b>33</b>	<b>31</b>	<b>20</b>	<b>22</b>	<b>24</b>	<b>27</b>	<b>16</b>	<b>32</b>	<b>29</b>	<b>23</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	6	3	4	–	4	2	5	1	6	7	2	6	5	3
2	<i>Pectinaria koreni</i>	1	–	5	3	3	3	3	5	1	7	2	3	–	5
3	<i>Proterae apicta</i>	3	4	2	9	–	5	7	3	4	–	5	2	1	6
4	<i>Lopadorhynchus uncinatus</i>	6	5	3	–	4	4	–	5	5	3	7	–	3	–
5	<i>Nereid nectochaete</i>	2	3	8	3	5	8	4	7	3	4	–	4	6	4
6	<i>Procerae acornuta</i>	–	4	5	4	3	6	5	3	5	1	8	3	3	3
7	<i>Serpulid trochopore</i>	6	9	–	5	4	–	3	–	2	1	2	3	–	3
8	<i>Travisioopsis lanceolata</i>	1	5	3	6	6	2	4	4	7	3	1	–	4	4
	<b>Total abundance (N)</b>	<b>25</b>	<b>33</b>	<b>30</b>	<b>30</b>	<b>29</b>	<b>30</b>	<b>31</b>	<b>28</b>	<b>33</b>	<b>26</b>	<b>27</b>	<b>21</b>	<b>22</b>	<b>28</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 75	EA 2	EA 3	EA 4	EA 5	EA 6	EA 18	EA 7	EA 8	EA 9	EA 10	EA 20	EA 17	EA 16
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	4	5	7	6	3	9	7	6	5	4	–	5	9	8
2	<i>Belone</i> sp	3	7	–	5	6	–	9	3	4	7	6	6	5	3



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3	<i>Triscoptera minitus</i>	5	3	4	4	–	3	6	–	5	5	–	–	7	5
4	<i>Solea solea</i>	2	4	3	6	4	7	4	2	–	3	5	9	2	–
5	<i>Trachinus vipera</i>	1	4	7	8	–	3	2	3	5	7	5	8	3	9
6	<i>Clopea sp</i>	4	6	–	3	7	5	3	7	5	8	7	5	–	4
7	Fish eggs	5	4	8	–	7	–	6	5	7	–	8	–	5	3
8	<i>Blennius pholis</i>	4	–	4	8	4	3	1	–	4	3	3	7	–	7
	<b>Total abundance (N)</b>	<b>28</b>	<b>33</b>	<b>33</b>	<b>40</b>	<b>31</b>	<b>30</b>	<b>38</b>	<b>26</b>	<b>35</b>	<b>37</b>	<b>34</b>	<b>40</b>	<b>31</b>	<b>39</b>
<b>E</b>	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	3	3	4	2	7	3	5	9	7	5	3	7	4	3
2	<i>O. fudiformis</i>	2	4	8	3	–	5	7	5	4	3	4	9	2	5
3	<i>O. labradoriensis</i>	5	2	–	3	2	3	3	–	5	4	–	–	3	2
4	<i>Clavelina lepadiformis</i>	3	8	9	9	–	–	4	3	4	–	3	4	1	6
5	<i>Fritillaria pellucida</i>	–	5	3	–	4	5	–	4	–	3	2	5	6	–
6	<i>Fritillaria tenalla</i>	4	–	3	5	3	3	2	1	7	2	3	4	–	–
	<b>Total abundance (N)</b>	<b>17</b>	<b>22</b>	<b>27</b>	<b>22</b>	<b>16</b>	<b>19</b>	<b>21</b>	<b>22</b>	<b>27</b>	<b>17</b>	<b>15</b>	<b>29</b>	<b>16</b>	<b>16</b>
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	7	3	5	2	6	7	9	2	9	3	4	2	5	4
2	<i>Pectinaria koreni</i>	2	4	3	5	2	3	4	3	2	5	3	5	3	5
3	<i>Proterae apicta</i>	9	2	3	–	4	3	3	–	–	3	3	7	3	3
4	<i>Lopadorhynchus uncinatus</i>	–	–	3	7	–	–	4	1	4	3	5	–	5	6
5	<i>Nereid nectochaete</i>	3	5	4	4	3	7	3	3	5		3	6	–	4
6	<i>Procerae acornuta</i>	8	2	8	–	2	3	–	5	4	7	–	3	4	3
7	<i>Serpulid trochopore</i>	4	3	–	5	–	1	8	3	4	7	6	3	5	–
8	<i>Travisioopsis lanceolata</i>	3	6	2	2	5	5	3	3	3	3	7	8	7	4
	<b>Total abundance (N)</b>	<b>36</b>	<b>25</b>	<b>28</b>	<b>25</b>	<b>22</b>	<b>29</b>	<b>34</b>	<b>20</b>	<b>31</b>	<b>31</b>	<b>31</b>	<b>34</b>	<b>32</b>	<b>29</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Samples ID
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**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

Zooplankton groups/species		EA 15	EA 14	EA 13	EA 12	EA 19	EA 21	EA 22							
D	PISCES (CHORDATA LARVAE)														
1	<i>Molva</i> sp	7	5	8	8	4	7	2							
2	<i>Belone</i> sp	4	3	5	4	2	9	8							
3	<i>Triscoptera minitus</i>	5	7	4	4	3	5	–							
4	<i>Solea solea</i>	4	5	–	6	–	5	9							
5	<i>Trachinus vipera</i>	9	–	–	5	3	–	7							
6	<i>Clopea</i> sp	5	7	4	3	2	7	4							
7	Fish eggs	4	3	4	–	3	5	5							
8	<i>Blennius pholis</i>	–	3	5	7	5	3	–							
	<b>Total abundance (N)</b>	<b>38</b>	<b>33</b>	<b>30</b>	<b>37</b>	<b>22</b>	<b>41</b>	<b>35</b>							
<b>E</b>	<b>APPENDICULARIA</b>														
1	<i>Oikopleu radioica</i>	3	4	8	6	8	5	9							
2	<i>O. fudiformis</i>	2	–	4	–	3	7	–							
3	<i>O. labradoriensis</i>	9	3	9	7	6	3	7							
4	<i>Clavelina lepadiformis</i>	6	3	–	8	3	5	–							
5	<i>Fritillaria pellucida</i>	–	5	3	3	4	1	5							
6	<i>Fritillaria tenalla</i>	4	3	8	7	–	3	3							
	<b>Total abundance (N)</b>	<b>24</b>	<b>18</b>	<b>32</b>	<b>31</b>	<b>24</b>	<b>24</b>	<b>24</b>							
<b>F</b>	<b>POLYCHAETA (ANNELIDA) (Larvae)</b>														
1	<i>Autolytus edwardsi</i>	4	3	4	6	3	7	6							
2	<i>Pectinaria koreni</i>	4	2	–	4	2	9	9							
3	<i>Proterae apicta</i>	7	9	3	8	3	–	3							
4	<i>Lopadorhynchus uncinatus</i>	5	3	1	–	4	6	2							
5	<i>Nereid nectochaete</i>	–	2	5	3	–	4	3							
6	<i>Procerae acornuta</i>	3	5	8	5	3	3	5							
7	<i>Serpulid trochopore</i>	7	4	–	4	7	3	4							
8	<i>Travisopsis lanceolata</i>	7	3	5	3	6	2	–							
	<b>Total abundance (N)</b>	<b>37</b>	<b>31</b>	<b>26</b>	<b>33</b>	<b>28</b>	<b>34</b>	<b>32</b>							

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 45	EA 59	EA 54	EA 48	EA 49	EA 55	EA 47	EA 50	EA 46	EA 53	EA 57	EA 52	EA 58	EA 51
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	9	7	9	7	7	-	2	6	4	3	3	6	6	4
2	<i>Asplanchna prodonta</i>	7	5	6	9	4	-	5	6	8	2	-	8	-	5
3	<i>Asplanchna</i> sp	7	6	8	5	6	9	4	5	6	2	4	5	7	6
4	<i>Polyerthrea</i> sp	-	6	5	-	6	5	2	-	5	5	2	3	5	-
5	<i>Philodina roseola</i>	5	7	-	8	5	6	4	2	5	-	4	3	4	2
6	<i>Brachionus liciflorus</i>	3	6	6	9	-	5	-	3	-	7	6	3	2	6
7	<i>Collotheca</i> sp	5	9	7	-	9	8	6	4	6	3	2	4	-	3
	<b>Total abundance (N)</b>	<b>36</b>	<b>46</b>	<b>41</b>	<b>38</b>	<b>37</b>	<b>33</b>	<b>23</b>	<b>26</b>	<b>34</b>	<b>22</b>	<b>21</b>	<b>32</b>	<b>24</b>	<b>26</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	3	-	3	5	3	5	3	-	3	4	2	5	2	5
2	<i>S. elegans</i>	2	4	3	3	4	2	1	2	2	3	2	3	4	2
3	<i>S. macrocephala</i>	4	3	1	3	2	3	3	2	1	3	5	5	2	4
4	<i>S. Iyra</i>	-	3	4	2	-	5	-	2	4	-	3	3	-	1
5	<i>S. serratodentata</i>	3	1	1	3	2	2	3	4	2	4	4	-	3	-
	<b>Total abundance (N)</b>	<b>12</b>	<b>11</b>	<b>12</b>	<b>16</b>	<b>11</b>	<b>17</b>	<b>10</b>	<b>10</b>	<b>12</b>	<b>14</b>	<b>16</b>	<b>16</b>	<b>11</b>	<b>12</b>
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	2	3	1	2	3	2	5	3	1	1	-	3	3	3
2	<i>Cerithiopsis barleei</i>	-	3	3	1	3	2	-	3	3	3	2	2	1	3
3	<i>Triphora perverse</i>	2	1	5	2	1	3	7	2	1	3	1	5	7	1
4	<i>Limapontia capitata</i>	3	3	2	1	1	-	1	-	2	4	4	1	3	3
5	<i>Nassarius increassatus</i>	1	2	1	1	3	2	1	2	3	1	3	2	2	-
6	<i>Balcis alba</i>	3	-	1	3	3	1	2	-	3	-	3	2	1	3
	<b>Total abundance (N)</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>10</b>	<b>14</b>	<b>10</b>	<b>16</b>	<b>10</b>	<b>13</b>	<b>12</b>	<b>13</b>	<b>15</b>	<b>17</b>	<b>13</b>

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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 56	EA 44	EA 43	EA 39	EA 38	EA 34	EA 40	EA 35	EA 31	EA 32	EA 33	EA 37	EA 42	EA 41
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	5	6	5	8	3	-	4	-	7	4	-	9	4	5
2	<i>Asplanchna prodonta</i>	-	4	-	7	6	5	8	2	5	8	8	7	3	8
3	<i>Asplanchna</i> sp	7	6	4	8	6	5	5	2	6	5	6	8	5	3
4	<i>Polyerthrea</i> sp	5	8	7	4	3	5	4	3	9	6	3	6	-	5
5	<i>Philodina roseola</i>	5	5	4	-	5	4	-	5	4	-	7	9	5	8
6	<i>Brachionus liciflorus</i>	3	6	9	9	8	7	-	9	-	9	6	7	7	5
7	<i>Collotheca</i> sp	9	6	8	-	4	6	3	-	5	6	-	6	8	-
	<b>Total abundance (N)</b>	<b>34</b>	<b>41</b>	<b>37</b>	<b>36</b>	<b>35</b>	<b>32</b>	<b>24</b>	<b>21</b>	<b>36</b>	<b>38</b>	<b>30</b>	<b>52</b>	<b>32</b>	<b>34</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	3	5	2	3	3	1	3	-	-	2	3	3	2	4
2	<i>S. elegans</i>	2	-	2	2	2	4	3	2	3	1	4	-	5	3
3	<i>S. macrocephala</i>	3	5	3	2	2	-	3	2	2	5	-	4	2	2
4	<i>S. Iyra</i>	5	3	3	2	-	1	1	2	4	2	3	-	3	4
5	<i>S. serratodentata</i>	-	4	-	3	1	4	5	2	4	1	-	2	5	-
	<b>Total abundance (N)</b>	<b>13</b>	<b>17</b>	<b>10</b>	<b>12</b>	<b>8</b>	<b>10</b>	<b>15</b>	<b>8</b>	<b>13</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>17</b>	<b>13</b>
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	3	3	7	2	3	-	3	3	3	-	2	3	3	5
2	<i>Cerithiopsis barleei</i>	3	7	3	7	2	1	3	-	4	2	4	7	2	3
3	<i>Triphora perverse</i>	2	3	3	3	-	7	2	3	5	4	2	2	2	4
4	<i>Limapontia capitata</i>	3	3	4	3	3	1	2	4	7	3	2	4	4	3
5	<i>Nassarius increassatus</i>	4	2	3	2	3	3	-	2	1	2	3	2	2	3
6	<i>Balcis alba</i>	-	1	-	5	5	2	1	-	3	3	-	-	4	-
	<b>Total abundance (N)</b>	<b>15</b>	<b>19</b>	<b>20</b>	<b>22</b>	<b>16</b>	<b>14</b>	<b>11</b>	<b>12</b>	<b>23</b>	<b>14</b>	<b>13</b>	<b>18</b>	<b>17</b>	<b>18</b>

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**Appendix 3b Continued: species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID													
		EA 36	EA CTL 1	EA 23	EA 76	EA CTL 3	EA 11	EA 25	EA 28	EA 29	EA 26	EA 24	EA 27	EA CTL 2	EA 100
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	7	6	7	6	6	5	5	-	3	-	-	7	-	6
2	<i>Asplanchna prodonta</i>	6	7	7	5	9	6	6	8	3	1	9	5	6	4
3	<i>Asplanchna</i> sp	8	8	6	4	4	-	2	-	6	6	-	4	5	6
4	<i>Polyerthrea</i> sp	5	-	4	-	5	4	4	2	7	6	3	4	6	5
5	<i>Philodina roseola</i>	-	5	-	3	-	2	-	5	5	2	3	-	5	6
6	<i>Brachionus liciflorus</i>	4	6	6	2	6	5	6	8	5	3	-	5	4	4
7	<i>Collotheca</i> sp	-	9	6	4	8	7	2	4	5	-	5	3	4	-
	<b>Total abundance (N)</b>	<b>30</b>	<b>41</b>	<b>36</b>	<b>24</b>	<b>38</b>	<b>29</b>	<b>25</b>	<b>27</b>	<b>34</b>	<b>18</b>	<b>20</b>	<b>28</b>	<b>30</b>	<b>31</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	4	3	2	5	3	1	2	3	5	3	3	1	-	3
2	<i>S. elegans</i>	2	1	-	3	2	3	2	2	3	2	2	2	3	3
3	<i>S. macrocephala</i>	3	2	-	4	3	3	-	1	2	-	2	5	3	2
4	<i>S. Iyra</i>	3	3	2	2	3	1	3	-	1	3	1	3	1	3
5	<i>S. serratodentata</i>	1	1	2	1	-	2	4	4	-	1	2	-	1	-
	<b>Total abundance (N)</b>	<b>13</b>	<b>10</b>	<b>6</b>	<b>15</b>	<b>11</b>	<b>10</b>	<b>11</b>	<b>10</b>	<b>11</b>	<b>9</b>	<b>10</b>	<b>11</b>	<b>8</b>	<b>11</b>
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	2	2	1	3	1	2	-	3	2	3	3	4	2	3
2	<i>Cerithiopsis barleei</i>	3	3	3	1	2	1	3	3	1	1	3	1	-	2
3	<i>Triphora perverse</i>	3	2	3	2	4	3	3	-	3	2	1	3	3	3
4	<i>Limapontia capitata</i>	1	5	1	2	2	-	1	2	-	1	2	1	3	7
5	<i>Nassarius increassatus</i>	-	1	2	-	-	1	-	3	3	3	2	1	2	2
6	<i>Balcis alba</i>	3	-	2	1	2	3	3	-	2	4	-	1	-	1

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<b>Total abundance (N)</b>	<b>12</b>	<b>13</b>	<b>12</b>	<b>9</b>	<b>11</b>	<b>10</b>	<b>10</b>	<b>11</b>	<b>11</b>	<b>14</b>	<b>11</b>	<b>11</b>	<b>10</b>	<b>18</b>
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**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 96	EA 92	EA 88	EA 90	EA 94	EA 98	EA 97	EA 93	EA 89	EA 91	EA 95	EA 99	EA 87	EA 86
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	6	8	6	–	7	5	9	–	4	5	7	6	–	7
2	<i>Asplanchna prodonta</i>	4	9	4	4	3	6	7	2	–	8	7	5	2	5
3	<i>Asplanchna</i> sp	2	5	–	5	–	3	–	4	4	6	–	6	4	7
4	<i>Polyerthrea</i> sp	5	8	5	3	2	2	–	5	–	5	2	5	2	3
5	<i>Philodina roseola</i>	7	9	3	2	5	–	4	–	5	–	6	2	–	–
6	<i>Brachionus liciflorus</i>	9	6	6	5	4	3	–	7	4	6	4	–	4	5
7	<i>Collotheca</i> sp	–	4	–	3	6	5	6	–	5	–	3	7	8	–
	<b>Total abundance (N)</b>	<b>33</b>	<b>49</b>	<b>24</b>	<b>22</b>	<b>27</b>	<b>24</b>	<b>26</b>	<b>18</b>	<b>22</b>	<b>30</b>	<b>29</b>	<b>31</b>	<b>20</b>	<b>27</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	3	4	3	2	2	4	2	3	1	1	–	2	–	2
2	<i>S. elegans</i>	2	3	5	–	3	2	2	5	1	–	4	3	3	1
3	<i>S. macrocephala</i>	2	2	3	3	1	3	1	2	2	1	5	3	2	4
4	<i>S. Iyra</i>	1	–	2	1	3	–	–	–	1	3	3	1	3	3
5	<i>S. serratodentata</i>	2	1	–	1	2	3	2	–	–	2	–	–	3	–
	<b>Total abundance (N)</b>	<b>10</b>	<b>10</b>	<b>13</b>	<b>7</b>	<b>11</b>	<b>12</b>	<b>7</b>	<b>10</b>	<b>5</b>	<b>7</b>	<b>12</b>	<b>9</b>	<b>11</b>	<b>10</b>
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	2	3	–	2	1	2	7	–	3	1	–	2	2	3
2	<i>Cerithiopsis barleei</i>	3	3	2	3	1	1	–	3	3	3	–	1	3	3
3	<i>Triphora perverse</i>	2	1	3	1	3	1	–	2	1	–	3	2	–	–
4	<i>Limapontia capitata</i>	1	3	3	2	–	–	5	2	2	2	5	2	4	2

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5	<i>Nassarius increassatus</i>	1	2	2	–	1	3	–	1	–	1	4	1	2	1
6	<i>Balcis alba</i>	1	–	1	–	3	4	2	3	3	3	2	3	1	1
	<b>Total abundance (N)</b>	<b>10</b>	<b>12</b>	<b>11</b>	<b>8</b>	<b>9</b>	<b>11</b>	<b>14</b>	<b>11</b>	<b>12</b>	<b>10</b>	<b>14</b>	<b>11</b>	<b>12</b>	<b>10</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 85	EA 30	EA 84	EA 83	EA 82	EA 102	EA 80	EA 78	EA 101	EA 77	EA 81	EA 79	EA 1	EA 67
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	7	3	–	7	4	2	5	–	4	3	4	3	7	3
2	<i>Asplanchna prodonta</i>	6	6	3	3	5	4	–	6	2	4	3	2	5	5
3	<i>Asplanchna</i> sp	3	–	7	2	–	7	6	5	3	2	2	–	2	4
4	<i>Polyerthrea</i> sp	5	3	–	2	8	3	2	3	5	4	–	3	2	5
5	<i>Philodina roseola</i>	5	6	2	4	–	3	5	6	2	–	5	5	2	–
6	<i>Brachionus liciflorus</i>	3	2	5	–	5	–	3	–	3	3	6	7	5	3
7	<i>Collotheca</i> sp	5	2	–	5	4	5	2	5	–	2	3	3	6	4
	<b>Total abundance (N)</b>	<b>34</b>	<b>22</b>	<b>17</b>	<b>23</b>	<b>26</b>	<b>24</b>	<b>23</b>	<b>25</b>	<b>19</b>	<b>18</b>	<b>23</b>	<b>23</b>	<b>29</b>	<b>24</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	5	3	3	2	3	–	5	2	5	2	1	3	3	–
2	<i>S. elegans</i>	3	–	1	1	4	3	3	2	3	2	3	1	1	3
3	<i>S. macrocephala</i>	2	1	3	2	1	4	3	3	2	2	5	3	4	1
4	<i>S. Iyra</i>	–	2	1	3	3	2	2	2	1	–	2	4	1	3
5	<i>S. serratodentata</i>	3	4	2	3	–	3	–	4	–	–	3	–	3	2
	<b>Total abundance (N)</b>	<b>13</b>	<b>10</b>	<b>10</b>	<b>11</b>	<b>11</b>	<b>12</b>	<b>13</b>	<b>13</b>	<b>11</b>	<b>6</b>	<b>14</b>	<b>11</b>	<b>12</b>	<b>9</b>
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	2	1	2	3	1	1	–	–	1	1	1	–	2	3

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2	<i>Cerithiopsis barleei</i>	3	3	2	–	2	3	2	5	1	1	3	2	–	3
3	<i>Triphora perverse</i>	3	2	3	3	2	3	2	2	3	3	–	5	6	2
4	<i>Limapontia capitata</i>	–	–	3	4	2	1	3	–	4	–	3	3	2	–
5	<i>Nassarius increassatus</i>	4	3	–	2	–	3	3	3	3	2	3	4	2	4
6	<i>Balcis alba</i>	2	3	1	1	3	–	–	2	–	1	–	–	–	3
	<b>Total abundance (N)</b>	<b>14</b>	<b>12</b>	<b>11</b>	<b>13</b>	<b>10</b>	<b>11</b>	<b>10</b>	<b>12</b>	<b>12</b>	<b>8</b>	<b>10</b>	<b>14</b>	<b>12</b>	<b>15</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		Samples ID													
Zooplankton groups/species		EA 62	EA 60	EA 66	EA 61	EA 68	EA 72	EA 69	EA 74	EA 73	EA 70	EA 71	EA 65	EA 63	EA 64
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	8	5	6	8	5	2	5	–	4	7	5	4	5	6
2	<i>Asplanchna prodonta</i>	5	4	3	3	7	4	–	5	8	4	3	4	3	4
3	<i>Asplanchna</i> sp	7	–	5	2	2	4	4	2	5	–	2	2	–	6
4	<i>Polyerthrea</i> sp	6	3	–	2	3	5	–	4	–	3	2	6	2	–
5	<i>Philodina roseola</i>	2	5	6	5	–	2	7	2	3	3	–	3	4	3
6	<i>Brachionus liciflorus</i>	6	–	2	–	5	4	–	7	4	6	3	–	3	5
7	<i>Collotheca</i> sp	5	3	2	2	5	3	4	2	6	–	7	4	–	–
	<b>Total abundance (N)</b>	<b>39</b>	<b>20</b>	<b>24</b>	<b>22</b>	<b>27</b>	<b>24</b>	<b>20</b>	<b>22</b>	<b>30</b>	<b>23</b>	<b>22</b>	<b>23</b>	<b>17</b>	<b>24</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	3	–	3	1	1	–	2	–	2	1	3	3	3	1
2	<i>S. elegans</i>	3	5	2	3	3	2	3	–	1	1	1	2	3	–
3	<i>S. macrocephala</i>	2	3	2	1	–	1	3	2	2	4	2	–	–	3
4	<i>S. Iyra</i>	1	3	–	2	4	2	2	2	3	2	–	5	1	3
5	<i>S. serratodentata</i>	2	1	1	–	1	1	–	3	–	–	1	2	2	2
	<b>Total abundance (N)</b>	<b>11</b>	<b>12</b>	<b>8</b>	<b>7</b>	<b>9</b>	<b>6</b>	<b>10</b>	<b>7</b>	<b>8</b>	<b>8</b>	<b>7</b>	<b>12</b>	<b>9</b>	<b>9</b>



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<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	1	1	2	2	-	1	-	2	3	1	3	-	2	3
2	<i>Cerithiopsis barleei</i>	3	2	2	1	1	-	2	3	2	3	2	-	-	4
3	<i>Triphora perverse</i>	1	2	3	3	2	3	-	4	2	1	3	3	1	3
4	<i>Limapontia capitata</i>	1	3	3	-	3	3	1	2	2	1	-	2	2	3
5	<i>Nassarius increassatus</i>	-	1	-	3	-	1	3	-	3	1	3	3	1	-
6	<i>Balcis alba</i>	2	-	2	2	4	1	-	3	2	1	-	-	3	2
	<b>Total abundance (N)</b>	<b>8</b>	<b>9</b>	<b>12</b>	<b>11</b>	<b>10</b>	<b>9</b>	<b>6</b>	<b>14</b>	<b>14</b>	<b>8</b>	<b>11</b>	<b>8</b>	<b>9</b>	<b>15</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

		<b>Samples ID</b>													
<b>Zooplankton groups/species</b>		<b>EA 75</b>	<b>EA 2</b>	<b>EA 3</b>	<b>EA 4</b>	<b>EA 5</b>	<b>EA 6</b>	<b>EA 18</b>	<b>EA 7</b>	<b>EA 8</b>	<b>EA 9</b>	<b>EA 10</b>	<b>EA 20</b>	<b>EA 17</b>	<b>EA 16</b>
<b>G</b>	<b>ROTIFERA</b>														
1	<i>Euchanis</i> sp	7	4	6	6	5	-	6	5	-	6	4	5	3	2
2	<i>Asplanchna prodonta</i>	5	2	8	3	3	5	-	2	7	2	5	4	2	6
3	<i>Asplanchna</i> sp	2	3	2	5	2	5	4	3	2	-	7	-	-	4
4	<i>Polyerthrea</i> sp	2	5	-	3	2	6	2	2	7	3	-	5	5	3
5	<i>Philodina roseola</i>	3	3	5	4	5	-	-	-	-	3	3	5	2	7
6	<i>Brachionus liciflorus</i>	3	-	4	-	6	5	3	5	5	4	5	2	3	-
7	<i>Collotheca</i> sp	-	2	5	5	-	4	2	-	4	-	3	5	-	5
	<b>Total abundance (N)</b>	<b>22</b>	<b>19</b>	<b>30</b>	<b>26</b>	<b>23</b>	<b>25</b>	<b>17</b>	<b>17</b>	<b>25</b>	<b>18</b>	<b>27</b>	<b>26</b>	<b>15</b>	<b>27</b>
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>														
1	<i>Sagutta hexaptere</i>	5	3	3	2	3	2	2	-	3	2	3	3	2	-
2	<i>S. elegans</i>	3	2	2	3	-	-	2	2	2	4	5	3	-	4
3	<i>S. macrocephala</i>	1	4	-	-	3	3	-	1	-	2	1	4	2	4

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4	<i>S. Iyra</i>	1	3	2	3	1	–	3	1	–	3	–	1	3	–
5	<i>S. serratodentata</i>	1	2	–	3	3	5	2	–	3	–	4	–	–	3
	<b>Total abundance (N)</b>	<b>11</b>	<b>14</b>	<b>7</b>	<b>11</b>	<b>10</b>	<b>10</b>	<b>9</b>	<b>4</b>	<b>8</b>	<b>11</b>	<b>13</b>	<b>11</b>	<b>7</b>	<b>11</b>
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	2	3	3	1	1	1	3	2	–	3	2	4	2	3
2	<i>Cerithiopsis barleei</i>	1	1	3	7	2	4	–	2	3	2	3	2	5	–
3	<i>Triphora perverse</i>	3	–	1	2	–	2	3	1	1	1	2	2	2	3
4	<i>Limapontia capitata</i>	–	3	3	1	3	1	3	3	1	–	3	5	3	5
5	<i>Nassarius increassatus</i>	3	3	1	–	3	3	1	1	3	3	–	–	–	3
6	<i>Balcis alba</i>	–	3	2	3	–	2	–	1	–	1	2	3	3	–
	<b>Total abundance (N)</b>	<b>9</b>	<b>13</b>	<b>13</b>	<b>14</b>	<b>9</b>	<b>13</b>	<b>10</b>	<b>10</b>	<b>8</b>	<b>10</b>	<b>12</b>	<b>16</b>	<b>15</b>	<b>14</b>

**Appendix 3b Continued: Species composition of the zooplankton within the OML 79 Field (Oct. – Nov., 2018)**

Zooplankton groups/species		Samples ID														
		EA 15	EA 14	EA 13	EA 12	EA 19	EA 21	EA 22								
<b>G</b>	<b>ROTIFERA</b>															
1	<i>Euchanis</i> sp	4	5	–	4	5	9	7								
2	<i>Asplanchna prodonta</i>	5	–	5	3	–	–	3								
3	<i>Asplanchna</i> sp	6	3	5	5	–	4	6								
4	<i>Polyerthrea</i> sp	2	–	2	4	3	3	6								
5	<i>Philodina roseola</i>	4	5	3	3	4	–	4								
6	<i>Brachionus liciflorus</i>	–	7	2	–	5	6	4								
7	<i>Collotheca</i> sp	3	2	2	–	3	–	5								
	<b>Total abundance (N)</b>	<b>24</b>	<b>22</b>	<b>19</b>	<b>19</b>	<b>20</b>	<b>22</b>	<b>35</b>								
<b>H</b>	<b>CHAETOGNATHA (Arrow worms)</b>															

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1	<i>Sagutta hexaptere</i>	2	3	1	1	2	1	1							
2	<i>S. elegans</i>	3	3	1	1	2	3	1							
3	<i>S. macrocephala</i>	5	2	3	3	3	-	1							
4	<i>S. Iyra</i>	-	2	3	-	2	2	3							
5	<i>S. serratodentata</i>	2	1	1	1	-	1	-							
	<b>Total abundance (N)</b>	<b>12</b>	<b>11</b>	<b>9</b>	<b>6</b>	<b>9</b>	<b>7</b>	<b>6</b>							
<b>I</b>	<b>MOLLUSCA (Gastro/bivalves) Larvae</b>														
1	<i>Clionelima acina</i>	-	3	3	-	2	3	3							
2	<i>Cerithiopsis barleei</i>	3	1	3	1	3	-	2							
3	<i>Triphora perverse</i>	2	3	1	2	3	4	4							
4	<i>Limapontia capitata</i>	4	-	1	2	1	1	-							
5	<i>Nassarius increassatus</i>	1	2	-	3	2	2	2							
6	<i>Balcis alba</i>	4	2	1	-	4	-	2							
	<b>Total abundance (N)</b>	<b>14</b>	<b>11</b>	<b>9</b>	<b>8</b>	<b>15</b>	<b>10</b>	<b>13</b>							

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**Appendix 3c: Species composition of the Macrobenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 45	EA 59	EA 54	EA 48	EA 49	EA 55	EA 47	EA 50	EA 46	EA 53	EA 57	EA 52	EA 58	EA 51	
Ai	<b>Mollusca (Bivalves)</b>															
1	<i>Donax rugosus</i>	18	13	10	15	11	10	11	9	-	8	12	14	13	19	
2	<i>Donax vittatus</i>	13	7	8	9	15	-	13	7	4	-	9	11	7	15	
3	<i>Donax pulchellus</i>	17	15	-	11	11	16	17	5	12	13	5	-	5	13	
4	<i>Chthamalus dalli</i>	13	4	7	9	14	6	9	9	7	-	10	11	10	9	
5	<i>Cardium costatum</i>	17	9	5	7	-	9	4	-	13	12	-	9	11	-	
6	<i>Callisella pelta</i>	-	11	13	6	13	-	8	7	10	15	9	-	8	13	
	<b>Abundance (n) per station</b>	<b>78</b>	<b>64</b>	<b>43</b>	<b>57</b>	<b>64</b>	<b>41</b>	<b>62</b>	<b>37</b>	<b>46</b>	<b>48</b>	<b>45</b>	<b>45</b>	<b>54</b>	<b>69</b>	<b>753</b>
ii	<b>Mollusca (Gastropods)</b>															
1	<i>Oliva acuminata</i>	12	10	19	18	10	-	8	16	19	18	15	17	16	11	
2	<i>Murex sp.</i>	9	14	8	9	16	4	15	4	6	-	5	8	10	6	
3	<i>Merita senegalensis</i>	8	-	5	5	8	4	8	6	4	9	10	-	10	8	
4	<i>Murex cornutus</i>	5	7	9	9	-	8	6	8	-	9	9	11	9	-	
5	<i>Fissurella nubecula</i>	10	8	-	9	10	15	6	-	14	15	6	13	-	6	
6	<i>Semifusus morio</i>	7	9	5	8	5	11	-	11	8	13	7	-	10	13	
7	<i>Drupa nodulosa</i>	14	10	11	13	6	8	9	8	-	13	9	10	-	5	
8	<i>Conus ambiguous</i>	-	11	9	-	5	8	-	7	8	6	4	7	-	5	
9	<i>Nassa semistriata</i>	7	6	6	9	8	6	8	8	6	8	-	5	7	16	
10	<i>Palices sp</i>	4	6	8	-	8	5	8	8	6	8	7	-	5	-	
11	<i>Cypraea zonata</i>	5	7	4	10	6	-	7	5	8	9	8	8	-	15	
12	<i>Amoria zebra</i>	-	4	6	-	7	8	8	9	-	7	-	10	6	-	
13	<i>Astraea jacquelina</i>	16	13	4	8	14	8	5	7	-	-	9	8	7	9	
	<b>Abundance (n) per station</b>	<b>97</b>	<b>105</b>	<b>94</b>	<b>98</b>	<b>103</b>	<b>85</b>	<b>88</b>	<b>97</b>	<b>79</b>	<b>115</b>	<b>89</b>	<b>97</b>	<b>80</b>	<b>94</b>	<b>1321</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	15	20	6	-	18	11	10	3	13	11	10	9	5	11	
2	<i>Tabulipora sp</i>	21	11	8	10	-	9	8	7	13	-	10	-	8	7	
3	<i>Culcumaria sp</i>	18	7	-	9	11	5	7	5	9	4	11	5	6	9	
	<b>Abundance (n) per station</b>	<b>54</b>	<b>38</b>	<b>14</b>	<b>19</b>	<b>29</b>	<b>25</b>	<b>22</b>	<b>15</b>	<b>35</b>	<b>15</b>	<b>31</b>	<b>14</b>	<b>19</b>	<b>29</b>	<b>359</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	11	13	16	7	9	9	21	11	-	7	18	9	12	18	
2	<i>Ophiura africana</i>	17	18	21	13	-	7	9	13	15	-	13	5	9	16	
3	<i>Poramía sp</i>	11		14	13	11	12	14	5	7	4	-	21	13	7	
	<b>Abundance (n) per station</b>	<b>29</b>	<b>31</b>	<b>51</b>	<b>33</b>	<b>20</b>	<b>28</b>	<b>44</b>	<b>29</b>	<b>22</b>	<b>11</b>	<b>31</b>	<b>35</b>	<b>34</b>	<b>41</b>	<b>439</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium vulgore</i>	18	21	11	17	11	8	12	14	18	14	18	24	12	9	
	<b>Abundance (n) per station</b>	<b>18</b>	<b>21</b>	<b>11</b>	<b>17</b>	<b>11</b>	<b>8</b>	<b>12</b>	<b>14</b>	<b>18</b>	<b>14</b>	<b>18</b>	<b>24</b>	<b>12</b>	<b>9</b>	<b>207</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	1	-	-	-	-	1	2	-	1	-	1	1	-	1	
	<i>Cynoponticus ferox</i>	-	2	-	1	-	-	-	-	-	-	-	-	1	-	
	<b>Abundance (n) per station</b>	<b>1</b>	<b>2</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>2</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>12</b>
F	<b>Crustacea</b>															
	<i>Chibanarius africana</i>	2	-	-	1	-	3	-	-	-	-	1	-	2	-	
	<i>Sylisrolifera sp</i>	-	-	1	-	-	5	1	-	-	-	-	-	-	1	
	<b>Abundance (n) per station</b>	<b>2</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>8</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>2</b>	<b>1</b>	<b>17</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	2	3	1	1	2	-	-	3	2	1	1	1	3	3	
2	<i>Sabella meranostigma</i>	1	1	1	3	3	-	1	2	2	3	2	-	1	-	
3	<i>Axiiothella sp</i>	1	-	3	-	1	1	3	1	1	-	-	3	2	1	
4	<i>Ophelia capensis</i>	2	1	-	1	-	1	2	-	-	-	-	1	1	2	
	<b>Abundance (n) per station</b>	<b>6</b>	<b>5</b>	<b>5</b>	<b>5</b>	<b>6</b>	<b>2</b>	<b>6</b>	<b>6</b>	<b>5</b>	<b>4</b>	<b>4</b>	<b>5</b>	<b>6</b>	<b>6</b>	<b>71</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	1	-	1	-	3	-	1	-	2	3	-	4	3	4	
2	<i>Ceratoporolla nicholsn</i>	2	-	-	-	-	3	1	-	5	5	-	-	1	2	
	<b>Abundance (n) per station</b>	<b>3</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>3</b>	<b>3</b>	<b>2</b>	<b>-</b>	<b>7</b>	<b>8</b>	<b>-</b>	<b>4</b>	<b>4</b>	<b>6</b>	<b>41</b>
	<b>Station by station overall abundance (n)</b>	<b>288</b>	<b>266</b>	<b>220</b>	<b>231</b>	<b>236</b>	<b>201</b>	<b>239</b>	<b>198</b>	<b>213</b>	<b>215</b>	<b>220</b>	<b>225</b>	<b>212</b>	<b>256</b>	<b>3220</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3c Continued: Species composition of the Macrobenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 56	EA 44	EA 43	EA 39	EA 38	EA 34	EA 40	EA 36	EA 31	EA 32	EA 33	EA 37	EA 42	EA 41	
Ai	<b>Mollusca (Bivalvia)</b>															
1	<i>Donax rugosus</i>	11	12	11	7	-	3	9	13	5	13	-	5	6	6	
2	<i>Donax vittatus</i>	7	4	6	7	-	7	15	7	10	7	11	-	9	7	
3	<i>Donax pulchellus</i>	9	6	7	3	7	4	7	5	4	-	8	3	9	9	
4	<i>Chthamalus dalli</i>	7	5	7	-	9	9	-	8	7	5	-	11	7	4	
5	<i>Cardium costatum</i>	11	13	12	4	7	7	14	-	4	12	7	6	-	8	
6	<i>Callisella pelta</i>	9	7	5	9	-	10	6	6	9	-	11	5	14	-	
	<b>Abundance (n) per station</b>	<b>44</b>	<b>47</b>	<b>48</b>	<b>30</b>	<b>23</b>	<b>40</b>	<b>51</b>	<b>39</b>	<b>39</b>	<b>37</b>	<b>37</b>	<b>30</b>	<b>45</b>	<b>44</b>	<b>554</b>
ii	<b>Mollusca (Gastropods)</b>															
1	<i>Oliva acuminata</i>	5	8	4	10	11	13	13	10	7	5	-	9	-	11	
2	<i>Murex sp.</i>	11	9	8	6	18	11	-	9	12	5	-	-	-	10	
3	<i>Merita senegalensis</i>	-	13	-	8	8	9	8	-	-	6	6	13	5	13	
4	<i>Murex cornutus</i>	11	8	6	9	3	6	6	8	6	4	-	11	-	9	
5	<i>Fissurella nubecula</i>	8	9	12	8	9	3	11	8	7	8	7	8	3	-	
6	<i>Semifusus morio</i>	6	8	10	-	6	4	7	-	9	7	3	11	13	10	
7	<i>Drupa nodulosa</i>	13	-	8	7	6	8	-	8	4	11	13	9	11	11	
8	<i>Conus ambiguous</i>	8	6	8	4	-	-	10	5	-	-	6	8	8	13	
9	<i>Nassa semistriata</i>	9	7	6	8	8	9	6	13	10	11	8	5	13	9	
10	<i>Palices sp</i>	9	4	7	4	6	8	-	9	-	8	-	5	8	-	
11	<i>Cypraea zonata</i>	-	6	-	5	-	13	10	-	10	13	9	-	2	9	
12	<i>Amoria zebra</i>	11	6	8	-	-	4	6	11	7	7	9	7	8	6	
13	<i>Astraea jacquelina</i>	14	12	10	-	7	9	8	8	-	-	4	7	5	9	
	<b>Abundance (n) per station</b>	<b>105</b>	<b>104</b>	<b>87</b>	<b>69</b>	<b>82</b>	<b>97</b>	<b>85</b>	<b>89</b>	<b>72</b>	<b>85</b>	<b>65</b>	<b>93</b>	<b>76</b>	<b>110</b>	<b>1219</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	13	16	11	-	6	12	7	10	6	6	-	9	7	13	
2	<i>Tabulipora sp</i>	15	9	-	11	3	7	5	-	11	8	13	15	-	11	
3	<i>Culcumaria sp</i>	6	-	8	3	-	6	7	11	9	-	5	8	5	7	
	<b>Abundance (n) per station</b>	<b>34</b>	<b>25</b>	<b>19</b>	<b>14</b>	<b>9</b>	<b>25</b>	<b>19</b>	<b>21</b>	<b>26</b>	<b>14</b>	<b>18</b>	<b>32</b>	<b>12</b>	<b>31</b>	<b>299</b>
C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	7	16	13	-	7	-	11	7	-	11	7	5	9	7	
2	<i>Ophiura africana</i>	13	8	-	11	13	13	8	-	11	9	-	7	6	8	

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 56	EA 44	EA 43	EA 39	EA 38	EA 34	EA 40	EA 36	EA 31	EA 32	EA 33	EA 37	EA 42	EA 41	
3	<i>Poramia sp</i>	15	9	7	10	5	10	6	10	8	6	10	5	9	-	
	<b>Abundance (n) per station</b>	<b>35</b>	<b>33</b>	<b>20</b>	<b>21</b>	<b>25</b>	<b>23</b>	<b>25</b>	<b>17</b>	<b>19</b>	<b>26</b>	<b>17</b>	<b>17</b>	<b>24</b>	<b>15</b>	<b>317</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium vulgore</i>	24	17	21	16	18	19	27	14	17	15	24	20	18	15	
	<b>Abundance (n) per station</b>	<b>24</b>	<b>17</b>	<b>21</b>	<b>16</b>	<b>18</b>	<b>19</b>	<b>27</b>	<b>14</b>	<b>17</b>	<b>15</b>	<b>24</b>	<b>20</b>	<b>18</b>	<b>15</b>	<b>265</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	-	-	-	-	-	-	-	-	4	-	2	-	-	-	
	<i>Cynoponticus ferox</i>	-	1	-	-	-	-	1	-	-	-	-	2	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>4</b>	<b>-</b>	<b>2</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>10</b>
F	<b>Crustacea</b>															
	<i>Chibanarius africana</i>	-	3	1	-	-	-	-	1	-	-	-	1	-	1	
	<i>Sylisrolifera sp</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>3</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>8</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	-	5	1	-	4	-	-	-	-	-	-	-	-	2	
2	<i>Sabella meranostigma</i>	-	-	-	1	1	-	-	-	-	-	-	-	1	1	
3	<i>Axiiothella sp</i>	-	-	-	3	-	-	-	-	-	-	1	-	-	-	
4	<i>Ophelia capensis</i>	-	1	-	-	-	4	-	-	-	1	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>6</b>	<b>1</b>	<b>4</b>	<b>5</b>	<b>4</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>3</b>	<b>26</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	-	-	1	-	2	-	-	3	-	-	1	2	-	1	
2	<i>Ceratoporolla nicholsn</i>	-	-	2	1	-	-	-	-	5	-	3	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>1</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>5</b>	<b>-</b>	<b>4</b>	<b>2</b>	<b>-</b>	<b>1</b>	<b>21</b>
	<b>Station by station overall abundance (n)</b>	<b>242</b>	<b>236</b>	<b>200</b>	<b>156</b>	<b>164</b>	<b>208</b>	<b>208</b>	<b>184</b>	<b>182</b>	<b>178</b>	<b>168</b>	<b>198</b>	<b>175</b>	<b>220</b>	<b>2719</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3c Continued: Species composition of the Macrobenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 36	EA CTL 1	EA 23	EA 76	EA CTL 3	EA 11	EA 25	EA 28	EA 29	EA 26	EA 24	EA 27	EA CTL 2	EA 100	
Ai	<b>Mollusca (Bivalvia)</b>															
1	<i>Donax rugosus</i>	12	17	9	9	13	7	6	11	13	14	11	10	7	13	
2	<i>Donax vittatus</i>	18	16	17	11	13	-	9	-	7	9	7	7	4	17	
3	<i>Donax pulchellus</i>	15	13	11	11	10	15	12	9	4	7	9	5	9	11	
4	<i>Chthamalus dalli</i>	9	7	5	7	5	-	7	9	7	-	4	9	3	5	
5	<i>Cardium costatum</i>	17	13	9	8	10	8	10	7	5	8	-	11	8	-	
6	<i>Callisella pelta</i>	5	-	6	3	6	7	-	5	10	8	5	-	-	3	
	<b>Abundance (n) per station</b>	<b>76</b>	<b>66</b>	<b>57</b>	<b>49</b>	<b>57</b>	<b>37</b>	<b>44</b>	<b>41</b>	<b>46</b>	<b>46</b>	<b>36</b>	<b>42</b>	<b>31</b>	<b>49</b>	<b>677</b>
ii	<b>Mollusca (Gastropods)</b>															
1	<i>Oliva acuminata</i>	16	14	11	10	13	16	13	11	11	18	16	19	10	13	
2	<i>Murex sp.</i>	18	10	9	7	12	10	7	8	13	-	9	13	11	9	
3	<i>Merita senegalensis</i>	13	11	-	4	15	8	6	6	-	7	5	8	-	7	
4	<i>Murex cornutus</i>	9	13	11	8	9	9	7	7	11	13	14	11	9	10	
5	<i>Fissurella nubecula</i>	12	6	10	-	10	6	-	9	5	13	7	8	7	11	
6	<i>Semifusus morio</i>	15	8	9	8	5	5	6	11	-	10	12	11	10	-	
7	<i>Drupa nodulosa</i>	8	9	6	5	6	9	10	12	7	-	-	8	6	11	
8	<i>Conus ambiguous</i>	9	-	6	6	9	11	4	11	9	11	13	-	9	14	
9	<i>Nassa semistriata</i>	9	8	-	11	6	8	9	-	7	7	6	7	6	8	
10	<i>Palices sp</i>	3	7	9	9	8	-	8	8	5	7	10	9	5	10	
11	<i>Cypraea zonata</i>	5	9	8	10	8	7	8	10	8	10	12	8	-	7	
12	<i>Amoria zebra</i>	-	8	4	8	-	9	-	5	11	-	-	5	9	-	
13	<i>Astraea jacquelina</i>	2	-	8	-	7	11	10	7	9	6	9	-	-	10	
	<b>Abundance (n) per station</b>	<b>119</b>	<b>103</b>	<b>91</b>	<b>86</b>	<b>108</b>	<b>109</b>	<b>88</b>	<b>104</b>	<b>96</b>	<b>102</b>	<b>113</b>	<b>106</b>	<b>82</b>	<b>110</b>	<b>1417</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	20	11	21	15	12	10	10	14	13	19	14	7	7	13	
2	<i>Tabulipora sp</i>	11	7	5	7	11	5	-	3	7	4	7	5	-	9	
3	<i>Calcumaria sp</i>	7	8	-	8	-	7	3	-	3	7	6	-	3	5	
	<b>Abundance (n) per station</b>	<b>38</b>	<b>26</b>	<b>26</b>	<b>30</b>	<b>23</b>	<b>22</b>	<b>13</b>	<b>17</b>	<b>23</b>	<b>30</b>	<b>27</b>	<b>12</b>	<b>10</b>	<b>27</b>	<b>324</b>
C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	8	11	9	9	7	6	9	6	6	7	5	5	11	14	



**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 36	EA CTL 1	EA 23	EA 76	EA CTL 3	EA 11	EA 25	EA 28	EA 29	EA 26	EA 24	EA 27	EA CTL 2	EA 100	
2	<i>Ophiura africana</i>	8	5	-	11	-	7	-	-	3	-	3	4	3	-	
3	<i>Poramia sp</i>	6	8	-	4	-	4	-	3	-	-	-	-	-	5	
	<b>Abundance (n) per station</b>	<b>22</b>	<b>21</b>	<b>9</b>	<b>24</b>	<b>7</b>	<b>7</b>	<b>9</b>	<b>9</b>	<b>9</b>	<b>7</b>	<b>8</b>	<b>9</b>	<b>14</b>	<b>19</b>	<b>184</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium vulgore</i>	27	19	18	20	17	24	18	18	12	19	23	15	17	21	
	<b>Abundance (n) per station</b>	<b>27</b>	<b>19</b>	<b>18</b>	<b>20</b>	<b>17</b>	<b>24</b>	<b>18</b>	<b>18</b>	<b>12</b>	<b>19</b>	<b>23</b>	<b>15</b>	<b>17</b>	<b>21</b>	<b>268</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	-	1	-	-	-	2	-	-	-	1	-	-	1	-	
	<i>Cynoponticus ferox</i>	-	-	1	-	-	-	-	1	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>7</b>
F	<b>Crustacea</b>															
	<i>Chibanarius Africana</i>	1	-	-	-	-	-	-	-	-	-	-	2	-	-	
	<i>Sylisrolifera sp</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>4</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	3	-	-	1	-	-	-	-	-	-	-	-	-	2	
2	<i>Sabella meranostigma</i>	-	-	-	-	-	2	-	-	-	1	-	-	-	-	
3	<i>Axiiothella sp</i>	1	-	-	1	-	-	-	-	-	-	-	1	-	1	
4	<i>Ophelia capensis</i>	-	-	-	-	1	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>4</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>1</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>3</b>	<b>14</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	-	-	1	-	1	-	-	-	-	-	-	-	1	-	
2	<i>Ceratoporolla nicholsm</i>	-	-	-	-	-	-	1	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>4</b>
	<b>Station by station overall abundance (n)</b>	<b>287</b>	<b>236</b>	<b>203</b>	<b>211</b>	<b>215</b>	<b>213</b>	<b>173</b>	<b>190</b>	<b>186</b>	<b>206</b>	<b>207</b>	<b>187</b>	<b>196</b>	<b>229</b>	<b>2899</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3c Continued: Species composition of the Macroenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 96	EA 92	EA 88	EA 90	EA 94	EA 98	EA 97	EA 93	EA 89	EA 91	EA 95	EA 99	EA 87	EA 86	
Ai	<b>Mollusca (Bivalvia)</b>															
1	<i>Donax rugosus</i>	13	15	10	15	9	10	15	13	9	7	11	9	13	11	
2	<i>Donax vittatus</i>	15	15	13	-	11	9	8	-	7	5	-	7	5	18	
3	<i>Donax pulchellus</i>	11	9	11	15	11	5	12	5	9	7	10	-	9	13	
4	<i>Chthamalus dalli</i>	14	11	12	4	7	14	-	7	5	4	7	6	13	4	
5	<i>Cardium costatum</i>	9	-	4	12	7	13	10	7	9	-	4	9	11	-	
6	<i>Callisella pelta</i>	7	10	11	8	-	7	6	9	-	9	6	8	-	9	
	<b>Abundance (n) per station</b>	<b>69</b>	<b>60</b>	<b>61</b>	<b>54</b>	<b>45</b>	<b>58</b>	<b>51</b>	<b>41</b>	<b>39</b>	<b>32</b>	<b>38</b>	<b>39</b>	<b>51</b>	<b>55</b>	<b>693</b>
ii	<b>Mollusca (Gastropods)</b>															
1	<i>Oliva acuminata</i>	21	10	13	14	-	10	15	19	14	13	11	13	12	13	
2	<i>Murex sp.</i>	10	10	15	9	10	13	9	7	13	16	-	12	10	9	
3	<i>Merita senegalensis</i>	13	8	13	7	16	16	13	-	5	15	5	13	12	13	
4	<i>Murex cornutus</i>	9	5	-	13	8	-	9	6	8	6	8	5	8	9	
5	<i>Fissurella nubecula</i>	6	-	9	11	11	8	5	8	13	7	13	13	11	7	
6	<i>Semifusus morio</i>	10	8	13	13	8	13	5	5	-	15	8	10	-	-	
7	<i>Drupa nodulosa</i>	9	10	7	11	6	10	8	8	11	9	6	-	-	8	
8	<i>Conus ambiguous</i>	-	11	11	-	9	-	7	-	5	8	7	10	9	7	
9	<i>Nassa semistriata</i>	9	5	8	8	3	14	-	8	7	7	-	10	8	8	
10	<i>Palices sp</i>	8	8	9	6	6	13	9	6	11	12	15	-	5	8	
11	<i>Cypraea zonata</i>	13	4	-	10	6	9	11	9	-	8	13	7	6	5	
12	<i>Amoria zebra</i>	11	8	9	-	8	-	7	11	9	-	7	6	13	11	
13	<i>Astraea jacquelina</i>	7	-	3	9	6	11	10	13	9	11	10	9	7	-	
14	<i>Ianthina fragilis</i>	-	-	1	-	2	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>126</b>	<b>87</b>	<b>111</b>	<b>111</b>	<b>99</b>	<b>117</b>	<b>108</b>	<b>100</b>	<b>105</b>	<b>127</b>	<b>103</b>	<b>108</b>	<b>101</b>	<b>98</b>	<b>1501</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	8	15	7	19	12	11	11	13	10	14	11	4	8	15	
2	<i>Tabulipora sp</i>	10	10	9	15	8	-	7	8	6	8	-	9	4	13	
3	<i>Culcumaria sp</i>	7	-	6	11	-	13	-	9	9	-	10	6	-	9	
	<b>Abundance (n) per station</b>	<b>25</b>	<b>25</b>	<b>22</b>	<b>45</b>	<b>20</b>	<b>24</b>	<b>18</b>	<b>30</b>	<b>25</b>	<b>22</b>	<b>21</b>	<b>19</b>	<b>12</b>	<b>37</b>	<b>345</b>
C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	17	13	6	5	9	11	9	17	9	-	10	5	6	9	

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 96	EA 92	EA 88	EA 90	EA 94	EA 98	EA 97	EA 93	EA 89	EA 91	EA 95	EA 99	EA 87	EA 86	
2	<i>Ophiura africana</i>	13	16	11	-	-	-	5	-	8	6	5	11	8	9	
3	<i>Poraria sp</i>	10	7	13	-	-	-	7	-	4	4	-	7	4	4	
	<b>Abundance (n) per station</b>	<b>40</b>	<b>36</b>	<b>30</b>	<b>5</b>	<b>9</b>	<b>11</b>	<b>21</b>	<b>17</b>	<b>21</b>	<b>10</b>	<b>15</b>	<b>23</b>	<b>18</b>	<b>22</b>	<b>278</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium vulgore</i>	12	18	18	11	12	18	15	18	21	17	18	12	19	23	
	<b>Abundance (n) per station</b>	<b>12</b>	<b>18</b>	<b>18</b>	<b>11</b>	<b>12</b>	<b>18</b>	<b>15</b>	<b>18</b>	<b>21</b>	<b>17</b>	<b>18</b>	<b>12</b>	<b>19</b>	<b>23</b>	<b>232</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	-	-	1	-	-	2	-	-	-	-	-	-	-	-	
	<i>Cynoponticus ferox</i>	-	-	-	-	-	-	3	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>3</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>6</b>
F	<b>Crustacea</b>															
	<i>Chibanarius africana</i>	4	-	-	-	-	-	-	-	1	-	-	-	-	-	
	<i>Sylisrolifera sp</i>	1	-	-	-	-	1	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>5</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>7</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	2	-	1	-	-	-	-	-	-	-	-	-	-	-	
2	<i>Sabella meranostigma</i>	-	-	-	-	-	-	-	1	-	-	-	-	-	1	
3	<i>Axiothella sp</i>	-	-	1	-	-	-	-	-	-	1	-	-	-	1	
4	<i>Ophelia capensis</i>	1	-	-	-	-	1	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>3</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>10</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	-	-	1	-	2	-	-	-	-	-	1	-	-	-	
2	<i>Ceratoporolla nicholsm</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>4</b>
	<b>Station by station overall abundance (n)</b>	<b>280</b>	<b>226</b>	<b>246</b>	<b>226</b>	<b>187</b>	<b>232</b>	<b>216</b>	<b>207</b>	<b>212</b>	<b>209</b>	<b>196</b>	<b>201</b>	<b>201</b>	<b>237</b>	<b>3076</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3c Continued: Species composition of the Macroenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 85	EA 30	EA 34	EA 83	EA 82	EA 102	EA 80	EA 78	EA 101	EA 77	EA 81	EA 79	EA 1	EA 67	
Ai	<b>Mollusca (Bivalvia)</b>															
1	<i>Donax rugosus</i>	13	15	9	12	11	14	10	9	13	17	9	10	10	15	
2	<i>Donax vittatus</i>	12	11	12	10	15	9	8	11	4	15	13	-	21	11	
3	<i>Donax pulchellus</i>	9	7	-	11	18	4	13	15	10	-	5	12	14	10	
4	<i>Chthamalus dalli</i>	9	10	15	-	11	13	11	16	-	9	8	13	-	14	
5	<i>Cardium pelta</i>	10	13	17	13	-	7	-	13	17	12	-	10	13	11	
	<b>Abundance (n) per station</b>	<b>53</b>	<b>56</b>	<b>53</b>	<b>46</b>	<b>55</b>	<b>47</b>	<b>42</b>	<b>64</b>	<b>44</b>	<b>53</b>	<b>35</b>	<b>45</b>	<b>58</b>	<b>51</b>	<b>702</b>
ii	<b>Mollusca (Gastropods)</b>															
1	<i>Oliva acuminata</i>	19	12	16	13	14	13	14	9	9	18	17	7	15	19	
2	<i>Murex sp.</i>	13	14	10	10	9	-	9	14	7	8	8	4	7	10	
3	<i>Merita senegalensis</i>	18	9	5	14	13	15	6	13	11	-	6	7	-	8	
4	<i>Murex cornutus</i>	15	9	8	13	7	12	8	11	15	11	9	8	5	8	
5	<i>Fissurella nubecula</i>	-	7	7	5	8	5	8	-	-	9	7	10	13	13	
6	<i>Semifusus morio</i>	7	-	8	-	5	13	10	12	9	11	13	-	12	8	
7	<i>Drupa nodulosa</i>	11	12	-	9	9	9	7	7	11	9	9	13	6	10	
8	<i>Conus ambiguous</i>	9	5	5	8	7	-	9	11	7	7	-	8	13	-	
9	<i>Nassa semistriata</i>	10	15	9	7	-	7	6	-	13	13	13	10	7	6	
10	<i>Palices sp</i>	7	8	8	5	9	6	10	-	16	8	9	8	-	13	
11	<i>Cypraea zonata</i>	4	10	5	8	11	7	-	5	4	6	7	-	8	14	
12	<i>Amoria zebra</i>	8	14	13	9	12	13	9	14	15	9	8	9	13	-	
13	<i>Astraea jacquelina</i>	11	8	-	10	-	9	8	6	9	7	2	-	4	10	
14	<i>Ianthina fragilis</i>	-	-	-	-	-	-	2	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>132</b>	<b>123</b>	<b>94</b>	<b>111</b>	<b>104</b>	<b>111</b>	<b>104</b>	<b>102</b>	<b>126</b>	<b>116</b>	<b>108</b>	<b>84</b>	<b>107</b>	<b>119</b>	<b>1541</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	17	15	10	10	12	9	7	6	14	-	9	9	13	10	
2	<i>Tabulipora sp</i>	11	10	8	11	8	7	-	9	5	7	5	7	15	13	
3	<i>Culcumaria sp</i>	21	4	9	5	-	6	10	5	7	8	-	9	11	10	
	<b>Abundance (n) per station</b>	<b>49</b>	<b>29</b>	<b>27</b>	<b>26</b>	<b>20</b>	<b>22</b>	<b>17</b>	<b>20</b>	<b>26</b>	<b>15</b>	<b>14</b>	<b>26</b>	<b>39</b>	<b>33</b>	<b>363</b>

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C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	9	6	9	8	10	-	5	13	-	6	13	10	3	7	
2	<i>Ophiura africana</i>	2	7	13	13	7	8	9	-	6	4	11	-	-	9	
3	<i>Poraria sp</i>	10	11	8	7	11	10	6	7	10	-	14	13	8	5	
	<b>Abundance (n) per station</b>	<b>21</b>	<b>24</b>	<b>30</b>	<b>20</b>	<b>28</b>	<b>18</b>	<b>20</b>	<b>20</b>	<b>16</b>	<b>10</b>	<b>38</b>	<b>23</b>	<b>11</b>	<b>24</b>	<b>296</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium vulgore</i>	25	25	31	18	21	18	27	15	19	31	23	28	19	30	
	<b>Abundance (n) per station</b>	<b>25</b>	<b>25</b>	<b>31</b>	<b>18</b>	<b>21</b>	<b>18</b>	<b>27</b>	<b>15</b>	<b>19</b>	<b>31</b>	<b>23</b>	<b>28</b>	<b>19</b>	<b>30</b>	<b>330</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	1	-	-	-	3	-	-	-	-	-	-	-	1	-	
	<i>Cynoponticus ferox</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
-	<b>Abundance (n) per station</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>5</b>
F	<b>Crustacea</b>															
	<i>Chibanarius africana</i>	-	-	2	-	-	-	-	1	-	-	-	-	-	-	
	<i>Sylisrolifera sp</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>4</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	
2	<i>Sabella meranostigma</i>	3	-	1	-	-	-	2	-	-	-	-	-	-	-	
3	<i>Axiiothella sp</i>	-	-	-	-	-	-	-	-	-	1	-	-	2	-	
4	<i>Ophelia capensis</i>	-	-	-	-	1	-	-	-	-	-	1	-	-	-	
	<b>Abundance (n) per station</b>	<b>4</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>12</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	-	-	1	-	-	-	-	2	-	-	-	-	1	-	
2	<i>Ceratoporolla nicholsm</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>4</b>
	<b>Station by station overall abundance (n)</b>	<b>285</b>	<b>257</b>	<b>239</b>	<b>221</b>	<b>232</b>	<b>216</b>	<b>212</b>	<b>224</b>	<b>231</b>	<b>226</b>	<b>219</b>	<b>207</b>	<b>238</b>	<b>257</b>	<b>3264</b>

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**Appendix 3c Continued: Species composition of the Macroenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 62	EA 60	EA 66	EA 61	EA 68	EA 72	EA 69	EA 77	EA 73	EA 70	EA 71	EA 65	EA 63	EA 64	
Ai	<b>Mollusca (Bivalvia)</b>															
1	<i>Donax rugosus</i>	15	11	9	9	8	11	13	12	9	11	7	9	7	15	
2	<i>Donax vittatus</i>	13	10	10	12	10	16	7	5	-	12	13	10	4	9	
3	<i>Donax pulchellus</i>	13	-	15	11	13	17	5	16	11	14	17	12	9	-	
4	<i>Chthamalus dalli</i>	10	10	9	13	-	11	12	7	13	-	7	-	-	11	
5	<i>Cardium costatum</i>	21	15	11	5	11	-	9	-	11	9	15	11	10	12	
6	<i>Callisella pelta</i>	18	11	7	12	10	11	5	11	-	13	5	13	9	14	
	<b>Abundance (n) per station</b>	<b>90</b>	<b>57</b>	<b>51</b>	<b>62</b>	<b>52</b>	<b>66</b>	<b>51</b>	<b>51</b>	<b>44</b>	<b>59</b>	<b>64</b>	<b>55</b>	<b>39</b>	<b>61</b>	<b>802</b>
ii	<b>Mollusca (Gastropode)</b>															
1	<i>Oliva acuminata</i>	18	11	18	19	13	18	17	10	19	12	18	16	11	21	
2	<i>Murex sp.</i>	10	10	9	5	9	15	10	-	14	10	-	11	6	13	
3	<i>Merita senegalensis</i>	13	10	8	-	5	8	9	10	13	9	5	7	11	-	
4	<i>Murex cornutus</i>	7	6	10	8	11	-	10	7	10	11	8	8	9	14	
5	<i>Fissurella nubecula</i>	9	15	13	7	9	11	-	11	8	13	11	-	15	11	
6	<i>Senifusus morio</i>	14	6	-	8	10	13	9	10	-	12	5	13	9	-	
7	<i>Drupa nodulosa</i>	13	5	7	13	7	-	10	8	9	8	7	8	8	10	
8	<i>Conus ambiguous</i>	9	14	13	9	9	8	-	6	8	-	9	9	-	10	
9	<i>Nassa semistriata</i>	5	13	8	7	9	7	8	5	8	13	8	6	7	13	
10	<i>Palices sp</i>	-	9	9	5	6	9	-	8	6	8	7	9	-	9	
11	<i>Cypraea zonata</i>	13	-	15	6	7	6	7	13	-	16	-	13	13	10	
12	<i>Amoria zebra</i>	5	8	4	8	-	4	-	7	8	-	8	5	8	6	
13	<i>Astraea jacquelina</i>	-	14	6	9	10	12	9	11	9	10	12	-	10	12	
	<b>Abundance (n) per station</b>	<b>116</b>	<b>121</b>	<b>120</b>	<b>104</b>	<b>105</b>	<b>111</b>	<b>89</b>	<b>106</b>	<b>112</b>	<b>122</b>	<b>98</b>	<b>105</b>	<b>107</b>	<b>129</b>	<b>1545</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	12	9	11	16	-	11	13	11	7	5	15	8	-	19	
2	<i>Tabulipora sp</i>	12	15	7	5	9	7	9	-	11	9	10	-	9	12	
3	<i>Culcumaria sp</i>	-	12	3	-	9	13	7	13	9	-	10	6	7	12	
	<b>Abundance (n) per station</b>	<b>24</b>	<b>36</b>	<b>21</b>	<b>21</b>	<b>18</b>	<b>31</b>	<b>29</b>	<b>24</b>	<b>27</b>	<b>14</b>	<b>35</b>	<b>14</b>	<b>16</b>	<b>43</b>	<b>353</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	13	17	7	13	18	8	6	8	10	9	6	9	7	17	
2	<i>Ophiura africana</i>	10	13	11	6	13	16	6	9	4	6	11	13	15	19	
3	<i>Poraria sp</i>	7	15	13	-	13	19	13	6	19	7	13	-	13	13	
	<b>Abundance (n) per station</b>	<b>30</b>	<b>45</b>	<b>31</b>	<b>19</b>	<b>44</b>	<b>43</b>	<b>25</b>	<b>23</b>	<b>33</b>	<b>22</b>	<b>30</b>	<b>22</b>	<b>35</b>	<b>49</b>	<b>451</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium sp</i>	30	23	18	27	19	33	15	17	24	27	31	30	27	28	
	<b>Abundance (n) per station</b>	<b>30</b>	<b>23</b>	<b>18</b>	<b>27</b>	<b>19</b>	<b>33</b>	<b>15</b>	<b>17</b>	<b>24</b>	<b>27</b>	<b>31</b>	<b>30</b>	<b>27</b>	<b>28</b>	<b>349</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	-	2	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Cynoponticus ferox</i>	-	-	-	-	-	-	-	-	-	1	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>3</b>
F	<b>Crustacea</b>															
	<i>Chibanarius africana</i>	-	3	-	-	-	-	-	-	-	-	-	-	-	-	
	<i>Sylisrolifera sp</i>	-	1	-	-	-	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>4</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>4</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	2	-	3	-	2	-	-	-	-	1	-	-	1	-	
2	<i>Sabella meranostigma</i>	3	-	-	-	2	-	4	-	-	-	-	-	-	2	
3	<i>Axiiothella sp</i>	-	-	1	1	-	3	-	-	-	1	-	-	-	-	
4	<i>Ophelia capensis</i>	1	-	-	-	-	-	-	-	-	-	-	-	1	-	
	<b>Abundance (n) per station</b>	<b>6</b>	<b>-</b>	<b>4</b>	<b>-</b>	<b>4</b>	<b>3</b>	<b>4</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>2</b>	<b>27</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	1	-	-	-	-	-	2	-	-	-	1	-	1	-	
2	<i>Ceratoporolla Nicholism</i>	-	-	-	-	-	-	-	-	-	-	-	-	-	1	
	<b>Abundance (n) per station</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>6</b>
	<b>Station by station overall abundance (n)</b>	<b>297</b>	<b>288</b>	<b>245</b>	<b>233</b>	<b>242</b>	<b>287</b>	<b>215</b>	<b>221</b>	<b>240</b>	<b>247</b>	<b>259</b>	<b>226</b>	<b>227</b>	<b>315</b>	<b>3542</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3c Continued: Species composition of the Macroenthos of the OML 79 Field during the October/November, 2018 EIA Studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified														Total
		EA 75	EA 2	EA 3	EA 4	EA 5	EA 6	EA 18	EA 7	EA 8	EA 9	EA 10	EA 20	EA 17	EA 16	
Ai	<b>Mollusca (Bivalvia)</b>															
1	<i>Donax rugosus</i>	13	15	12	11	15	11	10	9	9	11	9	11	9	13	
2	<i>Donax vittatus</i>	15	10	15	14	11	18	9	5	7	15	-	9	11	18	
3	<i>Donax pulchellus</i>	11	9	13	7	-	9	4	7	-	11	13	11	15	13	
4	<i>Chthamalus dalli</i>	9	14	7	-	13	4	5	12	9	5	15	13	-	11	
5	<i>Callisella pelta</i>	15	6	11	9	10	-	12	10	8	12	11	-	7	-	
	<b>Abundance (n) per station</b>	<b>63</b>	<b>54</b>	<b>58</b>	<b>41</b>	<b>49</b>	<b>42</b>	<b>40</b>	<b>43</b>	<b>33</b>	<b>54</b>	<b>48</b>	<b>44</b>	<b>42</b>	<b>55</b>	
ii	<b>Mollusca (Gastropods)</b>															
1	<i>Oliva acuminata</i>	13	12	11	9	10	13	11	8	13	12	13	8	9	13	
2	<i>Murex sp.</i>	11	13	10	7	8	7	-	13	8	5	9	9	11	7	
3	<i>Merita senegalensis</i>	13	-	15	12	8	16	8	6	13	9	5	8	13	11	
4	<i>Murex cornutus</i>	16	13	10	-	11	16	10	10	7	-	11	-	9	-	
5	<i>Fissurella nubecula</i>	16	18	8	13	-	7	13	8	5	8	7	9	5	12	
6	<i>Semifusus morio</i>	9	7	5	9	8	10	15	4	-	7	4	-	8	-	
7	<i>Drupa nodulosa</i>	14	15	13	11	-	7	7	5	15	7	9	8	13	11	
8	<i>Conus ambiguous</i>	7	8	-	8	7	9	-	8	8	9	6	7	9	-	
9	<i>Nassa semistriata</i>	13	9	10	13	9	14	10	4	10	11	8	11	-	13	
10	<i>Palices sp</i>	4	6	3	-	8	-	13	-	6	-	9	10	7	5	
11	<i>Cypraea zonata</i>	11	-	7	5	6	11	9	11	8	9	8	-	13	7	
12	<i>Amoria zebra</i>	3	8	-	-	3	5	7	4	5	11	-	2	2	11	
13	<i>Astraea jacquelina</i>	5	10	2	-	8	5	4	-	-	8	5	-	-	9	
14	<i>Ianthina fragilis</i>	-	-	-	1	-	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>135</b>	<b>119</b>	<b>94</b>	<b>88</b>	<b>86</b>	<b>120</b>	<b>107</b>	<b>82</b>	<b>98</b>	<b>96</b>	<b>94</b>	<b>72</b>	<b>99</b>	<b>99</b>	<b>1389</b>
B	<b>Bryozoans</b>															
1	<i>Evactinupora sp</i>	14	13	18	15	11	21	13	10	16	11	21	8	16	18	
2	<i>Tabulipora sp</i>	12	15	6	-	-	8	-	7	9	7	7	11	10	13	
3	<i>Culcumaria sp</i>	18	12	18	4	-	7	5	10	-	-	8	6	6	10	
	<b>Abundance (n) per station</b>	<b>44</b>	<b>40</b>	<b>42</b>	<b>19</b>	<b>11</b>	<b>36</b>	<b>18</b>	<b>27</b>	<b>25</b>	<b>18</b>	<b>36</b>	<b>25</b>	<b>32</b>	<b>41</b>	<b>414</b>



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C	<b>Echinodermata</b>															
1	<i>Asterias rubbens</i>	5	4	-	5	9	5	8	7	5	8	-	8	5	7	
2	<i>Ophiura africana</i>	8	10	4	11	6	3	-	2	-	4	7	4	4	4	
3	<i>Poraria sp</i>	9	7	6	7	5	-	-	-	4	2	9	7	3	-	
	<b>Abundance (n) per station</b>	<b>22</b>	<b>21</b>	<b>10</b>	<b>23</b>	<b>20</b>	<b>8</b>	<b>8</b>	<b>9</b>	<b>9</b>	<b>14</b>	<b>16</b>	<b>19</b>	<b>12</b>	<b>11</b>	<b>202</b>
D	<b>Scaphopoda</b>															
1	<i>Dentalium vulgore</i>	21	18	18	27	19	13	16	24	24	16	17	11	11	28	
	<b>Abundance (n) per station</b>	<b>21</b>	<b>18</b>	<b>18</b>	<b>27</b>	<b>19</b>	<b>13</b>	<b>16</b>	<b>24</b>	<b>24</b>	<b>16</b>	<b>17</b>	<b>11</b>	<b>11</b>	<b>28</b>	<b>263</b>
E	<b>Chordata</b>															
	<i>Erichelycore nigricans</i>	1	-	1	-	-	-	-	-	-	-	1	-	-	-	
	<i>Cynoponticus ferox</i>	-	-	2	-	-	-	-	-	-	-	-	-	-	2	
	<b>Abundance (n) per station</b>	<b>1</b>	<b>-</b>	<b>3</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>2</b>	
F	<b>Crustacea</b>															
	<i>Chibanarius Africana</i>	2	-	-	-	1	-	-	-	-	3	-	-	1	-	
	<i>Sylisrolifera sp</i>	-	-	-	-	-	1	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>3</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>8</b>
G	<b>Polychaeta (Annelids)</b>															
1	<i>Nereis ciliate</i>	4	-	-	-	-	-	-	-	-	-	-	-	-	1	
2	<i>Sabella meranostigma</i>	-	-	-	1	-	-	1	-	1	-	-	1	-	-	
3	<i>Axiothella sp</i>	-	-	-	-	1	-	-	-	-	-	-	-	1	-	
4	<i>Ophelia capensis</i>	1	-	-	-	-	-	-	-	-	-	-	-	-	-	
	<b>Abundance (n) per station</b>	<b>5</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>12</b>
H	<b>Sponges</b>															
1	<i>Verongia sp.</i>	-	-	-	-	1	-	-	-	-	-	1	-	-	-	
2	<i>Ceratoporolla Nicholism</i>	-	-	-	-	-	-	-	-	-	-	-	1	-	-	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>1</b>	<b>-</b>	<b>-</b>	<b>3</b>
	<b>Station by station overall abundance (n)</b>	<b>293</b>	<b>252</b>	<b>225</b>	<b>199</b>	<b>188</b>	<b>220</b>	<b>190</b>	<b>185</b>	<b>190</b>	<b>201</b>	<b>213</b>	<b>173</b>	<b>198</b>	<b>237</b>	<b>2964</b>

**Environmental Impact Assessment of EA/EJA Further Oil Development Project**

**Appendix 3c Continued: Species composition of the *Macrobenthos* of within OML 79 Field(October/November) EIA studies**

S/N	Taxonomic List	Sample ID / Number of individuals (n) identified							Total
		EA 15	EA 14	EA 13	EA 12	EA 19	EA 21	EA 22	
Ai	<b>Mollusca (Bivalvia)</b>								
1	<i>Donax rugosus</i>	19	21	15	13	16	18	16	
2	<i>Donax vittatus</i>	15	9	9	14	11	13	14	
3	<i>Donax pulchellus</i>	18	19	17	15	10	12	10	
4	<i>Chthamalus dalli</i>	12	15	9	-	8	10	7	
5	<i>Cardium costatum</i>	11	17	18	9	10	13	-	
6	<i>Callisella pelta</i>	15	13	12	-	9	-	9	
	<b>Abundance (n) per station</b>	<b>100</b>	<b>94</b>	<b>80</b>	<b>51</b>	<b>64</b>	<b>66</b>	<b>56</b>	<b>511</b>
ii	<b>Mollusca (Gastropoda)</b>								
1	<i>Oliva acuminata</i>	16	17	17	10	13	10	17	
2	<i>Murex sp.</i>	15	16	13	18	15	7	9	
3	<i>Merita senegalensis</i>	10	18	17	19	4	11	14	
4	<i>Murex cornutus</i>	8	6	8	13	-	-	16	
5	<i>Fissurella nubecula</i>	9	11	9	6	7	7	-	
6	<i>Senifusus morio</i>	8	10	5	-	6	9	9	
7	<i>Drupa nodulosa</i>	8	15	8	9	4	8	7	
8	<i>Conus ambiguous</i>	5	9	7	-	6	8	7	
9	<i>Nassa semistriata</i>	8	-	6	8	4	7	-	
10	<i>Palices sp</i>	5	-	8	8	-	7	9	
11	<i>Cypraea zonata</i>	9	6	-	9	8	-	9	
12	<i>Amoria zebra</i>	-	6	8	7	8	8	5	
13	<i>Astraea jacquelina</i>	-	5	4	-	5	7	-	
	<b>Abundance (n) per station</b>	<b>101</b>	<b>119</b>	<b>110</b>	<b>107</b>	<b>80</b>	<b>97</b>	<b>102</b>	<b>716</b>
B	<b>Bryozoans</b>								
1	<i>Evactinupora Sp</i>	25	19	9	11	17	10	14	
2	<i>Tabulipora Sp</i>	18	13	7	13	7	8	8	
3	<i>Culcumaria Sp</i>	-	6	4	9	-	12	6	
	<b>Abundance (n) per station</b>	<b>43</b>	<b>38</b>	<b>20</b>	<b>33</b>	<b>24</b>	<b>30</b>	<b>28</b>	<b>216</b>
C	<b>Echinodermata</b>								
1	<i>Asterias rubbens</i>	13	17	14	9	7	18	13	
2	<i>Ophiura africana</i>	12	18	14	8	5	7	15	
3	<i>Poraria sp</i>	7	4	10	4	5	10	9	

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	<b>Abundance (n) per station</b>	<b>32</b>	<b>39</b>	<b>38</b>	<b>21</b>	<b>17</b>	<b>35</b>	<b>37</b>	<b>219</b>
D	<b>Scaphopoda</b>								
1	<i>Dentalium sp</i>	21	20	15	15	19	17	24	
	<b>Abundance (n) per station</b>	<b>21</b>	<b>20</b>	<b>15</b>	<b>15</b>	<b>19</b>	<b>17</b>	<b>24</b>	<b>131</b>
E	<b>Chordata</b>								
	<i>Erichelycore nigricans</i>	1	-	2	-	-	1	-	
	<i>Cynoponticus ferox</i>	1	-	-	-	-	1	1	
	<b>Abundance (n) per station</b>	<b>2</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>2</b>	<b>1</b>	<b>7</b>
F	<b>Crustacea</b>								
	<i>Chibanarius africana</i>	-	-	1	-	2	-	2	
	<i>Sylisrolifera sp</i>	-	-	-	-	-	-	1	
	<b>Abundance (n) per station</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>2</b>	<b>-</b>	<b>3</b>	<b>6</b>
G	<b>Polychaeta (Annelids)</b>								
1	<i>Nereis ciliate</i>	4	-	-	-	2	-	1	
2	<i>Sabella meranostigma</i>	-	-	1	-	-	1	1	
3	<i>Axiothella sp</i>	-	1	-	-	1	-	-	
4	<i>Ophelia capensis</i>	1	-	-	1	-	-	1	
	<b>Abundance (n) per station</b>	<b>5</b>	<b>1</b>	<b>1</b>	<b>1</b>	<b>3</b>	<b>1</b>	<b>3</b>	<b>15</b>
H	<b>Sponges</b>								
1	<i>Verongia sp.</i>	1	-	-	-	1	-	-	
2	<i>Ceratoporolla Nicholsm</i>	1	-	-	-	-	-	1	
	<b>Abundance (n) per station</b>	<b>2</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>1</b>	<b>-</b>	<b>1</b>	<b>4</b>
	<b>Station by station overall abundance (n)</b>	<b>306</b>	<b>311</b>	<b>267</b>	<b>228</b>	<b>210</b>	<b>248</b>	<b>255</b>	<b>1825</b>