DRAFT

ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT OF THE PROPOSED FURTHER FIELD DEVELOPMENT OF UMUSETI-IGBUKU FIELDS OF PILLAR OIL LIMITED, OML56 IN NDOKWA WEST LGA OF DELTA STATE

Submitted To

FEDERAL MINISTRY OF ENVIRONMENT

Environment House, Mabushi, FCT, Abuja

By

PILLAR OIL LIMITED

4 Justice Rose Ukeje street, Lekki, Lagos State, Nigeria

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AUGUST, 2020

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LIST OF ABBREVIATIONS AND ACRONYMS

AFEL		Afruitful Environment Limited
ALARP	-	As Low as Reasonably Practicable
APHA	-	American Public Health Association
API	-	American Petroleum Institute
As	-	Arsenic
ASTM	-	American Society for Testing and Materials
Ba	-	Barium
BATNEEC	-	Best Available Technology Not Entailing Excessive Cost
BOD	-	Biochemical Oxygen Demand
BTEX	-	Benzene, Toluene, Ethylbenzene and Xylene
Ca	-	Calcium
CCR	-	Central Control Room
CCS	-	Convention on the Continental Shelf
Cd	-	Cadmium
CEC	-	Cation Exchange Capacity
cfu	-	Coliform Forming Unit
CFC	-	Chloroflorocarbons
CH_4	-	Methane
CHARM	-	Chemical Hazard Assessment and Risk Management
Cl^-	-	Chloride Ion
CLC	-	Convention on Civil Liability for Oil Pollution Damage
CNA	-	Clean Nigeria Associates
CO	-	Carbon Monoxide
CO_2	-	Carbon Dioxide
COD	-	Chemical Oxygen Demand
COLREG	-	Convention on the International Regulations for Preventing Collisions at Sea
Cr	-	Chromium

CTD	-	Conductivity Temperature Density Profiling
Cu	-	Copper
dBA	-	Decibels
Deg	-	Degree
DGPS	-	Differential Geographical Positioning System
DO	-	Dissolved Oxygen
DPR	-	Department of Petroleum Resources
DSMEnv	-	Delta State Ministry of Environment
EA	-	Environmental Assessment
EEZ	-	Exclusive Economic Zone
EGASPIN	-	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EHSS	-	Environmental Health and Safety Standards
EIA	-	Environmental Impact Assessment
EIS	-	Environmental Impact Statement
EMP	-	Environmental Management Plan
EMS	-	Environment Management System
EPA	-	Environmental Protection Agency
ESA	-	Environmentally Sensitive Areas
ESI	-	Environmental Sensitivity Index
ESP	-	Exchange Sodium Potential
E&P	-	Exploration and Production
Fe	-	Iron
FD		Field Development
FEPA	-	Federal Environmental Protection Agency
FID	-	Final Investment Decision
FMEnv	-	Federal Ministry of Environment
GPS	-	Global Positioning System
H_2S	-	Hydrogen Sulphide
HAZID	-	Hazard Identification Study

HAZOP	-	Hazard and Operability Study
HC	-	Hydrocarbon
HCFC	-	Hydro chlorofluorocarbons
HCO_3^-	-	Bicarbonate Ion
Hg	-	Mercury
HP	-	High Pressure
Hs	-	Shannon-Wiener Index
HSE	-	Health Safety and Environment
HSE-MS	-	Health Safety and Environment Management System
HSSE	-	Health, Safety, Security and Environment
HUB	-	Hydrocarbon Utilizing Bacteria
HUF	-	Hydrocarbon Utilizing Fungi
IFC	-	International Finance Corporation
IMO	-	International Maritime Organization
IMS	-	Integrated Management System
IOPC	-	International Oil Pollution Compensation Funds
ISO	-	International Organization for Standardization
ITCZ	-	Inter-Tropical Convergence Zone
j	-	Equitability Index
K	-	Potassium
Km	-	Kilometre
Lat	-	Latitude
LP	-	Low Pressure
LPG	-	Liquified Petroleum Gas
LRA	-	Lav-radioactive avleiringer
LSA	-	Low Specific Activity
Long	-	Longitude
MAP	-	Mutual Assistance Plan
MARPOL	-	Marine Pollution
Mg	-	Magnesium

Mg/kg	-	Milligram per kilogram
MMSCF/D	-	Million Standard Cubic Feet Per Day
MSL	-	Mean Sea Level
N	-	North
NAG	-	Natural Gas Association
NDHS		Nigerian Demographic Household Survey
NESRA	-	National Environmental Standards and Regulations Agency
NH_4^+	-	Ammonium
Ni	-	Nickel
NiMet	-	Nigerian Meteorological Agency
NNPC	-	Nigerian National Petroleum Corporation
NORM	-	Naturally Occurring Radioactive Materials
NO_2	-	Nitrogen Dioxide
NO_3	-	Nitrate
NO_3^-	-	Nitrate Ion
NO_x	-	Mono-Nitrogen Oxides
NORM	-	Naturally Occurring Radioactive Materials
NOSDRA	-	National Oil Spill Detection and Response Agency
NTU	-	Nephelometric Turbidity Unit
NW	-	North West
N_2O	-	Nitrous Oxide
OBM	-	Oil-Based Mud
OH	-	Open Hole
OILPOL	-	Convention for the Prevention of Pollution of the Sea by Oil
OML	-	Oil Mining License
OPL	-	Oil Prospecting License
OPRC	-	International Convention on Oil Pollution Preparedness, Response & Co-operation

OSPAR	-	Oslo/ Paris Convention for the Protection of the Marine Environment of the North East Atlantic
OSRL	-	Oil Spill Response Limited
PAH	-	Polynuclear Aromatic Hydrocarbons
Pb	-	Lead
pH	-	Hydrogen ion concentration
Plc	-	Public Limited Company
PPL	-	Platform Petroleum Limited
PM	-	Particulate Matter
POB	-	Persons on Board
POL	-	Pilar Oil Limited
PPE	-	Personal Protective Equipment
PSU	-	Practical Salinity Units
Pt-Co Units	-	Platinum-Cobalt Standard
SBM	-	Synthetic Based Mud
SO_4	-	Sulphate
SO_x	-	Sulphur Oxides
SOW	-	Scope of Work
Sp	-	Species
SPM	-	Suspended Particulate Matter
SSW	-	South South-West
STCW	-	Standards of Training Certification and Watch-Keeping for Seafarer
TAH	-	Total Aliphatic Hydrocarbon
TDS	-	Total Dissolved Solids
TDU	-	Thermal Desorption Unit
THB	-	Total Heterotrophic Bacteria
THC	-	Total Hydrocarbon Content
THF	-	Total Heterotrophic Fungi
TOC	-	Total Organic Content

ToR	-	Terms of Reference
TPH	-	Total Petroleum Hydrocarbon
TSS	-	Total Suspended Solids
µg/m^3	-	Microgram per cubic meter
UNCLOS	-	United Nations Conference on the Law of the Sea
UNEP	-	United Nations Environment Programme
USEPA	-	United States Environmental Protection Agency
UTM	-	Universal Transverse Mercator
V	-	Vanadium
V	-	Volts
VOC	-	Volatile Organic Carbon
W	-	West
WBM	-	Water-based mud
WHO	-	World Health Organization
WMO	-	World Meteorological Organization
WMP	-	Waste Management Plan
Zn	-	Zinc

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DECLARATION

PILLAR OIL LIMITED, THE PROPONENTS, IDENTIFIES AND ACCEPTS RESPONSIBILITY FOR ALL STATEMENTS AND JUDGMENTS MADE IN THIS REPORT ENTITLED 'ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT REPORT FOR FURTHER FIELD DEVELOPMENT OF UMUSETI-IGBUKU FIELDS OF PILLAR OIL LIMITED, IN NDOKWA WEST LGA OF DELTA STATE'

ACKNOWLEDGEMENTS
The Management of Pillar Oil Limited sincerely appreciates the representatives of Department of Petroleum Resources and Delta State Ministry of Environment for the unflinching supports they gave throughout the assessment study. The robust contributions of the staff of Pillar Oil and AFEL study team (the Environmental Consultant) are also generously recognised and appreciated.

EXECUTIVE SUMMARY

E.S.1 Background Information

Pillar Oil Limited is a wholly indigenous exploration and production oil and gas company operating in Nigeria. Incorporated on 10th July, 1997, the Company operates under the highest standards while making a positive impact on the Nigerian economy. Currently the Company has operations in Lagos and Delta States of Nigeria.

The Marginal Fields programme commenced following Decree No. 23 in 1996 and the "Government Policy and Guidelines on the Development of Marginal Fields in the Country" on 5th December, 2000. On 25th February, 2003, after rigorous competitive bidding for 24 fields hitherto operated by Shell (12), Chevron (8) and Elf (4), Pillar Oil Limited was awarded, on a sole risk basis, 100% participating interest and Operatorship of the onshore Umuseti/Igbuku field complex (OML 56) located in Kwale, Delta State, Nigeria. The field was previously operated by Elf Nigeria Limited.

The Umuseti/Igbuku field complex has two proven oil and gas fields (Umuseti and Igbuku) and four identified satellite prospects (Umuseti-North East, Umuseti-East, Igbuku-West and Igbuku-North). Pillar Oil Limited proposes to carry out further development of its field. The proposed Further Field Development activities include construction of Gas Plant, Drilling, laying of Pipeline and Work-over Projects, etc. which will be executed in phases over a period of five (5) years (herein referred to as project).

Pillar Oil Limited recognizes the importance of comprehensive environmental and social planning and management to the success of any project and is committed to the necessary studies aimed at describing and understanding the environment and social conditions of the project area in order to assess and evaluate possible environmental (natural and physical) and social impacts that may occur as a result of project development activities, and also during the operation of the facilities.

In compliance with *PART VIII A, Section 3.1.2 of the Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, Revised Edition 2018),* the Pillar Oil Limited through her consultant, AFEL, accredited by Department of Petroleum Resources (DPR), Federal Ministry of Environment and National Environmental Standards and Regulations Enforcement Agency (NESREA), carrid out an Environmental and Social Impact Assessment of the proposed Further Field Development activities and prepared this Environmental and Social Impact Assessment Report (ESIA). The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts

The assessment was carried out to amongst other things to

- Acquire and utilize environmental data from wet and dry seasons field data gathering exercises in the Field
- establish the environmental conditions of the projects location thereby identifying the resources that may be affected by the proposed project activities;
- identify the environmental aspects that will affect the proposed additional development activities in the Field;
- evaluate the extent of impacts (negative and beneficial), of project activities on the ecology/environmental media i.e. biophysical, health and socio-economic components of the area
- recommend preventive, reduction and control measures for identified potential/associated adverse impacts of the project;
- develop a cost effective EMP that recommends plans and procedures to manage the consequences and recover from exceptional events throughout the lifetime of the project;
- provide the basis for consultation with regulatory authorities, the public and other stakeholders; and support subsequent applications for associated environmental permits.
- Preparation of detailed draft report to meet FMEnv permitting requirements

The ESIA was carried out in line with procedures provided in the Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004 as well as EGASPIN, 1991 [Revised in 2018]. The study was carried out by a multidisciplinary team of experienced researchers employing standard methods from pure science, engineering, social and health sciences in order to obtain basic data for impact identification and establishment of mitigation and monitoring measures. The study generally involved desktop studies, field research, consultation, impact assessment and proffering of mitigation measures and development of an Environmental and Social Management Plan (ESMP).

The proposed project is affected by a number of national, state and international legislation which have been considered by the ESIA. A review of relevant legislation was done and briefed. These regulations are;

- Environmental Impact Assessment (EIA) CAP E12 LFN 2004

- Environmental Guidelines and Standards for the Petroleum Industry, EGASPIN (1991, as Revised in 2002 and 2018).
- National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)
- Petroleum Act 1969
- Petroleum Products and Distribution Act, CAP P12, LFN 2004
- National Environmental Protection (Effluent Limitations) Regulations, S.I.8
- National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes), S.I.9 of 1991
- National Environmental Protection (Management of Hazardous and Solid Wastes), S.I.15 of 1991
- Land Use Act, L5 LFN 2004
- Forestry Law CAP 55, 1994
- Endangered Species Act (Cap 108), 1990
- Delta State Ecology Law 2006
- Delta State Environmental Protection Agency Edict No 5 of 1997
- Delta State Climate Change Policy 2010
- Delta State Waste Management Law 2004
- Delta State Forestry Law Cap 59, 1976
- Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and their Disposal (1989)
- Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund, 1992)
- United Nations Framework Convention on Climate Change (1992)
- World Bank Guidelines on Environmental Assessment
- United Nations Guiding Principles on the Human Environment
- The Rio Declaration on Environment and Development
- International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990

E.S.2 Project Justification and Alternative

With Crude oil revenues constituting over 90% of Nigeria's foreign exchange earnings over the last couple of decades, the oil and gas industry therefore represents the primary earner for the country. Pillar Oil Limited plays its part in nation building by providing employment and revenue for the government as well as running a financially profitable company.

Due to the importance of the oil and gas industry to the Nigerian economy, the Federal Government is always in support of environmentally friendly schemes to expand and diversify the sector. The drilling of oil well and establishing a gas plant in Umuseti-Igbuku fields and will allow for increased near term oil and gas production which in turn will increase earnings accruing to the purse of the Nigerian Government. This benefit, coupled with the number of jobs this project would produce and the beneficial impacts to the immediate community, makes this project a necessity.

The benefit of the project includes:

- Expanding the scope of the proponent's participation in Nigeria's oil industry and diversifying the sources of investment and inflow of funds;
- Increasing the oil and gas reserves base through aggressive exploration;
- Promoting indigenous participation in the oil industry thereby fostering technological transfer;
- Providing opportunity to gainfully engage the pool of high-level technically competent Nigerians in the oil and gas business;
- Promoting common usage of assets/facilities to ensure optimum utilization of available excess capacities;
- Expanding production output capacity;
- Maximizing the production potentials of the field; and
- Enhancing employment opportunity.

On the other hand, Igbuku Gas Plant will produce Liquefied Petroleum Gas (LPG) as its product with the following advantages or benefits:

- Enable greater utilization of indigenous natural gas reserves targeted at domestic increasing domestic gas consumption, helping to develop national industrial and economic activity;
- Natural gas is a much cleaner fuel than diesel or petrol – reducing the risk of damage and extending the life of industrial equipment. Gas generators also have long service intervals (up to 30,000 hours), reducing maintenance and aftermarket costs; and
- Natural gas can replace several types of solid, liquid, and gaseous fuels in industrial processes (from steel to paper production) and is the most cost-effective fuel for power generation in Nigeria, boosting productivity and competitiveness

The anticipated cost of the proposed project will be in the region of US$ 80 – 100 million. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government.

The proposed project will be undertaken using the Best Available Technology (BAT) and internationally recognised processes in the industry. To ensure technical, economic, environmental and social sustainability of the project, the specific measures to be taken shall include but not necessarily limited to the following:

- ✓ **Technical Sustainability:** The proposed project will be technically sustainable, utilising modern practices and techniques in the plant design and adhering to international and national engineering design and construction standards and codes of practices that shall be adopted throughout all stages of the proposed project development e.g. NFPA 59A, EN 1473, EN 13645, ISO 16903, API 625, ASME VIII Div 1, ASME B31.3, ASME B16.5, ASME B16.47 series A, AGA-3, AGA-9, API 11P, API 618, ISO 13631, API-610 10th edition, API-660 as TEMA ‘C’, CSA B51, CSA certification, CSA certification, NEMA standards, NACE MR-0175, FM, API-2510 etc.
- ✓ **Economic Sustainability:** Pillar Oil shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security.
- ✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because Pillar Oil’s activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs.
- ✓ **Social Sustainability:** To ensure social sustainability of the project, Pillar Oil will ensure robust stakeholder engagement and establish a grievance mechanism

In line with *National Environmental Protection (Effluent Limitations) Regulation of 1991* which mandates early selection of best engineering and operational options for new point sources, a range of options and alternatives were evaluated to facilitate identification of the most appropriate means of meeting the project’s environmental objective.

The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

Project Options

The project options were evaluated; the no project option, delayed project option and Go-Ahead option were discussed for the proposed project. The Go-Ahead option was deemed viable and therefore considered the best option. Therefore, the proposed project shall be executed as planned.

- **Alternative Location**

The site/ location selection criteria included a wide range of engineering, environment, permitting and economic considerations. Current fields (Umuseti/Igbukur) and other fields were considered in selecting the location of the project.. Due to the considerations stated above, the preferred Alternative was the Umuseti/Igbuku Fields

- **Alternative LPG Processes**

An LPG Refrigeration Process and a Lean Oil Absorption Process was considered. The LPG refrigeration process was preferred because it is very economical and efficient

- **Alternative Transportation Method of Gas to the Plant**

The Umuseti/Igbuku pipeline was preferred to the use of barges/vessels as it is a more cost-effective option and the pipeline is currently operational and in good state.

- **Output Gas Transportation**

The Preferred alternative was Through Virtual Pipeline (Trucks) instead of pipelines from the Gas Plant due to environmental and economic considerations and its cost effectiveness

- **Alternative Technology**

Turbo Expansion was preferred compared with Inlet Compression + JT Gas Plant and MRU + Sales Compression due to safety concerns and its efficiency

- **Alternative Product Storage Type**

The Above-Ground Storage Tanks was preferred to the In-Ground Storage Tanks because visual checks for leaks can easily be performed, it can easily be repositioned and It is less costly to install and maintain.

From the foregoing, it is evident that there is no better alternative to the proposed Further Field Development that favors environment, social and economy except as planned

E.S.3 Project and Process Description

Pillar Oil Limited is a wholly indigenous exploration and production oil and gas company operating in Nigeria. Incorporated on 10th July, 1997, the Company operates under the highest standards while making a positive impact on the Nigerian economy. Currently the Company has operations in Lagos and Delta States of Nigeria.

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The Umuseti/Igbuku field complex has two proven oil and gas fields (Umuseti and Igbuku) and four identified satellite prospects (Umuseti-North East, Umuseti-East, Igbuku-West and Igbuku-North).

Description of the Existing Facilities

The licence to mine for oil and gas on this acreage was awarded to Pillar Oil Limited in 2003. The well history is presented as follows:

UMUSETI-1

Umuseti-1 was drilled based on 2-D seismic data. It was spudded in 1966 and found a total of nine hydrocarbon bearing intervals between 7730 –11672 ftah (7713 and 11655 ftss). After encountering a blow-out at depth of 12,914 ft, drilling was terminated and the well plugged back to 7,700 ftss. Sidewall coring, formation tests (FIT) and drill stem tests (DST) were attempted with mixed success. The well was suspended as an oil and gas producer.

UMUSETI-3 (EX-OBODUGWA-3)

Was drilled based on 2-D seismic data and was spudded in 1982 ostensibly to test one of the culminations along the Obodogwa - Obodeti trend in the central part of OML-56 and drilled to a total depth of 13,452 ft. The western part of the culmination was tested by Obodeti - 1 which found 23 ft of oil. Obodogwa-1 encountered the second culmination and found six hydrocarbon levels. Obodogwa-3 was planned to appraise the hydrocarbon potential of the third culmination, which is separated from the western culmination penetrated by Obodogwa - 1 by a saddle.

IGBUKU-1

Well was drilled in 1981 to test the Igbuku structure located south of the main Obodogwa-Umusati trend from which it is separated by a fault and drilled to a **total depth of 13,780 ft.** The well discovered six hydrocarbon bearing reservoirs between 3345 – 3930 m ah; four of these reservoirs are gas condensate bearing, while two contain oil. The most notable reservoir is the gas condensate reservoir VIIa with 60m net pay encountered in a down-to situation. This well had an extensive production test that yielded a maximum open hole flow of 6,420,000 m^3/day of gas of density 0.7/air with a condensate content of $3m^3/m^3$ with density of 0.816/water. The well was suspended as a gas, gas condensate and oil producer.

UMUSETI-2 (EX-UMUSETI NE-1)

Umuseti NE-1 was drilled to a **total depth of 12,485 ft** in the northern fault block in 1974 with the objective of exploring the structural closure identified in the block. The well did not encounter high pressure zones as anticipated. Umusati NE-1 was subsequently abandoned as a dry well.

ASE-RIVER-1

Ase River was drilled in the Umuseti/Igbuku farm out area in October 1973 to a total depth of 10,600ftah. The well encountered only water bearing sands and was therefore plugged and abandoned.

UMUSETI-4

Umuseti-4 was drilled in March 2012, following the reinterpretation of the 1991 vintage seismic data (2D and 3D) acquired by Elf. The Umuseti-4 well was drilled as a deviated well to a total depth of 12,898 ftah. The Umuseti-4 well encountered a total of 407.9 ft of oil, 450ft of gas and 271 ft of undifferentiated hydrocarbons in 24 intervals. The well was completed as a dual string well. Umuseti-4 is currently on stream.

UMUSETI-5

Umuseti-5 was drilled in 2013 as a deviated well to a total depth of 9510 ftah. The well was drilled as a development well in the Umuseti structure to provide additional drainage points, structural control, investigate sand continuity and resolve fluid types in several levels. Well-5 encountered eleven (11) hydrocarbon reservoirs; nine containing oil (RSVR II, III, VI, UI-II, UI-III, UI-V, UI-VI, UI-VIII and UI-IX) and two (2) gas bearing reservoirs (RSVR-I and RSVR UI-IV). The Umuseti-5 well was completed as a dual string well and is currently on stream.

UMUSETI-6

Umuseti-6 was drilled in 2014 as a vertical well in the Umuseti structure. The well was drilled as a development well to a total depth of 9510ftah, to provide drainage points, structural control, investigate sand development of the Umuseti -Obodugwa hanging wall structure in near crestal positions and resolve fluid type variations seen in Umuseti-1. The well encountered only four (4) hydrocarbon bearing reservoirs: 3 oil bearing – RSVR -II, -III and –VI and one gas- RSVR –I, other intervals were encountered wet. The well was completed as a dual string producer across RSVR III and VI. The long string has been put on stream, while the short string could not flow naturally due to the low permeability of the reservoir sand.

Description of The Further Field Development

The proposed Further Field Development activities include construction of Gas Plant, Drilling, laying of Pipeline and Work-over Projects, etc. which will be executed in phases over a period of five (5) years.

The scope of the project shall cover comprehensive and representative sampling activities for the Umuseti- Igbuku Field Further Development as highlighted below:

1. Progress And Conclude POL/NAOC/DPR Unitization Discussions – 2021
2. Igbuku1 (Reservoir VIIa) Well Test – Q2 2021
3. Drill and Complete Umuseti-7 – Q1 2021
4. FEED and DED: Igbuku Gas Plant – Q3 2021
5. Umuseti-3 Zone Change – Q4 2021
6. Igbuku Gas Plant Construction – 2022-2023
7. Gas Pipeline ROW, PTS, OPL & Acquisition – 2021
8. Gas Pipeline Construction - 2022
9. Commission Umuseti Gas Plant – Q4 2022
10. Re-enter and complete Igbuku-1 – Q2 2022
11. Commission Igbuku Gas Plant – Q2 2023
12. Drill and Complete Igbuku-2 (Appraisal/Exploration) – Q2 2023
13. Igbuku North-1 Location construction – Q4 2023
14. Umuseti-2 Location construction – Q4 2023
15. Drill and Complete Igbuku North-1 (Exploration) – Q2 2024
16. Sidetrack Umuseti-2 (Exploration) – Q4 2024
17. Upgrade Igbuku and Umuseti Gas Plants - 2024
18. Tie-in Igbuku-North-1 & Umuseti-2 well – Q4 2024

A synopsis of the entire project activities in project phases are as follows:

- Engineering design
- Right of way survey
- Right of way acquisition
- Drilling
- Hauling and Stringing the Pipes
- Welding of line pipes and coating
- Lowering of welded pipeline into trench

- Back-filling of the trench
- Integrity test of the pipes welds including Hydro test
- Clean-up, reinstatement and Commissioning
- Operation
- Abandonment and decommission

The different waste streams – classified as gaseous, liquid and solid waste – will be generated by the proposed plant. Anticipated wastes include:

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities.
- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics.
- Special wastes, such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead acid storage batteries, and used oil, will be generated during the construction.
- Sanitary wastes shall be managed by treating to acceptable discharge standards and discharging to the environment.

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Domestic Wastes will include food wastes, paper, household wastes generated from the accommodation area and food preparation facilities.
- All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor.
- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the operational phases of the proposed project.
- Combustible office waste shall be collected and transported off-site for disposal.

Air Emissions

There shall be emissions of air pollutants from various sources during the operations of the plant and these include emissions from: Combustion engines, Pilot flare, Vents, Heating oil furnaces, LPG loading vapours and tank vents.

Liquid Effluents

Both oily water and chemical waste water effluents will be generated by the plant operations. Effluents generated will include backwash effluent from pressure filters, regeneration effluent from the demineralisation plant as well as other chemical laboratory wastes, battery waste water and sludge.

All these wastes shall be handled in line with the FMEnv regulations

The project is scheduled to reach completion in 5 years.

E.S.4 Baseline Environmental and Social Characteristics of the Project Area

The environmental components of the study area were deciphered mainly by field observations, measurements and questionnaire administration and supplemented by secondary sources. Results obtained from the field sampling exercise were compared with national and international standards. The environment was characterized based on data obtained from two (2) climatic seasons (Dry and Wet) sampling carried out in Umuseti-Igbuku field (OML 56). The dry season sampling exercise was carried out from 24th February to 27th February, 2020. While the wet season sampling was carried out on 4th to 6th June, 2020.The field personnel were divided into teams (socioeconomics, biophysical sampling etc) for efficiency and comprehensive collection of field data/samples. A systematic approach was adopted in the selection of sample stations so as to ensure that samples collected were representative of the study area.

Soil, Air quality/noise level measurements were taken at twenty (20) sampling stations out of which three were control stations. Samples were also taken from four (4) stations, for surface water and sediment, with one of the stations being for control. Three (3) ground water locations were sampled, out of which one was the control station. The samples were analysed at Jenneoby Environmental and Laboratory Services Ltd., located in Lekki, Lagos State Nigeria. Socioeconomic data acquisition was also carried out with focused group discussions and one hundred and ninety questionnaires from four host communities – Umuseti-Ogbe, Emu-Iyasele, Igbuku and Ashaka.

The following environmental data were generated based on the study: Climatic data, air quality and noise pollution level, Soil Quality, Surface and ground water qualities, Planktons and sediment studies, Fisheries, Water and soil microbiology, Flora and Fauna, Socioeconomics and health, Land use, Geology and Hydrogeology

Geology
The geology of OML 56 area consists of sedimentary deposits of the Cenozoic age namely Benin, Agbada, and Akata formations. The sediments were eroded from Basement Complex rocks in the hinterland of the West African sub-region. The area is characterized by fairly uniform geomorphology and limited rocky and mountainous output.

Land Use Pattern
The lands within the proposed project are used mainly for Agricultural and Industrial purposes.

Air Quality, Noise and Climate
The NO_X concentrations during the wet season of 2020 have a constant value of <0.01ppm and ranged from <0.01ppm to 0.063ppm during dry season. All these values are below the stipulated limit of 0.08ppm by FMEnv. The SO_X concentrations during 2020 dry season and wet season sampling periods have values that are below detection limit of < 0.01 which is below the stipulated limit of 0.1 ppm by FMEnv.

In the study area, CO concentrations during wet season sampling period was below detection limit of < 0.01 ppm while dry season study CO ranged from <0.01 – 3.5ppm with a mean value of 1.75ppm for all the sampling stations. However, the values obtained during these two seasons were below the stipulated limit of 10ppm by the FMEnv. Concentration of Hydrogen Sulphide for wet season was below detection limit of < 0.01 ppm while it ranged from 0.2 to 0.7ppm with an average value of 0.45ppm during dry season of 2020.

The concentrations of volatile organic compounds during wet season sampling period showed that the VOC concentration were very low and varied from 0.1 to 2.3ppm with a mean value of 1.2 ppm. Furthermore, in dry season, the VOC concentration ranged from 82 to 228ppm. While most of the values obtained during the two seasons were below the stipulated limit of 160ppm by FMEnv, however, value from one of the locations is above the stipulated limits of 160ppm. This could be as a result of activities going on in the field.

The concentration of particulates in the ambient air during wet season ranged from 9.50µg/m^3 to 46.00µg/m^3 (mean value of 27.75µg/m^3) for particle size of 2.5micron and 10.20 to 152.40 µg/m^3 (mean value of 81.30µg/m^3) while concentration during dry season samples ranged from 48.70µg/m^3 to 519.40µg/m^3 (mean value of 284.05µg/m^3) for particle size of 2.5micron and 68.90µg/m^3 to 720.0µg/m^3 (mean value of 394.45µg/m^3) for particle size of 10micron. While the values recorded for particle size of 2.5 and 10micron for wet season were below the FMEnv limits of 150µg/m^3 and 250µg/m^3 respectively, some of the values for particle size of 2.5 and 10micron in 2020 were above FMEnv limit of 150µg/m^3 and 250µg/m^3 respectively. This could be as a result of anthropogenic activities in the field.

The noise levels recorded at the project area during dry season ranged respectively from 50.3 to 87.6dB (mean value of 68.95dB) and 41.2dB to 69.4dB (mean value of 55.3dB) for wet season. A large proportion of background noise in the area is due to human activities and vehicular effect. Generally, in spite of this, the mean values recorded for both seasons are still below the FMEnv limit of 90dB (A) for 8 hours exposure respectively.

Groundwater

During the wet season of 2020 the values of pH ranged from 5.79 to 6. while the values ranged from 6.37 to 6.9 during the dry season of 2020 which are slightly acidic. These values show that groundwater around the project area were all acidic and are below the FMEnv and WHO limit of 6.5 – 8.5 for drinkable water except a location during the dry season sampling

The water temperature for the wet season ranged from 29.4 to 30.8^{O}C while it had constant value of 24.90 ^{O}C during the dry season of 2020. The water Turbidity has a constant value of <0.01 (NTU) during the dry season of 2020 while the values ranged from 0.92 to 1.80 NTU during the wet season. Total Suspended Solids in 2020 dry season were not detected, meanwhile the values ranged from 0.25 to 0.37mg/l during the wet season. Electrical conductivity varied between 51.2 and 387.0 µS/cm in 2020 dry season while the values ranged from 35 to 48µS/cm during wet season. Total Alkalinity values were nil in 2020 dry season while the parameter ranged from 4.0 to 10mg/L during wet season 2020 study.

The groundwater Dissolved Oxygen (DO) recorded for dry season was between 3.82 and 3.94mg/L while the values ranged from 6.6 to 7.1 mg/L during the wet season. The groundwater Chemical Oxygen Demand (COD) values as an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution were sampled and the values ranged from 8.0 to 16.0mg/L in 2020 dry season while the values ranged from 7.73 to 9.93 mg/L during the wet season. The groundwater Biological Oxygen Demand (BOD_5) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period has a mean value of 1.84mg/l during dry season and 3.7 mg/L in wet season.

The groundwater cations were dominated by Sodium (Na), Calcium (Ca) and Potassium (K). Sodium has values ranging from 5.43 to 40.68mg/L in dry season while he values ranged from 2.75 to 10.32 mg/L during wet season. Also Potassium has values ranging from 0.621 to 1.72mg/L in dry season while he values ranged from 0.21 to 0.41 mg/L during wet season. Calcium (Ca) and Magnesium (Mg) were also measured during the 2 season with Magnesium ranging from 1.94 to 13.31mg/L during dry season and 0.71 to 0.98mg/L during wet season. Also, Calcium ranged from 3.21 to 22.04 during dry season while 1.44 to 2.71mg/L in wet season. During the wet and dry seasons studies, the heavy metal concentration values were low in all the stations and do not pose any pollution threat related to hydrocarbon contamination.

Bacteria Identified in Groundwater are *Streptococcus spp, Enterobacter spp., Enterococcus spp* while the Fungi identified in Groundwater are *Penicillium spp., Aspergillus spp.*

Soil

pH: The soils had a mean pH of 5.8 with a range of 5.3 to 6.3 for the top soil and 5.1 to 6.2 with a mean value of 5.81 for the sub soil in dry season while it range ranged from 4.12 to 5.16 for the top soil and 4.08 to 5.34 with a mean value of 4.86 for the sub soil in the wet season, indicating acidic conditions of the area activities.

The cation exchange capacity of the soils ranged from 36.59 to 87.451.11 cmol/kg with a mean value of 62.02 cmol/kg for top soil and 37.15 to 97.97 cmol/kg with a mean value of 77.95 cmol/kg for sub soil during dry season while it ranged from 9.2 to 10.24cmol/kg with a mean value of 1.2.06cmol/kg for top soil and 6.98 to 16.5 for subsoil in wet season. The C.E.C. is the sum of the exchangeable bases, namely, calcium, magnesium, potassium and sodium.

The Total Organic Carbon value were between 1.29% and 1.84%, with a mean value of 1.565% for top soil and 1.04 to 13.1% in dry season while it ranged from 0.27% to 1.21% for top soil and 0.16 to 0.98% in wet season.

Total Nitrogen content of the soil was between 20.09 and 29.9% with a mean concentration of 24.99% for top soil while it ranges from 21.73 to 28.23% with a mean value of 22.76% for sub soil during dry season while it ranged 0.11 to 0.25% for top soil and 0.09 to 0.28% in wet season.

The electrical conductivity values were between 50.1 and 90.05 µS/cm for both top and sub soil during dry season. This also ranged from 27 to 421µS/cm during wet season. The electrical conductivity were all generally low. This is an indication of low levels of electrolytes in the soil, and where they are abundant; the sandy texture of the soils facilitates leaching.

The mean concentrations of the anions were as follows: Sulphate SO_4^{2-} (78.74 mg/kg for top soil and 76.44 mg/kg for sub soil) during dry season and (11.4 mg/kg for top soil and 3.96mg/kg for sub soil) during wet season; nitrate, NO_3^- (11.97mg/kg for top soil and 11.52 mg/kg for sub soil) during dry season and (0.7 mg/kg for top soil and 0.79mg/kg for sub soil) during wet season; nitrite, NO_2 (0.085mg/kg for top soil and 0.082 mg/kg for sub soil) during dry season and (0.052mg/kg for top soil and 0.059mg/kg for sub soil) during wet season.

The mean concentration of the heavy metals were as follows; Iron, Fe (2.066 mg/kg for top soil and 2.294mk/kg for sub soil) during dry season and (7866 mg/kg for top soil and 8088mk/kg for sub soil) during wet season; Nickel, Ni (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (1.44mg/kg for top soil and 3.525mk/kg for sub soil) during wet season; Chromium, Cr (0.057mg/kg for top soil and 0.0485mk/kg for sub soil) during dry season and (1.73 mg/kg for top soil and 1.83mk/kg for sub soil) during wet season; Cadmium, Cd (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (0.56 mg/kg for top soil and 0.58mk/kg for sub soil) during wet season; Zinc, Zn (0.154mg/kg for top soil and 0.176mk/kg for sub soil) during dry season and (20.66 mg/kg for top soil and 35.83mk/kg for sub soil) during wet season; Mercury, Hg (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during wet season; Lead, Pb (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (1.98 mg/kg for top soil and 2.04mk/kg for sub soil) during wet season.

Total Hydrocarbon (THC) has a mean value of 0.312mg/kg and 0.917mg/kg for both top and sub soils respectively in the dry season while it has a mean value of 0.32mg/kg and 0.43mg/kg for both top and sub soils respectively during the wet season. Total Petroleum Hydrocarbon (TPH): The total petroleum hydrocarbon content of the soil was ranged from 0.738 to 0.895mg/kg for both the wet and the dry season while it has a mean value of 0.246mg/kg and 0.358mg/kg for both top and sub soils respectively during the wet season.
Predominant bacteria isolates identified in the soil were *Streptococcus spp., Bacillus spp, Pseudomonas spp. Lactobacillus spp, Mycobacterium spp, Arthrobacter spp,* while Predominant fungi isolates identified in pillars soil were *Aspergillus spp., Mucor spp, Fusarium spp, Candida spp, Cladosporium spp, Rhodotorula spp, Penicillium spp*

Surface Water Quality

The mean wet season surface water temperature was 31.3°C, with a range of 30.8 and 31.8°C while it has a constant value of 24.6°C during dry season.

The pH values determined across the study area during the wet season study ranged from 6.50 slightly acidic to 7.14 slightly basic with a mean value of 6.82 while it ranged from 6.26 to 6.38 with a mean value of 6.32 during dry season.

Electrical Conductivity values ranged from 19.20 to 50.20 micro Siemens per centimetre (µs/cm) (mean = 25.70) in the rainy season. The conductivity values were lower than the WHO limit of 900 µs/cm, this reveals that the water body is low in ions.

The mean value for dissolved oxygen was 4.45mg/L in the wet season and 4.43mg/L in the dry season of 2020. These values reveal that the oxygen requirement of the water body is within the favorable limit for fishes but could adversely affect the survival of other biological communities.

TDS values obtained for the wet season samples analyses showed a range of 14 to 39 mg/l and a mean value of 27mg/L across the sampled locations during wet season while the values ranged from 36.3 to 45.5 mg/l with a mean value of 40.9 mg/l during the dry season. Surface water turbidity values for the wet season ranged from 1.77 to 1.88 NTU, with a mean value of 1.83 and from 0.1 to 2.1NTU with a mean of 1.1NTU during dry season.

The concentration of heavy metals analysed were relatively very low in both seasons' samples. They were all below detection limit and no appreciable difference was observed except for Iron, Manganese, Zinc and Copper which had maximum values of 3.27mg/L, 0.094mg/L, 0.140 mg/L and 0.054mg/L respectively for the wet season. Also, during 2020 dry season, values for Iron (Fe) ranged from 0.419 to 0.621mg/L, zinc (Zn) ranged from 0.410 to 0.444mg/L, Copper (Cu) ranged from 0.132 to 0.147 mg/l.

The exchangeable bases (Ca2+, K+, Na+ and Mg2+) are present at varying levels in the dry season samples. Calcium ranged from 3.21 to 4.81mg/L, Magnesium ranged from 1.94 to 2.9mg/L, Potassium ranged from 1.148 to 1.358mg/L and Sodium ranged from 5.43 to 10.86mg/L. Also, during wet season, Calcium ranged from 1.76 to 2.04mg/L, Magnesium ranged from 0.52 to 0.68mg/L, Potassium ranged from 0.28 to 0.70mg/L and Sodium ranged from 4.43 to 5.89mg/L. Bacteria identified in surface water were *Staphylococcus spp., Pseudomonas spp., Streptococcus spp., Escherichia spp while* Fungi identified in surface water were *Penicillium spp., Aspergillus spp.and Mucor spp.*

Sediment Studies

The sediments in the entire area were mainly acidic with pH ranging from 5.7 slightly acidic to 6.19 also slightly basic in the dry season and 4.52 to 4.65 in the wet season indicating slightly acidic also.

The sediments exhibited wide variability in terms of total organic carbon content. TOC ranged from 1.06% to 1.23%, with a mean value of 1.145% in the dry season and ranged from 1.76 to 2.03% with a mean level of 1.9% in the wet season. The trend exhibited by the total organic carbon content was also manifested by the total organic matter content. Nitrate content varied between 14.01 to 14.85% with a mean value of 14.43% in the dry season. In the wet season, nitrate range from 0.091 to 0.107% with a mean value of 0.099%. In the present study, the reasons given for the trend observed in the total organic carbon content in the sediments is also applicable to the nitrate content in the sediments.

The mean levels of these anions (dry season) were as follows; Sulphate (129.8 mg/kg) and Chloride (33.47 mg/kg) respectively. In the wet season, the values were: sulphate (1.9 mg/kg) and chloride (21.28mg/kg).

The electrical conductivity of the sediments varied between 87.6 to 139 µS/cm with a mean value of 113.3 µS/cm (dry season) and range from 60 to 96 µS/cm in the wet season with a mean value of 78µS/cm.

The dry season samples showed results indicating that Total Petroleum Hydrocarbon Content were below the equipment detection limit (<0.001 mg/kg), Polynuclear Aromatic Hydrocarbon ranged from 0.14 to 0.18mg/kg, Total Hydrocarbon Content (THC) ranged from 1.305 to 1.39mg/kg while Oil and Grease ranged from 1.324 to 1.435mg/kg. On the other hand, during wet season, Total Petroleum Hydrocarbon Content ranged from 0.616 to 0.743mg/kg, Polynuclear Aromatic Hydrocarbon ranged from 0.14 to 0.210mg/kg, Total Hydrocarbon Content (THC) ranged from 0.73 to 0.86mg/kg while Oil and Grease ranged from 1.26 to 1.54mg/kg

The mean concentration of the heavy metals in the dry season and related sediment micronutrient elements were as follows; Iron (2.136 mg/kg), Zinc (0.4775mg/kg), Chromium (<0.001 mg/kg), Lead (<0.001 mg/kg), Copper (0.124mg/kg), Cadmium(<0.001 mg/kg), Nickel(<0.001 mg/kg), Barium (<0.001 mg/kg). However, in the wet season, the mean values were iron (1.66 mg/kg), zinc (17.62 mg/kg), chromium (0.68 mg/kg), Lead (<0.001mg/kg), Copper (2.83 mg/kg), Cadmium (0.08 mg/kg). These values are consistent with levels of these metals as found in non-contaminated or none anthropogenically impacted sediments, except for lead in the wet season. The concentration of heavy metals analysed were relatively very low in both seasons' samples.

Planktons
The phytoplankton recorded 4 (four) group of species. They were the Diatoms (Division – Bacillariophyta), Blue-green algae (Division – Cyanophyta), Green algae (Division – Chlorophyta) and Euglenoids (Division – Euglenophyta). The dominant group of phytoplankton was the Diatoms. In terms of species diversity, whereas the Diatoms, recorded 48% (15 taxa), the Blue-green algae recorded 34% (11 taxa), Green algae reported 13% (4 taxa) and Euglenoids 6% (2 taxa). In all a total of thirty - two (32) species were recorded at the stations studied. Total number of species recorded per station ranged between 18 and 22.

The zooplankton recorded 4 (two) group of species for the adult zooplankton (Holoplankton). The meroplankton or juvenile stages were also recorded. The adult zooplanktons were the Phylum – Arthropoda. Phylum–Rotifers and Juvenile stages. Cladocerans were also recorded. The dominant group of zooplanktons was the Arthropods, followed by Juvenile stages and then the Rotifers. Whereas the Arthropod recorded 50% (4 taxa), Juvenile stages reported 25%, whereas the Rotifers estimated 12.5% (2 taxa).

Fishery studies
In this study, five morphologically distinct fish species belonging to 5 different families namely: family Bagridae, family Polypteridae, family Mochokidae, family Channidae and family Cichlidae were encountered. Fishes reported in this study were caught in the study river (Ase River) by local fisher men. Two *Tillapia sp.* fingerlings were also encountered in the benthic samples.

Flora and Fauna
The floristic composition varies mainly with the age of the fallow and less with the season. However the species composition include: *Elaeis guineensis, Alchornia cordifolia, Musanga cecropioides, Bambusa vulgaris, Ficus exasperate, Spondias mombin, Anthocleista vogelii*, *Albizia adianthefolia, Nauclea diderichii, Alstonia boonei, Asystasia gangetica, Aspilia Africana, Chromoleana odorata, Baphia nitida, Trema guineensis, Acacia sp.* Others include, *Icacina trichantha, Urena lobata, Cnestis ferruginea Smilax anceps, Terminalia superba, Irvingia gabonensis, Spigelia anthelmia, Rauvolfia vomitoria, Calapogonium mucunoides, Mimosa invisa, Panicum maximum, Pennisetum purpureum, Psidium guajava, and Trema occidentalis.*

The invertebrate fauna were diverse and consisted of forest dwelling species dominated by ants, beetles and millipedes. Many genera and species of arthropods were recorded. The

Mollusca fauna was represented by the presence of the giant African land snail *Achatina fulica* and the garden snail, *Cornu aspersum*. Except for the Giant rats, the rodents are small mammals and are very varied in pelage coloration and patterning. They are mostly terrestrial and live in burrows, being mostly nocturnal. Because of their large numbers they are neither threatened nor endangered but rather considered a pest to field crops and stored products.

The presence in large numbers of rodents in particular, and the near absence of the bigger mammals which make up the typical rainforest wildlife are indicative of the changes in land cover/vegetation forms over the years. The bird species recorded by sighting, nest observations and call sounds include the white egrets, kites, weaverbirds, owls and hawks. Different species of reptiles and amphibians were also noticed. Prominent among these were *Agama agama* (common lizard), gecko, frogs and snakes.

Socioeconomic and Health Survey

The study communities are those that are within 5km radius of the Igbuku-Umuseti Field project. The project affected communities are Umuseti-Ogbe, Igbuku, Ashaka and Emu-Iyasele within Ndokwa-West LGA of Delta State and they are the host communities. The communities are predominantly inhabited by the Ukwuani/Ndokwa ethnic group of Delta State. Though autonomous in terms of traditional leadership, the communities have historical links. Ndokwa-West Local Government Area whose Local Government headquarter is in Kwale has an area of 816km^2 and a population of 150,024 based on the 2006 National Population Census figures, projected at 206,600 in 2016 and current year 2020 projected at 234,340 using 3.2% annual growth rate.

Responses from administered questionnaires and focus group, on the average, showed those engaged in farming amounted to 34.5 percent and barely 4.8% take to fishing, so that together less than one half (39.3%) are into agriculture. Trading and artisanship/technicians 13.2% and 10.6% respectively are the other occupations with some significance in the surveyed communities. Unemployed population amounted to some 8.4 percent; students/apprenticeship (13.6%) and small percentage of 3.2 percent are into business and contracting. More of the population are into trading as a secondary economic activity (42.4%), which in fact is more representative of the economic landscape of the study environment. Those in the informal sector of the economy, e.g. technical and artisan activities assumed higher percentage of response (20.9%) as a secondary occupation.

The survey analysis revealed 1.5% of the housing type in the host communities to be mud with thatch roof, mud houses with zinc roof 32.5%, wood/plank with zinc roof 4.6%, zinc with zinc roof 3.8%, while concrete houses with zinc roof are more in the communities with 56.3% and those others houses account to about 1.3%.

Each of the communities has one public primary and each has one public secondary school. The communities have electrification facilities and connected on the national grid. However, the people like other part of the country have power once in awhile and depend more on their individual generating set. Meanwhile, all the communities have market built with open and lock-up shops except Emu-Iyasele that doesn't have market. The markets are periodic. The youth organize themselves into vigilante groups. The closest security presence to Kwale and Ashaka comprises the police station. The communities do not have any developed public recreation facilities. Residents recreate by playing football in the school football fields or swimming in the river. Some stay at home and watch television for few who have television and can afford running cost of generator.

The resident population in the Igbuku-Umuseti Field FD study communities have access to functional primary health care services. Functional and effective public (government health care facilities) primary healthcare facilities and services are available at Umuseti-Ogbe/Kwale, Ashaka, and Igbuku respectively. There are also private clinics/maternities in the bigger communities like Umuseti-Ogbe (Kwale), Ashaka and Igbuku which have one public (government) health establishments including a general hospital and a maternity health centre and 1 private clinics. Meanwhile, Emu-Iyasele community doesn't have any health care facility.

Consultation

Interaction with the community was positive and there was widespread appreciation of the consultation process undertaken. POL would continue to consult with all relevant parties and all parties concerned with or are likely to be affected by the project, at all stages of the project development.

E.S. 5 Associated and Potential Impacts of the Project

The proposed projects will interact with the environment in various ways known as the *"development's aspects"* which could cause change or alteration in the baseline environmental condition, this change is known as *''impact''*.

The overall intent of the ESIA study is to identify and characterizes all the associated and potential environmental impacts or effects that will be caused by **Pillar Oil's** proposed project in Delta State. Though there are a number of approaches for the prediction and evaluation of project environmental impacts, the ISO 14001 method was selected for this study. The ISO 14001 method is simple to apply, provides a high level of details and relies on limited data.

Based on the method adopted, impacts ranging from low to high significance were identified, qualified and quantified. Among the impacts that have medium and high significance ranking include:

a) Injury and fatalities to personnel from heavy lifting during construction
b) air pollution and climate change potential arising from gas flaring, venting and fugitive emissions arising from gas process operations
c) surface water contamination from wastewater and effluent discharges
d) explosion and fire from routine activities and accidental occurrences
e) workers' ill health from release of VOCs, H_2S and other chemically dangerous substances
f) noise pollution from process equipment
g) land and water pollution from potential oil spill incidents
h) toxic air condition within nearby communities from release of benzene from the facility
i) Traffic and transport impact from loading of finished products

The significant positive impacts that will arise from the project are;

- ✓ Opportunity for Contracting and Supplies
- ✓ Employment opportunity for skilled and unskilled labour
- ✓ Opportunity for Skill enhancement/ acquisition
- ✓ Increase in income for individuals, community and the nation
- ✓ Improved natural gas supply to customers

E.S.6 Mitigation Measures

Mitigation measures are often implemented on a continuous basis through the project's life-cycle. Specific mitigation measures are aimed at reducing negative impacts to As Low As Reasonable Practicable (ALARP) and where possible enhance positive ones. The residual impacts that could arise despite these mitigation measures were also noted. Significant negative impacts are expected to be mitigated through effective implementation of the Health, Safety and Environment (HSE) policies put in place during the different phases of the project.

The following measures will mitigate adverse impacts;

- ✓ Designing, drilling, constructing, and field production according to international standards for the prevention and control of fire and explosion hazards, including provisions for segregation of process, storage, utility, and safe areas. Aggregate Greenhouse Gas emissions will be quantified annually in accordance with FMEnv and internationally recognized methodologies

- ✓ Return of spent catalysts to the manufacturer for regeneration or recovery, or transport to other offsite management companies for handling, heavy or precious metals recovery/recycling, and disposal in accordance with industrial waste management recommendations
- ✓ Preparation and implementation of an Emergency Management Plan, prepared with the participation of local authorities and potentially affected communities
- ✓ Implement good housekeeping practise on-site.
- ✓ workers and visitors are properly kitted with appropriate Personal Protective Equipments
- ✓ Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;
- ✓ Minimise destruction or modification of the vegetation cover
- ✓ all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner.
- ✓ Ensure a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained
- ✓ Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater
- ✓ A Job Hazard Analysis, to enable each worker assess the risks associated with the job and work safely using procedural guidelines in handling equipment and the facilities.

To enhance the positive impacts POL shall ensure:

✓local contractors are engaged;
✓prompt payment to engaged labour
✓that Indigenes are considered first

With the provision of the proposed mitigation measures outlined, the positive impacts of the scheme will considerably outweigh the negative impacts. The public as a whole will benefit from the completion of the project. Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

E.S.7 Environmental and Social Management Plan (ESMP)

The ESMP shall be employed as a tool for the management of the predicted environmental, social and health potential impacts. It provides the mechanism for

implementing mitigation measures that have been developed to reduce the effects of 'medium and 'high' negative impacts to as low as reasonably practicable (ALARP), prior to and through the life cycle of the project.
Environmental management activities of the proposed project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

The Management commitment and responsibility of Pillar Oil are detailed in its Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors, no matter how stringent. The HSE policy of Pillar Oil states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, the employees of Pillar Oil contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of Pillar Oil host communities.
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;
- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the gas plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve Pillar Oil assets and natural resources, and minimise the impact of gas plant's activities on the environment, by conducting impact assessments, and ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;
- identify present or future potential health, safety and environmental hazards resulting from gas plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;

- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate Pillar Oil's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the Pillar Oil's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits; and
- adequately resource health, safety and environment functions throughout the business.
- focus on HSE to safeguard our people and assets
- adopt Health, Safety and Environmental best practices in the design, construction and operation of her facilities.
- comply with National and applicable International standards and laws on Health, Safety and Environment in the conduct of her operation.
- demonstrate social and ethical responsibility by working together with all relevant stakeholders to promote harmonious HSE compliant relationship.
- engage and consult with employees and others on Health, Safety and Environmental conditions and provide Occupational Health Services.
- maintain emergency response capability to minimize the impact of unfavorable negative incidents related to her operation.
- liaise closely with relevant government agencies in the formulation of Health, Safety and Environmental protection legislations, regulations or policies that may significantly impact the Group business returns to shareholders.
- publicly report on her HSE performance.
- ensure all staff have the right and duty to intervene and stop any unsafe acts and conditions or when activities are not in compliance with HSE policy and commitment.
- ensure that our Customers, Partners, Visitors and other Stakeholders comply with this HSE Policy

E.S.8 Site Decommissioning and Abandonment

Projects are usually designed with an expected lifespan and so, no matter how long the design life, all projects eventually close out. The lifespan may sometimes be less than planned, while in some cases, it can be extended with proper planning and maintenance. The longevity of any development project is primarily dependent on a number of factors including:

- Availability of equipment and the servicing parts
- Durability of equipment and machinery
- Profitability of the project
- Usefulness and acceptability of end-product

The gas plant and its ancillary installations have a design life of 30 years. It is expected that a time will come when the facility technology will either be outdated or its operation no longer economically viable. Since the Project depends on non-renewable petroleum resources, the field project will eventually have to be abandoned and decommissioned at some point in its life cycle. Pillar Oil would need to decommission the entire system when this situation arises. While this is not expected to occur within the next thirty years, it is, all the same, necessary to start planning, at this stage, for the closure stage, when the use of the facility have to be discontinued. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment programme.

E.S.9 Conclusion

Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and ESMP that has been presented in earlier sections of this ESIA, it is therefore concluded that the technology, equipment and facilities that is proposed to be employed in the proposed project is one of the cheapest best available and environmentally friendly technology, which has been used by a number of developers in Nigeria

The ESIA shows that there is no potentially significant negative impact following application of mitigation measures. To this end, Pillar Oil Limited hereby solicits approval of the project by FMEnv, while appropriate mitigation and monitoring measures shall be carried out following implementation.

CHAPTER ONE

INTRODUCTION

1.1 Background Information

Pillar Oil Limited is a wholly indigenous exploration and production oil and gas company operating in Nigeria. Incorporated on 10th July, 1997, the Company operates under the highest standards while making a positive impact on the Nigerian economy. Currently the Company has operations in Lagos and Delta States of Nigeria.

The Marginal Fields programme commenced following Decree No. 23 in 1996 and the "Government Policy and Guidelines on the Development of Marginal Fields in the Country" on 5th December, 2000. On 25th February, 2003, after rigorous competitive bidding for 24 fields hitherto operated by Shell (12), Chevron (8) and Elf (4), Pillar Oil Limited was awarded, on a sole risk basis, 100% participating interest and Operatorship of the onshore Umuseti/Igbuku field complex (OML 56) located in Delta State, Nigeria. The field was previously operated by Elf Nigeria Limited.

The Umuseti/Igbuku field complex has two proven oil and gas fields (Umuseti and Igbuku) and four identified satellite prospects (Umuseti-North East, Umuseti-East, Igbuku-West and Igbuku-North). Pillar Oil Limited (POL) proposes to carry out further development of its field. The proposed Further Field Development activities include construction of Gas Plant, Drilling, laying of Pipeline and Work-over Projects, which will be executed in phases over a period of five (5) years (herein referred to as 'project').

Pillar Oil Limited recognizes the importance of comprehensive environmental and social planning and management to the success of any project and is committed to the necessary studies aimed at describing and understanding the environment and social conditions of the project area in order to assess and evaluate possible environmental (natural and physical) and social impacts that may occur as a result of project development activities, and also during the operation of the facilities.

In compliance with Act Cap E12, LFN 2004 of Federal Ministry of Environment (FMEnv) and PART VIII A, Section 3.1.2 of the Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN 1999, Revised Edition in 2018),the Pillar Oil Limited through her consultant, Afruitful Environment Limited (AFEL), accredited by Department of Petroleum Resources (DPR), Federal Ministry of Environment and National Environmental Standards and Regulations Enforcement Agency (NESREA), carried out an Environmental Impact Assessment of the proposed Further Field Development activities and prepared this Environmental and Social Impact Assessment (ESIA) Report. The ESIA presents the baseline environmental condition of the receiving environment, identified associated and potential impacts of the proposed development and recommended control techniques/mitigation measures to manage the impacts.

1.2 Project Location

Umuseti-Igbuku Field of OML 56 where the further field activities are to take place has a concession area of 102 square kilometres and is located in OML 56, Delta State within Latitudes 180042.921ºN; 187043.150ºN and Longitudes 44332.104ºE; 440558.420ºE in Ndokwa West Local Government Areas of Delta State, Nigeria **(Figures 1.1a, 1.1b and 1.1c**).

Figure 1.1a: Administrative Map of Delta State

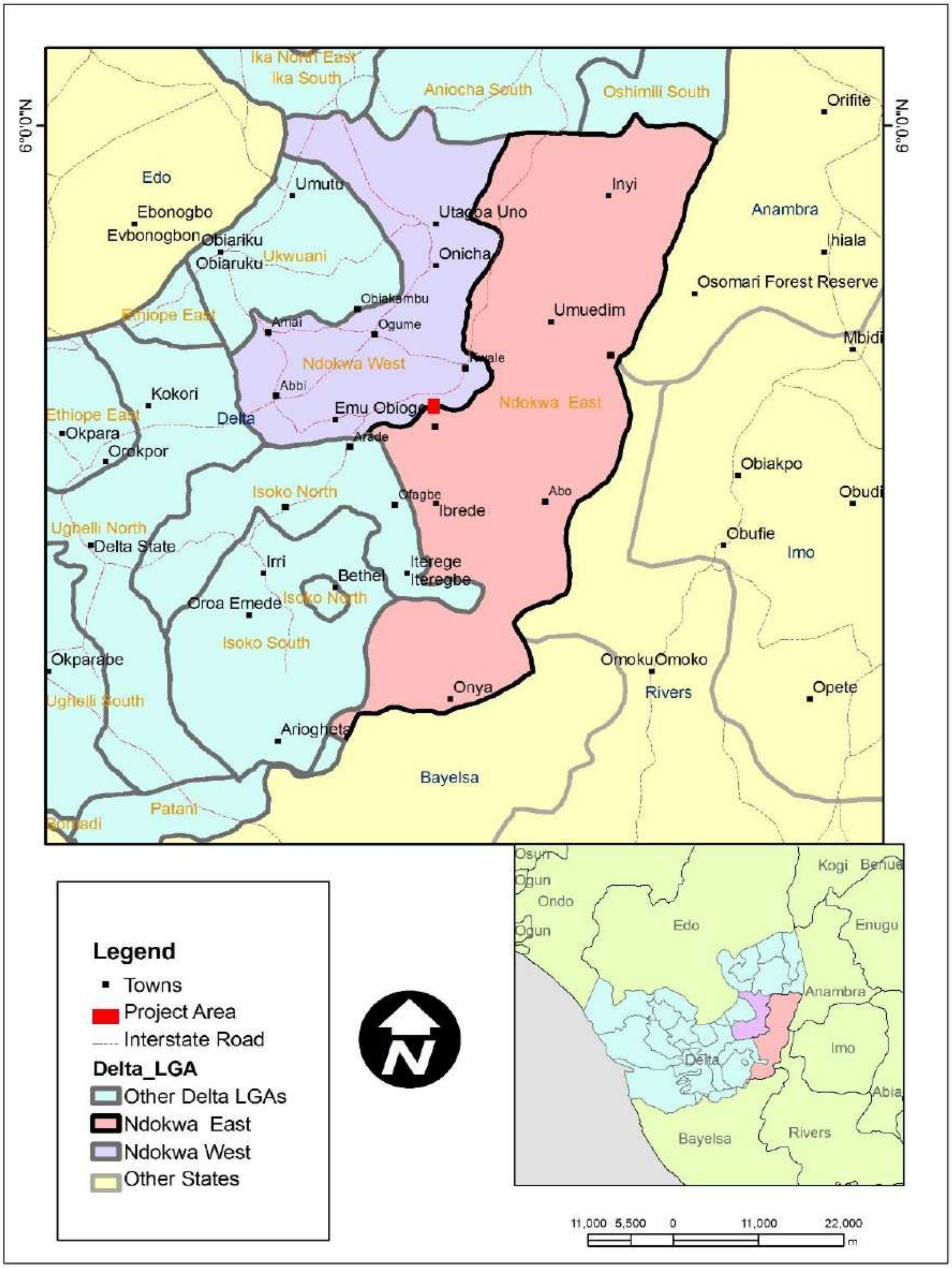

Figure 1.1b: Map showing Ndokwa West Local Government Areas

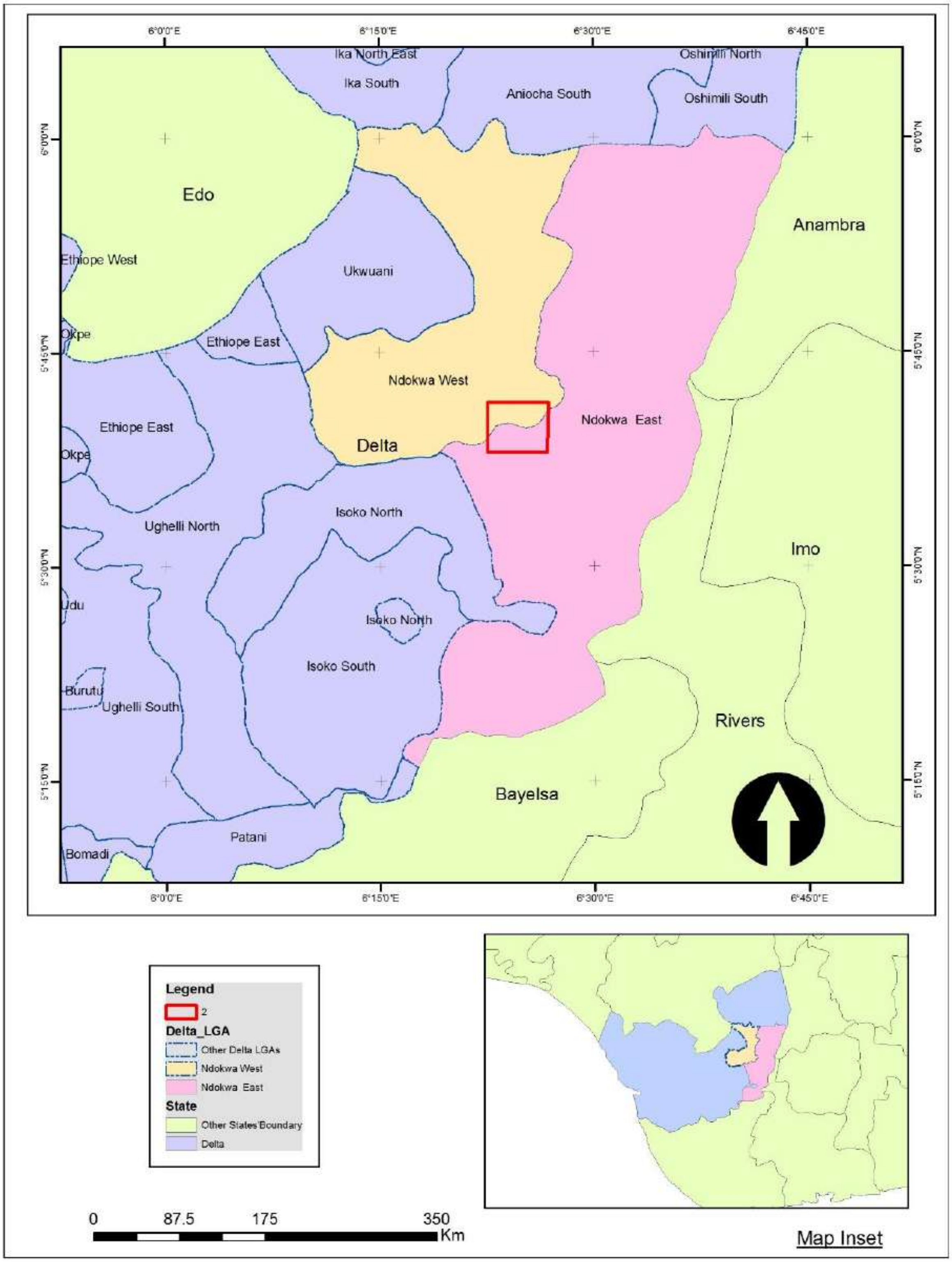

Figure 1.1c: Map showing OML 56

1.3 Objectives of the ESIA

The aim of the ESIA is to:

- ✓ provide an overview of the study area via existing secondary information as well as from a field studies.
- ✓ identify the environmental data that will affect the proposed additional development activities in the Field;
- ✓ identify knowledge and data gaps, highlight issues of concern, and make recommendations for mitigation and planning.
- ✓ identify the potential and associated environmental impacts
- ✓ identify general regulatory or mitigative measures and monitoring requirements that must be dealt with by Pillar Oil Limited.
- ✓ evaluate the extent of all observed impacts (negative and beneficial), of production activities on the ecology/environmental media i.e. air, land, water and socio-economic activities of the area
- ✓ recommend preventive, reduction and control measures for observed/associated adverse impacts of the project;
- ✓ provide the basis for consultation with regulatory authorities, the public and other stakeholders; and support subsequent applications for associated environmental permits.
- ✓ develop a cost effective ESMP that recommends plans and procedures to manage observed impacts and recover from exceptional events throughout the lifetime of the project;
- ✓ prepare a detailed ESIA presenting clear and concise information on the environmental impact of the project activities.

1.4 ESIA Scope

The ESIA scope of work includes:

- investigation of national and international environmental regulations guiding the activities to be carried out as well as consultation with FMEnv and other stakeholders;
- Literature review to obtain secondary data on the project area and project processes/ activities
- Acquisition of the environmental samples and data from sampling locations in OML 56 over two climatic seasons
- Comparison of data obtained from this study with FMEnv permissible limits
- impact identification, prediction, interpretation and evaluation;
- development of effective mitigation/ameliorative measures and monitoring programmes; and
- Preparation of detailed draft report to meet FMEnv permitting requirements.

1.5 ESIA Methodology

The ESIA was carried out in line with procedures provided in the Environmental Impact Assessment (EIA) Act Cap E12, LFN 2004 as well as EGASPIN, 1991 [Revised in 2018]. The study was carried out by a multidisciplinary team of experienced researchers employing standard methods from pure science, engineering, social and health sciences in order to obtain basic data for impact identification and establishment of mitigation and monitoring measures. The study generally involved desktop studies, field research, consultation, impact assessment and proffering of mitigation measures and development of an Environmental and Social Management Plan (ESMP).

a. Desktop Studies

Desktop studies were undertaken to acquire information on climate, geology, soil, vegetation, socio-economics, and other environmental aspects of the proposed project area. The materials consulted included textbooks, articles, charts, maps and previous study reports on the proposed project area. It involved the study of existing literature particularly reports of previous FMEnv approved EIA studies.

b. Fieldwork Activities/Laboratory Analysis

Fieldwork activities/Laboratory analysis were carried out to complement secondary data gathered from literature and to collect new and additional primary data to fill information gaps. The dry season field study was carried out from 24th February to 27th February, 2020 while the wet season sampling was carried out from 4th to 6th June, 2020.in accordance with requisite environmental sampling protocol.

c. Validation

The systematic incorporation of expert opinions was used to identify potential environmental impacts and to predict their magnitudes and significance (empirical worst-case scenario) using the data gathered from the field investigation. Experts in the relevant fields (as listed in the list of report preparers) were consulted for their opinions on issues relating to the potential ecological impacts of the proposed project.

d. Consultations with Stakeholders

Stakeholder consultation is a very important aspect of the EIA study and this was carried out with the proposed project stakeholders (FMEnv, DPR, Delta State Ministry of Environment and host communities). This was done to ensure that the views and opinions of all stakeholders regarding the proposed Project as associated with potential impacts are integrated into the ESIA.

e. Impact Assessment Methodologies

This involved impact identification, prediction and evaluation. Impact evaluation was carried out using ISO 14001, while the overall assessment was carried out through the use of the 'Strength of Relationship Matrix Approach' method. This method defines, numerically, the degree of interdependence of the various environmental parameters that were considered. The 1 - 5 ratings were assigned to characterize the interrelationship. The impact evaluation results obtained formed the basis for the development of the Environmental and Social Management Plan (ESMP) for the proposed project.

f. Project Logistics

The logistic support related to the ESIA includes a preliminary project kick-off/pre-mobilization meeting which was held between POL and the project consultants. The meeting discussed the Terms of Reference in relation to the work plan submitted by the Consultants. The details of the scope of services for the project were agreed upon; field work and sample collection at the proposed project site and surrounding areas for both climatic seasons, consultation and interaction with Stakeholders in the project area, administration of ESIA survey questionnaires in-depth interviews, focus group discussions, analysis of results, preparation of draft EIA Report and submission of ESIA Report to the Federal Ministry of Environment were carried out.

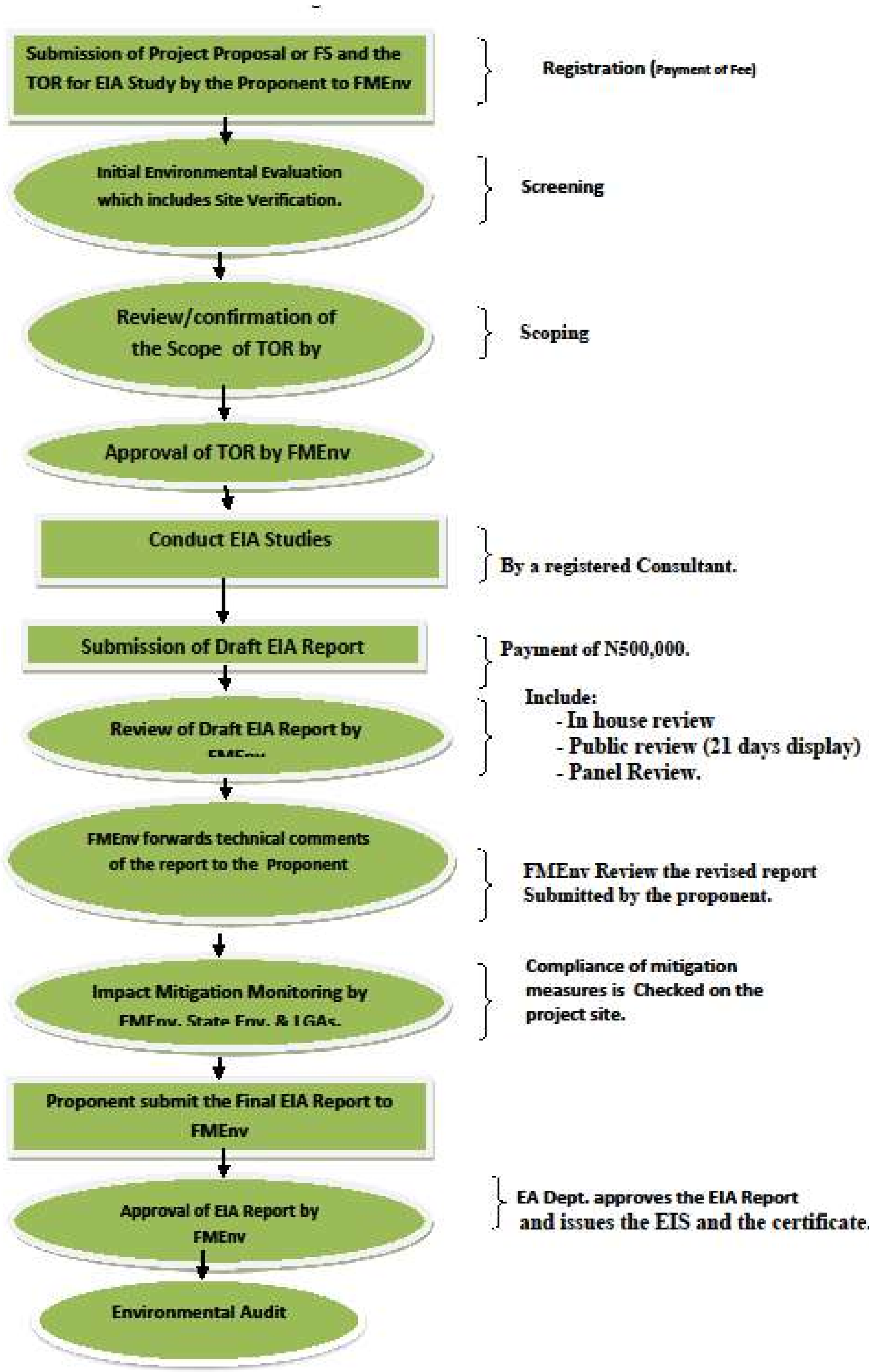

Figure 1.2: THE FMENV ESIA PROCEDURE

1.6 Legal and Regulatory Framework

The project is affected by a number of federal, state and international legislation which have been considered by the ESIA. A review of relevant legislation was done and presented in this section.

1.6.1 National Legislation

- **National Policy on Environment (1989, Revised 1999). Issued by Federal Environmental Protection Agency (FEPA)**

Nigeria enunciated a National Policy on the Environment to achieve sustainable development in Nigeria, and in particular to:

- Secure a quality of environment adequate for good health and well-being;
- Conserve and use the environment and natural resources for the benefit of present and future generations;
- Restore, maintain, and enhance the ecosystem and ecological processes essential for the functioning of the biosphere to preserve biological diversity and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;
- Raise public awareness and promote understanding of the essential linkages between the environment, resources, and development, and encourage individual and community participation on environmental improvement efforts; and
- Co-operate in good faith with other countries' international organizations and agencies to achieve optimal use of Trans-boundary natural resources and effective prevention or abatement of Trans-boundary environmental degradation (Article 2.0).

- ***Environmental Impact Assessment (EIA) Act CAP E12, LFN 2004***

The EIA institutional framework is provided by *Environmental Impact Assessment (EIA) Act. CAP E12, LFN 2004*. Environmental Impact Assessment (EIA) is an assessment of the potential impacts whether positive or negative, of a proposed project on the natural environment. The E.I.A Act, as it is informally called, deals with the considerations of environmental impact in respect of public and private projects. Sections relevant to environmental emergency prevention under the EIA include:-

- Section 2 (1) requires an assessment of public or private projects likely to have a significant (negative) impact on the environment.
- Section 2 (4) requires an application in writing to the Agency before embarking on projects for their environmental assessment to determine approval.
- Section 13 establishes cases where an EIA is required and
- Section 60 creates a legal liability for contravention of any provision.

- ***National Environmental Protection (Effluent Limitations) Regulations, S.I.8 of 1991*** Official Gazette, Federal Republic of Nigeria No. 42, Vol.78, August 1991, which requires installation of anti-pollution equipment for detoxification of effluents and chemical discharges from the company's existing facilities.

- ***National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes), S.I.9 of 1991*** Official Gazette, Federal Republic of Nigeria No. 42, Vol. 78, August 1991, which imposes restrictions on the release of hazardous or toxic substances into the air, water and land into Nigeria's ecosystems beyond the limits approved by FEPA.

- ***National Environmental Protection (Management of Hazardous and Solid Wastes), S.I.15 of 1991*****:** Official Gazette, Federal Republic of Nigeria, No. 102, Vol. 78, 31st December, 1991; describes the requirements for Groundwater protection, surface impoundment, land treatment, waste piles, landfill, incinerators, etc.

- **Environmental Guidelines and Standards for the Petroleum Industry, EGASPIN (1991, as Revised in 2002 and 2018).**

Part VIII A made preparation of EIA report mandatory for development activities. The EGASPIN is administered by Department of Petroleum Resources (DPR).

- **Associated Gas Re-Injection Act, CAP 20, LFN 2004.**

The Associated Gas Re-Injection Act deals with the gas flaring activities of oil and gas companies in Nigeria. The following sections are relevant to pollution prevention: -

- Section 3 (1) prohibits, without lawful permission, any oil and gas company from flaring gas in Nigeria.

Section 4 stipulates the penalty for breach of permit conditions.

- **Petroleum Products and Distribution Act, CAP P12, LFN 2004**

Under Petroleum Products and Distribution Act, CAP P12, LFN 2004, the offence of sabotage which could result in environmental pollution is punishable with a death sentence or an imprisonment term not exceeding 21 years.

- **National Gas Policy, 2017**

On Wednesday, June 28, 2017, the Federal Executive Council (FEC) at its monthly meeting approved the National Gas Policy, 2017 (“NGP”). The NGP, which was first released through the Ministry of Petroleum Resources (“MPR”), as a Consultation

Draft in October 2016, is based on a fundamental review of the policy positions of the Government over the last ten (10) years in respect of Nigeria's gas resources.

Fundamentally, the NGP sets the goals, strategies and an implementation plan for establishing a framework that will drive the institutional, legal, regulatory and commercial reforms necessary for attracting investment into the gas sector.

- ***Petroleum Act 1969***

Pollution control regulations in oil and gas operations are governed by the Principal legislation of Petroleum Act 1969. The regulations are made pursuant to section 8(i) b (iii) of the Petroleum Act 1969 that empowers the Minister of Petroleum Resources to make regulations for the prevention of pollution of water courses and the atmosphere. Some of the specific regulations include:

i. the Petroleum (Drilling and Production) Regulations 1969, Sections 25 and 36;
ii. the Mineral Oils (Safety) Regulation, 1963, Part III Section 7 and Part IV Sections 44 and 45;
iii. the Petroleum Regulations 1967; the Oil in Navigable Waters Decree NO.34/Regulations 1968;
iv. the Oil Pipeline Ordinance Cap 145 of 1956 as amended by the Oil Pipeline Act 1965, Section 17(3);
v. the Petroleum Refining Regulations 1974, Section 43;
vi. the Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2018 Revision)

The primary objective of the foregoing guidelines and standards is to regulate the environmental management practices in the production and discharge of produced formation waters, oily waste water, sludge and accidental spills of oils from oil and gas production installations within the territory and territorial waters of the Federal Republic of Nigeria.

- ***Forestry Law CAP 55, 1994***

This Act provides for the preservation of forests and the setting up of forest reserves.

- Prohibits any act that may lead to the destruction of or cause injury to any forest produce, forest growth or forestry property in Nigeria.
- Prescribes the administrative framework for the management, utilization and protection of forestry resources in Nigeria.

- **Endangered Species Act (Cap 108), 1990**

  The Endangered Species Act (Control of International Trade and Traffic) Cap.108 Law of Nigeria, 1990 prohibits the hunting, capture and trade of endangered species.

- ***Criminal Code***

The Nigerian Criminal Code makes it an offence punishable with up to 6-months imprisonment for any person who:

- Violates the atmosphere in any place so as to make it noxious to the health of persons in general dwelling or carry on business in the neighborhood, or passing along a public way; or
- Does any act which is, and which he knows or has reason to believe to be, likely to spread the infection of any disease dangerous to life, whether human or animal.

- ***Labour Act, 1999***

Nigeria has ratified all eight core International Labour Organization Conventions. The Labour Act (1999) is the primary law protecting the employment rights of individual workers. The Act covers protection of wages; contracts; employment terms and conditions; recruitment; and classifies workers and special worker types.

- ***Land Use Rights Act No. 6, 1978***

The Land Use Act No. 6 was enacted in 1978. The Act vests all land in the urban areas of each state under the control and management of the governor of the state. The governor of the state holds the land in trust for the people of the state and is solely responsible for the allocation of land in all urban areas to individuals who reside in the state and to organizations for residential, agricultural and commercial purposes. All other land in the state subject to conditions under the Land Use Act is under the control and management of the local government. The Act divests traditional owners of land and vests such land in the state governor for the benefit and use of all Nigerians. It provides the processes through which land may be acquired by the federal government.

- **The Nigerian Oil and Gas Industry Content Development Act 2010**

Section 2 of the Act gives a strong directive which requires Nigerian content to be considered as an important element in the overall project development and management philosophy for project execution.

All regulatory authorities, operators, contractors, subcontractors, alliance partners and other entities involved in any project, operation, activity or transaction in the

Nigerian oil and gas industry shall consider Nigerian content as an important element of their overall project development and management philosophy for project execution. There shall be exclusive consideration to Nigerian indigenous service companies which demonstrate ownership of equipment, Nigerian personnel and capacity to execute such work to bid on land and swamp operating areas of the Nigerian oil and gas industry for contracts and services contained in the Schedule to this Act.

1.6.2. Delta State Legislation

Delta State Ecology Law, 2006

The Delta State Ecology Law 2006 provide for the management of the environment within Delta State and matters incidental thereto. Section 18(1) makes provision that EIA should be undertaken for developmental projects in the State.

The Delta State Waste Management Law, 2004

The law was established for the purpose of evolving and maintaining a system of effective waste collection, management and disposal in the state and matters connected therewith.

Delta State Forestry Law Cap. 59, 1976

The law makes provision for the preservation and control of forests in Delta State and matters incidental thereto.

Delta State Consolidation Revenue law, 2009

The law provides for the assessment, harmonization and consolidation of internally generated revenue chargeable and collectable by the Delta State Government and Local Government Councils in Delta State and the establishment of the relevant administrative structures and other matters connected therewith

Delta State Ministry of Environment Policy, Revised 2009

This Policy provides for the Regulation, Monitoring, Compliance and Implementation and Sectoral Guidelines of the Delta State Ministry of Environment.

Delta State Environmental Protection Agency (DELSEPA) Edict No. 5 of 1997

The Delta State Environmental Protection Agency (DELSEPA) is charged with the primary responsibility for effluent monitoring in the State

Delta state Climate Change Policy 2010

The Policy recommends the implementation of measures that meet the sustainable development needs of the State. This integrated approach is grounded in the fact that the

Greenhouse gas mitigation is essential to avoid the unmanageable, while adaptation is crucial to manage the unavoidable.

1.6.3. International Conventions Ratified by Nigeria

The proposed development will have impacts on local as well as regional environment. The regional impact could result from emission of greenhouse gases (GHGs) via gas flaring which could have effect on global climate change. Therefore, the ESIA considered relevant international Conventions, Agreements and Protocols on climate change and other pertinent environmental issues relevant to Nigeria.

Pillar Oil Limited is committed to its environmental management by complying with relevant international legislation covering various environmental effects arising from the operation of Pillar Oil Limited facilities, including noise, gaseous emission, particulate, liquid effluent and solid waste.

- **Basel Convention on the Control of Trans-boundary Movements of Hazardous Wastes and Their Disposal, 1989 (Nigeria signed the Basel Convention document on 15th march, 1990 and ratified it on 13th march, 1991. Nigeria also ratified the amendment to the Basel Convention on 24th may, 2004)**

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

- The generator of hazardous waste should carry out duties with regard to the transport and disposal of such generated waste in a manner that is consistent with the protection of the environment, whatever the place of disposal,
- All should recognize that any State has the sovereign right to ban the entry or disposal of foreign hazardous wastes and other wastes in its territory,
- It should be recognized also that there is an increasing desire for the prohibition of trans boundary movements of hazardous wastes and their disposal in other States, especially developing countries,
- Hazardous wastes and other wastes should, as far as is compatible with environmentally sound and efficient management, be disposed of in the State where they were generated,
- Trans boundary movements of such wastes from the State of their generation to any other State should be permitted only when conducted under conditions

which do not endanger human health and the environment, and under conditions in conformity with the provisions of this Convention,

- Control of trans boundary movement of hazardous wastes and other wastes will act as an incentive for their environmentally sound management and for the reduction of the volume of such trans boundary movement,
- States should take measures for the proper exchange of information on and control of the trans boundary movement of hazardous wastes and other wastes from and to those States,

- **UNFCCC, Paris agreement of 2016[The agreement was signed on 22 September, 2016 and ratified by Nigeria on 16th May, 2017]**

The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort.

The Paris Agreement central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius.

Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework and an enhanced capacity building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their own national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework

- **Agenda 21 – United Nations Conference on Environment and Development**– also called the **Earth Summit [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

Held in Rio de Janeiro, Brazil (1992), with recommendations from the WHO Commission, more than 150-member states adopted ***Agenda 21*** – an action plan to guide future strategies for health and environment activities on a national and international level which in fact provided the background for FEPA's EIA framework to ensure environmental sustainability of all types of activities in the oil and gas industry (FEPA, 1995).

- **United Nations Guiding Principles on the Human Environment [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

The United Nations (UN) published the concept of Guiding Principles on the Human Environment in 1972. Ten of these Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action.

- **The Rio Declaration on Environment and Development [Nigeria signed the Basel Convention document in 1992 and ratified in 1994]**

The UN Conference on Environment and Development met at Rio de Janeiro in June 1992, at which time it reaffirmed the 1972 declaration on the Human Environment and sought to build upon it. This was done with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among states, key sectors of societies and people. It was also to aid work towards international agreements, which respect the interests of all, protect the integrity of the global environmental development system, and recognize the integral and interdependent nature of the earth.

- **Polluters Pays Principle (Adopted by Nigeria in 1999)**

In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organisation for Economic Co-operation and Development (OECD) and European Community (EC) countries.
The polluter pays principle underpins environmental policy such as an ecotax, which, if enacted by government, deters and essentially reduces greenhouse gas emissions. Some eco-taxes underpinned by the polluter pays principle include: the Gas Guzzler Tax, in US, Corporate Average Fuel Economy (CAFE) - a "polluter pays" fine. The U.S. Superfund law requires polluters to pay for clean-up of hazardous waste sites, when the polluters can be identified.

Polluter pays is also known as extended producer responsibility (EPR). This is a concept that was probably first described by Thomas Lundqvist for the Swedish government in 1990. EPR seeks to shift the responsibility dealing with waste from governments (and thus, taxpayers and society at large) to the entities producing it. In effect, it internalized the cost of waste disposal into the cost of the product, theoretically meaning that the producers will improve the waste profile of their products, thus decreasing waste and increasing possibilities for reuse and recycling.

- ***Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (IOPC Fund, 1992)***

The Fund Convention was adopted to provide additional compensation for victims of oil pollution and to transfer some of the economic consequences to the owner of the oil cargo as well as the ship owner. Compensation payable under the Fund is limited to 450 million francs per incident and an aggregate of 450 million francs for pollution damage resulting from a natural phenomenon of an exceptional, inevitable, and irresistible character.

- ***United Nations Framework Convention on Climate Change (1992)***

The convention on climate change was signed in 1992 during the Earth summit in Rio de Janeiro. Its implementation did not come into force till 1994. In this declaration, developed countries and economies in transition were mandated to limit their emissions of greenhouse gases which cause global warming. However, no mandatory emission/restrictions were placed on developing countries. This is now being reviewed including binding higher emission reduction by developed countries.

- ***World Bank Guidelines on Environmental Assessment***

The World Bank requires an Environmental Impact Assessment (EIA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable in order to improve decision making. Additionally, the policy specifies that the Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EIA. The Bank classifies projects into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. Details of World Banks EIA procedures and guidelines are published in the banks EA Source Books Vols. i – iii of 1991. Potential issues considered for EIA in the oil and gas industry include:

- Biological Diversity
- Coastal and Marine Resource Management
- Hazardous and Toxic Materials
- Cultural Properties
- International Waterways

World Bank Operational and Safeguard Policies

The World Bank is committed to a number of operational and safeguard policies which aim to prevent and mitigate undue harm to people and their environment in any development initiative involving the bank. These policies provide guidelines for bank and borrower staff in the identification, preparation, and implementation of programs and projects. There are ten World Bank Environmental/Safeguard Policies. As discussed below not all these policies are triggered by the proposed project development.

The World Bank policies that have been triggered by the proposed project are:

- **Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment (last updated February 2011)**.
  This is the umbrella policy for the Bank's environmental 'safeguard policies' which among others include: Natural Habitats (OP 4.04), Forests (OP 4.36) and Physical Cultural Resources (OP 4.11).
- **Operational Policy/Bank Procedure 4.04** - ***Natural Habitat*** - seeks to ensure that World Bank-supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society.
- **Operational Policy/Bank Procedure 4.36** - ***Forests.*** This policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development.
- **Operational Policy 4.09 - *Pest Management* -** policy recognizes that pesticides can be persistent and harmful to the environment for a long time. If pesticides must be used, the policy requires that Pest Management Plan (PMP) be prepared by the borrower, either as a stand-alone document or as part of an Environmental Assessment.
- **Operational Policy /Bank Procedure 4.11 - *Physical Cultural Resources*** seeks to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

➢ **United Nations Guiding Principles on the Human Environment**

The United Nations (UN), concerned about negative environmental trends since its formation, published two major concept documents: Guiding Principles on the Human Environment, 1972 and the Rio Declaration on Environment and Development. Ten of the Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action. The principles most relevant to the proposed project are summarized below.

- ***Principle Two***

The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate.

- ***Principle Four***

Man has a special responsibility to safeguard and wisely manage the heritage of wildlife and its habitat, which are now gravely imperiled by a combination of adverse factors. Nature conservation, including wildlife, must therefore receive importance in planning for economic development.

- ***Principle Six***

The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon the ecosystems. The just struggle of the peoples of all countries against pollution should be supported.

- **International Convention on Oil Pollution Preparedness, Response and Cooperation (OPRC), 1990**

Parties to the International Convention on Oil Pollution Preparedness, Response and Co-operation (OPRC) are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Ships are required to carry a shipboard oil pollution emergency plan. Operators of offshore units under the jurisdiction of Parties are also required to have oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents. Ships are required to report incidents of pollution to coastal authorities and the convention details the actions that are then to be taken. The Convention calls for the establishment of stockpiles of oil spill combating equipment, the holding of oil spill combating exercises and the development of detailed plans for dealing with pollution incidents.

- **Nagoya Protocol of 2010 (Ratified by Nigeria in 12 October 2014)**

The Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization to the Convention on Biological Diversity, also known as the Nagoya Protocol on Access and Benefit Sharing (ABS) is a 2010 supplementary agreement to the 1992 Convention on Biological Diversity (CBD). Its aim is the implementation of one of the three objectives of the CBD: the fair and equitable sharing of benefits arising out of the utilization of genetic resources, thereby contributing to the conservation and sustainable use of biodiversity. However, there are concerns that the added bureaucracy and legislation will, overall, be damaging to the monitoring and collection of biodiversity, to conservation, to the international response to infectious diseases, and to research.

- **Kyoto Protocol of 2004 (Ratified by Nigeria on 5th November, 2004)**

The Kyoto Protocol is an international treaty which extends the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two) it is extremely likely that human-made CO_2 emissions have predominantly caused it. The Kyoto Protocol was adopted in Kyoto, Japan on 11 December 1997 and entered into force on 16 February 2005. There are currently 192 parties (Canada withdrew from the protocol, effective December 2012)to the Protocol.

- **Stockholm Convention Against Persistent Organic Pollutants of 2004 (Signed on 23/05/2001, ratified by Nigeria on 24/05/2004 and came to force on 22/08/2004)**

Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty, signed in 2001 and effective from May 2004, that aims to eliminate or restrict the production and use of persistent organic pollutants (POPs). In 1995, the Governing Council of the United Nations Environment Programme (UNEP) called for global action to be taken on POPs, which it defined as "chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environment".

Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and trans-boundary threat.

- **Cartagena Protocol on Bio-safety of 2003 (Singed on May 24, 2000, ratified on Jul 15, 2003 and force into action on Oct 13, 2003)**

The Cartagena Protocol on Bio-safety to the Convention on Biological Diversity is an international agreement on bio-safety as a supplement to the Convention on Biological Diversity effective since 2003. The Bio-safety Protocol seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology.

- **Montreal Protocol on Substances that Deplete the Ozone Layer, 1988 (Ratified by Nigeria in 22/09/1988)**

The Montreal Protocol on Substances that Deplete the Ozone Layer (a protocol to the Vienna Convention for the Protection of the Ozone Layer) is an international treaty designed to protect the ozone layer by phasing out the production of numerous substances that are responsible for ozone depletion. It was agreed on 26 August 1987, and entered into force on 26 August 1989, followed by a first meeting in Helsinki, May 1989. Since then, it has undergone eight revisions, in 1990 (London), 1991 (Nairobi), 1992 (Copenhagen), 1993 (Bangkok), 1995 (Vienna), 1997 (Montreal), 1998 (Australia), 1999 (Beijing) and 2016 (Kigali, adopted, but not in force). As a result of the international agreement, the ozone hole in Antarctica is slowly recovering. Climate projections indicate that the ozone layer will return to 1980 levels between 2050 and 2070.

1.6.4 International Best Practices

Other considerations of the ESIA include other international best practices. International institutions provide guidance on best practice for the ESIA process and place emphasis on achieving sustainable environmental, social and health outcomes. They also provide environmental standards and limits for emissions and discharges. A number of key project impact mitigation measures such as resettlement are also specified.

The overall project design and this ESIA will align with international best practices such guidelines published by the International Finance Corporation (IFC) and the World Bank. The following is a summary of the specific international requirements and standards that will be applied to this ESIA. It should be noted that, given the private-sector nature of the development, the IFC Performance Standards described below will be most directly applicable to the project in this case.

- **The IFC Performance Standards**

The IFC applies Performance Standards to manage social and environmental risks and impacts and to enhance development opportunities in the private sector. The IFC Performance Standards encompass eight topics:

- ✓ **Environmental and Social Assessment and Management System:** Commercial clients/investees are required to manage the environmental and social performance of their business activity, which should also involve communication between the client/investee, its workers and the local communities directly affected by the business activity. This requires the development of a good management system, appropriate to the size and nature of the business activity, to promote sound and sustainable environmental and social performance as well as lead to improved financial outcomes.

- ✓ **Labour and Working Conditions:** For any business, its workforce is a valuable asset and a sound worker-management relationship is a key component of the overall success of the enterprise. By protecting the basic rights of workers, treating workers fairly and providing them with safe and healthy working conditions, commercial clients/investees can enhance the efficiency and productivity of their operations and strengthen worker commitment and retention.

- ✓ **Pollution Prevention and Abatement:** Increased industrial activity and urbanization often generate increased levels of pollution to air, water and land that may threaten people and the environment at the local, regional and global level. Commercial clients/investees are required to integrate pollution prevention and control technologies and practices (as technically and financially feasible as well as cost-effective) into their business activities.

- ✓ **Community Health, Safety and Security:** Business activities can increase the potential for community exposure to risks and impacts arising from equipment accidents, structural failures and releases of hazardous materials as well as impacts on a community's natural resources, exposure to diseases and the use of security personnel. Commercial clients/investees are responsible for avoiding or minimizing the risks and impacts to community health, safety and security that may arise from their business activities.

- ✓ **Land Acquisition and Involuntary Resettlement:** Land acquisition due to the business activities of a commercial client/investee may result in the physical displacement (relocation or loss of shelter) and economic displacement (loss of access to resources necessary for income generation or as means of livelihood) of individuals or communities. Involuntary resettlement occurs when affected individuals or communities do not have the right to refuse land acquisition and are displaced, which may result to long-term hardship and impoverishment as well as environmental damage and social stress. Commercial clients/investees are required to avoid physical or economic displacement or minimize impacts on displaced individuals or communities through appropriate measures such as fair compensation and improving livelihoods and living conditions.

- ✓ **Biodiversity Conservation and Sustainable Natural Resource Management:** Protecting and conserving biodiversity (including genetic, species and ecosystem diversity) and its ability to change and evolve, is fundamental to sustainable development. Commercial clients/investees are required to avoid or mitigate threats to biodiversity arising from their business activities and to promote the use of renewable natural resources in their operations.

- ✓ **Indigenous Peoples:** Indigenous Peoples are recognized as social groups with identities that are distinct from other groups in national societies and are often among the marginalized and vulnerable. Their economic, social and legal status may limit their capacity to defend their interests and rights to lands and natural and cultural resources. Commercial clients/investees are required to ensure that their business activities respect the identity, culture and natural resource-based livelihoods of Indigenous Peoples and reduce exposure to impoverishment and disease.

- ✓ **Cultural Heritage:** Cultural heritage encompasses properties and sites of archaeological, historical, cultural, artistic and religious significance as well as unique environmental features and cultural knowledge, innovations and practices of communities embodying traditional lifestyles, which are protected for current and future generations. Commercial clients/investees are required to avoid significant damage to cultural heritage due to their business activities.

- **Environmental and Social Safeguards Policies (African Development Bank)**

The African Development Bank issued its Environmental Assessment Guidelines (EAG) in 1992, but since then, many changes have occurred in the Bank' structure and operations. The revised Environmental and Social Assessment Procedures (ESAP 2015) have therefore been updated to reflect the more integrated approach addressing all crosscutting themes as well as the new organizational structure.

The main purpose of the Environmental and Social Assessment Procedures (ESAP) is to improve decision-making and project results in order to ensure that Bank-financed projects, plans and programs are environmentally and socially sustainable as well as in line with Bank's policies and guidelines. The ESAP apply to the Bank's public sector operations. Similar procedures were developed and approved for the Bank's private sector operations: AfDB Environmental Review Procedures for Private Sector Operations (2000). Other relevant AfDB policies are: AfDB Policy on the Environment (2004), AfDB Environmental Review Procedures for Private Sector Operations (2000), AfDB Gender Policy (2001), AfDB Policy on Poverty Reduction (2004) and AfDB Policy on Involuntary Resettlement (2003).

See **Table 1.1** below for the ten (10) IFC Equator Principles that was considered by the ESIA to ensure its conformity with international standard.

Table 1.1: IFC Equator Principles

Code	Principle	Description
1	Review and categorization	Screening to determine the magnitude of the proposed project's potential environmental and social risks and impacts
2	Environmental and social assessment	Aimed at addressing the relevant environmental and social risks and impacts of the proposed Project, as well as, propose measures to minimize, mitigate, and offset adverse impacts in a manner relevant and appropriate to the nature and scale of the proposed Project
3	Applicable environmental and social standards	Ensure compliance with relevant host country laws, regulations and permits that pertain to environmental and social issues
4	Environmental and Social Management System and Equator Principle Action Plan	Develop or maintain an Environmental and Social Management System (ESMS) to address issues raised in the assessment process
5	Stakeholder engagement	Ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities and other Stakeholders. The consultation process should be tailored to the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.
6	Grievance mechanism	Establish a grievance mechanism designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of the ESMS
7	Independent review	An Independent Environmental and Social Consultant, not directly associated with the client, will carry out an Independent Review of the Assessment Documentation

Code	Principle	Description
8	Covenants	Ensure compliance with all relevant host country environmental and social laws, regulations and permits in all material respects and during construction and operation
9	Independent monitoring and monitoring	Ensure the appointment of an Independent Environmental and Social Consultant, or /qualified and experienced external experts to verify monitoring information
10	Reporting and transparency	Ensure that, at a minimum, a summary of the ESIA is accessible and available online

1.6.5 Pillar Oil Limited Health, Safety and Environment Policy

POL Health, Safety, Security, Environment (HSSE) and Community Relations (Cr) Policy

- Pillar Oil Limited is committed to conducting its operations to utmost HSSE & CR standards internationally obtainable in the Oil and Gas industry. POL HSSE and CR policy which is a driver to environmental protection is stated thus:
- We will give utmost regards to Safety, Security of persons, preservation of operating environment and peaceful coexistence with host Communities and the public.
- We believe that the achievement of this commitment is an integral part of efficient and profitable business management. To achieve this, we will be guided by the following:

HEALTH AND SAFETY POLICY

- We will establish a safe work-permit system and conduct our operations in accordance with applicable statutory regulations and oilfield best practices. We will encourage Company and Contractor's employees to maintain a healthy work/life balance.

- We shall provide appropriate Personnel Protective Equipment (PPE) for employees and enforce their use in accordance with the Policy. Contractors are similarly required to provide appropriate equipment and ensure use in compliance with the POL PPE Policy. Compliance with POL Health and Safety rules and regulations will be a condition of employment for both Company and Contractors employees.

- We shall promptly report and investigate all incidents, including Near Misses to determine cause(s), and share lessons learnt, across the organization and contractors.

  We will establish contingency plans for foreseeable emergencies and regularly conduct exercises to train all on emergency response procedures.

ENVIRONMENT

We shall conduct all Company operations with due regard to the preservation of the environment and in compliance with applicable Local Regulations and Guidelines, and International codes of practice.

We will develop Environmental Management Plans and monitor effectiveness of mitigating measures and review as necessary.

SECURITY

We will partner with host Communities to secure lives and assets. We will apply non-confrontational security strategies in compliance with National and International Laws with respect to Human Rights.

COMMUNITY

We regard our host communities as stakeholders and our primary objective in the partnership is to promote capacity building. We will pursue proactive engagements with communities and utilize the atmosphere of peaceful coexistence achieved to implement sustainable development programs for communities.

1.7 Structure of the Report

The ESIA is structured in accordance with the EIA Sectorial and Procedural Guidelines, 1995 as presented below:

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CHAPTER TWO

PROJECT JUSTIFICATION AND ALTERNATIVE

2.1 Introduction

The general aim of any growing economy is to attain self-sufficiency in as many facets of its activities as possible. As such, the more self-sufficient an economy is, the more developed it is regarded to be. Nigeria is a developing economy, dependent almost exclusively on revenue from the oil and gas sector. In this chapter, the justification and appraisal of possible project options and alternatives for the proposed Further Field Development activities are discussed.

2.2 Need for the Project

With Crude oil revenues constituting over 90% of Nigeria's foreign exchange earnings over the last couple of decades, the oil and gas industry therefore represents the primary earner for the country. Pillar Oil Limited plays its part in nation building by providing employment and revenue for the government as well as running a financially profitable company.

Due to the importance of the oil and gas industry to the Nigerian economy, the Federal Government is always in support of environmentally friendly schemes to expand and diversify the sector. The drilling of oil well and establishing a gas plant in Umuseti-Igbuku fields will allow for increased near term oil and gas production which in turn will increase earnings accruing to the purse of the Nigerian Government. This benefit, coupled with the number of jobs this project would produce and the beneficial impacts to the immediate community, makes this project a necessity.

2.3 Benefits of the Project

The following are the advantages/ benefits of the Further Field Development:

- Expanding the scope of the proponent's participation in Nigeria's oil industry and diversifying the sources of investment and inflow of funds;
- Increasing the oil and gas reserves base through aggressive exploration;
- Promoting indigenous participation in the oil industry thereby fostering technological transfer;
- Providing opportunity for portfolio rationalization;
- Providing opportunity to gainfully engage the pool of high-level technically competent Nigerians in the oil and gas business;
- Promoting common usage of assets/facilities to ensure optimum utilization of available excess capacities;
- Expanding production output capacity;
- Maximizing the production potentials of the field; and

- Enhancing employment opportunity.

On the other hand, Igbuku Gas Plant will produce Liquefied Petroleum Gas (LPG) as its product with the following advantages or benefits:

1. LPG does not contain Sulphur hence it burns cleaner when compared to energy resources like oil
2. LPG has a higher heating value hence it burns consistently making it a reliable form of energy
3. Effects of corrosion are greatly reduced by use of LPG.
4. LPG has instantly controllable flame temperatures
5. LPG is more environmental friendly than other forms of energy. When compared to oil, LPG only releases 81% of the carbon dioxide and when compared to coal LPG releases only 70% of carbon dioxide.
6. LPG has very high thermal efficiency
7. LPG is pocket-friendly.
8. LPG is versatile as it has multiple uses. It is used in heating, automotive, power & feed stock.
9. LPG is easy to transport and can be stored underground with minimum danger for those who do not have natural gas.
10. LPG leaves no residue or deposits of coal which block the openings of lubrication causing wearing of vital engine parts.
11. LPG doesn't contain tetra ethyl lead which is a highly toxic carcinogen compound.
12. Combustion is almost complete thus lowering emissions of poisonous carbon monoxide, hydrocarbons, and nitrogen oxides.
13. The fuel pump is not required and there is no gasoline drowning in the engine.

Meeting the increasing demand for gas by customers:
This project will help to reducing the domestic gas supply gap by ensuring that the gas demand of industrial and commercial clusters are met.

Provision of Employment:
The project is in line with one of the Sustainable Development Goals (SDGs) to eradicate poverty, through the creation of employment opportunities. The project is poised to improve overall economic activity for the Umuseti/Igbuku communities. It is estimated that about 150 skilled and unskilled workers will directly or indirectly be engaged throughout the project lifecycle – pre-construction, construction, operations & maintenance and decommissioning phase.

a) **Pre-construction:** Workers from the community will be engaged to carry out pre-construction activities such as site clearance, excavation etc.

b) **Construction:** The project will provide short term local employment opportunities during the construction phase for community members in terms of loading and offloading materials and deliveries, drivers for the mobile site workforce etc. Other services include security, food vendors etc. Skilled labour required during this phase will include project managers, engineering consultants etc.

c) **Operations & Maintenance:** During the operational phase, jobs required will include site security/manning of the liquefaction facility, the general day to day operation and maintenance of the facility, cleaning etc. In addition, occasional opportunities such as vegetation clearance requiring unskilled labour will arise in the course of operations

d) **Decommissioning:** The facility is likely to remain in place for many years and therefore any decommissioning works would be a long time in the future. During this phase however, labour will be required for activities such as dismantling/demolishing, recycling, re-planting etc. This will largely be sourced from the local community.

In addition, a natural gas facility in Umuseti/Igbuku will attract new small and medium scale businesses to the community and immediate region because of the availability of a cheaper alternative to alternative fuels like Kerosene. This could potentially lead to the creation of more employment opportunities.

Overall, business activity will be enhanced through activities such as resident staff patronizing local businesses, local sourcing of construction materials where these are locally available (e.g. cement, glass, bricks etc.) and so on.

Other project benefits:

- Enable greater utilization of indigenous natural gas reserves targeted at domestic increasing domestic gas consumption, helping to develop national industrial and economic activity;
- Natural gas is a much cleaner fuel than diesel or petrol – reducing the risk of damage and extending the life of industrial equipment. Gas generators also have long service intervals (up to 30,000 hours), reducing maintenance and aftermarket costs; and
- Natural gas can replace several types of solid, liquid, and gaseous fuels in industrial processes (from steel to paper production) and is the most cost-

effective fuel for power generation in Nigeria, boosting productivity and competitiveness

2.4 Value of the Project

The anticipated cost of the proposed project will be in the region of US$ 80 – 100 million. A substantial amount of this fund will be injected into the local economy through various contracts and sub-contracts. In addition, the project has local and national economic values in terms of employment opportunities for various categories of Nigerian professionals, skilled and semi-skilled craftsmen, business opportunities and additional revenue for the government. Importantly, the site of the project was strategically selected with the intent to accomplish long term economic growth that will create local employment for various categories of indigenes in particular and Nigerian professionals in general.

2.5 Envisaged Sustainability

The proposed project will be undertaken using the Best Available Technology (BAT) and internationally recognised processes in the industry. To ensure technical, economic and environmental sustainability of the project, the specific measures to be taken shall include but not necessarily limited to the following:

- ✓ **Economic Sustainability:** Pillar Oil Limited shall ensure standard business ethics and transparency; preventing corruption, encourage public advocacy and lobbying, transparency in payment of taxes, encouraging human right and security. Funds accruing from the sales of crude oil and natural gas will continually enable Pillar Oil Limited meet its production and investment costs, contribute additional revenue to Delta State and Federal Government of Nigeria from tax payments, create more jobs and meet its financial, socioeconomic and material obligations to the host communities. The favourable enabling environment ensures that the fields will continue to exist for decades as a business venture and as an industry.

  The economic sustainability of the proposed project is, therefore considered highly feasible given the following highlighted reasons:
  - Crude Oil/Natural and Petroleum gas, which is the major raw material is currently available in the project area and is in abundance as a natural resource in Nigeria;
  - There is a ready and viable market for natural gas products from the plant;
  - Envisaged revenue accruing to the fields and Gas Plant from the sale of natural gas product will be sufficient to meet production and investment costs;

- The fields will continuously support the government and host communities with respect to taxes, employment generation, and facility improvement among others.

✓ **Technical Sustainability:** The proposed project will be technically sustainable, utilizing modern practices and techniques in the plant design and adhering to international and national engineering design and construction standards and codes of practices that shall be adopted throughout all stages of the proposed project development e.g. NFPA 59A, EN 1473, EN 13645, ISO 16903, API 625, ASME VIII Div 1, ASME B31.3, ASME B16.5, ASME B16.47 series A, AGA-3, AGA-9, API 11P, API 618, ISO 13631, API-610 10th edition, API-660 as TEMA 'C', CSA B51, CSA certification, CSA certification, NEMA standards, NACE MR-0175, FM, API-2510 etc. Pillar Oil Limited has a proven industrial records and strict adherence to internationally and nationally acceptable engineering design and construction standards. Innovative technologies that are economically viable and having minimal environmental, social and health impacts shall be utilized in the execution of the proposed project.

The manufacturer of the equipment is a world leader in the manufacturing and supplier of drilling and LPG equipment. Its services cover the following areas for this project.

- Equipment Supply.
- Engineering Support.
- Personnel Training.
- Operations & Maintenance Support.

✓ **Environmental Sustainability:** The proposed plant project shall be environmentally sustainable because Pillar Oil Limited's activities will continually be guided by its Health, Safety and Environment (HSE) policies and programs. The proposed activities will also be carried out in compliance with standard industry and regulatory guidelines as set by Nigerian environmental laws for the petroleum industry. Incorporating the findings and recommendations of this ESIA and subsequent implementation of the Environmental and Social Management Plan (ESMP) for the project's phases will ensure the desired environmental sustainability.

In addition, the project activities shall be guided by the Pillar Oil Limited's HSE Policy. A standard Environmental and Social Management System (ESMS) which conforms with ISO 14001:2015 shall be developed for management of aspects and anticipated impacts of the plant. The environmental sustainability of the project is premised on the following:

- Pillar Oil Limited shall ensure that all the plant is designed and installed in a manner that will keep all the potential adverse environment effects to the minimum and within the acceptable regulatory levels.
- A standard Waste Management Plan (WMP), aimed at pollution prevention strictly in line with regulator and best industry practice shall be developed for the plant.
- The principle of Best Available Technique (BAT) that prevents pollution shall be adopted.

The General Health, Safety and Environment (HSE) guidelines to be adopted by Pillar Oil Limited addresses "Good International Industry Practices" in four focus areas in line with *World Bank Group Environmental, Health, and Safety Guidelines for Petroleum Refining (2016):*

- Environmental.
- Occupational Health and Safety.
- Community Health and Safety.
- Construction and Decommissioning.

✓ **Social Sustainability:** To ensure social sustainability of the project, Pillar Oil Limited will ensure:

1. ***Robust stakeholder engagement****:* Pillar Oil Limited will ensure effective Stakeholder Engagement in a structured and culturally appropriate manner with likely to be affected Communities and other Stakeholders. The consultation process will be tailored to the risks and impacts of the Project; the Project's phase of development; the language preferences of the Affected Communities; their decision-making processes; and the needs of disadvantaged and vulnerable groups.
2. ***Establish a grievance mechanism:*** designed to receive and facilitate resolution of concerns and grievances about the Project's environmental and social performance as part of its Environmental and Social Management System (ESMS). Sources of grievances could include community youths, militia groups, etc.

2.6 Project Options and Alternatives

In line with *National Environmental Protection (Effluent Limitations) Regulation of 1991* which mandates early selection of best engineering and operational options for new point sources, a range of options and alternatives were evaluated to facilitate identification of the most appropriate means of meeting the project's environmental objective.

The benefits of evaluating alternatives are for the selection of the best project design, selection of the best project location, and most efficient use of resources which will aid avoidance of adverse impacts and achievement of sustainable development goals. Therefore, the following options and alternatives were appraised:

- Project options: No project options; Delayed project options; and Go-ahead option.
- Project alternatives: Alternative location/site and Alternative technology.

2.6.1 Project Options

- ***Option One: No Project Option***

This option assumes that the proposed project will not take place which means that the plan to further develop the field will not take place. The No Project option will have a negative impact on the local and national economies. The significant socio-economic and industrial development benefits associated with the proposed development such as increased business opportunities, increased revenue to government, increased foreign exchange earnings, employment opportunities, etc. will be forfeited. As a result, the 'No Project option' was not considered to be a viable or acceptable option for the proposed project.

- ***Option Two: Delayed Project Option***

Due to some unfavorable conditions such as civil unrest or hostilities within the stakeholder communities, malicious public opinion, unfavourable government policies, prevailing bad economic conditions or any force majeure, implementation of a proposed project may be delayed. Considering this option implies that the development's activities would be stalled until conditions become conducive. Interestingly, none of the above mentioned or any related delaying factors currently exist against the proposed development, therefore the delayed project option was not considered a preferred option and thus was not selected.

- ***Option Three: Go-Ahead Option***

This project option admits and emphasizes the vital need of the planned development. Considering its many benefits, this option was significantly weighed positive. This option will contribute to improved and increased production which will enhance the revenue base of Nigeria. It will also enhance the job creation and many more direct and indirect socioeconomic benefits. This Go-Ahead option was deemed viable and therefore considered. Therefore, the proposed Further Field Activities shall be executed as planned.

2.6.2 Project Alternatives

During the formulation of the proposed project design, possible alternatives have been considered in compliance with the requirements of Nigeria's EIA procedures together with international best practice and the IFC Performance Standards. The project alternatives considered are as follow:

- ***Alternative Location***
- The site/ location selection criteria included a wide range of engineering, environment, permitting and economic considerations. Current fields (Umuseti/Igbukur) and other fields were considered in selecting the location of the project.

Umuseti/Igbuku Fields

- Less complex as the secured site is located within Umuseti/Igbuku Field.
- Drilling will be carried out within already acquired land and right of way (RoW) in the field.
- Few communities are located close to the project site thus, there are minimal interface issues with the communities.
- Land is already secured thus avoiding the need for lengthy discussions/negotiations with new land-owners.
- There is a little likelihood to cause more damage to existing ecosystem during construction of interconnecting pipeline within the same field.
- Umuseti/Igbuku field has enjoyed support of local communities over the years.
- The necessary approval for the current site has been obtained and all required fees have been paid by the proponent. It is obvious that the issue of liability and compensation is not likely to arise throughout the life span of the project.
- No community will be displaced as a result of the project, and so there is no resettlement or compensation case for any aggrieved person or group of persons.

- ***Other Fields***
  - Locating the project in other locations will increase the complexity of constructing the interconnecting pipeline.
  - Longer trenching distance and more perturbation across the habitats in the area.
  - Higher cost of constructing interconnecting pipeline to Igbuku Gas Plant from other fields.
  - More developed towns requiring heavier interface with many communities.
  - Higher likelihood to cause more damage to existing ecosystem during construction of interconnecting pipeline.
  - Land not yet acquired in these locations thus lengthy discussions are required in order to secure a project site.
  - The good relationship between the present host communities and the company also cannot be guaranteed at a new oil field and this can lead to the project’s sabotage or further delay.

- Shifting the project to another location will incur additional cost on investment because new land has to be purchased, new business strategy needs to be adopted.
- This action plan will also result in loss of time.

Preferred Alternative: Umuseti/Igbuku Fields

- **Alternative Processes**

An LPG Refrigeration Process

- ✓ This process easily refrigerates the gas stream to obtain the LPG;
- ✓ Refrigeration can easily be employed in three different LPG production processes: expander plants, low temperature separation and combined processes;
- ✓ This will prevent excessive glycol injection to prevent hydrate formation and reduce duty required in the refrigeration unit; and
- ✓ Refrigeration Process is very economical

Lean Oil Absorption Process

- ✓ The complexity of the processes makes it capital intensive and not suitable for small-scale liquefaction plants
- ✓ This system is outdated and energy intensive.
- ✓ The process is very expensive to maintain

Preferred Alternative: LPG Refrigeration Process

- **Alternative Transportation Method of Gas to the Plant**
  - ✓ The Umuseti/Igbuku pipeline is a cost-effective option as the pipeline is currently operational and in good state. Also, pipelines are the most cost effective way of transporting gas.
  - ✓ Through Barges/Vessel: Adverse environmental impact due to continuous logistics requirements and liquid fuels used for transportation. Also, it is more expensive to transport gas to the project site via the listed virtual means as additional compression/processing equipment and logistics (trucks/barges) will need to be procured.

Preferred alternative*: The* Umuseti/Igbuku *pipeline as it is a more cost-effective option as the pipeline is currently operational and in good state.*

- **Output Gas Transportation**

Pipelines from the Gas Plant:

- ✓ Adverse environmental impact due to acquire of different RoWs for transportation.
- ✓ It is more expensive to transport gas from the project site via pipelines to receiving customers since the customers are located in different locations.
- ✓ High cost of maintenance.

Through Virtual Pipeline (Trucks)

- ✓ No adverse environmental impact from transporting through trucks.
- ✓ Virtual Pipeline is suited to a variety of transport modes and market segments including off-grids factories, power plants, communities etc.
- ✓ Virtual Pipeline (Trucks) are the most cost-effective way of transporting gas to customers.
- ✓ Creates more jobs compared to pipeline solution.
- ✓ Low cost of maintenance.

Preferred alternative*:* Through Virtual Pipeline (Trucks)

- **Alternative Technology**

Inlet Compression + JT Gas Plant

- ✓ For a fixed Gas plant inlet stream pressure of about 150 barg, inlet compression is required at some stage beyond early life to guarantee required expansion across the J-T valve and dew point attainment in downstream Low-Temperature Separator equipment. NGLs and LPG are recovered as well with additional processing equipment.
- ✓ Control hydrocarbon dew point to comply with pipeline specifications.
- ✓ Extract valuable natural gas liquids (NGLs), significantly increasing revenue.
- ✓ Simple and less expensive alternative to standard refrigeration plant.
- ✓ Skid-mounted for simple installation at any remote location.

MRU + Sales Compression

- ✓ This maintains a low Gas plant inlet stream pressure of about 30 barg and achieves dew pointing with a Mechanical Refrigeration Unit and downstream Low Temperature Separator equipment. NGLs and LPG are also recovered with additional processing equipment.
- ✓ Insensitivity to vessel motion as the refrigerant is in gas phase, and there is no concern on refrigerant distribution in heat exchangers.
- ✓ Flexibility to changes in feed gas conditions and ease of operation.
- ✓ Inherent safety with nitrogen as the refrigerant, and there are no liquid hydrocarbon refrigerants and no potential fire hazards.
- ✓ Rapid startup and shutdown.

- ✓ Less equipment counts, smaller plant footprint, and relatively low topside weight.

Turbo Expansion

- ✓ This requires a low inlet stream pressure of about 30 barg with inlet compression of 150 barg goes through an expander and downstream cold Separator equipment to achieve dew point. Energy generated by the expander is used to drive a complimentary compression before the gas stream passes through a final sales gas compression. NGLs and LPG are also recovered with additional processing equipment
- ✓ Performance guarantees
  Up to 95% to 97% propane recovery in ethane rejection and recovery modes, respectively.
- ✓ Performance guarantees
  Up to 90% ethane recovery in ethane recovery mode.
- ✓ Designed for heavy gas applications utilizing inlet refrigeration.
- ✓ Dehydration and hydrate prevention systems included.
- ✓ Flexible design to handle a wide range of inlet gas compositions.
- ✓ Efficient heat integrated design with low emissions hot oil system.
- ✓ Modular design for simple installation and mobility purpose.

Preferred alternative: Turbo Expansion

- **Alternative Product Storage Type**
  - ✓ Above-Ground Storage Tanks: For above-ground storage tanks, visual checks for leaks can easily be performed, it can easily be repositioned and It is less costly to install and maintain.
  - ✓ In-Ground Storage Tanks: For in-ground storage, it is difficult to maintain, difficulty in the detection of leakages, more complex interface with associated plant equipment, more expensive to install and maintain and higher environmental risk (especially where there are underwater reservoirs nearby.

Preferred alternative*: The selected option is an above-ground*

From the foregoing, it is evident that there is no better alternative to the proposed Further Field Development that favors environment, social and economy except as planned. Due to the advantages that the Go-Ahead Option has over other options considered, the proposed project is considered viable and should be executed as planned. The proposed project also considered environmental and social sustainability; therefore, it should be executed as planned.

CHAPTER THREE

PROJECT AND PROCESS DESCRIPTION

3.1 Introduction

This chapter provides a description of the proposed Further Field Development. It provides details of the proposed production process, the project location, project schedule and details of the plant's product. It also provides details on the project activities at each phase throughout the life cycle of the project namely: pre-construction/site preparation, construction, operation, maintenance and decommissioning. Specifically, the Chapter provides detailed information on the proposed further developmental activities of Umuseti-Igbuku field in sufficient depth to enable the scope and extent of the project to be understood, and for all potential sources of impacts to be identified. It also outlines the sources of waste and the company's approach for their management.

3.2 Facility Location

The Umuseti/Igbuku field complex has two proven oil and gas fields (Umuseti and Igbuku) and four identified satellite prospects (Umuseti-North East, Umuseti-East, Igbuku-West and Igbuku-North). The Umuseti -Igbuku marginal fields are situated within the low-lying freshwater forest of Delta state. The natural vegetation is in different stage of disturbances. The topography is a low lying and relatively flat terrain drained by the Ase River. Within the field, there are cultivated farmlands and forests.

Umuseti-Igbuku Field where the further field activities are to take place has a concession area of 102 square kilometres and is located in OML 56, Delta State within Latitudes 180042.921ºN; 187043.150ºN and Longitudes 44332.104ºE; 440558.420ºE in Ndokwa West Local Government Areas of Delta State, Nigeria **(Fig 3.1**).

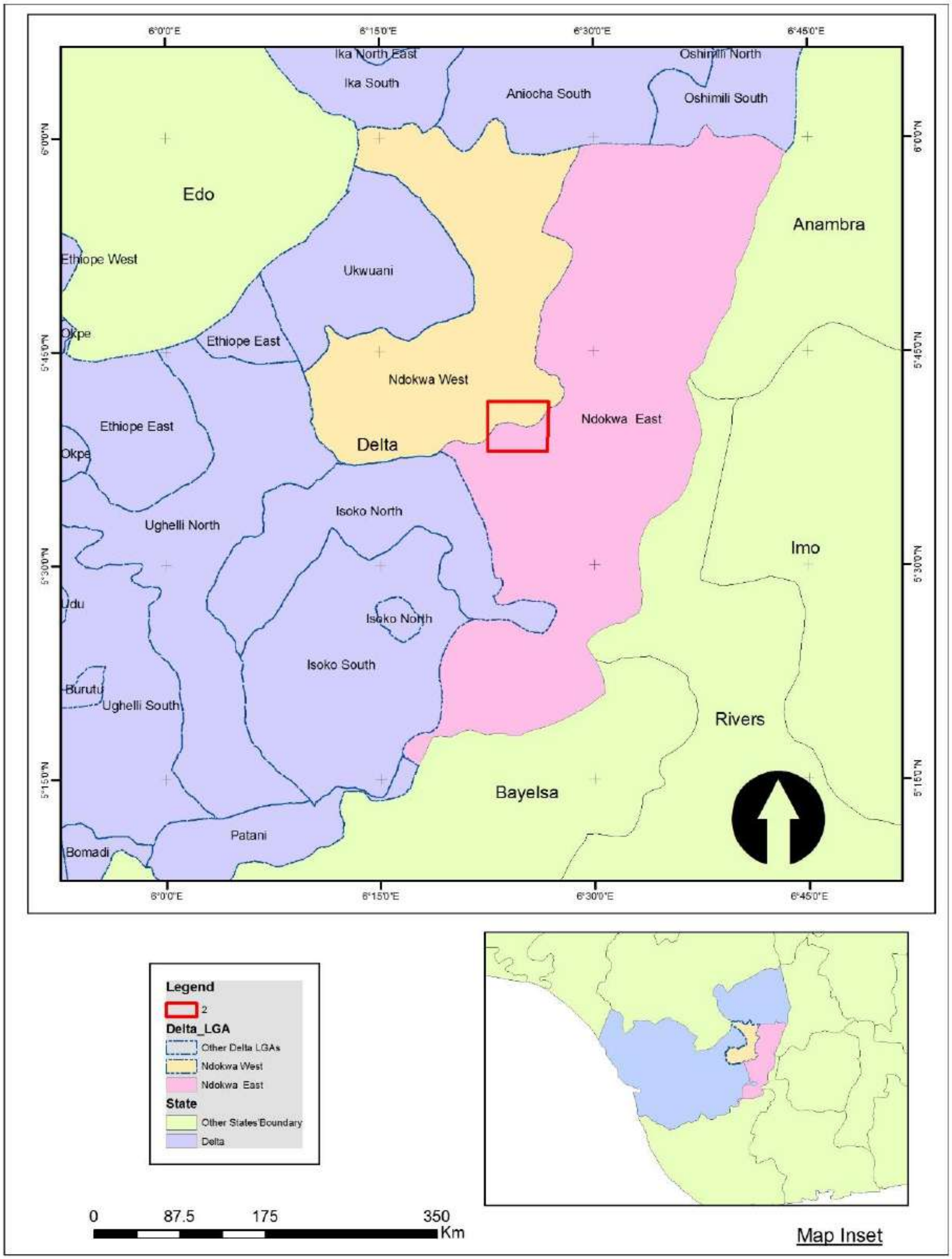


Fig. 3.1: Map showing Umuseti-Igbuku Field

3.3 Project Description /Activities

3.3.1 Description of the Existing Facilities

The licence to mine for oil and gas on this acreage was awarded to Pillar Oil Limited in 2003. The well history is presented as follows:

UMUSETI-1

Umuseti-1 was drilled based on 2-D seismic data. It was spudded in 1966 and found a total of nine hydrocarbon bearing intervals between 7730 –11672 ftah (7713 and 11655 ftss). After encountering a blow-out at depth of 12,914 ft, drilling was terminated and the well plugged back to 7,700 ftss. Sidewall coring, formation tests (FIT) and drill stem tests (DST) were attempted with mixed success. The well was suspended as an oil and gas producer.

One Gas (Level I) and five Oil reservoirs (Levels II to VI) in the Down-thrown Compartment. Three Oil reservoirs (Levels VII to IX) in the Up-thrown Compartment

Total Depth of reservoirs: (2,356 m ah to 3,558 m ah)

Well Coordinates: X = 441,393; Y = 185,657
Co-ordinate belt: TNW

UMUSETI-3 (EX-OBODUGWA-3)

Was drilled based on 2-D seismic data and was spudded in 1982 ostensibly to test one of the culminations along the Obodogwa - Obodeti trend in the central part of OML-56 and drilled to a total depth of 13,452 ft. The western part of the culmination was tested by Obodeti - 1 which found 23 ft of oil. Obodogwa-1 encountered the second culmination and found six hydrocarbon levels. Obodogwa-3 was planned to appraise the hydrocarbon potential of the third culmination, which is separated from the western culmination penetrated by Obodogwa - 1 by a saddle. The 3D data (now available) shows clearly that Obodogwa – 3 was drilled on the Umusati structure downdip of Umusati-1. The well encountered two oil bearing reservoirs and one gas bearing reservoir. The production test carried out on the main oil bearing reservoir (XXb), achieved a maximum flow of 328m3/day of oil and 186500m3/day of gas with GOR of 569 m3/m3 using a choke of 36/64. The gas and oil gravity are 0.733/ air and 0.798/ water respectively. The well was completed single string on the reservoir (no completion status diagram is available).

Two Levels - Level XXa (Gas/Condensate) and Level XXb (Oil)

Total Depth of reservoirs: (3,475m ah to 3,517m ah)

Well Coordinates: X = 440,867; Y = 184,385
Co-ordinate belt: TNW

IGBUKU-1

Well was drilled in 1981 to test the Igbuku structure located south of the main Obodogwa-Umusati trend from which it is separated by a fault and drilled to a **total depth of 13,780 ft.** The well discovered six hydrocarbon bearing reservoirs between 3345 – 3930 m ah; four of these reservoirs are gas condensate bearing, while two contain oil. The most notable reservoir is the gas condensate reservoir VIIa with 60m net pay encountered in a down-to situation. This well had an extensive production test that yielded a maximum open hole flow of 6,420,000 m^3/day of gas of density 0.7/air with a condensate content of 3m^3/m^3 with density of 0.816/water. The well was suspended as a gas, gas condensate and oil producer.

One Gas Reservoir (Level IV)

Two Oil Reservoirs (Levels V and VIa)

Three Gas Condensate Reservoirs (Levels VIIa, VIIb and VIIc)

Total Depth of reservoirs: (3,345 m ah to 3,930m ah)

Well Coordinates: X = 443,262; Y = 178,505
Co-ordinate belt: TNW

UMUSETI-2 (EX-UMUSETI NE-1)

Umuseti NE-1 was drilled to a **total depth of 12,485 ft** in the northern fault block in 1974 with the objective of exploring the structural closure identified in the block. The well did not encounter high pressure zones as anticipated. Umusati NE-1 was subsequently abandoned as a dry well.

Well Coordinates: X = 442604.0; Y = 186401.0
Co-ordinate belt: TNW

ASE-RIVER-1

Ase River was drilled in the Umuseti/Igbuku farm out area in October 1973 to a total depth of 10,600ftah. The well encountered only water bearing sands and was therefore plugged and abandoned.
Well Coordinates: X =442651m; Y =175681m

UMUSETI-4

Umuseti-4 was drilled in March 2012, following the reinterpretation of the 1991 vintage seismic data (2D and 3D) acquired by Elf. The Umuseti-4 well was drilled as a deviated well to a total depth of 12,898 ftah. The Umuseti-4 well encountered a total of 407.9 ft of oil, 450ft of gas and 271 ft of undifferentiated hydrocarbons in 24 intervals. The well was completed as a dual string well. Umuseti-4 is currently on stream.

Well Coordinates: X = 442950m Y = 185582m

UMUSETI-5

Umuseti-5 was drilled in 2013 as a deviated well to a total depth of 9510 ftah. The well was drilled as a development well in the Umuseti structure to provide additional drainage points, structural control, investigate sand continuity and resolve fluid types in several levels. Well-5 encountered eleven (11) hydrocarbon reservoirs; nine containing oil (RSVR II, III, VI, UI-II, UI-III, UI-V, UI-VI, UI-VIII and UI-IX) and two (2) gas bearing reservoirs (RSVR-I and RSVR UI-IV). The Umuseti-5 well was completed as a dual string well and is currently on stream.

Well Coordinates: X = 442801.77m Y = 185652.95m

UMUSETI-6

Umuseti-6 was drilled in 2014 as a vertical well in the Umuseti structure. The well was drilled as a development well to a total depth of 9510ftah, to provide drainage points, structural control, investigate sand development of the Umuseti -Obodugwa hanging wall structure in near crestal positions and resolve fluid type variations seen in Umuseti-1. The well encountered only four (4) hydrocarbon bearing reservoirs: 3 oil bearing – RSVR -II, -III and –VI and one gas- RSVR –I, other intervals were encountered wet. The well was completed as a dual string producer across RSVR III and VI. The long string has been put on stream, while the short string could not flow naturally due to the low permeability of the reservoir sand.

Well Coordinates: X = 441249m Y = N:185776m

3.3.1.1 Other Existing Facilities

The existing Umuseti 3 Production Facility (EPF) has an installed gross liquid capacity of 5,500bpd. This comprises of two independent trains of 3,500bpd and 2,000bpd respectively.

The EPF has two horizontal 3-phase production separators (V101 and V103), one vertical flash gas separator (V102), 2 x 20,000bbls crude oil storage tanks, 8 x 500bbls crude oil processing tanks, 3 x 60HP crude oil injection pumps, 2 x 20HP crude oil transfer pumps, 1 x 40HP crude oil injection / transfer pump, 2 x 40HP instrument air compressors, 2 x 275KVA diesel gen sets, 1 x 160KVA diesel gens et, mini fire station, fire hydrant system, wellheads, remote field, inlet and intermediate manifolds, flowlines and a 6inch x 7.2km crude oil delivery pipeline.

There are 5 producing well strings (3T, 4L, 4S, 5L, 5S and 6L).The dry well strings (5L, 5S, 4S) are produced through the bigger V103 separator whilst the wet strings (3T and 4L) are produced through the V101 to the processing tanks and finally to the crude oil storage tanks. Treated crude oil is then injected to the Umusadege Group Gathering Facility (GGF) for export through either Brass or Forcados Terminals. Production from V103 goes through V102 for further flashing of process gas which helps to stabilise the crude oil going into the storage tanks.

The production facility processes the hydrocarbon fluids and separates oil, gas and water as the oil must be free of dissolved gas before export. Similarly, gas must be stabilized and free of liquids and unwanted components such as hydrogen sulphide and carbon dioxide. Produced water from the production separators goes into a 2 stage oil saver pits for skimming of the oil sheen that may have accompanied the water production. The outlet of the 2 stage oil saver pits goes to the inlet of a produced water clarifier vessel (currently under construction) which further removes any remaining oil to 20ppm level (or less). The cleaned-up water is then sent to a containment chamber at the flare pit for incineration into water vapour and carbon dioxide.

The production wells feed into the gathering system (production and test manifolds). From here it is fed to the gas/ oil separation plant. The purpose of the gas-oil separation is to process the well flow into clean, marketable products: oil and natural gas. Also included are a number of utility systems, which are not part of the actual process but provide energy, water, air or other utility to the plant/ process.

Metering, Storage and Export

Storage tanks allows for the storage of crude oil to take up changes in demand, delays in transport, etc., amongst other operational factors. The metering station allows POL to monitor and manage the natural gas and oil exported from the Umuseti/Igbuku Field. These employ specialized meters to measure the natural gas or oil as it flows through the pipeline, without impeding its movement. This metered volume represents a transfer of ownership (custody transfer metering). This forms the basis for invoicing the sold product and also for production taxes and revenue sharing between partners. The metering installation consists of a number of meters runs so that one meter will not have to handle the full capacity range, and associated prover loops so that the meter accuracy can be tested and calibrated at regular intervals.

There are currently two export routes via Ase River (Brass NAOC) and UPIL / NPDC (Forcados Shell). These export routes give a combined RPC of 5,500 bbls / day for

Pillar Oil. Availabilities on these export routes vary during any given year with an average annual injection rate of between 2,000 to 3,000 bbls / day for the past few years. A third evacuation route will become available before the end of 2020 via the new OPAC Refinery currently under construction. The refinery is a 10,000 bbls / day capacity and has the ability to take 100% of Pillar Oil production.

Test separators and Well Test

Test separators are used to separate the well flow from one or more wells for analysis and detailed flow measurement. In this way, the behaviour of each well under different pressure flow conditions can be defined. This normally takes place when the well is taken into production and later at regular intervals (typically 1-2 months), and will measure the total and component flow rates under different production conditions. Undesirable consequences such as slugging or sand can also be determined. The separated components are analyzed in the laboratory to determine hydrocarbon composition of the oil and gas.

Utility Systems

Utility systems do not handle the hydrocarbon process flow, but provide some service to the main process. Some of the key Utilities include the following.

SCADA Systems

Many oil and gas processes are controlled by SCADA (Supervisory control and data acquisition) systems, which comprise software and hardware elements to control the production process locally or at remote locations and monitor, gather and process real-time data. The SCADA system directly interacts with sensors, valves, pumps, and more through Human Machine Interface (HMI) software and this helps minimize downtime.

Emergency Shutdown and Process Shutdown

The Emergency Shutdown (ESD) and Process Shutdown (PSD) systems take action when the process goes into a malfunction or dangerous state. The aim of an Emergency Shutdown (ESD) system is to isolate the facility from sources of hydrocarbon, reduce the inventory of hydrocarbon on the facility and consequently reduce the risk to the personnel and the facility.

In the event of confirmed fire / gas detection, abnormal hydrocarbon process conditions or hazards to personnel, the ESD system will trip the production facilities and process utility equipment. The emergency and abandon alarms will be initiated as defined in the F&G Cause & Effect chart-basedMatrix.

Fire and Gas System

The F&G Detection System is designed and installed to provide detection of fire or leak of flammable gas, in a rapid and reliable way. It continuously monitors all areas where a fire or accumulation of a flammable / explosive gas mixture may occur. The Fire and Gas system is not generally related to any particular process but instead is divided into fire areas by location. Each fire area is designed to be self-contained, in that it should detect fire and gas by several types of sensors, and control fire protection and firefighting devices to contain and fight fire within the fire area.

A mini fire area protection data sheet shows what detection exists for each fire area, and which fire protection action should be taken in case of an incident. The type and number of the detection, protection and fighting devices depends on the type of equipment and size of the fire area and they vary for different process areas. Key features of the F&G detection system are highlighted below.

Fire detection:

- Gas detection: Combustible and toxic gas, electro-catalytic or optical (IR) detector
- Flame detection: Ultraviolet (UV) or infra-red (IR) optical detectors
- Fire detection: Heat and ionic smoke detectors
- Manual pushbuttons

Fire fighting, protection:

- Gas-based firefighting, such as CO_2
- Foam-based firefighting
- Water-based firefighting: sprinklers, mist (water spray) and deluge
- Protection: Interface to emergency shutdown and HVAC fire dampers.
- Warning and escape: PA systems, beacons/lights, fire door and damper release

For fire detection, coincidence and logic are often used to identify false alarms. In such schemes, several detectors in the same area are required to detect a fire condition or gas leakage for automatic reaction. This will include different detection principles, e.g., a fire, but not welding or lightning strike. Action is controlled by a Fire and Gas system (F&G). Like the ESD system, F&G action is specified in a cause and effect chart called the Fire Area Protection Datasheet. This chart shows all detectors and fire protection systems in a fire area and how the system will operate. The F&G system provides supervisory functions, either in the F&G or the Information Management System (IMS) to handle such tasks as maintenance, calibration or replacement and hot work permits, e.g., welding. In the mini fire station, there is a 5,000bbls firewater storage tank, along with the associated firewater engines &

pumps. There is an existing water hydrant and foam distribution system within the Umuseti 3 EPF.

Instrument air

A large volume of compressed air is required for control of pneumatic valves and actuators, tools and purging of cabinets. It is produced by electrically driven screw compressors and further treated to be free of particles, oil and water.

HVAC

A HVAC system is generally provided to:

- Maintain a positive pressure within the accommodation/ office or canteen areas;
- Provide a workable environment for human habitation i.e. by maintaining suitable temperature and relative humidity level; and
- Provide an environment suitable for the electrical and electronic equipment to operate.

The Heat, Ventilation and Air Conditioning system (HVAC) feeds conditioned air to the equipment and accommodation rooms, etc. Cooling and heating is achieved by water-cooled or water/steam-heated heat exchangers. Generally, cooling is achieved by compressor refrigeration units to achieve sufficient efficiency and performance. A key consideration in setting up the HVAC system is to provide air to equipment rooms that are secured by positive pressure. This prevents potential influx of explosive gases in case of a leak.

Potable water

Potable water systems are provided by boreholes on the facilities to serve the needs of personnel and the production process.

Telecommunications and Communications

The telecom system consists of a variety of subsystems for human and computer wired and wireless communications, monitoring, observation, messaging and entertainment. Some of the main systems are:

- Public address and alarm system/F&G integration
- Access control
- UHF radio network system
- Closed circuit TV system
- Mandatory radio system
- Security access control
- Meteorological system
- Telecom antenna tower and antennas

- PABX telephone system
- Entertainment system
- Office data network and computer system
- Personnel paging system
- Telecom management and monitoring system
- Radio link system
- Mux and fiber optical terminal equipment
- Satellite systems

The communications system involves internal communication systems and external communication systems.

Internal Communications System

The internal communication system is provided to:

- Inform the control and radio rooms of an emergency or status during an emergency;
- Ensure that all personnel in any location in Umuseti/Igbuku Field can be made aware of any hazardous situations and to inform them of actions to be taken; and
- Provide emergency communication for the emergency response team.

External Communications System

External communication systems are provided to:

- Provide communication means during production operations, oil and gas evacuation and maintenance purposes;
- Report hazardous situations to nearby installations; and
- Co-ordination with medical facilities or external emergency resources so that assistance can be provided during Medevac, oil spill incidents and any other emergencies.

Electrical System

The facility's power generation system is designed to supply all production facility requirements and is able to start the largest electrical motor under normal conditions. The facility has 2 x 275KVA diesel gen sets and 1 x 160KVA diesel gen set for this purpose.

Emergency Generator

An emergency diesel engine driven generator has been provided as an emergency source of electrical power supply for maintaining essential processes. The emergency diesel generator supplies to the following system during power failures:

- HVAC;
- Instrument air compressor;
- Emergency lighting and small power;
- UPS;
- Communication System; and
- Pump for fire water system

UPS
Uninterruptible Power Supplies (UPS) is a consolidated, fully redundant system, providing power to safety systems, communications systems and monitoring and control systems to enable them to work continuously during a power outage.

Emergency lighting
Umuseti/Igbuku Field facilities are provided with emergency lighting to ensure personnel safety and escape during a power failure and to allow limited operations to be carried out by technical personnel attempting to restore power and/or operation. Emergency lighting is located at all escape routes and exit doors. The power for emergency lighting is supplied by the emergency lighting distribution board. Emergency lighting circuits in enclosed areas are un-switched and maintained energized at all times. The power cables provided are flame retardant, low smoke, metallic armoured and compliant with IEC 60332 or be UL Listed as meeting flame tests.

Escape Routes
Escape routes are required to enable quick departure of personnel from any area from the production facility to a safe area in the event of an emergency.

Muster Points
Muster points have been designated to allow personnel to:

- Assemble/muster in relative safety;
- Monitor and have certain control functions to mitigate the effects of the incident;
- Evaluate the incident as it develops;
- Make effective command decisions regarding control of the incident, deployment of emergency response teams and should it be necessary, the ultimate evacuation and abandonment of the installation; and
- Carry out essential communications, to alert emergency groups, to communicate with personnel and to assist with the coordination of rescue.

Production, Test and Injection Manifolds

The test manifold allows one or more Umuseti/Igbuku wells to be routed to the separators. Chokes are set to reduce the wellhead flow and pressure to the desired HP and LP pressures. The desired setting for each well and which of the wells produce at HP and LP for various production levels are defined by the reservoir specialists to ensure optimum production and recovery rates.

In Umuseti/Igbuku Field, the individual well streams are brought into the main production facilities over a network of gathering pipelines and the Oil Manifold. The purpose of these pipelines is to allow setup of production "well sets" so that for a given production level, the best reservoir utilization well flow composition (gas, oil, water), etc., can be selected from the available wells.

For gas gathering systems, the individual gathering lines are metered into the manifold. Wells with pure gas production are taken directly for gas treatment and/or compression though the wells that produce a combination of gas, oil and water, have various contaminants that are separated and processed.

The production separator employs the gravity separation method where the well flow is fed into a vessel and retained for a period. The retention period is typically five minutes, allowing gas to bubble out, water to settle at the bottom and oil to be taken out in the middle. The pressure is often reduced in several stages (high pressure separator, low pressure separator, etc.) to allow controlled separation of volatile components.

Flare Pit

A flare system is currently installed with one entry. The flare is used to flare the gas during early production, extended well tests, emergency blow down and when customer's gas facilities are shut down. The field currently produces a maximum of 1.5Mmscfd associated gas (AG), the bulk of which is being flared. A small percentage of this AG is being used for heat treatment of the wet wells and supply of instrument gas for the chemical injection pumps.

There is currently a demand for 1.2 to 1.5Mmscfd AG from the proximate OPAC Refinery for use in operation of their furnaces and for power generation. Pillar Oil is already partnering OPAC Refinery for exchange of the AG for electrical power supply from OPAC.

There is currently a plan to replace the existing flare with a smaller unit. This shall be located at least approximately 300 feet away from the flowstation equipment and shall replace the existing pit flare. Note that the existing 16" pit flare is considerably oversized for the current gas rate resulting in burnouts. The 16" Pit Flare was originally designed for 15.5 mmscfd AG whilst the current AG rate is considerably less. The flare is a horizontal pit flare installed around the old borrow pit area. It enhances water evaporation from the borrow pit. The new 8'' flare line design is ongoing and will be installed in Q1-Q2, 2021.

Oil and Water Separator

Produced water from the production separators goes into a 2 stage oil saver pits for skimming of the oil sheen that may have accompanied the water production. The outlet of the 2 stage oil saver pits goes to the inlet of a produced water clarifier vessel (currently under construction) which further removes any remaining oil to 20ppm level (or less). The cleaned-up water is then sent to a containment chamber at the flare pit for incineration into water vapour and carbon dioxide.

3.3.2 Description of the Further Field Development Projects

The proposed Further Field Development activities include construction of Gas Plant, Drilling, laying of Pipeline and Work-over Projects. which will be executed in phases over a period of five (5) years. Table 3.2 shows the synopsis of the Further Development Activities.

Project Scope

The scope of the project shall cover comprehensive and representative sampling activities for the Umuseti- Igbuku Field Further Development activities as highlighted below:

1. Progress And Conclude POL/NAOC/DPR Unitization Discussions – 2021
2. Igbuku1 (Reservoir VIIa) Well Test – Q2 2021
3. Drill and Complete Umuseti-7 – Q1 2021
4. FEED and DED: Igbuku Gas Plant – Q3 2021
5. Umuseti-3 Zone Change – Q4 2021
6. Igbuku Gas Plant Construction – 2022-2023
7. Gas Pipeline ROW, PTS, OPL & Acquisition – 2021
8. Gas Pipeline Construction - 2022
9. Commission Umuseti Gas Plant – Q4 2022
10. Re-enter and complete Igbuku-1 – Q2 2022
11. Commission Igbuku Gas Plant – Q2 2023
12. Drill and Complete Igbuku-2 (Appraisal/Exploration) – Q2 2023
13. Igbuku North-1 Location construction – Q4 2023
14. Umuseti-2 Location construction – Q4 2023
15. Drill and Complete Igbuku North-1 (Exploration) – Q2 2024
16. Sidetrack Umuseti-2 (Exploration) – Q4 2024
17. Upgrade Igbuku and Umuseti Gas Plants - 2024
18. Tie-in Igbuku-North-1 & Umuseti-2 well – Q4 2024

Project Process and Activities

A synopsis of the entire project activities are as follows:

- Engineering design
- Right of way survey
- Right of way acquisition
- Drilling
- Hauling and Stringing the Pipes
- Welding of line pipes and coating
- Lowering of welded pipeline into trench
- Back-filling of the trench
- Integrity test of the pipes welds including Hydro test
- Clean-up, reinstatement and Commissioning
- Operation
- Abandonment and decommission

3.3.2.1 Igbuku Gas Plant

The Concept which is being currently considered along its technologies is Turbo expansion Technology. This requires a low inlet stream pressure of about 30 barg with inlet compression of 150 barg goes through an expander and downstream cold Separator equipment to achieve dew point. Energy generated by the expander is used to drive a complimentary compression before the gas stream passes through a final sales gas compression. NGLs and LPG are also recovered with additional processing equipment. Its Performance, guarantees with up to 95% to 97% propane recovery in ethane rejection and recovery modes, respectively and also 90% ethane recovery in ethane recovery mode. It is designed for heavy gas applications utilizing inlet refrigeration with dehydration and hydrate prevention systems included. It has a Flexible design to handle a wide range of inlet gas compositions, efficient heat integrated design with low emissions hot oil system and a modular design for simple installation and mobility purpose.

The proposed site for Igbuku Gas plant shall occupy a plant footprint of 500 by 500m.

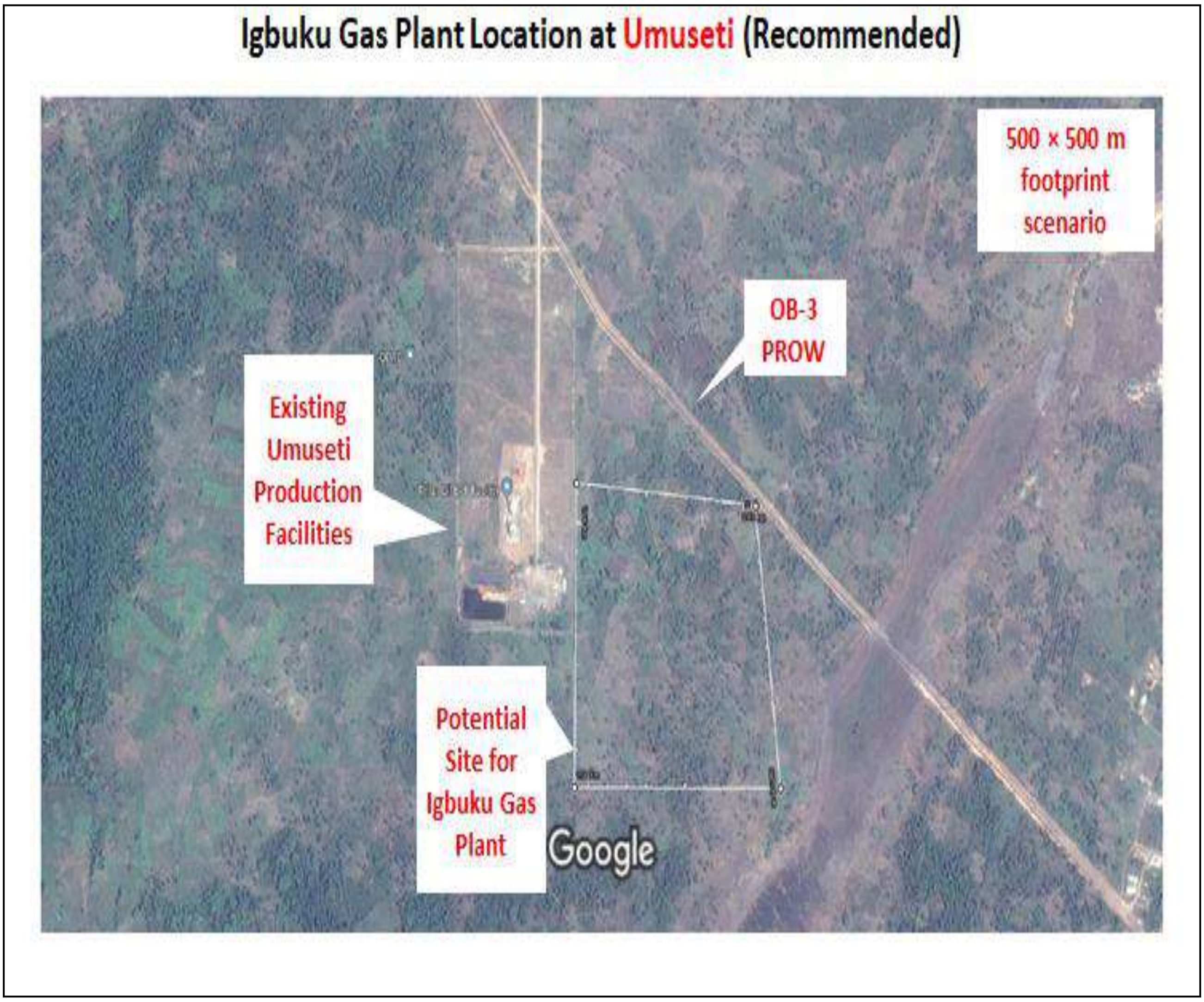
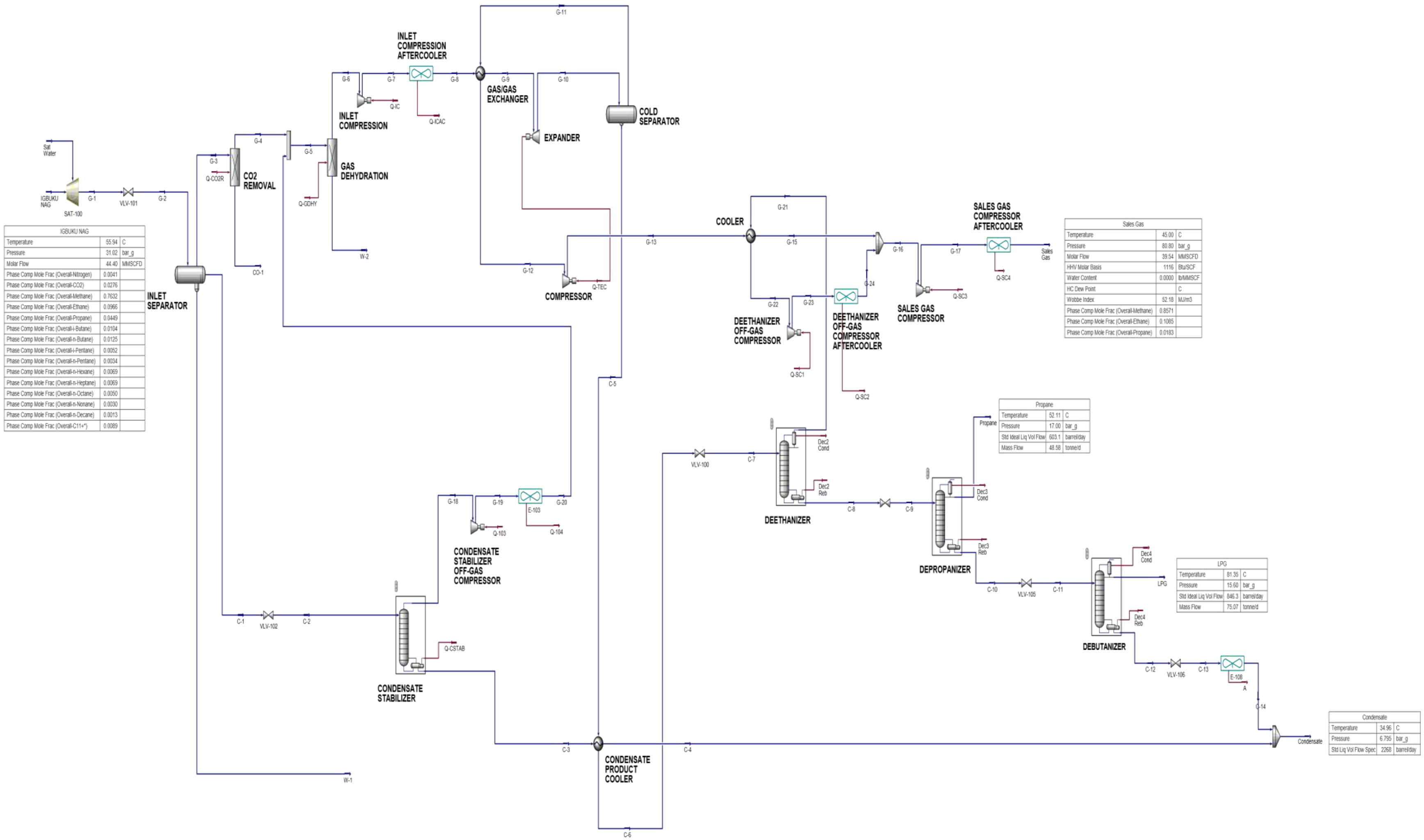


Figure 3.2: Igbuku Gas Plant Layout



IGBUKU NAG		
Temperature	55.94	C
Pressure	31.02	bar_g
Molar Flow	44.40	MMSCFD
Phase Comp Mole Frac (Overall-Nitrogen)	0.0041	
Phase Comp Mole Frac (Overall-CO2)	0.0276	
Phase Comp Mole Frac (Overall-Methane)	0.7632	
Phase Comp Mole Frac (Overall-Ethane)	0.0966	
Phase Comp Mole Frac (Overall-Propane)	0.0449	
Phase Comp Mole Frac (Overall-i-Butane)	0.0104	
Phase Comp Mole Frac (Overall-n-Butane)	0.0125	
Phase Comp Mole Frac (Overall-i-Pentane)	0.0052	
Phase Comp Mole Frac (Overall-n-Pentane)	0.0034	
Phase Comp Mole Frac (Overall-n-Hexane)	0.0069	
Phase Comp Mole Frac (Overall-n-Heptane)	0.0069	
Phase Comp Mole Frac (Overall-n-Octane)	0.0050	
Phase Comp Mole Frac (Overall-n-Nonane)	0.0030	
Phase Comp Mole Frac (Overall-n-Decane)	0.0013	
Phase Comp Mole Frac (Overall-C11+*)	0.0089	

Sales Gas		
Temperature	45.00	C
Pressure	80.80	bar_g
Molar Flow	39.54	MMSCFD
HHV Molar Basis	1116	Btu/SCF
Water Content	0.0000	lb/MMSCF
HC Dew Point		C
Wobbe Index	52.18	MJ/m3
Phase Comp Mole Frac (Overall-Methane)	0.8571	
Phase Comp Mole Frac (Overall-Ethane)	0.1085	
Phase Comp Mole Frac (Overall-Propane)	0.0183	

Propane		
Temperature	52.11	C
Pressure	17.00	bar_g
Std Ideal Liq Vol Flow	603.1	barrel/day
Mass Flow	48.58	tonne/d

LPG		
Temperature	81.35	C
Pressure	15.60	bar_g
Std Ideal Liq Vol Flow	846.3	barrel/day
Mass Flow	75.07	tonne/d

Condensate		
Temperature	34.96	C
Pressure	6.795	bar_g
Std Liq Vol Flow Spec	2268	barrel/day

Figure 3.3: Turbo Expansion Technology

3.3.2.2 Umuseti Gas Plant

The planned processing capacity for the Umuseti plant is 7MMscf/d. The design, construction and management of this plant will be handled exclusively by a third-party. The plan is to channel all NAG produced from the Umuseti structure to this processing facility and evacuate lean gas output via a CNG solution. Wet gas (wellstream gas) will be sold to the third-party offtaker less condensate. All recovered condensate will be routed to the existing POL oil production facility for export.

3.3.2.3 Umuseti-3 Well Re-entry (Zone Change)

This re-entry is planned to zone change the existing Umuseti-3 completion from the current producing XXB reservoir to undeveloped XXA reservoir. XXA will be produced from the existing completion equipment. Non associated gas (NAG) produced from XXA will be sold to a third-party gas offtaker downstream of the separator. All associated condensate from XXA will be retained by Pillar Oil Limited (POL) and blended for sales with existing oil production.

3.3.2.4 Umuseti-7 Development Well

Umuseti-7 is planned to penetrate the Umuseti structure at a structurally higher point than Umuseti-4 (Ex-Umuseti-2) and Umuseti-5. Umuseti-7 is primarily planned to develop 5 reservoirs (3 are oil bearing, 2 gas bearing). The well is aimed at bringing the main Umuseti structure to full life cycle. Oil and associated condensate produced from the well will be processed and exported using the existing oil production facility. Gas produced from the well will be processed using the third-party Umuseti Gas Plant. This well will be drilled from the existing Umuseti-5 well location. No new construction or rehabilitation work will be required.

3.3.2.5 Igbuku-1 Re-entry & Sidetrack

Pillar Oil Limited plans to re-enter and sidetrack the existing Igbuku-1 well sometime in year 2021. Igbuku-1 is planned to produce the discovered reservoir VIIa. VIIa is Retrograde Gas reservoir. A 40 - 50 MMscf/d gas plant will be required for optimal development. POL plans to produce and process all gas from the Igbuku field itself. Processed gas will be evacuated through the soon-to-be completed OB-3 gas pipeline. A fallback evacuation option (i.e. LNG) for processed Igbuku gas is also being considered. Prior to re-entry and drilling of Igbuku-1, efforts will be made to rehabilitate the existing well location. This rehabilitation work will be minor and should be completed in Q4 2020.

3.3.2.6 Igbuku-2 Exploration Well

Igbuku-2X is planned to appraise the discovered reservoir VIIa and explore deeper prospects within the Igbuku structure (Igbuku Deep). In an exploration success case, the Igbuku gas plant built for Igbuku-1 gas may be upgraded to accommodate Igbuku-2 production. In the event that exploration objectives are not met, Igbuku-2X will be completed as an additional drainage point on reservoir VIIa. This well will be drilled from the existing Igbuku-1 well location.

3.3.2.7 Igbuku North-1 Exploration Well

Igbuku North-1X is planned to explore the Igbuku North structure and in a success case develop sands IV & VII (Short String) & VIII (Long String). On the Short String, the deeper sand VII will be produced first, then IV produced after VII is fully depleted. All gas from Igbuku North will be processed using the Igbuku gas plant. A new location will be constructed prior to drilling this well.

3.3.2.8 Pipeline and Flowline

The table 3.1 below shows the pipelines and flowlines

Table 3.1: Pipeline and Flowline

6" x 10Km gas flowline - Igbuku 1 well to Umuseti
12" x 4km Sales Gas line from Umuseti GP to OB3 tie-in
6" x 0.5km Condensate/produced water line from GP to flowstation

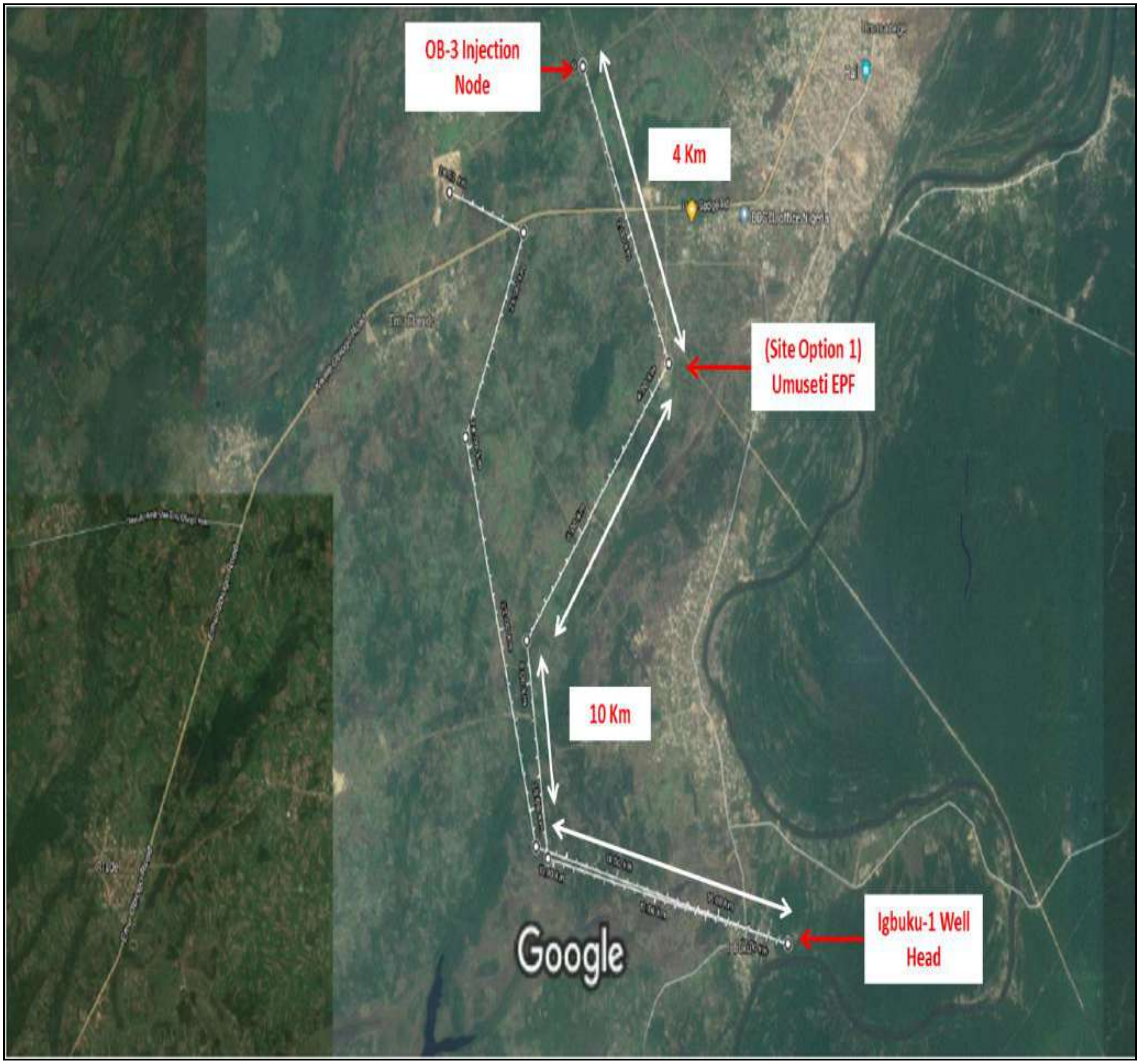


Figure 3.4: Pipeline and Flowline

Table 3.2: Further Development Activities

Well	Planned Activity	Target Onstream Date	Well String	Target Reservoirs for Production	Expected Gains		Estimated Activity Cost (Million $US)	Details
					Oil/Condensate (stb/d)	Gas (MMscf/d)		
Umuseti-3	Rig Less Zone Change	Q4 2021	Single String	XXA	400	5	0.8	Planned zone change from the current producing XXB reservoir to undeveloped XXA reservoir. XXA will be produced from the existing completion. Non associated gas (NAG) produced from XXA will be sold to a thirdparty gas offtaker downstream of the separator at about $1.5/Mscf. All associated condensate from XXA will be retained by Pillar Oil Limited (POL) and blended for sales with existing oil production. Product for Sales = Wellstream NAG + Condensate.
Umuseti-7	Drill & Complete	Q1 2021	Short String	UI-5 attic & UI-6	1000	-	18.0	Umuseti-7X is planned to penetrate the Umuseti structure at a higher point than Umuseti-4 (Ex-Umuseti-2) and Umuseti-5, hence it will be exposed to the attic portion of reservoir UI-5 (currently produced on Umuseti-4). UI-5 attic and undeveloped UI-6 will be completed as one level and flowed together. Product for Sales = Oil.
				LI-1	850	-		To be completed as one level. Production from the short string (oil) to commence from the deeper LI-1 reservoir then proceed to the commingled UI5 attic & UI-6 level after LI-1 is depleted. UI-5 attic & UI-6 will be closed behind SSDs until time

								for production. Product for Sales = Oil.
			Long String	LI-3	350	5		Commence production from the deeper reservoirs (XXIA & B). After depletion of XXIA & B proceed to produce shallower LI-3. Product for Sales = Well stream NAG + Condensate.
				XXIA & XXIB	300	5		
				XXA	300	5		Plans to have the XXA & XXB reservoirs behind casing for possible development after the main gas reservoirs (XXIA & B + LI-3). All NAG produced from Umuseti-7X Long String will be sold to a thirdparty offtaker at $1.5/Mscf (Sales point = downstream of separator). All associated condensate will be retained by POL. Product for Sales = Wellstream NAG + Condensate.
				XXB	-	5		
Umuseti-2	Side-track	Q4 2024	Short String	VII	500	-	7.0	Side-track well to target Reservoir VII, kick and deep reservoir seen in Umuseti1 well. Depth below (11,000ft).
			Long String	Attic, Kick & Deep	600	10		Fluid type in Deep reservoir is likely NAG. If successful produced gas will be sold based on Umuseti-3 and Umuseti-7X models above.
Igbuku-1	Re-entry	Q2 2022	Single String	VIIa	1140	20	22.2	Igbuku-1 is planned to produce the discovered reservoir VIIa. VIIa is Retrograde Gas reservoir. A 40 MMscf/d gas plant will be required for optimal development. POL plans to produce and process all gas from the Igbuku field itself. Processed gas will be

								evacuated through the soon-to-be completed OB-3 gas pipeline and sold at ca. US$3.5/Mscf. The fallback evacuation option for processed Igbuku gas is via LNG. Estimated gas plant cost = $US 40 million. Product for Sales = Condensate + Lean Gas + Propane/LPG.
Igbuku-2X	Drill & Complete	Q2 2023	Short String	VIII & IX	684	15	35.0	Igbuku-2X is planned to appraise the discovered reservoir VIIa and explore deeper prospects within the Igbuku structure (Igbuku Deep). In an exploration success case, the 20 MMscf/d gas plant built for Igbuku-1 will be upgraded to accommodate Igbuku-2 production. Estimated cost to upgrade gas plant to 40 MMscf/d = $US 30 million. In the event that exploration objectives are not met, Igbuku-2X will be completed as an additional drainage point on reservoir VIIa. Product for Sales = Condensate + Lean Gas + Propane/LPG.
			Long String	X & XI	641	15		
Igbuku North-1X	Drill & Complete	Q2 2024	Short String	IV & VII	456	10	30.0	Igbuku North-1X is planned to explore the Igbuku North structure and in a success case develop sands IV & VII (Short String) & VIII (Long String). On the Short String the deeper sand VII will be produced first, then IV produced after VII is fully depleted. All gas from Igbuku North will be processed using the Igbuku gas plant. Product for Sales = Condensate + Lean Gas + Propane/LPG.
			Long String	VIII	342	10		

From mid-2021, it is planned to install, subject to FMEnv/DPR approval, a produced water treatment and atomizer equipment which will treat the water to FMEnv/DPR standards before introduction into the atomizer unit which will then break it to tiny / micro droplets that can be easily dispersed and carried away by the wind, which will then be further diluted with the natural water moisture in the atmosphere.

3.4 Field Development Plan and Project Activities

Drilling from the preferred sub surface location at OML -56 will involve the following specific project activities:

3.4.1 Pre-Construction /Site Preparation phase activities

- Land take for Right of Way
- Mobilisation (transport) to site (equipment, personnel and construction modules)
- Energy requirements (provision of energy for construction)
- Labour requirements
- Site Preparation (vegetation and land clearing)
- Excavation of land area

Site preparation

Site preparation activities consist essentially of vegetation clearing and campsite/ well location preparation. Prior to the drilling activities, there will be access upgrade. This would involve road construction, refurbishment/repair of existing roads by filling pot-holes, provision of side drains and culverts.

The immediate areas of the wellheads will be prepared for Rig activity. To provide for the accommodation and boarding facilities for the workforce at site during the drilling.

Pre-Drilling

These investigations aimed at ensuring the viability and sustainability of the project while having minimal negative impacts on the environment. The results of these investigations culminated in the preparation of a detailed drilling, casing and mud programme. The operating environment was taken into consideration in deciding the type of drilling mud most suited for the project.

Consultations and meetings with regulatory bodies, host communities and contractors are prominent features of this activity. These consultations ensured that all stakeholders are notified and carried along, and that pathways and schedules are clearly defined. The benefits of these meetings/consultations are to ensure that the appraisal and development well drilling is carried out within regulatory compliance and to ensure community goodwill and social license to execute the project.

Movement and Transport of Equipment, Personnel, and Materials

Mobilization to site will commence from the period of site preparation. Apart from the rig itself, materials that shall be transported for the drilling will include:

- Pipes and casings;
- Drilling chemicals;
- Generators; and
- Diesel

Personnel that have been mobilized to the project area, shall be transported daily to the rig site from the campsite. It is estimated that 100–120 persons shall be involved in the drilling operations at any given time. It is expected that significant vehicular traffic will be made to the drilling site to transport equipment and supplies.

Flow line Laying

This will comprise of pipeline right of way (PROW) survey, bush clearing along PROW and excavation.

3.4.2 Construction phase activities

- Piling
- Site fabrication (welding) and coating
- Pipeline lowering/laying & tie-in
- Pipeline stringing
- Construction of Modules, campsites
- Backfilling
- Radiographic and Pressure testing.
- Construction of Gas Plant and Above Ground Storage Tanks
- Drilling Activities
- Demobilization

Drilling Activities

The only method by which oil or gas can be found is by drilling a hole into the reservoir. There are different techniques for drilling oil wells, depending on the Soil/Rock-type at the candidate location, as outlined in **Table 3.3**. Well drilling methods for various exploration purposes, like water well industry, foundation drilling and the mining industry are basically the same. The company intends to use horizontal techniques to avoid sensitive surface areas and gain access to the reservoir from less sensitive surface areas

Table 3.3: Drilling methods

Soil type	Drilling type	Remark
soil, silty/clayey	Auger Rotary	Mostly best choice temporary casing or mud additives required
rock, medium hard	Rotary Down-the-Hole-Hammer (DTH).	Roller bit, sometimes mud additives required large compressor required
rock, hard to very hard	Rotary DTH Top Hammer	With rock bit or hard-metal insert button bit, very slow large compressor required Special equipment, depth range ca. 70 m
rock under overburden	Overburden Drilling Equipment (ODEX) or similar tools	in combination with DTH

Drilling a hole/well is achieved by making up the Bottom-Hole Assembly (BHA) below pipes. Rotating this assembly generates formation cuttings. During this operation, drilling mud is pumped down into the hole and returns to the surface laden with cuttings as shown in the proposed schematic diagram for Umuseti/Igbuku Field (**Fig 3.5)**.

Water based mud (bentonite) will be used for the top-hole sections. At the intermediate and deeper-sections, synthetic based mud will be used. Oil based mud shall not be used for drilling. Blow-out prevention liquid will be circulated in a closed system. The wastes expected include drill cuttings, chemicals and spent mud. The drilling and completion operations shall be managed at Umuseti-Igbuku Field.

Drilling mud is required in drilling operations. It is continually pumped down the drill string and returned to the surface through the space between the drill string and borehole. Its main functions are:

- Exerting hydrostatic pressure on the downhole and preventing formation fluid from entering the well bore;

- Removing drill cuttings from the bottom of the hole and carrying them to the surface, and when circulation is interrupted, it suspends the drill cuttings in the hole
- Lubricating and cooling the drill bit and drill string
- Depositing an impermeable cake on the wall of the 'well bore' effectively sealing and stabilizing the formations being drilled
- Being used for pressure control. If the drill bit penetrates a formation with oil, gas or water under pressure, the fluids will be prevented from flowing into the borehole by ensuring that the mud is of sufficient density to counteract the natural formation pressures.

Drilling muds are inert solids suspended in a liquid phase, normally oil or water. Oil-based Muds (OBM) are considered more toxic and are more difficult to dispose of than Water-Based Mud (WBM). WBM are either biochemically inert or non-toxic derivatives of natural products. The primary components of water-based muds are barites and bentonites which are natural minerals. On the other hand, synthetic muds are generally considered by industry and regulators as being sufficiently toxic to require special disposal.

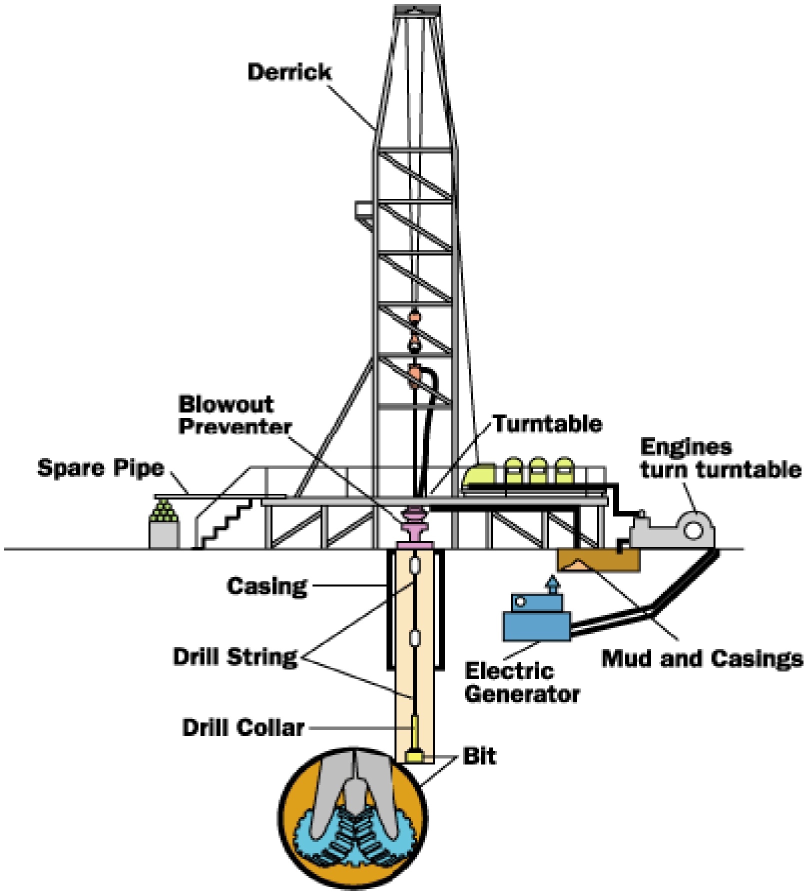


Figure 3.5: Onshore drilling schematics proposed for Umuseti/Igbuku Field

Workover Operations

The workover operation will begin by removing the well head and filling the well with brine/ workover fluids effectively killing the well. A well is successfully killed when the workover fluid whose specific gravity is appropriate for reservoir pressure totally fills up the well. The workover fluids should be prepared in such amounts such as three times the total volume of the well. This fluid keeps the well under control by its hydrostatic pressure and prevents damage to the formation. Workover fluids are displaced into a well either by circulation or squeezing while at the same time observing the well pressure.

Following this, the casing string will be pulled out if possible or the well will be side-tracked. The producing zone will be located and activated. The existing casing may be reused except if it proves to be unsuitable but only remedial cementing will be done if otherwise.

Well Completion

The well shall be completed with the same rig that drilled them and flushed with brine-based fluids. Drilling fluid is often not a serious concern here, and in most cases, only the casing content of the drilling fluid (about 800 – 1000 bbls) need to be managed. During completion, the well will be flushed with brine-based fluids. The main concerns during completion are salinity or chloride contents of the fluids.

Materials are: salt (NaCl), NaOH, XC polymer. Many of the fluids are low-density fluids. Special materials used for sand consolidation are diesel, iso-propyl alcohol, etc.

Well Testing

During well testing, the maximum amount of crude oil and gas that can be produced in a 24-hour period will be determined. The Maximum Efficiency Rate (MER) will also be determined during the well tests.

Test tools will be used to control the flow of hydrocarbons from the reservoir into the work string. By controlling the flow of hydrocarbons, the reservoirs in Umuseti-Igbuku Field will be allowed to produce for a period of time then shut in. This process will be repeated several times, resulting in measurements that will empower POL with the ability to predict the rate of production decline within the reservoir. Proven reliable test tools will be needed for controlling the flow of hydrocarbons and obtaining accurate reservoir performance indicators. The tools will be made up of five primary components:

- Packer
- Pressure and temperature gauges
- Pressure/ Volume/ Temperature (PVT) Samplers
- Tester Valve
- Circulating Valve

The data gathered during the test will include volumetric rate, hydraulic connectivity and average reservoir pressure observed in each of the wells.

The evaluation objectives for the planned development wells will be achieved through a combination of mud logging, logging-while-drilling, wireline logging, reservoir pressure and fluid sampling and analysis, conventional core and core analysis, and production testing measurement technologies.

The primary formation evaluation objectives for the production wells are to capture data that accurately:

- Broadens knowledge and understand the hydrocarbon properties and characteristics of the reservoir;

- Characterizes the reservoir fluids in the reservoir sands; and
- Determine and model the reservoir architecture / distribution in order to optimizes field development by minimizing well count and optimizing well placement.

Pipeline Construction

- ***Excavation and Trenching of Pipeline Routes***

  Before the construction of the pipeline commences, staging areas and storage yards will be cleared strategically along the Right-of-Way. These areas will be used to stockpile the pipes and equipment parts in addition to providing parking for construction equipment and trucks. Subsequently, the area to be used for the laydown of construction equipment and pipeline construction would be manually cleared of any grown vegetation. After clearing, the vegetation cuttings shall be left in the field and allowed to decompose.

  The excavation of trenches shall be carried out using an excavator. The excavated section shall be manually freed of roots, stones, or other hard objects that may damage the pipe or its coatings. The maximum width of the excavated section shall be 3 m with a minimum depth of 1 m.

- ***Welding and Non-Destructive Testing (Radiography)***

  The welding of the pipe sections shall be done along the ROW, with the welded sections subsequently sandblasted and coated with epoxy to prevent corrosion. The welding may be done manually or automatically which each weld subjected to visual inspection and radiography (non-destructive testing) as the welding progresses. Weld repairs shall be carried out where necessary, prior to pipeline pressure testing. The integrity of the line shall be guaranteed by the installation of pipes of sufficient thickness taking into consideration commercial activities in the vicinity of the pipeline. The pipeline material specification shall comply with the American Petroleum Industry (API) standard (API-5L-X52) which is specific to carbon steel pipelines with a specified strength of 52,000 psi. A functional pipeline protection system will be put in place consisting of the application of a three-layer polyethylene corrosion coating to ensure that the pipeline is protected while buried.

- **Pressure Testing of the Pipeline**

  The pipelines connecting the wells to the manifold shall be pressure-tested at 1650 psig for 24 hours to determine the mechanical strength and integrity of the weld joints and to ensure that the pipeline is capable of meeting the MAOP (Maximum Allowable Operating Pressure). A leak test will also be carried out by injecting air into the pipeline to test the welds for a second time. After these tests have been completed, the pipeline will be cleaned and dried.

- **Pulling-in (Laying) and Backfilling**

  The pipeline shall be lowered in the trenches from the ROW by surface pull technique using a crane. At this stage, it must be ensured that the pipeline lies naturally along its entire length on the bottom of the trench. Close observation of the lowered pipe shall be maintained to ensure that the pipeline profile conforms to the design. In addition, all field welds shall be coated using heat-shrinkable sleeves.

  After confirmation that the pipeline has been laid to the correct profile, the trench will be backfilled using the previously excavated materials. However, backfilling will be carried out manually, with the soil layers placed in their natural order to ensure the best possible recovery of soil and native vegetation. Beacons and markers will then be placed on the surface to indicate the route of the underground pipelines.

Health, Safety and Environmental (HSE) Considerations

POL's HSE policies will be fully adhered to during the Field Development and emphasis will be placed on risk assessment and control.

In order to meet HSE objectives, roles and responsibilities will be clear and defined. To guard against harm to personnel and damage to equipment or the environment, experiences gained through previous drilling operations have been assessed and a risk assessment has been conducted. This assessment will examine activities from the pre-mobilisation stage right up to the demobilisation phase. Scope of activities to be assessed includes personnel and equipment logistics; subsurface issues such as shallow hazards and pore pressure prediction. The major risks have been identified and an accompanying risk management plan has been developed.

POL is committed to industry standard and Nigeria compliant environmental standards. At the end of all project operations, the facilities shall be decommissioned in a safe and responsible manner, in line with POL's and DPR's decommissioning policies.

3.4.3 Operational phase activities

- Operations/ maintenance (Normal)
- Operations/ maintenance (Abnormal)

After drilling and completion of wells, they will be tied in to the main production facilities through the manifold. At this phase, crude oil production and evacuation will be the primary focus, and this will be accomplished through many processes. In addition, maintenance activities will have to be carried out, many of which will be routine and scheduled, and this will involve replacement of non-functional parts as a result of wear and tear, coupled with keeping the integrity and efficiency of production equipment in optimal condition to ensure that planned production levels are maintained.

The wellheads and other production facilities shall be operated in accordance with operational procedures developed through POL's extensive experience. The project will be managed by fully trained and qualified personnel who are conversant with POL's HSE policy guidelines.

The production process will result in the production facility processing hydrocarbon fluids which will be produced along with oil, water and sand; with the oil, gas and water to be separated as the oil must be free of dissolved gas before export. Similarly, the extracted gas will be stabilized and free of liquids and unwanted components such as hydrogen sulphide and carbon dioxide. The water produced in this process will be treated before disposal.

The production wells will then feed into the gathering system (production and test manifolds). From here it will be fed to the gas/ oil separation plant. The purpose of the gas-oil separation is to process the well flow into clean, marketable products: oil and natural gas. Also included will be a number of utility systems, which are not part of the actual process but provide energy, water, air or other utility to the plant/ process. A variety of unwanted components, such as water, carbon dioxide, salts sand will ultimately be disposed off.

3.4.4 Decommissioning phase activities

- Demolition and Evacuation

The wellhead and their ancillary installations have a life expectancy of about 30 years. Prior to the time when commercial hydrocarbon extraction of the Field is completed, a comprehensive decommissioning and restorative plan would be finalised and reviewed with the relevant authorities.

The decommissioning would start with the process to isolate the producing zones of the formation and literally stop production in the well. The production tubing and all completions jewelries will be removed from the well and the casing plugged with cement plugs at several depths, aligning with government regulations, about 500 ft of cement is pumped to plug off producing sand intervals.

Furthermore, the production tubing and any casing removed including topside facilities for the well will then have to be disposed of. It is highly unlikely that production tubing will be able to be re-used as such and therefore the most likely destination for this steel is as foundry feedstock.

Summary of the decommissioning process would involve:

(i) Demolition and site cleaning which will entail removal of surface and sub-surface structures, cleaning and plugging of well heads, backfilling of all pipelines and trenches;

(ii) Disposal of wastes involving waste pits, de-watering of borrow pits or their conversion to fish ponds; and

(iii) Rehabilitation of site comprising of re-vegetation of all bare surfaces. This will involve a provision of the decommissioning and restorative plan as well as a post decommissioning monitoring plan in consultation with the host communities and available resources.

The demolition exercise will be 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 will be segregated according to their types and then disposed of according to **POL** waste disposal guidelines.

Experience has shown that a phased approach to decommissioning, remediation and reclamation is the most practical and cost effective. This phased approach allows the level of investigative and remediation effort to be tailored to the size and complexity of the problem. The required level of effort for decommissioning, remediation and reclamation is dependent on the type, size and age of the sites, historical waste management practices, the environmental and regulatory setting, and the proposed future use of the property.

3.5 Wastes and Emissions Management

Pillar Oil Limited intends to operate in an environmentally safe manner, based on the need to conserve natural resources and safeguard the sanitary state of environment and protect public health, against deleterious impacts of waste. An important aspect of waste management process is waste segregation which involves the separation of hazardous and non-hazardous wastes, which could be further separated depending on the specific nature of wastes. The re-use of recyclable wastes is also put into practice. The key advantage of this phase is that wastes of different kinds are treated more efficiently, before being disposed of separately. (Appendix 3.1)

Used metal and plastic containers as well as drums inevitably contain variable quantities of residual chemicals and they are segregated and disposed of in accordance with POL waste management procedure. POL also practices the principle of waste minimization through the use of the "reduce, reuse, recover and recycle" philosophy. Waste storage areas are designed to contain spill and leaks and are secured prior to disposal /destruction/recycle/reuse. Waste are separated at the point of generation to enhance application of the waste hierarchy principle

3.5.1 Construction Waste

The types, sources, and management of wastes anticipated to be generated during the construction phase of the proposed project facilities are as follows:

- Combustible wastes, such as scrap wood, cardboard, paper, and land clearing wastes (trees, brush, etc.) will be generated during the site preparation, construction, and operational phases of the proposed project facilities.

- Bulky construction wastes, such as concrete, clean fill material, scrap metal, glass, and plastics will be generated during construction of the proposed project. The construction contractor shall be responsible for disposal at an approved location by an approved waste transporter.

- Special wastes, such as hazardous waste, drilling mud, drill cuttings, cement, acids, sand consolidation fluid (if necessary), industrial solvents and other chemical wastes, grease trap pumpings, lead acid storage batteries, and used oil, will be generated during the construction and operational phases of the proposed project. Special wastes could also include items such as waste lubricants, paints, maintenance-related wastes, used air and liquid filtration media, and empty or partially full chemical containers. Special wastes will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site for disposal at an approved location by an approved waste transporter.

- Sanitary wastes shall be managed by treating to acceptable discharge standards and discharging to the environment. Some human wastes shall be treated on site using engineered soak-away pit. This provides an excellent way of handling all human wastes.

3.5.2 Operational Related Waste

The types, sources, and management of wastes anticipated to be generated during the operation of the proposed project facilities are as follows:

- Domestic Wastes will include food wastes, paper, household wastes generated from the accommodation area and food preparation facilities.
- All recyclable materials will be segregated and stored in suitable containers, and periodically transported offsite for recycling or disposal at an approved location by an approved transporter and vendor.
- Plant Wastes such as office wastes, packaging materials, ashes, garbage, refuse, and rubbish will be generated during the operational phases of the proposed project.
- Combustible office waste shall be collected and transported off-site for disposal.
- Special Wastes such as hazardous waste, industrial solvents and other chemical wastes, grease trap pumpings, lead-acid storage batteries, septage, and used oil, will be segregated from other waste streams, collected and stored in suitable containers, within secondary containment and periodically transported off-site for proper disposal at an approved location.
- Sewage wastes will be disposed of in an on-site septic system.

3.5.3 Air Emissions

The total annual emissions of air pollutants from various sources during the operations of the plant are shown in Table 3.3. This estimate includes emissions from Combustion engines, Pilot flare, Vents, Heating oil furnaces, LPG loading vapours and tank vents

Table 3.4: Total Annual Emissions Tonnes per Annum

Total annual emissions tonnes per annum						
PM	**SO_2**	**NO_X**	**CO**	**CO_2**	**TOC/CH_4**	**N_20**
2.13	0	27.99	23.56	85329	3.079	0.065

3.5.4 Liquid Effluents

Both oily water and chemical waste water effluents will be generated by the plant operations. Effluents generated will include backwash effluent from pressure filters, regeneration effluent from the demineralization plant as well as other chemical laboratory wastes, battery waste water, and sludge. Further details of the effluents generated are provided in Table 3.4.

Table 3.5: Detail of Proposed Effluent Generation

Waste Water	Source	Characteristics / Contaminants	Disposal Method
Chemicals	Bulk chemical drains in water	Various chemicals	Fed into the neutralization pit, treated with acid/alkali and

	treatment plant		transferred to the central monitoring basin.
Oil in water	Lube oil and transformer oil mixed with water from transformer yard, wash drain, diesel fuel from oil tank, oil water runoff and drains	Oil contents:500 –10000ppm(in case of fire), pH:5-9, Suspended solids:0-30ppm	This will be collected into an oily water capture basin and pumped nto tankers for disposal offsite and the water effluent shall be pumped into an oil water separation tank for secondary treatment. The oil separation tank will collect oil by an oil skimmer, which will then run into the oil holding tank and will be transferred to a tank truck for final disposal offsite The oily wastes will be disposed of at a registered waste disposal facility. Heavier suspended solids will settle at the bottom of the separation tank and this sludge will be removed via the sludge tank and disposed to sludge drying beds. The treated effluent from this oil separation tank will be led to the central waste water monitoring basin before final discharge. Effluent discharge will be as per Nigerian and World Bank requirements. The oil removal from the catch basin, sludge disposal, and lube oil drain disposal shall be done manually by using portable sump pumps.

Water Based	DMplant regeneration waste Equipment drain	Dissolved solids:<1000 ppm PH: 6-9 Chemical traces, traces of suspended solids,pH:6-9	This will be directed to a filter backwash drain pit, and then transferred to a tube settler. The clarified effluent will be discharged into the central monitoring basin. Non-contaminated water will be directed to the storm water system and discharged to surrounding area as per Nigerian and World Bank requirements. Sludge from the collection of the suspended solids will be disposed of as hazardous waste at a licensed waste disposal facility.

In addition to the above, there will be domestic sanitary waste that will be treated in a small package sewerage treatment plant. Non-contaminated water from rainwater, floor drains, and other water drains from the equipment will be routed into a stormwater system and discharged to the surrounding areas per Nigerian, WHO and World Bank requirements.

All individual streams of effluents will be collected and treated as required, and the treated effluent will be collected in a central waste water monitoring basin. Effluent will be pumped and discharged from this collection basin once the water meets the discharge criteria for discharge of effluent. All pumps will be equipped with pressure gauges, locking valves by chain and padlocks wherever required. Effluent will be tested for pH measurement insitu before leaving the site. Turbidity and conductivity measurements will be measured at an onsite laboratory through periodic sampling at the outlet of the central monitoring basin.

Onshore drilling for oil and gas is a technically challenging operation that produces wastes, which must be treated and disposed of in an environmentally safe manner to avoid pollution. Table 3.5 below show the summary of Pillar Oil Waste Management Plan

Table 3.6: Summary of Waste Management Plan

Types	Source	EGASPIN / Management	Disposal Plan
Produced water	From formation	Part III D 3.6.2 (a)&(b) Inland/Near shore area: Produced formation/oily waters shall not be discharged into inland and near shore areas.	Disposed by re-injection into re-injection well.
Rain / Process area runoff	Drainage	Part II D 2.4 & 2.4.1 Collected and treated separately for oil removal by gravity separation or is handled by the produced water system before discharge	Oil skimmed off in a saver pit and treated before release. Laboratory analysis shall be carried out to ensure that parameter are within regulatory limit regularly.
Hydrotest waste water	Pipeline hydrotest	Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations that the hydro test fluid is disposed at an approved government site.	Disposal in each case shall be carried out in line with stipulated guideline and monitored by the appropriate regulatory bodies

Sewage	Camp site	Part II D 2.5 & 2.5.1 Sanitary waste shall be treated biologically if manned continuously by 10 or more persons or if lesser the waste shall be macerated and dumped overboard with no floating solids	▪ It is envisaged that the maximum number of personnel at drilling site at any one time will be about 100 - 120 persons. ▪ Sanitary sewage produced at site will be treated with a rig sewage treatment plant as per FMEnv/DPR standard. The water can be re-used for flushing the system or disposed in rivers after analysis. ▪ Regular monitoring of the waste water shall be carried out and the residue shall be used for agricultural purposes.
Drill Mud/Cuttings	Geological formation in drill holes	Part II D 2.3.1&2.3.1.1 On-site drilling with an oil content that does not cause sheen on the receiving water Washing of drill cuttings that contain to a level that would not cause sheen so that they may be discharged to receiving water Transportation of drill cuttings to land for proper land disposal or treatment. E.g. incineration or desorption /oil recovery. Injection into properly prepared and approved formation.	• Excess and used water based mud (WBM) will be re-used/re-injected. • Used pseudo oil based mud (POBM) will be properly stored for re-use in the drilling of other wells. • Spent POBM would be collected with skips to DPR/FMEnv accredited waste management facility for treatment. • Top-hole cuttings drilled with WBM will be fluidised and re-injected in the approved re-injection well. There is plans to engage DPR/FMEnv accredited contractors for this waste stream • Bottom-hole cuttings drilled with POBM and contaminated with POBM would be collected with skips to DPR/FMEnv accredited waste management facility for treatment. • The percentage mud on cuttings shall be kept below 10% before incineration through the use of installed high gravity shakers/dryers.

			• Total expected volume of drill cuttings from WBM & POBM drilled sections is 200 m^3 and 270 m^3 respectively. • Transport cuttings to TDU facility in Port Harcourt (Frigate Nig. Ltd) for treatment and disposal
Scraps	Cut-offs/Damages	Part V A 5.6.9& 5.6.9.2 Dispose of by methods that shall not endanger human life and living organisms and cause significant pollution to ground and surface waters.	• Segregate into usable & non usable, release non usable scrap to vendor
Lubricants	Plant Servicing at construction sites	Part II E 3.5.6.1 (g)	Reclaimed lube oil and other waste oils shall be disposed of by injection into the crude stream, if not directly utilised.
Condensate slug	Slug Catcher/pipeline	In line with regulatory requirement	Collected and treated

Exhaust Gas Emissions	Internal Combustion Engines		Part II D 2.1 & 2.1.1 Atmospheric emissions in both exploration and development activities are for the most part minor because of the level and nature of exploration and development activities, they occur mainly from vehicles and power generating plants and equipment.
Noxious air emission	Welding and coating equipment and generators.	This impact will be felt mostly by workers. So to manage this, workers must always use their PPEs	
Noxious air emission such as NOx, SO_2, NH_3, etc.	Equipment (such as excavator, lifting equipment, tractor, heavy trucks	Regular maintenance of equipment and workers must always use their PPEs	
Solid waste (Food waste, plastics etc.). Packaging wastes	Project Areas		Industrial and domestic wastes shall be segregated (food waste, paper waste, scrap metals, chemical waste, medical waste etc) at source in colour-coded bins. This will be manage by NPDC's waste management facility in Warri for recycling and disposal
Pigging operations waste	Operational area	• Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering	Wastes shall be collected, stored and disposed appropriately in line with FMEnv/DPR standard in an approved site

		measures. • Access to areas containing hazardous substances shall be restricted and controlled	

3.5.5 Oil Spill Contingency Plan

POL oil spill contingency plan shall be applied to the proposed drilling project. The spill contingency plan shall be based upon the location and volume of potential spill and shall address the possibilities of well blowouts in the drilling emergency plan.

The spill contingency plan clearly identifies the actions necessary in the event of an oil spill including communication network, the individual responsibilities of key personnel and the procedures for reporting to the authorities and arranging the logistics of extra labour needed for clean-up work. Finally, the plan shall address the disposal of contaminated waste generated by a spill. The following equipment would be deplored to site: Skimmers and other pick-up devices, Dispersants, Lightering equipment, communication and axillary Equipment, Emergency Safety Equipment, Lighting Equipment and First Aid Kits**. (Appendix 3.1)**

3.6 Employment

There shall be 50 permanent site employees on site during commercial operations. These will include plant management staff, maintenance staff, skilled technicians, drivers, cleaning staff and a number of semi-skilled operators who will operate and maintain the proposed plant. In addition, 20 ancillary and contract workers will be employed during the operation phase of the Gas plant and this will include security, cleaning and gardening staff.

Pillar Oil Limited shall seek to promote the development of local skills and the transfer of international technologies and expertise to local manpower and local manufacturers. It will also ensure that activities are fully compliant with the relevant(and evolving)"local content" provisions of Nigerian law and regulation.

Furthermore, the selection of sub-contractors by Pillar Oil Limited shall ensure that only high-quality sub-contractors (whether of local, national or international provenance) are selected. They will be required to adopt the policies of Pillar Oil Limited on community liaison and local workforce employment. Based on its analysis of other projects, Pillar Oil Limited believes that this approach will have a more direct and positive impact on the local community workforce and will lead to a greater degree of skills transfer.

3.7 Project Schedule

The overall conceptual project implementation schedule for the construction and commissioning of the Project is illustrated in table 3.7below:

Table 3.7: the conceptual project schedule for Pillar Oil Limited Further Field Development

S/N	ACTIVITIIES	PROPOSED DATE
1	Umuseti-7 Drilling and Completion	Q1 2021
2	Umuseti-3 Zone Change	Q4 2021
3	Igbuku-1 Re-entry and Sidetrack	Q2 2022
4	Igbuku Gas Plant	2022 - 2023
5	Umuseti Gas Plant	2022
6	Igbuku-2X Drilling	Q2 2023
7	Igbuku North-1X	Q2 2024

CHAPTER FOUR
DESCRIPTION OF THE ENVIRONMENT

4.1 Introduction

Existing environmental condition of a project area is established by determining the ambient levels of significant environmental parameters that could be affected by the implementation of a project. This chapter presents information on the baseline environmental conditions of the proposed project area. The environment was characterized based on data obtained from two (2) climatic seasons (Dry and Wet) sampling carried out in Umuseti-Igbuku field (OML 56) and secondary data obtained from literature research. The dry season sampling exercise was carried out from 24th February to 27th February, 2020. While the wet season sampling was carried out on 4th to 6th June, 2020.The field personnel were divided into teams (socioeconomics, biophysical sampling etc) for efficiency and comprehensive collection of field data/samples.

4.2 Study Methodology

4.2.1 Sampling Design

The sampling was carried out in accordance with the requirements of FMEnv *EIA Act CAP E12, LFN 2004* as well as *DPR Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN), 2018 Revised Edition.* Grid and transect sampling approaches were adopted with respect to environmental components intended for sampling. The sampling coordinate is attached in ***Appendices 4.3a and 4.3b while Figures 4.1-4.3*** show the sampling maps.

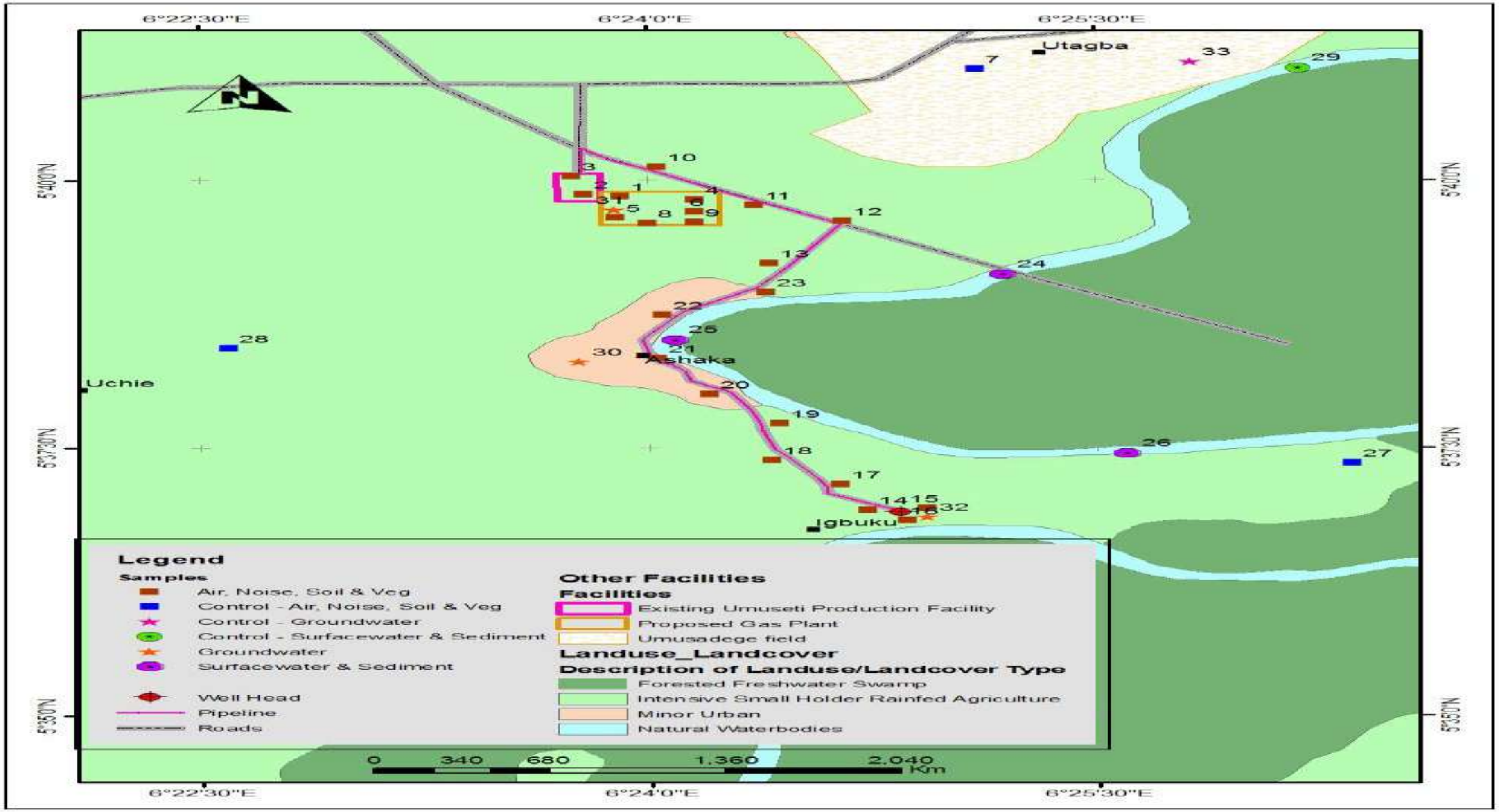


Figure 4.1: Sampling Locations Map (Dry and Wet Seasons)

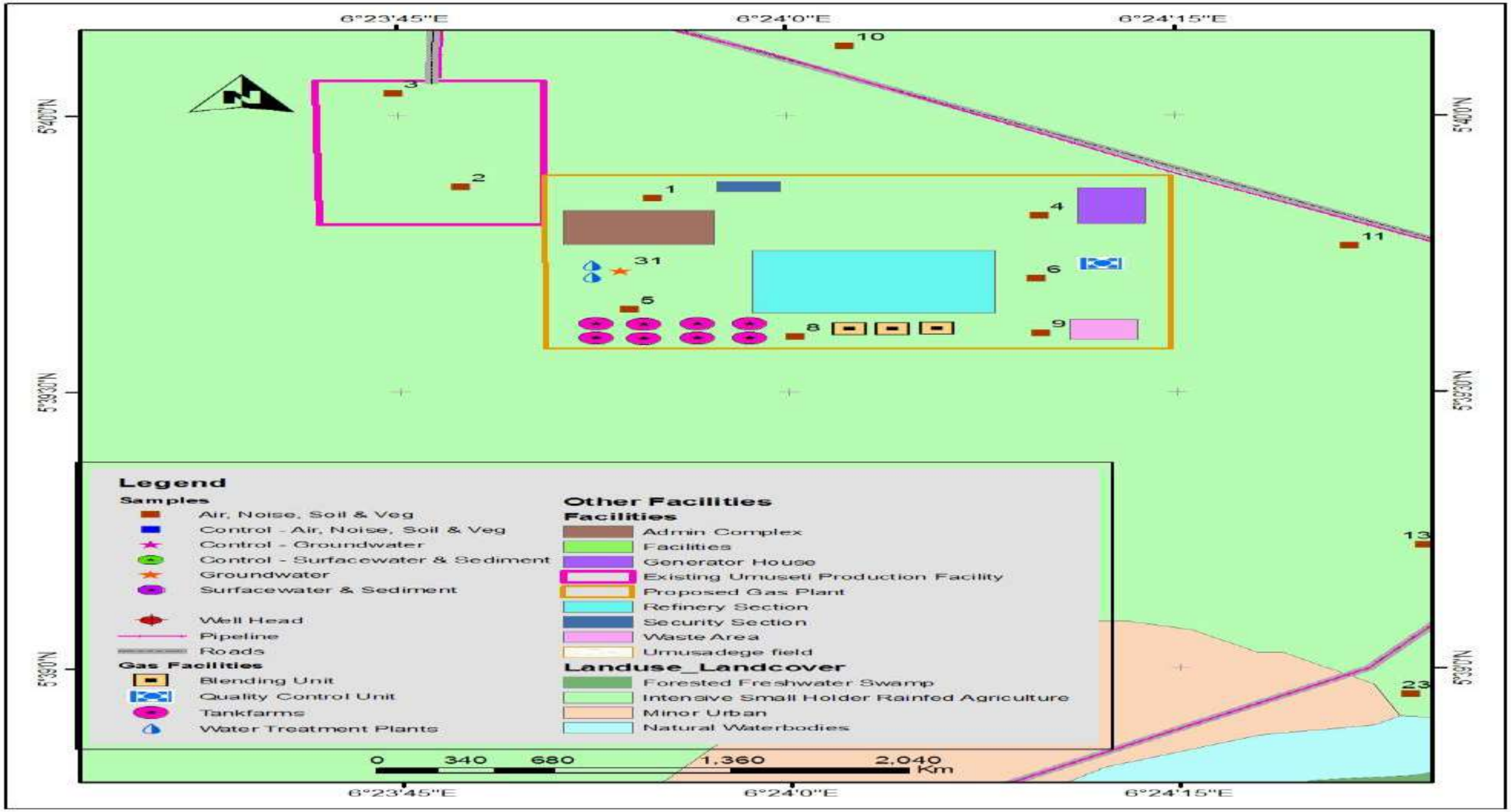


Figure 4.2: Map showing the Sampling Locations and facilities within the site

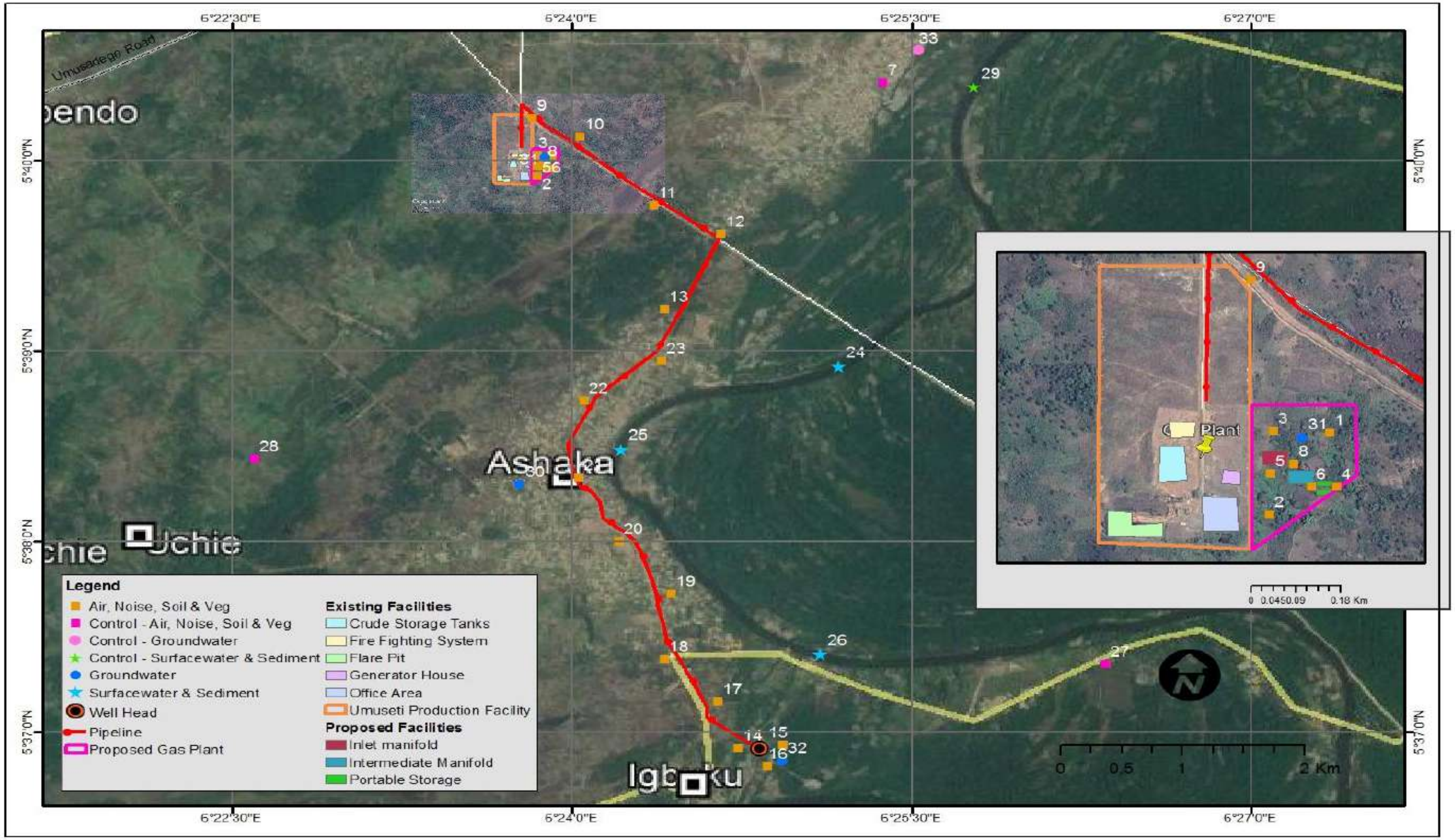


Figure 4.3: Google Map showing the Sampling Locations overlaid on the existing projects (Dry and Wet Seasons)

4.2.2 Sampling Equipment and Laboratory Technique

Sample collection, handling, storage, transfer, data coding and documentation followed the *E12, LFN 2004* as well as DPR guidelines laid out in *Part VIII (D) 2.0 – 3.0 of EGASPIN 2018.* All the samples collected on the field which were witnessed by DPR staff were preserved with ice chests and immediately taken to the laboratory in Warri, Delta State. The reception of samples by the laboratory followed *E12, LFN 2004* as well as *Part VIII (D) 3.6 of DPR's EGASPIN 2018* guidelines on data recording. The samples were then stored adequately in designated freezers at <4ºC prior to analysis. Laboratory analysis which was also witnessed by FMEnv staff was timely carried out in line with the samples' respective analytical times as recommended in FEPA (1991) (***Table 4.1***) and APHA *et al*, 1980; Goltermanet *al*., 1978; and US EPA, 1979.

Table 4.1: Sampling and Laboratory Technique

Parameter	Symbol	Unit	Test method
Physico-chemistry			
Ph	pH		in situ
Temperature	T	ºC	in situ
Conductivity	EC	S/cm	in situ
Dissolved oxygen	DO	mg/l	in situ
Salinity	S	‰	in situ
Turbidity	Turb	NTU	in situ
Total suspended solids	TSS	mg/l	APHA 2540D
Total dissolved solids	TDS	mg/l	APHA 2540C
Heavy metals			
Arsenic	As	mg/l	AAS
Cadmium	Cd	mg/l	AAS
Arsenic	As	mg/l	AAS
Chromium	Cr	mg/l	AAS
Copper	Cu	mg/l	AAS
Mercury	Hg	Mg/l	AAS
Ferric iron	Fe3+	mg/l	AAS
Ferro iron	Fe2+	mg/l	AAS
Lead	Pb	mg/l	AAS
Nickel	Ni	Mg/l	AAS
Manganese	Mn	Mg/l	AAS
Cations			
Magnesium	Mg	mg/l	AAS
Potassium	K	mg/l	AAS
Sodium	Na	mg/l	AAS
Zinc	Zn	mg/l	AAS

Parameter	Symbol	Unit	Test method
Aluminium	Al	mg/l	AAS
Anions			
Carbon dioxide	CO_2	mg/l	APHA 4500-CO2
Carbonate and bicarbonate	HCO_3	mg/l	APHA 2320B
Fluoride	F	mg/l	APHA 4500
Nitrate	NO_3	mg/l	APHA 4500
Nitrite	NO_2	mg/l	APHA 4500
Phosphorus total	P	mg/l	APHA 4500
Sulphate	SO_4	mg/l	APHA 4500
Sulphide	S^{2-}	mg/l	APHA 4500
Organics			
Total Organic Carbon (TOC)	TOC	mg/l	APHA 5310
Dissolved organic carbon	DOC	mg/l	APHA 5310
Total mineral oil		mg/l	EPA 8015
BTEX	BTEX	mg/l	EPA 8260
Phenol		mg/l	APHA 5330C
Chemical oxygen demand	COD	mg O_2/l	APHA 5220B
Biological oxygen demand	BOD	mg O_2/l	APHA 5210B
Polycyclic aromatic hydrocarbons	PAH	mg/l	EPA8260
Macro and Micro-biology			
Chlorophyll		mg/l	UV
Phytoplankton population density		number of cells / l	Coulter Counter
Bacteria count		(cfu/100ml x 103)	APHA 9215C

FEPA, 1991

4.2.3 Sampled Parameters

Abiotic and biotic components were studied; they include climate/meteorology, air quality and noise, soil, vegetation, wildlife, socio-economics and health status. During the field sampling, in situ measurement was done for parameters with short holding analytical time while other samples were collected for laboratory analysis.

4.2.3.1 Abiotic Component

a) Climate and meteorological studies

The purpose of the climatic and meteorological study is to establish meteorological conditions in-and-around the study area. The climatic characteristics of the study area relating to the following were extracted from historical and field sampling data. The following data were collected:

a) Temperature
b) Rainfall
c) Relative humidity
d) Wind patterns (speed and direction)
e) Sunshine (hours and intensity)

A hand held battery powered high precision Skymaster (SM 28) pocket Weather Tracker, made in the USA was used for data collection for wind speed, humidity, temperature and wind direction (i.e. microclimatic data). Although the microclimatic data was acquired via field measurement, macroclimatic data (long term data) was acquired from the database of the Nigerian Meteorological Agency (NiMet).

A weather station was set up at the same sampling stations for soil sampling during the field survey. Sampling was allowed to run for a minimum of 30 minutes in order to establish a microclimatic data of that particular station. All precautions taken when setting up a weather station and during measurements were observed for the onsite measurements according to the World Meteorological Organization (WMO) standard. These include setting up the weather station away from obstacles like buildings and tall vegetation, using an instrument shelter to display all temperature sensitive instruments, orienting the instrument shelter so that the sun's radiation does not fall directly on the instrument during reading and setting up the weather station in an area representative of the study area's totality. ***Table 4.2*** below presents weather data acquisition techniques.

Table 4.2: Weather Study Equipment

Climatic Variable	**Instrumentation/Method**
Air temperature	Dry bulb thermometer
Relative humidity	Psychrometer/hygrometer
Wind speed	Anemometer
Wind direction	Wind vane
Cloud cover	Direct observation

b) Ambient air quality and air borne noise level investigations

Gases that are of environmental importance such as toxic gases, greenhouses gases and ozone depleting gases were examined. Portable AEROQUAL Air Quality

Monitor (Series 300 Model) was used for air quality determination. Pollutant gases such as NOx, SOx, NH_3, H_2S, CO and VOC were determined. The analyser contains sensor for each gas and each sensor analyse the quality of the respective gases in the ambient air. It is a digital meter, which reads parameters at a time weighted average. An EXTECH instrument (USA), model 407730 Sound level meter with high sensitivity was used, the instrument can measure as low as 30 dB (A) and as high as 150 dB (A). The accuracy is ±1.5 dB (A). Air quality, Noise and Weather condition were determined in situ and recorded in 40 locations and 2 controls. Data collected was carried out from the hours of 10:00AM – 5:00PM on the sampling day.**Plate 4.1** below shows in situ sampling.

Plate 4.1: Air quality sampling activity

c) Water quality investigations (groundwater and surface water)

Groundwater samples were collected from 3 existing boreholes (2 and 1 control) while Surface water samples were collected from Ase River(covering up, mid &down stream) and a control and immediately analysed for parameters with short holding analytical time such as pH, dissolved oxygen (DO), temperature, and turbidity.

Samples were also collected for laboratory analysis. Sampling was carried out in line with standard quality control/quality assurance procedures. ***Plates 4.2a and b*** below shows in situ measurement of water pH using a hand held Hanna pH meter during the field sampling.

All sampling was carried out in line with standard quality control/quality assurance procedures. ***Plates 4.2a and b*** below shows in situ measurement of water pH using a hand held Hanna pH meterduring the field sampling.

Plate 4.2a: Sampling of groundwater and using of pH meter for in situ measurement of the water quality

Plate 4.2b: Sampling of Surface water and using of pH meter for in situ measurement of the water quality

d) Sediment studies

Sediment samples were collected with a hand trowel from shallow portions of the water body (Ase River) where surface water samples were collected. The sediment samples were placed in sampling bags after sieving to remove dirt and debris, labelled and stored with ice chest in a cooler to prevent microbial degradation of the hydrocarbons.

e) Soil quality investigation

To ensure a representative sampling, soil samples were collected from 3 cores from each sampling point at depths of 0-15cm and 15-30cm for top soil and sub soil respectively from seventeen (17) locations and three (3) controls***(Plate 4.3).*** Samples were collected with stainless screw type soil auger into plastic bags for physicochemical and microorganism analysis. Separate samples were also collected into aluminium foil for hydrocarbon content determination.

Plate 4.3: Soil sampling activity at the project site

4.2.3.2 Biotic Components

f) Vegetation and Wildlife Studies

- ***Sampling Technique for Floristic and Faunal Data Collection***

Floristic data were collected using systematic sampling technique with 6 quadrats of one square meter each at each sampling location for assessment of herbaceous flora. Sampling for faunal species followed point sampling design, and walking along foot paths was used (Walsh and White, 1999). Data collected on faunal species included species composition of each sampling location.

- ***Species Identification***

Identification of species was done in situ and all identification were done using available literatures like Akobundu and Agyakwa (1998); Johnson (1997) for herbaceous flora; and Dalziel and Hutchinson (1979) and Keay*et al.* (1967) for woody flora. Identification of faunal species was done using the methodology provided by Adeyanju*et al.* (2012)

- ***Data Analyses***

All quantitative data were subjected to Relative Importance Values analysis following Kent and Coker (1992) and Olubode*et al* (2009). Multivariate analyses for ordination and phytosociology of species and stands describing the ecology of the sampling stations followed Hammer *et al.* (2001) using Paleontological Statistics (PAST) 2.14 version software for detrended correspondence and cluster analyses. Two-Way Indicator Species Analyses (TWINSPAN), 2012 version software was used for determination of phytosociology of the flora (Hill, 1994, 2012).

⊙ ***Statistical analyses***

Indices of species diversity and evenness were used to characterize the faunal community structure. The Margalef's index (d) of taxa richness, Shannon-Wienner index of general diversity (H) and Evenness (E) were used to express the descriptive properties.

Margalef's Index (d): d= $\frac{S-1}{3.322 \log N}$

Where,
S = number of taxa
N = total number of individuals

Shannon-Wienner Diversity Index (H): H = $3.322(\log N - \frac{\sum Ni \log Ni}{N})$

Where,
N = Total number individuals in all species
Ni = Number of individuals in each species
3.322= Conversion factor from base 10 to base 2
H' = Diversity (0-4)

The Evenness component of diversity expresses the degree of uniformity in the distribution of individuals of each taxon in the collections.

Species evenness (j): j = $\frac{H}{Hmax}$

where,
H= Shannon-Wienner Diversity Index
Hmax. = logarithm of the number of species in the population (Zar, 1983).
The Slack system was used in the determination of dominant, sub-dominant, common and rare groups of genera. Taxonomic groups or genera comprising:
15% or more of the total number of individuals collected = Dominant
5 - 14% = Sub-dominant
1 - 4% = common
<1% = Rare.

g) Microbiology

Surface and ground water, bottom sediments and soil samples were collected into sterile plastic bottles and polythene bags, kept at 2-6^{o}C and analysed for microbial contents.

⊙ ***Heterotrophic Bacterial Counts***

The total heterotrophic bacteria in both water and sediment were enumerated using modified yeast extract agar (Cruickshank *et al*, 1975). Bacteria isolates were identified according to the scheme for Buchanan and Gibbons (1974).

⊙ ***Determination of Fungal Content***

The total fungal counts in the water and sediment samples were determined using Emmons, Binford and Utz's modified Sabouraud Dextrose Agar (Cruickshank, *et al*, 1975). Isolated fungi were identified based on the associated spores and mycelia and their growth characteristic on the isolation medium.

⊙ ***Determination of Percentage Petroleum Degrading Bacteria and Fungi***

The petroleum degrading bacteria were enumerated on petroleum agar medium, while chloramphenicol was added to this medium for the selective isolation and enumeration of petroleum degrading fungi. Any bacteria or fungi growing on these media were regarded as petroleum utilizers or degraders. The percentage of these counts on the total heterotrophic bacteria or fungal counts were then calculated to obtain the percentage petroleum degrading bacteria and fungi respectively in each sample.

4.2.4 Quality Control/Quality Assurance (QA/QC) Procedures

QA/QC procedures cover all aspects of the study, including sample collection and handling, laboratory analyses, generation of data and coding, data storage and treatment and report preparation. The quality assurance programme employed in the fieldwork and laboratory analyses were in accordance with *Appendix II-4 and Part VIII (D) 3.0 – 3.2 of EGASPIN(2018) and FEPA (1991)*.

⊙ ***Sample Collection and Handling***

In preparation for fieldwork, glassware to be used were washed with detergent solutions, rinsed with tap water, then soaked in 1:3 nitric acid solutions for 24 hours to remove organic materials, washed again with tap water and rinsed with distilled water. Plastic containers were washed with detergents, rinsed with tap water, followed by distilled water. After drying, all the containers were rinsed with acetone to remove organic materials, and rinsed with distilled water. Aluminium foils were obtained for soil and sediment samples. Sampling equipment was rinsed with portions of the water to be sampled. Samples per sampling point were taken with thoroughly cleansed containers. Sterile wide-mouth polypropylene and Pyrex glass sample bottles were used. Samples for oil and grease were collected in clean and dry glass-stoppered bottles and were usually not completely filled to avoid losing oil when the stopper was inserted.

⊙ ***Sample Identification***

Specific details on sample identification were entered on a permanent label to reflect node, date, sample matrix, sampling point, sample number, depth etc.

⊙ ***Laboratory Analysis and Generation of Data***

Possible sources of error in laboratory analysis include contamination of reagents and materials, lack of sensitivity of equipment, lack of calibrations, poor data entry and interpretation. Glassware and other containers used for each analysis were thoroughly cleansed as appropriate for each parameter. All glassware used for oil and grease determination was pre-rinsed with Analar grade xylene. Glassware for determination of metals were pre-soaked in dilute nitric acid and then rinsed well with distilled water. All reagents and chemicals of high purity (mostly Analar grade) were used. Freshly distilled water prepared in our laboratory was used for all dilutions.

The various instruments and equipment for measuring physico-chemical parameters used were in good working condition. Periodic control checks were usually carried out on such instruments/equipment and the performance record maintained. The pH meters were calibrated using HACH commercial buffer standards. Appropriate colour standards of diluted potassium dichromate or potassium permanganate solutions are frequently used to check the wavelength settings and sensitivities of the absorption spectrophotometer. For analytical determination requiring the use of calibration curves, such curves were plotted using standard solutions prepared from analytical grade reagents. Records of such calibration curves were maintained and frequent re-calibration checks were carried out. Analytical blanks were incorporated per specific batches of samples to compensate for the sample preparation and determination steps. All the analyses were replicated and the means reported. The samples were analysed at Jenneoby Environmental and Laboratory Services Ltd., located in Lekki, Lagos State Nigeria and Jacio Environmental Limited, Effurun, Delta State. The laboratory analysis were witnessed by regulators.

- ***Storage/Preservation***

Samples were analysed at minimum time after collection they could be subject to microbial degradation and transformation. Samples were stored in ice-chest as a cooling device and transported to the laboratory where they were refrigerated at 4°C or kept in a freezer as appropriate. Samples for heavy metal analyses were preserved with 1:1 nitric acid and oil and grease with 1 ml of 1:1 H_2SO_4 as soon as they were collected. Adherence to good preservation procedures ensured that errors were not introduced into the analytical process.

- ***Chain of Samples Custody Procedure***

There is a Master Register for all samples brought into the laboratory. Following registration of the sample, a Sample Data Sheet containing pertinent information on the sample was opened for each sample. The information includes:

a) sample reference number;
b) nature or type of sample;
c) site of collection;
d) date and time of collection; and
e) Mode of preservation (depends on nature of material) and analytical data from the field

And results of laboratory analyses of representative samples.

Appropriate methods were used in storing the remaining stock materials and sub samples. Samples for storage were kept in labelled compartments on shelves in a storage room. Samples sent to co-operating laboratories were recorded in the Master Register and accompanied by essential data pertaining to the sample material.

⊙ ***Evaluation of Results***

Raw data obtained from the instrumental measurements were used in calculating the concentrations of the various parameters, using standardized formulae. All such calculations were crosschecked. Outlying values were deleted from the replicate data before calculation of mean concentrations. A quick identification of results, which deviate from the normal trend, was usually done. The sum of the anion concentration in meq/l should be equal to the sum of the cations concentration also in meq/l. Differences within 5% are acceptable.

$$\%\ \text{Difference} = \frac{(\text{Cations})\ \text{minus}\ (\text{anions})}{(\text{Cations})\ \text{plus}\ (\text{anions})}$$

Also, calculated and observed conductivity measurements and IDS data were compared, to check reliability and accuracy of data. The laboratory analytical methods used were those recommended by FEPA, 1991.

⊙ ***Occupational Safety and Health (OSH) Program***

Safety measures were adopted for field samples and lab analysis in line with POL and AFEL HSE policies. On arrival at the POLbase office in Kwale, the entire team comprising of FMEnv, POL and AFEL were briefed on safety on site to familiarize them with essential safety precautionary measures, emergency response procedures and hazards associated with the each plant/facility. The safety briefing was corroborated with Safety pep-talk on each sampling day. Protective equipment were worn in all situations involving handling of toxic/dangerous materials in line with the procedures provided in the AFEL safe handling of chemical card (SHOC). A total of 150 man-hours was used for the sampling without lost time due to injury (LTI).

4.2.5 Socioeconomics and Stakeholder Consultation

4.2.5.1 Socioeconomics and Health Study Approach

Project influences and receptor exposure are felt by the human population. Consequently, data requirement, generic in nature were detailed in the terms of reference (ToR) to include but not limited to the following data needs:

Table 4.3: Socioeconomic Variables

	Social Features	Variables
1	Demography	Population size and distribution (age, gender, ethnic groupings, population density, dependency and sex ratio), marital status, educational attainment, primary and secondary school drop-out rates, history and trend of migration, net enrolment ratios for primary and secondary schools, etc.
2	Livelihood	Income distribution and consumption patterns, employment status, occupation, occupational mobility and adjustment, poverty profile, land use and tenure system, and other economic activities.
3	Social Infrastructure	Major means of transportation; educational institutions, water supply, electricity, communication, recreational facilities, waste management facilities, housing (type, pattern and quality) etc.
4	Cultural Properties	Value system, social norms, location and spatial distribution of historical sites, archaeological artefacts, shrines, sacred forests/scenic areas; religion, plants/animal species of cultural value, festivals, marriage practices, cultural calendar etc.
5	Natural Resources and Land Use	Values and use of natural resources including rights over private, rental, common ownership and access to resources – especially with respect to women; local conservation practices (closed seasons/closed locations) etc.
6	Perception of the project	Perception of associated project risks and impacts on quality of life, rating of relationship with the client, pleasure/displeasure with proposed project, expectations etc.
7	The role of women and children	Rights and privileges, contribution to socio-economic development; activity systems and political organisation, women trafficking, child labour etc.
8	Physically Challenged	Rights and privileges, contribution to socio-economic development; activity systems, social exclusion etc.
9	Social Structure and Organization	Settlement history, ethnic groups, social organization and traditional governance – power and authority structure; history of conflicts and their resolution including the role of women
10	Sex Trade	Population, Frequency, Nature, types, origin, and socio-

		economic aspects etc.

The socio-economic data gathering involve the use of some techniques like interview schedule, survey question administration, key informant interview (KII) and focus group discussion (FGD). These techniques are found to be useful in participatory rural and learning appraisal techniques. The field survey study was carried out across the identified project affected communities and also facilitated by the community's representative who attended the pre-field mobilization meeting as well as members of the communities who are familiar with data gathering exercise.

In the study both qualitative and quantitative techniques were used for data collection and as a primary technique of data gathering, community consultation and focus group discussions were used as well as community leaders and other participant. In the process, probing questions on crucial socio-economic issues were raised and answers gotten from the participants in relation to their positions in community and level of knowledge. Visitations were also carried out on the existing social infrastructural facilities and services, e.g., education and health care for necessary information on education and health. As a survey instrument and primary data gathering method, the questionnaire was structured such that binary, optional and open-ended questions were raised to solicit the necessary answers to questions from the community members.

Meanwhile, random sampling technique was used in selecting respondents from the surveyed communities during the community gathering (focus group discussion) as well as during the cross session of respondent within each community with the adult population as the target. At the end of the focus group discussion (FGD) sessions/community-wide interaction meetings, structured questionnaires were administered to a cross section of each of the community with the aid of the community's leadership and facilitator. As a survey instrument and primary data collection method, the questionnaire was structured such that binary, optional and open-ended questions were asked to solicit the necessary answers to questions from the householder. One hundred and ninety (190) questionnaires were administered at the communities and out of which 147 questionnaires were adequately completed for analysis, giving a response rate of 77.4%. Below are some sampled pictures during focus group discussion (FGD) with the stakeholder communities.

Table 4.4: Focus Group Discussion (FGD) Venue, Questionnaire administered and Retrieved

S/no	Community	Focus Group Discussion (FGD) Venue	Questionnaire administered	Questionnaire retrieved

1	Umuseti-Ogbe	CDC Chairman's Place	55	43
2	Igbuku	CDC Chairman's Place	45	35
3	Askaka	CDC Chairman's Place	50	38
4	Emu-Iyasele	Community Town Hall	40	31
	Total		190	147 (77.4%)

4.2.5.2: Socio-economic Data Analysis and Presentation

In analyzing the primary and secondary data, simple descriptive methods and summary statistics like mean, range, mode and percentage were used. Some of the data were presented in tables and graphs and also six key levels of aggregation and analysis were used. These are national, regional, state, local government area, community, household and individual respondent. Meanwhile, the population of the host community was projected using result of the 2006 national census released by the National Population Census (NPC). The linear extrapolation and exponential growth model of population projection method are often used in estimating population. While the linear extrapolation model assume population growth to occur in constant increment over time, the exponential model assume rate of population growth as not constant but rather changes with time, growing faster as the population size increases. Put differently, population more often than not grows exponentially rather than linearly. However, the exponential growth model was used in estimating the population of the community. Thus

Exponential Growth Model: $Pn = Po (1+r)^n$

Where:

Po = population in the base year

R = annual growth rate of the population

N = time lapse in years

Plate 4.4a: Fieldwork kick-off session at Pillar Oil Limited (POL) Base Office, Kwale

Plate 4.4b Meeting with community leaders from Umuseti-Ogbe and Igbuku Communities, Source: POL field wok, 2020

Plate 4.4c Meeting at Askaka Community with community leaders, Source: POL field work, 2020

Plate 4.4d: POL Meeting with Communty Leaders at Emu-Iyasele Community, Source: POL field work, 2020

4.3 Baseline Environmental Condition

4.3.1 Geology/Hydrogeology

Delta State is an integral part of Nigeria Coastal plain and extended continental shelf. The deposits are therefore, geologically young, ranging from the Eocene to the recent Pilocene (Dr. Madedor, et al). The soil is mainly alluvial mix with sand, clay, peat and silt in various proportions. The state has an annual rainfall range of 2,200 to 2,400mm. The territory lies in typical West African continental shelf with beaches and bars draining into the big sea.

The south-south zone of Nigeria is characterized by three (3) litho-stratigraphic units of tertiary, namely, from the oldest to the youngest, Akata, Agbada, and Benin formations. Geologically, the continental margin of West Africa along the Atlantic Gulf of Guinea is brought about as a consequence of the separation of the South American plate from the African plate during the Jurassic Period i.e. about 180 million years ago. The separation is in a rift-like setting that developed into a triple R (RRR) junction arm, two of which collapsed to form the continental margins while the third formed the Benue Trough (Stracher, 1995). Following this separation, marine and marginal sedimentation commenced, depositing thick successions of sediments in cycles of transgressions and regression of the sea.

The Akata formation consists of holomarine shales, silts and clays. The Agbada formation consists of a paralic and stratigraphic component that serves both as hydrocarbon source and reservoir rocks. The Benin formation, also called coastal plain sands, is the youngest tertiary formation in the south-south. It consists predominantly of coarse to medium grained sands, poorly consolidated sandstones with minor shale intercalations deposited in the continental environment. The lithological composition of the Benin formation makes it the most prolific regional aquifer in Southern Nigeria. The Benin formation sequence comprises continental alluvial to coastal plain sandstones interbedded with mudstones of lacustrine origin. The sequence forms the massive freshwater continental sands.

Based on previous studies in the area, regionally, there are two significant aquifer systems in the zone. The first is a phreatic or water table aquifer. This consists of fine to coarse sand with traces of clay and silt. This water bearing horizon is underlain by the more regionally extensive Benin formation, with its multiple aquiferous layers, which are interrupted by shale intercalations forming confining beds within the aquifer horizon. The thickness of the water table aquifer is not known, but it is believed that the water bodies are conditioned by topography and therefore may not form a continuous or extensive water-bearing zone.

Geomorphology

The geomorphology of the land is dominated by an almost flat terrain that is only a few meters above mean sea level. Depressions and a few minor undulations that are perennially flooded also occur in the area.

Geology and Hydrogeology of the Study Area

The knowledge of the Geology of the project area was obtained from examination of available literature of previous studies. The study area is part of the Niger Delta Basin characterised by nearly flat topography and underlain by quaternary sands of the Sombriero plain. It is within the Deltaic Plain Belt (Sombriero-Warri) which is characterized by an extensive low-lying area dominated by fluvial systems, some with braided characteristics. The typical Lithology range from very fine to very coarse grained sand with variable amount of Quartz and Feldspar minerals as confirmed by Borehole Cuttings and Grain Size analysis of the Drill Cuttings. The Sand is unconsolidated, reddish to light coloured from top to bottom.

Hydrogeology

Groundwater in most parts of the State is found in two aquifers all within Benin formation and the poorly understood recent deposits of Ameki and Ogwashi-Asaba Formations which extend from Anambra State into Asaba in Delta State. The maximum thickness of the first aquifer is less than 50 meters and aquifer here is unconfined to semi-confined and prone to contamination. The second aquifer is found at greater depths and sandwiched between grey-dark clays, clay shale, and lignite bands and the aquifer here is confined (Orji, and Egboka, 2015). The water table contour map of the study area revealed that groundwater flow direction is moderately toward the south (Aboh) and extensively towards the North-Western parts of the Region (Beneku and Ashaka) (Figure 4.4).

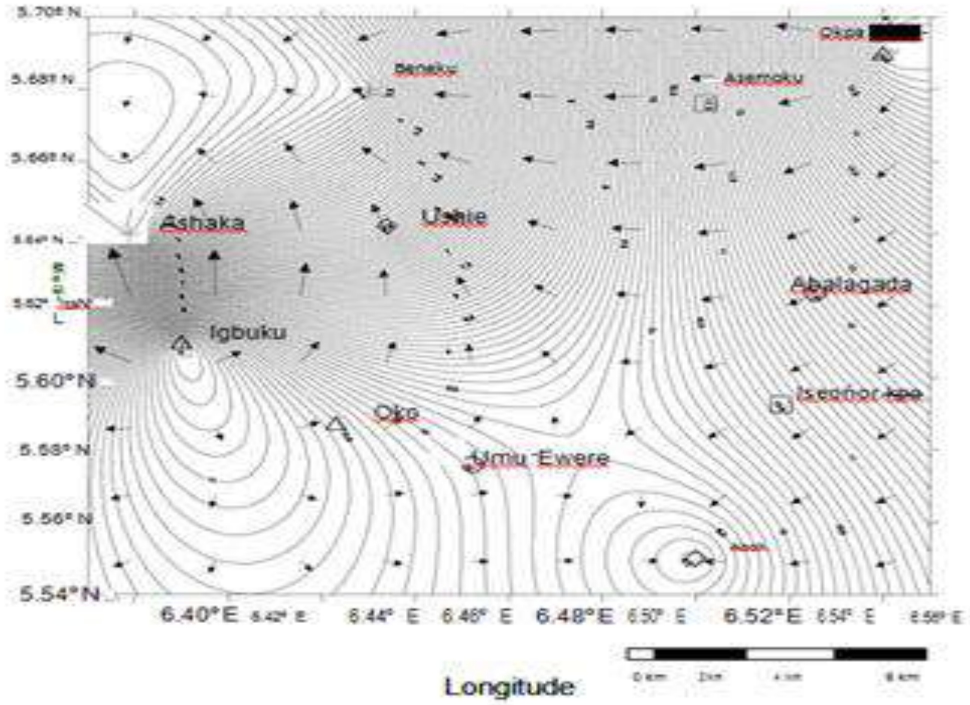


Figure 4.4 Water Table Contour Map of the Study Area Showing the Flow Direction, Source: Otutu , 2010

The depth to the groundwater aquifer usually about 50m or greater makes exploring this resource quite challenging and therefore requiring proper planning and technique.

Some of the techniques that have been used to source groundwater includes aerial, surface, subsurface and esoteric (Fetter, 2007). The most common procedures are the surface and subsurface methods (Anomohanran, 2014). The surface methods are made up of geophysical, geological, geomorphological, hydrogeological, geobotanical, and geochemical methods (Anomohanran, 2015).

The region is built up by the sedimentation of the Niger Delta and consists of the delta in various stages of development. Four major physiographic units are identifiable within it. First, the freshwater swamp which is the most active area. It is located close to the River Niger, where annual flooding and deposition occurs up to 45 km from the river's course. Second, the mangrove swamp area described as an intermediate delta stage. It is much lower and a great proportion of it is brackish, having been invaded by the sea since large amounts of freshwater have ceased flowing into it. Third, the upland and swamp, which is also called the coastal plain. It lies between the flood plain and Benin lowlands. The swamps are more restricted to broad drainage channels created when this area was an active delta. Fourth and finally, the upland Niger valley, which is a narrow strip above the delta and relatively flood free (http://www.onlinenigeria.com/delta-state, 2017).

The River Niger drains the eastern flank of the state and discharges into the sea through its several distributaries such as the Forcados, Escravos and Warri rivers and creeks such as the Bomadi creeks, amongst others. Rivers Jamieson and Ethiope rise from the north and northeast respectively, and subsequently join and form the Benin River, which eventually discharges into the sea in the West. (http://www.onlinenigeria.com/delta-state, 2017).

4.3.2 Climate/Meteorology, Ambient Air Quality and Noise of the Study Area

Climate/Meteorology

Nigeria is located between latitudes 4 and 11 degrees north. The term "tropical" generally refers to any region falling between the Tropic of Cancer and the Tropic of Capricorn. Therefore, Nigeria's climate is basically tropical. The country enjoys a climate characterised by the hot and wet conditions associated with the movement of the Inter-Tropical Convergence Zone (ITCZ) north and south of the equator. ITCZ is the convergence of two air masses which are the Tropical maritime (Tm) and the Tropical continental (Tc). The former is associated with the moisture-laden south-west winds (south westerlies) which blow from the Atlantic Ocean, while the latter is the dry and dusty north-east winds (easterlies) which blow from the Sahara Desert. When the zone of convergence of the two air masses, is to the south of the equator, the north-east winds prevail over Nigeria, thus producing the dry-season conditions (November – March).

Conversely, when the ITCZ moves into the Northern Hemisphere, the rain-bearing south westerlies prevail as far inland as possible, bringing rain fall during the wet season (April – October). This low pressure belt begins its northward shift in January and returns to southern Nigeria in July. The 2012 Climate Review of Nigerian Metrological Agency (NiMet) noted that the ITCZ moved northwards from latitude 7.9ºN in January to reach latitude 20.9ºN in August. Its positions from June through October were 1-2 degrees of latitude higher than normal positions but its positions were below normal in April, November and December. Thus, the seasonal northward and southward oscillatory movement of the ITCZ largely dictates the weather pattern of Nigeria.

The weather elements that make up climate include rainfall, temperature, humidity, wind, cloud, solar radiation, dust and aerosol. Climate is not static and is often defined as "average weather" together with its variability from the average. Climate fluctuation or variability refers to variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all spatial and temporal scales beyond that of individual weather events (Ologunorisa, 2011). The overall changes in temperature, rainfall and other meteorological parameters determine the annual changes in climate over a given region.

Four seasons have been observed from the seasonal pattern of climatic conditions over southern Nigeria based on rainfall occurrence and distribution. They are, The Long Rainy Season (March – July) with a peak period in July, the Short Dry Season experienced in August for 3-4 weeks known as "August Break", the Short Rainy Season from early September to mid-October with a peak period at the end of September and the Long Dry Season from late October to early March with peak dry conditions between early December and late February. The typical bimodal distribution of monthly mean rainfall is indicated by the short break in August while the monthly temperature distribution peaks in February. The Short Dry Season has not been well defined as in recent years and in addition; it impacted on the July rainfall rather than the usual August rainfall due to the period of its occurrence (NiMet, 2010 Climate Review).

- ***Baseline macroclimatic description of the study area***

Atmospheric temperature is a measure of the temperature of the atmosphere of the earth atmospheric which varies slowly with day and night season. The study area recorded average maximum temperature of 31.35^{O}C in the 2015 and 22.48^{O}C in the same year. Based on NiMet (2017), temperature has been stable in the study area from 1991 – 2015 as the average minimum and average maximum recorded in 1991 was 23.99^{O}C and 31.36^{O}C respectively. Also the average minimum and average maximum recorded in 2015 was 22.48^{O}C and 31.35^{O}C, showing stable temperature condition within the period under review. See ***Figure 4.5*** below.

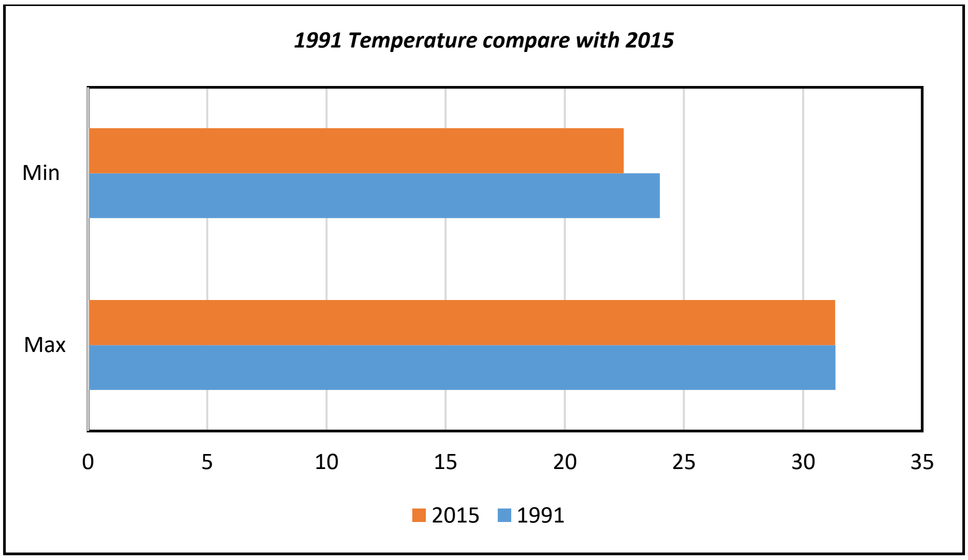


Figure 4.5: Stable temperature condition from 1991 – 2015 for the study area

Relative humidity (RH) is the amount of water in the air compared with the amount of water required to saturate the same volume of water at the same temperature. Similar to atmospheric temperature trend, based on NiMet weather data (2017) , the Relative Humidity of the study area from was observed to be in stable condition from 1991 – 2015. The average RH recorded for the study area within the period under review was 71.97%, while maximum RH was 85% and the minimum recorded was 46% (***Figure 4.6***).

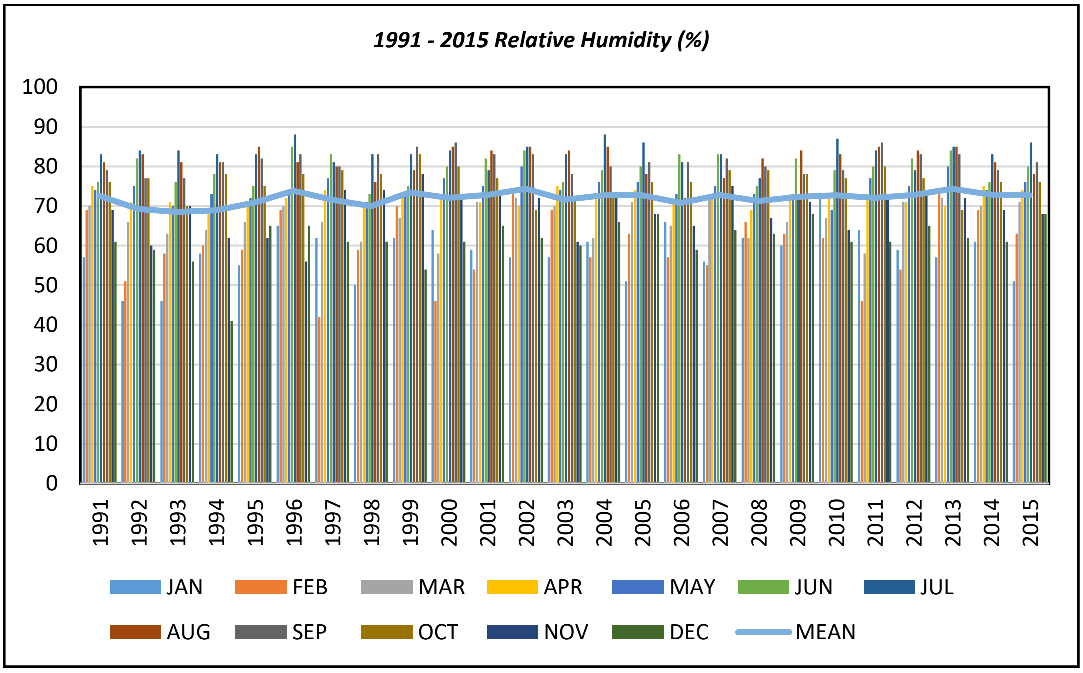


Figure 4.6: Relative humidity of the study area from 1991 – 2015

The mean cloud cover of 6.88 oktas was recorded for the study area from 1991 – 2015. Highest cloud cover was recorded in 1997 after which cloud cover for the study has remain stable (***Figure 4.7***). Cloud cover is another important weather variable that could be impact by the project from emission related aspects such as vapour and particulates.

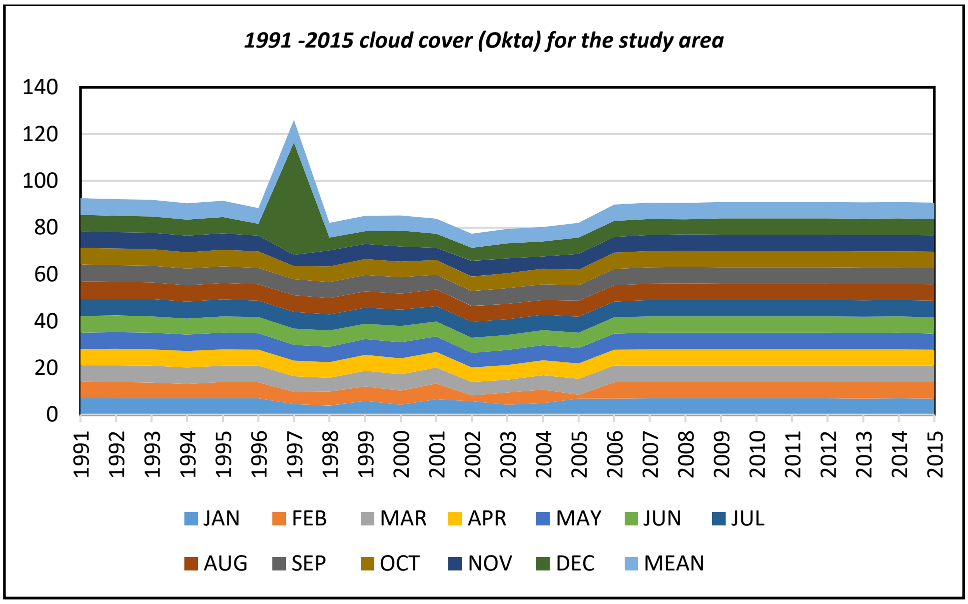


Figure 4.7: 1991 -2015 cloud cover (Okta) for the study area

- ***Baseline microclimatic data of the study area***

Microclimatic data can be described as the weather data for a short period of time typically daily, unlike macroclimatic data which covers a longer period typically in years, as discussed above. The baseline microclimatic description of the study area was based on in situ data collection (fieldwork 2020) ***(Appendices 4.3a and 4.3b).*** The microclimatic condition of the area shows similar condition with the data derived from NiMet, 2017.

Ambient temperature is a weather variable that could be directly but temporarily affected by the OML 56. Sources of heat causing ambient temperature rise include flaring, vapour emission and thermal emission from process equipment. Therefore, the ESIA established the ambient temperature for the project area. The study was carried out within the hours of 8:00 AM to 6:00 PM, to present a representative temperature value for day and night.

The study recorded 33.65^{O}C as the mean temperature of the project with the maximum being 37.7^{O}C and the minimum 29.60^{O}C during dry season and mean temperature of 37.05^{O}C with highest being 41.0^{O}C during wet season (***Appendices 4.3a and 4.3b***). The temperature variation was observed to be influenced by daily time variation. It was low in the morning and gradually increases towards afternoon. Maximum temperature was recorded just after noon. Also, towards the evening, temperature also declines (***Figure 4.8***).

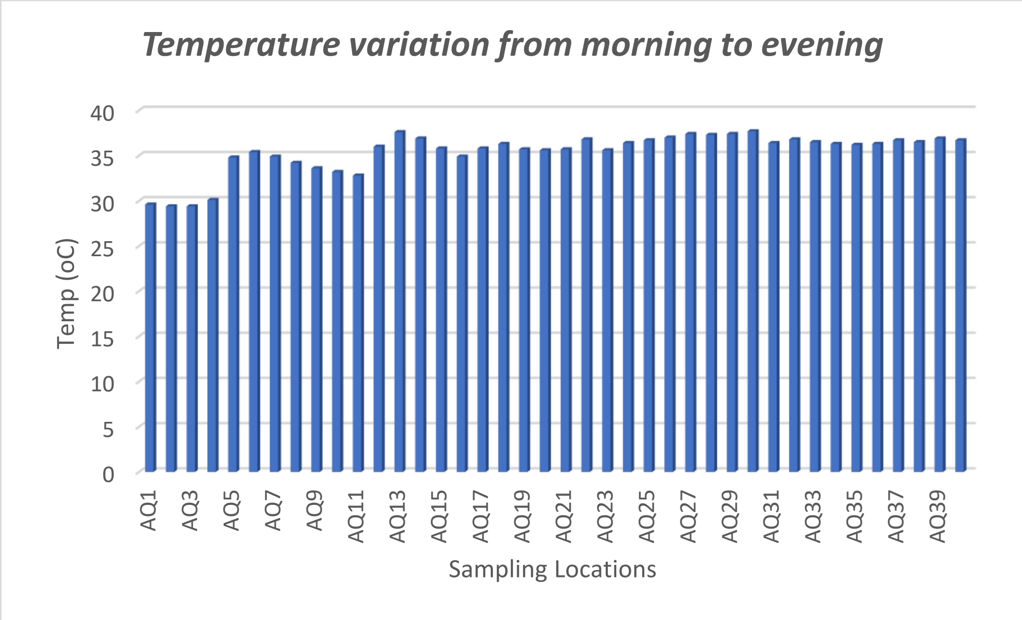


Figure 4.8: Temperature variation with time of the day

The mean ***Relative humidity*** for the study area was 53.0% during dry season and 60.05% during wet season, while the mean ***Wind speed*** was 1.4 and 3.1ms^{-1} for dry and wet season respectivelyThe dominant wind direction was observed to be north-west and north-east directions.

Air Quality Study

- **Oxides of Nitrogen (NOx)**

NOx is the group formula for nitric oxide (NO) and nitrogen dioxide (NO_2). Nitrogen dioxide is a toxic component in the air; it could be released directly from combustion points or arises as the oxidation product of nitric oxide which is a less harmful species. NO_2 forms quickly from emissions from cars, trucks and buses, power plants, and off-road equipment. The NO_X concentrations during the wet season of 2020 have a constant value of <0.01ppm and ranged from <0.01ppm to 0.063ppm during dry season . All these values are below the stipulated limit of 0.04 – 0.06ppm by FMEnv.

- ***Oxides of Sulphur (SO_X)***

SO_X is the group formula for SO_2, SO_3 and SO_4^{2-} which usually occur as both primary and secondary air pollutants. Power plants, industry, and the oceans emit these gases as primary pollutants. In addition, biological decay processes and some industrial sources emit H_2S which is oxidized to form the secondary pollutant, SO_2. The combustion of fossil fuels containing Sulphur yields SO_2 in direct proportion to the Sulphur content of the fuel.

The primary threat of SO_2 to urban atmosphere may arise not from SO_2 itself but from the changes it undergoes in the atmosphere such as the formation of sulphuric acid (H_2SO_4),a reaction which is catalysed by particulate matter; and the formation of sulphate aerosols. SO_2 can also be absorbed on small particles such as the salts of iron, manganese and vanadium present in the atmosphere and thus enter the alveoli of the lungs. The SO_X concentrations during 2020 dry season and wet season sampling periods have valuesthat are below detection limit of < 0.01 which is below the stipulated limit of 0.01ppm by FMEnv.***(Appendices 4.3a and 4.3b).***

- ***Carbon monoxide (CO)***

CO is a colorless, odorless gas emitted from combustion processes. In urban areas, the majority of CO emissions to ambient air come from mobile sources. At extremely high levels, CO can cause death (Kao, 1994). In the study area, CO concentrations during wet season sampling period was below detection limit of < 0.01 ppm with During dry season study CO ranged from <0.01 – 3.5ppm with a mean value of 1.75ppm for all the sampling stations ***(Appendices 4.3a and 4.3b).*** However, the values obtained during these two seasons were below the stipulated limit of 10ppm by FMEnv

- ***Hydrogen sulphide (H_2S)***

Concentration of hydrogen sulphide forwet season was below detection limit of < 0.01 ppm while it ranged from 0.2 to 0.7ppm with an average value of 0.45ppm during dry season of 2020.

- ***Volatile Organic Compounds (VOCs)***

VOC is an aggregate parameter defining volatile hydrocarbon compounds. These are airborne and are usually composed of low and intermediate molecular weight hydrocarbons. The concentrations of volatile organic compounds during wet season sampling period showed that the VOC concentration were very low and varied from 0.1 to 2.3ppmwith a mean value of 1.2ppm.

Furthermore, in dry season, the VOC concentration ranged from 82 to 228ppm. ***(Appendices 4.3a and 3b).*** While most of the values obtained during the two seasons were below the stipulated limit of 160ppm by FMEnv, however, value from one of the locations is above the stipulated limits of 160ppm. This could be as a result of activities going on in the field.

- ***Suspended Particulate Matters (SPM)***

The concentration of particulates in the ambient air during wet season ranged from 9.50µg/m^3 to 46.00µg/m^3 (mean value of 27.75µg/m^3) for particle size of 2.5micron and 10.20 to 152.40 µg/m^3 (mean value of 81.30µg/m^3) while concentration during dry season samples ranged from 48.70µg/m^3 to 519.40µg/m^3 (mean value of

284.05µg/m^3) for particle size of 2.5micron and 68.90µg/m^3 to 720.0µg/m^3 (mean value of 394.45µg/m^3) for particle size of 10micron. While the values recorded for particle size of 2.5 and 10micron for wet season were below the FMEnv limits of 150µg/m^3 and 250µg/m^3 respectively, some of the values for particle size of 2.5 and 10micron in 2020 were above FMEnv limits of 150µg/m^3 and 250µg/m^3 respectively. This could be as a result of anthropogenic activities in the field.

Noise Level

The noise levels recorded at the project area during dry season ranged respectively from 50.3 to 87.6dB (mean value of 68.95dB) and 41.2dB to 69.4dB (mean value of 55.3dB) for wet season. A large proportion of background noise in the area is due to human activities and vehicular effect. Generally, in spite of this, the mean values recorded for both seasons are still below the FMEnv limit of 90dB (A) for 8 hours exposure respectively.

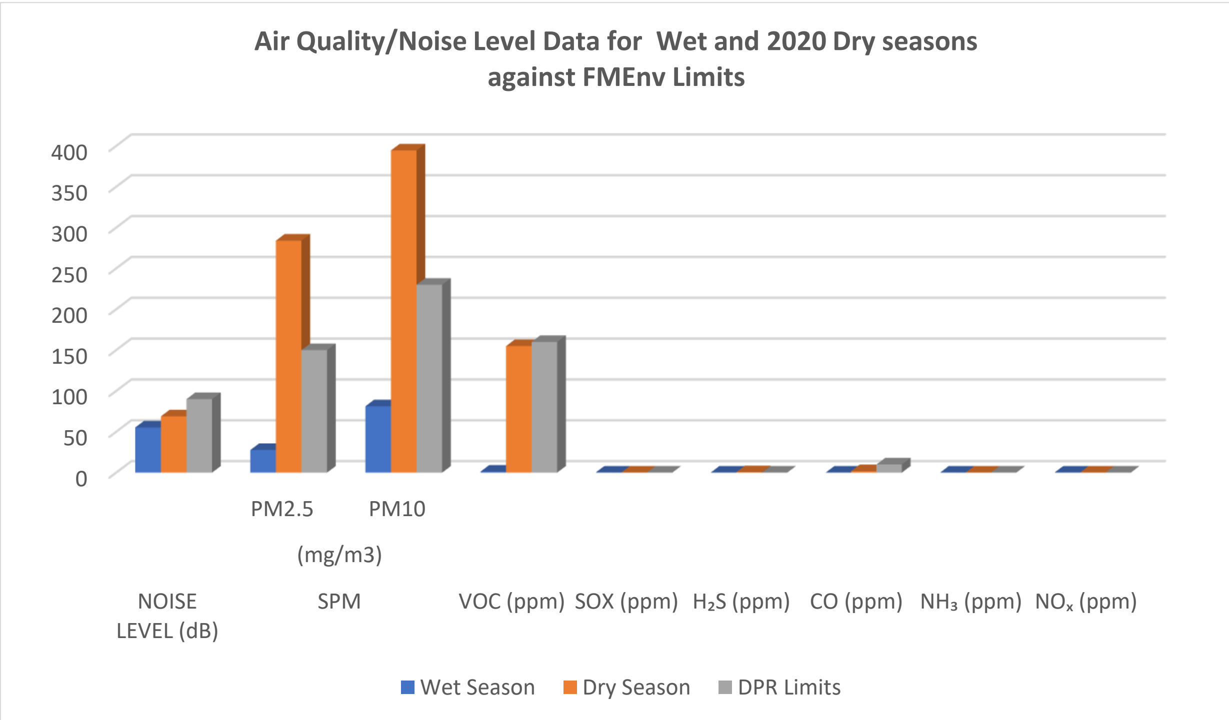


Figure 4.9: Air Quality/Noise Level Data for Wet and 2020 Dry seasons against FMEnv Limits

Table 4.5: Comparison of Air Quality and Noise during Wet and Dry seasons against FMEnv limits

		NOISE LEVEL (dB)	SPM (µg/m³)		VOC (ppm)	SOX (ppm)	H_2S (ppm)	CO (ppm)	NH_3 (ppm)	NO_x (ppm)
			$PM_{2.5}$	PM_{10}						
2020 Wet Season Air Quality and Noise Data	**Minimum**	41.2	9.5	10.2	0.1	0	0	< 0.01	< 0.01	< 0.01
	Maximum	69.4	46	152.4	2.3	0	0	< 0.01	< 0.01	< 0.01
	Average	55.3	27.75	81.3	1.2	0	0	< 0.01	< 0.01	< 0.01
2020 Dry Season Air Quality and Noise Data	**Minimum**	50.3	48.7	68.9	82	< 0.01	0.2	< 0.01	< 0.01	< 0.01
	Maximum	87.6	519.4	720	228	< 0.01	0.7	3.5	< 0.01	0.063
	Average	68.95	**284.05**	**394.45**	155	< 0.01	0.45	1.75	< 0.01	0.0315
FMEnv Limits		**90**	**150**	**250**	**160**	**0.01**	**-**	**10**	**0.29**	**0.04 0.06**

<d.l = Below detection limit; Detection limit for NO_2 = 0.10ppm; Detection limit for SO_2 = 0.10ppm; Detection limit for CO = 1ppm

Source: ***2020 Field work***

4.3.3 Groundwater Baseline Description

The Physico-chemical analysis results of groundwater collected from existing borehole in the project area during wet and dry seasons are presented in ***Appendices 4.3a and 4.3b .*** The quality of the groundwater samples were compared with World Health Organisation (WHO) drinking water quality index, with most of the parameters recorded to be within WHO drinking water quality index, except for low pH value recorded at some stations. The water is generally clear and unobjectionable in terms of odour and other physical appearances.

- ***Physico-chemical Description of groundwater***

During the wet season of 2020 the values of pH ranged from 5.79 to 6.12 which are slightly acidic while the values ranged from 6.37 to 6.9 which are slightly acidic during the dryseason of 2020. (***Appendices 4.3a and 4.3b***). These values show that groundwater around the project area were all acidic and are below the FMEnv and WHO limit of 6.5 – 8.5 for drinkable water except a location during the dry season sampling

The water temperature for thewet season ranged from 29.4 to 30.8^{O}C while it had constant value of 24.90 ^{O}C during the dry season of 2020. The water Turbidity has a constant value of <0.01 (NTU) during the dry season of 2020 while the values ranged from 0.92 to 1.80 NTU during the wet season. Total Suspended Solids in 2020dry season were not detected, meanwhile the values ranged from 0.25 to 0.37mg/l during the wet season. Electrical conductivity varied between 51.2 and 387.0 µS/cm in 2020 dry season while the values ranged from 35 and 48µS/cm during wet season. Total Alkalinity values were nil in 2020 dry season while the parameter ranged from 4.0 to 10mg/L during wet season 2020 study.

The groundwater Dissolved Oxygen (DO) recorded for dry season was between 3.82 and 3.94mg/L while the values ranged from 6.6 to 7.1 mg/L during the wet season. The groundwater Chemical Oxygen Demand (COD) values is an indicative measure of the amount of oxygen that can be consumed by reactions in a measured solution were sampled and the values ranged from 8.0 to 16.0mg/L in 2020 dry seasonwhile the values ranged from 7.73 to 9.93 mg/L during the wet season. The groundwater Biological Oxygen Demand (BOD_5) is the amount of dissolved oxygen needed (i.e. demanded) by aerobic biological organisms to break down organic material present in a given water sample at certain temperature over a specific time period has a mean value of 1.84mg/lduring dry season and 3.7 mg/L in wet season.

The groundwater cations were dominated by Sodium (Na), Calcium (Ca) and Potassium (K) as presented in Table 4.6***.*** Sodium has values ranging from 5.43 to 40.68mg/L in dry season while he values ranged from 2.75 to 10.32 mg/L during wet season. Also Potassium has values ranging from0.621 to 1.72mg/L in dry seasonwhile he values ranged from 0.21 to 0.41 mg/L during wet season. Calcium (Ca) and Magnesium (Mg) were also measured during the twio seasons with Magnesium ranging from 1.94 to 13.31mg/L during dry season and 0.71 to 0.98mg/L during wet season. Also, Calcium ranged from 3.21 to 22.04during dry season while 1.44 to 2.71mg/L in wet season. During the wet and dry seasons studies, the heavy metal concentration values were low in all the stations and do not pose any pollution threat related to hydrocarbon contamination.

Groundwater hydrocarbon concentration is a very important quality monitoring parameter for oil and gas activities, as it can be used to detect any oil related groundwater pollution. Hydrocarbon concentration of the groundwater was generally low during dry season (***Table 4.6***). Similarly, during wetseason study, the ground water hydrocarbon concentration also recorded low concentration below detection limit. This is an indication of no oil pollution in the project area. Both seasons groundwater hydrocarbon concentration are within FMEnv limits.

- ***Groundwater microbial analysis***

From the Microbiology results recorded, THB count which varied from 2.1 x 10^4 cfu/ml to 2.30 x 10^4cfu/ml for wet season while the values ranged from 2.11 x 10^4 cfu/ml to 3 x 10^4cfu/ml during dry season. THF count of 1.0 x 10^3cfu/ml to 1.40 x 10^3cfu/ml was recorded for wet season while THF count of 1.0 x 10^3cfu/ml to 2.0 x 10^3cfu/ml was recorded for dry season . HUB was not detected during dry season andwet season activities. HUF count also could not be detected during the field sampling for the two seasons under consideration.

Bacteria Identified in Groundwater were *Streptococcusspp, Enterobacter spp., Enterococcus spp*while theFungi identified in Groundwater are *Penicillium spp., Aspergillus spp*

Table 4.6: Summary of Physical, Chemical and Microbiological Properties of the Groundwater Sampled During Wet and Dry Seasons of 2020

	2020 (Dry Season)					2020 (Wet Season)					FMEnv Limits	WHO Limits
Parameters	**Min**	**Max**	**Mean**	**Stdev**	**Control**	**Min**	**Max**	**Mean**	**Stdev**	**Control**		
pH	6.37	6.94	6.655	0.285	7.38	5.79	6.12	5.96	0.17	6.10	6 – 8.5	6 - 9
Electrical Conductivity (µS/cm)	51.2	387	219.1	167.9	65.6	25	48	36.5	11.50	17	NS	900
TDS (mg/L)	25.6	193.7	109.65	84.05	32.8	9	35	22	13.00	6	1500	-
Temperature (ºC)	24.5	24.5	24.5	0	24.6	29.4	30.8	30.1	0.70	29.9	30	<40
TSS (mg/L)	ND	ND	ND	0	ND	0.25	0.37	0.31	0.06	0.14	-	-
Turbidity(NTU)	<0.01	<0.01	<0.01	0	<0.01	0.92	1.80	1.36	0.44	0.61	-	5
Total Hardness(mg/L)	16	95	55.5	39.5	16	7.0	11.0	9.0	2.00	8.0		
Cl^-(mg/L)	8.37	62.7	35.535	27.165	10.46	6.49	18.50	12.50	6.01	5.00	-	250
SO_4^{2-} (mg/L)	2.823	8.912	5.8675	3.0445	5.143	1.16	3.67	2.41	1.25	0.86	-	100
NO_3 - N (mg/L)	1.321	1.384	1.3525	0.0315	1.304	0.34	0.47	0.40	0.07	0.31	-	-
Phosphate (mg/L)	0.157	0.172	0.1645	0.0075	0.156	<0.01	<0.01	<0.01	0.00	<0.01	-	-
Alkalinity (mg/L)	Nil	Nil	Nil	0	Nil	4.0	10.0	7.0	3.00	4.0	-	100.00
Salinity(mg/L)	0.03	0.19	0.11	0.08	0.04	0.01	0.02	0.01	0.00	0.01		
COD (mg/L)	8	16	12	4	8	7.73	9.93	8.83	1.10	4.67	-	-
O & G (mg/L)	0.035	0.05	0.0425	0.0075	0.025						10	-
DO (mg/L)	3.82	3.94	3.88	0.06	3.9	6.6	7.1	6.9	0.25	7.0	6	-
BOD_5 (mg/L)	1.77	1.91	1.84	0.07	1.85	3.3	4.0	3.7	0.35	1.4	-	-
Cr^{+6} (mg/L)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05	0.005
Cd(mg/L)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	0.005
Cu(mg/L)	0.014	0.025	0.0195	0.0055	0.016	0.005	0.014	0.010	0.00	0.005	-	1.00
Pb(mg/L)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	0.05	0.01
Ba(mg/L)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0.00	<0.001		
Fe(mg/L)	0.287	0.321	0.304	0.017	0.292	0.635	1.029	0.832	0.20	0.956	1	0.3
Ni(mg/L)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	-	

V(mg/)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	-	-
Zn(mg/L)	0.188	0.211	0.1995	0.0115	0.207	<0.001	0.14	0.142	0.00	<0.001	1.5	5.00
Hg(mg/L)	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0.00	<0.001	-	-
Mn(mg/L)	0.113	0.144	0.1285	0.0155	0.122	<0.001	<0.001	<0.001	0.00	<0.001	0.01	0.10
Ca(mg/L)	3.21	22.04	12.625	9.415	3.21	1.44	2.71	2.08	0.63	1.26	-	-
Mg(mg/L)	1.94	13.31	7.625	5.685	1.94	0.71	0.98	0.85	0.13	0.65	-	-
Na(mg/L)	5.43	40.68	23.055	17.625	6.79	2.75	10.32	6.53	3.78	1.97	-	--
K(mg/L)	0.621	1.72	1.1705	0.5495	0.714	0.21	0.41	0.31	0.10	0.16	-	-
PAH(mg/L)	0.004	0.01	0.007	0.003	0.007	BDL	BDL	BDL	0.00	BDL	<5.0	-
Total TPH (mg/L)	0.018	0.03	0.024	0.006	0.014	BDL	BDL	BDL	0.00	BDL	<5.0	-
THC(mg/L)	0.026	0.04	0.033	0.007	0.02	BDL	BDL	BDL	0.00	BDL		
Total Coliform MPN/ 100ml	<1.8	1.8	1.8	0	<1.8	Nil	Nil	Nil	0.00	Nil	-	-
THB cfu/ml X 10^4	2.11	3	2.555	0.445	2	2.1	2.3 x 10^3	2.2 x 10^3	0.10	1.7 x 10^3	-	100
THF cfu/ml X 10^3	1	2	1.5	0.5	1	1.0 x 10^2	1.4 x 10^2	1.2 x 10^2	0.20	1.3 x 10^2	-	-
HUB cfu/ml X 10^3	ND	ND	ND	0	ND	Nil	Nil	Nil	0.00	Nil	-	-
HUF cfu/ml X 10^2	ND	ND	ND	0	ND	Nil	Nil	Nil	0.00	Nil	-	-

Source: POL Field work 2020

4.3.4 Soil Description

The soils are mainly derived from alluvium deposits of the deltaic plain. The entire area is generally flat and only slightly medium inclined with slope hardly exceeding 2^0. The maximum elevation above sea level was 27 m. Furthermore, the soils are relatively deep with rooting depths exceeding 80 cm. Parts of the entire area are susceptible to flooding / inundation. However, there were no visible evidences of pronounced erosion conditions. The summaries (descriptive statistics) of the Physico-chemical, Heavy metals and Microbial properties of the soils are as shown in ***Appendices 4.3a and 4.3b*****.**

- ***Soil textural description***

The entire soil texture fraction was dominated by sandy loamy soil in most of the sampling locations.

- ***Physico-chemical Description***

pH: The soils had a mean pH of 5.8 with a range of 5.3 to 6.3for the top soil and 5.1 to 6.2 with a mean value of 5.81 for the sub soil in dry season while it range ranged from 4.12 to 5.16 for the top soil and 4.08 to 5.34 with a mean value of 4.86 for the sub soil in the wet season, indicating acidic conditionsof the area activities. (Tables 4.8a and b).

Cation Exchange Capacity (CEC) of the soils: The cation exchange capacity of the soils ranged from 36.59 to 87.451.11cmol/kg with a mean value of 62.02cmol/kgfor top soil and 37.15 to 97.97 cmol/kg with a mean value of 77.95 cmol/kg for sub soil during dry season while it ranged from 9.2 to 10.24cmol/kg with a mean value of 1.2.06cmol/kg for top soil and 6.98 to 16.5 for subsoil in wet season. The C.E.C. is the sum of the exchangeable bases, namely, calcium, magnesium, potassium and sodium***(Tables 4.7a and b).***

Total Organic Carbon (T.O.C): The Total Organic Carbon value were between 1.29% and 1.84%, with a mean value of 1.565% for top soil and 1.04 to 13.1% in dry season while it ranged from 0.27% to 1.21% for top soil and 0.16 to 0.98% in wet season***(Tables 4.7a and b).***The production, accumulation and degradation of organic matter are greatly dependent on climate. Temperature, soil moisture and topography are the major factors affecting the accumulation of organic matter in soils.

Organic matter tends to accumulate under wet or cold conditions where decomposer activity is impeded by low temperature (Buol, 1990) or excess moisture which results in anaerobic conditions (Trofimov et al 2008). Conversely, high temperatures of tropical climates as in the present assessment enables rapid decomposition of organic matter and leaching of plant nutrients. Excessive slope may encourage the erosion of the top layer of soil which holds most of the raw organic material that would otherwise eventually become humus.

In view of the observations during the field studies, the present variability in total organic carbon content of the soils could be attributed to its high accumulation around the densely vegetated and unhampered secondary forest portion of the area. The other areas possess less dense vegetation cover leading to reduced rate of plant residue returns and accumulation with inherent high decomposition rate on the texture of the soil.

Total Nitrogen: Total Nitrogen content of the soil was between 20.09 and 29.9% with a mean concentration of 24.99% for top soil while it ranges from 21.73 to 28.23% with a mean value of 22.76% for sub soil during dry season while it ranged 0.11 to 0.25% for top soil and 0.09 to 0.28% in wet season***(Tables 4.7a and b).***The total nitrogen content of soil depends on the climate, vegetation, topography, age and soil management. Usually more nitrogen is under grassland than under forest. Humans formation promotes nitrogen immobilization. Cultivation decreases soil nitrogen by exposing soil to more air which bacteria can use and no-tillage maintains more nitrogen than tillage. The relative high values of total nitrogen indicates fertility level of the soils.

Electrical Conductivity: The electrical conductivity values were between 50.1 and 90.05 µS/cm for both top and sub soil during dry season.This also ranged from 27 to 421µS/cm during wet season. The electrical conductivity were all generally low. This is an indication of low levels of electrolytes in the soil, and where they are abundant, the sandy texture of the soils facilitates leaching.

Anions: The mean concentrations of the anions were as follows: Sulphate SO_4^{2-} (78.74 mg/kg for top soil and76.44 mg/kg for sub soil) during dry season and (11.4 mg/kg for top soil and 3.96mg/kg for sub soil) during wet season, and nitrate, NO_3^- (11.97mg/kg for top soil and 11.52 mg/kg for sub soil) during dry season and (0.7 mg/kg for top soil and 0.79mg/kg for sub soil) during wet season, nitrite, NO_2 (0.085mg/kg for top soil and 0.082 mg/kg for sub soil) during dry season and (0.052mg/kg for top soil and 0.059mg/kg for sub soil) during wet season.

- ***Heavy Metals Soil Composition***

Heavy Metals: The mean concentration of the heavy metals were as follows; Iron, Fe (2.066 mg/kg for top soil and 2.294mk/kg for sub soil)during dry season and (7866 mg/kg for top soil and 8088mk/kg for sub soil) during wet season; Nickel, Ni (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (1.44mg/kg for top soil and 3.525mk/kg for sub soil) during wet season; Chromium, Cr (0.057mg/kg for top soil and 0.0485mk/kg for sub soil) during dry season and (1.73 mg/kg for top soil and 1.83mk/kg for sub soil) during wet season; Cadmium, Cd (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (0.56 mg/kg for top soil and 0.58mk/kg for sub soil) during wet season; Zinc, Zn (0.154mg/kg for top soil and 0.176mk/kg for sub soil) during dry season and (20.66 mg/kg for top soil and 35.83mk/kg for sub soil) during wet season;Mercury, Hg (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during wet season; Lead, Pb (<0.001mg/kg for top soil and <0.001mk/kg for sub soil) during dry season and (1.98 mg/kg for top soil and 2.04mk/kg for sub soil) during wet season.

- ***Soil Oil and Grease (O & G) and Organic Composition***

Total Hydrocarbon (THC) has a mean value of 0.312mg/kg and 0.917mg/kg for both top and sub soils respectively in the dry season while it has a mean value of 0.32mg/kg and 0.43mg/kg for both top and sub soils respectively during the wet season.Total Petroleum Hydrocarbon (TPH): The total petroleum hydrocarbon content of the soil was ranged from 0.738 to 0.895mg/kg for both the wet and the dry season while it has a mean value of 0.246mg/kg and 0.358mg/kg for both top and sub soils respectively during the wet season.

- ***Microbial Composition***

Hydrocarbon utilizing bacteria (HUB) and Hydrocarbon utilizing fungi were not detected during dry season while they had a mean 1.1 x 10^2cfu/g and 0.9 x 10^2cfu/g and 0.55 x 10^2cfu/g and 0.6 x 10^2cfu/g respectively during wet season.Total Heterotrophic Bacteria (THB) had a mean amount of 5.575 and 5.275 x 10^4cfu/g for bothtop and sub soils respectively during dry seasonand 9.4 and 4.85 x 10^4cfu/g during wet season for both top and sub soils respectively, while Total Heterotrophic Fungi (THF) had a mean amount of 3.2 and 3.0 x 10^4cfu/g during dry season for both top and sub soils respectively and 5.4 and 3.9x 10^4cfu/g during wet season for both top and sub soils respectively.

Predominant bacteria isolates identified in the soil were *Streptococcus spp., Bacillus spp, Pseudomonas spp. Lactobacillus spp, Mycobacterium spp, Arthrobacter spp,* while Predominant fungi isolates identified in pillars soil were *Aspergillus spp., Mucor spp, Fusarium spp, Candida spp, Cladosporium spp, Rhodotorulaspp, Penicillium spp*

Table 4.7a: Summary of Physical, Chemical and Microbiological Properties of the Soil sampled during Dry season 2020

	Top Soil					Sub Soil				
	Min	**Max**	**Average**	**Control**	**StDev**	**Min**	**Max**	**Average**	**Control**	**StDev**
pH	5.3	6.3	5.8	5.79	0.5	5.1	6.2	5.65	5.81	0.55
Temp. (^{0}C)	25.6	26.4	26	25.96	0.4	25.5	26.1	25.8	25.91	0.3
Cond. (µS/cm)	50.1	83.5	66.8	66.38	16.7	52.1	90.05	71.075	67.16	18.975
Redox Pot. (mV)	100.2	151.5	125.85	130.9	25.65	105.5	140.5	123	132.48	17.5
TOC(%)	1.29	1.84	1.565	1.54	0.275	1.04	13.1	7.07	1.45	6.03
Porosity(%)	63	68	65.5	66.2	2.5	63	69	66	66.87	3
Sulphate(mg/kg)	52.37	105.1	78.735	88.11	26.365	55.86	96.94	76.4	81.48	20.54
Phosphate(mg/kg)	0.869	1.401	1.135	0.96	0.266	0.853	1.343	1.098	0.94	0.245
Total-Nitrogen(%)	20.09	29.9	24.995	23.56	4.905	21.73	28.23	24.98	22.76	3.25
Nitrate(mg/kg)	9.52	14.41	11.965	11.15	2.445	9.125	13.92	11.5225	10.67	2.3975
Nitrite(mg/kg)	0.05	0.119	0.0845	0.12	0.0345	0.035	0.129	0.082	0.12	0.047
Carbonate(mg/kg)	58.01	89.5	73.755	89.45	15.745	58.02	89.72	73.87	89.37	15.85
Ammonium(mg/kg)	10.52	15.49	13.005	12.29	2.485	11.42	14.41	12.915	11.98	1.495
Sodium(mg/kg)	21.71	43.42	32.565	34.72	10.855	21.71	54.28	37.995	34.71	16.285
Potassium(mg/kg)	2.022	4.658	3.34	2.1	1.318	2.045	3.545	2.795	2.1	0.75
Calcium(mg/kg)	8.02	32.06	20.04	25.65	12.02	8.02	32.06	20.04	25.65	12.02
Magnesium(mg/kg)	4.84	19.36	12.1	15.49	7.26	4.84	19.36	12.1	15.49	7.26
CEC(cmol/kg)	36.59	87.45	62.02	77.96	25.43	37.15	97.97	67.56	77.95	30.41
Iron(mg/kg)	1.51	2.621	2.0655	1.98	0.5555	1.716	2.871	2.2935	1.97	0.5775
Zinc(mg/kg)	0.128	0.18	0.154	0.16	0.026	0.161	0.19	0.1755	0.16	0.0145
Chromium(mg/kg)	0.037	0.076	0.0565	0.06	0.0195	0.013	0.084	0.0485	0.06	0.0355
Lead(mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0

Cadmium(mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0
Mercury(mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0
Vanadium (mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0
Nickel(mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0
Barium(mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0
TPH(total) (mg/kg)	0.295	1.18	0.7375	1.1	0.4425	0.38	1.41	0.895	1.18	0.515
BTEX(mg/kg)	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0
THC(mg/kg)	0.312	1.205	0.7585	1.12	0.4465	0.4	1.433	0.9165	1.19	0.5165
THB(cfu/g) x10^4)	3.05	8.1	5.575	3.56	2.525	2.05	8.5	5.275	3.89	3.225
THF(cfu/g) x10^3)	1	5.4	3.2	3.09	2.2	1	5	3	2.62	2
HUB(cfu/g) x10^1)	ND	ND	ND	ND	0	ND	ND	ND	ND	0
HUF(cfu/g) x10^1)	ND	ND	ND	ND	0	ND	ND	ND	ND	0
Feacal coliform	11	21	16	15.8	5	11	26	18.5	17.13	7.5
SRB	ND	ND	ND	ND	0	ND	ND	ND	ND	0

Source POL Fieldwork 2020

Table 4.7b: Summary of Physical, Chemical and Microbiological Properties of the Soil sampled during wet season 2020

Parameters	**Top Soil**							**Sub Soil**						
Physiochemical:	**Min**	**Max**	**Mean**	**StDev**	**TS C1**	**TS C2**	**TS C3**	**Min**	**Max**	**Mean**	**StDev**	**TS C1**	**TS C2**	**TS C3**
pH (1:1, soil to water)	4.12	5.16	4.84	0.459852	5.20	5.57	4.12	4.08	5.34	4.86	0.63592	5.34	5.46	4.19
Electrical Conductivity	27	109	73	75.73379	76	41	100	27	421	113	207.162	90	32	72
Temperature	26.8	27.1	26.98	0.129615	27.1	26.9	26.9	26.7	27.2	27.00833	0.25226	27.1	27.1	27
Nitrite	0.036	0.082	0.052	0.016439	0.046	0.049	0.039	0.03	0.092	0.059	0.03102	0.039	0.043	0.033
Chloride	1.77	10.64	9.57	20.12239	7.09	3.55	10.64	1.77	106.35	17.21	56.4525	10.64	1.77	7.09
Sulphate	2.64	18.41	11.4	21.11173	7.89	5.27	13.15	2.64	5.27	3.96	1.315	10.52	2.64	7.89
TOC	0.27	1.21	0.58	0.377	1.05	0.20	1.05	0.16	0.98	0.79	0.42922	0.31	0.08	0.47
Total Phosphorous	0.013	0.028	0.018	0.005409	0.016	0.017	0.014	0.011	0.031	0.021	0.01	0.014	0.015	0.012
Ammonium	0.14	0.32	0.2	0.064499	0.18	0.19	0.16	0.12	0.36	0.23	0.12014	0.16	0.17	0.13
Nitrate	0.49	1.11	0.7	0.221317	0.62	0.66	0.53	0.4	1.24	0.79	0.42036	0.53	0.58	0.44
Total Nitrogen	0.11	0.25	0.16	0.050066	0.14	0.15	0.12	0.09	0.28	0.18	0.09504	0.12	0.13	0.10
Oil & Grease	0.43	1.12	0.56	0.334592	0.99	0.16	0.99	0.16	0.99	0.73	0.42454	0.43	0.16	0.57
Phenols	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Bulk density	1.42	2.29	2.05	0.22526	1.92	2.13	1.88	1.54	2.15	2.02	0.3213	1.99	2.12	1.96
Porosity	12.5	30.6	21.9	7.12131	27.5	19.6	29.1	9.1	41.9	23.3	16.4491	24.9	20.0	26.0
THC	0.17	0.76	0.32	0.204273	0.51	0.13	0.73	0.04	0.55	0.43	0.26665	0.23	0.11	0.43
Percent Carbon	0.21	0.93	0.43	0.291527	0.81	0.15	0.81	0.12	0.9	0.57	0.39154	0.24	0.06	0.36
CEC	9.20	10.24	12.06	2.968301	13.04	13.31	17.21	6.98	16.5	12.11	4.76479	10.54	15.89	16.20
Particle Size Distribution:														
Sand	2	84	72.12	25.15762	81	86	78	3	87	75.21	45.4776	78	83	84
Silt	4	85	17.56	23.13626	8	6	11	2	76	14.13	39.6884	11	7	4
Clay	7	18	10.32	4.115532	11	8	11	3	21	10.33	9.0515	11	10	12
Heavy Metals:														
Cu	0.46	10.53	3.39	3.044775	1.90	0.75	1.03	0.56	8.83	3.36	4.20622	0.86	0.27	0.54
Fe	3658	33615	7866	5972.799	3149	4999	5563	2759	13303	8088	5272.1	3064	3988	4991
Ni	1.56	7.32	1.44	1.669898	1.26	0.55	0.63	0.18	5.48	3.525	2.74804	1.84	0.40	0.20
Zn	13.20	34.25	20.66	7.054775	18.88	17.80	15.35	10.84	35.83	20.82	12.5791	16.35	18.62	16.49
Pb	0.75	4.57	1.98	1.185974	3.25	0.89	0.73	0.8	4	2.04	1.61344	3.17	1.09	0.40
Mn	6.60	59.75	14.93	11.82064	14.28	10.10	7.11	5.3	33.65	15.24	14.3843	12.38	9.46	8.56
Cd	0.12	1.32	0.56	0.392458	0.32	0.25	0.26	0.18	1.33	0.58	0.58381	0.47	0.31	0.19

Cr	0.54	3.39	1.73	0.971006	1.00	1.97	0.99	0.78	4.2	1.83	1.75194	1.45	0.54	0.68
Ba	0.34	2.65	1.28	0.690994	1.00	0.78	0.86	1.25	2.5	1.3	0.7077	1.20	0.63	0.92
V	<0.001	0.20	0.11	0.031241	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Hg	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Cations:														
Na	0.53	2.98	1.26	0.690754	0.54	1.21	1.89	0.58	2.74	1.36	1.0938	0.68	1.13	0.79
K	0.10	1.20	0.62	0.481811	0.18	0.46	0.34	0.11	1.31	0.6	0.60335	1.13	1.57	1.28
Ca	1.22	5.86	3.48	1.236175	4.24	3.44	5.77	1.68	4.98	3.33	1.65	2.54	4.87	3.86
Mg	1.38	3.21	1.63	0.742356	1.08	1.20	2.21	0.19	3.25	1.58	1.53213	1.19	1.32	2.27
Organics:														
TPH	0.148	0.736	0.246	0.158234	0.475	0.125	0.432	0.027	0.388	0.358	0.20033	0.180	0.097	0.328
PAH	0.000	0.130	0.07	0.040825	0.090	BDL	BDL	0	0.08	0.086	0.04801	BDL	BDL	BDL
Benzene	0.000	0.000	0	0	BDL	BDL	BDL	BDL	BDL	BDL	0	BDL	BDL	BDL
Microbiological Test:														
THB x 10^4	10.1	9.7	9.4	0.351188	4.8	4.9	7.6	2.4	7.3	4.85	2.45	2.6	2.8	4.7
THF x 10^3	3.2	7.6	5.4	2.2	4.0	4.0	4.0	2.2	5.6	3.9	1.7	6.8	5.6	2.2
HUB x 10^2	0.2	2	1.1	0.9	2.2	0.2	1.7	0	1.8	0.9	0.9	0.5	1.3	0.7
HUF x 10^2	0	1.1	0.55	0.55	1.4	Nil	0.9	0	1.2	0.6	0.6	0.2	0.4	0.3

Source POL Fieldwork 2020

4.3.5 Surface Water Quality

Surface and ground water within the project area were sampled and analysed for both conservative and non-conservative determinants. Surface water was sampled at four (4) sampling stations (covering up & down stream and along the Ase River). The samples were analyzed using standard recommended methods of water analysis for physico-chemical and microbiological parameters. The obtained characteristics are as summarized in Table 4.8.

4.3.5.1Surface Water Physico-Chemical Properties

The physico-chemical properties of the water investigated in the study area are presented in this section.

Temperature

Water bodies undergo temperature variations along with normal climatic fluctuations. These variations occur seasonally and in some water bodies over a period of 24 hours. Temperature affects physical, chemical, and biological processes in water bodies, and therefore the concentration of many variables. Increased temperature also decreases the solubility of gases. The metabolic rate of aquatic organisms is also related to temperature and in warm waters respiration rate increases leading to increased oxygen consumption and increased decomposition of organic matter. Growth rates also increase (this is most noticeable in bacteria and phytoplankton. The water temperatures fluctuated seasonally with lowest values occurring in the dry season and as depicted in the adopted wet season data, the highest values were recorded in the dry season. The mean wet season surface water temperature was 31.3°C, with a range of 30.8 and 31.8°C while it has a constant value of 24.6°C during dry season.

pH

The pH is an important variable in water quality assessment as it influences many biological and chemical processes within the rivers. The pH is the measure of acid balance of a solution and is defined as the negative of the logarithm to the base 10 of hydrogen ion concentration. The pH scale runs from 0 to 14 (i.e very acidic to very alkaline) with a pH of 7 representing a neutral condition. It is controlled by the dissolved chemical compounds and biochemical processes in the rivers. Daily variation in pH can be caused by photosynthesis and respiratory cycles of algae in eutrophic waters. High values can be obtained in eutrophic waters. The pH values determined across the study area during the wet season study ranged from 6.50slightly acidic to 7.14 slightly basic with a mean value of 6.82 while it ranged from 6.26 to 6.38 with a mean value of 6.32 during dry season.

Specific Conductivity

This is the ability of an aqueous solution to carry an electric current. The conductivity of a medium depends on the presence of ions, their total concentration, mobility, valence, relative concentration and the temperature of the system. The conductivity of an aqueous solution is also roughly proportional to the concentration of dissolved solids it contains. Thus conductivity is useful as an index of total dissolved solids in water. Specific conductivity values ranged from 19.20 to 50.20 micro Siemens per centimetre (µs/cm) (mean = 25.70) in the rainy season. The conductivity values were lower than the WHO limit of 900µs/cm, this reveals that the water body is low in ions.

Dissolved Oxygen (Mg/L)

The oxygen content of a water body is a fundamental measurement in water quality, providing information which can elucidate water mass movements, net primary productivity, atmosphere-water interactions and carbon remineralization process. The oxygen content of a water sample is largely determined by a balance between: (a) the exchange of atmospheric oxygen with the upper layer, (b) net increase due to photosynthetic processes and (c) net decrease due to respiratory demands and heterotrophic processes. Concentrations of oxygen below 5 mg/l may adversely affect the functioning and survival of biological communities and below 2 mg/l may lead to the death of most fish. Oxygen requirements for fish vary with species and age of the fish. The ranges between 3.0 mg/l and 6.0 mg/l is the critical range level for nearly all fishes. The mean value for dissolved oxygen was 4.45mg/L in the wet season and 4.43mg/L in the dry season of 2020. These values reveal that the oxygen requirement of the water body is within the favorable limit for fishes but could adversely affect the survival of other biological communities.

Total Dissolved Solids (Mg/L)

TDS values obtained for the wet season samples analyses showed a range of 14 to 39 mg/l and a mean value of 27mg/L across the sampled locations during wet season while the values ranged from 36.3 to 45.5 mg/l with a mean value of 40.9 mg/l during the dry season.

Turbidity (NTU)

Surface water turbidity values for the wet season ranged from 1.77 to 1.88 NTU, with a mean value of 1.83 and from 0.1 to 2.1NTU with a mean of 1.1NTU during dry season.

Salinity (%)

Salinity is a measure of the total amount of dissolved salts in a water body. The anions and cations that make up the salinity include chloride, sodium, sulfate, magnesium, calcium and potassium. Since these constituent ions are low in fresh water, the salinity of most fresh waters are 0. The salinity was zero in all the locations. The wet season samples results obtained for salinity from the fresh water system ranged from 0.01 to 0.03% across all the sampled stations while the values ranged from 0.04 to 0.06% during dry season.

***Organics* (mg/L)**

The wet season samples showed results indicating that Total Petroleum Hydrocarbon Content (Total Aliphatic Hydrocarbon Content ranged from 0.181 to 0.853mg/L while Polynuclear Aromatic Hydrocarbon, Total Hydrocarbon Contents (THC) and Oil and Grease were below the equipment detection limit (<0.001 mg/L). However, Oil and Grease ranged from 0.062 to 0.083 mg/L, Total Petroleum Hydrocarbon Content ranged from 0.045 to 0.0065mg/L while Polynuclear Aromatic Hydrocarbon Content ranged from 0.024 to 0.30 mg/L during dry season.

***Heavy Metals* (mg/L).**

The concentration of heavy metals analysed were relatively very low in both seasons' samples. They were all below detection limit and no appreciable difference was observed except for Iron, Manganese, Zinc and Copper which had maximum values of 3.27mg/L, 0.094mg/L, 0.140 mg/L and 0.054mg/L respectively for the wet season. Also, during 2020 dry season, values for Iron (Fe) ranged from 0.419 to 0.621mg/L, zinc (Zn) ranged from 0.410 to 0.444mg/L, Copper (Cu) ranged from 0.132 to 0.147 mg/l.

***Exchangeable Cations* (mg/L).**

The exchangeable bases (Ca2+, K+, Na+ and Mg2+) are present at varying levels in the dry season samples. Calcium ranged from 3.21 to 4.81mg/L, Magnesium ranged from 1.94 to 2.9mg/L, Potassium ranged from 1.148 to 1.358mg/L and Sodium ranged from 5.43 to 10.86mg/L. Also during wet season, Calcium ranged from 1.76 to 2.04mg/L, Magnesium ranged from 0.52 to 0.68mg/L, Potassium ranged from 0.28 to 0.70mg/L and Sodium ranged from 4.43 to 5.89mg/L

Surface water Microbiology

The microbial properties of surface water samples obtained from the study area are presented in Table 4.9b for the wet season and dry season 2020.

The resultshows during wet season that the statistical variation in the microbial population densities of Total Heterotrophic Bacteria (THB) in the samples count, varied from 4.7 x 10^3cfu/ml to 6.2 x 10^3cfu/ml, and Total Heterotrophic Fungi (THF) count ranged from3.6 to 4.4 x 10^2cfu/ml. While those of Hydrocarbon Utilising Bacteria species (HUB) count of 1.0 x 10^3cfu/ml to 2.1 x 10^3cfu/ml and Hydrocarbon Utilising Fungi (HUF) count of 0.30 x 10^3cfu/ml to 0.70 x 10^3cfu/m. Coliform bacteria were also present in the surface water, with a variation of 18 to 32 MPN/100ml. Also, during dry season, Total Heterotrophic Bacteria (THB) in the samples count, varied from 3.18 x 10^3cfu/ml to 4.11 x 10^3cfu/ml, and Total Heterotrophic Fungi (THF) count of 1.87 x 10^2cfu/ml to 2.15 x 10^2cfu/ml. While those of Hydrocarbon Utilising Bacteria species (HUB) count and Hydrocarbon Utilising Fungi (HUF) were not detected. Coliform bacteria were also present in the surface water, with a variation of 2 to 3.6 MPN/100ml.

Bacteria identified in surface water were *Staphylococcus spp, Pseudomonas spp., Streptococcus spp., Escherichia spp while* Fungi identified in surface water were *Penicillium spp., Aspergillus spp.and Mucor spp*

Table 4.8: Physico-Chemical and Microbiological Analysis Results of Surface Water Samples Collected from Ase River (Dry Season and Wet Season 2020)

Sample		Dry Season 2020					Wet Season 2020				
		Min	Max	Average	Stdev	Control	Min	Max	Average	Stdev	Control
Colour	Pt/Co	1	1	1	0	1	-	-	-	-	-
Alkalinity	mg/L	Nil	Nil	Nil	0	Nil					
Conductivity	µs/cm	72.6	91.1	81.85	9.25	69.8	36	102	69	31.51	96
pH		6.26	6.38	6.32	0.06	6.07	6.50	7.14	6.82	0.31	7.32
Temp.	^{0}C	24.6	24.6	24.6	4.35E-15	24.6	30.8	31.8	31.3	0.49	30.8
Total Hardness	mg/L	20	25	22.5	2.5	16	12.0	24.0	18.0	5.43	18.0
COD	mg/L	8	8	8	0	8	22.4	26.7	24.5	1.96	20.3
BOD	mg/L	1.83	2.21	2.02	0.19	2.1	8.7	9.6	9.2	0.44	8.4
DO	mg/L	4.22	4.63	4.425	0.205	4.56	4.20	4.70	4.45	0.22	5.50
Salinity	%	0.04	0.06	0.05	0	0.04	0.01	0.03	0.02	0.01	0.02
TSS	mg/L	0.06	1.1	0.58	0.52	1.24	0.63	1.06	0.85	0.19	0.75
TDS	mg/L	36.3	45.5	40.9	0	34.9	14	39	27	11.83	37
Turbidity	NTU	0.1	2.1	1.1	1	2.4	1.77	1.88	1.825	0.05	1.63
Redox Potential	mV	36.3	45.5	40.9	4.6	34.9	19	33	26	6.47	23
Phosphate	mg/L	0.164	0.175	0.1695	0.0055	0.176	0.01	0.07	0.04	0.03	0.01
Sulphate	mg/L	6.432	6.974	6.703	0.271	4.718	1.50	4.58	3.04	1.46	4.24
Nitrate	mg/L	1.364	1.832	1.598	0.234	1.869	0.46	0.68	0.57	0.1	0.56
Chloride	mg/L	8.37	16.73	12.55	4.18	6.27	5.00	15.49	10.25	4.94	9.49
Calcium	mg/L	3.21	4.81	4.01	0.8	3.21	1.76	2.04	1.90	0.13	1.31
Ammonium	mg/L	0.341	0.509	0.425	0.084	0.564	0.15	0.31	0.23	0.08	0.23
Potassium	mg/L	1.148	1.358	1.253	0.105	1.031	0.28	0.70	0.49	0.2	0.42
Sodium	mg/L	5.43	10.86	8.145	0	4.07	4.43	5.89	5.16	0.68	5.54
Carbonate	mg/L	Nil	Nil	Nil	0	Nil	0.00	0.00	0.00	0	0.00
Magnesium	mg/L	1.94	2.9	2.42	0.48	1.94	0.52	0.68	0.60	0.07	0.37
Iron	mg/L	0.419	0.621	0.52	0.101	0.522	1.545	3.267	2.406	0.82	1.862
Zinc	mg/L	0.41	0.478	0.444	0.034	0.422	0.060	0.140	0.100	0.04	0.089

Manganese	**mg/L**	0.214	0.233	0.2235	0.0095	0.217	0.058	0.094	0.076	0.02	0.035
Copper	**mg/L**	0.132	0.147	0.1395	0	0.133	0.032	0.054	0.043	0.01	0.028
Chromium	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	0.004	0.010	0.007	0	<0.001
Lead	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	0.008	0.016	0.012	0	0.006
Cadmium	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
Mercury	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
Vanadium	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
Nickel	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
Barium	**mg/L**	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
PAHs	**mg/L**	0.024	0.036	0.03	0.006	0.015	BDL	BDL	BDL	0	BDL
TPH	**mg/L**	0.045	0.065	0.055	0.01	0.037	0.181	0.853	0.517	0.3	0.035
Oil & Grease	**mg/L**	0.062	0.104	0.083	0.021	0.05	BDL	BDL	BDL	0	BDL
THC	**mg/L**	0.053	0.095	0.074	0.021	0.044	BDL	BDL	BDL	0	BDL
THB	**cfu/ml (x10^3)**	3.18	4.11	3.645	0.465	3.11	4.7	6.2	5.5	1.06	5.8
THF	**sfu/ml (x10^2)**	1.87	2.15	2.01	0.14	134	3.6	4.4	4.0	0.57	5.0
HUB	**cfu/ml (x10^1)**	ND	ND	ND	0	ND	1.0	2.1	15.5	0.78	0.7
HUF	**sfu/ml (x10^1)**	ND	ND	ND	0	ND	0.3	0.7	0.5	0.28	Nil
Feacal coliform	**MPN/100ML**	2	3.6	2.8	0.8	2	18	32	25	7	24

Source: POL Fieldwork 2020

4.3.6 Sediment Studies

The summary (in mean and range) of the physiochemical characteristics of the sediments in the study area is presented in Table 4.9. The sediments are slightly acidic to almost neutral and the Total Hydrocarbon level of the sediments was low. The heavy metals have a relatively high and wide range of concentrations.

The summary (in mean and range) of the physiochemical characteristics of the sediments in the study area is presented in table 4.9.

pH: The sediments in the entire area were mainly acidic with pH ranging from 5.7 slightly acidic to 6.19 also slightly basic in the dry season and 4.52 to 4.65 in the wet season indicating slightly acidic also.

Total Organic Carbon (TOC %): The sediments exhibited wide variability in terms of total organic carbon content. TOC ranged from 1.06% to 1.23%, with a mean value of 1.145% in the dry season and ranged from 1.76 to 2.03% with a mean level of 1.9% in the wet season. The production, accumulation and degradation of organic matter are greatly dependent on climate. Temperature, sediment moisture and topography are the major factors affecting the accumulation of organic matter in sediments.

Organic matter tends to accumulate under wet or cold conditions where decomposer activity is impeded by low temperature (Buol, 1990) or excess moisture which results in anaerobic conditions (Trofimov et al 2008). Conversely, excessive rain and high temperatures of tropical climates as in the present assessment enables rapid decomposition of organic matter and leaching of plant nutrients. Excessive slope may encourage the erosion of the top layer of sediment which holds most of the raw organic material that would otherwise eventually become humus.

Nitrate: The trend exhibited by the total organic carbon content was also manifested by the total organic matter content. Nitrate content varied between 14.01 to 14.85% with a mean value of 14.43% in the dry season. In the wet season, nitrate range from 0.091 to 0.107% with a mean value of 0.099%. In the present study, the reasons given for the trend observed in the total organic carbon content in the sediments is also applicable to the nitrate content in the sediments.

Anions: Sulphate, Chloride: The mean levels of these anions (dry season) were as follows; Sulphate (129.8 mg/kg) and Chloride (33.47 mg/kg) respectively. In the wet season, the values were: sulphate (1.9 mg/kg) and chloride (21.28mg/kg).

Electrical Conductivity (E.C): The E.C. of the sediments varied between 87.6 to 139 µS/cm with a mean value of 113.3 µS/cm (dry season) and range from 60 to 96 µS/cm in the wet season with a mean value of 78µS/cm.

Organics (mg/kg)

The dry season samples showed results indicating that Total Petroleum Hydrocarbon Content were below the equipment detection limit (<0.001 mg/kg), Polynuclear Aromatic Hydrocarbon ranged from 0.14 to 0.18mg/kg, Total Hydrocarbon Content (THC) ranged from 1.305 to 1.39mg/kgwhile Oil and Grease ranged from 1.324 to 1.435mg/kg. On the other hand during wet season, Total Petroleum Hydrocarbon Content ranged from 0.616 to 0.743mg/kg, Polynuclear Aromatic Hydrocarbon ranged from 0.14 to 0.210mg/kg, Total Hydrocarbon Content (THC) ranged from 0.73 to 0.86mg/kg while Oil and Grease ranged from 1.26 to 1.54mg/kg

Heavy metals: The mean concentration of the heavy metals in the dry season and related sediment micronutrient elements were as follows; Iron (2.136 mg/kg), Zinc (0.4775mg/kg), Chromium (<0.001 mg/kg), Lead (<0.001 mg/kg), Copper (0.124mg/kg), Cadmium(<0.001 mg/kg), Nickel(<0.001 mg/kg), Barium (<0.001 mg/kg). However, in the wet season, the mean values were iron (1.66 mg/kg), zinc (17.62 mg/kg), chromium (0.68 mg/kg), Lead (<0.001mg/kg), Copper (2.83 mg/kg), Cadmium (0.08 mg/kg). These values are consistent with levels of these metals as found in non-contaminated or none anthropogenically impacted sediments, except for lead in the wet season.The concentration of heavy metals analysed were relatively very low in both seasons' samples.

The result shows during dry season that the statistical variation in the microbial population densities of Total Heterotrophic Bacteria (THB) in the samples count, varied from 4.3 x 10^3cfu/g to 5 x 10^3cfu/g, and Total Heterotrophic Fungi (THF) count ranged from 2 to 4.3 x 10^2cfu/g. While those of Hydrocarbon Utilising Bacteria species (HUB) count and Hydrocarbon Utilising Fungi (HUF) were not detected. Coliform bacteria were also present in the sediment, with a variation of 8 to 12 MPN/100g. Also, during wet season, Total Heterotrophic Bacteria (THB) in the samples count, varied from 6.7 x 10^3cfu/g to 9.2 x 10^3cfu/g, and Total Heterotrophic Fungi (THF) count of 4.7 x 10^2cfu/g to 5.8 x 10^2cfu/g. While those of Hydrocarbon Utilising Bacteria species (HUB) count ranged from 1.3 to 2.1 x 10^1cfu/g and Hydrocarbon Utilising Fungi (HUF) ranged from 1.0 to 1.3 x 10^1cfu/g. Coliform bacteria were not present in the sediment water during this season

Bacteria identified in the sediments are *Staphylococcus spp., Bacillus spp, Pseudomonas spp.*whileFungi identified in surface water are *Penicillium spp., Aspergillus spp. Mucor spp and Fusarium spp.*

Table 4.9: Physico-Chemical and Microbiological Analysis Results of Sediments (Dry Season and Wet Season 2020)

Sample ID			Min	Max	Average	Stdev	Control	Min	Max	Average	Stdev	Control
Conductivity	µs/cm		87.6	139	113.3	25.7	131	60	96	78	18	78
pH			5.7	6.19	5.945	0.245	5.52	4.52	4.65	4.59	0.065	4.51
Redox Potential	mV		113.5	125	119.25	5.75	151.5	138	142	140	2	140
TOC	%		1.06	1.23	1.145	0.085	1.76	1.76	2.03	1.9	0.135	1.71
Salinity	psu		0.06	0.09	0.075	0.015	0.09					
Particle Size	Sand	%	87	90	88.5	90	1.5	43	66	55	11.5	47
	Clay	%	7	8	7.5	7	0.5	8	19	14	5.5	14
	Silt	%	3	5	4	3	1	26	38	32	6	39
Phosphate	mg/Kg		1.042	1.209	1.1255	0.0835	1.078					
Sulphate	mg/Kg		120	139.6	129.8	9.8	97.22	1.76	2.03	1.9	0.135	1.71
Nitrate	mg/Kg		14.01	14.85	14.43	0.42	14.2	0.091	0.107	0.099	0.008	0.089
Chloride	mg/Kg		33.47	50.2	41.835	8.365	50.2	17.73	24.82	21.28	3.545	21.27
Ammonium	mg/Kg		14.64	15.49	15.065	0.425	15.85	0.37	0.43	0.4	0.0315	0.35
Calcium	mg/Kg		16.03	40.08	28.055	12.025	32.06	2.69	4.04	3.37	0.6735	4.85
Potassium	mg/Kg		3.777	5.451	4.614	0.837	5.147	0.88	1.56	1.22	0.34	1.47
Sodium	mg/Kg		32.57	43.42	37.995	5.425	32.57	1.90	2.17	2.04	0.132	2.00
Carbonate	mg/Kg		89.47	90	89.735	0.265	88.74					
Magnesium	mg/Kg		9.68	24.2	16.94	7.26	19.36	3.01	4.56	3.79	0.7755	2.27
Iron	mg/Kg		2.125	2.147	2.136	0.011	2.201	0.67	2.64	1.66	0.985	2.44
Zinc	mg/Kg		0.413	0.542	0.4775	0.0645	0.461	12.60	22.64	17.62	5.0175	25.63
Copper	mg/Kg		0.107	0.141	0.124	0.017	0.112	1.65	4.00	2.83	1.175	2.50
Chromium	mg/Kg		<0.001	<0.001	<0.001	0	<0.001	0.51	0.85	0.68	0.17	0.42
Lead	mg/Kg		<0.001	<0.001	<0.001	0	<0.001	0.87	1.24	1.06	0.185	0.76
Cadmium	mg/Kg		<0.001	<0.001	<0.001	0	<0.001	<0.001	0.15	0.08	0.0745	<0.001
Mercury	mg/Kg		<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
Vanadium	mg/Kg		<0.001	<0.001	<0.001	0	<0.001	<0.001	0.12	0.061	0.0595	<0.001
Nickel	mg/Kg		<0.001	<0.001	<0.001	0	<0.001	0.67	2.64	1.66	0.985	2.44

Barium	**mg/Kg**	<0.001	<0.001	<0.001	0	<0.001	0.21	0.47	0.34	0.13	0.28
PAHs	**mg/Kg**	0.14	0.18	0.16	0.02	0.132	0.140	0.210	0.175	0.035	0.080
TPH	**mg/Kg**	<0.001	<0.001	<0.001	0	<0.001	0.616	0.743	0.68	0.0635	0.518
Oil & Grease	**mg/Kg**	1.324	1.435	1.3795	0.0555	1.284	1.26	1.54	1.4	0.14	1.26
THC	**mg/Kg**	1.305	1.39	1.3475	0.0425	1.245	0.73	0.86	0.8	0.065	0.70
Phenols	**mg/Kg**	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001	<0.001	0	<0.001
THB	**cfu/g ($x10^3$)**	4.3	5	4.65	0.35	8.05	6.7	9.2	7.95	1.25	5.3
THF	**sfu/g($x10^2$)**	2	4.3	3.15	1.15	1.05	4.7	5.8	5.25	0.55	3.6
HUB	**cfu/g ($x10^1$)**	ND	ND	ND	0	ND	1.3	2.1	1.7	0.4	1.5
HUF	**sfu/g($x10^1$)**	ND	ND	ND	0	ND	1.0	1.3	1.15	0.15	1.4
Feacal coliform	**MPN/100ML**	8.2	12	10.1	1.9	9.1	ND	ND	ND	ND	ND
SRB	**cfu/g ($x10^1$)**	ND	ND	ND	0	ND	ND	ND	ND	ND	ND

Source:POL Fieldwork 2020

4.3.7 Aquatic Studies (Hydrobiology)

Aquatic environments are affected in different ways by human activities. Organisms living in the aquatic environment are sensitive to these changes and usually respond with peculiarity synonymous with each taxa. In situ organisms show integrated effects of all impacts on the water body. This can be used to compare relative changes in water quality between locations and over a period of time and it can be used to determine water quality and ability to support aquatic life (GESAMP 1980; Friedrich et al., 1992; GESAMP 1995). Aquatic organisms were therefore investigated (Plate 4.5) during this study to determine the quality of the surface water especially its ability to support life.

Plate 4.5: Collection of plankton samples in one of the study stations.

Phytoplankton and Zooplankton Investigation

Fixed plankton samples were allowed to settle in the laboratory for at least 48 hours and the supernatant decanted until a concentration of 40ml was obtained. Each sample was thoroughly mixed and investigated using the drop count method as described by Onyema (2007). Two drops (0.2ml) from each sample five different times were placed on a glass slide with the aid of a dropper and cover slip placed over the mouth. This was then thoroughly investigated at transacts with each transact at right angle with the first. Phytoplankton and Zooplankton species were examined, drawn, identified and counted using a Carl Zeiss (CE WF 10×18mm) binocular microscope with a calibrated eyepiece at different magnifications (×50, ×100, ×400).

Outcomes were then recorded. The number of each taxon occurring in each field and the total number of taxa per group were recorded as number of species. Appropriate texts were used to aid identification of the species. (Phytoplankton- Patrick and Reimer, 1966, 1975; Whitford and Schmacher, 1973; Vanlandingham, 1982; Nwankwo, 1990, 1995, 2004; Bettrons and Castrejon, 1999; Lange-Bertalot, 2001; Witkowski *et al.,* 2000; Siver, 2003; Rosowski, 2003; Zooplankton - Olaniyan, 1975; Barnes *et al*., 1993 and Waife and Frid, 2001). For phytoplankton and zooplankton community's, eco-mathematical indices (biological indices) were used. Apart from the Total number of species (S), abundance of species (N), Log of Species diversity (Log S) and Log of species abundance (Log N) others used were Shannon-Wiener Index (Hs), Menhinick Index (D), Margalef Index (d), Equitability (j) and Simpson's Dominance Index (C) (Ogbeibu, 2005).

Community Structure Analysis

Biodiversity or Biological Diversity is the sum of all the different species of animals, plants, fungi, and microbial organisms living on Earth and the variety of habitats in which they live. Biodiversity is also the variation of life forms within a given ecosystem, biome or for the entire Earth. Consequently, biodiversity is often used as a measure of the health of systems. A diversity index is a mathematical measure of species diversity in a community. Diversity indices provide important information about rarity and commonness of species in a community. The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure.

The following diversity indices were used for biological data analysis. Furthermore, results on these indices are presented in two (2) decimal places. For phytoplankton and zooplankton community's, eco-mathematical indices (biological indices) were used. Apart from the Total number of species (S), abundance of species (N), Log of Species diversity (Log S) and Log of species abundance (Log N) others used were Shannon-Wiener Index (Hs), Menhinick Index (D), Margalef Index (d), Equitability (j) and Simpson's Dominance Index (C) (Ogbeibu, 2005).

Species Richness Index (d)

The Species richness index (d) according to Margalef (1951) is a measure of diversity and was used to evaluate the community structure. Species Richness is a measure of the number of different kinds of organisms present in a particular area. This index is also referred to as Margalef index. The equation below was applied.

$$d = \frac{S - 1}{\text{In}\, N}$$

Where:

d = Species richness index

S = Number of species in a population

N = Total number of individuals in S species.

***Menhinick's Index (D)*.**

The Menhinick's Index (D)is one of several diversity indices used to quantify diversity and hence measure diversity in categorical data. It represents a biological association with a number which give a measure of its community structure. The equation below was applied.

$$d = \frac{S - 1}{\ln N}$$

S = Number of species in a population

N = Total number of individuals in S species.

***Shannon and Weiner diversity index (Hs)*.**

The Shannon and Weiner diversity index (Hs)is one of several diversity indices used to measure diversity in categorical data. It is simply the Information entropy of the distribution, treating species as symbols and their relative population sizes as the probability. Shannon and Wiener (1963) diversity index is also called Shannon index. The equation below was applied.

$$Hs = \frac{N \log N - (\sum Pi \log Pi)}{N}$$

- *Where Hs = Shannon and Wiener diversity Index*

  i = Counts denoting the ith species ranging from 1 – n

  a. Pi **=** Proportion that the ith species represents in terms of numbers of individuals with respect to the total number of individuals in the sampling space as whole.

Species Equitability or Evenness index (j).

The Species Equitability or Evenness index (j)is one of several diversity indices used to measure diversity in categorical data. Evenness is a measure of the relative abundance of the different species making up the richness of an area. The equation below was applied.

$$j = \frac{Hs}{\log_2 S}$$

Where

j = Equitability index

Hs = Shannon and Weiner index

S = Number of species in a population

***Simpson's dominance index (C)**.*

Simpson's Diversity Index is a measure of diversity. In ecology, it is often used to quantify the biodiversity of a habitat. It takes into account the number of species present, as well as the abundance of each species. Simpson's diversity index (D) is a simple mathematical measure that characterizes species diversity in a community. The proportion of species *i* relative to the total number of species (p_i) is calculated and squared. The squared proportions for all the species are summed, and the reciprocal is taken. The equation below was applied.

$$C = \sum \left(\frac{n_i}{N}\right)^2$$

Where n = the **total number of organisms of a particular species**

N = **the total number of organisms of all species**

Phytoplankton Spectrum

The phytoplankton recorded 4 (four) group of species. They were the Diatoms (Division – Bacillariophyta), Blue-green algae (Division – Cyanophyta), Green algae (Division – Chlorophyta) and Euglenoids (Division – Euglenophyta). The dominant group of phytoplankton was the Diatoms. In terms of species diversity, whereas the Diatoms, recorded 48% (15 taxa), the Blue-green algae 34% (11 taxa), Green algae reported 13% (4 taxa) and Euglenoids 6% (2 taxa) (Figure 4.10).

The diversity, biological indices and distribution of phytoplankton per ml per station is shown in Table 4.10. In all a total of thirty - two (32) species were recorded at the stations studied. Total number of species recorded per station ranged between 18 and 22. Figure 4.11 shows a graphical relationship between Total Number of Species (S) and Total Abundance of the species (N). Graphical representations of the ecological indices are show in Figure 4.12.

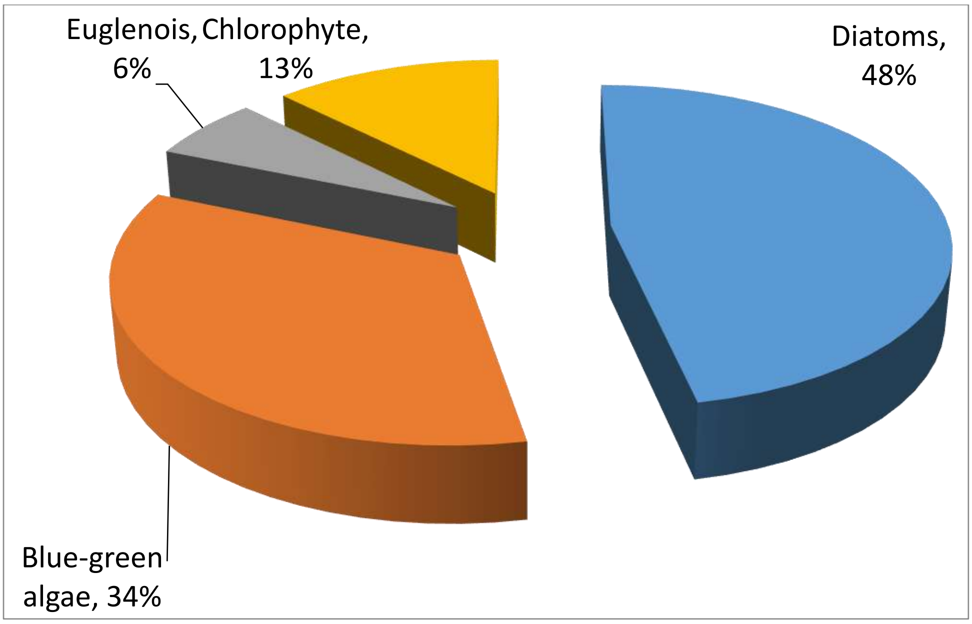


Figure 4.10: Percentage occurrence of major phytoplankton groups

The key species occurring for the study were *Aulacoseiragranulata ,Aulacoseiragranulata*var. *angstissima Oscillatoria borneti*, *Synedra ulna* and*Synedra ulna* var. *biceps* in terms of occurrence and abundance. These species is known to indicate prevalent fresh water and moderate to high nutrient conditions.

Table 4.10: Composition and abundance distribution of phytoplankton per ml.

	POL/SW/01	POL/SW/0	POL/SW/0	POL/SW/CL
DIVISION – BACILLARIOPHYTA				
CLASS-BACILLARIOPHYCEAE				
ORDER I – CENTRALES				
Aulacoseir agranulata Ehrenberg (Ralfs)	15	10	15	20
*Aulacoseir agranulata*var. *angstissima* Muller	20	15	25	10
Cyclotella menighiniana Kutzing	-	-	5	10
Cyclotella sp.	-	15	-	-
Order II – PENNALES				
Amphora ovalis Kutzing	5	-	-	-
Fragillariaconstruens Ehrenberg	15	5	10	25
*Fragillaria*sp.	10	10	5	15
Naviculacryptocephala (Kutz) Hustedt	-	10	-	-

Navicula mutica Kutzing	-	-	5	-
*Navicula*sp. I	10	-	15	10
*Nitzschia*sp.		10	-	
Pinnularia major (Kutzing) Rabenh	5	-	-	10
Pinnularia gibba Ehrenberg	-	10	-	-
Synedra ulna (Nitzsch) Ehrenberg	20	15	35	30
Synedra ulna var. *biceps* Ehrenberg	20	15	15	20
DIVISION – CYANOPHYTA				
CLASS – CYANOPHYCEAE				
Order – HORMOGONALES				
Anabaena constricta Geitler	5	20	-	15
Lynbgyamartensiana Meneghini	10	-	20	40
Oscillatoria borneti Zukal	15	5	15	45
Oscillatoria chalybea Gomont	-	-	25	10
Oscillatoria curviceps C.A. Agardh	15	25	5	5
Oscillatoria Formosa Bory	10	15	-	-
Oscillatoria limnosa Agardh	10	-	5	5
Oscillatoria tenius Agardh	-	10	10	5
Oscillatoria trichodes Szafer	-	-	5	10
Oscillatoria sancta Sancta	5	15	-	10
Oscillatoria sp.	-	10	10	10
DIVISION – EUGLENOPOHYTA				
CLASS – EUGLENOPHYCEAE				
ORDER – EUGLENALES				
Euglena acus Ehrenberg	5	-	10	5
Euglena sp.	-	5	5	-
DIVISION – CHLOROPHYTA				
CLASS – CHLOROPHYCEAE				
ORDER I – ULOTHRICALES				
Spirogyra africana Fritsch Cruda	-	5	-	10
Spirogyra sp.	-	-	5	5
ORDER II - ZYGNEMATALES				
Closterium ehrenbergii Meneghini	5	-	-	-
Closterium sp.	-	-	5	-
Total species diversity (S)	**18**	**19**	**21**	**22**

Total abundance (N)	200	225	250	325
Log of Species diversity (Log S)	1.26	1.28	1.32	1.34
Log of abundance (Log N)	2.30	2.35	2.40	2.51
Shannon-Wiener Index (Hs)	1.20	1.24	1.23	1.24
Menhinick Index (D)	1.27	1.27	1.33	1.22
Margalef Index (d)	3.21	3.32	3.62	3.63
Equitability Index (j)	0.96	0.97	0.93	0.93
Simpson's Dominance Index (C)	0.07	0.06	0.07	0.07

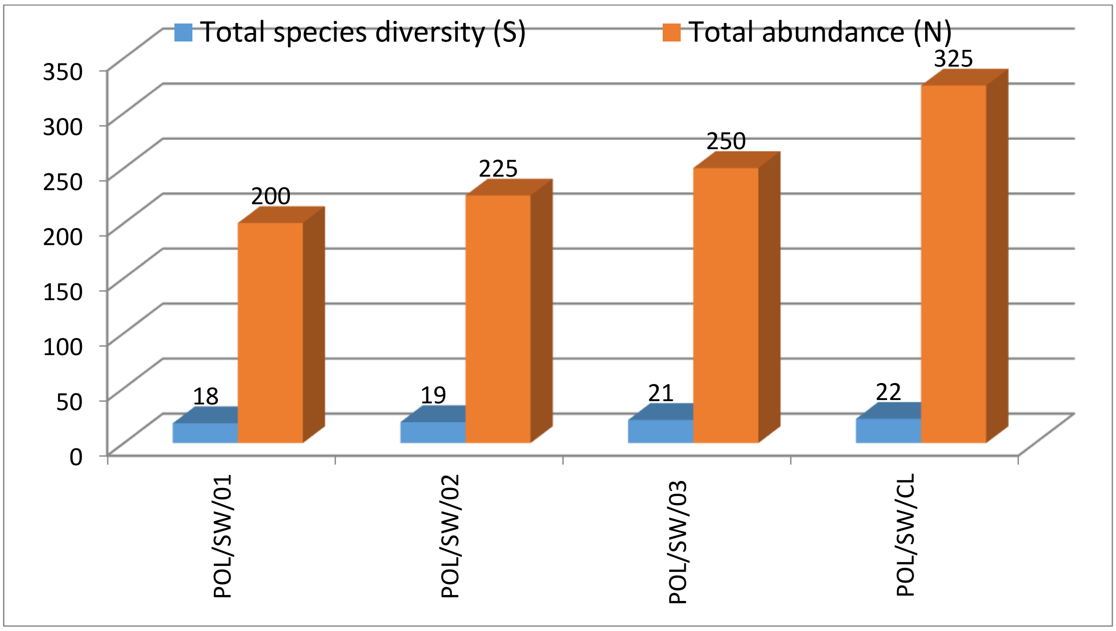


Figure 4.11: Phytoplankton Total number of species (S) and abundance (N).

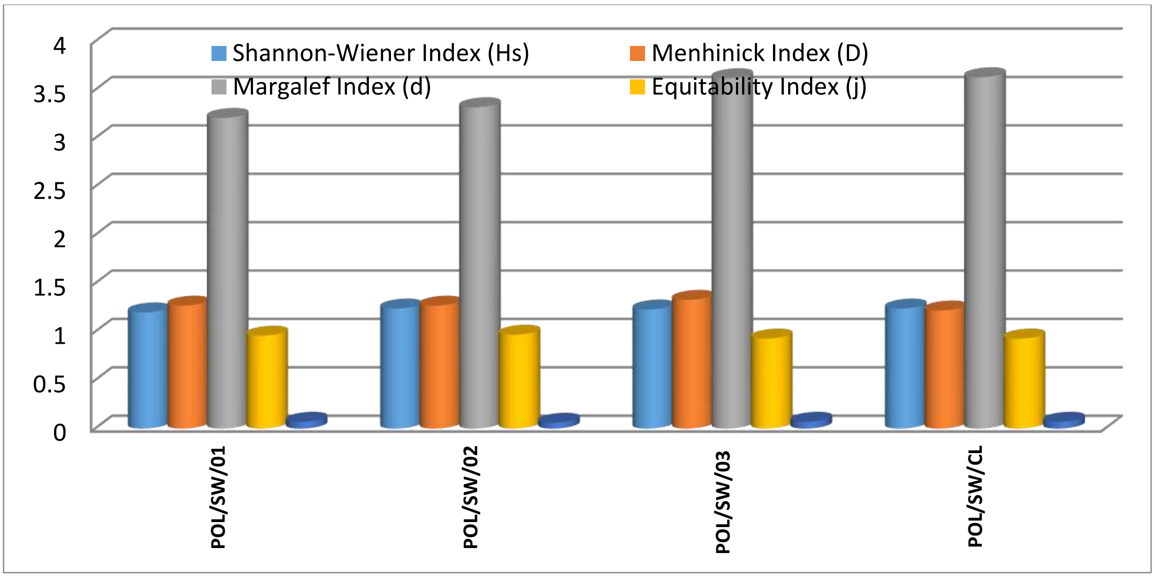


Figure 4.12: Phytoplankton ecological indices

Zooplankton Spectrum.

The zooplankton recorded 4 (two) group of species for the adult zooplankton (Holoplankton). The meroplankton or juvenile stages were also recorded. The adult zooplankton were the Phylum – Arthropoda., Phylum–Rotifers and Juvenile stages. Cladocerans were also recorded. The dominant group of zooplankton were the Arthropods, followed by Juvenile stages and then the Rotifers. Whereas the Arthropod recorded 50% (4 taxa), Juvenile stages reported 25%, whereas the Rotifers estimated 12.5% (2 taxa). (Figure 4.13). The juvenile stages were represented by four forms namely: Copepods eggs and Nauplii larva of copepods.

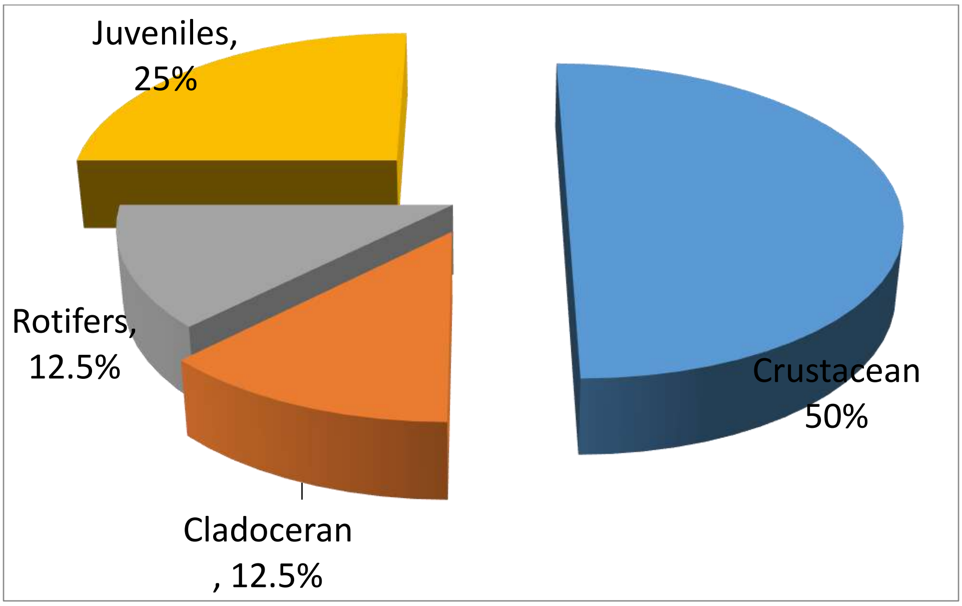


Figure 4.13: Percentage Occurrence of Zooplankton Phyla and Juvenile Stages

The diversity and distribution of zooplankton per ml per station is shown in Table 4.11. In all a total of six (6) species and two (2) juvenile forms were recorded at the 4 stations studied. Figure 4.12 shows a graphical relationship between Total Number of Species (S) and Total Abundance of the species (N). Graphical representations of the ecological indices are show in Figure 4.13.

Lecane bulla Gosse, (Rotifers), *Cyclops strenus* and Nauplii larva of Copepods (Juvenile stages) were the key species / forms occurring in terms of occurrence and abundance.

Table 4.11: Composition and abundance distribution of zooplankton per ml.

PHYLUM: ARTHROPODA	POL/SW/01	POL/SW/0	POL/SW/0	POL/SW/CL
CLASS: CRUSTACEA				
ORDER: COPEPODA				
SUB-ORDER: CYCLOPOIDA				
Cyclops strenus Fisher	30	10	-	10
Cyclops sp. I	5	-	-	10
Cyclops sp. II	-	-	15	-
Microcyclops sp.	-	5	-	-
ORDER: CLADOCERA				
SUB-ORDER: EUCLADOCERA				
Diaphnia sp.	-	10	-	10
PHYLUM: ROTIFERS				
CLASS: MONOGONOTA				
ORDER: PLOIMA				
Lecane bulla Gosse	10	10	5	-
JUVENILE STAGES				
Copepod eggs	15	-	-	10
Nauplii larva of Copepods	-	15	10	15
Total species diversity (S)	**4**	**5**	**3**	**5**
Total abundance (N)	**60**	**50**	**30**	**55**
Log of Species diversity (Log S)	0.60	0.70	0.48	0.70
Log of abundance (Log N)	1.78	1.70	1.48	1.74
Shannon-Wiener Index (Hs)	0.52	0.68	0.44	0.69
Menhinick Index (D)	0.52	0.71	0.55	0.67
Margalef Index (d)	0.73	1.02	0.59	1.00
Equitability Index (j)	0.86	0.97	0.92	0.99
Simpson's Dominance Index (C)	0.35	0.22	0.39	0.21

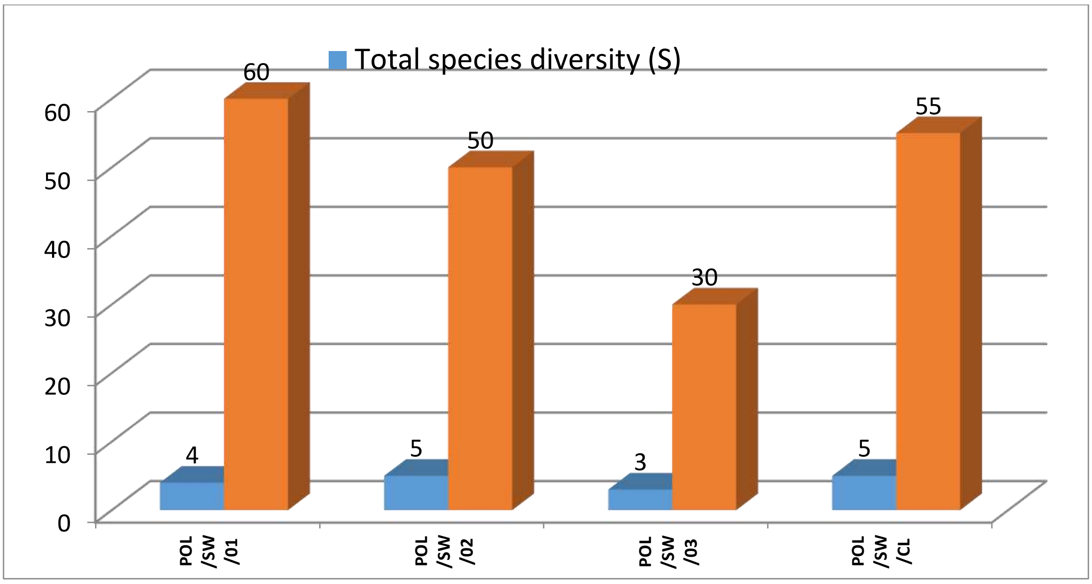


Figure 4.14: Zooplankton Total number of species (S) and abundance (N).

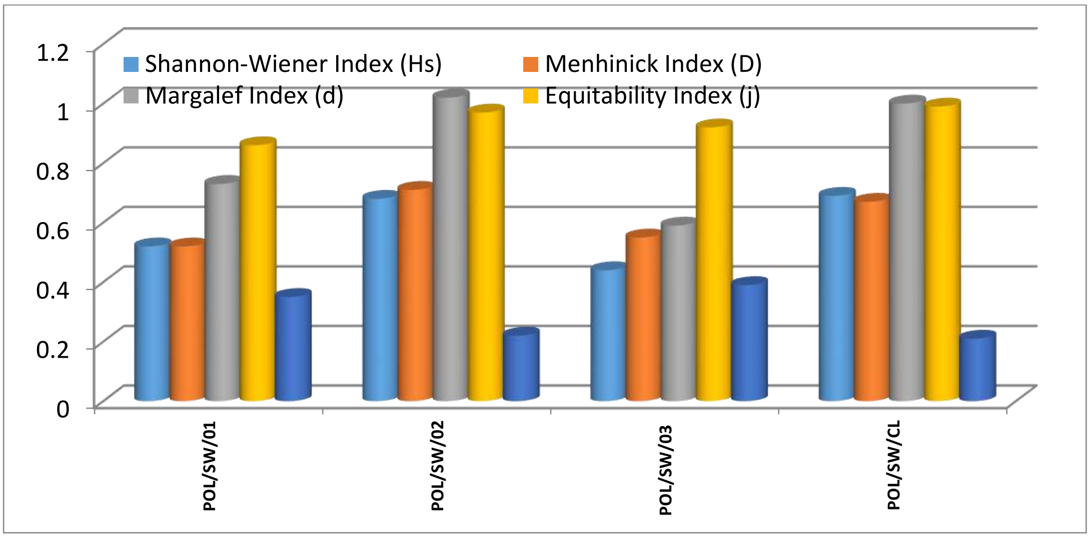


Figure 4.15: Zooplankton ecological indices

Fishery studies

The term "fish" comprises all sea foods including crustaceans with chitinous exoskeleton such as lobster, crab, shrimps. Molluscs such as mussels, cockles, clams and oysters, Adams and Moss (1995). Fish have been defined generally as vertebrates that use gills to obtain oxygen from water and have fins with variable number of skeletal elements called fin rays (Zapala*et al*., 1996).

Fisheries Activities

Fish catch in this area, according to response from the fishermen are on the average, though gradually declining, when compared to the past years. Fishing activity was very low in the project area. Only few fishermen were seen in fishing canoes checking their overnight fish traps and nets for catch. Women fish mainly using basket traps but sometimes they use long lines, set gill nets and lift nets. The fishermen operate different types of gears such as cast nets, gill nets, beach seines, filter nets, long lines and encircling nets in near and distant waters.

Only few members of the communities are involved in aquacultural practices, using monoculture fish ponds constructed near homes, for the rearing of catfishes.

The checklist of fish species in the study area

Table 4.12 shows the checklist of commercially important fish species recorded during the field study, based on data from direct sampling and secondary information from fisherfolk. The list shows that 38 species in 18 families of fish were recovered from the study area. The families Characidae, Bagridae and Cyprinidae appeared extensively in the catches. The bagrid species included *Chrysichthys nigrodigitatus,* and *Clarotes macrocephalus*. The details of species composition and the relative abundance in the study area are given the Checklist Table: 4.12.

Table 4.12: Checklist of fish species in the study area. (+ Low Abundance, ++ Moderate Abundance, +++ High Abundance)

Family	Scientific Name	Common Name	Relative Abundance
Bagridae	*Chrysichthys nigrodigitatus*	Silver cat fish	++
	Clarotes macrocephalus	,, ,,	+
Channidae	*Channa obscura*	Snakehead	+
Characidae	*Alestes macrolepidotus*		+
	A. longipinis		+++
	A. nurse		+
Cichlidae	*Hemichromis fasciatus*	Cichlid fish, tilapia	++
	Pelmatochromis taeniatus		+
	Sarotherodon niloticus		+
	Tilapia macrocephala		+
	T. melanopleura		+
	T. zillii		++
Citharinidae	*Citharinus citharus*	Moonfish	++
	Citharinus distichodoides		+
	Citharinus latus	Moonfish	++
	Distichodus engycephalus	Grass-eaters, fin-nippers	++

Family	Scientific Name	Common Name	Relative Abundance
Clariidae	*Clarias anguillaris*	Mudfish, clariid catfish	+++
	C. gariepinus	,,	+++
Cyprinidae	*Epiplatys sexfasciatus*	African carp	+
	Labeo capensis		++
Gymnarchidae	*Gymnarchus niloticus*		++
Hepsetidae	*Hepsetus odoe*	African pike	+
Malapteruridae	*Malapterurus electricus*	Electric cat fish	++
Mochokidae	*Parauchenoglanis* sp.		+
	Synodontis omias	Catfish	+
	Synodontis clarias		+++
	Synodontis nigrita	,,	+++
Mormyridae	*Gnathonemus abadi*		
	Hyperopisus bebe accidentalis		+
	Gnathonemus cyprinoids	Elephant – Snout fish	
Notopteridae	*Papyrocranus afer*	Featherback	+
	Xenomystus nigri	Knife-fish	+
Osteoglossidae	*Heterotis niloticus*	Bony -tongues	++
Polynemidae	*Polynemus quadrifillis*	Shiny-nose	
Polypteridae	*Erpectoichthys calabaricus*	*Bichirs*	+
	Eutropius niloticus	*Butter Catfish, Glass Catfish*	++
Schilbedae	*Schilbe mystus*	Glass catfish	++
Tetraodontidae	*Tetraodon fashaka*	Puffer fish	+

The commonest species caught during the study were *Clarias gariepinnis, Alestes macrolepidotus, Synodontis clarias, S. nigrita, Gnathonemus abadi, Schilbe mystus* and *Labeo capensis* (Plates 4.6 – 4.10). Other abundant species reported by the interviewed fishermen include *Heterotis niloticus* mostly caught in October, *Citharinus latus, Synodontis clarias Gymnarchus niloticus* and *Distichodus brevipinus.* The fishing season that gives the fishermen the greatest catch per unit effort is usually October to December of every year.

Plate 4.6 *Labeo capensis*

Plate 4.7 *Brycinus longipinnis*

Plate 4.8: ***Alestes macrolepidotus***

Plate 4.9: ***Synodontis clarias***

Plate 4.10: *Synodontis nigrita*

The fishing population in the study area is about 300 persons on 150 fishing boats with an average of 2 persons per boat.

Catch per Unit Effort Assessment

The castnet and surface set gill nets were used in assessing catch per unit effort at two fishing locations. The average catch per unit effort was low. Interview with fishermen indicates that sometimes, the day's effort can be fruitless without any catch. Because of the low catch from the castnet gear, the locals resort mainly to the use of fenced seine nets and traps and hooks for littoral bank edge fishes like *Clarias* and *Gymnarchus*, which ensures more yield. The net stays up to 6 hrs in the water. The catch however depends on the time, season and the type of net.

Fish Pathological Conditions

The dominant and commercially important fish species were subjected to parasitic analysis. In *Clarias gariepinus*, a popular fish species in Nigeria, the parasites identified were mainly intestinal and they included the nematodes, *Spirocamallanus spiralis*, *Camallanus* sp. and *Procamallanus laeviconchus.*

In *Brycinus*, an acanthocephalan worm, *Acanthogyrus tilapiae* was recovered from the intestine while a trematode metacecaria *Clinostomum* sp. in scales, muscles and gills. In *Synodontis clarias* and *Hemichromis fasciatus*, the nematodes *Procamallanus laeviconchus* and *Cucullanus* sp were recovered from the body cavity and intestine.

Although the effects of these parasites were not pronounced on the fishes examined, they are known to cause nutritional imbalance and stunted growth in fishes. No observable physical deformities were examined in the fishes.

Heavy Metals in Fish Species

Heavy metal concentrations and the TPH content in selected fish samples are presented in Table 4.13. The laboratory results indicate that all heavy metals associated with crude oil such as V, Hg, Cd, As, Cr and Ba were below detection limit. Trace metals like Zn and Fe were high in fish tissue, slightly above WHO limits but below FAO limits. In general, the toxic heavy metal concentrations in the tissue of fish were within the recommended acceptable limits and in most cases not detectable (WHO, 1989).

Table 4.13: Concentration (mg/kg) of heavy metals in selected fish samples

Fish species	Pb	Zn	Cu	Cr	Fe	Ni	V	Hg	Cd	As	Mn
	mg/kg										
Labeo senegalensis	ND	15.7	0.59	ND	32.7	ND	ND	ND	ND	ND	0.08
Brycinus longipinnis	ND	19.4	1.22	ND	29.4	ND	ND	ND	ND	ND	0.05
WHO (1989) LIMITS	2	10	1	0.5	1	0.5			2		0.1
FAO (1983) LIMITS	0.5	30	30						2		

ND = Below detection limit, Not Detected

4.3.8 Fauna and Flora Study

The study of fauna and flora diversities was carried out within the study area with the aim of establishing a baseline and for identifying potential impacts that the project may cause on species diversity within the premise.

Flora

The Igbuku marginal field is located within the lowland rainforest belt of Nigeria. The vegetation components of the area consist of typical rainforest elements ranging from phaneropytes through chamaeplytes, hemicryotoplytes, and cryptophytes to therophytes. The floristic composition of this forest consists generally of typical transitional species, several shrubby lianes and herbaceous species. Vegetation survey of the entire area enabled the identification of 4 distinct vegetation types: fresh water swamp/riparian forest, lowland secondary rainforest, bush fallows and farmlands/plantations/home gardens.

The forest types had stratified layers comprising an upper storey and a lower storey with layers of shrubs and herbs. Representative species include *Ficus exasperate, Cieba pentandra, Anthocleista vogelii, Elaeis guineensis, Alstonia boonei, Irvingia* *gabonensis, Terminalia superba, Terminalia catapa,* and *Mitragyna ciliata*. Others include, *Albizia sp, Sterculia sp, and Bambussa vulgaris*. The riparian forest was characterized by plants that have morphological and physiological adaptations to water-logging.

Common vegetation constituting the riparian forest include: *Terminalia superba, Diospyros mespiliformis*, *Nauclea diderrichii*, *Baillonella, Vossia cuspidata*, large communities of *Cyperus spp*. Grass vegetation consisting of *Acroceras amplectens, Paspalum sp*., the arum, *Cyrtosperma senegalense*, the fern, *Nephrolepis biserrata* are common. Furthermore, the bush fallow was characterized by light loving, fast growing species such as *Chromoneana odorata,Albiziazygia* and *Spondias mombin. Ficus exasperate*, *Panicum maximum, Bambusa vulgaris, Tridax procumbens, Ageratum conyzoides, Aspilia africana, Cyathula prostrata, Axonopus compressus, Pennisetum purpureum*, *Calopogonium mucunoides* were also present. All the plant communities within the study area are secondary as most of the primary forest had been removed to allow for the establishment of farms and other human activities. The main crops grown in the study area are cassava, cocoyams, yams, melon, plantain and corn. These serve as staples for communities within the study area.

Synopsis on the vegetation characteristics in the area is discussed in this subsection. Table 4.14a, shows the composition, life form and frequency of plant species discovered during the field activities.

Table 4.14a:The Composition, Life form and Frequency of Plant Species in Igbuku Field

Habitat	**S/N**	**Botanical Name**	**Common Name**	**Life form**	**Frequency (%)**	Sensitivity
					Wet season	
Bush fallow	1	*Aspilia africana*	Haemorrhage plant	Tree	38	Endemic
	2	*Alchornea cordifolia*	Christmas bush	Shrub	50	Endemic
	3	*Anthocleista vogelii*	Cabbage tree	Tree	20	Endemic
	4	*Albizia adianthefolia*		Tree	13	Rare
	5	*Asysta siagangetica*		Herb	10	Endemic
	6	*Acacia sp*		Tree	13	Endemic
	7	*Andrpogon tectorum*	Giant bluestream	Herb	13	Endemic
	8	*Ageratum conyzoides*	Goat weed	Herb	25	Endemic
	9	*Baphia nitida*		Tree	13	Endemic
	10	*Bambusa vulgaris*		Tree	38	Endemic
	11	*Chromolaena odorata*	Siam weed	Shrub	50	Endemic
	12	*Cnestis ferruginea*		Shrub	13	Endemic
	13	*Emilia coccinea*		Herb	12	Endemic
	14	*Elaeis guineensis*	Oil palm	Tree	50	Endemic
	15	*Spigelia anthelmia*		Herb	20	Endemic
	16	*Icacina trichantha*		Shrub	30	Endemic
	17	*Mimosa invisa*	Giant Sensitive plant		18	

	18	*Panicum maximum*	Guinea grass	Herb	50	Endemic
	19	*Pennisetum purpureum*	Elephant grass	Herb	15	Endemic
	20	*Psidium guajava*		Tree	10	Endemic
	21	*Rauvolfia vomitoria*		Shrub	25	Endemic
	22	*Solanum torvum*			12	Endemic
	23	*Spondias mombin*	Hog plum	Tree	30	Endemic
	24	*Trema occidentalis*		Tree	10	Endemic
	25	*Urena lobata*		Shrub	8	Endemic
	26	*Smilax anceps*		Climber		
Farmland/ Plantation	1	*Musa paradisiaca*	Plantain	Tree	38	Endemic
	2	*Musa sapientum*	Banana	Tree	25	Endemic
	3	*Lycopersicon esculentum*	Tomato	Herb	10	Endemic
	4	*Manihot esculenta*	Cassava	Shrub	75	Endemic
	5	*Cucumeropsis mannii*	White melon	Creeper	50	Endemic
	6	*Capsicum chinensis*	Pepper	Shrub	25	Endemic
	7	*Capsicum frutescens*	Small hot pepper	Shrub	10	Endemic
	8	Hevea brasiliensis	Rubber	Tree	25	Endemic
	9	*Elaeis guineensis*	Oil palm	Tree	50	Endemic
	10	*Colocasia esculenta*	Cocoyam	Herb	8	Endemic
	11	*Dioscorea sp*	Yam	Climber	25	Endemic
	12	*Ananas comosus*	pine apple),	Herb	20	Endemic
	13	*Telfaria occidentalis*	Ugwu, Oyster nut	Climber	12	Endemic
	14	*Zea mays*	Maize	Shrub	50	Endemic
	15	*Abelmoschus esculentus*	Okra	Shrub	20	Endemic
	16	*Axonopus compressus*	Carpet grass	Herb	15	Endemic
	17	*Aspilia africana*	Crowfoot	Shrub	50	Endemic
	18	*Tridax procumbens*		Herb	40	Endemic
	19	*Talinium trangulare*	Water leaf	Herb	30	Endemic
	20	*Spondias mombin*	Hog plum	Tree	30	Endemic
	21	*Mimosa pudica*	Sensitive plant	Herb		Endemic
	23	*Icacina trichantha*		Shrub	30	Endemic
	24	*Ipomoea involucrata*	Morning glory	Creeper	40	Endemic
	25	*Myrianthus arboreus*		Tree	12	Endemic
	26	*Daniellia oliveri*		Tree	12	Endemic
	27	*Vernonia amygdalina,*	Bitter leaf	Shrub	12	Endemic
Secondary Lowland Rainforest	1	*Cieba pentandra*	Silk or cotton tree	Tree	12	Endemic
	2	*Bambussa vulgaris*		Tree	50	Endemic
	3	*Albizia sp*		Tree	12	Endemic
	4	*Piptadenistrumafricanum*		Tree	12	Endemic
	5	*Cynometra megalophylla*		Tree	12	Endemic
	6	*Mitragyna Ciliata*	Abura	Tree	12	Endemic
	7	*Terminalia catapa*	Almond tree	Tree	18	Endemic
	8	*Terminalia superba*		Tree	18	Endemic
	9	*Ficus exasperate*		Tree	25	Endemic
	10	*Anthocleista vogelii*	Cabbage tree	Tree	38	Endemic
	11	*Elaeis guineensis*	Oil palm	Tree	50	Endemic

	12	*Alstonia Boonei*	Stool wood	Tree	12	Endemic
	13	*Milicia excelsa*		Tree	12	Endemic
	14	*Nauclea diderrichii*	Opepe	Tree	12	Endemic
	15	*Musanga cercropioides*	Umbrella tree	Tree	25	Endemic
	16	*Erythrophleum invorese*		Tree	12	Endemic
	17	*Irvingia gabonensis*		Tree		Endemic
	18	*Sterculia sp*		Tree	12	Endemic
Fresh water swamp/Riparian forest	1	*Terminalia superba,*		Tree	25	Endemic
	2	*Raphia hookerii*		Tree		Endemic
	3	*Musanga cercropioides*	Umbrella tree	Tree	25	Endemic
	4	*Dissotis rotundifolia*		Herb	12	Endemic
	5	*Cyrtosperma senegalense*	Swamp arum	Herb	12	Endemic
	6	*Anthocleista vogelii*	Cabbage tree	Tree	38	Endemic
	7	*Diospyros mespiliformis*		Tree	12	Endemic
	8	*Vossia cuspidate*		Herb	12	Endemic
	9	*Baillonella toxisperma*		Tree	12	Endemic
	10	*Nauclea diderrichii*	Opepe	Tree	12	Endemic
	11	*Ipomoea aquatica*	Swamp morning glory	Herb	18	Endemic
	12	*Cyper usiria*		Herb	12	Endemic
	13	*Killinga bulbosa*		Herb	12	Endemic
	14	*Saciolepis africana*		Herb	38	Endemic
	15	*Nephrolepis biserrata*		Herb	18	Endemic
	16	*Acrocera samplectens*		Herb	12	Endemic
	17	*Paspalum sp.*		Herb	12	Endemic
	18	*Pterocarpus sp*		Tree	8	Endemic
	19	*Kyllingan emoralis*		Herb	18	Endemic
	20	*Antiaris africana,*		Tree	12	Endemic
	21	*Parkiabi globosa*		Tree	12	Endemic
	22	*Clitoriat ernatea*		Herb	12	Endemic

Source: POL Field Study, 2020

Bush fallows

The floristic composition varies mainly with the age of the fallow and less with the season. However the species composition include: *Elaeis guineensis, Alchornia cordifolia, Musanga cecropioides, Bambusa vulgaris, Ficus exasperate, Spondias mombin, Anthocleista vogelii*, *Albizia adianthefolia, Nauclea diderichii, Alstonia boonei, Asystasia gangetica, Aspilia Africana, Chromolea aodorata, Baphia nitida, Trema guineensis, Acacia sp.* Others include, *Icacina trichantha, Urena lobata, Cnestis ferruginea Smilax anceps, Terminalia superba, Irvingia gabonensis, Spigelia anthelmia, Rauvolfia vomitoria, Calapogonium mucunoides, Mimosa invisa, Panicum maximum, Pennisetum purpureum, Psidium guajava, and Trema occidentalis.*

Farmlands

Farming is the predominant occupation among the people living within and around Igbuku field. Common crops cultivated include but not limited to the following: *Cocos nucifera, Elaeis guineensis, Ananas comosus, Manihot esculenta, Dioscorea sp, Colocasia esculenta, Citrus sinensis, Lycopersicon esculentum , Musa sp., Cucumeropsis mannii , Hevea brasiliensis , Talinium trangulare, Abelmoschus esculentus , Zea mays , Telfaria occidentalis, Psidium guajava.* Shrubs and herbs within and around most farm lands, include but not limited to the following: *Panicum maximum, Tridax procumbens, Ageratum conyzoides, Aspilia africana, Cyathula prostrata, Axonopus compressus, Pennisetum purpureum, Calopogonium mucunoides, Synedrella nodiflora, Vernonia amygdalina, Asysta siagangetica, Bulbophyllum sp), Alchornea laxiflora, Bambusa vulgaris, Rauvolfia vomitoria, Mimosa pudica, Cieba pentandra, Mallotus oppositifolia and Sida acuta.*Plate 4.10, shows a farm land in Ushie community encountered during the wet season study.

Plate 4.11a: Farm land in Ushie community, ***Source: POL Field Study, 2020***

Secondary low land Forest

The forest types had stratified layers comprising an upper storey and a lower storey with layers of shrubs and herbs as shown in Plate 4.10. Representative species include

Ficus exasperate, *Cieba pentandra, Bambussa vulgaris, Albizia sp, Piptadenistrum africanum, Mitragyna Ciliata, Terminalia catapa, Cynometrame galophylla , Terminalia superba, Ficus exasperate, Sterculia Sp, Irvingia gabonensis, Alstonia Boonei , Elaeis guineensis* and *Anthocleista vogelii*. Others include Erythrophleum Invorese, Albizia sp, *Piptadenistrum africanum, Musanga cercropioides, Nauclea diderrichii, Milicia excels* and *Sterculia sp.*

Plate 4.11b: Secondary Low Land Forest, Source: POL Field Study, 2020

Riparian forest

The vegetation around Ase river and creek are luxuriant. The riparian forest was characterized by plants that have morphological and physiological adaptations to water-logging as seen in Plate 4.12. Common vegetation constituting the riparian forest include: *Terminalia superba, Pterocarpus sp, Nauclea diderrichii, Kyllingane moralis*, *Raphia hookerii, Anthocleista vogelii, Alstonia boonei, pterocarpus sp, Sterculia sp, Musanga crecipioides, Antiaris africana, Clittoria ternantia, Dissotis rotundifolia, Parkia biglobosa, Calopogonium mucunoides, Baillonella toxisperm, Diospyros mespiliformi, Cyrtosperma senegalense, Vossia cuspidate.* It also includes*, Cyperusiria, Ipomoea aquatic, Killinga bulbosa, Saciolepis Africana, Acroceras amplectens* and *Clitoria ternatea.*

Plate 4.12: Riparian Area, Ase river, *Source: POL Field Study, Feb., 2020*

Population Density

The highest plant population density was *recorded for Manihot esculenta (Cassava)* of 1100 plants per hectare*. Elaeis guineensis (oil palm tree), Ananas comosus*(pine apple),*Dioscorea sp (yam), Colocasia esculenta (cocoyam), and Musa sp*(Plantain) had intermediate densities. The lowest density was recorded for *Pterocarpus sp.*

Plant Pathological Assessment

Disease symptoms and their causative microorganisms isolated from diseased plants in the project area for the wet season are presented in Table 4.14b. Visual and on-sight pathological assessment showed that leaf spots and chlorosis were the most dominant disease symptoms affecting several plants. The severity index also expressed in Table 4.14b is based on the extent of spread of the infection within a plant and among 5 – 10 plants in a population. When more than half of the leaves on a single plant are infected, it is considered high; when more than five leaves in a group of 3 – 44 plants of the population are infected, it is considered moderate, while if only 1 or 2 leaves of plants are infected it is considered a light infection. The overall state of health of the vegetation and the commonest species appeared quite typical for the region in both seasons. None of the diseases isolated were unusual to the plant species.

Table 4.14b: Plant Diseases, Causal Organisms and Severity Index of Infection in the Project Area during the dry season study

S/N	Plant Species	Type of Disease	Casual Organism	Severity Index
1	*Panicum maximum*	Necrosis, Leaf spot	*Aspergillus niger* *Penicillium sp*	1
2	*Musa sapientum*	Chlorosis Cigar end	*Pseudomonas andropogonii* *Trachshaea fructigena*	1
3	*Manihot esculenta*	Necrotic patches and chlorosis Mosaic leaf blight	*Cocliobolus lunatus, Collectotrichum spp*. African cassava mosaic virus.	2
4	*Telfiria occidentalis*	Powdery mildew, leaf spot	*Oidium levea*	3
5	*Zea mays*	Ragged appearance with defoliation occurring from the leaf edge toward the midrib.	*Pseudaletiaunipuncta*	2

Source: POL Field Study, 2020

Fauna

The wildlife (fauna) discovered in the project area during the wet season study consists of mammals, birds, reptiles, amphibians and invertebrates Table 4.15. Sustained exploitation through hunting, trapping and human–induced habitat alterations have combined to threaten or endanger several species (Plate 4.13).

Plate 4.13: A Hunter Displaying His Kill (Monkey and Sun Squirrel) In Umu-Eze Iwerie*Source: POL Field Study, Feb 2020*

The invertebrate fauna were diverse and consisted of forest dwelling species dominated by ants, beetles and millipedes. Many genera and species of arthropods were recorded.

The Mollusca fauna was represented by the presence of the giant African land snail *Achatina fulica* and the garden snail, *Cornua spersum*. Except for the Giant rats, the rodents are small mammals and are very varied in pelage coloration and patterning. They are mostly terrestrial and live in burrows, being mostly nocturnal. Because of their large numbers they are neither threatened nor endangered but rather considered a pest to field crops and stored products.

The presence in large numbers of rodents in particular, and the near absence of the bigger mammals which make up the typical rainforest wildlife are indicative of the changes in land cover/vegetation forms over the years. The bird species recorded by sighting, nest observations and call sounds include the white egrets, kites, weaverbirds, owls and hawks. Different species of reptiles and amphibians were also noticed. Prominent among these were *Agama agama* (common lizard), gecko, frogs and snakes (Table 4.15).

Table 4.15: **List of Wildlife species within and outside Igbuku Field**

S/N	Taxa	Common names	Scientific names	Sensitivities
1	**Mammalia**	Cane rat or Grass cutter	*Thryonomys swinderianus*	Endemic
2		Sun Squirrel	*Heliosciurus gambianus*	Endemic
3		Bush tailed Porcupine	*Anthemrus africanus*	Endemic
4		West African ground Squirrel	*Xerus crythropus*	Endemic
5		Giant rat	*Cricetomys gambianus*	Endemic
6		Common duiker	*Cephalophus sp*	Endemic
7		Spotted grass mouse	*Lemnisco mysstriatus*	Endemic
8		The black bellied pangolin	*Manis tetradachyta*	Endemic
9		Common African least nosed bat	*Hipposi deroscaffe*	Endemic
10		Common genet	*Genetta genetta*	Endemic
11		Monkey	*Cercopithecus mona*	Endemic
12	**Reptilia**	Rainbow lizard	*Agama agama*	Endemic
1		Green mamba	*Dendroapsis viridis*	Endemic
13		skink	Scincidae	Endemic
14	**Aves**	Sparrow Hawk	*Accipiter erythropus*	Endemic
15		Pied crow	*Corvus albus*	Endemic
16		Palm swift	*Cypsiurus parvus*	Endemic
		Common Bulbul	*Pycnonotus barbatus*	Endemic
17		Cattle egret	*Bubicus ibis*	Endemic
18		Jungle fowl	*Gallus gallus*	Endemic
19		Bush fowl	*Francohanus bicalcaratus*	Endemic
20		African swift	*Apus barbatus*	Endemic
21		Red eyed dove	*Streptopelia semitorquata*	Endemic
22		Forest robin	*Stiphrornisery throrax*	Endemic
23		White faced owl	*Ptilopsisle ucotis*	Endemic

24		Harrier Hawk	*Polyboroides radiatus*	Endemic
25		Yellow wagtail	*Budytes flavus*	Endemic
26		Hornbill	*Lophocerossemi fasciatus*	Endemic
27		Village weaver	*Ploceus cucullantus*	Endemic
28	**Arthropoda**	Nigerian land snail	*Limicolaria aurora*	Endemic
29		Garden snail	*Cornua spersum*	Endemic
30		Giant snail	*Achatina fulica*	Endemic
31		Water snail	*Lymnea sp*	Endemic
32		Cockroaches	*Blatella sp*	Endemic
33		Crickets	*Gryllus sp*	Endemic
34		Ants		Endemic
35		Beetles		Endemic
36		Millipedes		Endemic
37	**Amphibia**	African toad	*Bufo regularis*	Endemic
38		Common frog	*Rana temporaria*	Endemic
39		Goliath frog	*Goliath temporaria*	Endemic
40		Tree frogs	*Hyperlolius sp*	Endemic

POL Field Study, 2020

4.3.9 Socio-Economics Study

Project influences and receptor exposure are felt by the human population. This section of the Impact Assessment (IA) focuses on the Socio-Economic parameters such as settlement history, population characteristics, educational status, occupation, employment, income, expenditure, land and water resource ownership, housing, infrastructure, social structure, religion, customs, belief, power and governance, conflicts, conflict resolution and inhabitants perception of the Igbuku-Umuseti Further Field development project.

Study Communities

The study communities are those that are within 5km radius of the Igbuku-Umuseti Field project. The project affected communities are Umuseti-Ogbe, Igbuku, Ashaka and Emu-Iyasele withi Ndokwa-West LGA of Delta State and they are the host communities. The communities are predominantly inhabited by the Ukwuani/Ndokwa ethnic group of Delta State. Though autonomous in terms of traditional leadership, the communities have historical links. Ndokwa-West LGA whose Local Government headquarters is in Kwale with an area of 816km², a Density of 253.2/km^2 and a population of 150,024 based on the 2006 National Population Census figures, projected at 206,600 in 2016 and current year 2020 projected at 234,340 using 3.2% annual growth rate. The Ndokwa-West LGA's male-female population ratio in 2006 was 73,842(49.2%).

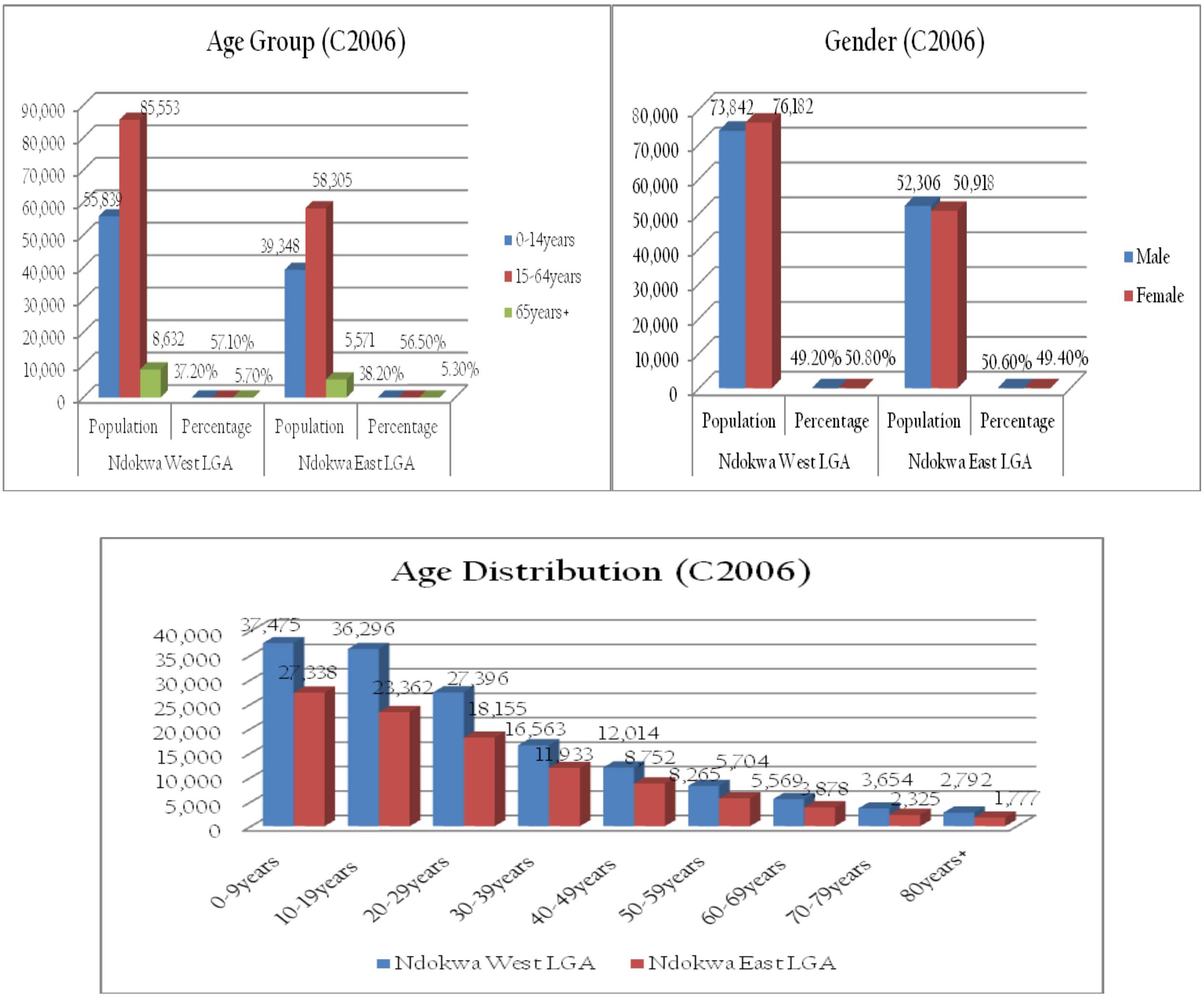


Figure 4.16: Gender, Age group and Age Distribution of Ndokwa-West (C2006), Source: NPC, NBS

Delta State: Delta State is one of the nine States created in 1991, excised from the old Bendel State. At its inception, it had nineteen (19) Local Government Areas (LGAs). Delta State as revealed in 2006 census had a population of *4,112,445*, comprises of *2,069,309* males and *2,043,136* females, distributed into about *890,312* households. It also encompasses a landmass or area of over *17,239.24 km²* and this shows an average density of *238.6* persons per km^2 (NPC 2006). According to the 2006 census, Delta State, like the nation Nigeria, has witnessed much increase in her population with a total population of *4,112,445*. Meanwhile, with this population figure, Delta State now ranks the 12th most populous State in the country and the 2nd most inhabited among the nine (9) oil producing States that comprises the Niger Delta Region. The population is being estimated to be growing at an annual growth rate of 3.2% just as that of the entire country (FGN, Official Gazette, 2007). ***See Figure 4.17***.

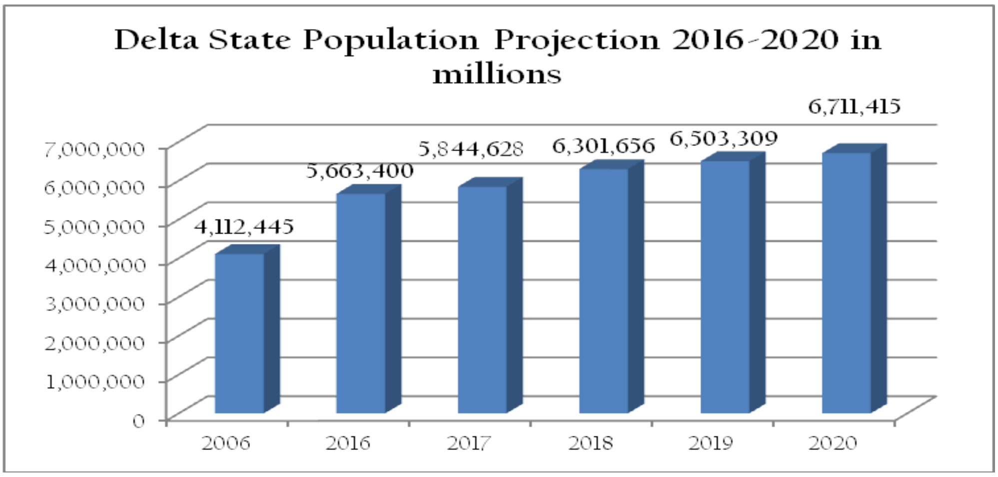


Figure 4.17: Delta State population projection,Source: GTZ projections (2006) based on National Population Commission Data

Nigeria: Nigeria, one of Africa's largest countries and its most populous, is located in West Africa. The country covers an area of about 923,768 km^2, with an estimated 4,049 km of land boundaries, shared with Cameroon in the east, the Republic of Niger in the north, Chad in the north-east and Benin in the west. In the south, Nigeria's 853-km long coastline opens onto the Atlantic Ocean. The southern lowlands join into the central hills and plateaus, with mountains in the south-east and plains in the north. The country's largest river is the Niger, which joins with the River Benue to form a confluence at Lokoja.

***Niger Delta*:** The Niger Delta, situated in the southernmost part of Nigeria and covering an area of about 70,000 km^2, is the largest river delta in Africa and the third largest in the world. From a coastal belt of swamps, stretching northwards the land becomes a continuous rainforest which gradually joins with woodland and savanna grasslands in central Nigeria. The swamp, forest and woodland areas occupy about 12 per cent of the delta's land surface. Nigeria gained independence from the United Kingdom in 1960. With a population in excess of 200 million people, Nigeria is a multi-ethnic federation divided into 36 states and the Federal Capital Territory, within which lies the capital city of Abuja.

More than 250 ethnolinguistic groups are spread across the country; however the three dominant groups are the Hausas in the north, the Igbos in the south-east and the Yoruba mainly living in the south-west. Nigeria is rich in natural resources, including natural gas, petroleum, tin, iron ore, coal, limestone, niobium, lead, zinc, timber and extensive arable land. Prior to the discovery of oil in the 1950s, agriculture was the mainstay of the economy, with agricultural produce exported to the more developed parts of the world.

By 1971 there had been a shift from agriculture to petroleum production, such that between 1973 and 1981 the value of agricultural exports declined from more than USD 1.5 billion to about USD 0.3 billion. Currently, oil and gas provides 80% of budget revenues and 95% of forex earnings.

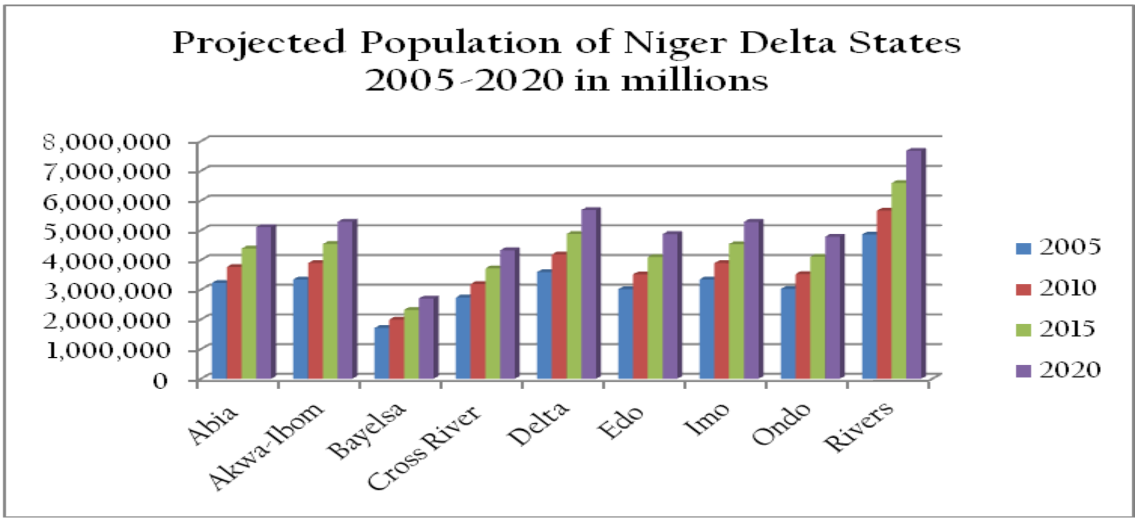


Figure 4.18: Niger Delta State Population Projection
Source: GTZ projections (2004) based on NPC Data & growth rates

Meanwhile, host communities in the Igbuku-Umuseti Field project are permanent communities and rural settlements. The housing pattern, type and structure of the settlements reveal a typical rural setting of the project environment. Houses, it is said, are built according to family/lineage ties, including transportation and communication routes. Land before the discovery of oil in 1977, was not that of an issue and so the major influence on the pattern of settlements was basically the kinship/lineage ties and land ownership right. Even though, the host communities are mostly rural, their cultural affinities to family ties still play a major role on how houses are built. In most Delta State communities, housing patterns are both nucleated and scattered ***(Plate 4.14a)***.

Plate 4.14a: Showing the Igbuku-Umuseti Field communities traversed by both tarred and un-tarred roads with internal streets/quarters; also the housing type/quality, showing a typical rural-environment

Political Structure/ Governance

- **Community Power Structure and Governance**

The internal structures of a small community living in a single settlement and the structures of the community belonging to a larger community spread out over several hamlets are the same. The men of a community are subdivided into the youth (young men able to work) and the elders, the latter being committed persons who have actively contributed to the development of the community and have to be recommended by other elders or the chiefs/traditional ruler. The women of a community are organized in the same way. Also, there is the young group, married women of working age and the group of the 'elder women. The "elders" (women and men) have a high status in the community because of their experience and often makes the final decisions regarding important activities at the community level. Be that as it may, for over a decade now, many youth groups and movements have hijacked this position due to the perceived inaction of the elders to exploitation.

Even though, a more dynamic indigenous political system based on representative participation and fair sharing of power and responsibilities among the community members and age-grade associations have emerged…many of the independent villages of the Ukwuani/Ndokwa ethnic group are still being governed on the principles of gerontocracy; executive, legislative and judicial functions are still vested in the hands of the oldest man and his cohorts. As a result, majority, if not all of the Ukwuani communities, the traditional governance and power structure is organized into hierarchies from the clan level to the individual village/community down to the quarters that constitute each settlement.

The Okpala-ukwu is the traditional leader and the oldest person in the host communities; the Oduas (Council of elders), and the Okwa (title holders), and the Odogwu-Abi, which is the prime minister. After the prime minister, you have the Ngbume-eka or Abi, who assist the prime minister in the hierarchy of leadership. Followed by the Abi is the Egwe-Ukwu and Egwe-Nta age grade who are title holders in the communities. Next are the Anonkinti and Otuolile age grade that have attained the age of obtaining Inotu title but have not been able to do so. These age grade assist in doing some menial jobs/activities in the communities, like cutting of grasses, burying of deceased. The Community Development Committee (CDC), Youth group and the Women's forum respectively constitute the local and traditional administrative structures of the Igbuku-Umuseti Field communities.

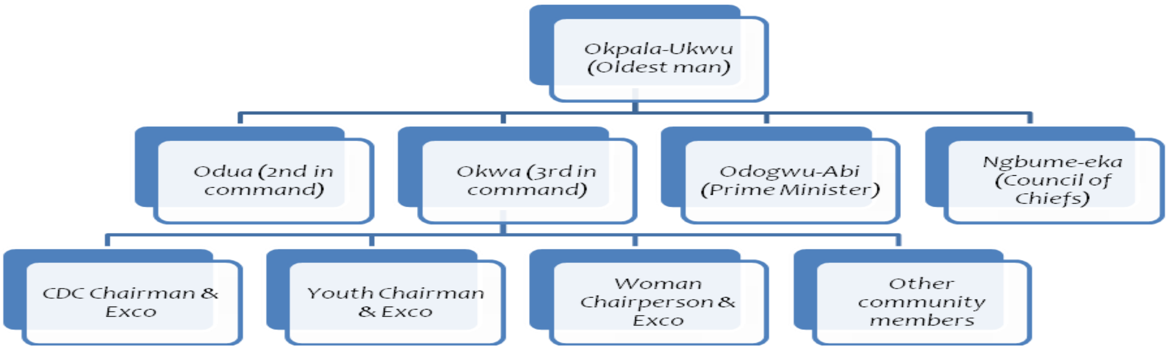


Figure 4.19: Traditional Administrative Structure in Ukwuani/Ndokwa communities

On the other hand, at the formal level of modern governance system, apart from the roles of the Federal and State Governments in fostering development and security of lives and properties, the Local Government Area (LGA) administration is overseen by an elected Executive Chairman. There is also the legislative arm of the LGA administration made up of Counselors elected from the political wards in the LGA. Communities in each LGA are grouped into political wards for purposes of representation and administration. Political participation is very keen in the communities and the main political parties with offices in the communities studied in Delta State are: Peoples Democratic Party (PDP), All Progressive Congress (APC) and others.

Population and Socio-demographic Characteristics

- **Population Size, Growth and Distribution**

Delta State is one of the nine States created in 1991, excised from the old Bendel State. At its inception, it had nineteen (19) Local Government Areas (LGAs). Delta State as revealed in 2006 census had a population of 4,112,445, comprises of 2,069,309 males and 2,043,136 females, distributed into about 890,312 households. It also encompasses a landmass or area of over 17,239.24 km^2…and this shows an average density of 238.6 persons per km^2 (NPC 2006). According to the 2006 census, Delta

State, like the nation Nigeria, has witnessed much increase in her populationwith a total population of 4,112,445.Meanwhile, with this population figure, Delta State now ranks the 12th most populous State in the countryand the 2nd most inhabited among the nine (9) oil producing States that comprises the Niger Delta Region. The population is being estimated to be growing at an annual growth rate of 3.2% just as that of the entire country (FGN, Official Gazette, 2007).
Knowledgeable individuals and key informants whose views were sought as to what their community estimated population might be as at the time of the study have near an exaggerated estimate of how many persons may be inhabiting the community as follows: Umuseti-Ogbe 3500, Igbuku 2500, Ashaka 3500, and Emu-Iyasele 1000. Although, the figures appear very bogus even if the number of houses, physical size and internal migration and pull-factors (growth-inducing factors) are considered.

Natural increases, like excess of births over deaths and migration are the two most known determining factors of population growth. The population growth may have been influenced by the oil exploration activities and entitlements given to the various community leaders. In addition, population projection using the exponential model reveal practically that rather than population growth occurring in constant increments over time, i.e. linearly, the rate of growth changes over time, growing faster as the population size increases. It is therefore, to be expected, why the project stakeholder communities have actually witnessed an increase over the years.

- **Population Growth Rate**

Population growth is determined by the demographic processes of fertility, mortality and migration. Considering the impact of these demographic processes, NPC has estimated annual population growth across Nigeria at 3.2% (NDHS, 2008). Fertility rates are influenced by a number of factors in the communities studied, which include early procreation and the practice of polygamy. The most commonly used measures of fertility in Nigeria are the Total Fertility Rate (TFR) and the Crude Birth Rate (CBR). The TFR provides an indication of the total number of children a woman will have in her reproductive life time. There were no available TFR values for the communities and LGAs, but the National Bureau of Statistics (NBS) in its Annual Abstract of Statistics (ABS), 2010 provides a TFR value of 4.6 for the South-South geo-political region and 5.9 for the nation.

The implication of these values is that the rate of fertility in the South-South states, including Delta is lower than the national average. Another measure of fertility, the Crude Birth Rate (CBR) describes the relationship between the number of life births per 1000 of the population and the midyear population in an area. Expressing the CBR in percentage, the NBS estimates the national CBR at 13.65% and in Delta State at 16.09% (ABS, 2010). Delta State has a higher CBR of 2.59 % than the national average of 1.78%. A major factor that has influenced mortality in the communities is the non-availability of adequately staffed and equipped medical facilities.

Migration is another factor that is responsible for population growth rate in Nigeria. This has been mostly characterized by a rural to urban movement of individuals and families. Overall, results obtained from the survey of the communities indicate that about 75% of respondents across the study area were non-migrants and 25% were migrants. Specifically, the figure was 75% non-migrants to 25% migrants across Igbuku-Umuseti Field proposed further development stakeholder's communities. Thus, there has been increased ethnic mix arising from migration by non-indigenous population in search of services for the oil and gas operations of Pillar Oil Limited in the area.

- **Socio-Economic Characterization and Age Distribution of Respondents**

The age distribution of respondent is dominated by youth ranging between 20–49years (54.2%). About 44.4% were found to fall within the age bracket of 50–69 year while above 70 years accounted for only 1.4% as depicted in (***Fig. 20a &b).*** This result suggests that the population of the project people has great potentials for future growth. The age range is in conformity with the local and state government age group where the bulk of the population falls within 15-64years of age.

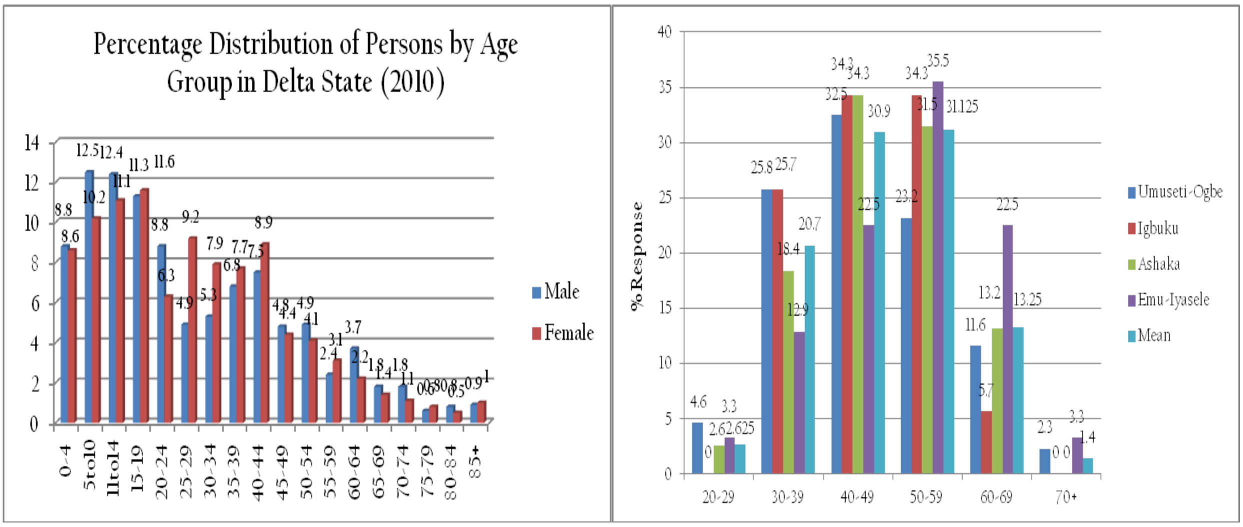


Figure 4.20a &b: Age Range of Respondents & Percentage Distribution of Person by Age Group
Source: NBS/CBN/NCC Social-Economic Survey on Nigeria, 2010

- **Household Size and Marital Status of Sampled Population**

Information on household composition is critical for understanding family size, household headship, and for implementing meaningful population-based policies and programmes. Household composition is also a determinant of health status and well-being (NPC and ICF Macro, 2014). These characteristics are important because they are associated with household welfare. Female-headed households are, for example, typically poorer than male-headed households. Economic resources are often more limited in larger households. Moreover, where the size of the household is large, crowding also can lead to health problems (NPC and ICF Macro, 2009).

The household structure in the Igbuku-Umuseti Field stakeholder communities parallels the patriarchal leadership structure of most Nigerian ethnic groups. The majority (82%) of households in Nigeria are headed by men, with only 18 percent headed by women. The proportion of female-headed households has remained almost the same in the last five years (i.e. between 2008 and 2013) (NPC and ICF Macro, 2014). The three different types of male-headed household structures are traditional (one husband and one spouse), polygamous, and single male (male with no spouse, including widowers and males that have never been married). Traditionally, the male is responsible for all the major household decisions.

Returned responses from administered questionnaires of the surveyed communities revealed on average some 30.9% to be of single marital status while over one half (53.4%) were married persons ***(Figure 4.21a).*** The percentage of respondents divorced, separated from their spouses and those widowed amounted to some 15.7%, implying that the vulnerable proportion is comparatively low. The proportion of married persons tallied with the age of the respondents. There are two obvious implications; higher proportions of the population were of the marital age and there was also a wide range of matured representation of opinions during the field study. Less than one fifth (23.3%) of the respondents were aged less than 30 years.

The field results confirmed an earlier survey findings that found approximately 58.3% on average of the respondents in the study area to be married, while fewer percentages were single and separated or divorced from their spouses. Those widowed were also fewest in the population. Both in the current and previous surveys, married males were found to have an average of one wife, with few of the older genre or folks having morethan one wife. This implies that polygamy is either no longer fashionable or common in the study area. Sizes of families vary from community to community and this is influenced greatly by the cultural attitude of the people. Another critical determinant of household size and marital status is economy of the settlement as well as educational status/awareness of the resident population. Specifically, the average household size in the Igbuku-Umuseti Field stakeholder communities was 5.3 according to number of households and total population in (NPC 2006); socioeconomic survey of the sampled communities revealed however, that household sizes had since increased beyond this level.

Women have an average of 5 children and average household size approximates to 5.3. If other dependants living in the households are added, (a minimum of 2 and maximum of 5 was reported within the communities), household size now comes to 10. This trend of large household sizes can be attributed to several reasons in the studied communities in particular and the South-South (Niger Delta) region as a whole. For instance, people marry at a relatively early age thereby extending their period of child bearing. On the other hand, the men marry more than one wife (i.e polygamy) as well as keep other concubines. On the average, about 53.4% of the sampled respondents are married while about 30.9% are single. Widowed persons account for about 5.7%, Divorced 7.3% and Separated 2.7%. This is in line with the Delta State marital status where the married and single are higher with 32.3% and 57.3% respectively as depicted in ***(Figures 4.21a & b).***

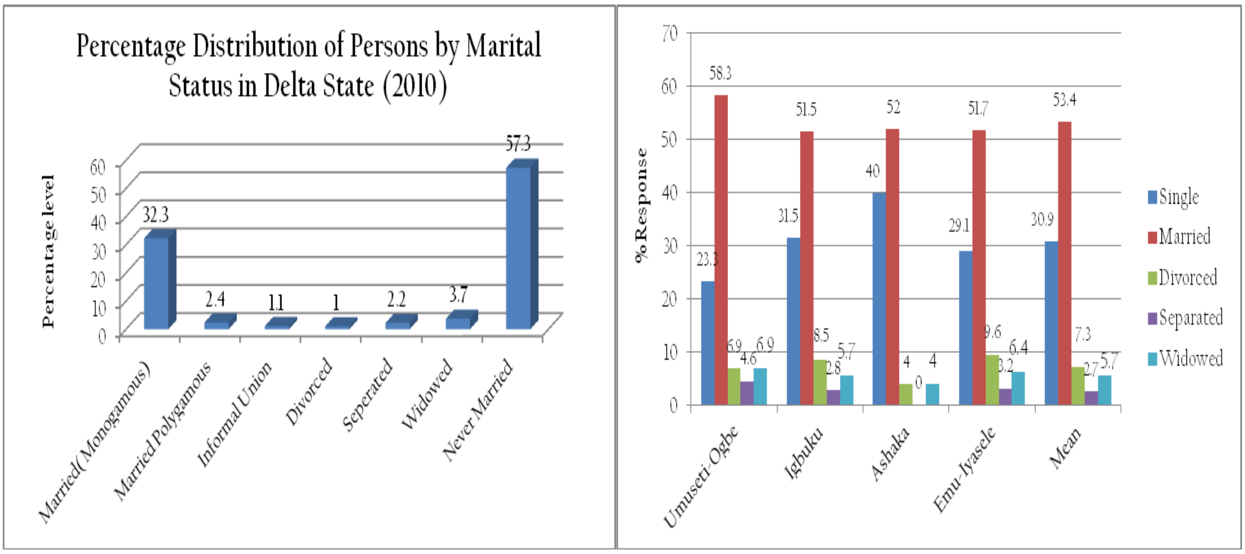


Fig. 4.21a: Marital Status of Sampled Respondents; Fig.4.21b: Delta State marital status
Source: National Bureau of Statistics (NBS)

- ### Household and Population Structure (Age/Sex Distribution and Ratio)

Age and sex are important demographic classification variables. As high as 31.2% of the household population is aged 0-12 years while 20.4% is within the 13-18 years age bracket. Together therefore, children make up 51.6% of total household population. Also 40.8% of the household members are within the productive workforce age cohort of 19-59 years. Household members aged 60 years and above are few, constituting only 7.6% (***Figures 4.22a & b***).

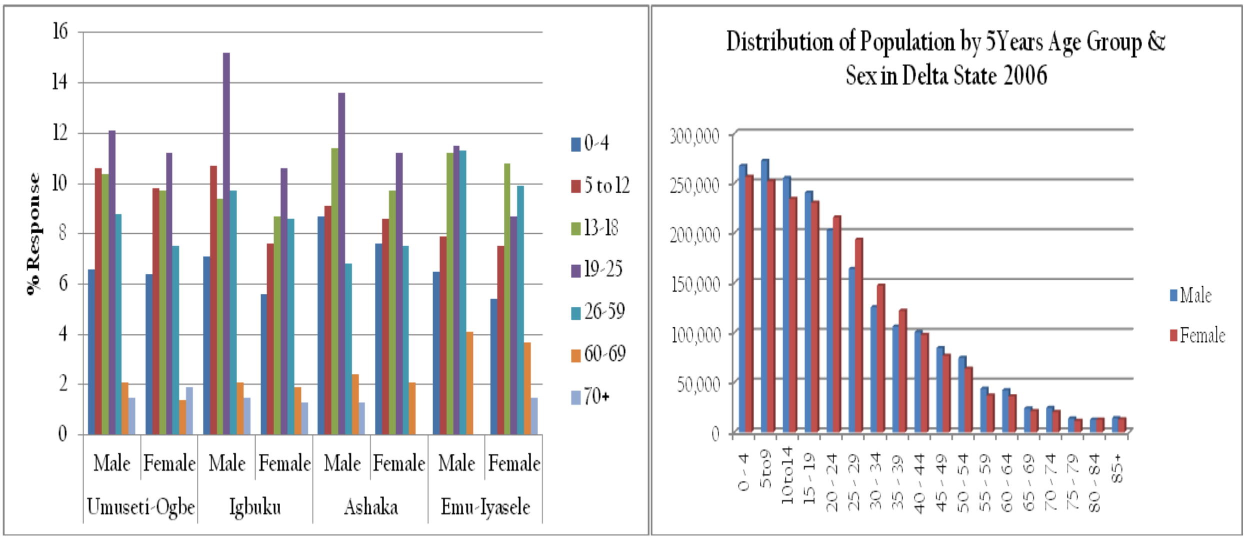
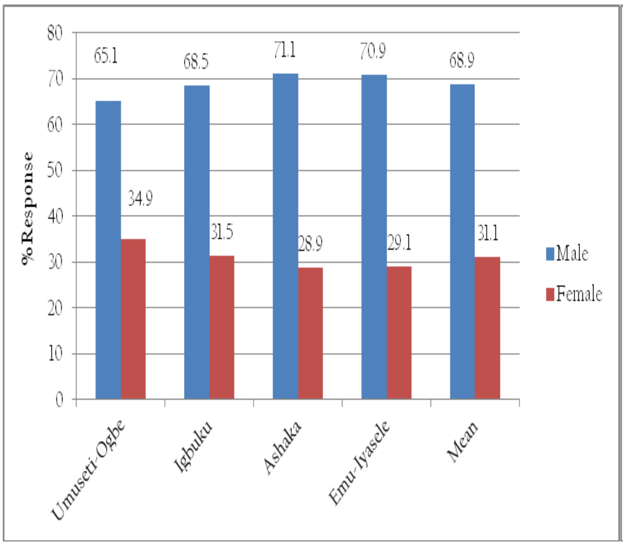


Fig 4.22a: Age and Sex Structure of Sampled Households; Fig.4.22b: Distribution of population by 5years age Group and Sex in Delta State - Source: NPC 2006

This household Age-Sex composition conforms to what was found in Delta State, and indeed Nigeria's population age-sex structure (National Population Commission, 2006). By this structure, the population is overwhelmingly loaded from the lower age-cohorts with the bulk of the population made up of persons below 18 years, and descriptively classified as children (NPC, 2002). As a result, communities in Delta State have high dependency ratio with child dependency ratio (for age group of 0-14 years) of 31.23%, disaggregated into 16.37% for males and 14.86% for females. The implications of this age profile is that the population is young and growing and places heavy burden of dependence on the workforce population especially with regards to provision of education and health care services for the young and medical care for the aged. The household structure of the Igbuku-Umuseti Field stakeholder communities shows that there are more male (68.9%) heads of households than females (31.1%). The three (3) different type of male-headed household structures are as follows; (one husband and one spouse), polygamous, and single male (male with no spouse, including widowers and males that have never been married). Traditionally, the male is responsible for all the major household decisions.

The socioeconomic survey of the communities also showed that households' structural composition is typically pyramidal; i.e. broad-based with the younger ones predominant and the aged fewest in proportion. On the average, children aged 0-4 years (infants) is about 13.4% of the household members and children aged 5-12 years (primary school age) makes-up about 17.8% of the population. The age range of 13-18 years (Secondary school age) is about 20.4% while 19-25years (Tertiary education) made up of 23.4%.

Also 17.4% make up 26-59 years (active working proportion) and the aged (60 years and above) make up 7.6% of the household composition. The socio-economic data also indicates that most of those surveyed are adults of at least 20 years old. On the average, about 23.3% and 62.1% of the community respondents were respectively in the 20-39 and 40-59 years age brackets, 30.9% were aged 40-49; 31.2% (50-59) while 14.6% were aged 60+ years and above *(Figure 4.23a).* Sex distribution of the population in the communities shows the males are more in number constituting approximately 68.9% to the females' 31.1% of the population (*Figure 4.23b*). According to the 2006 census, the males outnumbered the females. At the State level, the male-female ratio is almost equal at 50.4% males to 49.6% females.



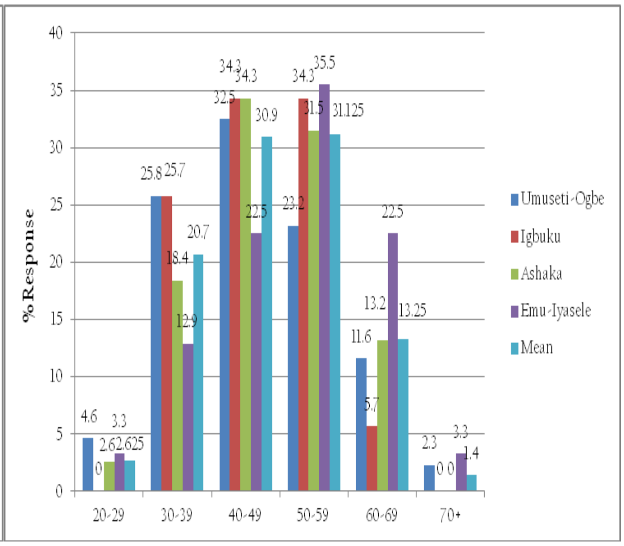


Fig.4.23a: Age Range of Respondents **Fig. 4.23b: Sex Respondents**

Dependency ratio

The dependency ratio relates the number of children (0-14 years old) and older persons (65 years or over) to the working-age population (15-64 years old). The unit of measurement is per hundred persons aged 15-64. The policy relevance and purpose of the Dependency ratios is to indicate the potential effects of changes in population age structures for social and economic development, pointing out broad trends in social support needs.

Relevance to Sustainable/ Unsustainable development*:* By relating the group of the population most likely to be economically dependent (net consumers) to the group most likely to be economically active (net producers), changes in the dependency ratio provide an indication of the potential social support requirements resulting from changes in population age structures. In addition, the ratio highlights the potential dependency burden on workers and indicates the shifts in dependency from a situation in which children are dominant to one in which older persons outnumber children as the demographic transition advances (that is, the transition from high mortality and high fertility, to low mortality and low fertility). A high dependency ratio indicates that the economically active population and the overall economy face a greater burden to support and provide the social services needed by children and by older persons who are often economically dependent. A high youth dependency ratio, for instance, implies that higher investments need to be made in schooling and child-care.

The need to ensure access to basic services, such as education and health, as well as to ensure the economic security of children and older persons has been emphasized in many international conferences and summits, including the World Summit for Children (1990), the International Conference on Population and Development (1994), the World Summit for Social Development (1995), The United Nations Millennium Declaration and the World Assembly on Ageing (2002).

Methodologically, the dependency ratio refers to the number of children aged 0 to 14 years plus the number of persons aged 65 years or over per 100 persons aged 15 to 64 years:

Dependency Ratio =100 x (Population (0-14) + Population (65+)) / Population (15-64). The dependency ratio can be disaggregated into: 1. the youth dependency ratio, which is the number of children, aged 0-14 per 100 persons aged 15-64, and (2) the old-age dependency ratio, which is the number of persons aged 65 or over per 100 persons aged 15-64. The dependency ratio, also referred to as total dependency ratio, is the sum of the youth and old-age dependency ratios. Some studies employ other age groups in calculating dependency ratios, for instance 0-19 years to represent the population of children or the population aged 60 or over to represent the population of older persons.

Limitations of the Indicators: The dependency ratio is an approximation to the ratio of net consumers to net producers. As a proxy for that ratio, the dependency ratio suggests that children under age 15 as well as persons aged 65 or over are economically dependent. In many populations, however, people do not stop being economically active at age 65, nor is it true that all persons aged 15-64 are economically active. Although older persons often require economic support from others, in many societies they have economic resources of their own and provide support to their adult children. Furthermore, as the period of training for a productive life increases, most adolescents and young adults remain in school and out of the labour force, effectively extending the period of young-age dependency well beyond age 15. Whenever available, direct estimates of net producers and net consumers can be used for a more precise assessment and analysis of economic dependency.

(i) Data needed to compile the indicator: The information on population classified by age that is necessary to calculate the dependency ratio is usually derived from censuses or demographic surveys. The United Nations recommends that countries undertake population censuses every 10 years. Since the last census of 2006, no other has been conducted in Nigeria. Even the 2006 Census had no complete release of relevant data such as those related to dependency ratios.

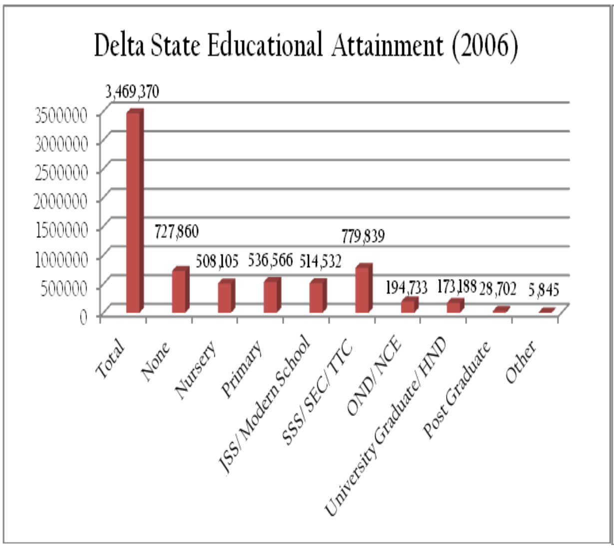
The communities have a high dependency ratio typical of the Delta State relatively high dependency pattern. The total overall dependency ratio for the study communities was calculated to stand at 76.06. So, in theory, slightly over one half of the population is of the working age (15-59 years) and supporting the other half of the population, who were either children or retired/old. In practice, the over-reliance on farming as occupation in the study environment, the over exploitation of the land which may have resulted in high infertility of the soil (a major complaint identified amongst the respondents) and the rearing of large family sizes (high average household size) makes higher dependency ratio inevitable. The overall implications of the age profile are that the population is young and growing and places a heavy burden on the adult population, as well as a huge unemployed human number. There is therefore the need to provide more training, including vocational education and educational facilities to accommodate this young population.

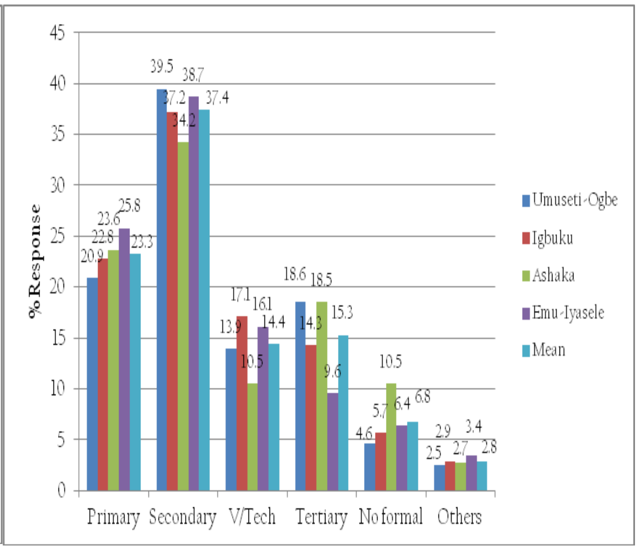
At the State level (Delta), child dependency ratio (age group of 0-14 years) was found to be 31.23%, disaggregated into 16.37% (males) and 14.86% (females). The same source reported old age dependency (60 years and above) for both sex at 5.06% (Delta State Household Survey, 2006). The overall implication of the age profile is that the population is young and growing and places a heavy burden on the adult population. More importantly, the State Government need to commit more resources in the provision of socioeconomic infrastructure, particularly in the area of educational facilities as well as employment opportunities and other social welfare scheme required for the preparation of the dependent young population to become productive when they move into the productive age group.

Educational Status and Characteristics

Education is a key determinant of lifestyle and social status among individuals. Studies have consistently shown that educational attainment is highly correlated with socio economic wellbeing, health behaviours and attitudes. A large proportion of the sampled population has formal education indicating a literate society. The common classes of educational attainment among the sampled population are the tertiary, post primary and primary education. On the average, 15.3% of the respondents had tertiary education training. Those with post primary (secondary) and primary education accounted for 37.4% and 23.3% respectively.

The possession of vocational/technical education among the sampled population is quite high (14.4%) and this is good on occupational skill needed for prospective employment positions that may be offered to members of the communities. Those of NFE constitute 6.8% and 2.8% others *(Figure 4.25a).* The educational attainment of the studied communities is in conformity with the Delta State educational attainment where the bulk of attainment is in secondary educational level *(Figure 4.25b)*.





Figures 4.25a & b: Educational attainment of respondents and Delta State Educational Attainment

Beyond the aggregate figure for Delta State, the literacy level amongst the respondents in the project area of influence, indicate that mostly the retirees make up the bulk of those with tertiary education. 10.2% of the respondents had either Teachers certificate while some have other training in addition to WASC/GCE; Another 6.8% of the respondents had intermediate non-degree qualification such as OND. Furthermore, about 21.1% and 25.2% of the respondents fall within the categories of junior and senior secondary school certificate holders. Also, 11.5% had vocational/technical education while 18.4% had primary school leaving certificate, 4.1% and 2.7% had Non-Formal education and others respectively.

Table 4.16: Educational Status of Respondents in the Study Area

Educational Category	Male	Female	Total	Percentage
No Formal Education	2	4	6	4.1
Primary	11	16	27	18.4
Junior Secondary	13	18	31	21.1
Senior Secondary	22	15	37	25.2
Post-Secondary (non-degree)	6	4	10	6.8
Post-Secondary (degree)	10	5	15	10.2
Vocation/ Technical education	9	8	17	11.5
Others	2	2	4	2.7
Total	**75**	**72**	**147**	**100**

Source: Field Survey, 2020

Livelihood and Micro-economy

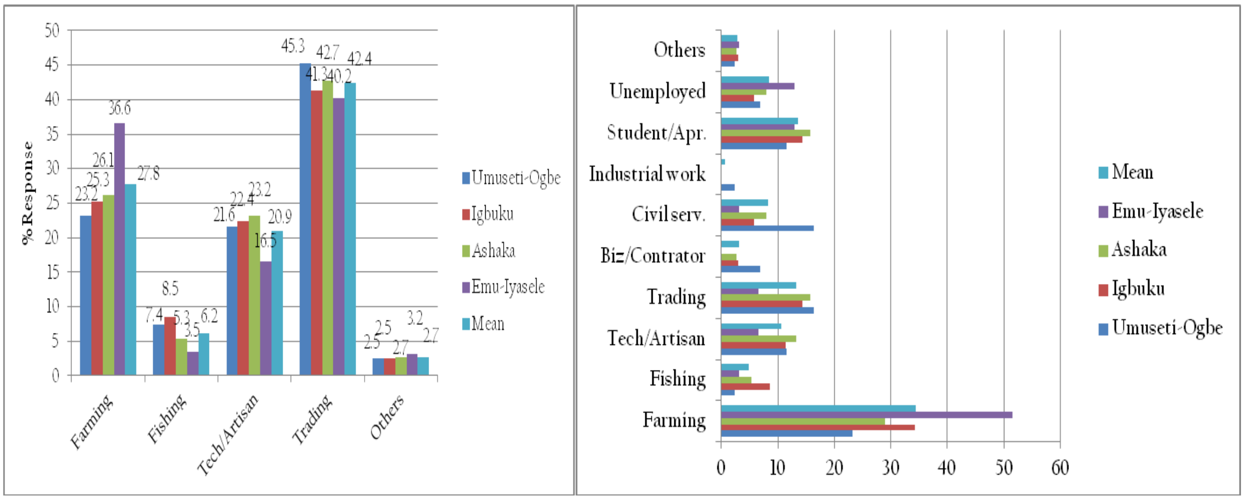
- **Occupation, Employment and Income Generating Activities**

Economic conditions have a vital role to play in people's experience and perceptions of place. A person or a household's socioeconomic status influences the range of opportunities and constraints that people face. In fact, socioeconomic status affects almost all aspects of life. It affects nutrition levels and health, geographic mobility, educational attainment, and overall quality of life.

The livelihood of the communities in the study area depends much on their natural resource-based traditional occupations. Farming is obviously the major occupation practiced, supplemented with other agriculture-based enterprises such as palm fruits harvesting and processing into palm oil. Most of these activities are carried out at subsistence level, i.e. peasant farming.

Aside from the traditional occupation, other income generating activities identified include petty trading, contracting, transportation/driving, and technical and artisan works (tailoring, welding, motor mechanical works, electrical works, and carpentry). In addition, there are few company workers and civil servants as well as teachers in local schools in the area. All of these other economic engagements have affected traditional agriculture. As a consequence and contrary to expectations, the percentage of people currently cultivating the land appears to be dwindling as the years pass on.

Responses from administered questionnaires and focus group discussions (FGDs) confirm the above assertions. On the average, those found to be engaged in farming amounted to 34.5 percent and barely 4.8% take to fishing, so that together less than one half (39.3%) are into agriculture ***(Figure 4.26a).*** Trading and artisanship/technicians 13.2% and 10.6% respectively are the other occupations with some significance in the surveyed communities. Unemployed population amounted to some 8.4 percent; students/apprenticeship (13.6%) and small percentage of 3.2 percent are into business and contracting. More of the population are into trading as a secondary economic activity (42.4%), which in fact is more representative of the economic landscape of the study environment. Those in the informal sector of the economy, e.g. technical and artisan activities assumed higher percentage of response (20.9%) as a secondary occupation ***(Figure 4.26b).***



Figures 4.26a &b: Primary and Secondary Occupation of Respondents in the FD Study Communities

The principal crops planted by the population are cassava, yam, maize, pumpkin, plantain, cocoyam, sweet potatoes, banana, maize, melon, beans, okra, pepper, tomatoes, groundnut, soybeans, garden eggs and pineapples and other vegetables. In addition to these food crops, fruit crops like orange and cash crops such as rubber, rice, and palm produce are major cash crops cultivated in the area.

Cassava (either in its raw form or processed into cassava flour, i.e. garri or *akpu,* the staple food of some Niger Delta people) ***(Plate 4.14),*** plantain and yam serve dual purposes; they are the most important food crops (staples) and cash crops. However, plantain, cassava, banana, cocoyam, maize and melon yield more income to the householders than any other crop. Palm produce (oil) is major income generating activity for those involved in its production**.** Palm nuts from individual farms or collected from the wild are cut, and then processed in local mills into palm oil. Rearing of livestock is limited to poultry, especially the local fowl and goats. Local implements such as machetes and hoes are used for farming. The communities lack access to modern farm inputs and technologies such as fertilizers, credit, agro-chemicals (herbicides, pesticides etc.) and tractors etc.

Although a higher proportion of the resident population in the study environment are engaged in agricultural activities, responses revealed a gradual withdrawal adduced to several reasons chiefly because of the disproportionate harvests resulting from the continued efforts invested. Many claimed to have had their environment and livelihoods affected over the years. Over one half (50.3%) on average claimed have experienced a reduced harvest over the past few years, over a third (39.1%) also claimed to have had increased harvest and a tenth (10.3%) also thought the harvest had remained the same over the years. Over a third (39.6%) also claimed to have had increased harvest. The reasons adduced by those who thought agricultural productivity have continuously declined over the years varied from, 'oil pollution/spillages', 'gas flaring', and 'environmental degradation' to ''changes in climate'', ''youth leaving farming to engage in other more productive activities, including oil/gas'', according to a very knowledgeable key informant in the study communities. These varied reasons have resulted in 'loss of soil fertility', in addition to the perennial ''flooding'', that inundates the farmlands resulting in loss of crops.

The principal constraints being experienced in farming in the proposed further development study area include ''inadequate/lack of capital (51.8%)'', a characteristic of rural poverty, ''insufficient labour hands'' to engage in the farming business (6.7%), because younger ones no longer take to farming, and ''insufficient land to farm on'' (20.5%). The ''use of poor technology/local tools and methods'' (17.6%), and 3.4% others was also mentioned as a principal constraint to improved agricultural productivity ***(Figure 4.27).***

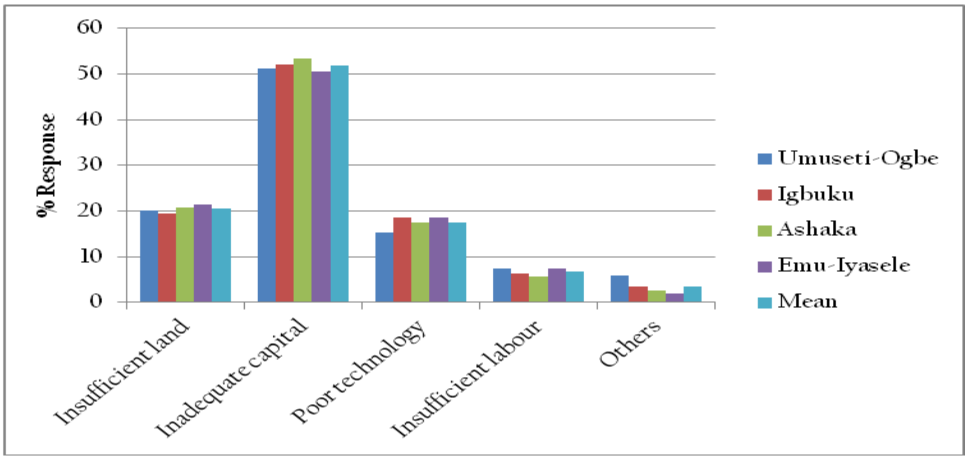


Figure 4.27: Constraints experienced by farmers in study environment

Plate 4.14b: Cassava, processed into cassava flour is both a major staple and income earner for households across the project area communities (above); palm produce, processed into oil is also a source of income earning (middle); welding activities (below) as well as lumbering employ also a smaller percentage in the area

Trading Activities**:** Although the livelihood system in the study area appears predominantly subsistent, excess produce from the farming efforts are taken to the markets for sale to earn incomes. The trading system in the area is such that each of the community has a market day, which holds on regular intervals of every four-day or every seven-day. Some of the communities have functional marketing structures within their immediate domain from which periodic markets are held ***(Plate 4.15).*** Agricultural produce and manufactured goods are sold in almost all the markets which hold on every *Eke* day (market day). Some of the markets attract people from far-flung areas and agricultural produce bought are taken to the urban markets for sale while some of the farmers also prefer taking their produce outside of the producing areas to the urban markets usually to attract higher market value.

Plate 4.15: Typical of shops along major road and market in the Igbuku-Umuseti Field stakeholder communities

Employment Status in the Communities

Residents of the communities experience employment and unemployment. The employed are engaged in one or more of the identified livelihood activities as identified in the preceding section. The Unemployed here refers to those who are ready and willing to work but are unable to secure one. During discussion and interview sessions, community sources indicate that several households among them had one or two unemployed members. They estimate the rate of unemployment among residents at between 25% and 30%. Sources at host communities estimated the higher figure at 30%. These figures conform to the unemployment situation in Nigeria. For instance, in its 2011 Annual Socio-Economic Report, the National Bureau of Statistics (NBS) estimated the level of unemployment among rural residents in the country as follows: Among the uneducated, the rate of unemployment was 22.8%, among primary school levers it was 22.7%, among JSS graduates it was 36.9% and among SSS graduates it was 22.5%.

The age distribution showed that among 18-24 year olds, unemployment rate was38.2% in the rural areas, among 25-44 year olds it was 24.1% while for those aged 45-59 years it was 19.65% and among those aged 60-64 years it was 22.1%. The sex distribution of unemployment was 25.1% among males and 26.1% among females. This would suggest that the rate of unemployment across these communities is highest among females aged between 15 and 24 years whose only qualification is Junior Secondary School Certificate (NBS, 2011). The International Labour Organization (ILO), however, estimated that unemployment rate across Nigeria in 2014 was 10%. It also indicated that the main employment problem in the country was underemployment rather than unemployment (This Day Newspaper, 23 July 2014). The Igbuku-Umuseti Field obviously will provide more employment for some residents of the stakeholder communities.

Income Levels and Distribution

Income is an important variable that influences socio-economic status of individuals and its distribution pattern has the potential of influencing other demographic variables. However, 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-endeavors. Household members are engaged in several income-generating activities and their respective contributions to the overall household income most times are difficult to calculate. The consequence is that presented incomes of rural households are often less reliable.

For the Further Development of Igbuku-UmusetiField EIA study, income estimation extracted from the administered structured copies of the questionnaire, revealed a spread of monthly income across the income brackets. The modal income bracket is the N35, 000 – 40,000; some 28.1 percent of the respondents earn this much. Other relatively significant income brackets are the 25,000-30,000; 30,001-35,000 and 40,001-45,000 respectively. Some 11.8%, 18.4% and 15.6% earn these monthly incomes while a very insignificant percentage (6.2%) reported earning less than N15, 000 ***(Figure 4.28).*** Interactions at FGDs revealed that residents, who are into business and contracting earn better incomes that averaged about ₦100, 000 in a month. However, the frequency of getting such businesses was unpredictable.

Studies across the Niger Delta communities (UNDP, 2006, NDDC, 2006) have confirmed that except for those employed in oil and gas related activities, income of majority of the people in the rural communities are generally low and highly variable.

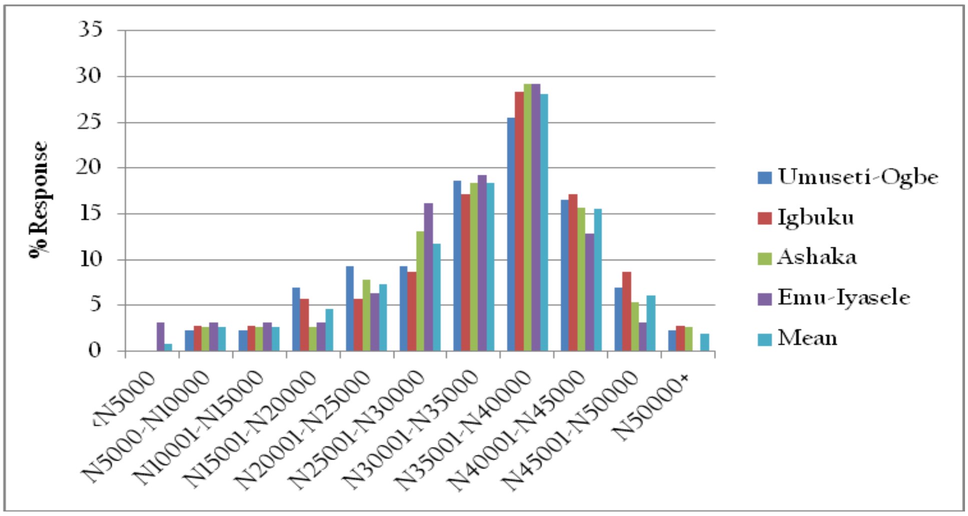


Figure 4.28: Monthly income level of respondents at study environment

Monthly income levels from primary and secondary livelihood activities in the FD stakeholder communities are further presented in Table 4.17.

Table 4.17: Monthly Income Levels in the Study Communities

Income Range and Midpoint (N)	Community/Frequency				Total of Study Communities					
	Umuseti-Ogbe		Igbuku		Ashaka		Emu-Iyasele		**(No)**	**(%)**
	(No.)	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**	**(No.)**	**Total Income (N'000)**		
1,000-5,000 (2,500)	0	0	0	0	0	0	1	2.5	**1**	**0.6**
6,000-10,000 (7,500)	1	7.5	1	7.5	1	7.5	1	7.5	**4**	**2.8**
10,001-15,000 (12,500)	1	12.5	1	12.5	1	12.5	1	12.5	**4**	**2.8**
15,001-20,000 (17,500)	3	52.5	2	35.0	1	17.5	1	17.5	**7**	**4.7**
20,001-25,000 (22,500)	4	90.0	2	45.0	3	67.5	2	45.0	**11**	**7.5**
25,001-30,000 (27,500)	4	110.0	3	82.5	5	137.5	5	137.5	**17**	**11.5**
30,001-35,000 (32,500)	8	260.0	6	195.0	7	227.5	6	195.0	**27**	**18.4**
35,001-40,000 (37,500)	11	412.5	10	375.0	11	412.5	9	337.5	**41**	**27.8**
40,001-45,000 (42,500)	7	297.5	6	255.0	6	255.0	4	170.0	**23**	**15.6**
45,001-50,000 (47,500)	3	142.0	3	142.5	2	95.0	1	47.5	**9**	**6.2**
Above 50,000 (52,500)	1	52.5	1	52.5	1	52.5	0	0	**3**	**2.1**
Total	**43**	**1,437,000**	**35**	**1,202,500**	**38**	**1,285,000**	**31**	**972,500**	**147**	**100**
Community Average Income (₦)	**33,418.60**		**34,357.14**		**33,815.78**		**31,370.96**		**33,240.60**	

Source: Field Data 2020

The mean monthly incomes in the communities are as follows; Umuseti-Ogbe ₦33,418.60, Igbuku ₦34,357.14, Ashaka ₦33,815.78, and Emu-Iyasele ₦31,370.96. The modal income bracket across the communities is N35, 000 and above. Given the mean income values and assuming naira to United States of America dollar (USD) conversion rate of ₦360: 1USD and 30 days in a month, the daily individual incomes will be ₦1,113.95 or 3.10UzxzxSD in Umuseti-Ogbe, ₦1145.24 or 3.20USD in Igbuku, ₦N1,127.19 or 3.13 USD in Ashaka, and ₦1045.69 or 2.90USD in Emu-Iyasele.. Using the midpoint of the modal income range (i.e. ₦37, 500) individual daily incomes in the communities will be ₦1, 250 or 3.50USD. Daily incomes in the communities are higher than the World Bank extreme poverty income of 1.9USD.

Household Expenditure/Consumption Patterns & Ownership of Household Items

A ranking in order of concern on issues for household expenditure during FGDs indicates that *food* was listed by 75.0% of heads of households as the most important spending priority, with *entertainment* ranked the least in priority in the communities. Spending on *Education* was ranked the second most important household expenditure item by the respondents. Healthcare, energy, and transportation were rated low in their expenditure priority lists. It was however, difficult for the discussants to estimate accurately how much individual households spent on these priority items per month.

The availability of durable consumer goods is a good indicator of a household's socioeconomic status. Moreover, particular goods have specific benefits. For instance, having access to a radio or a television exposes household members to innovative ideas; a refrigerator prolongs food storage; and a means of transport allows greater access to several services away from the local area.

As a measure of the overall quality of life apart from incomes and available community-wide basic infrastructures, the proportion of the population with or without the requisite amenities in their dwellings indicates a satisfactory situation. Generally, many households were found with basic household amenities; approximately 82 percent on the average reported having one of the many amenities like telephone (mobile/GSM), electric fan, radio, television and generator as opposed to 18 percent without basic household amenities/properties. Householders at Umuseti-Ogbe, Ashaka (86.7%) were found to possess more of household properties while those at Igbuku and Emu-Iyasele (68.6%) have the least possession of household amenities/properties.

The 2008 NDHS report revealed that 74% of households in Nigeria own a radio (84 percent in urban areas and 69% in rural areas), and 39% own a television (69% in urban areas and 23% in rural areas). A mobile telephone is owned by 50% of households (76% in urban areas and 35% in rural areas), while 16% of households own a refrigerator (NPC and ICF Macro, 2009).

Religion, Customs, Belief System and Heritage

- **Religious Affiliations, Customs, Belief Systems, and Heritage**

Delta State, with its diverse ethnic and linguistic groups, is also very rich in culture and the arts. Several cultural bonds exist among the ethnic groups, particularly in music, dances, plays and masquerades which are very dependent on socio-cultural and religious background.

Christianity with long historical origin is predominant among the Delta Ibos, herein includes the Ndokwa/Ukwuani ethnic group as in other parts of Delta State, although there are strong influences from traditional religious beliefs. It is safer to say that the religious persuasions of the majority of the population is ‘’mixed’’. For the practicing Christians, religious houses, i.e., Churches of various denominations and sects of Christendom abound in the area, including those of the orthodox and Pentecostal denominations, dominated by the Anglican Communion and the Catholic Church with gigantic structures.

Although Christianity has an overwhelming presence and influence on the people, the communities still retain some of their traditional beliefs. In the project affected communities, there are areas considered sacred; such sacred sites or forbidden ‘grounds’’ regarded as the abode of the gods are ‘out-of-entry’ (i.e. non-accessible) for ‘strangers’. Any ‘’unauthorized’’ trespasses are sanctioned for the sacrilege. Cultural and traditional practices relating to such ‘’forbidden grounds and forests’’, are either conducted at the individual level with the nuclear family or at the community level. Although the participants at the group meetings (FGDs) failed to mention the existence of such forbidden/sacred sites on their land, it is safer to say that the older genre (elders and those of the traditional African religious persuasion) may be more knowledgeable about issues of this nature. There is however, indications that the role of shrines and sacred places has seriously been downplayed by Christianity and development as the years pass by.

Festivals, Calendars, cultural Groups, and Value System, Taboos and Social Norms

The most cultural heritage of the people remains their festivals, which are tied to their way of life and livelihood, i.e. the seasons. Culturally therefore, the subsisting festivals relate to either the fertility of the land and waters or the blessings of the ‘’gods’’. Their celebrations therefore coincide mostly with the beginning of the farming/planting and harvest seasons. As Christian communities, the Easter and the Christmas celebrations are part of their cultural heritage. There is a wide variety but same commonality of festivals still celebrated by the Igbuku-Umuseti Field stakeholder communities in the area, with marked periods of celebrations and some have serious strictures attached to them (e.g., some masquerade cults require all and sundry to keep off the streets when it is to be celebrated at night, though prior notices are given to this effect). These annual festivals are considered important for warding off evil, promoting fertility in marriages and profitable enterprise with farming and other activities. The reality on ground

however, is that traditional worship is rooted in the culture of the communities and even acclaimed Christians participate in the festivals at different levels of commitment.
Every society is guided by some value systems which attempt to regulate or guide the way of living, otherwise there could be anarchy with disastrous results. The inhabitants of the study environment with cultural allegiance to the Ukwuani ethnic group have its value system, taboos and social norms as well. Other belief systems revolve around the communal social life of the inhabitants in the affected communities. Social maladies such as incest, adultery, stealing, fighting with cutlass, bottles or gun and mating with a woman in the bush are amongst the customs and beliefs, which are seriously frowned at. Violators are dealt with by either being physically beaten up and subjected to some punishment or asked to pay some fine, including the appeasement of the offended deity and/or ancestors.

Social capital:
Community service and exemplary behaviour are rewarded with membership in social clubs or chieftaincy titles. Religious groups, traditionalist groups, cults, community based organizations and thrift clubs provide strong social networks that unite members through a common set of shared values.

Taboos
In addition to the shrines (Agbadore, Exade and Ogbure-ewu, Uzu and Ojeh) and festival attached to them, the people observed some taboos. These taboos are:

- Having sexual intercourse with a woman in the bush/forest,
- A woman under menstruation is not allowed to enter the shrine,
- Sleeping with another man's wife (adultery)
- At Igbuku community, corpse are not allowed at "Otiti" area
- Eating of bush fowl (Okwukwu-ogo) is highly forbidden

It is a general belief of the traditional worshippers that these shrines and forbidden forests provide their community spiritual protection against external aggression and promote progress. As a result, these shrines and forest are held in high esteem and ensure that nothing is done to desecrate them.

Family Structure and Marriage
Most traditional communities are composed of the nuclear families, the extended family units and the lineage wards, a conglomeration of which make up a settlement (Okaba, 1999). An amalgam of three to eight nuclear families of common descent constitutes an extended family unit, and these have residential locations that are easily distinguished. Four to six of these extended families make a lineage ward, all sharing a common ancestry (Okaba, Ibid.) Polygamy is a widely practiced form of matrimony.

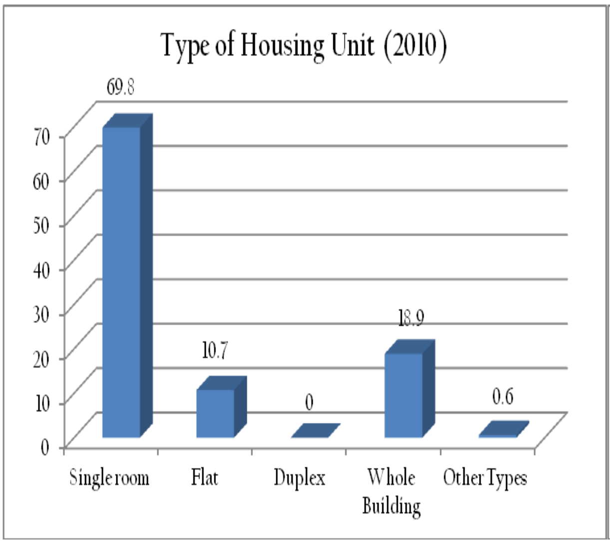
Households are partrilineal and patrilocal, both serving as basic residential and economic units. The marriage custom of bride price payment on woman and marriageable girls is widely practiced within the study area. The traditional marriage which requires the kith and kin of both family to gather while the bride price of the girl is paid. On paying the bride price as well as all traditional rite is done, the offspring belong to the man. On the other hand, where bride price of a woman is not paid, the offspring(s) more often than not belong to the woman's family. The categorization of the marriage custom as described here influences patterns of kinship relations and inheritance.

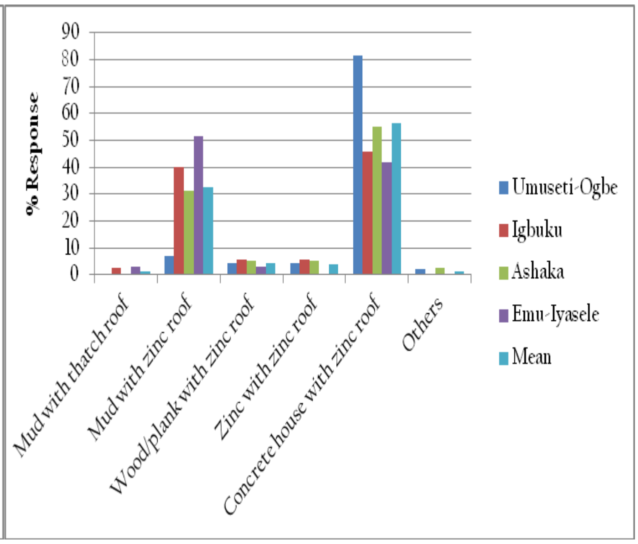
Housing

- **House Types**

Housing is a basic social need and an integral part of the human environment and the physical structure of settlements. Housing has been defined by WHO as "residential environment which includes in addition to the physical structure that man uses for shelter, all necessary services, facilities, equipment and devices needed or desired for the physical and mental health and social well-being of the family and individual" (WHO cited in Owei O. et. al., 2002). Housing in the communities is a mixture of modern and traditional designs and construction materials. A few houses have modern designs and they are built with utilities like kitchen, toilet and bath. Most houses in the communities are also constructed with stable and permanent materials like cement blocks and roofed with corrugated iron sheets.

Most houses across the Igbuku-Umuseti Field stakeholder communities are bungalows and flats. The bungalows are built with many rooms and are mostly multi tenanted. A few houses are built with single rooms or as self-contained units of room and parlour. Bungalows account for a significant number of houses in the communities. Residents in the project communities believe that further development of the field would encourage the building of more flats in the communities for rental purposes. Some of the houses are owner occupied houses; some, especially the flats, have toilets and baths located in-house; but most are not provided with these utilities. Some also have kitchens in-house. However, the survey analysis revealed 1.5% of the housing type in the host communities to be mud with thatch roof, mud houses with zinc roof 32.5%, wood/plank with zinc roof 4.6%, zinc with zinc roof 3.8%, while concrete houses with zinc roof are more in the communities with 56.3% and those others houses account to about 1.3% (Figures 4.29a &b).





Figures 4.29a & b: Housing type & Housing unit Source: NBS/CBN/NCC Social-Economic Survey on Nigeria, 2020

Plate 4.16: Housing type/quality in Igbuku-UmusetiField proposed Further Development stakeholder communities

Availability and Cost of Rental Accommodation

Rental accommodation is available in the communities. A number of residents, including indigenous members of the communities, live in rented accommodation. Value of house rent in the communities varies according to the construction material. A room in a house built with mud walls and roofed with zinc attracts N1000 per month across the communities while a one room accommodation in cement block house costs N3000 monthly while a room and parlour in a similar house costs N5, 000. Flats, two and three bed rooms, cost between N12, 000 and N17, 000 at Umuseti-Ogbe and Ashaka but differs in Igbuku and Emu-Iyasele where same accommodation are relatively cheaper.

Available Housing Utilities

Houses in the communities are built with limited utilities. For instance, as a result of the problem of public power supply, residents use alternative sources like private electricity generators, kerosene lamps, torches and candles to light up their houses. Common sources of energy for cooking household meals are firewood and kerosene. About 90% of households across the communities cook with firewood. The project stakeholder communities' drinks and cook from river/stream water around them. However, some have functional public and private borehole in their communities.

Plate 4.17: Typical of public borehole at Igbuku-UmusetiField proposed FD stakeholder communities (Igbuku, Ashaka, Emu-Iyasele and Umuseti-Ogbe respectively)

Meanwhile, some houses in the communities do not have running pipe borne water because the public supply does not have the distribution network that facilitates delivery to houses in the communities. A few houses have private water boreholes installed, and these are the most reliable sources of water to many residents. In addition to the private boreholes, residents use water from the river and rain water.

Existing Businesses

Existing businesses in the communities are small scale. They comprise primary production activities as represented in the two traditional occupations of farming and fishing, commercial activities represented in trading, in shops and markets. The communities have major provision store and drug stores. Apart from these there are also business centers, welding shops, carpentry and furniture making shops, electrical and electronic repair shops, motorcycle repair and tire vulcanizing shops. Another existing business is transportation by commercial motorcycles, Keke NAPEP and motor vehicles. Available businesses in the study communities are in the informal sector, there are organized private sector businesses and industries in the communities especially at Umuseti-Ogbe and Ashaka.

Banking and Informal Credit Institutions

Residents do their banking transactions mainly at Kwale and POS stands located in some major communities like Umuseti-Ogbe, and Ashaka. Existing informal credit practices among residents are the traditional contribution and Osusu. Contribution entails a group, usually made up of friends and acquaintances, who commit themselves to a fixed monthly contribution over a number of months, usually determined by the number of members of the group. A member takes each monthly contribution, and this is done in rotation until every member has had an opportunity. For participants, this represents a source of funds for business investments, payment of fees and bills and purchase of various items, among others. Osusu, on the other hand is organized by an individual who collects money from participants in the scheme. The sum collected is agreed with the participant, the duration is varied but mostly daily or weekly. The total sum collected, less an agreed amount (usually one daily or weekly collection, depending on agreed frequency of collection) is returned to the participant at the end of the month. Osusu is common among petty traders and artisans and it provides some savings which is used at month end to pay salaries of their assistants and purchase essential materials for their trade. Usually the person who organizes the 'Osusu' deploys the funds collected as short term credit to micro and small scale businesses and charges an interest.

Land Use and Resource Harvesting

- **Available Resources**

The Igbuku-UmusetiField proposed FD stakeholder communities is endowed with a lot of natural resources. These resources have been exploited by generations of residents, and have kept and sustained the continuous human settlements in the entire area. The resources are the water bodies, the forest and the land mass. Water bodies in the study area include the rivers, ponds and wetlands. Ponds and wetlands are situated in bushes and forests around the communities. These water bodies yield the fishes on which the communities depend for food and livelihood. The forests are home to a number of resources including timber, firewood, economic trees like the raffia and bush mango (Ogbono).

The timber is useful in building houses and supports canoe repairs activities. The land provides for the physical development of the communities including housing and infrastructure. It is a major resource for farmers as it supports the growing of a variety of crops like plantain, cassava and vegetables etc. A traditional natural resource conservation practice among farmers is shifting cultivation and its attendant bush fallow system practiced in the communities. The practice requires that farmlands are cultivated for a period and left fallow for a number of years. The period of lying fallow allows for the farmland to regenerate naturally. During the fallow period also, farmers cultivate alternative farmlands which had been left fallow in the previous period. This is a common cultural practice that has served to protect and conserve the communities' farmlands, which are a valuable natural resource, from excessive exploitation.

- **Land Ownership and Tenure**

The Land Use Act of 1978 provides the framework for land ownership and payment of compensation for land acquisition for development purposes in Nigeria. However, some of its provisions like the ownership of all lands by the Government have not been well received, especially in southern Nigeria (including Delta State and the Igbuku-Umuseti Field proposed FD stakeholder communities). The rejection stems mostly from the socio-cultural significance of lands.

Therefore, in spite of the law, communities and families still assert their ownership rights over lands. Lands in the communities are primarily owned by extended families, compounds and the community. In the communities, families and compounds own lands. Ownership rights over lands are handed down from one generation to another within the extended family, compound and community. Such inherited land is put to any use as desired by the owners.

These are the lands on which family, compound and community members build their houses. They are also allocated to members for use as farm lands and for other economic purposes. These lands revert back to the families and compounds at the end of the farming period. Farmlands can be leased by non-family and compound members. Such lands similarly revert back to the owners after the period of lease. Lands are managed by males within the extended families and compounds. ***Figure 4.30*** shows that 67.7% of lands are owned through family inheritance, 21.6% bought it, 6.5% rented/lease it, while 1.5% sharecropping and 2.7% others.

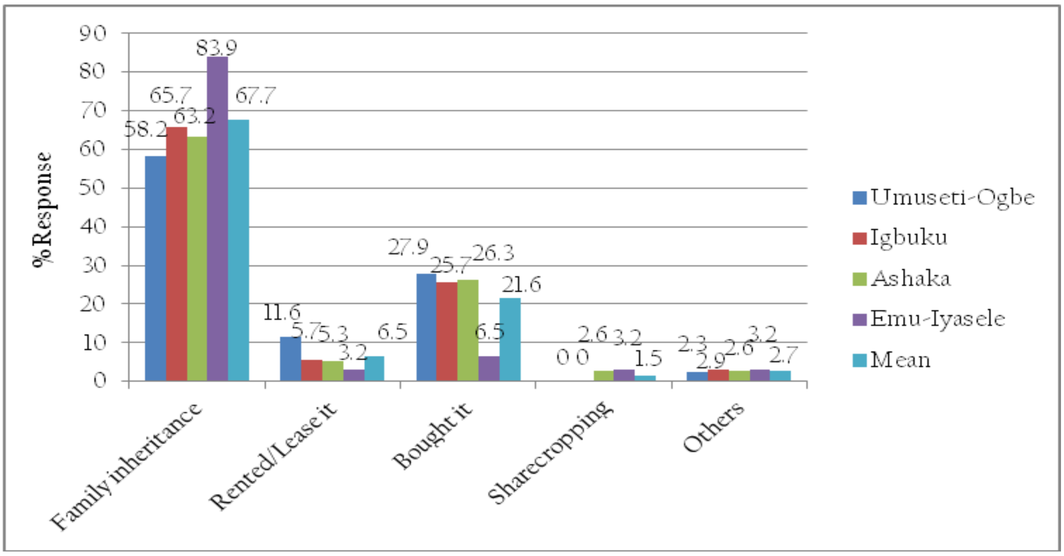


Figure 4.30: Land ownership system

- **Classification of Land Use**

Land in the Igbuku-Umuseti Field proposed FD stakeholder communities are an invaluable resource. Traditionally, these have been used over the years for farming and housing, and in more recent times there have been additional uses for infrastructural development and industrial purposes. Residents were conscious of a gradual decrease of the lands in the communities over the years. Their perceptions and estimates of the proportion of lands put to various uses and lands lost to natural factors are presented in ***Table 4.18***. Most of the lands have been put to agricultural use. Lands put to industrial use mainly could be the one on the Igbuku-Umuseti Field project and occupied by oil exploration companies in the area. Land loss has also mostly been attributed to the natural factors of erosion from the river and rain fall.

Table 4.18: Land Use Structure in the Igbuku-Umuseti Field FD Study Communities

Land Classification	Communities/Frequencies (%)			
	Umuseti-Ogbe	Igbuku	Ashaka	Emu-Iyasele
Agricultural	60.0	70.0	70.0	79.0
Industrial	10.0	5.0	5.0	1.0
Housing	15.0	15.0	15.0	15.0
Institutional	10.0	5.0	5.0	5.0
Loss from	5.0	5.0	5.0	5.0
Total	100.0	100.0	100	100

Source: Field Survey, 2020

Land use Tenure System and natural Resources

Land use and ownership system in any society is generally governed by a tenure system evolved over time and determined by the perceived demand as well as the potential and actual social pressure associated with its supply and use (Powell, 1995, Swallow and Kamaro, 2000). Land use pattern visible in all societies include public land use, commercial land use, industrial land use, recreational land use and social land use. As in the case in most communities in the Niger Delta area, land ownership is rested in individual, families as well as communities.

As shown in Table 4.19, the predominant land tenure system practiced in the proposed FD stakeholder communities was individual ownership (60.5%), family ownership (20.5%); communal (12.4%); while rented/leased was 6.6%. FGDs discussions conducted with members of the surveyed communities confirmed the arrangement. They also agreed that access to land was through inheritance while control is left in the hands of the individual families and communities that owned bush land. In most cases community's lands are used for developmental projects such as schools, health care service.

Table 4.19: Natural Resources Assessment of Igbuku-Umuseti Field FD communities

Community	Tenure Right			Access to land rent inheritance	Access to forest free (yes/no)	Access to water (yes/no)	Presence of forest reserved (yes/no)	Land control	Land used/ farming development habitation and cemetery
	Land individual/ family/ community	Forest individual/ family/ community	Water/ Lake Community						
Umuseti-Ogbe	C F	F C	C	Inheritance	Yes	Yes	No	F C	✓
Igbuku	C F	C F	C	✓	✓	✓	✓	✓	✓
Ashaka	C F	C F	C	✓	✓	✓	✓	✓	✓
Emu-Iyasele	C F	C F	C	✓	✓	✓	✓	✓	✓

Source: Field survey, 2020

C = Community, **F** = Family, **I** = Individual

Infrastructure

- **Functional Status of Available Infrastructure**

The infrastructural framework in the proposed FD study communities is made up of a few physical and social amenities. Some of the available amenities are functional while some are not. Most of the amenities have been provided by governments, development agencies. The physical amenities include paved access roads, internal roads, community halls and telecommunication services. Social amenities consist mainly of education, health, water supply and electrification facilities.

The proposed FD project communities are accessed by paved road. Some sections of these roads have potholes and need extensive repairs. They also have some paved internal streets of varying lengths. The communities are accessible from Kwale through the paved Ashaka road. Taxis/Bus from Eke Market square to Igbuku-UmusetiField cost N400 per passenger. Internal transportation in each of the communities is by commercial motorcycles which cost N50 per passenger depending on the distance. Wooden boats and canoes are commonly used in the communities for fishing purposes. Another major physical infrastructure in all the communities is Telecommunication services. Telecommunication services from GSM service providers (MTN, Airtel, 9Mobile and Glo) are received in the communities, though depending on your network and position.

Each of the communities has one public primary and each has one public secondary school. The primary schools run classes 1-6 and the secondary schools have JSS 1-3 and SSS 1-3 classes. Health centers are located in all the communities except at

Emu_Iyasele where there is none. The communities have electrification facilities and connected on the national grid. However, the people like other part of the country have power once in awhile and depend more on their individual generating set. Meanwhile, all the communities have market built with open and lock-up shops except Emu-Iyasele that doesn't have market. The markets are periodic. The youth organize themselves into vigilante groups. The closest security presence to Kwale and Ashaka comprises the police station. The communities do not have any developed public recreation facilities. Residents recreate by playing football in the school football fields or swimming in the river. Some stay at home and watch television for few who have television and can afford running cost of generator.

- **Available Social Infrastructures and Services**

The development, availability and access to basic social infrastructure, in addition to employment were the greatest concerns of the resident community population in the Igbuku-Umuseti Field study environment. Complaints were rife that both the Delta State Government and the Ndokwa West LGA Council have had minimal intervention in the area in terms of amenity provision. The oil and gas company on the other hand (POL), relatively new on the scene have had better impact was greatly appreciated by many in their efforts so far. The NDDC (and its predecessor, OMPADEC) had sponsored some welfare-enhancing projects, but the benefits derivable from some of such basic social amenities were not sustainable. Some of the facilities have been left uncompleted or un-maintained, leading to depreciation and non-functionality of some. There are public primary schools in each of the communities, potable water, access to primary health care services; electricity and accessible roads to the communities are available although in different functional status.

Table 4.20: Available Social Infrastructural facilities in the FD stakeholder communities and its provider/donors and state

S/no	Community	Type of infrastructure	Provider/Donor	Functional
1	Ashaka	4 Borehole water	NDDC, EU & State government	No
		Health center Have both primary and secondary school	By State government	Yes, functional
2	Igbuku	**Water and Sanitation**	By European Union (MPP9)	Not functional
		Market with open shop	Community self effort	Yes, functional
		Primary School	By State Government	Yes, functional
		Community Secondary School	By State Government	Yes, functional
		Other Primary and Secondary Schools	By Private individual	Yes, functional

		Energy/Electricity - Connected to the national grid	BEDC	Energy supply complained to be irregular. Private generators and local hurricane lanterns used by some as alternatives.
3	Umuseti-Ogbe	**Water and Sanitation**	By NDDC	Not functional, depend more on private borehole
		Utilizes popular Eke Market with lock up and open shops	By Ndokwa West LGA	Functional
		Primary and Secondary School	By Delta State Government	Functional
		Utilizes popular Kwale General Hospital	By Delta State Government	Functional
		Energy/Electricity - Connected to the national grid	By BEDC	Energy supply complained to be irregular. Private generators and local hurricane lanterns used by some as alternatives.
4	Emu-Iyasele	**Water and Sanitation**	MPP3	Functional
		Have Primary school but no Secondary school. Children and wards attend their secondary education in the neighbouring communities of Ashaka and kwale	By Delta State Government	Functional

Educational Institutions

The Igbuku-Umuseti Field Project stakeholder communities are endowed with at least a public primary and secondary school within their immediate domains. The biggest of the communities among the four, Umuseti-Ogbe and Ashaka, has privately-operated schools to support and provide the needed basic education to the children and wards of the communities. The schools on ground had relatively adequate capacities in terms of structures (some need rehabilitation/renovation) and pupils/students enrolments were adequate but the number of teachers in the schools was a cause for concern.

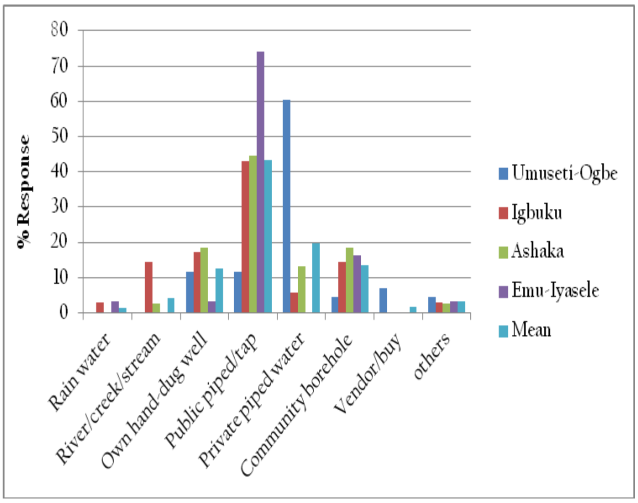
Plate 4.18: Typical of educational institutions at the Igbuku-Umuseti Field FD stakeholder communities

Electricity Supply

Electricity supply in the area is mainly from Benin Electricity Distribution Company (BEDC). Though there is electricity power but like in every other part of Nigeria, supply is not regular in the communities. Power supply has therefore formed one of the expectations of the people. The people currently depend mainly on generator and for those who can't afford generator uses local lantern and candle light in some homes. Some respondents claim to spend between ₦10000.00- ₦15000.00 on fueling of their gen set on monthly basis.

Water Supply Facilities

There are public borehole water facilities in all the communities provided by government and different developmental agencies but unfortunately most of them are no longer functional. It is also good to know that the boreholes are functional. The people rely more on private borehole water, and few who uses river/stream, hand dug well and sachet water (pure water)/bottle water as source of water supply. However, from the survey analysis 1.5% rely on rain water for source of domestic water, 4.3% depends on rivers/stream, 12.6% uses own hand dug well, 43.4% (public piped/tap), 19.8% (private piped water), 13.4% (community borehole), 1.7% buys from tanker/truck/vendor or private owned borehole owners and 3.3% others (*fig 4.31a*). However, when compared with Delta State distribution of households by source of water for drinking and cooking, the use of rainwater conformed to Igbuku-UmusetiField FD stakeholder communities' source of water but contrary to the use of stream/river/creek where it is 4.3% compared to NBS data of 30.8%. This is because; the stakeholder communities have functional public and private owned borehole water. Again, according to NBS data 29.3% uses borehole and this appears to be true with the studied communities, 43.4% who rely on borehole water, *(See fig 4.31b).*



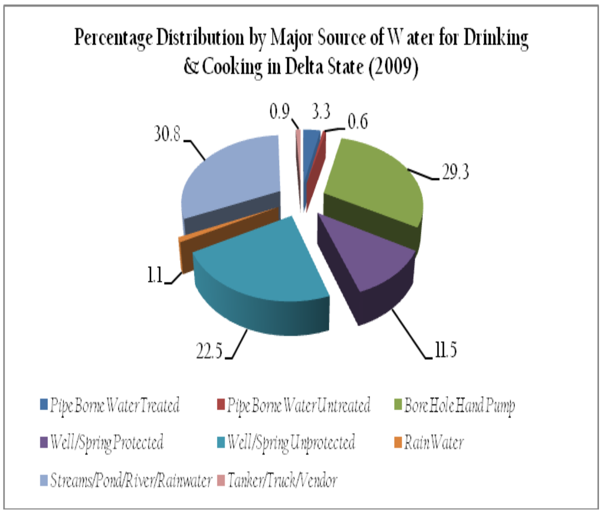


Fig. 4.31a: Source of water supply; Fig. 4.31b: % of Delta State Distribution of Households by Source of Water NBS (2009)

Plate 4.19: Borehole & mono-pump major source of water supply in Igbuku-Umuseti Field FD stakeholder communities

Transportation and Communication Facilities

The Igbuku-Umuseti proposed FD study environment has no physical conditions and constraints to road construction as in some riverine communities in the Delta. The communities are therefore, very accessible via several distributor roads. One area in which the Ukwuani/Ndokwa land has received in large measure democratic dividends is the area of road construction. Within the Ndokwa West LGA, accessibility has been greatly enhanced by the State Government with the construction of several roads, which connects most of the settlements. However, some of the roads have started suffering from wear and tear, no thanks to poor road construction and lack of maintenance and neglect by the responsible authorities.

The Umuseti-Ogbe-Ashaka-Igbuku road is the major artery, from which all the communities are accessed, with feeder roads connecting all neighbouring settlements. The link road from Eke Market square junction at Kwale to Ashaka also runs through to Igbuku, at Ashaka by the Water Board to join the Ashaka-Emu-Iyasele road. Ashaka-

Emu-Iyasele road is not motor-able during core raining season, becoming the only road within the project area is yet to be constructed.

Access to public communication facilities like the telephone in the study communities was also found to be greatly enhanced. In fact, the new mode of telephony, the GSM has made telecommunications quite easy across the area; there is hardly any part within the area where the population does not have access to one of the networks, as base stations and masts are located in some of the communities.

Conflicts and Conflict Resolution

Conflict in the area predates the advent of oil and gas exploitation. Most of these conflicts were related to issues of land ownership, possession of palm oil bearing land, quests for autonomy and struggles for leadership. And now are conflicts arising from issues surrounding crude oil exploitation. In the Niger Delta, where oil exploration has been going on since 1960s, causes of conflict has always been between communities and companies which include: Non-recognition of community as stakeholder, oil spillages, border/land disputes, agitation for employment, refusal of companies to repair damaged roads, non-payment of compensation, 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. These conflicts obviously may surface from time to time but from our interaction with community members during Focus Group Discussion (FGDs), POL was commended in the area of community-company relationship while they (the community members) suggested they (POL) can always improve on the existing cordial relationship.

Be that as it maybe, the conflict resolution strategies of communities in the study area are through dialogue in special meetings summoned by the most elderly person and his cabinet. Traditionally, issues are discussed at the lower levels of family, age grade and women or taken directly to the community leadership. In addition, appeals and summons are common processes utilized at community level. Issues are referred to the police and courts, when they are criminal offences that are mandatory to be reported and when the resolution of the conflict overwhelms community leadership. Conflict resolution at community level could attract penalties such as fines, seizures of assets and ostracizing.

4.3.10 Community Health Environment and Related Issues

(a) Water Supply Facilities

Increasing access to improved drinking water was part of Suatainable Development Goal adopted by Nigeria and other nations globally. A number of indicators are useful in monitoring household access to improved drinking water. The source of drinking water is an indicator of whether it is suitable for drinking. Sources that are likely to provide water suitable for drinking are identified as improved sources. These include a piped source within the dwelling, yard, or plot; a public tap/stand pipe or a borehole; a protected well or spring; and rainwater (WHO and UNICEF, 2010). Lack of easy access to a water source may limit the quantity of suitable drinking water available to a household, even if the water is obtained from an improved source. Water that must be fetched from a source that is not immediately accessible to the household may become contaminated during transport or storage. Especially in such situations, home water treatment can be effective in improving the quality of household drinking water.

According to the Nigerian Demographic Household Survey, 2013, some 61% of the households in Nigeria have access to an improved source of drinking water, with a much higher proportion among urban households (76%) than among rural households (49%). The results show an overall improvement in the quality of sources of water in Nigeria since the 2008 NDHS (when the figure was 56%). This improvement was higher in rural areas (45-49%) than in urban areas (75-76%). The most common source of improved drinking water in Nigeria is tube well or borehole water, used by 44% of urban and 32% of rural households. Thirteen percent of urban households and 10% of rural households have access to drinking water from a protected well. Use of sachet water, which is included under non-improved sources, is common in Nigeria, with 6 percent of households using it as their main source of drinking water. It is used more in urban areas than in rural areas (12% versus 1%).

In the 2013 NDHS, only 20% of households reported having water on their premises, as compared with 25% in the 2008 NDHS. Households not having water on their premises were asked how long it takes to fetch water. About a quarter of households (24%) travel 30 minutes or longer to obtain their drinking water (20% in urban areas and 28% in rural areas).

In the 2013 NDHS, all households were asked whether they treat their water prior to drinking. An overwhelming majority, 88%, do not treat their drinking water. Urban households (8%) are somewhat more likely than rural households (3%) to use an appropriate treatment method to ensure that their water is safe for drinking. The statistics indicates that many households in some of Nigeria's states have no access to improved source of drinking water.

More than any other amenity, water facilities are present in most communities across the Niger Delta region but more often than not, water never flows from the facilities for the population (Ojile, 2010). The availability of social infrastructures in the Igbuku-Umuseti Field stakeholder communities, including those of potable drinking water presents a disproportionate access to potable water supplies for the resident population thus a challenge to human health and well-being. The communities with functional water facilities have complaints of inadequate capacity for the population served. The Igbuku, Emu-Iyasele, and Ashaka communities have access to potable water supplies, thanks to EU and MPP3 but not identifiable running public water at Umuseti-Ogbe. The people depend more on private owned boreholes.

Plate 4.20: Water facilities at Igbuku, Emu-Iyasele and Ashaka by EU, MPP3 and Delta State government respectively aimed at achieving MDG goal of increasing access to improved drinking water

(b) Access to sanitation facility

About 25% of community's members do not have a toilet facility within the ideal 50m distance from their houses, even though most of the facilities were of pit toilet, and some excrete directly in the surrounding bush, a practice that often contaminate surface water, and are not technically considered a toilet facility. The use of these toilet facilities is really a threat to the community member's health as admitted by the respondents since it can contaminate the receiving water body with raw faeces like one of the respondent asked, 'what will they do', since some of the community members can't afford an ideal toilet facility in their individual household.

(c) Energy for cooking

The use of firewood and charcoal was observed from some members of the community as a source of fuel for domestic cooking as well as the predominant method of roasting plantain (bole) and smoking of ice fish, which is preservation in the community notwithstanding the health implications.

(d) Waste management

Waste generated in the communities was mainly garbage and other domestic wastes. These wastes were usually dumped near residential buildings at the backyard. These wastes can become a source of contamination of the water body yet this is what is commonly practiced in the communities.

(e) Sexual behaviour

Sexual behaviour is directly related to the incidence of sexually transmissible infections and diseases, including HIV/AIDS. The two key behaviours useful in public health action are number of sexual partners and condom use. Majority of the Igbuku-Umuseti

Field community members claimed to have only one sexual partner while a few admitted to having more than one. The uptake of condoms from the drug stores was used as proxy indicator to measure the behaviour of the people with regards to preventive measures relating to unwanted pregnancies and sexually transmitted infections. Condom uptake was relatively low.

The knowledge of the existence of HIV/AIDS is high in the communities. The methods of STIs transmission (needles, razor blade and sexual contact) is also well known in the communities. The 2003 NDHS reported that 70.6% of female youths in the South-South reported having high risk (unprotected) sex in past one year (higher than the national averages of 29.4%). However, the HIV/AIDS Reproductive Health Survey showed figures for South West females and males to be 69.3% and 68.6% respectively (FMOH, Nigeria 2005). This shows a slight decline but is still higher than the National average of 67% for females and 63% for males from the same report.

This risky sexual behavior increases vulnerability to both STIs and HIV/AIDS. HIV prevalence in Nigeria has not been increasing but the level is still worrisome. The factors that drive increase in HIV/AIDS prevalence such as industrialization, promiscuity; low condom use is prevalent in the study area. The high prevalence rate of HIV/AIDS in an area is sustained by several factors including; project-induced influx of workers who have a higher income level than locals, migration of commercial sex workers due to the economic attraction of workers, risky sexual behaviours, high sexual activities, early sexual exposures.

(f) Housing

The provision of good housing is an important aspect of environmental health. It represents a significant part of man’s environment; shelter from the elements; workshop (the kitchen for the housewife, the playroom for the children and tool-shed for the adult males); and home (the residence of the family), where this social institution carries out some of its major functions. Consequently, good housing should minimize physical and biological hazards in the environment, provide a good social environment and promote the health of the inhabitants.

The housing pattern, type and structure within any given community or communities and study area are more often than not, a reflection of the settlement pattern itself. As a consequence, the housing pattern, type and structure within the Igbuku-Umuseti Field study communities are a reflection of its generally and predominantly rural environmental setting; old housing stocks are generally intermixed with emergent modern types. The bigger and more populated the community, the better the quality of housing stock with housing patterns depending on the status of a family/compound. Majority of the houses are of the rooming type, with modal walling and roofing materials being constructed of concrete block with corrugated iron sheets (zinc/aluminium) for roofing. A sizeable proportion of the housing stock are also of the wattle and daub (mud-wall) type, some of which have been rendered (plastered with cement) and have both corrugated iron zinc and thatched roofing. Going by responses from administered questionnaires, one could conclude that housing type and quality are generally better in the order of Umuseti-Ogbe, Ashaka, Igbuku and Emu-Iyasele respectively.

The quality of housing in the communities measured by the walling, flooring and roofing materials used indicates that majority of the respondents (56.3%) live in houses constructed of concrete block or cement walls and with zinc roofing. On average, 32.5% of the respondents live in houses constructed of mud wall with corrugated iron roofing sheets (zinc) and mud with thatch roofing accounting for 1.5%. Smaller fractions (1.3%) of the population live in varied other types of housing in the area. ***(Plate 4.21)*** show the variety of housing type in the study area communities.

Plate 4.21: Housing type and quality at Igbuku-UmusetiField FD stakeholder communities, characteristically rural and with mixed housing stock

The availability of durable consumer goods is a good indicator of a household's socioeconomic status. Furthermore, particular goods have specific benefits. For example, having access to a radio or a television exposes household members to innovative ideas; a refrigerator prolongs food storage; and a means of transport allows greater access to many services away from the local area.

As a measure of the overall quality of life apart from incomes and available community-wide basic infrastructures, the proportion of the population with or without the requisite amenities in their dwellings should indicate either a satisfactory situation or otherwise. Valid responses could however, not be gleaned from retrieved questionnaires.

Generally, many households could own basic household amenities like telephone (mobile/GSM), electric fan, radio, television and generator especially where facilities to enjoy the amenities, e.g. electricity is readily available. Householders in bigger urban areas are more likely to own household goods than their rural counterparts.

(g) Knowledge of HIV/AIDS AND OTHER DISEASES

Most respondents during the focus group discussion in the communities have heard of HIV/AIDS but knowing how it's usually contacted was observed to be very low. There is need to carry out awareness campaign to educate members of the communities on HIV/AIDS. And most recent is the deadly coronavirus codenamed Covid-19, although this is being widely publicized worldwide but few still claim ignorance of it. There is a need to keep educating the public on the preventive measure of these deadly diseases.

(h) Household Food

Common foods eaten by the Igbuku-Umuseti proposed FD project communities include garri, plantain, loiloi, rice, and yam. Others eaten at lesser levels include fish, vegetables, beans, milk, eggs and meat. Malnutrition is a major health problem in Nigeria and provides an overall picture of the health status of the population. Children who are malnourished are at a greater risk of falling sick and dying than children who are not malnourished.

Three standard indices of child growth are used to describe nutritional status, Height-For-Age (stunting), Weight-For-Height (wasting) and Weight-For-Age (underweight). To ensure that the results obtained in this study are comparable on an international scale, they are expressed in terms of Z scores. The Z score gives indication in units of standard deviation how far from the reference value a given value lies. The standard used here is based on the National Canter for Health Statistics (NCHS) growth references as recommended by the World Health Organisation (WHO).

An assessment of the nutritional status of 190 children in the surveyed community, aged 0-5 years, was carried out. The indices of malnutrition recorded showed that 26.7% were underweight, 32% were stunted and 13.4% were wasted. A child with a significantly low height-for-age ratio is considered to be stunted or short for his age. This is generally the result of a failure to receive adequate nutrition over an extended period of time and is also affected by recurrent episodes of chronic illness. Children whose Weight-For-Height (W/H) ratio is significantly low are defined as wasted or thin for their age. One in ten surveyed children was classed as wasted. Stunting and wasting are both most severe in the second year of life. This pattern is likely to be due to poor weaning diets (with breast milk offering significant protection in the first year) and infected sources of water resulting in acute illnesses from diarrhoea mainly in the second, third and fourth years of life.

Table 4.21: Weight and height for age of pre-school children in the studied communities

Age (months)	Mean Weight (kg)	Mean Height (m)	Weight for age (Normal range) kg
0 – 11	6.73	0.54	3.5 – 9.4
12 – 23	9.17	0.76	9.5 – 12.4
24 – 35	11.45	0.91	12.5 – 14.4
36 – 47	12.60	0.94	14.5 – 17.4
48 – 60	13.98	1.02	17.5 – 19.4

(i) Mortality Rate

The mortality figures from questionnaire survey are grossly unreliable. The indigenes tend to give exaggerated values when asked about mortality cases may be to lend credence for their demand for more government presence. Inadequate records on mortality rates from the local government level where cases of death are supposed to be registered were also noted. The common causes of mortality in the project area especially in children includes; diarrhoea, malnutrition, malaria, respiratory tract infections, and measles as well as other vaccine preventable diseases. These illnesses were prevalent in the area from the hospital record.

(j) Morbidity Rate

Mortality rates between the ages of 0-5 and maternal mortality rates are said to be low in Igbuku-Umuseti proposed FD communities. This was observed during the focus group discussion with the communities. It was said that women dies during pregnancy and childbirth, and that this doesn’t happen often but at most once in five years in the communities. The causes of the maternal death that happened in the communities in the last five years according to the respondents are attributed to prolonged labour, and abortion.

(k) Health system

The resident population in the Igbuku-Umuseti Field FD study communities have access to functional primary health care services. Functional and effective public (government health care facilities) primary healthcare (PHC) facilities and services are available at Umuseti-Ogbe/Kwale, Ashaka, and Igbuku respectively. There are also private clinics/maternities in the bigger communities like Umuseti-Ogbe (Kwale), Ashaka and Igbuku which have one public (government) health establishments including a general hospital and a maternity health centre and 1 private clinics. Meanwhile, Emu-Iyasele community doesn’t have any health care facility.

(l) Traditional and Herbal Medicine Practices

Traditional medical practice is available in the community. Their practice commonly involved the use of herbs derived from medicinal plants. Several medicinal plants abound in the area. Some of the medicinal plants used in the traditional medical practice in this study area and their uses are given in Table 4.22.

Table 4.22: Common Medicinal Plants and their Uses in the Area

Common/local names	Botanical Names	Medicinal Uses
Pawpaw leaves	*Carica papaya*	Treatment of malaria
Alligator pepper plant	*Afromomum melegueta*	Galactogogue, purgative, sore throat, malaria, used by herbalists for consulting their oracles
Lemon orange	*Citrus aurantium*	Abdominal upset, and as a base for other herbs in treatment of malaria
Cashew fruit, leaf and bark	*Anarcadium occidentale*	Treatment of diarrhoea and menstrual problems
Mango leaves and bark	*Mangifera indica*	Treatment of malaria
Banana plant	*Musa spp*	Treatment of fever
Guava tree leaves and bark	*Psidium guajava*	Treatment of malaria, diarrhoea and menstrual disorders

4.4 Community Expectations and Suggestions

Naturally, community members in the study environment entertained high expectations regarding the proposed further development project activities with particular reference to the benefits and/or positive effects. Overall social issues, including increased and more permanent employment opportunities for the indigenes at the skilled, semi-skilled and unskilled levels are paramount. Unemployment was particularly mentioned as the most troubling social problem in the Igbuku-Umuseti FD study communities, as is the case across Nigeria in general, while youth delinquency and disputes over land and prostitution were ranked highly by respondents as disturbing social problems in the area ***(Figure 4.32).*** The associated opportunities with regard to economic empowerment of youth and women groups through skills training/acquisition and micro-credit programs; vendor services/minor supplies (contracts), compensation for resource losses (particularly on land take), scholarships and provision of infrastructures, are expectations of the stakeholder communities.

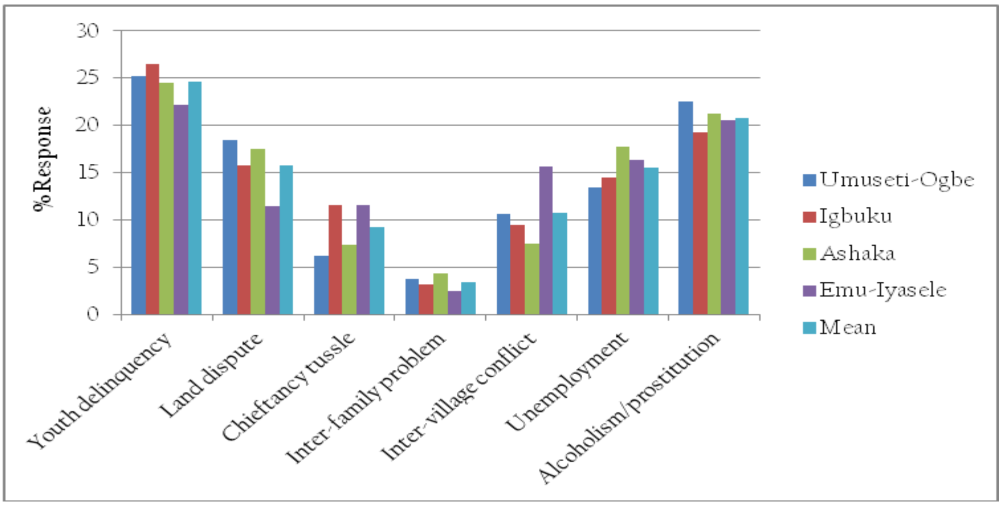


Fig. 4.32: Social problems in Igbuku-Umuseti Field stakeholder communities

As agrarian communities, the land uses for agricultural activities are of serious concern to the inhabitants. It is therefore, very understandable when the people express concerns about its use and misuse. Statistically, therefore, loss of soil fertility attracted some over one half (53.2%) mention it as a main environmental problem or challenge of the study environment.

The Ase River is the water body and its course naturally runs behind the stakeholder communities. The location of the communities on the Deltaic floodplain naturally makes them amenable and susceptible to erosion and flooding problems. These twin problems of flooding and erosion are serious environmental challenge with close to one quarter (23.9%) mentioned by the respondents ***(Figure 4.33).*** Oil pollution is mentioned as the third most important environmental problem across the communities with a 15.9% mention. The most visible facility in the Igbuku-Umuseti Field is the Pillar Oil flowstation which spews smoke into the air with the attendant gas flaring. Oil well location activities area is also beginning to be noticeable landmarks. This shall certainly increase as Igbuku new wells are proposed for drilling and development and tie to the existing processing facility (flowstation) via flowlines. Even with the best industry practice, human and engineering errors are possible causes of oil pollution. Utmost care and due diligence must therefore, be exercised by POL and her contractors as proposed activities come on-stream to avoid negative throwbacks and effects.

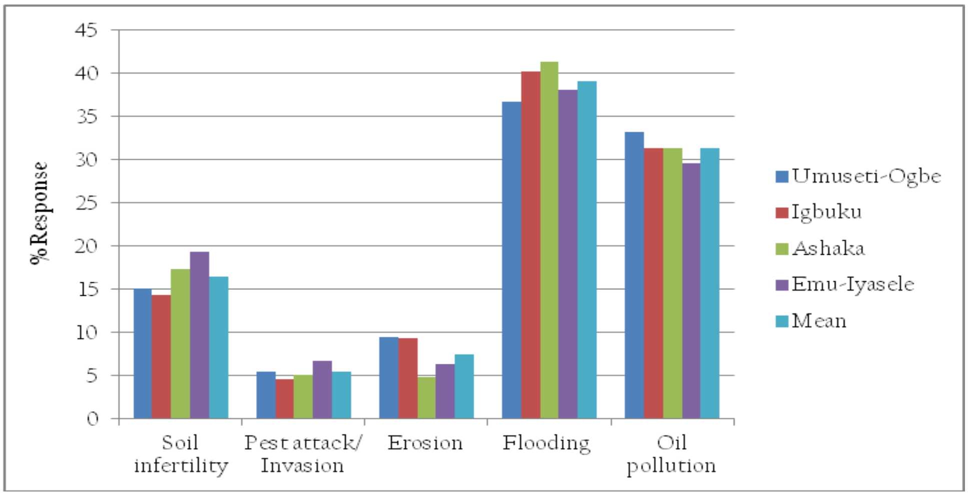


Figure 4.33: Environmental problems in neighbourhood/community

The primary concerns of the people focused on negative activities during the project development period as well as potential negative impacts on livelihood, health and environment as the project proponent embark on further development of the wells and its operational activities. They made suggestions on how best to improve their socio-economic conditions and reduce the negative impacts on their livelihoods. Community members want the project to bring about improvements in employment, education facilities and services, provide good health centres and improve access to health care, and access to potable water in line with their infrastructure needs.

Though POL has always supported the host communities in so many ways in line with the signed MOU and their Corporate Social Responsibility (CSR), however the communities are eagerly expecting some more benefits; they expect that the already entered GMoU agreement can always be improved on and total adherence with the terms of the contract. Social issues, including employment opportunities for skilled, semi-skilled and unskilled indigenes at various levels as the proposed project as operations commence are expected. They also want economic empowerment of youths and women groups 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. Pooled responses of these positive expectations put employment opportunities ahead of all expected benefits while a boost in education through awards of scholarships to children and wards, and the provision of primary healthcare facilities were recognized equally by respondents.

Corporate Social Responsibility (CSR) Initiative

Maintaining ethical and transparent community relations with host communities is one of POL commitments. Therefore, POL evaluate the potential environmental, social and economic value of our activities and employ dialogue, meetings, discussion forums, and development of the local economies productive chains to foster a peaceful relationship. POL have a number of initiatives for communities located around their operational facilities. These include Umuseti Town Hall and Mini markets projects, skills acquisition programmes, scholarships, qualitative electrification schemes for our host and pipeline right of way communities and several other developmental community projects. We have built joint solutions based on the knowledge of our host communities, and have organized various sustainable projects for the use of the people living within our host communities.

Plate 4.22:Mini Market In Umuseti Community and Town Hall Reconstruction In Umuseti Community- 2017

Plate 4.23:Skill acquisition trainees from Umuseti, Umusam, Umusadege & Isumpe communities

Plate 4.24:Educational assistance presentation and free medical programme in Umuseti community

4.5 Consultations

Consultation is the process of asking for information about the environmental implications of projects subject to Impact Assessment process from designated bodies, organizations or persons with environmental responsibilities or interest. From the foregoing definition, it is clear that consultations vary widely in different countries. It is also clear that provisions and practices relating to consultation and particularly to public participation, must be strongly influenced by the culture, the educational level and the political consciousness in the jurisdiction concerned.

Objectives of Consultation

The key objects of consultation are to:

- Inform and educate so as to improve understanding
- Establish areas of cooperation and involvement
- Identify problems, concerns and needs
- Learn and enrich the Impact Assessment process through local knowledge
- Evaluate alternatives and seek solution and
- Resolve and avoid conflicts

Levels of consultation

There are different levels of consultation used in the study. These include the following;

- **Institutional Consultation**

  This level of consultation is intended to show how regulatory authorities such as Federal Ministry of Environment, Department of Petroleum Resources (DPR) etc participated in the assessment. The FMEnv was consulted early and approved the terms of reference for the study. They also took part in the field work and carried out QAQC on the samples during laboratory analysis. The report of this Environmental Impact Assessement study will also be sent to them for review and approval.

- **Primary Stakeholders**
  The primary impact stakeholders are the host communities, which will be directly affected by the project, the local government area responsible for the welfare of the affected community, youth vanguards, local association of property owners as well as the project proponent. The host community was involved early via early visits, gratifications and getting the Freedom to Operate (FTO) which enabled the Consultants to proceed with the field work. In addition, consultations were held in the community prior to sample collection to intimate them about the job, get them on board and also fill the questionnaires for health and social assessment studies.

- **Secondary stakeholders**
  The secondary-impact stakeholders are those not directly affected by the project, but who may have an influence, interest or expertise to offer. These include non-government organizations, security personnel, regulatory authorities (at all levels of governments), corporate stakeholders, donor agencies and contractors/suppliers

Future consultations

POL would continue to consult with all relevant parties (host community, Federal Ministry of Environment, DPR, Ndokwa West LGA, Delta state government) and all parties concerned with or are likely to be affected by the project, at all stages of the project development

CHAPTER FIVE

ASSOCIATED AND POTENTIAL ENVIRONMENTAL IMPACTS

5.1 Introduction

The key objective of an ESIA is to predict changes (adverse or beneficial, whole or partial) in the ecological and socio-economic environment resulting from a proposed development project or activity as well as recommend mitigation measures to minimize, eliminate or offset those aspects that adversely impact on the environment. This was achieved through the public participation process, environmental assessment practitioners (EAPs) and biophysical specialists' assessment. The impacts cover all the proposed project phases which include pre-construction, construction, operation/maintenance and decommissioning. Also, the impacts' likelihood of occurrence, magnitude and significance were evaluated for screening exercise. Emphasis was placed on valued ecosystem, social components and resources in and around the proposed Umuseti/Igbuku Field Further Development project.

This section identifies and characterizes all the associated and environmental impacts or effects that will be caused by the Umuseti/Igbuku Field Further Development.

5.2 Impact Assessment Methodology

The guidelines of ISO 14001 were used for impact prediction and evaluation. This allows for interactive and descriptive analysis of relationships between the proposed project activities and the various environmental components (biophysical, health and social). The pathway followed is the identification/assessment and evaluation of the potential and associated impacts of the proposed project. The methodology adopted in the assessment of impacts entailed identification of the aspects and impacts using source reference materials; defining impacts criteria and determination of mitigation measures followed by the formulation of impact management plan. The impacts are analysed and discussed in detail in line with the EIA scope.

5.3 Summary of Environmental Impact Indicators

The environmental impact indicators are easily observable parameters that will indicate change/deviation, which can be used to monitor the various environmental components. Those considered in this study are as summarized in **Table 5.1.**

Project Activities

The activities anticipated in the proposed project and its existing facilities' modifications cover all the anticipated phases including construction, operation/maintenance and decommissioning. The anticipated activities of each of these phases include:

A. Pre-Construction phase activities

- Land take for Right of Ways
- Mobilization (transport) to site (equipment, personnel and
- construction modules)
- Energy requirements (provision of energy for construction)
- Labor requirements
- Site Preparation (vegetation and land clearing)
- Excavation of land area

Table 5.1: Environmental Components and Potential Impact Indicators

S/No	Environmental Components	Impact Indicators
1	Air Quality and Noise	SPM, NO_X, SO_2, CO, VOCs, NH_3, H_2S and Noise
2	Soil/Agriculture	Soil type, Soil pH, TOC, Soil nutrients, Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer; topography
3	Surface Water Quality	Dissolved and suspended solids, pH, BOD, COD, turbidity, toxicity, Pb, Cd, As, Ni, Fe, Hg, Mg.and Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer
4	Ground water quality	Dissolved and Suspended solids, Turbidity, pH, BOD, COD, Toxicity, Pb, Cd, As, Ni, Fe, Hg, Mg. and Total Heterotrophic bacteria and fungi, Hydrocarbon Utilizing bacteria and fungi and Coliform, Hydrocarbon Utilizer
5	Socio-economic/Health	Needs and concern of host communities/third party concerns; opportunities for employment; income level; health risks; waste streams, Handling, Treatment and disposal; access to household water; access to roads; access to transport; opportunities for contracting and procurement; respect for labour rights; respect for human rights;

B. Construction phase activities

- Piling
- Site fabrication (welding) and coating
- Pipeline lowering/laying & tie-in
- Pipeline stringing
- Construction of Modules
- Backfilling
- Radiographic and Pressure testing.
- Construction of Gas Plant and Above Ground Storage Tanks

- Demobilization

C. The operational phase activities are

- Operations/ maintenance (Normal)
- Operations/ maintenance (Abnormal)

D. The decommissioning activities include

- Demolition and Evacuation

5.4 Impact Identification and Evaluation

To adhere strictly to general guidelines for an Environmental and Social Impact Assessment (ESIA) process, the following basic steps were adopted for identification and evaluation of impacts in this study:

- Impact identification;
- Impact qualification;
- Impact rating; and
- Impact description

5.4.1 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 potential impacts during the different phases of the proposed project are as listed in **Table 5.2.**

Table 5.2: Identified Project Impacts of the Proposed Project

Impacts	Phase		
	Pre-Construction and Construction	Operation/Maintenance	Decommissioning
Acceleration of erosion	√		
Acidification of soil and water	√		√
Alteration of local topography	√		
Alteration of soil profile	√		√
Blockage of drainage pattern	√		√
Blockage of roads/motorways	√		√
Burns/injuries from welding sparks	√	√	√

Impacts	Phase		
	Pre-Construction and Construction	Operation/Maintenance	Decommissioning
Change in land use	√	√	√
Change in water quality	√		√
Contamination of groundwater	√	√	√
Contamination of surface water and soil	√	√	√
Damage to communication cables	√		
Exposure to heat and light	√		√
Exposure to radioactive emissions	√	√	
Exposure to welding flash	√	√	√
Impairment of air quality	√	√	√
Improved livelihood	√	√	√
Increased demand on social infrastructure	√	√	√
Increased surface water turbidity	√		√
Increase in incidence of STI's including HIV	√		√
Increase in income	√	√	
Increase in price of locally sourced materials	√		
Increase in social vices	√		√
Increased opportunity for business and employment	√	√	√
Influx of migrant workers and camp-followers	√		√
Injuries and death from falling objects	√		√
Interference with road transportation	√		√
Kidnapping of workers and visitors on site	√	√	√
Land utilize for temporary base camps/restriction on land use	√		√
Legal issues	√	√	√
Loss of land	√	√	
Loss of employment/ income			√
Noise and vibration nuisance	√	√	√
Road traffic accidents	√	√	√
Work site accidents	√	√	√

5.4.2 Impact Qualification

The identified impacts of the project were qualified using four criteria including:

- Positive or negative

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

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

5.4.3 Impact Rating

This stage involves evaluation of the impact to determine whether or not it is significant. The quantification scale of 0, 1, 3 and 5 was used. The ratings are as adapted from the International Organization for Standardization (ISO) 14001– Environmental Management System Approach*.* The criteria and weighting scale used in evaluating significance are:

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

5.4.3.1 Legal /Regulatory Requirements (L)

This asks the question ‘is there a legal/regulatory requirement or a permit required?’ The scoring is as follows:

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

The legal/regulatory requirements were identified based on national laws/guidelines/standards (FMEnv, DPR, Delta state Ministry of Environment, etc) relating to the project activity.

5.4.3.2 Risk (R)

This uses a matrix based on the interaction of the probability of occurrence of the impact **(Table 5.3)** against consequences **(Table 5.4).** The matrix **(Figure 5.1)** is referred to as the Risk Assessment Matrix (RAM). Five probability categories were interacted against four groups of consequences. The resultant outcomes were given scores with colour-coding. High-risk categories are red; intermediate risk, yellow and low risk, green as follows:

1=Low risk (green)
3=Intermediate risk (yellow)

5=High risk (red)

5.4.3.3 Frequency of Impact (F)

Frequency of impact refers to the number of occurrences of impact. The frequency of impact was determined using historical records of occurrence of impacts, and consultation with experts and local communities. The criteria for rating the frequency of impacts are outlined in **Table 5.5.**

5.4.3.4 Importance of Affected Environmental Component and Impact (I)

The importance of the affected environmental components was determined through consultation and consensus of opinions. This was also further facilitated by information on experiences on the impacts of already existing facilities in the proposed project area. The rating of the importance of impacts is summarized in **Table 5.6.**

Table 5.3: Probability of Occurrence

Probability Category	Definition
A	Possibility of Repeated Incidents
B	Possibility of Isolated Incidents
C	Possibility of Occurring Sometime
D	Not Likely to Occur
E	Practically Impossible

Table 5.4: Consequence Categories

Consequence Category	Considerations			
	Safety / Health	**Public Disruption**	**Environmental Aspects**	**Financial Implications**
I	Fatalities / Serious Impact on Public	Large Community	Major/Extended Duration/Full Scale Response	High
II	Serious Injury to Personnel / Limited Impact on Public	Small Community	Serious / Significant Resource Commitment	Medium
III	Medical Treatment for Personnel / No Impact on Public	Minor	Moderate / Limited Response of Short Duration	Low
IV	Minor Impact on Personnel	Minimal to None	Minor / Little or No Response Needed	None

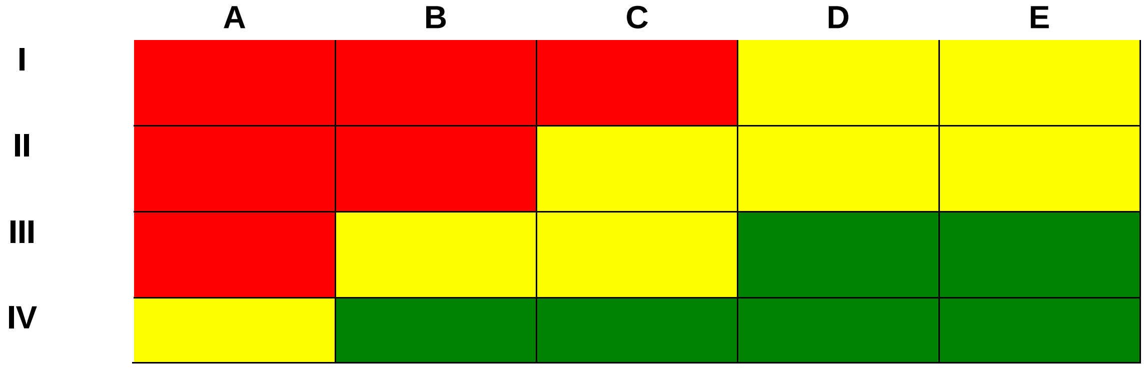


Figure 5.1: Risk Assessment Matrix

5.4.3.5 Public Perception (P)

The consensus of opinions among the project stakeholders were used to determine the public perception on the potential impacts and the criteria applied are as summarized in **Table 5.7**.

The combination of the five impact rating weights formed the basis for judging the level of significance of each impact. A matrix displaying the combination based on the ISO 14001 tool

The final ratings of the identified impacts are presented in **Tables 5.8 - 5.10.** In this study, medium and high significant negative impacts were judged to require mitigation, and all positive impacts required enhancement.

Table 5.5: Frequency Rating and Criteria

Frequency	Rating	Criteria
Low	1	Rare, not likely to happen within project lifespan
Medium	3	Likely to happen ≥ 5 years
High	5	Very likely to happen throughout the project lifespan

Table 5.6: Importance Criteria

Importance	Rating	Criteria
Low	1	• Imperceptible outcome • Insignificant alteration in value, function or service of impacted resource • Within compliance, no controls required
Medium	3	• Negative outcome • Measurable reduction or disruption in value, function or service of impacted resource • Potential for non-compliance
High	5	• Highly undesirable outcome (e.g., impairment of endangered species and protected habitat)

		• Detrimental, extended animal behavioural change (breeding, spawning, moulting) • Major reduction or disruption in value, function or service of impacted valued ecosystem resource • Impact during environmentally sensitive period • Continuous non-compliance with existing statutes

Table 5.7: Public Perception Criteria

Public Perception	Rating	Criteria
Low	1	• No risk to human health, acute and/or chronic • No possibility of life endangerment for residents, associated communities • Minor reduction in social, cultural, economic values • Unlikely adverse perception among population
Medium	3	• Limited incremental risk to human health, acute and/or chronic • Unlikely life endangerment for residents, abutting communities • Some reduction in social, cultural, economic value • Possibility of adverse perception among population. • Potential for non-compliance
High	5	• Elevated incremental risk to human health, acute and/or chronic • Possibility of life endangerment for residents, abutting communities • Major reduction in social, cultural, economic value • Continuous non-compliance with statute • Any major public concern among population in study area

Table 5.8: Impact Value and Rating Colour Code

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

Table 5.9: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phases

- where *L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception*

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Site Preparation	Mobilisation (transport) to site (drilling rig, construction materials, other equipment and personnel to site)	Road traffic/ accidents		√	√		√	√	√		3	3	3	3	3	15	6	H
		Population - Influx of people to project site could directly and negatively impact existing infrastructure and also influence social behaviour		√	√		√		√		3	3	1	1	1	9	2	M
		Noise nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M
		Loss of biodiversity		√	√		√		√		3	3	1	1	1	9	2	M
		Increased opportunity for business and employment	√		√		√		√		-	-	-	-	-	-	-	P
	Energy consumption	Impairment of air quality		√	√		√		√		3	3	1	1	1	9	2	M

	(provision of energy for pre-construction activities)	Noise and vibration nuisance		√	√		√		√		3	3	1	1	1	9	2	M
		Contamination of soil by waste oil		√	√		√		√		3	1	3	1	1	9	4	M
	Site Preparation – clearing, excavation and landscaping	Acceleration of erosion		√	√		√		√		3	1	3	1	1	9	4	M
		Alteration of local topography		√	√		√		√		3	1	3	1	1	9	4	M
		Alteration of soil profile		√	√	√	√		√		3	1	3	1	1	9	4	M
		Blockage of drainage pattern		√	√	√	√		√		3	1	1	1	1	7	2	L
		Contamination of soil by run-offs		√	√	√	√		√		3	1	1	1	1	4	2	L
		Impairment of air quality		√	√	√	√		√		3	1	3	1	1	11	4	M
		Noise and vibration nuisance		√	√		√		√		3	1	3	1	1	9	4	M
		Worksite accidents		√		√		√	√	√	3	5	3	5	5	23	8	H
		Security/artificial light at night		√	√		√		√		0	1	3	1	1	6	4	L
		Habitat alteration		√	√			√		√	3	5	5	5	5	23	10	H

Table 5.10: Potential and Associated Impacts of the Proposed Project

Construction Phases- ***Where L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long-term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Construction	Transport activities during construction/drilling	Road traffic accidents		√	√		√		√		3	5	5	5	5	23	10	H
		Noise nuisance from steaming engines/ heavy vehicles		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality – emission from Heavy vehicles		√	√		√		√		3	1	1	1	3	13	2	M
	Excavation of land area and Casting of the plinths/ drilling of wells	Loss of vegetal cover with possible impact on biodiversity loss		√	√	√	√	√	√		3	3	3	3	3	21	6	H
		Impairment of air quality – emission from trucks, construction activities and drilling process		√	√		√		√		3	1	1	1	3	13	2	M
		Noise and vibration nuisance		√	√		√		√		3	5	3	1	3	15	4	H
		Waste generation from excavated materials		√	√		√		√		3	1	3	1	1	9	4	M
		Impairment of air quality		√	√	√	√		√		3	5	3	3	1	15	6	H

		Contamination in the event of oil spills from equipment and machinery		√	√			√	√		5	3	3	5	1	17	8	H
		Soil damage - compaction by clearing tractors causing change in soil micro structures such as porosity, permeability and removal of soil organics		√	√			√	√		5	3	3	5	1	17	8	H
		Waste Management - The potential effects will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded packaging materials such as metal cuttings Drilling fluids and drilled cuttings, produced sand, Completion and well work-over fluids, naturally occurring radioactive materials (NORM)and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		√	√		√		√		5	1	1	3	1	11	4	M

	Construction of Gas Plant, Pipeline and Storage Facilities	Burns/injuries from welding sparks		√	√			√	√		3	5	3	5	1	17	8	H
		Exposure to welding flash		√	√		√		√		3	5	3	5	1	17	8	H
		Kidnapping of workers		√	√			√		√	3	5	5	5	5	23	10	H
		Increased opportunity for business and employment																P
	Construction of Treatment plant	Waste water management from construction Inappropriate waste management can lead to contamination of groundwater		√	√		√		√		3	1	1	1	3	7	2	M
	Water utilization for concrete-weight	Changes in surface hydrology from water utilization for construction		√	√		√		√		0	1	1	1	1	4	2	L
	Coating	Contamination of soil by paints and coating as a result of spillage		√	√		√		√		3	5	3	5	1	17	8	H
		Hazardous waste generation from coating operations such as metals			√	√		√		√	3	5	3	5	1	17	8	H
	Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil			√	√		√		√	3	5	3	5	1	17	8	H

		erosion and destruction of biodiversity																
		Dust generation from activity (air quality)		√	√	√	√		√		3	5	3	3	1	15	6	H
		Changes in surface hydrology from water utilization for construction		√	√		√		√		3	1	1	1	1	7	2	L
	Commissioning – Radiography and hydrotesting / Well testing	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.		√	√			√	√		3	5	3	5	1	17	8	**H**
		flaring of produced hydrocarbons		√	√			√	√		3	5	3	5	1	17	8	**H**
	Site demobilization	Road traffic accidents		√	√			√		√	3	3	2	3	3	14	5	M

Table 5.11: Impacts of the Proposed Project –Operation (Normal)

where *L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception*

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Operation/ Maintenance	Field production/Gas production/ Transportation of crude through the pipeline/ inspection and maintenance of the pipeline and environmental monitoring/ Storage of oil products	• Air Pollution Fugitive emissions from marginal field facilities are associated with leaks in the tubing; valves; connections; flanges; packings; open-ended lines; floating roof storage tank, pump, and compressor seals; conveyance systems, pressure relief valves, tanks or open pits /containment, and loading and unloading operations of hydrocarbons.		√	√			√		√	3	5	5	5	5	23	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		Increased opportunity for business and employment																P
		Improved natural gas supply to customers,																P
		Air Pollution Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation		√	√			√		√	3	5	5	5	5	23	10	H
		Air Pollution from venting, flaring and greenhouse gases emission from the release of unburnt methane. Particulates from other burning sources such as well		√	√			√		√	3	5	5	5	5	23	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		testing																
		Water Pollution (1) as a result of Processing wastewater to include stormwater and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents. Water Pollution as a result of drilling fluid, spillage and leaks from cutting and well treatment chemicals		√	√		√		√		5	3	3	5	3	19	8	H
		Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during		√	√		√		√		3	3	3	3	3	15	6	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		depressurisation																
		Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination		√			√	√		√	3	3	3	3	3	15	6	H
		Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water. Chemical additives, oxygen scavenger, dye and corrosion inhibitor may be added to the interconnecting pipeline for protection.	√		√		√		√		3	3	3	3	3	15	6	H
		Condensate spills or leaks from interconnecting		√			√	√		√	0	5	3	5	5	18	8	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		pipeline operation																
		Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as a nuisance. Non-Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons, and empty plastic containers. Although the impact of this waste is expected to be minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature.		√	√	√	√		√		3	3	3	3	3	15	6	H
		The threat from major		√	√			√		√	3	5	5	5	5	23	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.																
		Air emission during Maintenance/servicing of production equipment and ancillaries		√	√	√	√		√		3	1	1	3	1	9	4	M
		Surface water and soil contamination: this could happen by treatment chemical (chemical injection process) and sludge/other materials removal during routine cleaning/repair		√	√			√		√	3	5	5	5	5	23	10	H

Project Phase	**Project Activity**	**Description of Impact**	**Impact Qualification**								**Impact Quantification**							**Impact Rating**
			Positive	**Negative**	**Direct**	**Indirect**	**Short term**	**Long term**	**Reversible**	**Irreversible**	**L**	**R**	**F**	**I**	**P**	**Total**	**F+I**	
		Due to the potential contamination of water sources (surface water); Water sanitation issues may arise, health indicator such as life expectancy, mortality rate might be affected negative. Fishing productivity will also contribute negatively to some health indicators mortality rate, underweight percentage index etc. Addition pressure on the existing health care services will be expected		√	√			√		√	3	5	5	5	5	23	10	H
	Transport activities during operation	Road traffic accidents		√	√			√		√	3	5	5	5	5	23	10	H

Table 5.12: Impacts of the Proposed Project –Operation (Abnormal)

where ***L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase		Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
	Emergencies	Air Pollution Loss of containment of crude due to interconnecting pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution		√	√			√		√	3	5	5	5	5	23	10	H
		Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure		√	√			√		√	3	5	5	5	5	23	10	H
		Fire leading to impact on fish and fishing activities as well as the benthic ecosystem		√	√			√		√	3	5	5	5	5	23	10	H
		Health and Safety Fire and explosion incident		√			√	√		√	3	5	5	3	5	21	8	H

		resulting in injury and fatalities																
		Economic Loss of gas flaring: Aside from the health and environmental consequences of gas flaring, the nation also loses billions of dollars' worth of gas which is literally burnt off daily in the atmosphere. Much of this can be converted for domestic use and for electricity generation. By so doing the level of electricity generation in the country could be raised to meet national demand. Flaring gas by POL in Umuseti/Igbuku field will contribute to Nigeria's recorded of a huge revenue loss due to gas flaring and oil spillage. Though more than 65 % of governmental revenue is from oil.																
		Spills from onshore facilities, including pipelines, can occur due to leaks, equipment failure, accidents, and human error or as a result of third-party		√	√			√		√	3	5	5	5	5	23	10	H

		interference																

Table 5.13: Impacts of the Proposed Project – Decommissioning

where ***L= Legal/Regulatory, R = Risk, F= Frequency, I = Importance, P = Public Interest/ Perception***

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
Decommissioning	Demolition and Evacuation	Loss of vegetal cover with possible impact on biodiversity loss along RoW		√	√	√	√	√	√		3	3	3	3	3	15	6	H
		Interference with road transportation		√	√		√		√		3	3	3	1	3	13	4	M
		Noise and vibration nuisance		√	√		√		√		3	3	3	1	3	13	4	M
		Impairment of air quality		√	√	√	√		√		3	3	3	3	3	15	6	H
		Contamination of groundwater		√	√	√	√		√		3	1	3	3	1	11	6	M
		Contamination of soil		√	√	√	√		√		3	1	3	3	1	11	6	M
		Solid waste generation and impact on disposal facility		√	√	√	√		√		3	3	3	3	3	15	6	H
		Loss of job		√	√			√		√	0	5	5	5	5	20	10	H

Project Phase	Project Activity	Description of Impact	Impact Qualification								Impact Quantification							Impact Rating
			Positive	Negative	Direct	Indirect	Short term	Long term	Reversible	Irreversible	L	R	F	I	P	Total	F+I	
		Kidnapping of workers		√	√			√		√	0	5	5	5	5	20	10	H
		Injury/fatalities in workforce /communities		√	√	√	√		√		3	1	3	3	1	11	6	M
		Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.		√	√	√	√		√		3	1	3	3	1	11	6	M
		Revegetation	√		√		√		√		-	-	-	-	-	-	-	P

5.5 Description of Associated and Potential Impacts.

The variety of impacts associated with the different stages of the project is further herein described. The proposed development is envisaged to impact the following baseline parameters:

1. Environment
2. Occupational safety and health
3. Community health and safety

5.5.1 Pre Construction, Construction/Installation Phase

The negative medium impacts in this phase are: Noise nuisance resulting from mobilization / road transportation of equipment, personnel, and construction modules to site. impairment of air quality, loss of biodiversity, noise and vibration nuisance, alteration of local topography, alteration of soil profile, blockage of drainage pattern, Population- Influx of people to project site could directly and negatively impact existing infrastructure and also influence social behavior

The site preparation (vegetation and land clearing), excavation of land area, interconnecting pipeline construction / lowering and backfilling activities will lead to high impacts and the acceleration of erosion, exposure to heat, light and radiation, impairment of air quality by gas emissions, and noise/vibration nuisance.

Also, other high impacts with negative significant ratings in this phase include road accidents from mobilization, injuries and death from falling objects, and work site accidents from the site preparation – excavation of land area and backfilling. Also burns/injuries from welding sparks will be a high negative rating impact from site

This phase also creates positive impacts that include increase in income from mobilization; increased opportunity for business and employment from energy requirements; increase in income and improved livelihood from labor requirements; and increase in income from demobilization.

Transport and traffic

The field is accessible via Kwale express road currently. Other minor untarred roads link the well sites from the express road. The impact will be direct on the express though this is short lived and reversible.

Impairment of air Quality

Emission of greenhouse gases such as VOC, CO and CH_4 could result from use of lifting equipment, vehicles, diesel generator, etc. Other pollutant gases such as SOx, NOx, etc. are also associated with equipment that that will be used for construction, drilling and installation activities. Emission can cause air pollution impact and endanger people's health; this impact may be considered high.

Loss of land usage and Soil alteration

Land that shall be used for the project shall not be available for any other possible project in the entire lifespan of the proposed plant so as to maintain the plant integrity. The non-availability of this land and the change in its use due to the proposed project is of direct impact on land availability in the host area thus qualified the impacts to be rated long term. However, this land can be returned to the owner after the life-span of the project if so desired thus the impacts are rated reversible. Application of the impacts quantification elements qualified it to be rated medium.

Land clearing and removal of top soil can cause erosion of top soil. Movement of heavy machinery can also contribute to top soil erosion. Trees will also be cut. This can have impact on soil erosion as well as reduce the carbon consumption/intake potential of the area, a phenomenon known as carbon sink which helps reduce global warming**.**

Wastewater *release*

Waste from excavation, water from cleaning tools and sanitary water are potential sources of ground and surface water pollution. The impact is may be considered medium significance.

Solid waste generation

Potential sources of waste include excavated waste materials, municipal waste, inert waste, ordinary waste, toxic and hazardous waste and other construction waste. Waste release into the environment could impact soil, water and air quality. Waste generation can cause land as well as surface water pollution. Waste handling can equally be an issue.

Consumption of resources

During site construction, drilling of wells and installation of the modules, resources such as water, electricity, fuel and raw materials will be consumed. This impact can include depletion of natural non-renewable resources. The impact significance is low.

Local issues

Local issues include dust generation from machinery, earthwork and cutting operations. Others are noise and vibration from machinery and landscape alteration. Social local issues such as grievances can also be recorded at this stage of the development.

Accidents and incidents

Heavy lifting and dropped object are potential sources accident when lifting modules during installation. Other potential sources of accidents include traffic, fire, etc. The impact significance is medium. Other occupational health and safety issues that may occur during the construction, drilling and decommissioning of the facilities may be similar to those of other industrial facilities. These may include traffic and transport impact, dust/air pollution, surface water contamination, etc.

Effects on biodiversity

Loss of biodiversity includes vegetation removal, loss of edaphic soil, interception of water bodies and interference with ecosystem.

5.5.2 Operation Phase

Most of the anticipated impacts of the proposed project are more pronounced at the operation phase which includes gas production, transportation of crude through the pipeline, inspection / maintenance of the pipeline, storage of oil products and environmental monitoring. This phase is anticipated to have high and medium ratings negative impacts including Noise and vibration nuisance as well as impairment of air quality. The positive impacts ratings in the phase include improved natural gas supply to customers, increased opportunity for business and employment and increase in income and improved livelihood.

Impact could occur infrequently during normal operations, but given a breakdown of the safeguards and controls (i.e. lack of maintenance for a protecting device) it could occur more readily. There is the possibility of traffic accidents involving Pillar Oil Limited vehicles alone or Pillar Oil Limited engaged contractors and third party vehicles during mobilization and demobilization and operation phases. Since some of these accidents may result in death which is negative, direct and irreversible, they are rated high.

Impairment of air quality

Normal operations and activities of the project during this phase may be sources of air pollution from the supporting equipment including flue gas (flue gas is the gas exiting to the atmosphere via a flue), gas flares and compressors. This may result in air emission of suspended particulates matters (SPM), Carbon Monoxide (CO), oxides of Nitrogen (NOX), hydrocarbons (HC), and Sulphur Dioxide (SO2). Though the quantities of these emissions will be determined by emission inventory with ground level concentrations to be quantified using emission dispersion modeling, the volume of gas to be handles made them to be rated high in the preliminary investigations.

However, during abnormal conditions arising from loss of containment there is possibility of fire and explosion leading to severe air pollution. In the event of such an occurrence environment may be affected.

- ***Venting and Flaring***

Venting and flaring are important operational and safety measures used in marginal field facilities, particularly during non-routine operational periods such as malfunction or upset, as a means of safely disposing of vapors. Hydrocarbons will be emitted from emergency process vents and safety valve discharges. These will, however, be collected in the blow-down network that is flared.

Flaring modifies, by means of combustion, the chemical nature of the emitted substances (e.g., the combustion of H_2S generates sulfur dioxide (SO_2), while the combustion of hydrocarbon generates CO_2 plus water vapor).

- ***Fugitive Emissions***

Fugitive emissions in the proposed field facility may occur from leaking tubing, valves, connections, flanges, gaskets, steam traps, packing, open-ended lines, floating roof storage tanks and pump seals, gas conveyance systems, compressor seals, pressure relief valves, breathing valves, tanks or open pits/containments, oil-water separators, and in the storage, loading, and unloading operations of hydrocarbons. The fugitive emissions may comprise:

- Hydrogen (H);
- Methane (CH_4);
- Volatile organic compounds (VOCs) e.g. ethane, ethylene, propane, propylene, butanes, butylene, pentanes, pentene, C6-C9 alkylate, benzene, toluene, xylenes, phenol, and C9 aromatics);
- Polycyclic aromatic hydrocarbons (PAHs) and other semi-VOCs;
- Inorganic gases, including ammonia (NH_3), CO, CO_2, SO_2 and sulfur trioxide (SO_3) from sulfuric acid regeneration in the sulfuric acid alkylation process, NO_x, methyl tertiary butyl ether (MTBE), ethyl tertiary butyl ether (ETBE), t-amylmethyl ether (TAME), methanol, and ethanol; and
- If occurring, hydrofluoric acid (HF) from hydrogen fluoride alkylation and H_2S.

There is significant potential for VOC emissions from cone-roof storage tanks during loading due to fugitive releases from the out-breathing valves; fugitive emissions of hydrocarbons through the roof seals of floating roof storage tanks; fugitive emissions from flanges and/or valves and machinery seals; VOC emissions from blending tanks, valves, pumps, and mixing operations; and VOC emissions from oily sewage and wastewater treatment systems. It is also possible for nitrogen to be emitted from bitumen storage tanks and possibly saturated with hydrocarbons and sulfur compounds at storage temperature (150–180°C) in the form of aerosols. Other potential fugitive emission sources include the vapor recovery unit vents and gas emissions from caustic oxidation. With regard to naphtha, gasoline, methanol/ethanol, and ethers—including MTBE, ETBE, and TAME—loading/unloading racks shall be provided with vapor controls, e.g. vapor recovery units.

- ***Nitrogen Oxides***

NO_x may be emitted from boilers, process heaters, furnaces, Combined Heat Power (CHP) units, gas turbines, fluid catalytic cracking (FCC) regenerators, as well as flare and other process and combustion units. NO_x formation arises from three mechanisms: fuel NO_x (due to nitrogen content in the fuel), thermal NO_x (due to nitrogen in the air under high temperatures and excess air conditions during combustion), and prompt

NO_x (due to the reaction of atmospheric nitrogen (N_2) with free radicals such as C, CH, and CH_2 fragments derived from fuel in the earliest stage of combustion).
The ammonia (NH_3) formed during the naphtha and gasoil hydrodesulfurization process is fed as a component of the sour feed gas to the thermal reactor of the SRU and converted to fuel NO_x. In addition, thermal NO_x is formed at the SRU due to high-temperature (approximately 1,400°C) oxidation of nitrogen from the process air.

- ***Sulfur Oxides***

Sulfur oxides (SO_x) and H_2S may be emitted from boilers, heaters, and other process units (such as SRUs, FCC regenerators, flares, wastewater stripping, incondensable off-gas incinerators, decoking operations, and coke calcinations). Emissions will vary according to the sulfur content of the processed crude oil, the sulfur content of the fuel that is being combusted, the degree of sulfur recovery, and the level of SO_x emission controls. Sulfur dioxide (SO_2) and sulfur trioxide (SO_3) may be emitted from sulfuric acid regeneration in the sulfuric acid alkylation process.

- ***Particulate Matter***

Particulate emissions are associated with flue gas from furnaces and boilers; catalyst fines emitted from fluidized catalytic cracking regeneration units and other catalyst-based chemical processes; the handling of pet-coke; fines and ash generated during incineration of sludge; and decoking and soot blowing off furnaces and flares. Particulates may contain metals (e.g., vanadium, nickel). Condensable $PM_{2.5}$ (e.g., nitrates, sulfates) are another type of particulate emissions.

- ***Greenhouse Gases***

Carbon dioxide (CO_2) and methane (CH_4) are the primary greenhouse gases (GHGs) emitted by the marginal field and may be produced in significant amounts during field production and related combustion processes. Carbon dioxide and other gases (e.g., N_2O) may be discharged to the atmosphere during the in-situ catalyst regeneration of noble metals.

Solid, Liquid and Hazardous Waste

- **Solid and Hazardous Wastes**

There are numerous larger-volume wastes, hazardous and non-hazardous, generated as a result of field operation, processes and maintenance operations.

- **Industrial Process Wastewater**

Significant volumes of wastewaters in marginal field activities include "sour" process wastewater and non-oily/non-sour process wastewater. Sour wastewater is generated from desalting, topping, vacuum distillation, pretreating, light- and middle-distillate hydrodesulfurization, hydrocracking, catalytic cracking, coking, and visbreaking/thermal cracking. Sour wastewater may be contaminated with hydrocarbons, H2S, NH3, organic sulfur compounds (R-S-H mercaptans), organic acids, and phenol.

Process wastewater that is high in H_2S and/or NH_3 is treated in the Sour Water Stripper Unit (SWSU) to remove these and other compounds, before recycling for internal process uses, or before final treatment and disposal through an on-site wastewater treatment unit. Non-oily/non-sour process wastewater has the potential to cause wastewater treatment plant (WWTP) disturbances. Boiler blowdown and demineralization plant reject streams have the undesirable potential to extract phenolic compounds from the oil phase into the water phase, as well as cause emulsions in the WWTP if incorrectly neutralized.

Liquid wastewater may also result from accidental releases or leaks of small quantities of products from process equipment, machinery, and storage areas/tanks. Treated sour water will typically be returned to the SWSU for stripping, rather than being sent to a facility wastewater treatment plant.

- **Spent Catalysts**

Spent catalysts result from several process units in the management of marginal field, including the pretreating and catalytic reformer; light- and middle-distillate hydrodesulfurization; the hydrocracker; FCCU; RCCU; MTBE/ETBE and TAME production; butanes isomerization; the dienes hydrogenation and butylenes hydroisomerization unit; sulfuric acid regeneration; selective catalytic hydrodesulfurization; and the sulfur and hydrogen plants. Spent catalysts may contain molybdenum, nickel, cobalt, platinum, palladium, vanadium iron, copper, and silica and/or alumina, as carriers. There are several types of spent catalysts, and their physio-chemical properties influence their handling.

- **Other Hazardous Wastes**

In addition to hazardous spent catalysts, industrial hazardous waste may include solvents; filters; mineral spirits; used sweetening; spent amines for CO_2, H_2S, and carbonyl sulfide (COS) removal; activated carbon filters and oily sludge from oil/water separators and desalters; tank emulsions or bottoms; and spent or used operational and maintenance fluids (e.g., oils and test liquids). Other hazardous wastes, including contaminated sludges, sludge from jet water pump circuit purification, exhausted molecular sieves, and exhausted alumina from HF alkylation, may be generated from crude oil storage tanks, desalting and topping, coking, propane, propylene, butanes streams dryers, and butanes isomerization.

Process wastes will be tested and classified as hazardous or non-hazardous based on FMEnv regulatory requirements or internationally accepted approaches.

- **Non-Hazardous Wastes**

HF alkylation produces neutralization sludge, which may contain calcium fluoride, calcium hydroxide, calcium carbonate, magnesium fluoride, magnesium hydroxide and magnesium carbonate. After drying and compression, they may be marketed for uses—in steel mills, for example—or landfilled.

Noise and Vibration

The principal sources of noise in this project shall include large rotating machines, such as compressors and turbines, pumps, electric motors, air coolers, blowers, fans, and heaters. In addition, steam leaks, if significant, can be noisy. During emergency depressurization, high noise levels can be generated due to high-pressure gases released to flare and/or steam release into the atmosphere.

Occupational Safety and Health

The most significant occupational health and safety hazards prevalent during the operational phase of a marginal field facility primarily include:

- Process safety;
- Oxygen-deficient atmosphere;
- Chemical hazards;
- Fire and explosions.
- Process Safety
- Oxygen-deficient Atmosphere
- Chemical Hazards

The potential release and accumulation of nitrogen gas into work areas may result in the creation of asphyxiating conditions due to the displacement of oxygen.
Releases of hydrofluoric acid, carbon monoxide, methanol, and H_2S may present occupational exposure hazards. H_2S leakage may occur from amine regeneration in amine treatment units, and SRUs. CO leakage may occur from FCCU and RCCU and from the syngas production section of the Hydrogen Plant. CO/air mixtures are explosive and spontaneous; explosive re-ignition may occur. Excessive H_2S concentration can be immediately dangerous to life and health (IDLH), H_2S poses an immediate fire hazard when mixed with air.

Workers may be exposed to potential inhalation hazards (e.g., H_2S, CO, VOCs, PAHs) during routine plant operations. Dermal hazards may include contact with acids, steam, and hot surfaces.

- **Hydrofluoric Acid**

Workers may be exposed to hydrofluoric acid (HF) in the HF alkylation unit.

- **Fire and Explosions**

Fire and explosion hazards generated by process operations include the accidental release of syngas (containing carbon monoxide and hydrogen), oxygen, methanol, and other gases. Gas releases may cause “jet fires” if ignited in the release section, or give rise to a vapor cloud explosion (VCE), fireball, or flash fire, depending on the quantity of flammable material involved and the degree of confinement of the cloud. Methane, hydrogen, carbon monoxide, and H_2S may ignite even in the absence of ignition sources at temperatures that are higher than their auto-ignition temperatures of 580°C, 500°C, 609°C, and 260°C, respectively. Flammable liquid spills present in Umuseti/Igbuku Field where the project is to be taken place may cause "**pool fires.**" Explosive hazards may also be associated with the accumulation of vapors in storage tanks (e.g., sulfuric acid and bitumen).

Community Health and safety

Community health and safety impacts during the construction, drilling and decommissioning of the marginal field are common to those of other industrial facilities. The most significant community health and safety hazards associated with the project shall occur during the operational phase, including the threat from major accidents related to fires and explosions at the facility and potential accidental releases of raw materials or finished products during transportation outside the processing facility.

- **Major Hazards**

The most significant safety hazards are related to the handling and storage of liquid and gaseous substances. Impacts may include significant exposures to workers and, potentially, to surrounding communities, depending on the quantities and types of accidentally released chemicals and the conditions for reactive or catastrophic events, such as fire and explosion.

5.5.3 Decommissioning Phase

Environmental and safety issues that could result from the decommissioning activities are similar to those experienced during construction. However, the impact created by decommissioning may be more pronounced than those created during construction as project is winding down and the site is being prepared for abandonment, it is easier for procedures to be bypassed, chances of safety and environmental incidents therefore becomes greater. In this phase, interference with road transportation and noise are the two medium ratings anticipated while kidnapping of workers and visitors on site is a high rating negative impact.

Impairment of air quality

Emission of greenhouse gases such as VOC, CO and CH_4 could result from dismantling, removal and site clean-up at the end of the project. These activities may require the use lifting equipment, vehicles, diesel generator, etc. Other pollutant gases such as SOx, NOx, dust suspension etc. are also associated with equipment that will be used for the decommissioning activities. This impact will last the entire period of the decommissioning activities and has a reversible high impact rating.

Solid, Liquid and Hazardous Waste

- **Solid and Hazardous Wastes**

Potential sources of waste include excavated waste materials, municipal waste, inert waste, ordinary waste, toxic and hazardous waste and other construction waste. Waste release into the environment could impact soil, water and air quality.

- **Wastewater release**

Waste from exhumed buried pipes, cables, tanks, etc. and backfilling left overs, water from cleaning tools and sanitary water are potential sources of ground and surface water pollution.

Soil alteration

Removal of the modules, plinths, storage facility and other physical structure can cause erosion of top soil. Movement of heavy machinery can also contribute to top soil erosion.

Nuisance (Noise, emission, Vibration etc) from heavy machinery.

The process of decommissioning could also result in the generation of noise, generation of dust from machinery, vibration etc. from heavy equipment. The impact was rated as direct, negative, short-term, local, reversible, and medium.

Movement of heavy equipment, modules, tanks, pipes, etc. with load beds and maneuvering of long vehicles along the Kwale Express Road will impact the baseline traffic of the road. However, before demobilization, the road may have been upgraded to highway by Federal or Delta State Government. The, the impact is expected to be minimal.

Consumption of resources

During decommissioning, resources such as water, electricity, fuel and raw materials will be consumed. This impact can cause depletion of natural non-renewable resources.

Accidents and incidents

Heavy lifting and dropped object are potential sources of accident when lifting modules during decommissioning. Other potential sources of accidents include traffic, fire, etc. The impact significance is high. Other occupational health and safety issues that may occur during the decommissioning of project facility may be similar to those during construction. These may include traffic and transport impact, dust/air pollution, surface water contamination, etc.

Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.
Loss of both direct and indirect employment created by the marginal field is anticipated during site decommissioning. However, the process of decommissioning may involve the repairs of damaged roads, removal of structures, and restoration of site. These activities could increase opportunities for employment and contract.

Kidnapping of workers and visitors on site
The kidnapping of workers and visitors on site are among the major security concerns in Nigeria now. During movements as required in decommissioning, personnel and company contractor may be victims of kidnappers. Some of these attacks may result in the death of victims which is negative, direct and irreversible, thus rated high.

5.6 Cumulative Impacts
Cumulative impacts are regarded as combination of existing impacts derived from operations and maintenance of existing facilities and potential and associated impacts from the proposed project activities. Table 5.14 present cumulative effects. Air quality parameter can cumulate e.g CO, H_2S NOx, SOx. In water quality, only few parameters could have cumulative effect such as N, P, Zn, Fe and Cu. Sediment parameters that could have accumulative effects include N, P, Cd, Zn, Cu and Pb. Social and health issues could cumulate over time.

Table 5.14: Cumulative Effect of Existing and New Project

S/N	**Environmental Components**	**Existing Facilities Impacts (EER Report, 2012)**	**Cumulative Negative Impacts (Yes/ No)**
1	Air quality	Biophysical environment	Parameters like CO, H_2S NOx, SOx
2	Water quality	Biophysical Environment	Some parameters could cumulate such as N, P, Zn, Fe and Cu
3	Sediment	Biophysical Environment	Some parameters could cumulate such as N, P, Cd, Zn, Cu and Pb
4	Socio-economics	Social environment	Yes
5	Community health	Health environment	Yes

CHAPTER SIX
MITIGATION MEASURES

6.1 Background Information

This chapter provides mitigation measures that will be taken by POL against identified impacts to ensure environmental sustainability of its proposed Further Field Development in Umuseti/Igbuku field. The impact identification and evaluation process showed that components of the biophysical, health and social environments will be impacted both positively and negatively. A number of measures are hereby proposed to mitigate the impacts of the facility to acceptable residual impact level.

The control measures are based on the baseline conditions with regard to the biophysical environment, socio-economic and health status of the host community. Also considered were the project activities and their envisaged impacts, the concerns of stakeholders during consultation meetings and socio-economic/health status of the host communities

The HSE design and operation objectives of the facilities is to implement all cost-effective measures to reduce the risks and impacts from routine or major hazards including accidents. Thus, the steps taken in the HSE process for the proposed Further Field Development include the following:

- design based on codes, standards and regulations
- improved operation based on quantitative risk assessment and
- best international practice

6.2 Criteria for Selection of Mitigation Measures

Selection of mitigation measures for the identified impact is based on the following considerations:

a) Engineering design of the field,
b) Regulatory requirements (Act Cap E12, LFN 2004 of Federal Ministry of Environment (FMEnv), DPR EGASPIN 1999 revised in 2018, Delta State Ministry of Environment Laws)
c) Industry international best practice (IFC EHS Guidelines for Onshore Oil and Gas Production, 2007)
d) Best Available Technology for Sustainable Development
e) Social wellbeing and concerns of stakeholders

6.3 Mitigation Measures

Mitigation measures are actions taken to minimize negative impacts, while also enhancing positive ones. Mitigation measures are often implemented on a continuous basis throughout the project's life span. Emphasis on the mitigation measures are placed on those negative impacts rated as significant medium and high. These measures are aimed at reducing the impacts to As Low As Reasonably Practicable (ALARP). The residual impacts that could arise despite these mitigation measures were also noted. These measures aim to improve the environmental sustainability of the project in the following areas:

a) Environment
b) Occupational safety and health
c) Community health and safety.

6.3.1 Recommendations for Environmental Protection

The mitigation measures developed for environmental issues associated with further field development include the following:

- Emissions to atmosphere;
- Handling and disposal of process wastewater (storage,transportation, and treatment)
- Handling of hazardous materials and wastes; and
- Noise from operating machinery.

6.3.1.1 Recommended Mitigation Measures for Emissions to Atmosphere

➢ ***Flue Gases***

For POL process heaters, the following primary pollution prevention and control measures will be considered:

✓ Installation of combustion air preheaters, to increase furnace efficiency;
✓ Optimization of furnace operations, and hence combustion efficiency, by continuous monitoring and advanced control of the operations variables (temperature and oxygen concentration of flue gas for combustion optimization air/fuel ratio for the fuel mix; optimizing excess air to minimize heat losses via unburned gases or unburned residues);
✓ High-thermal-efficiency heater designs with good control systems (e.g., oxygen trim);
✓ Prevention of the condensation of exhaust gas on surfaces;
✓ Minimization of power requirements by use of high-efficiency pumps, fans, and other equipment;
✓ Techniques to control CO emissions, such as good operation and control, constant delivery of liquid fuel in the secondary heating, good mixing of the exhaust gases, and catalytic afterburning;
✓ Regular cleaning of heating surface (soot blowing) for liquid fuel or mixed firing; and
✓ High-emissivity refractories for radiant heat transfer improvement, e.g., by application of ceramic coatings as reflecting surfaces.

➢ ***Venting and Flaring***

Venting and flaring will be collected in the blow-down network that is flared.

- ✓ For planned start-up and shutdown, a flare gas recovery system will be used. During nonemergency releases, excess gas from process vents will be recovered or controlled and the volume of gas to be flared will be minimized.
- ✓ Monitoring of gas emissions will encompass both the concentration of pollutants at ground level as well the total quantity of pollutants released annually.
- ✓ Before flaring is adopted, feasible alternatives for the use of the gas will be evaluated by POL and—where practical, reasonable, and safe— integrated into production design to the maximum extent possible
- ✓ Flaring volumes for the facility will be estimated during the initial commissioning period so that fixed-volume flaring targets can be developed. The volumes of gas flared for all flaring activities shall be recorded. Flare management plans shall be prepared and implemented

The following pollution prevention and control measures shall be considered for gas flaring:

- ✓ Gas production through the proposed gas plant
- ✓ Implementing source gas reduction measures to the maximum extent possible;
- ✓ Using efficient flare tips (i.e., optimal released gas sonic velocity, in order to avoid malfunctioning of the flare due to its flame off), and optimization of the size and number of burner nozzles (not less than three, which will ensure—acting as pilot burners, positioned 120° from each other—the continuity of flaring);
- ✓ Maximizing flare combustion efficiency by controlling and optimizing flare fuel/air/steam flow rates to ensure the correct ratio of assist stream to flare stream;
- ✓ Minimizing flaring from purges and pilots, without compromising safety, through measures including the installation of purge gas reduction devices, flare gas recovery units (mainly for continuous or predictable releases), an upstream knock-out drum (vapor–liquid separator used to avoid entrainment of liquid to the flare stack), soft-seat valve technology (where appropriate), conservation pilots and the use of inert purge gas;
- ✓ Minimizing the risk of pilot blow-out by ensuring sufficient exit tip velocity and providing wind guards;
- ✓ Using a reliable pilot auto-ignition system;
- ✓ Installing high-integrity instrument pressure protection systems, where appropriate, to reduce over-pressure events and avoid or reduce flaring situations;
- ✓ Minimizing liquid carry-over and entrainment in the gas flare stream with a suitable liquid separation system;
- ✓ Minimizing flame lift (flash off) and flame lick (flash back);

- ✓ Operating flares to control odor and visible smoke emissions using suitable optical instruments, such as flame detectors, which act on the steam injection in case of black smoke at tip;
- ✓ Locating flares at a safe distance from local communities and the workforce, including workers' accommodation units;
- ✓ Implementing burner maintenance planning and replacement programs to ensure continuous maximum flare efficiency;
- ✓ Metering flare gas on a monthly basis in the interest of pollution evaluation, mainly in terms of CO_2 and SO_2, as well as of released heat (which is an indirect estimation of the greenhouse gas (GHG) emissions);
- ✓ Avoiding over-steaming, as too much steam in a flare will reduce flare performance;
- ✓ Avoiding a wake-dominated flame. A strong crosswind at high velocity can have a powerful effect on the flare's flame dimensions and shape, causing the flame to be wake-dominated (i.e., the flame is bent over on the downwind side of a flare and imbedded in the wake of the flare tip), reducing flare performance and potentially damaging the flare tip; and
- ✓ Avoiding flame lift-off, a condition in which a flame separates from the tip of the flare and there is space between the flare tip and the bottom of the flame due to excessive air induction as a result of the flare gas and center steam exit velocities. This type of flame can reduce flare performance and can progress to a condition where the flame becomes completely extinguished.

➢ ***Fugitive Emissions***

Recommendations to prevent and limit fugitive emissions include the following:

- ✓ A structured leak detection and repair (LDAR) program shall be implemented; based on a systematic review of Process and Instrumentation Diagrams (P&IDs), this program shall identify streams and equipment (e.g., pipes, valves, seals, tanks, and other infrastructure components) where fugitive VOC emissions are a possibility (through component degradation, for example) and prioritize their monitoring with vapor detection equipment, followed by maintenance or replacement of components, as needed.
- ✓ When selecting appropriate valves, packings, flanges, fittings, and seals, consideration shall be given to their effectiveness to reduce gas leaks and fugitive emissions.
- ✓ To minimize their release to the atmosphere, hydrocarbon vapors shall be either contained (e.g., using a nitrogen blanketing system an internal floating roof for tanks, or a cover system for separator) or routed back to the process.
- ✓ Installing a Vapors Recovery Unit, in lieu of open venting or flaring. Use of vent gas scrubbers shall be considered to remove oil and other oxidation products from overhead vapors in specific units (e.g. loading racks).

- ✓ The incineration of gas should be conducted at a high temperature (approximately 800°C) to ensure complete destruction of minor components (e.g., H_2S, aldehydes, organic acids, and phenolic components) and to minimize emissions and odor impacts.
- ✓ With regard to emissions from HF, alkylation plant vents shall be collected and neutralized for HF in a scrubber before being sent to flare.
- ✓ With regard to naphtha, gasoline, methanol/ethanol, and ethers—including MTBE, ETBE, and TAME—loading/unloading racks shall be provided with vapor controls, e.g. vapor recovery units.

➢ ***Nitrogen Oxides***

To reduce NO_x emissions, low-NO_x burners are the most commonly installed technology on combustion devices, while controlling NO_x emissions associated with FCCs typically involve the consideration of selective catalytic reduction (SCR) or thermal de-NO_x technologies. Recommended pollution prevention and minimization measures to be adopted by POL include

- ✓ High-Temperature Air Combustion (HiTAC), otherwise called flameless (or colorless) combustion. It can be used in SRUs, especially those employing lean acid gas streams, which cannot be burned without the use of auxiliary fuel or oxygen enrichment under standard conditions. With the use of HiTAC, lean acid gas streams can be burned with uniform thermal fields without the need for fuel enrichment or oxygen addition. The uniform temperature distribution favors clean and efficient burning, with an additional advantage of significant reduction of NOx, CO, and hydrocarbon emission.

➢ ***Sulfur Oxides***

To reduce SO_x emissions and improve product quality, recommended pollution prevention and minimization measures include the following:

- ✓ SO_x emissions will be minimized through desulfurization of fuels, to the extent feasible, or by directing the use of high-sulfur fuels to units equipped with SO_x emission controls.
- ✓ Sulfur will be recovered from tail gases using high-efficiency SRUs (e.g., Claus units, equipped with the specific section of Tail Gas Treatment (TGT)).
- ✓ Scrubbers will be installed with caustic soda solution to treat flue gases (caustic wash of acid gas stream, to remove acids) from the alkylation unit absorption towers.

➢ ***Particulate Matter***

Recommended pollution prevention and minimization measures include the following:

- ✓ On large sources of particulate matter emissions such as FCCU regeneration units and sludge incinerators, high-efficiency air pollution control devices (e.g., bag filters, electrostatic precipitators, scrubbers, third-stage cyclones) shall be installed. These shall be considered along with NO_x and SO_x emissions control technologies (e.g. wet gas scrubbers). A combination of these techniques is expected to achieve >99 percent abatement of particulate matter.

- ✓ Particulate emission reduction techniques shall be implemented during coke handling, including:
  - Store (green sponge) pet-coke in bulk under enclosed shelters;
  - Keep coke constantly damp;
  - Cut coke in a crusher and convey it to an intermediate storage silo (hydrobins);
  - Spray coke with a fine layer of gasoil, to stick the dust fines to the coke;
  - Use covered conveyor belts with extraction systems to maintain a negative pressure;
  - Use aspiration systems to extract and collect coke dust; and
  - Pneumatically convey the fines collected from the cyclones into a silo fitted with exit air filters, and recycle the collected fines to storage.

➢ ***Greenhouse Gases***

Aggregate GHG emissions will be quantified annually in accordance with FMEnv and internationally recognized methodologies. POL will include at the design stage or when considering major revamping improvements enhancement to stationary combustion sources (i.e., steam generation boilers, process heaters, combined heat and power), upgrading fuel gas systems and flares, and installing power/waste heat recovery units to minimize GHG emissions. The overall objective shall be to reduce GHG emissions and evaluate cost effective options for reducing emissions that are technically feasible.

6.3.1.2 Handling and Disposal of Process Wastewater (storage, transportation, and treatment)

➢ ***Industrial Process Wastewater***

Recommended process wastewater management practices include:

- ✓ Prevention and control of accidental releases of liquids through regular inspections and maintenance of storage and conveyance systems, including stuffing boxes on pumps and valves and other potential leakage points, as well as the implementation of spill response plans;
- ✓ Provision of sufficient capacity for storing process fluids to enable maximum recovery into the process and, as a consequence, avoiding large discharges of process liquids into the oily wastewater drainage system;

- ✓ Design and construction of wastewater and hazardous materials storage containment basins with suitably impervious surfaces to prevent infiltration of contaminated water into soil and groundwater;
- ✓ Segregation of process wastewater from storm water and segregation of wastewater and hazardous materials containment basins; and
- ✓ Implementation of good housekeeping practices, including conducting product transfer activities over paved areas and prompt collection of small spills.

POL specific provisions to be considered for the management of individual wastewater streams include the following:

- ✓ Direct spent caustic soda from sweetening units and chemical treating to the wastewater treatment system following caustic oxidation.
- ✓ Direct spent caustic liquor from caustic oxidation (containing soluble thiosulfates, sulfites, and sulfates) to the wastewater treatment system.
- ✓ Install a closed-process drain system to collect and recover leakages and spills of MTBE, ETBE, and TAME. These substances are not responsive to biological treatment and shall be prevented from entering and adversely affecting the wastewater treatment system.
- ✓ If present at the facility, acidic and caustic wastewater from the demineralized water preparation shall be neutralized prior to discharge into the wastewater treatment system.
- ✓ Cool blowdown from the steam generation systems prior to discharge. This wastewater, as well as blowdown from cooling water towers, may contain additives (e.g., biocides) that may require treatment in the WWTP prior to discharge.
- ✓ Hydrocarbon-contaminated water from scheduled cleaning activities during facility turnaround and hydrocarbon-containing wastewaters from process leaks will be treated in the WWTP.

- ➢ ***Process Wastewater Treatment***

Techniques for treating industrial process wastewater include source segregation and pretreatment of concentrated wastewater streams. Typical wastewater treatment steps to be adopted by POL include:

- ✓ Grease traps, oil skimmers, Coalescing Plate Separators (CPS), Dissolved Air Flotation (DAF) or oil water separators for separation of oils and floatable solids;
- ✓ Filtration for separation of filterable solids;
- ✓ Flow and load equalization;
- ✓ Sedimentation for suspended solids reduction using clarifiers;
- ✓ Biological treatment—typically aerobic treatment—for the reduction of soluble organic matter, measured as Biological Oxygen Demand (BOD);

- ✓ Chemical or biological nutrient removal for reduction of nitrogen and phosphorus;
- ✓ Chlorination of wastewater when disinfection is required; and
- ✓ Dewatering and disposal of residuals in designated hazardous waste landfills.

Additional engineering controls may be required for:

a) containment and treatment of volatile organics stripped from various unit operations in the wastewater treatment system;
b) advanced metals removal using membrane filtration or other physical/chemical treatment technologies;
c) removal of recalcitrant organics and non-biodegradable Chemical Oxygen Demand (COD) using activated carbon or advanced chemical oxidation;
d) reduction in wastewater toxicity using appropriate technology (such as reverse osmosis, ion exchange, activated carbon); and
e) containment and neutralization of nuisance odors

➢ ***Other Wastewater Streams & Water Consumption***

- Contaminated streams will be routed to the treatment system for industrial process wastewater.
- *Hydrostatic Testing Water:* Hydrostatic testing (hydro-test) of equipment and pipelines involves pressure testing with water (generally, filtered raw-water) to verify system integrity and to detect possible leaks. Chemical additives (e.g., a corrosion inhibitor, an oxygen scavenger, and a dye) are generally added to the fresh water to prevent internal corrosion and to highlight leaks. In managing hydro-test waters, the following pollution prevention and control measures will be implemented by POL:
    - Use the same water for multiple tests;
    - Reduce the need for corrosion inhibitors and other chemicals by minimizing the time that test water remains in the equipment or pipeline; and
    - If chemical use is necessary, select effective chemicals with the lowest toxicity, bioavailability, and bioaccumulation potential, and with the highest biodegradability.
- If discharge of hydro-test waters to surface water is the only feasible alternative for disposal, a hydro-test water disposal plan will be prepared that considers points of discharge, rate of discharge, chemical use and dispersion, environmental risk, and required monitoring.
- Hydro-test water disposal into shallow surface waters shall be avoided.

6.3.1.3 Handling of Hazardous Materials

- ***Wastes (spent catalyst)***

There are numerous larger-volume wastes, both hazardous and non-hazardous, generated as a result of field production processes and maintenance operations. Recommended management strategies for hazardous catalysts to be adopted by POL include the following:

- ✓ Use long-life catalysts and regeneration to extend the catalyst lifecycle;
- ✓ Use appropriate on-site storage and handling methods to avoid uncontrolled exothermic reactions; and
- ✓ Return spent catalysts to the manufacturer for regeneration or recovery, or transport to other offsite management companies for handling, heavy or precious metals recovery/recycling, and disposal in accordance with industrial waste management recommendations

- ***Other Hazardous Wastes***

Recommended industry-specific management strategies for hazardous waste to be adopted by POL include the following:

- ✓ Send oily sludges—such as those from crude oil storage tanks (bottom drains) and from desalter (bottom drains)—to the delayed coking drum, where applicable, to recover the hydrocarbons.
- ✓ Ensure excessive cracking is not conducted in the vis breaking unit to prevent production of an unstable fuel oil, resulting in increased sludge and sediment formation during storage.
- ✓ Maximize recovery of oil from oily wastewaters and sludges. Minimize losses of oil to the wastewater system. Oil can be recovered from slops using separation techniques (e.g., gravity separators and centrifuges).
- ✓ Sludge treatment may include land application (bioremediation) or solvent extraction, followed by combustion of the residue and/or use in asphalt or cement kilns, where feasible. In some cases, the residue may require stabilization prior to disposal to reduce the leachability of toxic metals.

- ***Non-Hazardous Wastes***

HF alkylation produces neutralization sludge, which may contain calcium fluoride, calcium hydroxide, calcium carbonate, magnesium fluoride, magnesium hydroxide and magnesium carbonate. After drying and compression, they may be marketed for uses—in steel mills, for example—or landfilled.

6.3.2 Occupational Health and Safety

As a general approach, process health and safety management planning will include the adoption of a systematic and structured approach for the prevention and control of physical, chemical, biological, and radiological health and safety hazards. Major occupational health and safety hazards will be prevented by POL through the implementation of a Process Safety Management (PSM) Program that includes all of the minimum elements including:

- ✓ Facility-wide risk analysis, including a detailed consequence analysis (e.g., failure mode and effects analysis (FMEA), hazard identification study (HAZID), hazard and operability study (HAZOP), or quantitative risk assessment (QRA)). This analysis will be carried out alongside the Front End Engineering Design (FEED) and with the Detailed Engineering Design prior to commissioning;
- ✓ Employee training on operational hazards;
- ✓ Procedures for the management of change in operations, process hazard analysis, maintenance of mechanical integrity, pre-start review, hot work permits, safe systems of work (SSW), and other essential aspects of process safety;
- ✓ Safe Transportation Management System, for raw or processed materials;
- ✓ Procedures for handling, transportation, and storage of hazardous materials.

6.3.2.1 Process Safety

Process safety programs will be implemented based on industry-specific conditions, such as complex chemical reactions, use of hazardous materials (e.g., toxic, reactive, volatile, flammable, or explosive compounds), and multi-step reactions. Process safety management will include the following:

- ✓ Physical hazard testing of materials and reactions;
- ✓ Hazard analysis studies to review the process chemistry and engineering practices, including thermodynamics and kinetics;
- ✓ Effective preventive maintenance routines and examination of the mechanical integrity of the process equipment and utilities;
- ✓ Operator/technician training and development; and
- ✓ Development of Safe System of Work (SSW), operating instructions, and emergency response procedures.

6.3.2.2 Oxygen-deficient Atmosphere

The potential release and accumulation of nitrogen gas into work areas may result in the creation of asphyxiating conditions due to the displacement of oxygen. Prevention and control measures to reduce the risks of asphyxiant gas release to be adopted by POL include:

- ✓ Design and placement of nitrogen venting systems according to industry standards;
- ✓ Installation of an automatic Emergency Shutdown System that can detect and sound an alarm warning of the uncontrolled release of nitrogen (including the presence of oxygen-deficient atmospheres in working areas. Working areas with potential for oxygen deficient atmosphere shall be equipped with equipment capable of detecting such conditions. Workers also will be

equipped with personal monitoring systems. Both type of monitoring systems will be equipped with warning alarms set at 19.5% concentration of O_2 in the air), automatically initiate forced ventilation, and shut down equipment to minimize the duration of releases;

- ✓ Implementation of confined space entry procedures with consideration of facility-specific hazards.

6.3.2.3 Chemical Hazards

Chemical hazards will be managed based on the results of a job safety analysis (JSA) and industrial hygiene survey. Protection measures include

- ✓ worker training,
- ✓ work permit systems,
- ✓ use of personal protective equipment (PPE), and
- ✓ toxic gas detection systems with alarms

➢ ***Hydrofluoric Acid***

Workers may be exposed to hydrofluoric acid (HF) in the HF alkylation unit. Occupational safety measures to be adopted by POL include the following:

- ✓ Reducing HF volatility by adding suitable vapor pressure suppression additives;
- ✓ Minimizing HF hold-up volume (circuit inventory);
- ✓ Designing the plant layout to limit the extent of the plant area exposed to potential HF hazards, and to facilitate escape routes for workers;
- ✓ Clearly identifying HF hazardous areas, and indicating where PPE must be adopted;
- ✓ Implementing a worker decontamination procedure in a dedicated area;
- ✓ Use of scrubbing systems to neutralize and remove HF prior to flaring;
- ✓ Use of an HF neutralization basin for wastewater before it is discharged into the oily wastewater system;
- ✓ Use of a dedicated tank to collect alkylate product and undertake routine pH measurements before dispatching to gasoline pool;
- ✓ Treating butane and propane products in alumina defluorinators to destroy organic fluorides, followed by alkali to remove any remaining HF; and
- ✓ Transport of HF to and from the plant should be handled according to guidance for the transport of dangerous goods.

6.3.2.4 Fire and Explosions

Recommended measures to be adopted by POL to prevent and control fire and explosion risks from process operations include the following:

- ✓ Designing, drilling, constructing, and field production according to international standards for the prevention and control of fire and explosion hazards, including provisions for segregation of process, storage, utility, and safe areas. Safety distances can be derived from specific safety analyses for the facility and the QRA, and through application of internationally recognized fire safety standards;

- ✓ Providing early warning systems, such as pressure monitoring of gas and liquid conveyance systems, in addition to smoke and heat detection for fires;
- ✓ Evaluation of potential for vapor accumulation in storage tanks and implementation of prevention and control techniques (e.g., nitrogen blanketing for sulfuric acid and bitumen storage);
- ✓ Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high-temperature piping, equipment, and/or rotating machines);
- ✓ Providing passive fire protection measures within the modeled fire zone that are capable of withstanding the fire temperature for a time sufficient to allow the operator to implement the appropriate fire mitigation strategy;
- ✓ Limiting/containing the areas that may be potentially affected by the accidental releases of flammable liquids by;
    - Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area, including secondary containment of storage tanks;
    - Installing fire/blast partition walls in areas where appropriate separation distances cannot be achieved; and
    - Designing the oily wastewater system to avoid the propagation of fire.

6.3.3 Recommendations for Community Health and Safety

Emergency planning to be adopted by POL, to prevent major hazards to the community will include, at a minimum,

- ✓ the preparation and implementation of an Emergency Management Plan, prepared with the participation of local authorities and potentially affected communities
- ✓ periodic environmental and health surveillance
- ✓ develop and implement mechanism for monitoring and correcting community complaints and grievances

The comprehensive mitigation measures encapsulating the project phases from pre-construction to construction, operation and decommissioning is presented in ***Table 6.1*** below. Following adoption of mitigation measures, residual impacts are also presented.

Table 6.1: Potential and Associated Impacts of the Proposed Project – Pre-Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Mobilisation (transport) to site (drilling rig, construction materials, other equipment and personnel to site)	Road and traffic accidents and agitation of the locals	H	POL shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods • To involve POL security in traffic control in traffic management • Defensive driving course for POL and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities • Employment opportunities for the communities shall be assured; • Implement agreement on compensation promptly; • Regular consultation with stakeholders (Government, public,	L

			NGO, etc) shall be carried out. • Ensure compensations are made before construction work starts	
	Noise nuisance	M	POL shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L
	Impairment of air quality	M	POL shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way ▪ Implement good housekeeping practise on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodable soil	L
	Population - Influx of people to project site could directly and	M	As part of the company policy, POL shall ensure that workforce will be sourced from the stakeholder communities to reduce the impact of emigration, however with uppermost consideration for	L

	negatively impact existing infrastructure and also influence social behaviour		competence and qualification. This will reduce the impact of population influx.	
	Increased opportunity for business and employment	P	POL shall ensure: • local contractors are engaged; • prompt payment to engaged labour • that Indigenes are considered first • that alternative will be made and vehicular traffic will be reduced • that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.	P
Energy consumption (provision of energy for pre-construction activities))	Impairment of air quality	M	POL shall ensure that: • there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used	L
	Noise and vibration nuisance	M	POL shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not in use; • soundproof electric power generators are engaged	L
	Contamination of soil	M	POL shall ensure: • Soil disturbance shall be kept to minimum required for operation	L

			and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil. • Implement good housekeeping practise on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	
Site Preparation – clearing, excavation and landscaping	Acceleration of erosion	H	POL shall: • Stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential • Mechanically stabilize the soil in order to reduce potential for erosion • Avoid excavation and burial in steeply sloped ground and avoid creation of great breaks • Provide for the placement of siltation ponds in areas subject to heavy erosion • Select vehicles suited for erodible soil • Limiting activities in erodable soil	M
	Alteration of local topography	M	• POL shall: • re-grading the sites, then replacing the layer of top soil that was previously put. • restoring the operational site by restoring the original profile of the topography and the soil • strictly regulating heavy equipment traffic • restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way	L
	Alteration of soil profile	M	POL shall:	L

			• ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities • stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential	
	Blockage of drainage pattern	L	POL shall ensure that: • strict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	Negligible
	Contamination of soil by runoffs	L	POL shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are provided to reduce oil spill from getting to the soil • Implement good housekeeping practise on-site. • Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimises perturbation to aquatic environment. • Avoid spills prohibiting refuelling near waterway	Negigible
	Impairment of air quality	M	POL shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled; • equipment engines are turned off when not in use	L

			• POL shall ensure that all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if appropriate • POL shall provide and enforce the use of PPE (e.g. nose masks and ear muffs) • POL shall construct sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;	
	Noise and vibration nuisance	M	POL shall ensure that: • equipment are fitted with effective silencers; • there shall be regular maintenance of equipment; • equipment are switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected	L

	Work site accidents	H	POL shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L
	Security/artificial light at night	L	POL shall ensure that: • work at night shall be done without impacting the visual element of the area by reducing luminosity of night light. • As far as possible, the operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged	Negligible
	Habitat Alteration	H	POL shall: ▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L

Table 6.2: Potential and Associated Impacts of the Proposed Project– Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Transport activities during drilling/construction	Road traffic accidents	H	POL shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods • Involve POL security in traffic control in traffic management • Defensive driving course for POL and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities	L
	Noise nuisance	M	POL shall ensure: • regular maintenance of vehicles	L

			• Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	
	Impairment of air quality – emission from truck, construction activities and drilling process	M	POL shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust	L
Excavation of land area and Casting of the plinths/ drilling of	Loss of vegetal cover with possible impact on biodiversity loss	H	POL shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers. ▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover	L

wells			restoring vegetation at the end of the work	
	Impairment of air quality emission from trucks, construction activities and drilling process	M	POL shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;	L
	Noise and vibration nuisance	H	POL shall ensure that: • Machine engines are fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines • seismic activities in the vicinity of local populations wherever possible minimze; • simultaneous operations on closely spaced survey lines are minimize; • the use of the lowest practicable vibrator power levels; • they reduce operation times, to the extent practical;	L

			• When shot-hole methods are employed, charge size and hole depth should be appropriately selected to reduce noise levels. • Proper back-fill or plugging of holes will also help to reduce noise dispersion;	
	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded packaging materials such as metal cuttings Drilling fluids and drilled cuttings, produced sand, Completion and well work-over fluids, naturally occurring radioactive materials (NORM)and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are	M	POL shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes are minimize as much as practically possible • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials must not be burned; • Optimize the reuse of spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided;	L

	expected to be reused		• disposal of construction and related waste materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management agencies to enforce appropriate sanitation and other bye laws. • Storage in dedicated storage tanks or lined pits prior to treatment, recycling, and / or final treatment and disposal; • On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal • using established methods such as thermal desorption in an internal thermal desorption unit to remove NADF for reuse, bioremediation, landfarming, or solidification with cement and / or concrete. Final disposal routes for the non-hazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill including landfill cover and capping material where appropriate. In the case of land farming it should be demonstrated that subsoil chemical, biological, and physical properties are preserved and water resources are protected; • Recycling of spent fluids back to the vendors for treatment and re-use; • Use of high efficiency solids control equipment to reduce the need for fluid change out and minimizing the amount of • residual fluid on drilled cuttings; • Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids	

			• and cuttings generated. • Minimizing environmental hazards related to residual chemicals additives on discharged cuttings by careful selection of the fluid system. • Careful selection of fluid additives taking into account technical requirements, chemical additive concentration, toxicity, bioavailability and bioaccumulation potential; • Monitoring and minimizing the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock used in the fluid formulation. • The pit waste should be analyzed and the maximum lifetime loads should be calculated. A risk based assessment may be necessary to demonstrate that internationally recognized thresholds for chemical exposure are not exceeded.	
	Soil damage - compaction by clearing tractors causing change in soil micro structures such as porosity, permeability and removal of soil organics	H	POL shall ensure that: • Area and depth to be excavated shall be strictly limited to the minimum required.	L
	Burns/injuries from welding sparks	H	• POL shall ensure that workers and visitors are properly kitted • Use of experienced/competent workers • Pipe joining techniques such as welding shall meet international standards	L
Construction of Gas Plant/ Pipeline and	Exposure to welding	H	• POL shall ensure that workers and visitors are properly kitted (appropriate PPEs are used)	L

Storage Facilities	flash			
	Kidnapping of workers and visitors on site	H	• POL shall ensure that both contractor and POL personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the POL Project Manager • Special security force shall be established and deployed for the project. • POL shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, POL shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • POL shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	L
	Noise and vibration nuisance	M	POL shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • generators are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs shall be encouraged	L

	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and machinery	H	POL shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L

	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused	H	POL shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;	L

Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.	L
	Dust Generation	M	POL shall: • Implement good housekeeping practice on-site. • POL shall ensure the use of appropriate PPEs • POL shall ensure that backfilling is followed by mechanical compaction so as to retain the original level.	L
	Worksite accidents	H	POL shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L
	Increase in communicable disease (including STDs and	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons	L

	HIV/AIDS)		living with the HIV • POL shall insure immunization of workforce against as appropriate • Regular spraying of work sites Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and the need to sustain cultural values • POL shall assist the activities of the state action committee on STIs/HIV/AIDS as part of her stakeholders' engagement plan. • POL shall ensure site clinic is provided to take care of minor illnesses for all construction workers	
Construction of Pipeline/Storage facilities	Temporary change in land use	M	POL shall: • Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate Excavation sites by filling. • Ensure Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary • Ensure new structures such as signboards, bill boards for the project shall be removed after construction. Those required such as direction or warning signs shall be properly placed.	L
Coating	Contamination of soil by	H	POL shall ensure:	L

	paints and coating as a result of spillage		• Using of engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills	
	Hazardous waste generation from coating operations such as metals	H	POL shall ensure: • Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv standard at an approved disposal sites	L
Construction of treatment plant	Waste water management from construction - Inappropriate management can lead to contamination of surface and groundwater	M	POL shall ensure: • Disposal of water and waste products arising from the sites via a suitably designed temporary drainage system in a manner that shall not cause pollution problems or other nuisance; • Ensure storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • Vehicles and equipment shall be maintained in good condition, ensuring no leakage of oil or fuel; • Provide sanitation arrangements at work sites/facilities to avoid	L

			release of waste water and sewage to the environment. • Waste water shall be treated in line with an approved standard by FMEnv before of its release to the environment	
	Changes in surface hydrology from water utilization for construction	L	POL shall ensure: • Drilling of borehole for water utilization for construction of concrete-weight	Negligible
Commissioning – Radiography and hydrotesting / Well testing	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.	H	POL shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations • that the hydro test fluid is disposed at an approved government site within each state. • Disposal in each case shall be monitored by the appropriate regulatory bodies and POL	L
	Flaring of produced hydrocarbons	H	POL shall ensure that: • Feasible alternatives be evaluated for the recovery of hydrocarbon test fluids, while considering the safety of handling volatile hydrocarbons, for transfer to a processing facility or other alternative disposal options. An evaluation of disposal alternatives for produced hydrocarbons shall be adequately documented and	L

			recorded. • Only the minimum volume of hydrocarbons required for the test should be flowed and well test durations should be reduced to the extent practical. • An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout. Volumes of hydrocarbons flared should be recorded.	
Site demobilization	Road traffic accidents	M	POL shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard analysis is carried out • compliance with journey management policy	L

Table 6.3: Potential and Associated Impacts of the Proposed Project – Operation/Maintenance (Normal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Field production/ Transportation of crude through the pipeline/ inspection and maintenance of the pipeline and environmental	Air Pollution (1) Fugitive emissions in natural gas processing facilities that are associated with leaks in tubing; valves; connections; flanges; packings; open-ended lines;	H	POL shall ensure: • Regular monitoring of fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of components as needed in a prioritized manner • Maintain stable tank pressure and vapor space by: ○ Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during filling activities	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
monitoring/ Storage of oil products	floating roof storage tank, pump, and compressor seals; gas conveyance systems, pressure relief valves, tanks or open pits / containments, and loading and unloading operations of hydrocarbons.		is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); ○ Using white or other color paints with low heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; • Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses considering, for example, storage capacity and the vapor pressure of materials being stored. • Use of supply and return systems, vapor recovery hoses, and vapor-tight trucks / railcars / vessels during loading and unloading of transport vehicles; • Use of bottom-loading truck / rail car filling systems; and • Where vapor emissions contribute or result in ambient air quality levels in excess of health based standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion units, or gas adsorption media.	
	Air Pollution (2) Exhaust gas emissions produced by the combustion	H	POL shall ensure that: • Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation		includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	
	Air Pollution (3) Venting, flaring and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure	H	POL shall: • Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	L
	Processing wastewater to include storm water and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents	H	POL shall ensure: • The adoption of water conservation opportunities for facility cooling systems • Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential; and dosing according to local regulatory requirements and manufacturer recommendations; and • Testing for the presence of residual biocides and other pollutants of concern to determine the need for dose adjustments or treatment of cooling water prior to discharge. • Where liquids are handled, segregate contaminated and non-contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit	
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level is also expected during	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise • Improving the acoustic performance of constructed buildings,	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	depressurisation		apply sound insulation • Installing acoustic barriers without gaps and with a continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Re-locating noise sources to less sensitive areas to take advantage of distance and shielding • Encourage the use PPEs	
	Pigging operations waste management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination	H	• Establishing hazardous materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment; • Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing management controls (procedures, inspections, communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Storing and handling of hazardous waste in accordance to	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			approved WMP • Access to areas containing hazardous substances shall be restricted and controlled; • Hydrocarbon and hazardous materials shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv standard in an approved site; • solid hazardous waste shall not be burned;	
	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipelines with water. Chemical addatives, oxygen scanvenger, dye and corrosion inhibitor may be added for pipeline protection	H	POL shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations.;	L
	Condensate spills or leaks from pipeline rupture	H	POL shall ensure: • Training of employees and contractor personnel in safety procedures, together with provision of appropriate tools and	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			equipment; • Identification and location of buried utility infrastructure prior to excavation for installation or repair of pipeline. Installation of visual marking of crude oil lines as part of installation, and updating as necessary on an ongoing basis; • Removal of sources of ignition prior to gas venting for maintenance and repair activities. Purging of gas from pipeline or pipe components prior to welding or cutting activities; • Installation of crude oil lines and components using sufficient separation distance and appropriate pipe protection layering to minimize potential interference with other underground infrastructure. Separation of plastic pipes from sources of heat; • Training of workers in procedures for emergency preparedness and response involving appropriate public authorities, in addition to emergency shutdown and • Pressure reduction in the piping system.	
	Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as nuisance. Non Hazardous waste will mainly	H	POL shall ensure: • Toilets are created at the site. • Site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
	come from discarded packaging materials such as metal cuttings, paper cartons and empty plastic containers. Although the impact from this waste is expected to be minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature.		labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated • Nonhazardous wastes are segregated, stored and disposed through an approved state waste collector	
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	POL shall ensure: • Provision of early release detection, such as pressure monitoring of crude oil conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines); • Controlling the potential effect of fires or explosions by segregation of process, storage, utility, and safe areas by	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility and between the facility and adjacent buildings, provision of additional cooling water capacity for adjacent tanks, or other risk based management approaches; and • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; ○ Designing the oily sewage system to avoid propagation of fire.	
	Air emission during maintenance/servicing of production equipment and ancillaries	M	POL shall ensure • Regular maintenance or servicing of production equipment as at when due • Prompt attention shall be given to any faulty production equipment • Use of original part to replace the faulty ones • Experts and professional must always be used to handle	L

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
			any repairs of production equipment and ancillaries • POL shall treat and dispose all waste oil and lubricants in accordance with regulatory requirements • and best practice using approved contractors • POL shall ensure that none of these wastes are disposed into any water body or on land	
	Road and traffic accidents as a result of transportation activities during facility operation	H	POL shall ensure: • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers	L
	Surface water and soil contamination: this could happen by treatment chemical (chemical injection process) and sludge/other materials removal during routine cleaning/repair	H	POL shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEnv guidelines • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc.	L

Table 6.4: Potential and Associated Impacts of the Proposed Project –Operation/Maintenance (Abnormal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Emergencies	Air Pollution Loss of containment of crude due to pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution	H	POL shall ensure: • General installation and pipe joining techniques such as welding, shall meet international standards for structural integrity and operational performance; • Testing of pipeline components for pressure specifications and presence of leaks shall be undertaken prior to commissioning. • Leak and corrosion detection programs shall be undertaken, including use of appropriate leak detection assessment techniques and equipment. Maintenance programs to repair and replace infrastructure shall be undertaken as indicated by detection results. • Typical urban testing sites include atmospheres in confined spaces of utility infrastructure (e.g. sewer and water system manholes), as well as at openings in pavement and on streets and walkways. • Regulating stations and vaults, both above and below ground, may contain equipment (e.g. safety valves, filters) that may emit fugitive emissions of gas. Valves, and other component infrastructure shall be regularly maintained, and ventilation and gas detection / alarm equipment installed in station buildings or vaults.	L

			• The plant design incorporates a Safety Integrity Level-3(SIL-3) programmable control system for Compressors and valves systems to ensure minimal probability of failure. Similarly, a high Safety Instrumentation System (SIS) designed with predictive maintenance configuration and risk mitigation applications for better system performance. • The Plant process area shall be fitted with sensor gas leak detectors and ESD	
	Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of emergency or equipment failure	H	POL shall ensure that: • Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Provide back-up systems to achieve as high a plant reliability as practical; and • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.	L
	Fire leading to impact on fish and fishing activities as well as the benthic ecosystem	H	POL shall ensure: • Providing early release detection, such as pressure monitoring of crude conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the	L

			layout of piping to avoid spills over high temperature piping, equipment, and / or rotating machines);
			• Limiting the areas that may be potentially affected by accidental releases by:
			  ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks;
			  ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; and
			  ○ Designing the oily sewage system to avoid propagation of fire.	

	Health and Safety Fire and explosion incident resulting in injury and fatalities	H	POL shall ensure: • Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment. • The equipment shall be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum number of people present. • Provision of manual firefighting equipment that is easily accessible and simple to use • Fire and emergency alarm systems that are both audible and visible • Permit to work system (PTW) shall be enforced	L

	Spills from onshore facilities, including pipelines, can occur due to leaks, equipment failure, accidents, and human error or as a result of third party interference	H	POL shall • Conduct a spill risk assessment for the facilities and design, drilling, process, and utility systems to reduce the risk of major uncontained spills; • Ensure adequate corrosion allowance for the lifetime of the facilities or installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks; • Install secondary containment around vessels and tanks to contain accidental releases; • Install shutdown valves to allow early shutdown or isolation in the event of a spill; • Develop automatic shutdown actions through an emergency shutdown system for significant spill scenarios so that the facility may be rapidly brought into a safe condition; • Install leak detection systems. On pipelines consider measures such as telemetry systems, Supervisory Control and Data Acquisition (SCADA9), pressure sensors, shut-in valves, and pump-off systems, • Develop corrosion maintenance and monitoring programs to ensure the integrity of all field equipment. For pipelines, maintenance programs should include regular pigging to clean the pipeline, and intelligent pigging should be considered as required; • Ensure adequate personnel training in oil spill prevention, containment, and response; • Ensure spill response and containment equipment is deployed or available for a response	L

Table 6.5: Potential and Associated Impacts of the Proposed Project – Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation
Demolition and Evacuation	Interference with road transportation	M	• POL shall monitor the no of trucks per day to know if there is need to create other accessible roads • POL shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles	L
	Noise and vibration nuisance	M	POL shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used	L
	Impairment of air quality	H	POL shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on sites to reduce dust levels	L

			especially during dry season.	
	Contamination of surface and Groundwater & soil	M	POL shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Follow FMEnv guidelines on waste management • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc. • Restore the to a condition in no way inferior to the condition prior to the commencement of work.	L
	Solid waste generation and impact on disposal facility	H	• POL shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors • POL shall ensure that none of these wastes are disposed into any water body or on land • follow safety measures while disposing wastes • POL shall keep all waste consignment, treatment and disposal records for regulatory verification • Proper disposal of solid waste from labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water to the environment • All other wastes generated including environmentally deleterious materials generated by construction activities will	L

			be disposed offsite in an appropriate, legal, and safe manner. • There is minimum generation of waste • Unsuitable excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible • Wastes shall be segregated, stored and disposed by an accredited state waste collector	
	Loss of job	H	POL shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L
	Injury / fatalities in workforce /communities	M	POL shall • Ensure Safety awareness training for workforce • Emergency response procedures shall be put in place and enforced • ensure use of PPE • provide first aid and clinic on site	L
	Kidnapping of workers and visitors on site	H	• POL shall ensure that both contractor and POL personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the POL Project Manager • Special security force shall be established and deployed for the project. • POL shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is	L

			established and sustained • In order to beef up security for the project, POL shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved security • POL shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized	
	Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.	M	POL shall: • Assist staff that are likely to lose job in skill acquisition • Assist in setting small scale business	L
	Revegetation	P	• Restoring vegetation after decommissioning of facility	P

6.4 Summary of Residual Impacts after Mitigation

Residual Effects can be considered as those that remain significant following the application of mitigation measures, although they are likely to have been reduced in magnitude as a result of the implementation of the mitigation measure.

In all, the positive impacts of the project will considerably outweigh the negative impacts if the mitigation measures outlined in Tables 6.1 to 6.4 is implemented and the public will benefit from the completion of the project. Once the mitigation measures outlined are implemented, the residual impact of construction and operation on the different elements identified will not be significant.

An overall mitigation measure is to undertake a Job Hazard Analysis (JHA), so as to enlighten the workers on the risks associated with the job and work safely using procedural guidelines in handling equipment and the facilities.

CHAPTER SEVEN

ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.1 Introduction

Environmental management is concerned with a planned, integrated programme aimed at ensuring that identified and unidentified impacts of a proposed project are contained and brought to an acceptable minimum. It provides confidence on the part of project planners that a reliable scheme will be put in place to deal with any contingency that may arise during all phases of development from preliminary study to abandonment.

In keeping with the Pillar Oil Limited's policy on the environment, consideration of the environmental implications of this project began from preliminary study, conceptual design, up to the present stage of ESIA. This ESIA is intended to provide an environmental input into the planning and execution of the project as being addressed by environmental management plan.

Environmental and Social Management Plan (ESMP) is the tool for managing the predicted environmental impacts of a project. It provides the means whereby the mitigation measures developed for reducing the effects of moderate and major impacts to as low as reasonably practicable (ALARP) are implemented and monitored throughout the project lifecycle.

The ESMP shall be used as a tool for the management of the predicted environmental, social and health potential impacts. It provides the mechanism for implementing mitigation measures that have been developed to reduce the effects of "medium" and "high" negative impacts to as low as reasonably practicable (ALARP), prior to and through the life cycle of the project.

Environmental management activities of the proposed Pillar Oil Limited project shall be governed by a series of regulations that impose standards and mitigation of environmental hazards. Thus, it is a planned and integrated programme aimed at ensuring that both identified and unidentified impacts that may arise during the various phases of the project are brought to an acceptable level.

This ESMP is developed in line with the framework provided in Act Cap E12, LFN 2004 of Federal Ministry of Environment (FMEnv)

7.2 Objectives of the ESMP

The objectives of the ESMP is to:

- ensure compliance with regulatory requirements and the company policy;

- achieve, enhance and demonstrate sound environmental performance built around the principle of continuous improvement;
- integrate environment fully into the business;
- rationalise and streamline existing environmental activities to add value in efficiency and effectiveness;
- encourage and achieve the highest performance and response from individual employees and contractors;
- provide standards for overall planning, operation, audit and review;
- enable management to establish environmental priorities;
- ensure early consultation is held with communities and regulating authorities to ensure hitch free operations;
- establish a structure that will ensure compliance by POL and its Contractors with the ESMP

In order to accomplish its objectives, the ESMP considered each environmental, social and health impact of the project as well as the parameters for their monitoring. The ESMP translates recommended mitigation and monitoring measures into specific actions that will be carried out by POL.

For the development of this ESMP, POL recognised that sound environmental management of the proposed project can only be guaranteed through the integration of the provisions of the plan as an integral part of business quality management. To this end Pillar Oil Limited shall put in place measures to enforce compliance by the project team on a daily basis throughout the duration of the project. It outlines the actions necessary to attain this goal, and describes the means, time frames, and designation of responsibility required for compliance and conformance.

The Pillar Oil Limited ESMP:

- identifies and discusses the management and implementation of commitments to stakeholders, as identified in the report;
- discusses how to implement the mitigating/amelioration measures, as identified in the report;
- designed and implement an appropriate post-ESIA monitoring;
- identified the action parties and provide time frame for implementation of issues identified
- is accompanied with fiscal plan for implementation of mitigating measures and monitoring; and
- puts in place a systematic procedure of obtaining all necessary regulatory approvals/permits for all the aspects of the project

7.3 Management Commitments and Responsibility

The Management's commitment and responsibility are detailed in the company's Health, Safety and Environmental (HSE) policy. The company operates in strict compliance with all the provisions of this HSE policy which specifies the need for adherence to national standards and guidelines by every member of staff and contractors.

The HSE policy of POL states that projects are planned and executed in a manner that achieves the following:

- preserves the health, safety and security of its employees, contractors, and all members of the public who may be affected by its operations;
- minimizes the impact of its operations on the environment; and
- be sensitive to the needs and concerns of POL host communities
- integrate health, safety and environmental matters into every aspect of its activities and set objectives to drive continual improvement;
- comply with all relevant health, safety and environmental laws and regulations;
- initiate and maintain effective arrangements for communication within the organisation, with contractors, the public or its agents and other stakeholders regarding health, safety and environmental matters;
- apply relevant standards, good engineering practices and principles of risk management to protect health, safety and the environment and to ensure the integrity, reliability and efficiency of the gas plant facilities;
- exhibit socially responsible leadership, demonstrate exemplary health, safety and environmental performance and publicly report performance;
- conserve POL's assets and natural resources, and minimise the impact of gas plant's activities on the environment, by conducting impact assessments, and ensuring responsible management of emissions, discharges and waste streams. This includes efficient use of energy in its operations;
- identify present or future potential health, safety and environmental hazards resulting from gas plant operations, conduct risk assessments and select and implement appropriate measures to manage the risks;
- develop and implement a health, safety and environment plan which includes implementation of prioritised procedures to form a complete management system;
- maintain adequate emergency preparedness and response capabilities;
- effectively communicate POL's health, safety and environmental requirements to all contractors and subcontractors and require them to manage HSE in accordance with the POL's policy;
- ensure conformity with this policy by a comprehensive compliance program including audits; and

- adequately resource health, safety and environment functions throughout the business.

The primary vehicles through which POL shall meet the commitments in the HSE Policy are a comprehensive Health, Safety and Environment Management System (HSE-MS) and the associated planning documents which include the following which are also specific to the ESMP:

- HSE Management Plan (Safety Plan)
- Waste Management Plan;
- Security Plan;
- Labour Plan (including Job Rules);
- Community Relations Plan;
- Influx Management Plan;
- Community Development Plan; and
- Transportation and Journey Management Plan.

7.3.1 Organisation Structure

Pillar Oil Limited has an organisation structure that describes the various departments, responsibilities and responsible parties that will help it achieve its overall environmental objective (**Figure 7.1**). The HSE department is primarily responsible for environmental, safety, security and occupational health management. The Pillar Oil Limited ESMP is administered by the HSE department.

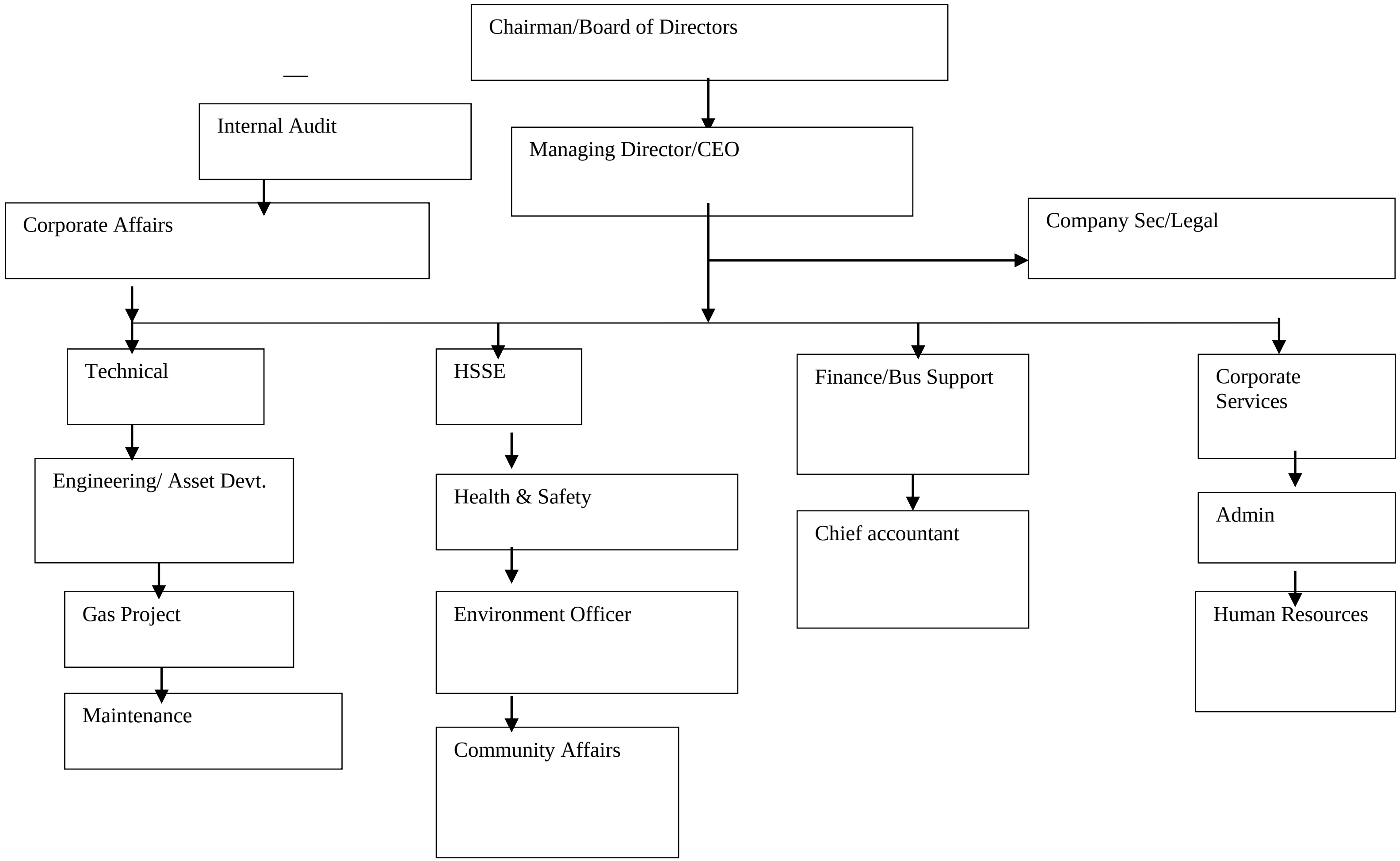


Figure 7.1: Organisation Organogram

7.3.2 Contractor Management Plan

POL will engage contractors to carry out the various project activities. The contractors are responsible for performing all work in compliance with relevant national and international HSE legislation and regulations, and with other requirements to which POL subscribes; and in conformance with POL's HSE MS requirements; and in accordance with POL's technical and quality specifications.

POL will provide specifications for environmental compliance and performance (through this ESIA and ESMP and the associated plans) and, as a contractual requirement, the Contractor must develop and provide to POL its own specific management plans, incorporating:

- Health, Safety and Environment Policy Statements, Programs, and Management Systems;
- Health, Safety, and Environment Organization;
- Health, Safety, and Environment Responsibilities;
- HSE Procedures;
- Employee HSE Training Programs;
- Waste Management Plans;
- Emergency Response/Evacuation Plans;
- Transportation Safety Management System;
- Hazardous Materials Management Program;
- Industrial Hygiene and Medical Protection Plans.

The Contractors must also provide documentation detailing their plans for implementing the measures required in the ESIA and this ESMP; Local Content; Logistics; Security; and Community Relations. The Contractor's management plans must conform to the requirements of POL's overarching plans. Contractor's plans will be reviewed and approved by POL and incorporated into, and form part of, POL's overall ESMP. Contractors will be required to self-monitor against their plan and the contractor's compliance with the plan will be routinely monitored by POL directly or by third-parties and in conjunction with environmental regulators. Contractors will be required to submit regular reports of monitoring activities and POL will review these on a regular basis.

As a contractual requirement, the Contractor will provide sufficient resources to manage HSE aspects of the work to be performed. This includes providing resources to ensure sub-contractor compliance and a process for emergency stop-work orders in response to monitoring triggers.

7.4 Implementation

7.4.1 Training

POL shall identify, plan, monitor, and record training needs for personnel whose work may have a significant adverse impact on the environment or social conditions. It recognizes that it is important that employees at each relevant function and level are aware of POL's environmental, social, and health policy; potential impacts of their activities; roles and responsibilities in achieving conformance with the policy and procedures.

This will be achieved through a formal training process. Employee training will include awareness of and competency with respect to:

- environmental and social impacts that could potentially arise from their activities;
- necessity of conforming to the requirements of the ESIA and ESMP, in order to avoid or reduce those impacts; and
- roles and responsibilities to achieve that conformity, including with regard to change management and emergency response

The HSE Manager is responsible for coordinating the training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The HSE Manager will also periodically verify that staffs are performing competently through discussion and observation. Employees responsible for performing site inspections shall receive training drawing on external resources as necessary. Training will be coordinated by the HSE Manager and/or Community Relations Manager prior to the beginning of field activities. Upon completion of training and once deemed competent in the requirements, staff will be allowed to train other people.

Similarly, POL shall require that each of the Contractors institute training for its personnel. Each Contractor is responsible for site HSE awareness training for personnel working on the job sites. The Contractor is also responsible for identification of any additional training requirements to maintain required competency levels.

The Contractor training program will be subject to approval by POL and it will be audited to ensure that:

- training programs are adequate;
- all personnel requiring training have been trained; and
- Contractor has periodically verified that personnel perform competently after training

7.4.2 Documentation

POL will control HSE documentation, including plans (e.g., the ESMP); associated procedures; and checklists, forms, and reports, through a formal company procedure. The document control procedure also describes the processes that POL and the Contractor will employ for official communication of both hardcopy and electronic (through the intranet) document deliverables. In addition, it describes the requirement for electronic filing and posting and for assignment of a document tracking and control number (including revision codes).

The POL Document Control Officer is responsible for maintaining a master listing of applicable documents, including HSE documents, and making sure that this list is communicated to the appropriate parties. The POL HSE Manager is responsible for providing notice to the affected parties of changes or revisions to documents, for issuing revised copies and for checking that the information is communicated within that party's organization appropriately.

The Contractor shall be required to develop a system for maintaining and controlling its own HSE documentation and describe these systems in their respective HSE Plans and Site-Specific HSE Plans.

7.4.3 Operational Control Procedures

Each potentially significant impact identified in this ESMP shall have an operational control associated with it that specifies appropriate procedures, work instructions, best management practices, roles, responsibilities, authorities, monitoring, measurement, and record keeping for avoiding or reducing impacts. Operational controls are monitored for compliance and effectiveness on a regular basis through a monitoring and auditing procedure described in the ESMP.

Operating control procedures shall be reviewed and, where appropriate, amended to include instructions for planning and minimizing HSE impacts, or to at least reference relevant documents that address HSE impact avoidance and mitigation. To be comprehensive, suitable, adequate, and effective, the ESMP shall ensure that operational controls for avoiding and minimizing impacts are properly maintained for the project's life-cycle.

7.4.4 Emergency Preparedness and Response

POL has developed plans and procedures to identify the potential for and response to environmental accidents and health and safety emergency situations and for preventing and mitigating potentially adverse environmental and social impacts that may be associated with them. The Emergency Management Plan describes how detailed emergency response planning for foreseeable emergencies at all locations will be planned, implemented, reviewed, improved. Individual Emergency Response

Plans are written to provide additional detail for responding to incidents at specific locations. Emergency methods shall be reviewed by POL on an annual basis and after the occurrence of accidents or emergency situations.

7.5 Checking and Corrective Action

The objective of the inspection and monitoring activities described in this section is to verify compliance with the ESMP. The inspection and monitoring approach will also be reflected in Contractor's HSE procedures. Contractors will be responsible for implementing POL's environmental and social commitments in the field on a daily basis. Auditing of the monitoring and inspection activities by the Contractor and by POL provide the mechanism by which POL insures that it remains compliant with regulatory commitments as well as its own HSE standards and policies.

The *inspection* activities described in this ESMP refer to qualitative monitoring, e.g., visual inspections. The *monitoring* activities described in this ESMP refer to empirical monitoring (e.g., measurements).

7.5.1 Inspection

Inspections shall be conducted by Staff, Contractor's HSE department on a daily basis. The results of the inspection and monitoring activities shall be made available to POL on a weekly basis or more frequently if requested by the POL Head HSE.

7.5.2 Monitoring

Monitoring will be conducted to ensure compliance with regulatory requirements as well as to evaluate the effectiveness of operational controls and other measures intended to mitigate potential impacts. With respect to the significant impacts identified in the ESIA, POL has developed a program to monitor the effectiveness of the mitigation measures. The program describes what effect is to be measured and the frequency.

In conjunction with monitoring of the effectiveness of specific mitigation measures, POL has developed a program to monitor for compliance with relevant regulatory standards. This program also ensures that staffs are meeting contractual obligations with respect to work practices and design specifications. Monitoring is carried out by POL HSE department and/or by Supervisors and Contractors pursuant to their contractual obligations. The parameters to be measured during the Pillar Oil Limited activities along with the frequency of monitoring are provided in **Tables 7.1 – 7.6** below.

7.6 POL's Waste Management Policy

The waste management policy stipulates that:

- All practical and reasonable measures are taken to minimize the generation of solid, liquid and gaseous wastes;
- management and disposal of wastes in an environmentally responsible manner be observed; and
- tracking and maintenance of records of waste streams, and provision of verifiable trail of their management and disposal be maintained.

7.6.1 Waste and Hazardous Materials Management

The management of all wastes and hazardous materials that may be generated during the various activities of this gas plant project shall form an integral part of the overall HSE-MS (HSE Management System) and shall be based on a “cradle to grave” approach. The standard for the guideline includes the regulations of the FMEnv, DPR and other National and International Agencies. These standards shall be binding on all staff and contractors involved in the project with respect to the:

- emission or release of pollutant, exhaust and/or fugitive gases;
- discharge or spill of effluent into the ecosystem; and
- discharge of solid wastes (including domestic waste).

7.6.2 Waste Handling

For proper handling and disposal, wastes shall be well defined at source and the definition transmitted along with the waste to the final disposal points. Contractor shall define and document all wastes generated in the course of work. Basic information that shall be provided, as a minimum, for adequate definition of wastes include:

- waste type identification;
- proper waste categorization
- waste segregation information; and
- recommended waste management practices

7.6.3 Waste Minimization

Waste minimization aims at a reduction of the volume of wastes to the greatest extent possible. The four principles of waste minimization process: recycle, reduce, reuse and recover shall be applied. A large proportion of excavated materials shall be used on site.

7.6.4 Waste Segregation

In order to ensure effective implementation of appropriate waste disposal methods, it is important that wastes are segregated at source. During construction, the types of wastes expected include off-cut metals, spent electrodes, cement slurry, spent lube oil, oil filters, cartridges, etc. These wastes shall be segregated into clearly designated bins at strategic locations with the waste bins located at the construction site.

7.6.5 Waste Disposal

All waste shall be disposed regularly in line with the POL waste management manual. Instructions on a product's Material Safety Handling Sheet shall be strictly adhered to and this shall form the basis for the disposal of wastes related to such products. In line with the POL, wastes in transit shall be accompanied and tracked by consignment notes.

7.6.6 Waste Tracking

In keeping with standard practice and regulatory requirements, the POL shall maintain a standard waste tracking system (cradle to grave).

7.6.7 Operational Wastes and Disposal Methods

All wastes generated during the construction, operation and decommissioning phases shall be fully segregated and disposed of safely at designated locations by FMEnv, DPR, Delta State Ministry of Environments' accredited contractor in line with the POL management procedure.

7.6.8 Hazardous Materials Handling

In keeping with the POL HSE policy, this company shall ensure that:

- Material data sheets are readily available at site for all hazardous substances, including a short write up on ecological impacts (and mitigation) of accidental spills or incidents;
- Staff (including contractors" and casuals) handling hazardous materials shall be appropriately re-trained to be aware of the health and environmental implications.

7.7 Environmental Audit Programme

Prior to mobilization, an environmental audit shall be carried out and during project execution additional environmental audit shall be conducted. The environmental audit process shall be used to ensure that measures are put in place for ensuring sustainable development through enforcement of the necessary management procedures. The essence of the audit shall be to:

- Determine compliance with regulatory requirements.
- Inspect facility management systems, its operations, monitoring practices etc.

- Identify current and potential environmental problems during the various phases of the project.
- Ensure implementation of recommended practices and procedures.
- Make recommendation(s) for the improvement of the management system of the project.

7.8 Implementation of the Mitigation Measures for Potential Impacts

Mitigation measures have been proposed for medium and high rated negative impacts. The measures represent POL commitment to environmental protection and shall be incorporated into the project's HSE-MS document.

7.9 Monitoring Programmes

In order to comply with regulatory requirements, monitoring programmes for biophysical, social and health aspects have been developed and these shall apply throughout the project lifecycle. Separate monitoring plans have been prepared for the associated potential impacts and cumulative impacts.

The monitoring of the ESMP implementation shall involve the statutory regulators; Federal Ministry of Environment (FMEnv). Department of Petroleum Resources (DPR) and Delta State Ministry of Environment.

The environmental/social components and characteristics to be monitored are included in ***Table 7.1.***

Table 7.1: Environmental and Social Management Plan (ESMP) of Umuseti/Igbuku Fields (OML 56) Further Field Development – Pre-Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Mobilisation (transport) to site (drilling rig, construction materials, other equipment and personnel to site)	Road and traffic accidents	H	POL shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • minimize movement at the peak hours of the day	L	Site inspection/ stakeholder engagement report Inventory of approved journey management forms	POL	During Pre-Construction

			• ensure that all traffic rules are obeyed by the drivers • Large and slow-moving vehicles shall be scheduled during off peak periods • Involve POL security in traffic control in traffic management • Defensive driving course for POL and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	POL shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use	L			

			• Vehicles are fitted with effective silencers.				
	Impairment of air quality	M	POL shall ensure: • Engine to comply with international standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water shall be sprayed on construction sites to reduce dust levels especially during dry season.	L	Site inspection report Compliance monitoring report *Preventive maintenance schedule for all engines and their maintenance logbook.*	POL	During Pre-Construction
	Loss of biodiversity	M	▪ Strictly regulating heavy equipment traffic ▪ Restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access	L	Site inspection report Compliance monitoring report	POL	During Pre-Construction

			way ▪ Implement good housekeeping practise on-site. ▪ Storing and handling of hazardous waste in accordance to approved WMP ▪ Selecting vehicles suited for erodible soil ▪ Limiting activities in erodable soil				
	Population - Influx of people to project site could directly and negatively impact existing infrastructure and also influence social behaviour	M	As part of the company policy, POL shall ensure that workforce will be sourced from the stakeholder communities to reduce the impact of emigration, however with uppermost consideration for competence and qualification. This will reduce the impact of population influx.	L	Contract documents/ list of community members employed	POL	During Pre-Construction
	Increased opportunity for business and employment	P	POL shall ensure: • local contractors are engaged; • prompt payment to	P	Contract documents/ list of community	POL	During Pre-Construction

			engaged labour • that Indigenes are considered first • that alternative will be made and vehicular traffic will be reduced that they agree with community before mobilization on modalities of promoting Local entrepreneurship in the provision of housing and transport.		members employed		
Energy consumption (provision of energy for pre-construction activities)**)**	Impairment of air quality	M	POL shall ensure that: • there is regular maintenance of the generators; • generators are switched off when not in use • dust control and dust recovery machinery are used	L	Site inspection report Compliance monitoring report *Preventive maintenance schedule for all engines and their maintenance logbook.*	POL	During Pre-Construction
	Noise and	M	POL shall ensure that:	L	Site	POL	During Pre-

	vibration nuisance		• electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • noise barrier are erected • generators are switched off when not in use; • soundproof electric power generators are engaged		inspection report Compliance monitoring report		Construction
	Contamination of soil	M	POL shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil. • Implement good housekeeping practise on-site. • Storing and handling of hazardous waste in accordance to approved WMP.	L	Site inspection report Compliance monitoring report	POL	During Pre-Construction
Site	Acceleration of	H	POL shall:	M	Site	POL	During Pre-

Preparation – clearing, excavation and landscaping	erosion		• Stabilize soil within the well location and campsite mechanically using compactors to reduce erosion potential • Mechanically stabilize the soil in order to reduce potential for erosion • Avoid excavation and burial in steeply sloped ground and avoid creation of great breaks • Provide for the placement of siltation ponds in areas subject to heavy erosion • Select vehicles suited for erodible soil • Limiting activities in erodable soil		inspection report Compliance monitoring report		Construction
	Alteration of local topography	M	• POL shall: • re-grading the sites, then replacing the layer of top soil that was previously put.	L	Site inspection report Compliance	POL	During Pre-Construction

			• restoring the operational site by restoring the original profile of the topography and the soil • strictly regulating heavy equipment traffic • restricting the number of traffic lanes and limiting the movement of the machinery to the work site and to the marked access way		monitoring report		
	Alteration of soil profile	M	POL shall: • ensure that stripping and excavation of topsoil is strictly limited to areas acquired for the activities. • ensure proper re-vegetation of all other areas with indigenous species from adjoining forest after activities • stabilize soil within the	L	Site inspection report Compliance monitoring report	POL	During Pre-Construction

			well location and campsite mechanically using compactors to reduce erosion potential				
	Blockage of drainage pattern	L	POL shall ensure that: • trict environmental policy shall be ensured • Regular cleaning of the drainage shall be ensured • The drainage network shall be covered	Negligible	Site inspection report Compliance monitoring report	POL	During Pre-Construction
	Contamination of soil by runoffs	L	POL shall: • Ensure that soil disturbance shall be kept to minimum required for operation and safety • Ensure that oil spill containment are provided to reduce oil spill from getting to the soil • Implement good housekeeping practise on-site.	Negligible	Site inspection report Compliance monitoring report	POL	During Pre-Construction

			• Store and handle hazardous waste in accordance to approved WMP. • Place filtration berms and sediment barriers. • Use methods that minimises perturbation to aquatic environment. • Avoid spills prohibiting refuelling near waterway				
	Impairment of air quality	M	POL shall ensure that: • only pre-mobbed equipment are used; • all equipment are controlled; • equipment engines are turned off when not in use • POL shall ensure that all construction equipment shall be in proper operating condition and fitted with factory standard silencing features if	L	Site inspection report Compliance monitoring report *Preventive maintenance schedule for all engines and their maintenance logbook*	POL	During Pre-Construction

			appropriate • POL shall provide and enforce the use of PPE (e.g. nose masks and ear muffs) • POL shall construct sound proofing walls around stationary power generating sources • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the				

			height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust;				
	Noise and vibration nuisance	M	POL shall ensure that: • equipment are fitted with effective silencers; • there shall be regular maintenance of equipment; • equipment are	L	Site inspection report Compliance monitoring report	POL	During Pre-Construction

			switched off when not in use; • Vibration containment be made for equipment which are likely to cause vibration • noise barriers are erected				
	Work site accidents	H	POL shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on work site • Clinic / first aid kit shall always be available within the site	L	Site inspection report Compliance monitoring report	POL	During Pre-Construction
	Security/artificial light at night	L	POL shall ensure that: • work at night shall be done without impacting the visual element of the area by reducing luminosity of night light. • As far as possible, the	Negligible	Site inspection report Compliance monitoring report	POL	During Pre-Construction

			operation of heavy equipment shall be conducted in day light hour in locations that are not close to residential areas • Job shift is encouraged				
	Habitat Alteration	H	POL shall: ▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by restoring vegetation at the end of the work	L	Site inspection report Compliance monitoring report	POL	During Pre-Construction

Table 7.2: Environmental and Social Management Plan (ESMP) of Umuseti/Igbuku Fields (OML 56) Further Field Development – Construction Phase

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Transport activities during drilling/construction	Road traffic accidents	H	POL shall ensure: • the creation of awareness amongst local communities on the potential of increase in traffic, and the need for extra precautions through public enlightenment • compliance with journey management policy • Vehicles are pre-mobbed and pre-mobilization/co	L	Site inspection / stakeholder engagement report Inventory of approved journey management forms	POL/ Delta State Ministry of Environment/FMEnv/DPR	During Construction

			mpliance certificate issued. • the use of PPEs at sites; daily pep talk, • to carry out job hazard analysis • minimize movement at the peak hours of the day • ensure that all traffic rules are obeyed by the drivers • Large and slow moving vehicles shall be scheduled during off peak periods • Involve POL security in traffic control in traffic management • Defensive				

			driving course for POL and contractor drivers • First aid training of workforce and provision of first aid boxes in operational vehicles • Visible warning signs on roads and vehicles • Speed breakers at sections traversing communities				
	Noise nuisance	M	POL shall ensure: • regular maintenance of vehicles • Vehicles are turned off when not in use • Vehicles are fitted with effective silencers.	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

	Impairment of air quality – emission from truck, construction activities and drilling process	M	POL shall ensure: • Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and	L	Site inspection report Compliance monitoring report *Preventive maintenance schedule for all engines and their maintenance logbook*	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance; • Use of loading and unloading equipment that minimizes the height of fuel drop to the stockpile to reduce the generation of fugitive dust and installing of cyclone dust collectors; • Use of water					

			spray systems to reduce the formation of fugitive dust from solid fuel storage in arid environments; • Use of enclosed conveyors with well designed, extraction and filtration equipment on conveyor transfer points to prevent the emission of dust				
Excavation of land area and Casting of the plinths/ drilling of wells	Loss of vegetal cover with possible impact on biodiversity loss	H	POL shall: ▪ Provide siltation pond in areas of heavy erosion ▪ Place filtration berms and sediment barriers.	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			▪ Use methods that minimises perturbation to aquatic environment. ▪ Avoid spills prohibiting refuelling near waterway ▪ Minimise destruction or modification of the vegetation cover by restoring vegetation at the end of the work				
	Impairment of air quality	M	POL shall ensure: • there is regular maintenance of the engines; • engines are switched off when not in use • engines to comply with international standards for	L	Site inspection report Compliance monitoring report *Preventive*	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			exhaust gases; • Maintenance of engines and exhaust gas check; • that nose masks and ear muffs are worn by site workers during excavation • Use of the cleanest fuel economically available shall be adopted • Combustion technology and pollution control technology, which are all interrelated, shall be evaluated very carefully upstream of the project to optimize the project's environmental performance;		*maintenance schedule for all engines and their maintenance logbook*		
	Noise and vibration nuisance	H	POL shall ensure that: • Machine engines are	L	Site inspection report	POL/Delta State Ministry of Environment/FMEn	During Construction

			fitted with effective silencers; • regular maintenance of machine/ engines are performed; • engines are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs is encouraged • vibration containment shall be made for generators and machines • seismic activities in the vicinity of local populations		Compliance monitoring report	v/DPR	

			wherever possible minimze; • simultaneous operations on closely spaced survey lines are minimize; • the use of the lowest practicable vibrator power levels; • they reduce operation times, to the extent practical; • When shot-hole methods are employed, charge size and hole depth should be appropriately selected to reduce noise levels.				

			• Proper back-fill or plugging of holes will also help to reduce noise dispersion;				
	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Hazardous waste will mainly come from discarded packaging materials such as metal cuttings Drilling fluids and drilled	M	POL shall ensure that: • all other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • generation of all wastes are minimize as much as practically possible • Unsuitable	L	Site inspection report Compliance monitoring report Waste Management Plan	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

	cuttings, produced sand, Completion and well work-over fluids, naturally occurring radioactive materials (NORM)and empty plastic containers. Poor disposal methods can lead to environmental problems due to their non-biodegradable nature. Most of the packaging		excavated materials shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste				

	wastes are expected to be reused		materials must not be burned; • Optimize the reuse of spoil and construction waste; • All the construction camps and facilities shall be dismantled and removed from the site, unless otherwise desired by the local public; • site shall be restored to a condition in no way inferior to the condition prior to the commencement of work. • safety measures while				

Construction of Gas Plant, Pipeline and Storage Facilities			disposing wastes are followed; • introduction of foreign soil and synthetic materials is avoided; • disposal of construction and related waste materials at designated and approved waste dump site; • waste management plan in road planning and contract specifications is incorporated; • there is collaboration with relevant waste management				

			agencies to enforce appropriate sanitation and other bye laws. • Storage in dedicated storage tanks or lined pits prior to treatment, recycling, and / or final treatment and disposal; • On-site or off-site biological or physical treatment to render the fluid and cuttings non-hazardous prior to final disposal • using established methods such as thermal				

			desorption in an internal thermal desorption unit to remove NADF for reuse, bioremediation, landfarming, or solidification with cement and / or concrete. Final disposal routes for the non-hazardous cuttings solid material should be established, and may include use in road construction material, construction fill, or disposal through landfill including				

			landfill cover and capping material where appropriate. In the case of land farming it should be demonstrated that subsoil chemical, biological, and physical properties are preserved and water resources are protected; • Recycling of spent fluids back to the vendors for treatment and re-use; • Use of high efficiency solids control equipment to reduce the				

			need for fluid change out and minimizing the amount of • residual fluid on drilled cuttings; • Use of slim-hole multilateral wells and coiled tubing drilling techniques, when feasible, to reduce the amount of fluids • and cuttings generated. • Minimizing environmental hazards related to residual chemicals additives on discharged cuttings by				

			careful selection of the fluid system. • Careful selection of fluid additives taking into account technical requirements, chemical additive concentration, toxicity, bioavailability and bioaccumulation potential; • Monitoring and minimizing the concentration of heavy metal impurities (mainly mercury and cadmium) in barite stock used in the				

			fluid formulation. • The pit waste should be analyzed and the maximum lifetime loads should be calculated. A risk based assessment may be necessary to demonstrate that internationally recognized thresholds for chemical exposure are not exceeded.				
	Soil damage - compaction by clearing tractors causing change in	H	POL shall ensure that: • Area and depth to be excavated shall be strictly limited to the minimum	L	Site inspection report Compliance monitorin	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

	soil micro structures such as porosity, permeability and removal of soil organics		required.		g report		
	Burns/injuries from welding sparks	H	• POL shall ensure that workers and visitors are properly kitted • Use of experienced/competent workers • Pipe joining techniques such as welding shall meet international standards	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction
	Exposure to welding flash	H	• POL shall ensure that workers and visitors are properly kitted	L	Site inspection report Complian	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			(appropriate PPEs are used)		ce monitorin g report		
	Noise and vibration nuisance	M	POL shall ensure that: • electric power generators are fitted with effective silencers; • there shall be regular maintenance of the generators; • generators are switched off when not in use; • soundproof electric power generators are engaged • the use of PPEs shall be encouraged	L	Site inspection report Complian ce monitorin g report	POL/Delta State Ministry of Environment/FMEn v/DPR	During Construct ion

	Surface water may be polluted due to increased erosion, run off from construction site, and contamination in the event of oil spills from equipment and machinery	H	POL shall ensure that: • Soil disturbance shall be kept to minimum required for operation and safety to reduce erosion • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface • there shall be regular maintenance of the equipment and machineries • Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.				

	Waste Management - The potential effects will be of aesthetics as well as a nuisance. Wastes shall mainly come from discarded packaging materials such as metal cuttings and empty plastic containers. Poor disposal methods can lead to environmental problems	H	POL shall ensure that: • toilets are created at the site. • site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment	L	Site inspection report Compliance monitoring report Waste Management Plan	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

	due to their non-biodegradable nature. Most of the packaging wastes are expected to be reused		• Minimum wastes are generated • Reuse waste materials wherever possible and use designated disposal sites; • Used oil and lubricants shall be recovered and reused or removed from the site in full compliance with the national and local regulations; • Oil wastes, debris and/or other waste materials shall not be burned; • safety measures are followed while disposing wastes;				

Backfilling	Alteration of hydrological patterns resulting in temporary or permanent flooding, soil erosion and destruction of biodiversity	H	• Mechanically stabilising the soil in order to reduce potential for erosion • Avoiding excavation and burial in steeply sloped ground and avoiding creation of great breaks • Providing for the placement of siltation ponds in areas subject to heavy erosion • Selecting vehicles suited for erodible soil • Limiting activities in erodable soil • At the completion of	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			the work, levelling the disturbed soil and quickly seeding or replanting bushes in order to control soil erosion.				
	Dust Generation	M	POL shall: • Implement good housekeeping practice on-site. • POL shall ensure the use of appropriate PPEs • POL shall ensure that backfilling is followed by mechanical compaction so	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			as to retain the original level				
	Kidnapping of workers and visitors on site	H	• POL shall ensure that both contractor and POL personnel develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the POL Project Manager • Special security force shall be established and deployed for the project. This shall include	L	Site inspection report Security Report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			deploying some of POL police to strengthen security in the area • POL shall ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, POL shall support government authorities by providing assistance with equipment e.g. patrol vehicles,				

			to ensure improved security • POL shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized				
	Worksite accidents	H	POL shall ensure that: • workers and visitors are properly kitted (use of appropriate PPEs) • use of warning signs • non-consumption of alcoholic beverages on	L	Site inspection report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			work site • Clinic / first aid kit shall always be available within the site				
	Increase in communicable disease (including STDs and HIV/AIDS)	M	• Health awareness lectures shall be given to workers on the mode of transmission of STIs (including HIV/AIDS) • As much as possible provide psychological support to persons living with the HIV virus • POL shall insure immunization of workforce against as	L	Site inspection report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			appropriate • Regular spraying of work sites Provision of insecticide treated nets to field workers to reduce incidence of malaria • Awareness campaign shall be carried out to enlighten the communities /field workers on the common communicable diseases and the health implications of drug and alcohol abuse, unprotected sex, prostitution and				

			the need to sustain cultural values • POL shall assist the activities of the state action committee on STIs/HIV/AIDS as part of her stakeholders' engagement plan. • POL shall ensure site clinic is provided to take care of minor illnesses for all construction workers				
Construction of Pipeline/Storage facilities	Temporary change in land use but land will be returned to its	M	• Ensure prompt landscaping/reclamation of degraded lands. • Rehabilitate	L	Site inspection report Compliance	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

	original use after completion of works and subsequent sand filling		Excavation sites by filling. • Ugly scars left around sites shall be leveled and landscaped. • Plant shrubs/grasses to be planted to check erosion. • Develop embankment on steep slopes to protect them from erosion. • Stone pitch to protect slopes where necessary • New structures such as signboards, bill boards for the project shall be		monitoring report		

			removed after construction. Those required such as direction or warning signs shall be properly placed.				
Coating	Contamination of surface water and soil by paints and coating as a result of spillage	H	• Ensure compliance with the MDS (material data sheet) of paints or any chemical to be used during tanks coating Implementing of management controls (procedures, inspections, communications, training, and drills) to address residual risks	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			that have not been prevented or controlled through engineering measures. • Safe ventilation for storage of volatile materials shall be provided; • Access to areas containing paint substances shall be restricted and controlled; • Paints shall be stored on impervious ground under cover; the area shall be constructed as spill tray to avoid spread of				

			accidental spills				
	Hazardous waste generation from coating operations such as metals	H	• Good housekeeping shall be instituted and maintained • hazardous wastes shall be collected, stored and disposed appropriately in line with DPR standard at an approved disposal sites	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction
Construction of treatment plant	Waste water management from construction - Inappropriate management can lead to	M	• Disposal of water and waste products arising from the sites via a suitably designed temporary drainage system in a manner that shall not cause pollution problems or other nuisance;	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

	contamination of surface and groundwater		• Ensure storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • Vehicles and equipment shall be maintained in good condition, ensuring no leakage of oil or fuel; • Provide sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment. • Waste water shall be treated in line with an approved standard by FMEnv before of its release to the environment				
	Changes in surface	L	• Drilling of borehole for	Negligible	Site inspection	POL/Delta State Ministry of	During Construct

	hydrology from water utilization for construction		water utilization for construction of concrete-weight		report Compliance monitoring report	Environment/FMEnv/DPR	ion
Commissioning – Radiography and hydrotesting / **Well testing**	Discharge of hydrotest water from hydrostatic testing of equipment and interconnecting pipeline with water.	H	POL shall ensure: • Using the same water for multiple tests to conserve water and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous	L	Site inspection report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according to local regulatory requirements and manufacturer recommendations • that the hydro test fluid is disposed at an approved government site within each state. • Disposal in each case shall be monitored by the appropriate regulatory bodies and POL				
	Flaring of produced hydrocarbons	H	POL shall ensure that: • Feasible alternatives be	L	Site inspection report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			evaluated for the recovery of hydrocarbon test fluids, while considering the safety of handling volatile hydrocarbons, for transfer to a processing facility or other alternative disposal options. An evaluation of disposal alternatives for produced hydrocarbons shall be adequately documented and recorded. • Only the minimum volume of hydrocarbons required for the test should be flowed and well		Compliance monitoring report Flare report		

			test durations should be reduced to the extent practical. • An efficient test flare burner head equipped with an appropriate combustion enhancement system should be selected to minimize incomplete combustion, black smoke, and hydrocarbon fallout. Volumes of hydrocarbons flared should be recorded.				
Site demobilization	Road traffic accidents	M	POL shall ensure: • enforcement of the use of PPEs • daily pep talk is carried out • job hazard	L	Site inspection report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Construction

			analysis is carried out • compliance with journey management policy				

Table 7.3: Environmental and Social Management Plan (ESMP) of Umuseti/Igbuku Fields (OML 56) Further Field Development – Operation/Maintenance (Normal)

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Field production/ Transportation of crude through the pipeline/ inspection and maintenan	Air Pollution (1) Fugitive emissions in natural gas processing facilities that are associated with leaks in tubing; valves; connections; flanges;	H	POL shall ensure: Regular monitoring of fugitive emissions from pipes, valves, seals, tanks, and other infrastructure components with vapor detection equipment, and maintenance or replacement of	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
ce of the pipeline and environmental monitoring/ Storage of oil products	packings; open-ended lines; floating roof storage tank, pump, and compressor seals; gas conveyance systems, pressure relief valves, tanks or open pits / containments, and loading and unloading operations of hydrocarbons.		components as needed in a prioritized manner Maintain stable tank pressure and vapor space by: Coordinating filling and withdrawal schedules, and implementing vapor balancing between tanks, (a process whereby vapor displaced during filling activities is transferred to the vapor space of the tank being emptied or to other containment in preparation for vapor recovery); Using white or other color paints with low				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			heat absorption properties on exteriors of storage tanks for lighter distillate such as gasoline, ethanol, and methanol to reduce heat absorption; Selecting and designing storage tanks in accordance with internationally accepted standards to minimize storage and working losses considering, for example, storage capacity and the vapor pressure of materials being stored. Use of supply and return systems,				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			vapor recovery hoses, and vapor-tight trucks / railcars / vessels during loading and unloading of transport vehicles; Use of bottom-loading truck / rail car filling systems; and Where vapor emissions contribute or result in ambient air quality levels in excess of health based standards, installation of secondary emissions controls, such as vapor condensing and recovery units, catalytic oxidizers, vapor combustion				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			units, or gas adsorption media.				
	Air Pollution (2) Exhaust gas emissions produced by the combustion of gas or other hydrocarbon fuels in turbines compressors, pumps and other engines for power generation	H	POL shall ensure that: Emissions related to the operation of power sources shall be minimized through the adoption of a combined strategy which includes a reduction in energy demand, use of cleaner fuels, and application of emissions controls where required	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation
	Air Pollution (3) Venting, flaring and greenhouse gases emission from the release of unburnt methane, flaring	H	POL shall: • Optimize plant controls to increase the reaction conversion rates;	L	Internal Audit report Compliance monitorin	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	of methane as a result of emergency or equipment failure		• Recycle unreacted raw materials and by-product combustible gases in the process or utilize these gases for power generation or heat recovery, if possible; • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high		g report		

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			efficiency.				
	Processing wastewater to include storm water and cooling water at the treatment plant which may contain condensate, biocides and anti-fouling agents	H	POL shall ensure: • The adoption of water conservation opportunities for facility cooling systems • Use of heat recovery methods (also energy efficiency improvements) or other cooling methods to reduce the temperature of heated water prior to discharge to ensure the	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			discharge water temperature does not result in an increase greater than 3°C of ambient temperature at the edge of a scientifically established mixing zone that takes into account ambient water quality, receiving water use, assimilative capacity , etc.; • Minimizing use of				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			antifouling and corrosion-inhibiting chemicals through proper selection of depth for placement of water intake and use of screens; selection of the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential;				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			and dosing according to local regulatory requirements and manufacturer recommendations; and • Testing for the presence of residual biocides and other pollutants of concern to determine the need for dose adjustments or treatment of cooling water prior to discharge. • Where liquids				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			are handled, segregate contaminated and non-contaminated stormwater, implement spill control plans, and route stormwater from process areas into the wastewater treatment unit				
	Noise and vibration nuisance from processing equipment like compressors, pumps, turbines, electric motors. High noise level	H	• Selecting equipment with lower sound power levels • Installing silencers for fans • Installing	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	is also expected during depressurisation		suitable mufflers on engine exhausts and compressor components • Installing acoustic enclosures for equipment casing radiating noise • Improving the acoustic performance of constructed buildings, apply sound insulation • Installing acoustic barriers without gaps and with a				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			continuous minimum surface density of 10 kg/m^2 in order to minimize the transmission of sound through the barriers. • Barriers shall be located as close to the source or to the receptor location to be effective • Installing vibration isolation for mechanical equipment • Limiting the				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			hours of operation for specific pieces of equipment or operations, especially mobile sources operating through community areas • Re-locating noise sources to less sensitive areas to take advantage of distance and shielding • Encourage the use PPEs				
	Pigging operations waste	H	• Establishing hazardous	L	Internal Audit	POL/Delta State Ministry of	During Operatio

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	management – Improper handling of hazardous waste from pigging operations leading to soil and groundwater contamination		materials management priorities based on hazard analysis of risky operations identified through Social and Environmental Assessment; • Using engineering controls (containment, automatic alarms, and shut-off systems) commensurate with the nature of hazard; • Implementing management controls (procedures, inspections,		report Compliance monitoring report	Environment/FMEnv/DPR	n

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			communications, training, and drills) to address residual risks that have not been prevented or controlled through engineering measures. • Storing and handling of hazardous waste in accordance to approved WMP • Access to areas containing hazardous substances shall be restricted and controlled; • Hydrocarbon and hazardous materials shall be stored on				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			impervious ground under cover; the area shall be constructed as spill tray to avoid spread of accidental spills • hazardous wastes shall be collected, stored and disposed appropriately in line with FMEnv standard in an approved site; • solid hazardous waste shall not be burned;				
	Discharge of hydrotest water from hydrostatic testing of equipment and	H	POL shall ensure: • Using the same water for multiple tests to conserve water	L	Internal Audit report Complian	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	interconnecting pipelines with water. Chemical addatives, oxygen scanvenger, dye and corrosion inhibitor may be added for pipeline protection		and minimize discharges of potentially contaminated effluent; • Reducing the use of corrosion inhibiting or other chemicals by minimizing the time that test water remains in the equipment or pipeline; and • Selecting the least hazardous alternative with regards to toxicity, biodegradability, bioavailability, and bioaccumulation potential, and dosing according		ce monitoring report		

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			to local regulatory requirements and manufacturer recommendations .;				
	Condensate spills or leaks from pipeline rupture	H	POL shall ensure: • Training of employees and contractor personnel in safety procedures, together with provision of appropriate tools and equipment; • Identification and location of buried utility infrastructure prior to excavation for installation or repair of pipeline. Installation of	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			visual marking of crude oil lines as part of installation, and updating as necessary on an ongoing basis; • Removal of sources of ignition prior to gas venting for maintenance and repair activities. Purging of gas from pipeline or pipe components prior to welding or cutting activities; • Installation of crude oil lines and components using sufficient separation distance and appropriate pipe				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			protection layering to minimize potential interference with other underground infrastructure. Separation of plastic pipes from sources of heat; • Training of workers in procedures for emergency preparedness and response involving appropriate public authorities, in addition to emergency shutdown and • Pressure reduction in the				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			piping system.				
	Waste generation from the platform if they are to be manned. The potential effects will be of aesthetics as well as nuisance. Non Hazardous waste will mainly come from discarded packaging materials such as metal cuttings, paper cartons and empty plastic containers. Although the impact from this waste is expected to be	H	POL shall ensure: • Toilets are created at the site. • Site remain clean, well maintained and free of hazards, with thoughtful location of litter bins • Proper disposal of solid waste from construction activities and labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures;	L			

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	minimal, poor disposal methods can lead to environmental problems due to their non-biodegradable nature.		• sanitation arrangements at work sites/facilities to avoid release of waste water and sewage to the environment • Minimum waste are generated • Reuse waste materials wherever possible and use designated • Nonhazardous wastes are segregated, stored and disposed through an approved state waste collector				

Project Activity	**Description of Impacts**	**Rating before Mitigation**	**Mitigation/Control Measures**	**Rating after Mitigation**	**Parameters for Monitoring**	**Action Party**	**Monitoring Frequency**
	Threat from major accidents related to the fires and explosions at the facility and potential accidental releases of raw materials or finished products during their transport outside of the processing facility.	H	POL shall ensure: Provision of early release detection, such as pressure monitoring of crude oil conveyance systems, in addition to smoke and heat detection for fires; Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature piping,	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			equipment, and / or rotating machines); Controlling the potential effect of fires or explosions by segregation of process, storage, utility, and safe areas by designing, constructing, and operating them according to international standards for the prevention and control of fire and explosion hazards, including provisions for distances between tanks in the facility and between the facility and adjacent buildings, provision of				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			additional cooling water capacity for adjacent tanks, or other risk based management approaches; and Limiting the areas that may be potentially affected by accidental releases by: Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary containment of storage tanks; Installing				

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			fire / blast partition walls in areas where appropriate separation distances cannot be achieved; Designing the oily sewage system to avoid propagation of fire.				
	Air emission during maintenance/servicing of production equipment and ancillaries	M	POL shall ensure Regular maintenance or servicing of production equipment as at when due Prompt attention shall be given to any faulty production equipment Use of original part to replace the faulty ones Experts and	L	Internal Audit report Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
			professional must always be used to handle any repairs of production equipment and ancillaries POL shall treat and dispose all waste oil and lubricants in accordance with regulatory requirements and best practice using approved contractors POL shall ensure that none of these wastes are disposed into any water body or on land				
	Road and traffic accidents as a result of transportation	H	POL shall ensure: • compliance with journey management	L	Inventory of approved journey	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	activities during facility operation		policy • Vehicles are pre-mobbed and pre-mobilization/compliance certificate issued. • the use of PPEs at sites; daily pep talk, carry out job hazard analysis • ensure that all traffic rules are obeyed by the drivers		management forms		
	Surface water and soil contamination: this could happen by treatment chemical	H	POL shall ensure: • Soil disturbance shall be kept to minimum required for	L	Internal Audit report Compliance	POL/Delta State Ministry of Environment/FMEnv/DPR	During Operation

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
	(chemical injection process) and sludge/other materials removal during routine cleaning/repair		operation and safety • Oil spill containment shall be provided to reduce oil spill from getting to the soil and surface/ groundwater • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc.		monitoring report		

Table 7.4: Environmental and Social Management Plan (ESMP) of Umuseti/Igbuku Fields (OML 56) Further Field Development –Operation/Maintenance (Abnormal)

Project	Descripti	Rating	Mitigation/Contr	Rating	Parameters	Action Party	Monitori

Activity	on of Impacts	before Mitigation	ol Measures	after Mitigation	for Monitoring		ng Frequency
Emergencies	Air Pollution Loss of containment of crude due to pipeline rupture from collision impact leading to the release of natural gases majorly methane. This has a potential for air pollution	H	• General installation and pipe joining techniques such as welding, shall meet international standards for structural integrity and operational performance; • Testing of pipeline components for pressure specifications and presence of leaks shall be undertaken prior to commissioning.	L	Compliance monitoring report/Emergency shut down	POL/Delta State Ministry of Environment/FMEnv/ DPR	During Operation

			• Leak and corrosion detection programs shall be undertaken, including use of appropriate leak detection assessment techniques and equipment. Maintenance programs to repair and replace infrastructure shall be undertaken as indicated by detection results. • Typical urban testing sites include atmospheres in confined				

			spaces of utility infrastructure (e.g. sewer and water system manholes), as well as at openings in pavement and on streets and walkways. • Regulating stations and vaults, both above and below ground, may contain equipment (e.g. safety valves, filters) that may emit fugitive emissions of				

			gas. Valves, and other component infrastructure shall be regularly maintained, and ventilation and gas detection / alarm equipment installed in station buildings or vaults. • The plant design incorporates a Safety Integrity Level-3(SIL-3)					

			programmable control system for Compressors and valves systems to ensure minimal probability of failure. Similarly, a high Safety Instrumentation System (SIS) designed with predictive maintenance configuration and risk mitigation applications for better				

			system performance. • The Plant process area shall be fitted with sensor gas leak detectors and ESD.				
	Air Pollution (2) Venting and greenhouse gases emission from the release of unburnt methane, flaring of methane as a result of	H	POL shall ensure that: • Optimize plant controls to increase the reaction conversion rates; • Recycle unreacted raw materials and by-product combustible gases in the process or utilize these	L	Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/ DPR	During Operation

	emergency or equipment failure		gases for power generation or heat recovery, if possible; • Provide back-up systems to achieve as high a plant reliability as practical; and • Locate the flaring system at a safe distance from residential areas or other potential receptors, and maintain the system to achieve high efficiency.				
	Fire leading to impact on fish and fishing	H	• Providing early release detection, such as pressure	L	Facility inspection Compliance monitoring	POL/Delta State Ministry of Environment/FMEnv/ DPR	During Operation

	activities as well as the benthic ecosystem		monitoring of crude conveyance systems, in addition to smoke and heat detection for fires; • Limiting the inventory that may be released by isolation of the process operations in the facility from large storage inventories; • Avoiding potential sources of ignition (e.g., by configuring the layout of piping to avoid spills over high temperature		report		

			piping, equipment, and / or rotating machines); • Limiting the areas that may be potentially affected by accidental releases by: ○ Defining fire zones and equipping them with a drainage system to collect and convey accidental releases of flammable liquids to a safe containment area including secondary				

			containment of storage tanks; ○ Installing fire / blast partition walls in areas where appropriate separation distances cannot be achieved; and ○ Designing the oily sewage system to avoid propagation of fire.				
	Health and Safety Fire and explosion incident resulting in injury and fatalities	H	• Equipping facilities with fire detectors, alarm systems, and fire-fighting equipment.	L	Facility inspection Compliance monitoring report	POL/Delta State Ministry of Environment/FMEnv/ DPR	During Operation

			• The equipment shall be maintained in good working order and be readily accessible. It should be adequate for the dimensions and use of the premises, equipment installed, physical and chemical properties of substances present, and the maximum				

			number of people present. • Provision of manual firefighting equipment that is easily accessible and simple to use • Fire and emergency alarm systems that are both audible and visible • Permit to work system (PTW) shall be enforced				
	Spills from onshore	H	POL shall • Conduct a	L	Facility	POL/Delta State Ministry of	During Operation

	facilities, including pipelines, can occur due to leaks, equipment failure, accidents, and human error or as a result of third party interference		spill risk assessment for the facilities and design, drilling, process, and utility systems to reduce the risk of major uncontained spills; • Ensure adequate corrosion allowance for the lifetime of the facilities or installation of corrosion control and prevention systems in all pipelines, process equipment, and tanks;		inspection Compliance monitoring report	Environment/FMEnv/ DPR	

			• Install secondary containment around vessels and tanks to contain accidental releases; • Install shutdown valves to allow early shutdown or isolation in the event of a spill; • Develop automatic shutdown actions through an emergency shutdown system for significant spill scenarios so				

			that the facility may be rapidly brought into a safe condition; • Install leak detection systems. On pipelines consider measures such as telemetry systems, Supervisory Control and Data Acquisition (SCADA9), pressure sensors, shut-in valves, and pump-off systems, • Develop corrosion				

			maintenance and monitoring programs to ensure the integrity of all field equipment. For pipelines, maintenance programs should include regular pigging to clean the pipeline, and intelligent pigging should be considered as required; • Ensure adequate personnel training in oil spill prevention,				

			containment, and response; • Ensure spill response and containment equipment is deployed or available for a response				

Table 7.5: Environmental and Social Management Plan (ESMP) of Umuseti/Igbuku Fields (OML 56) Further Field Development –Operation/Maintenance– Decommissioning

Project Activity	Description of Impacts	Rating before Mitigation	Mitigation/Control Measures	Rating after Mitigation	Parameters for Monitoring	Action Party	Monitoring Frequency
Demolition and Evacuation	Interference with road transportation	M	• POL shall monitor the no of trucks per day to know if there is need to create other accessible roads	L	Inventory of approved journey management forms	POL/Delta State Ministry of Environment/FMEnv/DPR	During Decommissioning

			• POL shall develop a transport management plan specifying routes, speeds, times of travel and key roads/waterway in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use private vehicles				
	Noise and vibration nuisance	M	POL shall ensure that: • electric power	L	Complianc	POL /Delta State Ministry of Environment/FMEnv/	During Decommissioning

			generators are fitted with effective silencers; • there shall be regular maintenance of vehicles and generators; • generators and vehicles are switched off when not in use; • soundproof electric power generators are engaged • PPEs are used		e monitoring report	DPR	
	Impairment of air quality	H	POL shall ensure: • Engine to comply with internatio nal	L	Complianc e monitoring report	POL /Delta State Ministry of Environment/FMEnv/ DPR	During Decommissioni ng

			standards for exhaust gases; Maintenance of engines and exhaust gas check; Adoption of engine off policy at construction site • that nose masks and ear muffs are worn by site workers during excavation • that water				

			shall be sprayed on construction sites to reduce dust levels especially during dry season.				
	Contamination of surface and Groundwater & soil	M	POL shall ensure: • Soil disturbance shall be kept to minimum required for operation and safety • Oil spill containment shall be provided to reduce oil spill from	L	Compliance monitoring report	POL /Delta State Ministry of Environment/FMEnv/ DPR	During Decommissioning

			getting to the soil and surface/ groundwater • Follow FMEnv guidelines on waste management • Cleanup in compliance with relevant national and International guidelines, involving the removal of the waste, etc. • Restore the to a condition in no way inferior to				

			the condition prior to the commencement of work.				
	Solid waste generation and impact on disposal facility	H	• POL shall treat and dispose all wastes in accordance with regulatory requirements and best practice using approved contractors • POL shall ensure that none of these wastes are disposed into any water body or on land • follow safety measures	L	Site inspection report Waste Management Policy/ tracking sheet	POL /Delta State Ministry of Environment/FMEnv/ DPR	During Decommissioning

			while disposing wastes • POL shall keep all waste consignment, treatment and disposal records for regulatory verification • Proper disposal of solid waste from labour camps; • storage of lubricants, fuels and other hydrocarbons in self-contained enclosures; • sanitation arrangements at work				

			sites/facilities to avoid release of waste water to the environment • All other wastes generated including environmentally deleterious materials generated by construction activities will be disposed offsite in an appropriate, legal, and safe manner. • There is minimum generation of waste • Unsuitable excavated materials					

			shall be systematically carried away from areas prone to erosion; • Reuse waste materials wherever possible • Wastes shall be segregated, stored and disposed by an accredited state waste collector				
	Loss of job	H	POL shall • Counsel worker who losses job. • Give enough notice • Assist staff that are likely to loss job in skill	L			

			acquisition • Assist in setting small scale business				
	Injury / fatalities in workforce /communities	H	POL shall • Ensure Safety awareness training for workforce • Emergency response procedures shall be put in place and enforced • ensure use of PPE • provide first aid and clinic on site	L	Contract documents / list of community members employed	POL /Delta State Ministry of Environment/FMEnv/ DPR	During Decommissioning
	Kidnapping of workers and visitors on site	H	• POL shall ensure that both contractor and POL personnel	L	Daily/weekly security report	POL	During Decommissioning

			develops a high level of security consciousness both within and outside the work area • Daily security reports shall be reviewed by the POL Project Manager • Special security force shall be established and deployed for the project. This shall include deploying some of POL police to strengthen security in the area • POL shall				

			ensure that a liaison to foster partnership with the community so as to guarantee security for the project is established and sustained • In order to beef up security for the project, POL shall support government authorities by providing assistance with equipment e.g. patrol vehicles, to ensure improved				

			security • POL shall ensure that safety workshops to identify, evaluate and recommend contingency plans for all security risks are regularly organized				
	Third Party Agitation due to Employment Issues and Loss of Benefits as Host Communities.	M	• Assist staff that are likely to loss job in skill acquisition • Assist in setting small scale business	L	Contract documents / list of community members employed	POL /Delta State Ministry of Environment/FMEnv/ DPR	During Decommissioning
	Revegetation	P	• Restoring vegetation after decommissioning of facility	P	Site inspection and progress	POL/Delta State Ministry of Environment/FMEnv/ DPR	During Decommissioning

					report		

7.9.1 Performance Indicator Monitoring

7.9.1.1 Emissions and Effluent Standards

Pillar Oil Limited will comply with relevant local standards provided by FMenv/DPR and good international industry practice such as provided by IFC for emissions and effluent. The IFC emission and effluent guidelines for Petroleum and gas sector provided in ***Tables 7.6*** and ***7.7*** below will serve as benchmark value for the Pillar Oil Limited.

Table 7.6: IFC air emission levels for petroleum and Gas facility

Pollutant	Units	Guideline Value
NO_X b	mg/Nm^3	300 100 for FCCU
SO_X c	mg/Nm^3	150 for SRU; 300 for FCCU 500
Particulate Matter (PM10) [d]	mg/Nm^3	25
Vanadium [e]	mg/Nm^3	5
Nickel	mg/Nm^3	1
H_2S [e]	mg/Nm^3	5

a) Dry gas at 3 percent O_2.

b) NO_x means $NO+NO_2$ expressed in NO_2 equivalent. Guideline value from European

Commission Joint Research Center (EC JRC), “Best Available Techniques Reference (BREF) Document for the Refining of Mineral Oil and Gas” (2015).

c) SO_x means SO_2 + SO_3 expressed in SO_2 equivalent.
d) Guideline value from EC JRC, "BREF Document for the Refining of Mineral Oil and Gas" (2015). Particulate matter guideline value is also valid for FCCU.
e) From G.S.R. 186(E) and 820(E), India Ministry of Environment and Forests Notification

Source: IFC, 2017

Table 7.7 Liquid Effluents Levels for Petroleum and Gas Facilities [a]

Pollutant	Units	Guideline Value
pH	S.U.	6 – 9
BOD_5	mg/L	30 [b]
COD	mg/L	125 [c]
Total Suspended Solids (TSS)	mg/L	30
Oil and Grease	mg/L	10
Chromium (total)	mg/L	0.5
Chromium (hexavalent)	mg/L	0.05
Copper	mg/L	0.5
Iron	mg/L	3
Cyanide Total Free	mg/L	1 0.1
Lead	mg/L	0.1
Nickel	mg/L	0.5
Mercury	mg/L	0.003 [d]
Arsenic	mg/L	0.1
Vanadium	mg/L	1
Phenol	mg/L	0.2

Benzene	mg/L	0.05 [e]
Benzo(a)pyrene	mg/L	0.05
Sulfides	mg/L	0.2
Total Nitrogen	mg/L	10 [f]
Total Phosphorus	mg/L	2
Temperature increase	□C	<3 [g]

Notes:

a. Assumes an integrated petroleum and gas facility.

b. Guideline value from EC JRC, BREF (2015) Table 3.16; National legislations may have lower values such as China: 20 mg/L.

c. Guideline value from EC JRC, BREF (2015); National legislations may have lower values such as China: 120 mg/L.

d. EC JRC, BREF (2015) Table 3.16.

e. Guideline value from EC JRC, BREF (2015).

f. The effluent concentration of nitrogen (total) may be up to 40 mg/l in processes that include hydrogenation.

g. At the edge of a scientifically established mixing zone, which takes into account ambient water quality, receiving water use, potential receptors, and assimilative capacity.
EC JRC, BREF (2015) Table 3.16.

Source: IFC, 2017

7.10 Environmental and Social Management Plan Implementation

In preparing this ESMP, POL recognized that sound environmental management of the proposed project can only be guaranteed through the integration of provisions of the ESMP as an integral part of business quality management. To this end, the company shall enforce compliance by the project team on a daily basis throughout the duration of the project. The Project Manager shall be responsible for the implementation of the provisions of the ESMP while regular inspection of sites and facilities shall be undertaken by an Environmental Inspection Team throughout the project duration.

7.11 Environmental Monitoring Program and Auditing

Environmental monitoring programs shall be implemented to address all activities that have been identified to have potentially significant impacts on the environment, during both normal operations and upset conditions (emergencies and consequent flaring). Environmental monitoring activities will be based on direct or indirect indicators of emissions, wastewater, and resource use applicable to the project, and for point sources of emissions which will include both concentration and mass flow rate of pollutants.

Monitoring frequency will be sufficient to provide representative data for the parameter being monitored. Monitoring will be conducted by trained individuals following suitable and appropriate monitoring and record-keeping procedures and using regularly calibrated and suitably maintained equipment. Monitoring data shall be analyzed and reviewed at regular intervals and compared with the operating standards so that any necessary corrective actions can be taken. The proposed operation phase monitoring programme is provided in Table 7.8. However, during construction, the surveillance programme will exclude wastewater and emissions monitoring.

Table 7.8: Environmental Monitoring Programme for Pillar Oil Limited

Component	Type	Monitoring Parameter	Source point / Sampling point	Monitoring Frequency	Responsibility
Environment					
Emissions	Flue gases	Carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and particulate matter (PM), Hydrogen sulphide (H_2S)	Bitumen Blowing Unit (BBU), Fluid Catalytic Cracking Unit (FCCU), Residue Catalytic Cracking Unit (RCCU), sulfur recovery unit (SRU),	Weekly and 2 year Audit	Consultant/ HSE
	Fugitive emission	H; CH4; VOCs, PAHs; NH_3, CO, CO_2, SO_2 and SO_3, NOx, MTBE, ETBE, TAME, HF and H_2S.	Storage tanks, Flanges and/or Valves and machinery seals; Blending tanks, Pumps, Oily sewage and Wastewater Treatment Systems, Bitumen storage tanks, Vapor recovery unit vents	Weekly and 2 year Audit	Consultant/ HSE
Wastewater (Influent and effluent)	Process wastewater	Quantity, pH, Temperature, Heavy metals, TDS, Hydrocarbons (BTEX, TPH, PAH, THC), H_2S, NH_3, organic sulfur compounds (R-S-H mercaptans), organic acids, and phenol.	Waste water treatment plant (WWTP)	Weekly and 2 year Audit	Consultant/ HSE
	Hydrostatic test fluid	Inhibitor, Ferrous, TDS, pH	Storage tanks, pipes	During tests	Consultant/ HSE

Component	Type	Monitoring Parameter	Source point / Sampling point	Monitoring Frequency	Responsibility
Nuisance	Ambient	Noise level, odour, vibration, radiation	Within site and 2km radius	Weekly and 2 year Audit	Consultant/ HSE
Surface water	Rivers, streams, ponds, etc. (2km radius)	pH, Hydrocarbons (BTEX, TPH, PAH, THC), Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*	Upstream, midstream and downstream	Quarterly (Compliance monitoring) and 2 year Audit	Consultant/ HSE
Ground water	Shallow wells and boreholes (2km radius)	Temperature, hydrocarbons (BTEX, TPH, PAH, THC), pH, Electrical Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol, Heavy metals, Total coliform and Faecal Coliform bacteria	Boreholes and shallow wells	Quarterly (Compliance monitoring)	Consultant, HSE
Rainwater and storm water	Rainwater and storm water	Precipitation rate, pH, TDS, acidity, alkalinity, colour, hardness, etc.	Storm water (Point of discharge from the facility / Oil water separator)	Quarterly (Compliance monitoring), 2 year Audit	Consultant, HSE
Sanitary sewage	-	Residual chlorine, pH, TSS, DO, BOD_5, Total Coliform and Faecal coliform	Sanitary sewage treatment plant (SSTP)	Post treatment	Consultant/ HSE

Component	Type	Monitoring Parameter	Source point / Sampling point	Monitoring Frequency	Responsibility
Air quality	Ambient air	Particulate matter, C_XH_Y, SOx, CO, VOC, NOx, Noise, H_2S, NH_3.	Established sampling points and 2km radius of the facility	Weekly and 2 year Audit	Consultant/ HSE
Traffic	Vehicular traffic	Vehicular volume count, origin and destination survey	Established observation points and 20km radius of the facility	2 year audit	Consultant, HSE/ Logistics
Safety and health					
	Occupational safety and health	Lost time injury (LTI), Lost time injury frequency (LTIF), Medical cases, Fatality, etc.	Within site	Daily	HSE
	Community health	Oil spill, fire, explosion, benzene concentration, vehicular accident, accidental chemical release or other major hazards	Stakeholder communities	Daily	HSE

7.11.1 Auditing Programme

In addition to the routine inspection, environmental monitoring and audits shall be carried out internally and externally by POL to ensure compliance with regulatory requirements as well as its own HSE standards and policies. The audit will include a review of compliance with the requirements of the ESIA and of this ESMP and include, at minimum, the following:

- Completeness of HSE documentation, including planning documents and inspection records;
- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping. There will be a cycle of audits into specific areas of the project such as waste management, and effectiveness of local content plans and discharge controls. The frequency of audits will be risk based and will vary with the stage of the project (more frequent during operation and in the early stages of the project and later part of the well life) and will depend on the results of previous audits.

In order to improve the management of fugitive emissions from the entire marginal field activities and to protect human health in affected communities, in addition to monitoring and management requirements, fence line monitoring of benzene concentration will be done according to local and internationally recognized methodologies.

Where annual average benzene concentrations associated with process emissions exceed the guideline value given in ***Table 7.9*** below, corrective actions shall be taken to reduce benzene emissions from the facility. Corrective actions and monitoring results shall be reported to relevant regulatory bodies (FMEnv and DPR) and stakeholders.

Table 7.9: Fence line monitoring action level

Pollutant	**Guideline Value**
Benzene	9 µg/m^3 [a]
[a] Annual average concentration that is corrected for background contribution. Guideline value from U.S. EPA 40CFR63 Subpart CC—National Emission Standards for Hazardous Air Pollutants from Petroleum Refineries (2015).	

7.11.2 Reporting

POL shall keep regulatory authorities informed of the project performance with respect to HSE matters by way of written status reports and face-to-face meetings throughout the project. POL shall prepare a monthly report on environmental and social performance and submit same to relevant regulators. In addition to regular reporting, official notification shall be made to the government for any of the following:

- Significant modifications to this ESMP or the ESIA;
- Significant design, routing or implementation changes;
- Results of environmental monitoring;
- Community incidents; and
- Safety incidents or accidents.

POL will make accessible to government authorities, or provide upon request appropriate documentation of HSE related activities, including internal inspection records, training records, and reports. Subcontractors are also required to provide HSE performance reporting to POL on a regular basis through weekly and monthly reports.

7.11.3 Regulatory Oversight

Communications between the POL management and government regulatory agencies will be instituted through a variety of mechanisms, including written reports and memos, as well as informal and formal meetings. Meetings will include regularly scheduled sessions as well as additional meetings called on an as-needed arise. At the field level, formal meetings with government regulatory agency representatives will be held as needed to discuss scheduling/planning issues, current areas of concern, and emerging HSE and socioeconomic issues.

At the management level, formal meetings are expected to be held, but on a less frequent basis. Informal meetings and communications will also hold as necessary. With respect to formal meetings, the HSE Manager will meet with government regulatory agency representatives to review HSE and socioeconomic performance based on the analysis of internal HS-EMS and field reports. These meetings can be expected to include discussion of upcoming work plans and coordination issues and resolution of problems that could not be adequately addressed at the field level. At the field level, government regulatory agency field representatives will inform appropriate POL representatives if compliance concerns arise. At the management level, regularly scheduled meetings will hold between HSE Mangers and the appropriate government regulatory agency representative to review HSE performance, areas of concern, and emerging issues.

7.11.4 Occupational Health and Safety

7.11.4.1 Occupational Health and Safety Guidelines

Currently, there is no standard for occupational safety and health established by Nigeria. However, the project's occupational health and safety performance will be evaluated against internationally published exposure guidelines, of which examples include the

- Threshold Limit Value (TLV®) occupational exposure guidelines
- Biological Exposure Indices (BEIs®) published by the American Conference of Governmental Industrial Hygienists (ACGIH),
- Pocket Guide to Chemical Hazards published by the United States National Institute for Occupational Health and Safety (NIOSH),
- Permissible Exposure Limits (PELs) published by the Occupational Safety and Health Administration of the United States (OSHA),
- Indicative Occupational Exposure Limit Values published by European Union member states, or other similar sources.

7.11.4.2 Accident and Fatality Rates

The projects will put in place safety and health management system (MS) in place to help reduce the number of incidents and near misses among the project workers (whether directly employed or subcontracted) to a rate of zero, especially incidents that could result in lost work time, different levels of disability, or even fatalities. Facility rates may be benchmarked against the performance of facilities in this sector in developed countries through consultation with published sources (e.g., U.S. Bureau of Labor Statistics and U.K. Health and Safety Executive).

7.11.4.3 Occupational Health and Safety Monitoring

The working environment will be monitored for occupational hazards relevant to the project. Monitoring will be designed and implemented by accredited consultant/professional as part of the project's occupational health and safety monitoring program. Facilities shall also maintain a record of occupational accidents and diseases and dangerous occurrences and accidents.

7.11.4.4 Corrective Action

Impacts will be proactively identified and associated risks as part of the corrective action implementation process. Investigating a 'near miss' or actual incident after it occurs can be used to obtain valuable lessons and information that can be used to prevent similar or more serious occurrences in the future. POL will implement a formal non-compliance and corrective action tracking procedure for investigating cause and identifying corrective actions in response to accidents or environmental or social non-compliances.

This will ensure coordinated action between POL and its subcontractors. The HSE coordinator will be responsible for keeping records of corrective actions and for overseeing the modification of environmental or social protection procedures and/or training programs to avoid repetition of non-conformances and non-compliances.

7.12 Fiscal Plan for the ESMP

To effectively implement the environmental and social management measures suggested as part of the ESMP, estimated budget has been made by POL for the project components. Please see budget section in **Tables 7.10** below.

Table 7.10: Budget for the ESMP

Component	Type	Monitoring Parameter
Emissions	Flue gases, gas flaring	Carbon dioxide (CO_2), nitrogen oxides (NOx), sulfur oxides (SOx), carbon monoxide (CO), and particulate matter (PM), Hydrogen sulphide (H_2S)
	Fugitive emission	H; CH4; VOCs, PAHs; NH3, CO, CO_2, SO_2 and SO_3, NOx, MTBE, ETBE, TAME, HF and H_2S.
Budget	***5,500,000.00***	
Wastewater (Influent and effluent)	Process wastewater	Quantity, pH, Temperature, Heavy metals, TDS, Hydrocarbons (BTEX, TPH, PAH, THC), H_2S, NH_3, organic sulfur compounds (R-S-H mercaptans), organic acids, and phenol.
	Hydrostatic test fluid	Inhibitor, Ferrous, TDS, pH
	Sanitary sewage	Residual chlorine, pH, TSS, DO, BOD_5, Total Coliform and Faecal coliform
Budget	***4,000,000.00***	
Air quality and Nuisance	Nuisances	Noise level, odour, vibration, radiation
	Ambient air quality	Particulate matter, C_XH_Y, SOx, CO, VOC, NOx, Noise, H_2S, NH_3, etc.
Budget	***2,000,000.00***	
Surface water	Rivers, streams, ponds, etc. (2km radius)	pH, Hydrocarbons (BTEX, TPH, PAH, THC), Temperature, Conductivity, Chloride, Turbidity, TDS, BOD_5, COD, THC, DO, Total hardness, Heavy metals, *E. coli* and *Enterococci*
Ground	Shallow wells and	Temperature, hydrocarbons (BTEX, TPH, PAH,

Component	Type	Monitoring Parameter
water	boreholes (2km radius)	THC), pH, Electrical Conductivity, Total Solids, Dissolved Oxygen, Total Hydrocarbon Content, BOD_5, COD Sulphate, Nitrate, Phosphate, phenol, Heavy metals, Total coliform and Faecal Coliform bacteria
Rainwater and storm water	Rainwater and storm water	Precipitation rate, pH, TDS, acidity, alkalinity, colour, hardness, etc.
Budget	***3,500,000.00***	
Traffic	Vehicular traffic	Vehicular volume count, origin and destination survey
Budget	***2,500,000.00***	
Safety and health		
	Occupational safety and health	Lost time injury (LTI), Lost time injury frequency (LTIF), Medical cases, Fatality, etc.
	Community health	Oil spill, fire, explosion, benzene concentration, vehicular accident, accidental chemical release or other major hazards
Budget	***7,000,000.00***	

CHAPTER EIGHT

DECOMMISSIONING AND RESTORATION PLAN

8.1 Introduction

The ESIA process requires that project of this status contain an environmentally sound decommissioning and Abandonment plan. These plans need to be fully prepared a few years before decommissioning and abandonment would actually take place and take into account the best applicable technology at that time. A general approach will be to commence detailed planning of decommissioning and abandonment activities five years to the decommissioning date.

Decommissioning heralds the end of a project facility. At decommissioning stage, the facility is taken out of operational service with isolation of all process streams and services and the removal of all hazardous materials. When the facility has undergone this process, it is referred to as a decommissioned facility. All decommissioning and restoration activities will be carried out in line with the decommissioning and restoration guidelines provided in Act Cap E12, LFN 2004 of Federal Ministry of Environment (FMEnv) for oil and gas facilities. The aim of decommissioning is to ensure the environment is returned to, as much as reasonably practicable, its original/baseline conditions. The lifespan may sometimes be less than planned, while in some cases, it can be extended with proper planning and maintenance. Appropriate provisions shall be made to cater for decommissioning plan right from operational phase before the proposed project reached the end of its life span. To this end, 1% of the profit made monthly right from the operational phase shall be set aside for this plan.

8.2 Decommissioning and Restoration Principle

Pillar Oil Limited shall:

1) Commence activities related to decommissioning, at least, one year before close of project activities.
2) Put in place a decommissioning plan report for approval by FMEnv/DPR. The plan shall include:
    - identification of all components of the project that will be removed/exhumed
    - method(s) for removal or re-use of any project equipment/ material if applicable
    - effort being put in place to mitigate any environmental impacts associated with the decommissioning process
    - appropriate site remediation/rehabilitation programme

3) Ensure the safety of operation, taking into consideration all appropriate international conventions, regulatory requirements and corporate policies.
4) Remove all structures (surface and sub-surface structures) with due regard for the protection of the environment.
5) Inform and discuss with staff, employees, contractors, Federal Ministry of Environment, Department of Petroleum Resources, Delta stated Ministry of Environment and stakeholder communities.

8.3 Decommissioning/ Restoration Process

All installations buried or fixed on land shall be removed entirely. All wastes items arising from decommissioning process shall be managed in line with Pillar Oil Limited's Waste Management Plan (WMP). Decommissioning shall be carried out in line with standard decommissioning procedure (**Figure 8.1 and appendix 8.1).**

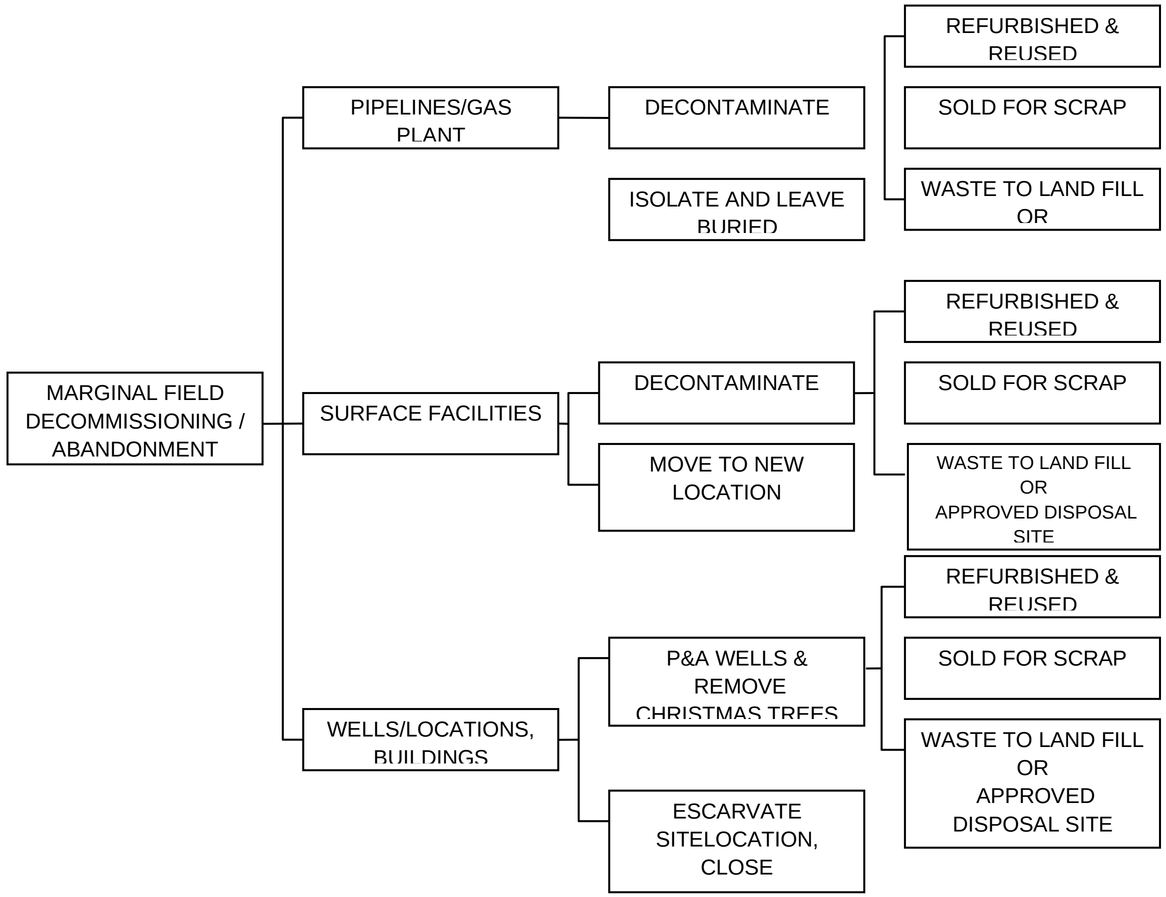


Figure 8.1: Decommissioning and Restoration procedure

8.3.1 Facility Abandonment Policy and Strategy

Pillar Oil Limited shall:

1) isolate oil wells from surface;
2) plug (using liquid or mechanical plug method) and abandon downhole according to permit;
3) place surface cement plug below cellar to allow removal of surface components;
4) avoid any significant adverse effect on the environment; and
5) isolate production interval to prevent communication between aquifers
6) Provide a platform for reuse of decommissioned items locally in line with its WMP

8.3.2 Well Abandonment

Abandonment of well (production and injection wells) is a succession of operations to restore the isolation of all permeable levels crossed by wells. The isolation will block communication between the reservoir and the surface to ensure there is no cross flow between reservoirs or into usable groundwater aquifers. The procedures for abandonment of a produced water injection well are not significantly different from those employed in abandoning other sorts of wells.

- ***Well Plugging***

A well plugging used during well abandonment shall generally make use of two different types of barriers. These are:

Liquid plug – a column of liquid from the surface to the top of the reservoir with sufficient density to balance the pressure of the reservoir

Mechanical plug – a system (bridge plug, cement retainer, packer) set in a section of the well of known dimensions.

8.3.3 Tank Farm and Process Equipment/Plants

1) All facilities/plants shall be appropriately decontaminated
2) All equipment shall be disposed of by selling, recycling, re-using.
3) In order to allow easy intervention during abandonment, if necessary, the wellhead shall not be cut until the stability of each annulus has been determined. Thereafter, the wellheads shall be cut just below the land or mud line

8.3.4 Pipelines/Plants Abandonment

Although, Pillar Oil Limited promotes re-use of materials as parts of its waste management methods, however, decommissioned materials shall not be re-used for the same purpose for which it was originally designed. For instance, once a pipeline is decommissioned, it cannot be used to carry oil and gas products or any commodities.

Therefore, all decommissioned pipelines shall be labeled unfit for pipeline use for oil/gas transfer prior to transfer to end-user or waste site. All buried pipelines shall be exhumed and denominated.

8.4 Remediation and Restoration

This will entail:

1) A survey of the decommissioned site for contamination as part of a Conceptual Site Model and Strategy Plan;
2) Initial conclusions on the hydrology and geology;
3) Preparation of a Site Assessment Action Process Flow Sheet to be approved by FMEnv/DPR as provided in Fig. VIII-F1 in EGASPIN; and
4) Interim action or remediation designed to confirm applicability and feasibility of one or more potential remedial options: such as application of dispersants or biological treatment using petroleum degrading bacteria or by aeration process.

Finally, the site shall be monitored for compliance and performance to confirm effectiveness to remedial measures. At the end of the site abandonment, the following useful documentations shall be reviewed:

1) The initial abandonment plan
2) The abandonment operations conducted in the field, along with changes to plan necessitated by field conditions
3) The configuration and lengths of casing and tubing remaining in the well (for well abandoned wells).
4) The location and length of plugs, including pumping duration and cement volumes as applicable
5) Test reports for well plugs.
6) Toxicity test report carried out on all decommissioned items

8.5 Impact Assessment Reporting

Prior to abandonment, a post decommissioning Impact Assessment Report shall be prepared detailing the state of the environment after remediation. The report shall be submitted toFMEnv.

The report will provide the following details:

- Overview of decommissioned facilities.
- Details of methods used for decommissioning.
- Nature of decommissioning (partial or whole).
- Record of consultation meetings.
- Details of recyclable/reusable materials/facility components.

- Decontaminated facilities.
- Decommissioning Schedule.
- State of the surrounding environment.
- Waste Management Plan.
- Plans for restoration/remediation where necessary.

CHAPTER NINE

CONCLUSION AND RECOMMENDATIONS

9.1 Introduction

This Environmental and Social Impact Assessment (ESIA) Report was prepared in line with the requirements of Act Cap E12, LFN 2004 of Federal Ministry of Environment (FMEnv) as well as Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN 1999, Revised Edition in 2018). The ESIA study involved detailed literature search, data analyses, impact identification, evaluation and reporting. Given the detailed description of baseline environmental characteristics of the proposed project area and the impact assessment, mitigations and ESMP that has been presented in earlier sections of this ESIA, it is therefore concluded that:

- Some aspects of the project are expected to produce positive impacts on the socioeconomic environment. Measures to enhance the positive impacts were also recommended. Mitigation and enhancement measures were proffered for the identified negative and impacts of the project respectively. Also, an Environmental and Social Management Plan (ESMP) was developed to ensure that the identified potential impacts are reduced to "as low as reasonably practicable" (ALARP). The comprehensive effluent and waste water treatment plants incorporated into the design of this project will ensure the complete treatment of effluent to regulatory requirements before discharging into the nearby stream or river

- A number of negative impacts have also been identified to be associated with the project. Such impacts include potential pollution of ambient air, water and soil, erosion, increase in noise level, pressure on limited infrastructures, and health and safety issues. However, the mitigation measures recommended for this project if judiciously implemented will reduce some of the significant negative impact to negligible extent which could be short term, localized and reversible.

- Monitoring and audit programs were recommended throughout the project life span. This is to ensure that all impact indicators for the various environmental components are within statutory limits.

9.2 Recommendations

Pillar Oil Limited has shown strong commitment to implementing this project in an environmentally friendly manner that will reduce associated negative impacts. Her reputation of having good relationship with host communities and deployment of best available technology has shown POL is disposed to enhance the successful implementation of the proposed Further Field Development project. More so, the application of the proffered mitigation measures contained in chapter six of this report built into the environmental management plan and other provisions incorporated herewith, the construction, operation and decommissioning of the proposed development can be carried out with minimal impacts on the environment.

Generally, in line with Pillar Oil Limited's HSSE policy, the following specific recommendations shall be adhered to, to ensure sustainability and continual environmental performance of the project.

- The Environmental and Social Management Plan (ESMP) designed for the project shall be implemented throughout the lifespan of the project viz; construction, operation and decommissioning.

- The waste management plan shall be appropriately implemented; all personnel assigned to respective responsibilities shall also duly carry out their duties.

- A 3-year environmental-auditing of the site shall be carried out by competent third party in line with regulatory requirement.

- Environmental monitoring plan proposed in this report shall be implemented

- Pillar Oil Limited shall continually support the stakeholder communities as part of its Corporate Social Responsibility's (CSR) objective;

- Continuous implementation and improvement of the emergency response procedures should be strictly adhered to throughout the life cycle of the proposed project. As this is one of the ways of entrenching best practices throughout the lifecycle of the project.

The ESIA shows that there is no potentially significant negative impact following application of mitigation measures. To this end, Pillar Oil Limited hereby solicits approval of the project by FMEnv, while appropriate mitigation and monitoring measures shall be carried out following implementation.

REFERENCES

Akpofure, E.A. & **Ojile, M.O. (1999)** "Social Impact Assessment: an interactive & Participatory Approach – Case Study Example from the Niger Delta, Nigeria in UNEP EIA Training Resource Manual, pp211-222, UNEP, Kenya.

Allen, J. R. L (1965) Late Quaternary Niger Delta and Adjacent Areas: Sedimentary Environments and Lithofacies

Angela Dale & Richard B. Davies (Eds.) (1995). Analyzing Social & Political Change: A Case – book of Methods. Sage Publications, London.

Barnes, R.S.K., Calow, P. and Olive, P.J.W. (1993). The invertebrates: a new synthesis. Blackwell Scientific Publications. London. 488pp.

Bettrons, D.A.S. and Castrejon, E.S. (1999). Structure of benthic diatom assemblages from a mangrove environment in a Mexican subtropical lagoon. *Biotropica*. **31**(1): 48 – 70.

Bogden, R. and Taylor, S. (1975). Introduction to qualitative research methods: a phenomenal approach to social sciences, Wiley and Sons, N.Y.

Canter L. W. (1996): Environmental Impact Assessment. Second Edition. New York, USA McGraw Hill

Cook, T. D. & Campbell, D. T. (1979). Quasi-Experimentation: Design and Analysis Issues for Field Setting: Houghton Melflin Company, Boston.

DPR (1991, 2002 Revised Edition). Environmental Guidelines & Standards for the Petroleum Industry in Nigeria. Department of Petroleum Resources, Ministry of Petroleum Resources, Lagos.

Federal Republic of Nigeria Official Gazette (2007) Legal Notice on Publication of the details of the breakdown of the National and State Provisional Totals, 2006 Census, No. 24, Vol. 94, Lagos-15th May, 2007.

FEPA (1991) Guidelines and Standards for Industrial Effluents, Gaseous Emissions and Hazardous Waste Management In Nigeria.

FEPA (1991b). Guidelines and standards for Environmental Pollution Control in Nigeria.
Frenier, W.W and Ziauddin, M. (2013) Chemistry for Enhancing the production of Oil and Gas. Richardson, TX. Society of Petroleum Engineers.

Glasson, J. (1995).”Socio-economic impacts 1: overview and economic impacts”, in Methods of Environmental Impact Assessment (Peter Morris and Riki Therivel. Editors) UCL Press, England.

GreenFacts (2005) Scientific facts on Air Pollution: Ozone. Available from < http://www.greenfacts.org/en/ozone-o3/index.htm> assessed 28th July 2011. Updated 24th July, 2011.

Lange-Bertalot, H. (2001). *Diatoms of Europe. Diatoms of the European Inland Waters and Comparable Habitats.* Vol.2. A.R.G. Gantner Verlag K.G. 520pp.

Lucas, A.O. and Gilles, H.M (1990). A New Short Textbook of Preventive Medicine for the Tropics, Third Edition, Edward Arnold

Michael Q (1977). *Invertebrates of streams and Rivers. A key to identification*. Edward Arnold Publishers Ltd., London. 84pp.

National Population Commission (NPC) (2006). Nigeria Population Census 1991 Analysis: *Children, Adolescents and Youths.* National Population Commission, Abuja.

National Population Commission (NPC) (2006). Nigeria Population Census 1991 Analysis: Children, Adolescents and Youths. National Population Commission, Abuja.

National Population Commission (NPC) [Nigeria] and ICF Macro. 2009. Nigeria Demographic and Health Survey 2008. Abuja, Nigeria: National Population Commission and ICF Macro.

NIMET (2012) Nigerian Meteorological Agency Report.
Nimrod, A.C., Benson, W.H., 1996. Environmental estrogenic effects of alkylphenol ethoxylates. *Crit. Rev. Toxicol*. 26, 335e364.

Nwankwo D.I . (2004b). *A Practical Guide to the study of algae*. JAS Publishers, Lagos. Nigeria. 86pp.

Nwankwo, D. I. (1988). A preliminary Check-List of Planktonic Algae of Lagos Lagoon. *Nigerian Journal of Basic and Applied Sciences .* **2**(1): 73 – 85.

Nwankwo, D. I. (1995). Euglenoids of some Polluted Storm-water Channels in Lagos, Nigeria. *Tropical Freshwater Biology.* **4**: 29 – 39.

Nwankwo, D. I. and Akinsoji, A. (1988). Periphyton Algae of eutrophic Creek and their possible use as Indicator. *Nigerian Journal of Botany.* **1**: 96 – 105.

Nwankwo, D.I. (1990). Contribution to the Diatom flora of Nigeria. Diatoms of Lagos lagoon and the adjacent sea. *Nigerian Journal of Botany.* **3**: 53-70.

Nwankwo, D.I. (1998). The influence of sawmill wood wastes on diatom population at Oko-baba, Lagos, Nigeria. *Nigerian journal of Botany 11*: 15 – 24.

Nwankwo, D.I. (2004a). The Microalgae: Our indispensable allies in aquatic monitoring and biodiversity sustainability. University of Lagos Press. Inaugural lecture seris. 44pp.

Nybakken, J.W. (1988). Marine Biology*: An Ecological Approach* 2nd edition, Harper and Row Publishers, New York. 514pp.

Ogbeibu, A.E. (2005). *Biostatistics: A practical approach to research and data handling*. Mindex Publishing Company limited, Benin city, Nigeria.264pp.

Ogbeibu, A.E. (2005). *Biostatistics: A practical approach to research and data handling*. Mindex Publishing Company limited, Benin city, Nigeria.264pp
.

Olaniyan C. I. O. (1978). *An Introduction to West African Animal Ecology*. (Second Edition) Heinemann Educational Books Ltd. Ibadan 170p.

Olaniyan, C.I.O. (1975). *An introduction to West African Ecology*. Heinemann Education Books Ltd., London. 170pp.

Onyema, I.C. (2007). Mudflat microalgae of a tropical bay in Lagos, Nigeria. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*. 9 (4): 877 – 883.

Onyema, I.C. (2007). Mudflat microalgae of a tropical bay in Lagos, Nigeria. *Asian Journal of Microbiology, Biotechnology and Environmental Sciences*. **9** (4): 877 – 883.

Onyema, I.C. and Ojo, A.A. (2008). The zooplankton dynamics and chlorophyll a concentration of a tropical tidal creek in relation to water quality indices. *Life Science Journal*. 5 (4): 7 - 14

Patrick, R. and Reimer, C.W. (1966). The diatoms of the United States exclusive of Alaska and Hawaii (Vol. 1). *Monogr. Acad. Nat. Sci. Philadelphia*. 686pp.

Patrick, R. and Reimer, C.W. (1975). The diatoms of the United States exclusive of Alaska and Hawaii (Vol. 2, part 1). *Monogr. Acad. Nat. Sci. Philadelphia*. 213pp.

Pillar Oil Limited (POL) (2020), Environmental (and Social) Impact Assessment Study (ESIA) Terms of Reference (TOR) & Scope of Work (SOW)

Priatna, R., Syahbandi, E., Sudewo, B., 1994. Phenol Compounds in Produced Water. *Society of Petroleum EnginEESs*, pp. 365e371. SPE-27134.

Research Planning Institute (RPI), (1985) Environmental Baseline Studies for the Establishment of Control Criteria and Standards against Petroleum Related Pollution in Nigeria. Research Planning Institute Inc. Columbia USA.

Rosowski, J.R. (2003). Photosynthetic Euglenoids. **In**: *Freshwater Algae of North America*. Ecology and Classification, Wehr, J.D. and Sheath, R.G. (Eds). Academic Press, New York. pp 383 – 422.

Scott-Samuel A, Birley M, and Andern K (1998): The Merseyside Guidelines for Health Impact Assessment. Liverpool. Merseyside Health Impact Assessment StEESing Group.

Short, K. C. & Stauble, A. J. (1967) Outline of Geology of Niger Delta. *Am. Assoc. Petroleum Geologists Bull.* Vol 51, 761-779pp

SIEP (1996/2000) Social Impact Assessment Guidelines HSE Manual. Shell International Exploration and Production B. V. The Hague.

SIEP; 1985 Environmental Assessment, EP 95 – 070; HSE Manual Vol. 3 Hazards and Effects Management Tools and Techniques.

Siver, P.A. (2003). Synurophyte algae. **In**: *Freshwater Algae of North America*. Ecology and Classification. Wehr, J.D. and Sheath, R.G. (Eds). Academic Press, New York.pp523 - 558.

Siver, P.A. (2003). Synurophyte algae. **In**: *Freshwater Algae of North America*. Ecology and Classification. Wehr, J.D. and Sheath, R.G. (Eds). Academic Press, New York. pp 523 - 558.

Soto, A.M., Justicia, H., Wray, J.W., Sonnenschein, C., 1991. Para-nonyl-phenol - an estrogenic xenobiotic released from modified poystyrene. *Environ. Health. Perspect*. 92, 167e173.

UNEP, (1996): Environmental Impact Assessment Training Resource Manual. Case Studies from Developing Countries United Nations Environmental Programme (UNEP).

United Nations Development Programme (UNDP) (2006), *Niger Delta Human Development Report 2006* UNDP, Nigeria, Abuja.

USEPA, (1989); United States Environmental Protection Agency

Vanlandingham S.L. (1982). Guide to the identification and environmental requirements and pollution tolerance of freshwater blue-green algae (cyanophyta). U.S. Environmental Protection Agency, EPA – 60.

Vanlandingham S.L. (1982). Guide to the identification and environmental requirements and pollution tolerance of freshwater blue-green algae (cyanophyta). U.S. Environmental Protection Agency, EPA – 60.

Waife, G. and Frid, C.L.J (2001). Marine zooplankton of West Africa. Marine Biodiversity Capacity Building in the West African Sub-region. Darwin Initiative Reports 5, Ref. 162/7/45/. 120pp

Wathern (1998): Environmental Impact Assessment. Theory and Practice. London. Rouledge.

Whitford, L.A. and Schmacher, G.H. (1973). *A manual of freshwater algae*. Sparks press Raeigh. 324pp.

Witkowski, A., Lange – Bertalot, H. and Metzeltin, D. (2000). Diatom flora of Marine Coasts 1. (219 plates). A.R.G.Gantner Verlag K.G. 925pp.

World Health Organization (WHO) (2004) *Guidelines for Drinking-Water Quality, 3rd ed. Vol 1. Summary, Geneva,* World Health Organization*.*

World Health Organization (WHO) (2008) Petroleum Products in Drinking-Water. *Background Document for the Development of WHO Guidelines for Drinking-Water Quality,* World Health Organization*.* Available from <www.who.int/water_sanitation_health/dwq/chemicals/petroleumproducts_1add_june2008.pdf> Assessed <19th January, 2018>

World Health Organization (WHO) (2017) *Guidelines for Drinking-Water Quality: 4th ed. incorporating the first addendum. Geneva,* World Health Organization 2017*.* License: CC BY-NC-SA 3.0 IGO

Appendix 3.1-POL Waste Management Plan

Pillar Oil Limited

WASTE MANAGEMENT PLAN (WMP)

REVISION STATUS LOG						
Revision Number	Date of Issue	Revision Description	Number of pages	Composed By	Checked	Approved

FOREWORD

The Pillar Oil Limited Waste Management Plan (WMP) provides guidance on the management of waste in all areas of operations.

This document is for the use and guidance of all Staff and Contractors of Pillar Oil Limited. Except for environmental regulators, other external parties, with the approval of the Managing Director, may also sight the document if they request.

The WMP is intended to be a dynamic working tool. Consequently, users are invited to comment on the document and to suggest changes and additional material that they consider would be useful for inclusion in future revisions. The document will be formally reviewed on an annual basis and any additions amendments circulated to all document holders.

In addition, HSE audit reports and incident reports (related to waste management) are to serve as established feedback mechanisms that will be used to ensure the relevance of the document and its continual improvement.

1. Introduction

This specification describes Pillar Oil Limited minimum requirements for managing wastes, which result from activities, products or services that have the potential to be hazardous to human health or to contaminate the environment. A number of operational wastes will be generated from all project activities.

1.1 Scope

This specification applies to all Hazardous and Non-Hazardous waste generated through Pillar Oil Limited personnel, Contractor and Sub-Contractor activities.

1.2 Pillar Oil Limited Waste Management Policy

"Take all practical and reasonable steps to minimize the generation of solid and liquid waste, as well as atmospheric emissions from flare or otherwise. Manage and dispose all wastes in line with relevant regulatory requirements and environmentally responsible manner. Track and maintain records of the full life cycle of waste streams and provide an auditable trail as to its management and disposal".

1.3 Waste Management Hierarchy

All wastes shall be managed in accordance with the principle of the Waste Management Hierarchy. This principle tends to minimize risks to the natural environment and personnel associated with waste handling, storage and disposal.

The following waste management hierarchy shall be considered as shown in figure 1.

- **Reduction** – generation of less waste through more efficient processes
- **Re-use** – use of materials or products that are reusable in their original form
- **Recovery -** the extraction of energy or materials from waste
- **Recycle** – the conversion of waste into useable materials
- **Responsible Disposal** – depositing wastes using appropriate methods for a given situation

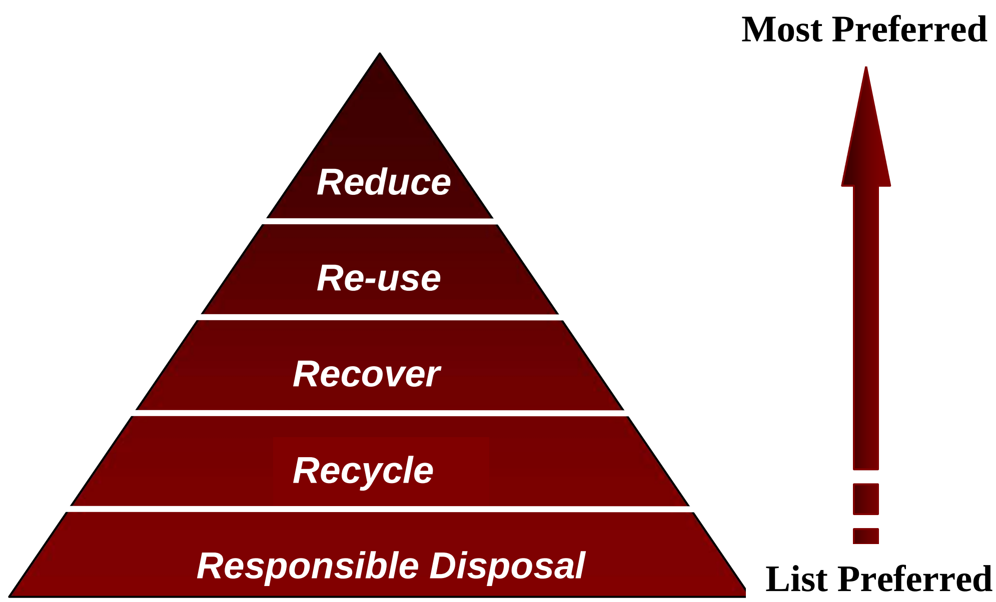


Figure 1.The Waste Management Hierarchy

Waste Management Contractors

The licensed waste recycling / disposal contractors utilized by Pillar Oil Limited shall be subject to stringent controls, including: initial comprehensive assessment before contract award, site inspection and performance monitoring. They must have been registered with relevant regulators (DPR and Federal and State Ministry of the Environment and shall have current permit for waste management services).

Segregation of Waste

All categories of wastes are segregated according to their physical and chemical characteristics. Apart from safety concerns, an initial waste characterization will help determine which waste streams are similar and may be combined to simplify storage, treatment, recycling and disposal. Colour coded receptacles will be utilized for hazardous waste; this will assist waste handlers in identifying contaminated waste quickly and without risk of injury.

Waste Collection

Various types of receptacles (containers; skips, bins, drums etc.) shall be provided for the collection, movement and storage of waste. Containers will be of suitable design to prevent leaks (e.g. from failure through corrosion), weathering and scavenging, and to facilitate safe transportation. Compactors will be used where practicable to reduce waste volume. All waste receptacles shall be labelled with the facility's name, waste types (hazardous or non-hazardous), and personnel shall take their waste to the various collection points.

Prevent
Reduce
Recycle
Disposal

Recordkeeping of Waste Inventory

Record of all listed materials purchased or brought on location shall be kept. Records should include:

- The amount of material purchased, date supplied to location, amount of material used with dates.

- An inventory of all material considered hazardous or which may be hazardous.

Operational Wastes and Disposal Methods

The operational wastes associated with the project activities can be classified into three phases; solid wastes, liquid wastes and gaseous wastes.

Solid wastes

Provision shall be made for the proper storage and subsequent disposal of all sludge/solid/sewage wastes generated at the facilities. Organic wastes, cuttings, rejects, spoils etc. generated during construction shall be collected, segregated and transported to an approved disposal facility.

Liquid wastes

These will include effluent wastewaters, chemical and hydrocarbon spills. All contingency plans for pollution control shall be maintained. Where discharges are unavoidable, they shall be closely monitored and minimized.

(i) Wastewaters

Effluent wastewaters generated from the project facilities shall not be disposed into the environment unless treated, such that they comply with the government (DPR/FMNEV) specified limits of contaminants prior to disposal.

(ii) Chemical Spills

Appropriate measures will be employed in managing chemical spills. Where applicable, a direct flushing with water will be carried out. Covered containers shall be provided for chemicals used on a routine basis in order to minimize spills. Material Safety Data Sheet (MSDS) shall be clearly displayed on each chemical container.

(iii) Hydrocarbon Spills

Minor hydrocarbon spills shall be cleaned immediately using appropriate absorbent granules and powders. Direct flushing to water bodies shall not be permitted. All major spills will be subjected to clearance and clean up requirements from the approved oil spill contingency plan.

Gaseous Waste

Gaseous emissions are primarily resulting from the burning of diesel as fuel for the machines, rigs and generators. Additional minor gas emissions may occur from atmospheric venting of closed drain systems, exhaust from attendant vessels and and vehicles

.

Provisions shall be made in the facilities design to enable the upgrading of equipment that will reduce emissions and discharges as new technology emerges. Facilities for in-situ measurements of emissions and discharge levels shall be provided where practicable.

Table 1:Types of wastes expected from Project Activities

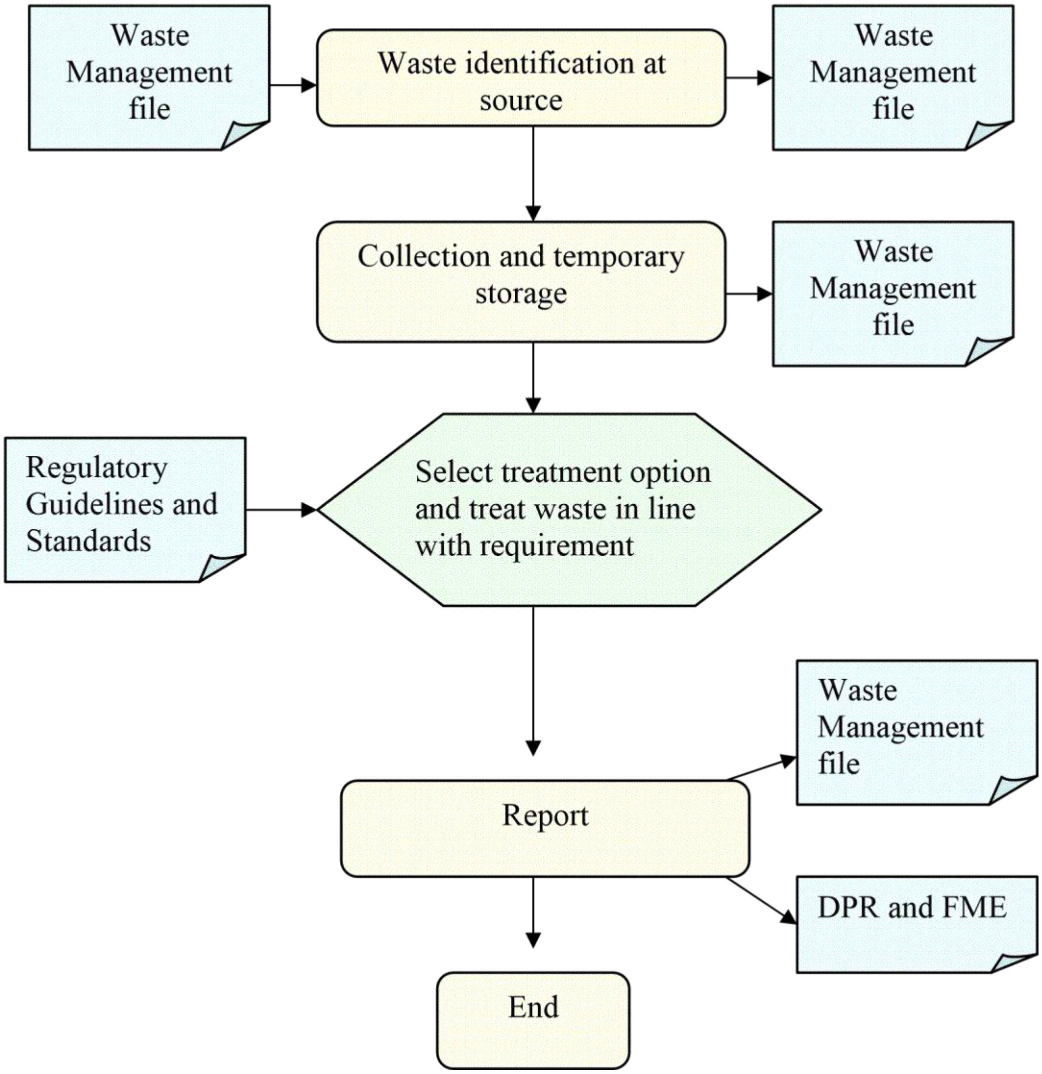
Types	Source	EGASPIN	Disposal Plan
Produced water	From formation	Part III D 3.6.2 (a)&(b) Inland/Nearshore area: Produced formation/oily waters shall not be discharged into inland and near shore areas.	Disposed by re-injection into re-injection wells and abandoned wells.
Rain / Process area runoff	Drainage	Part II D 2.4 & 2.4.1 Collected and treated separately for oil removal by gravity separation or is handled by the produced water system before discharge	Oil skimmed off in a saver pit and Laboratory analysis shall be carried out to ensure that parameter are within regulatory limit before discharge.

Types	Source	EGASPIN	Disposal Plan
Sewage	Personnel	Part II D 2.5 & 2.5.1 Sanitary waste shall be treated biologically if manned continuously by 10 or more persons or if lesser the waste shall be macerated and dumped overboard with no floating solids	It is envisaged that the maximum number of personnel at drilling site at any one time will be about 150 persons. Sanitary sewage produced at site will be treated on the rig sewage treatment plant in line with regulatory standards. The water can be re-used for flushing the system or disposed in rivers. Regular monitoring will be carried out.
Drill Cuttings	Geological formation in drill holes	Part II D 2.3.1&2.3.1.1 On-site drilling with an oil content that does not cause sheen on the receiving water Washing of drill cuttings that contain to a level that would not cause sheen so that they may be discharged to receiving water Transportation of drill cuttings to land for proper land disposal or treatment. E.g. incineration or desorption /oil recovery. Injection into properly prepared and approved formation.	Treat to reduce oil and grease content to Regulatory limits by chemical, physical and biological methods. Transport cuttings to TDU Montego Upstream Services in Amukpe for treatment and disposal

Types	Source	EGASPIN	Disposal Plan
Scraps	Cut-offs/Damages	Part V A 5.6.9& 5.6.9.2 Dispose of by methods that shall not endanger human life and living organisms and cause significant pollution to ground and surface waters.	Segregate into usable &non usable, release non usable scrap to vendor
Lubricants	Plant Servicing at construction sites	Part II E 3.5.6.1 (g)	Reclaimed lube oil and other waste oils shall be disposed of by injection into the crude stream, if not directly utilised.
Rig Bilge	Rig		• Oily water discharges shall be controlled to less than 20ppm through treatment oil in water by the rig oil/water separation system. • The rig bilge cockpit has a hollow bridge deck with a secure lid across the forward end, this decrease its size and is used as grab bag for any spilled oil. • The rig bilge is also fitted with storm shutters to cover all the

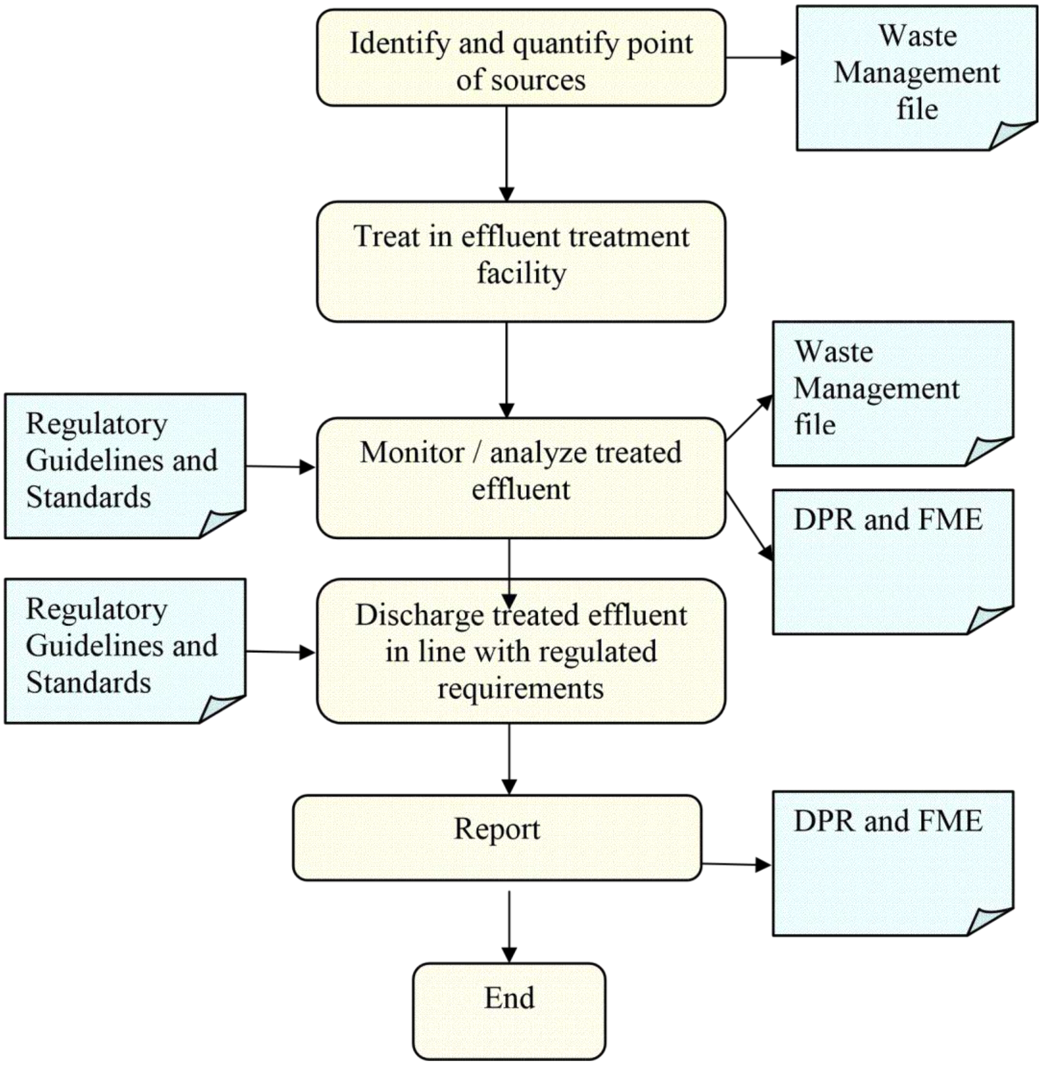
Types	Source	EGASPIN	Disposal Plan
			windows to prevent oil spill into water bodies.
Exhaust Gas Emissions	Internal Combustion Engines		Part II D 2.1 & 2.1.1 Atmospheric emissions in both exploration and development activities are for the most part minor because of the level and nature of exploration and development activities, they occur mainly from vehicles and power generating plants and equipment.
Food Waste	Project Areas		Send to SPDC's waste management facility in Warri for treatment and disposal

P.01 MANAGEMENT OF OILY WAX AND SLUDGE



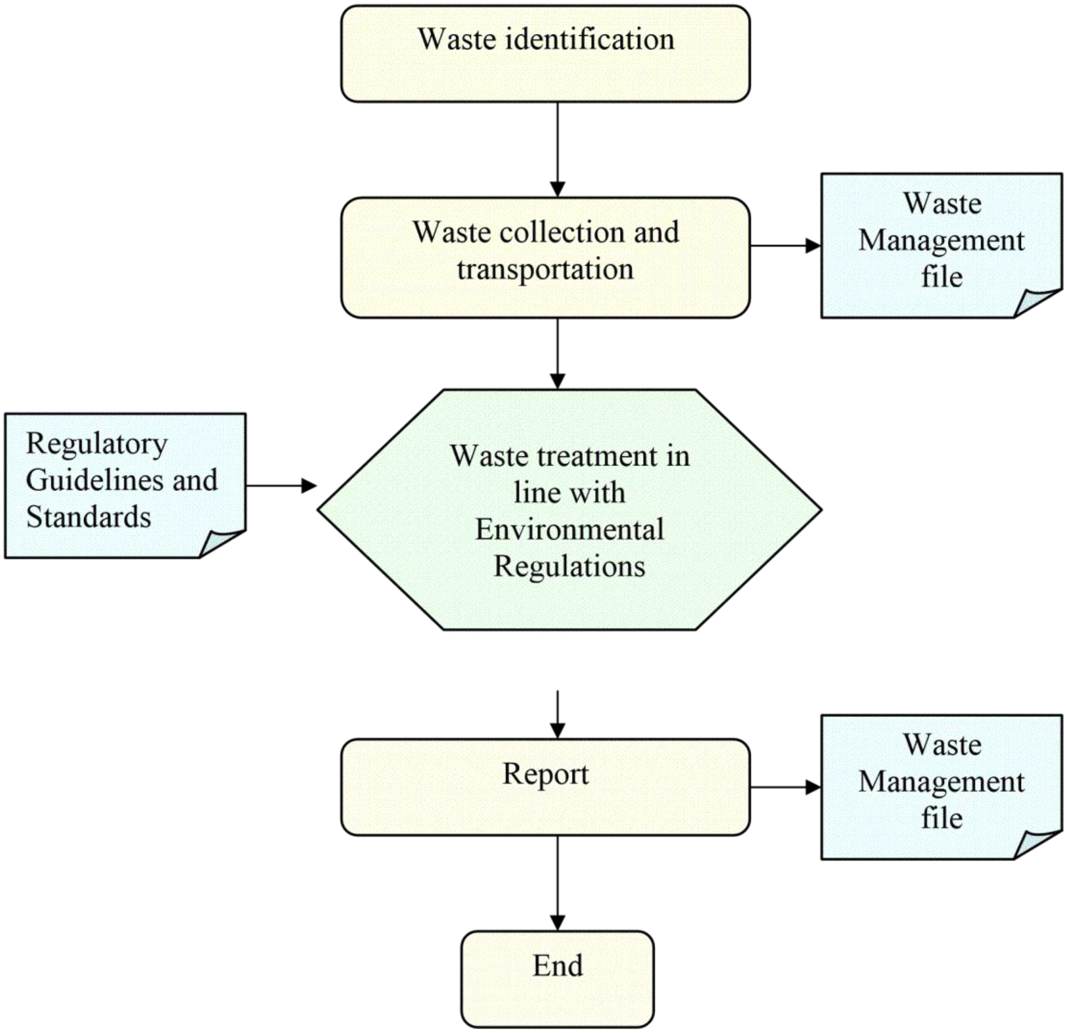
1. **Facility Supervisor**
   - Communicates schedules for operations generating oily wax and sludge e.g. pigging to HSE Coordinator
2. **Facility Supervisor, HSE Coordinator**
   - Organize clean up crew and logistic to collect the waste
   - Provide sealable containers (drums)for storage of the waste
   - Ensure waste is treated as flammable (stored in line with safety requirements)
   - Transport to TDU Montego Upstream Services in Amukpe for treatment and disposal
   - Produce initial report detailing waste quantity, source data and time of collection, temporary storage method, etc

P.02 MANAGEMENT OF OILY WASTEWATER AND PROCESS EFFLUENT



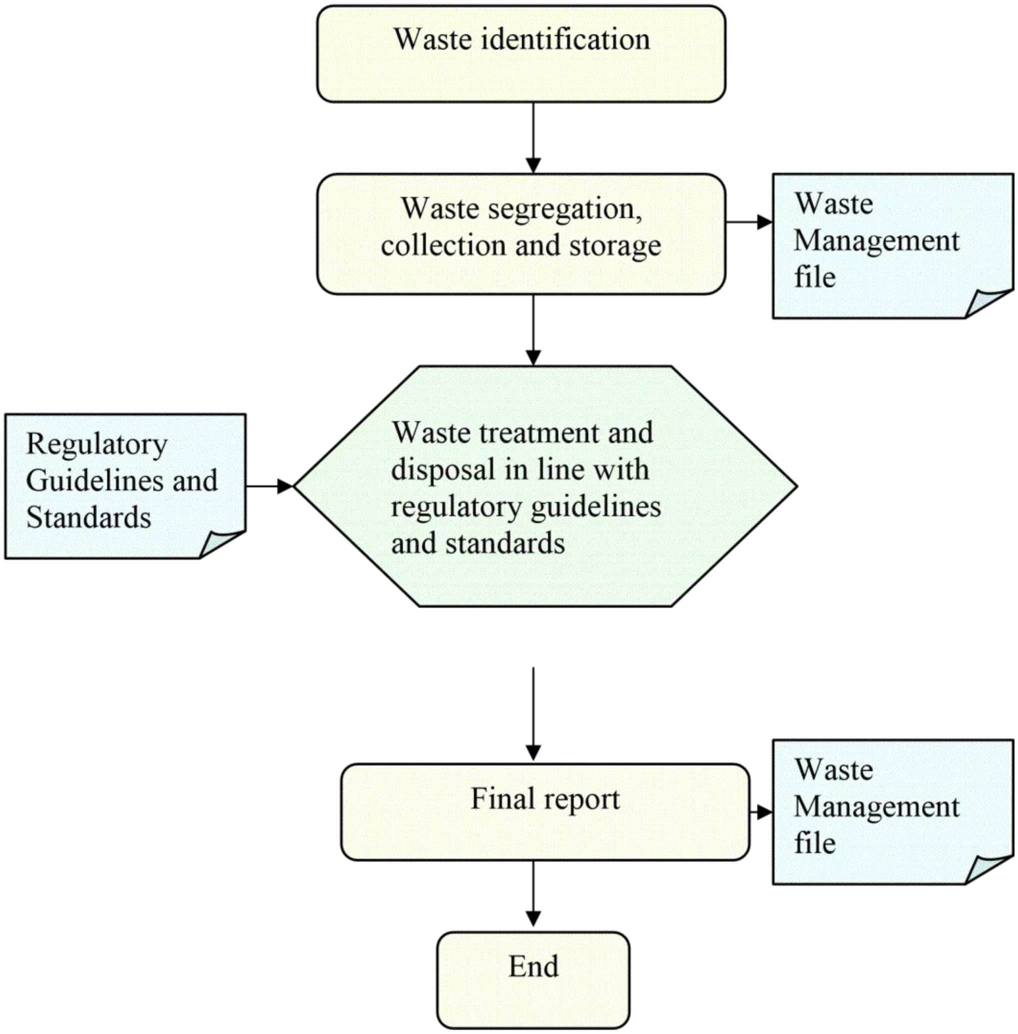
1. **HSE Coordinator, Facility Supervisor**
    - Identify and quantify all point sources of oil wastewater and process effluent
    - Ensure all point sources are routed to effluent treatment facility
    - Document point sources and quantities.
2. **Facility Supervisor**
    - Ensure effluent treatment facility is functional
3. **HSE Coordinator**
    - Ensure treated effluent is monitored/analysed in line with Regulations.
4. **HSE Coordinator,**
    - Request/get approval to discharge treated wastes
    - Supervise discharge of treated waste
5. **HSE Coordinator,**
    - Compile and produce final report
6. **HSE Coordinator**
    - Archive all documents

P.03 MANAGEMENT OF OIL STAINED COMBUSTIBLE MATERIAL



1. **Facility Supervisor, HSE Coordinator**
   - Identify oil stained combustible generated during operations
2. **HSE Coordinator, Cleanup Crew**
   - Cleanup crew – collect the waste in sealable containers for transportation
   - HSE Coordinator organise cleanup crew and logistics for transportation of waste to point of incineration in Koko (Ebenco Company)
   - Ensure waste is treated as flammable (stored in-line with safety requirements)
   - Produce initial report detailing waste quantity, source, date and time of evacuation, temporary storage method, etc.
3. **HSE Coordinator**
   - Request/get approval to treat waste by:
     a) Incineration
     d) Biodegradation
   - Supervise treatment of waste
   - Ensure proper documentation
4. **HSE Coordinator,**
   - Produce final report
   - Recommend/communicate improvement strategies
5. **HSE Coordinator**
   - Archive all documents

P.04 MANAGEMENT OF METAL, WOOD AND POLY- BASED SCRAPS



1. Facility Supervisor

- Identify/inform HSE coordinator of scraps generated during operations

2. HSE Coordinator, Warehouse Supervisor

- Organise cleanup crew and logistics to collect scraps to central scrap yard
- Ensure scrap is segregated into:
  a) Re-usable scrap
  b) Re-saleable scrap
  c) Non re-usable or sale able scrap
  d) hazardous and nonhazardous
- Ensure segregated scraps are stored in appropriate caravans or other suitable facility
- Produce initial report detailing waste quantity, source etc.

3. HSE Coordinator, Warehouse Supervisor

- Request/get approval to:
  a) Re-use
  b) Re-sell
- Ensure waste consignment notes are issued/signed as appropriate

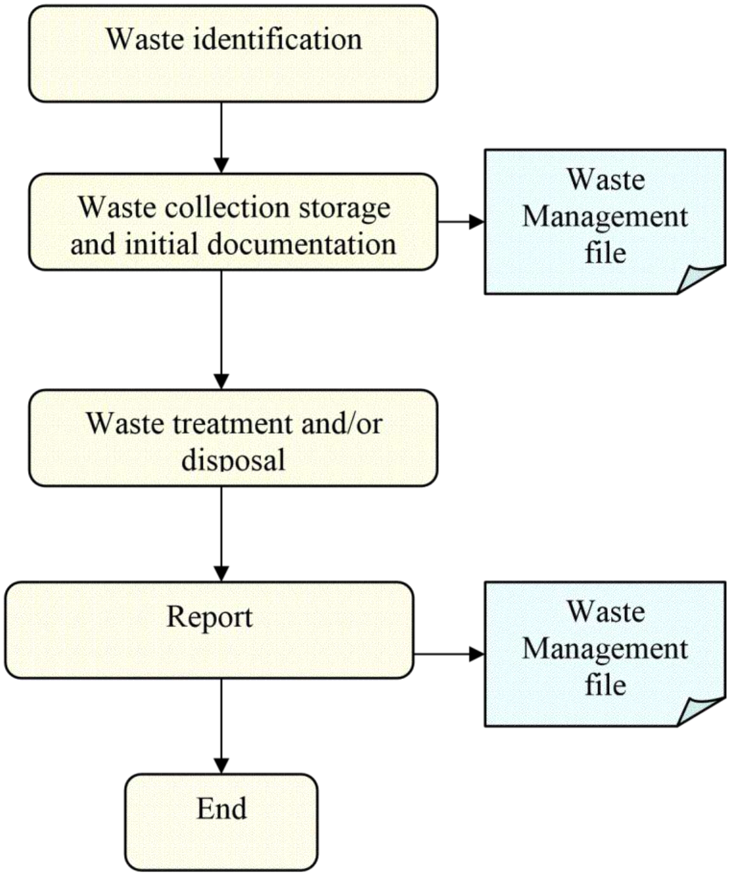
4.HSE Coordinator, HSE Manager

- Produce final report
- Recommend/communicate improvement strategies

5. HSE Coordinator

- Archive all documents

P.05 MANAGEMENT OF EMPTY METAL CONTAINERS



1. Facility Supervisor

- Identify /inform HSE Coordinator of empty chemical containers

2. HSE Coordinator, Warehouse Supervisor

- Organize cleanup crew and logistics to collect the containers at central scrap yard.
- Ensure containers are segregated into:
  a) Re-usable containers
  b) Re-saleable containers
  c) Non re-usable and non re- saleable containers
- Returnable containers (ensure they are returned to the vendor)
- Isolate containers used for hazardous chemicals which cannot be re-used or re-sold
- Ensure instructions and conditions for re-use are clearly indicated on appropriate containers
- Produce initial report detailing no. of containers, categories, source etc.

3. HSE Coordinator, Warehouse Supervisor

- Request/get approval to reuse, resale or dump empty containers at SPDC waste dumpsite
- Ensure waste consignment notes are issued/signed as appropriate
- Ensure containers of hazardous chemicals are returned to supplier or sod/given to recyclers
- Ensure transfer of custody for containers of hazardous chemicals is properly documented

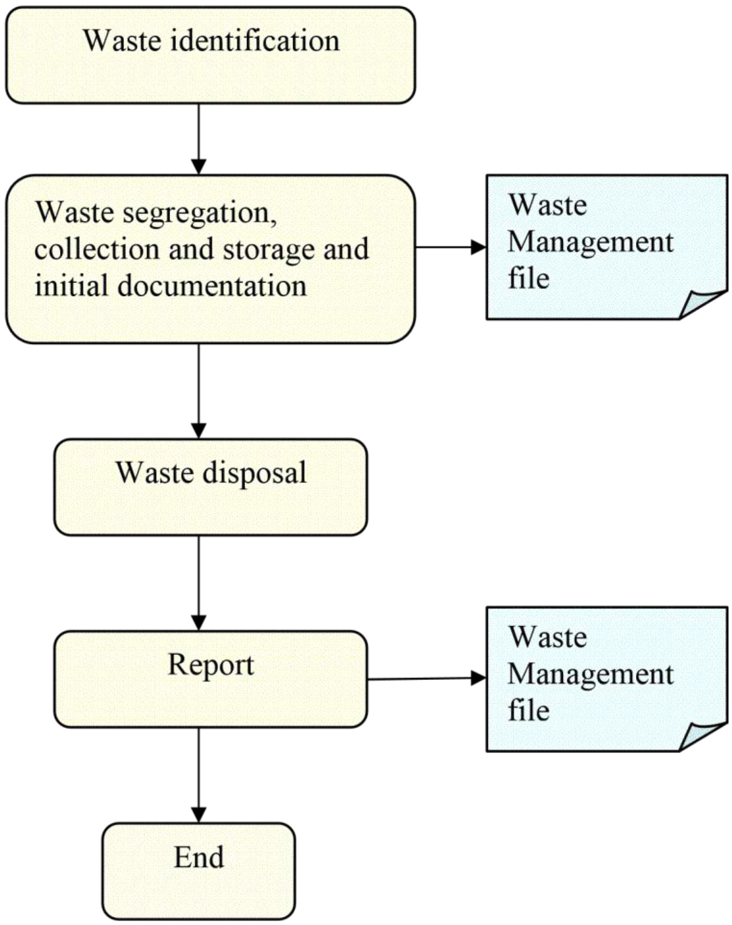
4. HSE Coordinator, HSE Manager

- Produce final report
- Recommend/communicate improvement strategies

5. HSE Coordinator

- Archive all documents

P.06 MANAGEMENT OF CONSTRUCTION DEBRIS



1.

Construction Supervisor • Identify/inform HSE Coordinator of debris generated during construction works

2. **HSE Coordinator, Warehouse Supervisor**

- Organise cleanup crew and logistics to collect scraps to central scrap yard
- Ensure scraps are segregated into;
- Hardcore
- Scraps (metal, wood and
- polybasic)
- Ensure segregated scraps are stored as appropriate
- Produce initial report detailing waste quantity, source etc.

3. **HSE Coordinator, Warehouse Supervisor**

- Request/get approval to reuse, resale or dump debris at government approved waste dump site
- Contact waste vendor to dispose of the non-useable and non re-saleable debris
- Ensure waste consignment notes are issued/signed as appropriate

4. **HSE Coordinator, HSE Manager**

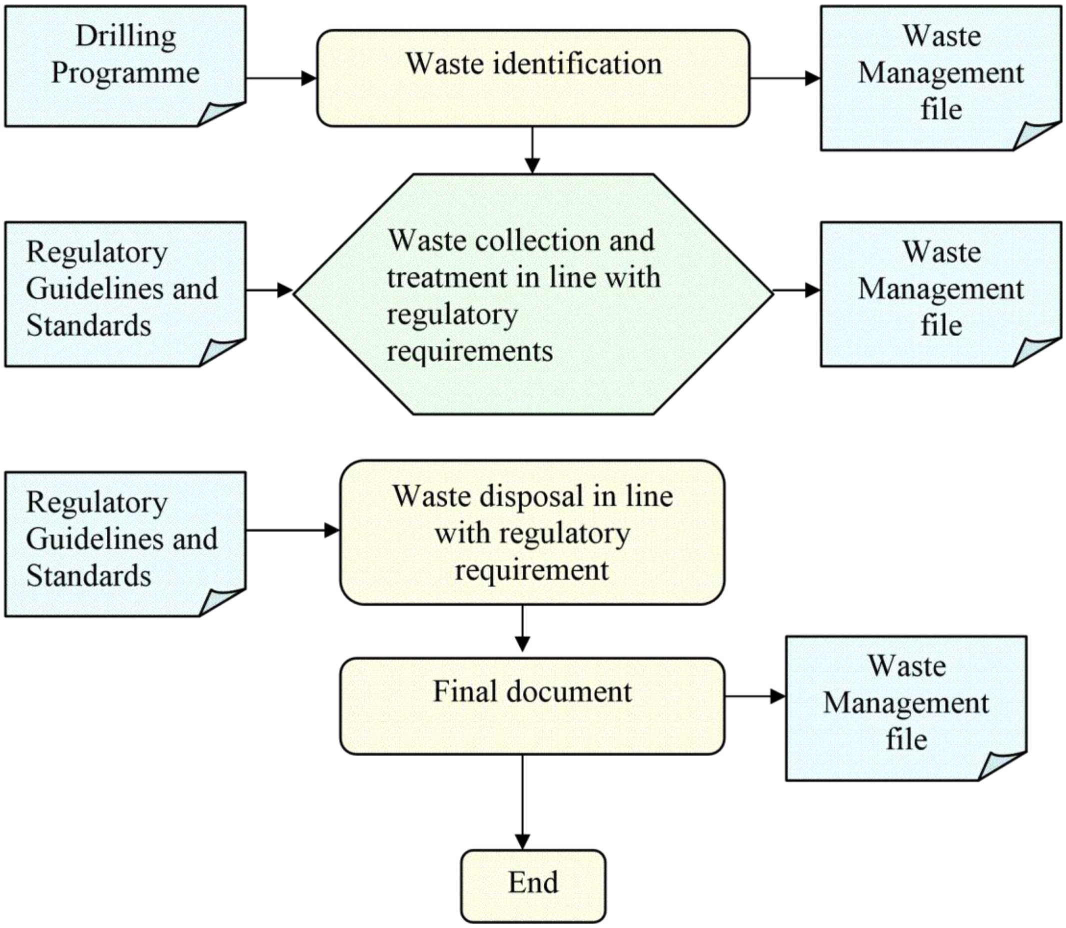
- Produce final report
- Recommend/communicate improvement strategies

5.

HSE Coordinator

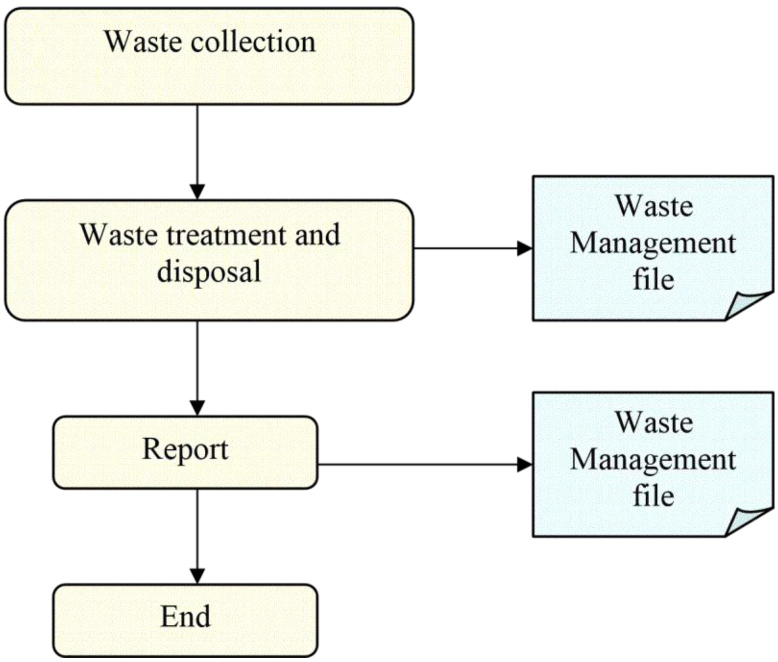
- Archive all documents

P.07 MANAGEMENT OF DRILL CUTTINGS



1. **Drilling Supervisor**
   - Communicate drilling programme including drill cuttings generation forecasts to HSE Coordinator
2. **Drilling Supervisor**
   - Ensure drill cuttings are evacuated by skips to waste treatment facility TDU Montego Upstream Services in Amukpe for treatment and disposal
   - Ensure drill cuttings are treated to reduce oil & grease content to regulatory limits by:
     a) Mechanical methods
     b) Chemical methods
   - Produce initial report detailing quantity, date and time of generation, oil content, etc.
4. **HSE Coordinator,**
   - Produce final report
   - Send report to Regulator
   - Recommend/communicate improvement strategies
5. **HSE Coordinator**
   - Archive all documents

P.8 MANAGEMENT OF SEWAGE-GREY AND BLACK WATER

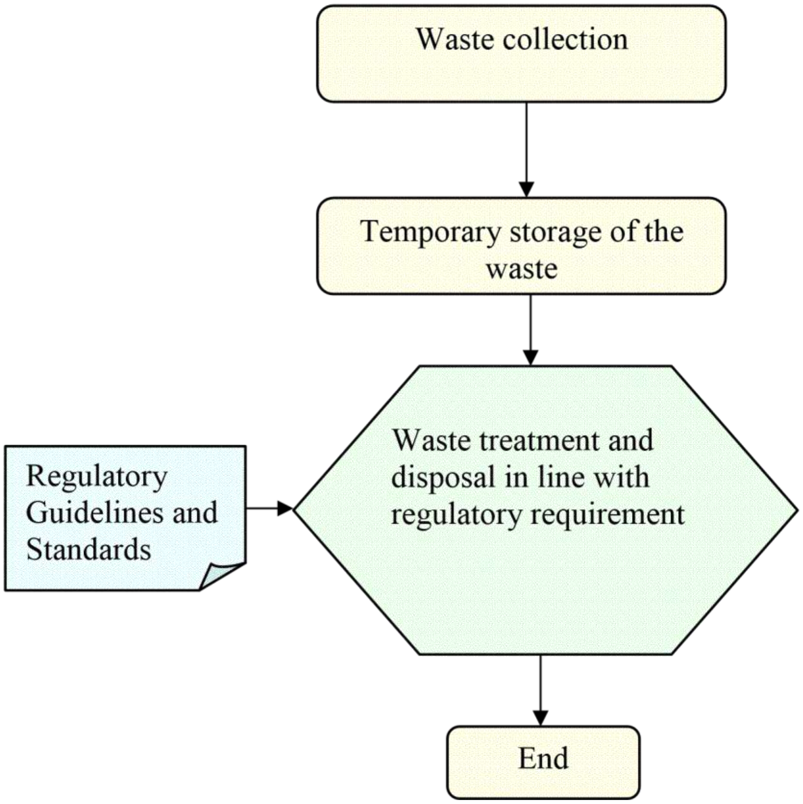


1. **All Staff and Persons using Convenience Facilities**
   - Ensure sewage is discharged into functional convenience facilities
2. **HSE Coordinator, Maintenance Supervisor, Production Supervisor**
   - Monitor soak-away pits and plumbing systems
   - Identify registered/ approval disposal contractor
   - Request/get approval for contractor to evacuate sewage
   - Invite waste contractor to evacuate sewage
   - Supervise evacuation of sewage
   - Ensure waste consignment notes are issued/signed as appropriate
   - Evacuate sewage to SPDC facility for treatment and disposal

4. **HSE Coordinator,**
   - Produce final report
   - Recommend/communicate improvement strategies

5. **HSE Coordinator**
   - Archive all documents

P.9 MANAGEMENT OF BIODEGRADABLE KITCHEN WASTE

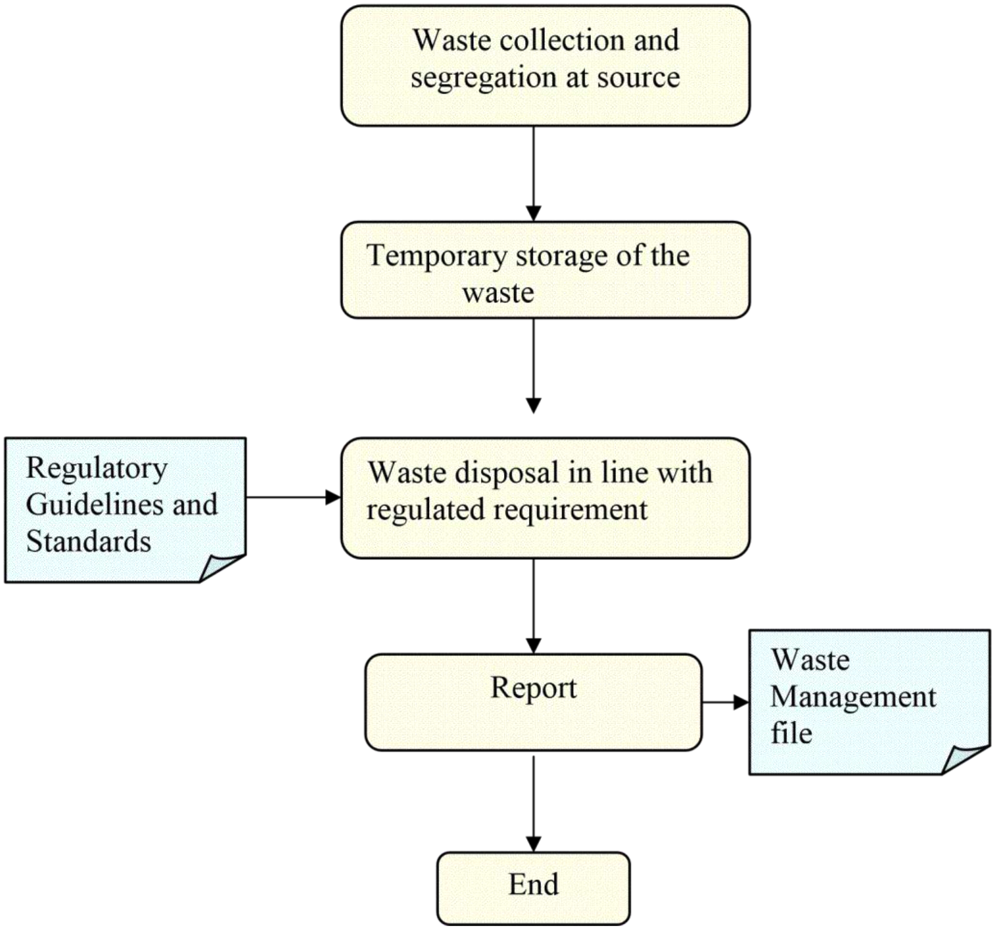


1. **Campsite Resident, Kitchen staff**
   - Isolate biodegradable kitchen wastes and collect in appropriate containers
2. **Cleaners, HSE Cleanup Crew HSE Coordinator**
   - Collect waste from various points and store in central (colour coded, sealable and plastic) bins
   - Request/get approval to evacuate and dispose of waste
   - Dispose waste at
   - SPDC waste disposal facility in Warri

3 HSE Coordinator, HSE Manager
- Produce final report
- Recommend/consignment notes are issued/signed as appropriate

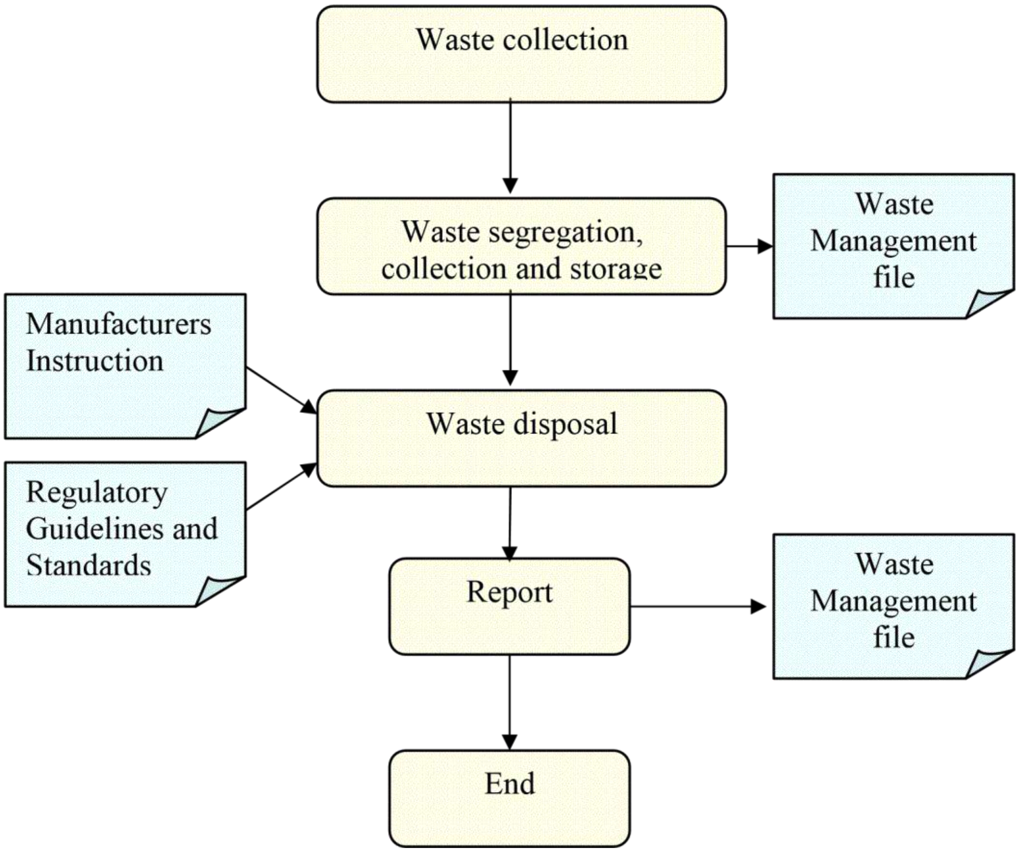
4 HSE Coordinator
- Archive all documents

P.10 MANAGEMENT OF NON-BIODEGRADABLE KITCHEN WASTES



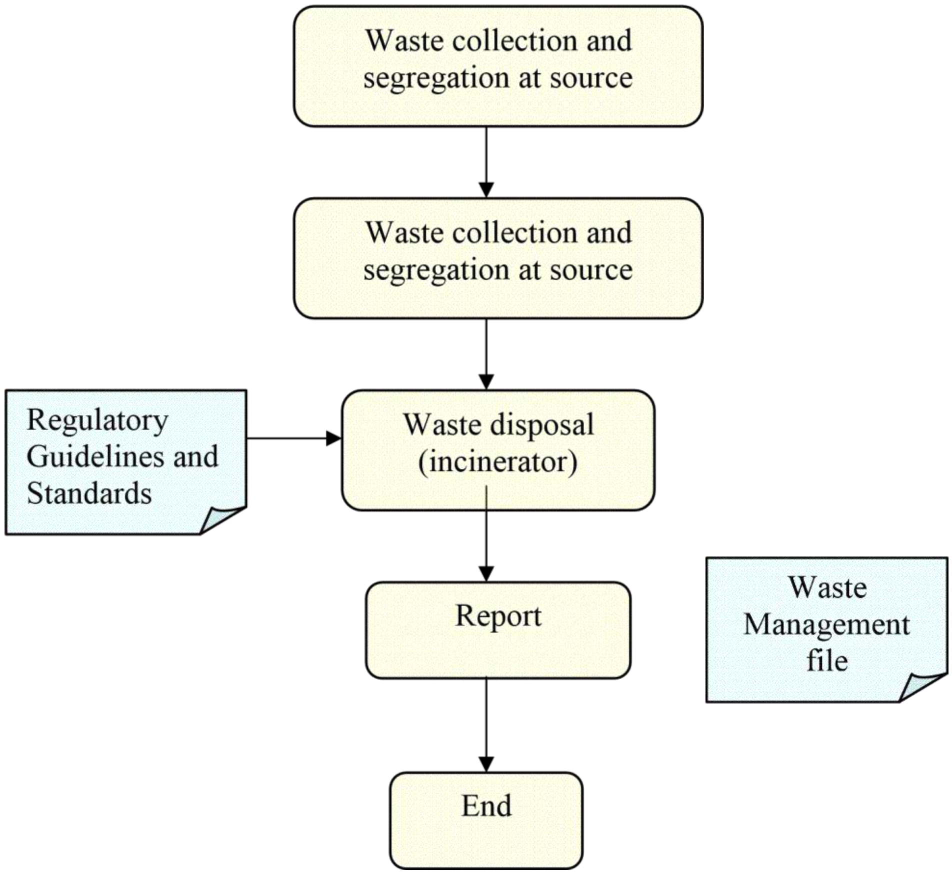
1. **Kitchen Staff, Campsite Residents**
   - Ensure colour coded bins are available at strategic and designated locations
   - Isolate waste at source and collect in appropriate bins
2. **Cleaners, HSE Cleanup Crew, HSE Coordinators**
   - Collect waste from various points and store in central (colour coded and sealable) bins
3. **HSE Coordinator**
   - Request/get approval to evacuate and dispose of waste
     Select and ensure implementation of waste treatment option in-line with regulatory guideline
   - Ensure waste consignment notes are issued/signed as appropriate
4. **HSE Coordinator, HSE Manager**
   - produce final report
   - recommend/communicate improvement strategy
5. **HSE Coordinator**
   - Archive all documents

P.12 MANAGEMENT OF UNSERVICEABLE EQUIPMENT AND EQUIPMENT PARTS



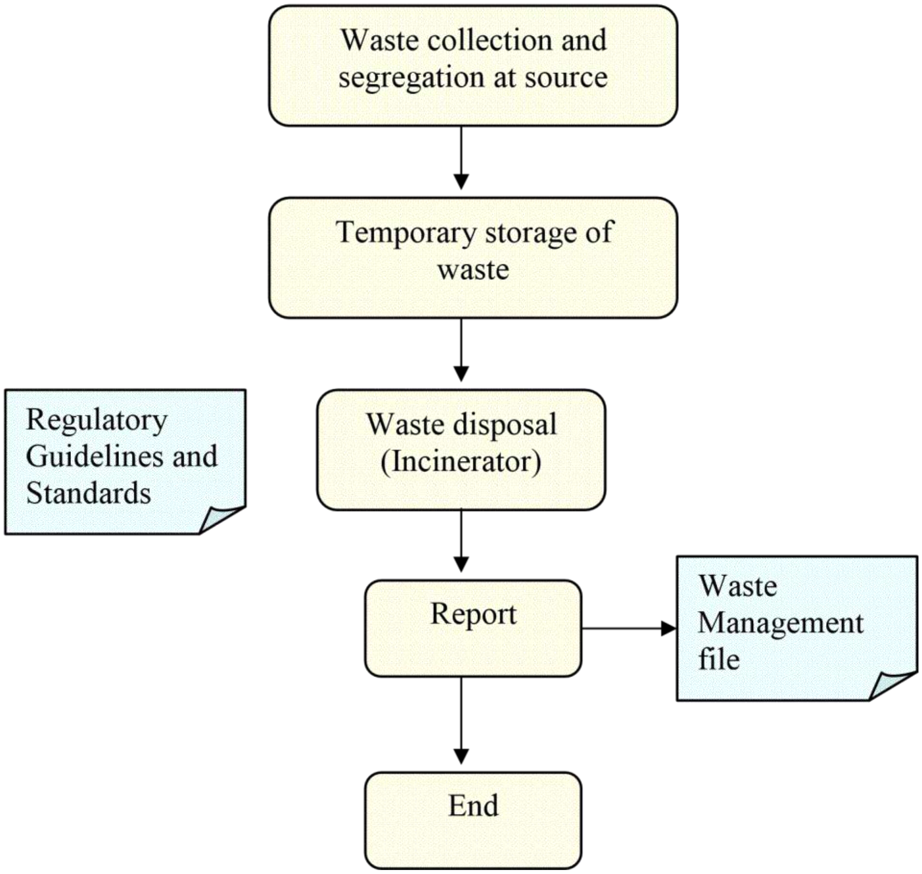
1. **Maintenance Crew, Warehouse Supervisor**
   - Identify/inform HSE coordinator of waste generated during operations
2. **HSE Coordinator, Warehouse Supervisor**
   - Organise cleanup crew and logistics to collect waste to central scrap yard
   - Ensure waste segregation into:
     a) Re-useable items
     b) Re-saleable items
     c) Non re-usable and non re-saleable items
   - Ensure segregated waste are stored in appropriate caravans or other suitable facility
   - Produce initial report detailing waste quantity, source etc.
3. **HSE Coordinator, Warehouse Supervisor**
   - Determine regulatory requirements and confirm specialized manufacturers instructions on disposal if any
   - Request/get approval (in-line in and regulatory requirements) to reuse, resale or dump waste at government approved waste dump site
   - Ensure waste consignment notes are transfer for custody notes are issued/signed as appropriate.
4. **HSE Coordinator,**
   - Produce final report
   - Recommend/communicate improvement strategies
5. **HSE Coordinator**
   - Archive all documents

P.13 MANAGEMENT OF USED SURGICAL MATERIALS, AMPOULES, ETC.



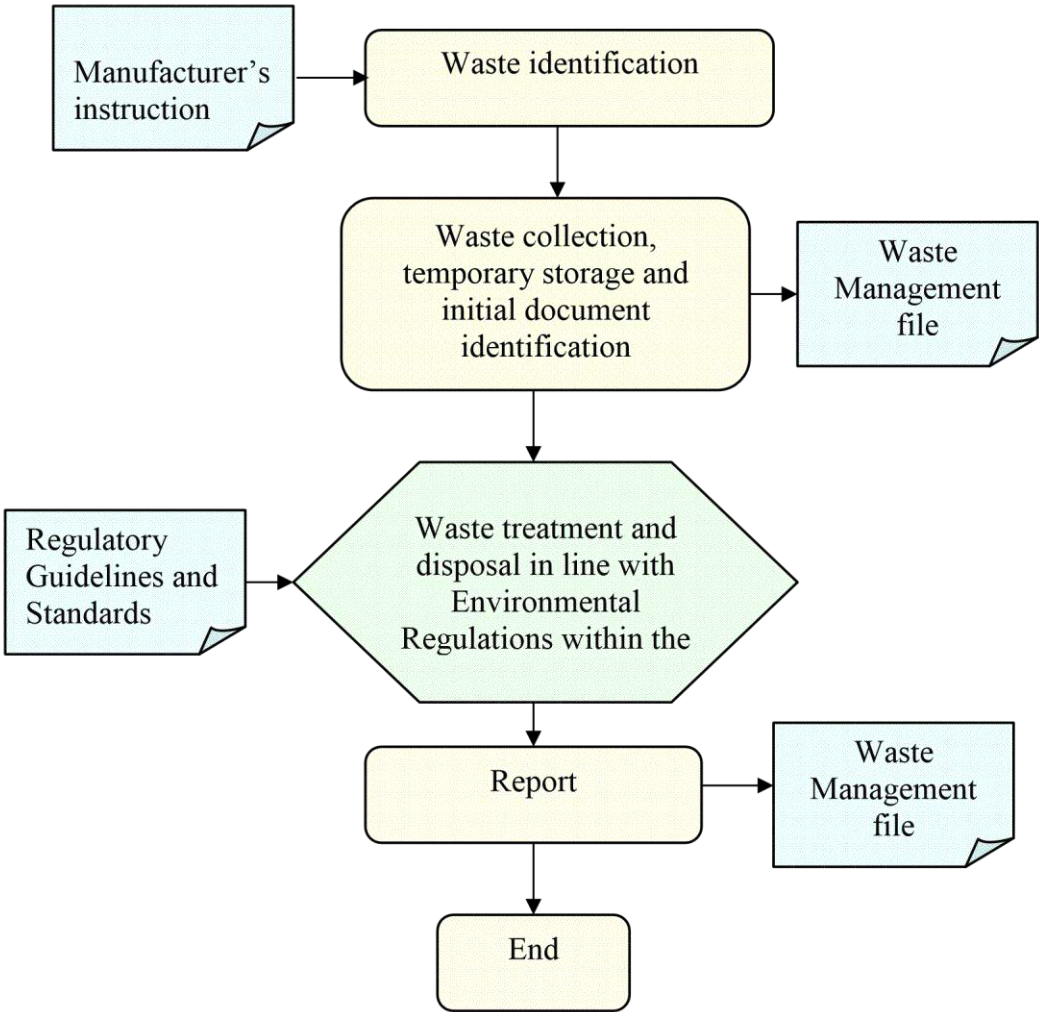
1. **Health Centre Staff**
   - Ensure designated bins are available at strategic locations
   - Isolate sharps at source sterilize and collect in appropriate bins
2. **Cleaners, HSE Cleanup Crew HSE Coordinator**
   - Collect waste from various points and store in central (sealable) bin
3. **HSE Coordinator**
   - Request/get approval to evacuate and dispose of waste
   - Organise cleanup crew and logistics or invite waste contractor to evacuate/dispose waste by incineration at SPDC facility in Warri
   - Ensure proper documentation
4. **HSE Coordinator,**
   - Produce final report
   - Recommend/communicate improvement strategies
5. **HSE Coordinator**
   - Archive all documents

P.14 MANAGEMENT OF SOILED MEDICAL DRESSINGS



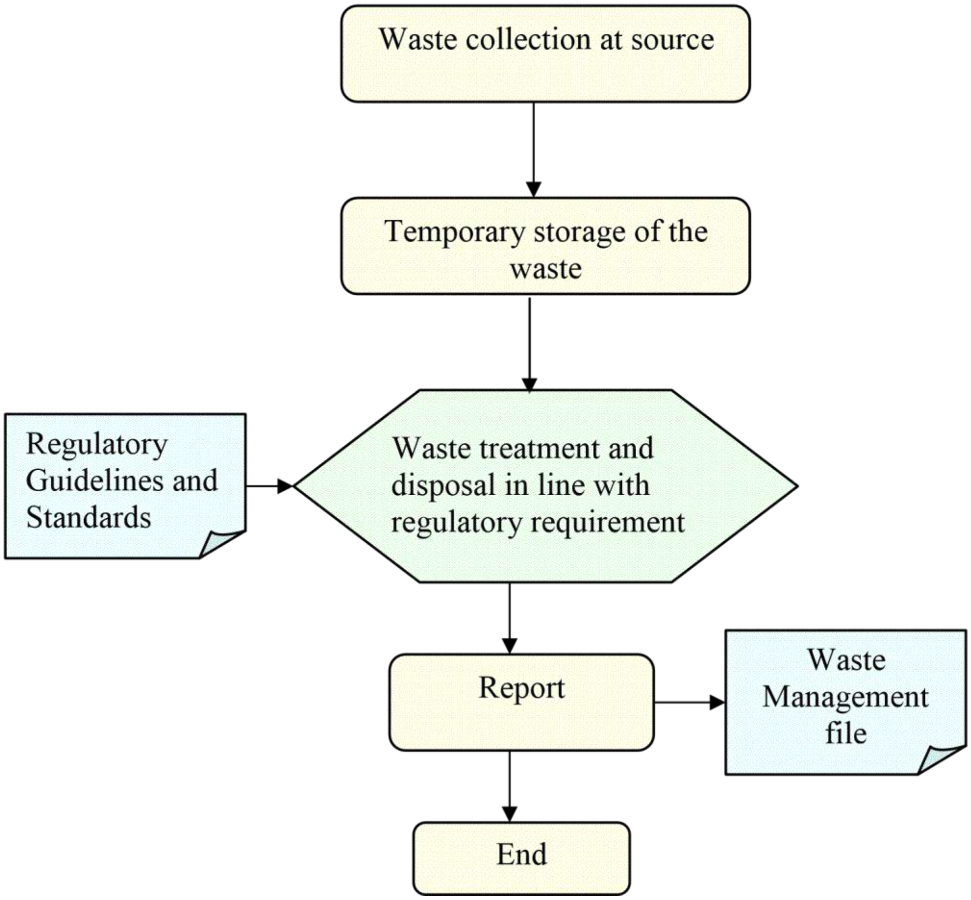
1. **Health Centre Staff**
   - Ensure designated bins are available at strategic locations
   - Isolate soiled dressing at source and collect in appropriate bins
2. **Cleaners, HSE Cleanup Crew, HSE Coordinator**
   - Collect waste from various points and store in central (sealable) bin
3. **HSE Coordinator**
   - Request/get approval to evacuate/dispose waste by incineration at SPDC facility in Warri
   - Ensure proper documentation
4. **HSE Coordinator, HSE Manager**
   - Produce final report
   - Recommend/communicate improvement strategies
5. **HSE Coordinator**
   - Archive all documents

P.15 MANAGEMENT OF EXPIRED DRUGS AND MEDICAL SUPPLIES



1. **Health Coordinators, HSE Coordinator,**
   - Identify/inform HSE Coordinator of expired drugs
2. **Health Coordinators, HSE Coordinator**
   - Isolate expired drugs and tag with appropriate indicative labels
   - Collect waste from various points and store in specialised bin
3. **HSE Coordinator**
   - Request/get approval to return expired drugs and medical supplies to the supplier.
   - Ensure proper documentation
4. **HSE Coordinator,**
   - Produce final report
   - Recommend/communicate improvement strategies
5. **HSE Coordinator** •
   Archive all documents

P.16 MANAGEMENT OF OFFICE WASTE

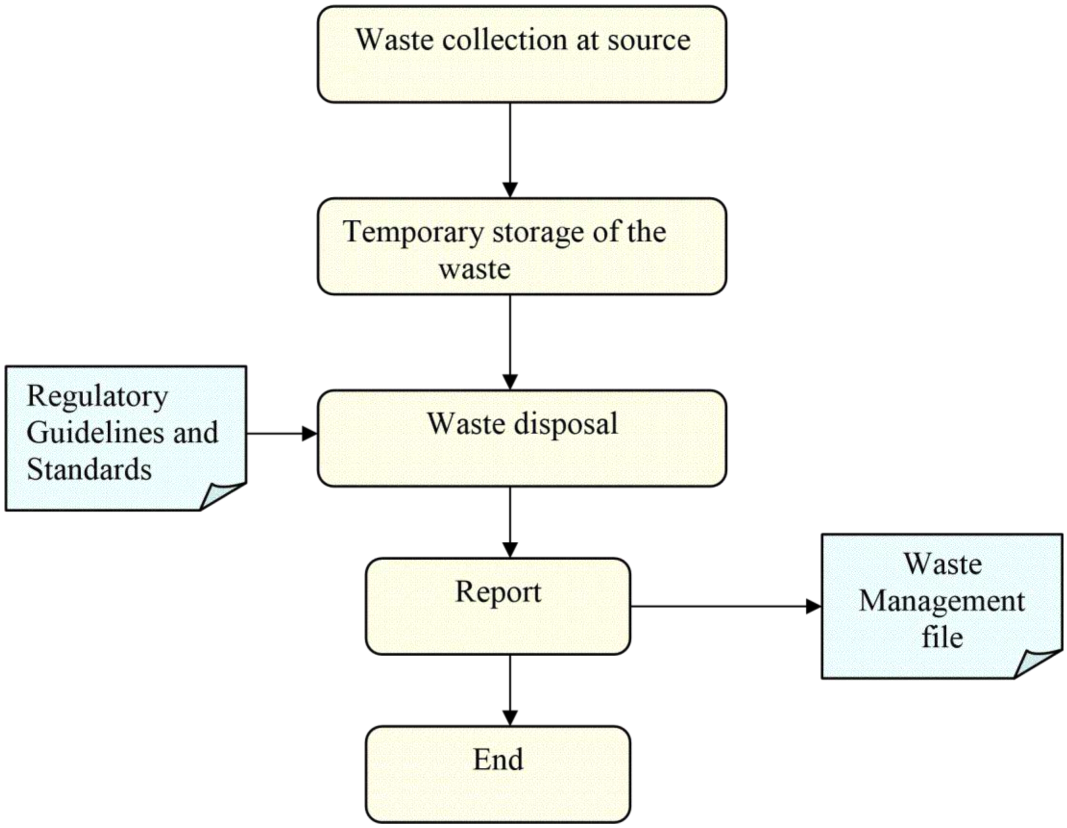


1. **All Staff i.e. Office Occupier**
   - Ensure waste baskets/bins are available in office
   - Ensure all office waste are isolated and collected in appropriate baskets/bins
2. **Building Operator**
   - Collect waste from various points and store in central (designated and sealable) bins
3. **Building Operator, HSE Coordinator**
   - Select treatment option and request/approval to evacuate, treat and dispose waste by: a) Resale
     b) Reuse/recycle
     c) Reclaim
   - Ensure waste consignment notes are issued/signed as appropriate

3. **HSE Coordinator,**
   Produce final report
   - Recommend/communicate improvement strategies

5. **HSE Coordinator**
   - Archive all documents

P.17 MANAGEMENT OF REFUSE AND GARDEN WASTES



1. Cleaners, Gardeners

- Collect waste at source and take to SPDC waste treatment facility in Warri

2. Cleaners, Gardeners, Maintenance Supervisor

- Ensure wastes are stored in designated facility

3. Maintenance Supervisor

- Request/get approval to evacuate and dispose of waste
- Invite waste contractor to evacuate/dispose waste in line with Environmental Regulations
- Ensure waste consignment notes are issued/signed as appropriate

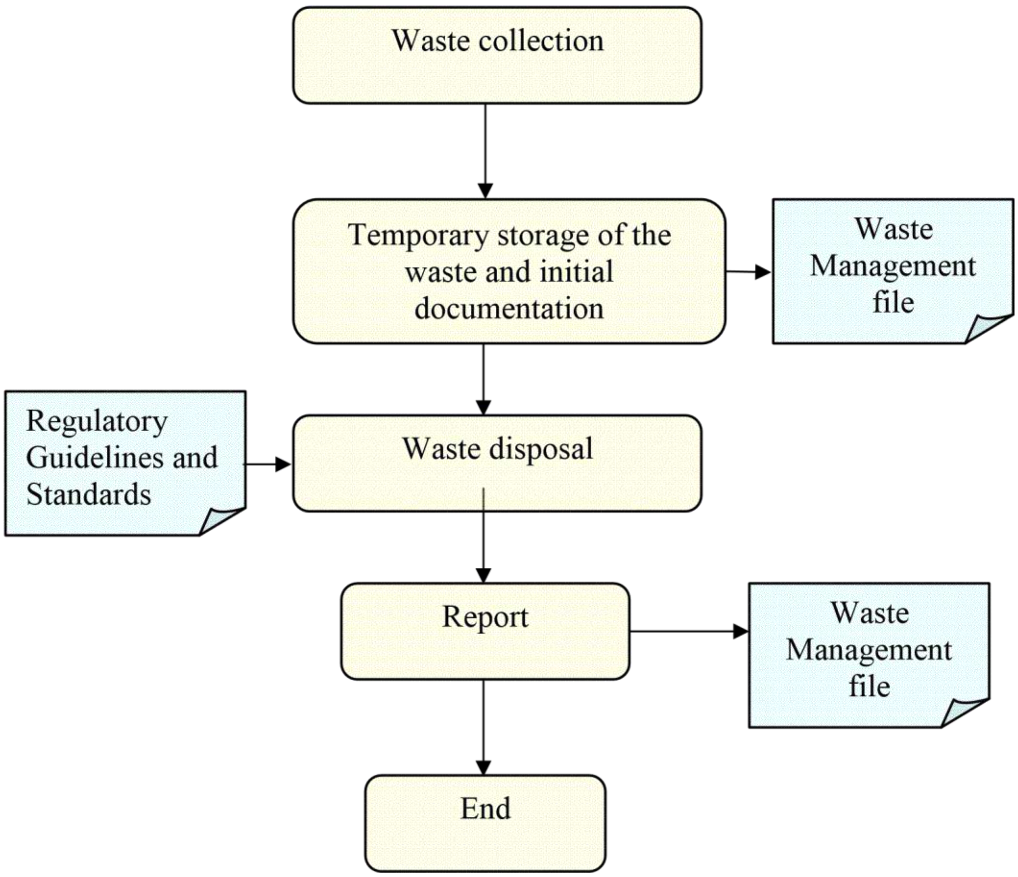
4. HSE Coordinator,

- Produce final report
- Recommend/communicate improvement strategies

5. HSE Coordinator

- Archive all documents

P.18 MANAGEMENT OF SPENT LUBRICATION OILS



1. Maintenance Personnel

- Collect waste and store waste in designated (sealable) containers

2. Maintenance Personnel, HSE Coordinator

- Ensure wastes are stored in designated facility (API separator or process facility)
- Ensure waste is treated as highly flammable (stored in-line with safety requirements)
- Document volume, source, nature etc. of lube oil

3. HSE Coordinator

- Request/get approval to evacuate and dispose of waste
- Invite waste contractor to evacuate/dispose of waste in line with Environmental Regulations
- Ensure waste consignment notes are issued/signed as appropriate

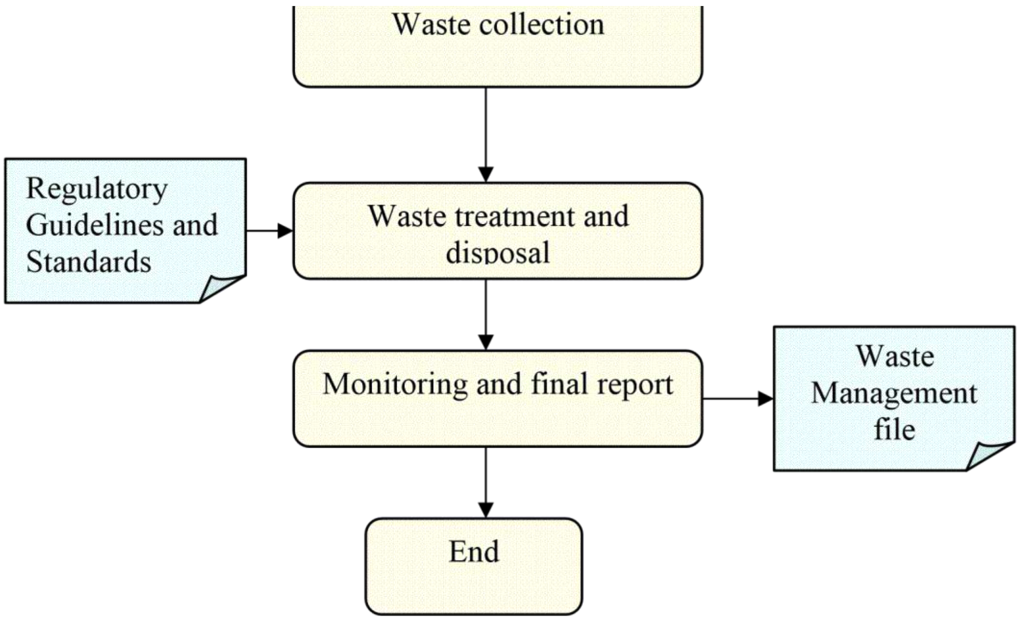
4. HSE Coordinator,

- Produce final report
- Recommend/communicate improvement strategies

5. HSE Coordinator

- Archive all documents

P.19 MANAGEMENT OF CRUDE OIL TESTING LABORATORY WASTES



1. Laboratory Personnel

- Discharge into designated drainage facilities

2. Maintenance Personnel, HSE Coordinator

- Ensure wastes are treated at designated facilities in-line with regulatory requirements

3. HSE Coordinator, HSE Manager

- Monitor discharge of treated effluent stream
- Produce monitoring report
- Recommend/communicate improvement strategies
- Submit monitoring report to appropriate regulatory authorities

4. HSE Coordinator

- Archive all documents

PROCEDURE FOR COMPLETING WASTE CONSIGNMENT NOTE (WCN)

Section 1	This shall be completed in full by the originator of the waste.
Section 2	The captain/Driver of the waste evacuation Vessel/Vehicle shall complete this section at commencement of loading with the last entry (Time completed) being made once the loading is completed
Section 3	The waste supervisor at the base, acting as intermediate receiver, shall complete this section on receipt of waste at the base, with the finish time entry being completed once evacuation of waste from the base has been completed by the contractor.
Section 4	The waste contractor shall complete this section upon evacuation of the wastes from the base/location and completion of housekeeping at the temporary waste storage area.
Section 5	This shall be completed in full by the waste originator. Extra rows are provided to respectively capture waste types that are not listed.
Section 6	The waste contractor shall complete this section upon disposal of the waste, indicating the disposal sites or strategy e.g. (sell of paper, plastics etc to merchants)

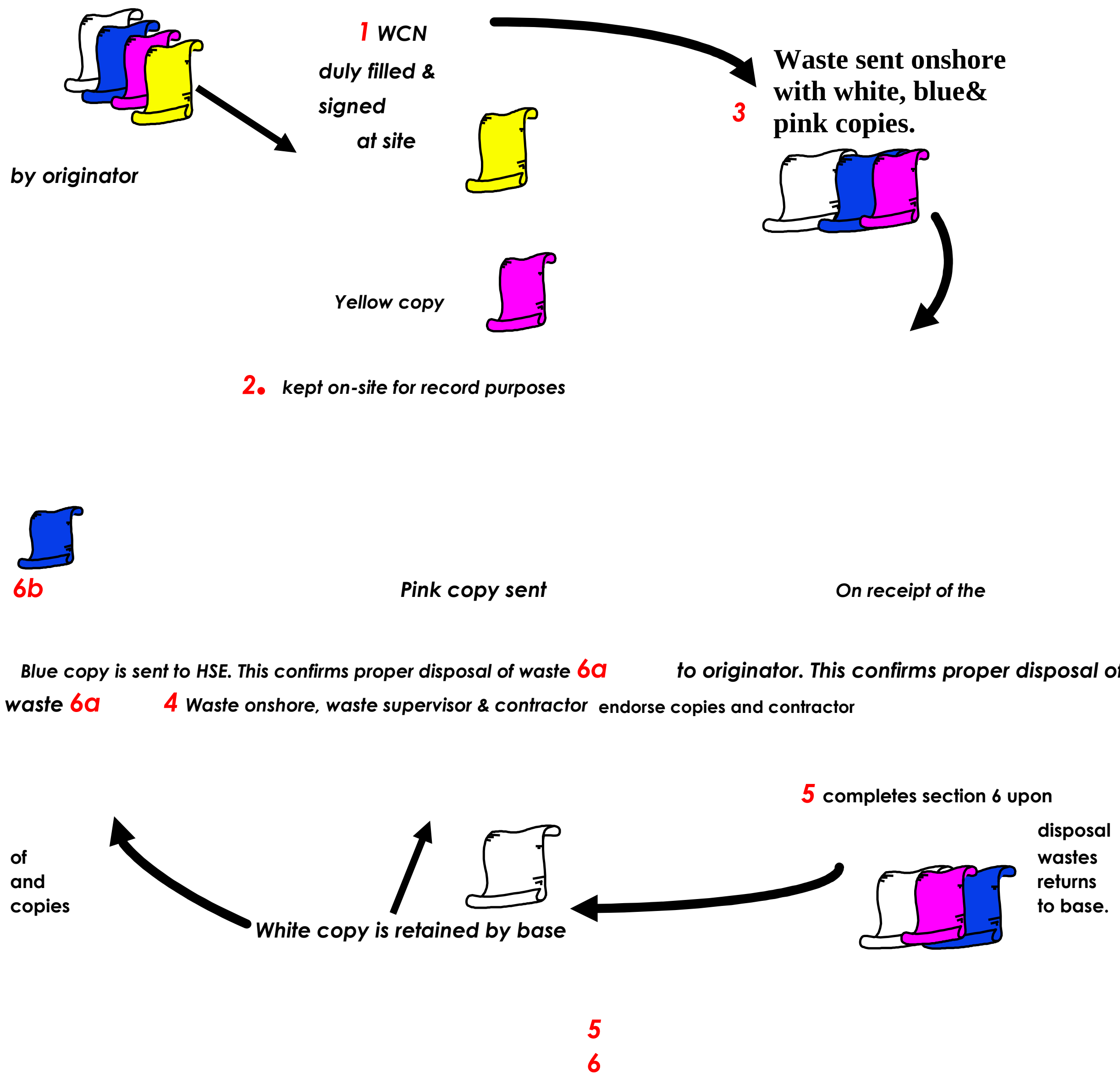
On completion of the disposal, the copies of the completed form are distributed as follows:

White copy (original)	-	Waste Contractor
*Blue copy	-	HSE
*Pink copy	-	Originator (Company rep.)
Yellow Copy	-	Kept on site for record purpose

* Sent after endorsement (signature) by waste contractor.

Appendix 1.

Guidance on WCN distribution for_is presented below.



Appendix 2

WASTE CONSIGNMENT NOTE

1.	**ORIGINATOR**	
1.1.	Name:	
1.2	Company/Dept:	
1.3	Signature:	
1.4	Loading Point:	
1.5	Date:	
1.6	Time:	
2.	*TRANSPORTER*	
2.1	Name:	
2.2	Company/Dept	
2.3	Signature:	
2.4	Vehicle No/Vessel Name	
2.5	Date:	
2.6	Time Started	
2.7	Time Completed	
3.	**WASTE SUPERVISOR** (CBQ Base, Onne Base only)	
3.1	Name:	
3.2	Company/Dept	
3.3	Signature:	
3.4	Tel No.:	
4.	**WASTE CONTRACTOR**	
4.1	Name:	
4.2	Company:	
4.3	Signature:	
4.4	Date:	
4.5	Time:	

** After signature by waste contractor, BLUE and PINK copies to be returned to Originator and HSE Dept. YELLOW copy kept on site for record purpose.

5.	**WASTE TYPES & AMOUNTS**		
5.1	*DOMESTIC WASTE*	Truckload	Tonnes
5.1.1	Food Waste		
5.1.2	Garden Refuse		
5.1.3	Glass Waste		
5.1.4	Paper Waste		
5.1.5	Plastic Waste		
5.1.6	Unsegregated Waste		
5.1.7	Other Domestic Waste		
5.2	**INDUSTRIAL WASTE**	TONNES	
5.2.1	Toner/Cartridges		
5.2.2	Dry-type Batteries		
5.2.3	Wet Type Batteries		
5.2.4	Scrap Metal		
5.2.5	Glass Waste		
5.2.6	Paper Waste		
5.2.7	Spent Lube Oil		
5.2.8	Drill cuttings		

6.	**DISPOSAL/RECYCLING SITE**
	Dumpsite/Composting
	Glassware Merchant.
	Paper Merchant
	Plastic Merchant
	Dumpsite
	Incinerator/Dumpsite
	Incinerator
	Dumpsite
	Battery Merchant
	Scrap Yard (Base W/Hours)
	Glassware Merchant
	Paper Merchant
	Recycle at Flowstation

NOTE: DISTRIBUTION OF COPIES			
Original Copy WHITE	1st Copy BLUE	2nd Copy PINK	3rd Copy YELLOW
WASTE CONTRACTOR	HSE	ORIGINATOR	Kept on site for records

Remarks

Appendix 3.

WASTE STREAMS AND COLOUR CODES

WASTE STREAM	COLOUR CODES
Waste Paper	WHITE
Metals	BLUE
Garden/Food Waste	BLACK
Aerosol cans & filters	RED
Glass	GREEN
Fluorescent Tubes and Bulbs	PURPLE
Plastics (including water containers)	YELLOW
Spent batteries	GREY
Contaminated waste (Oily rags, Absorbent pads and chemical contaminated waste)	BROWN
Medical waste	PINK

Appendix 3.2-Pillar Oil OSCP

Oil Spill Contingency Plan

January, 2018

PILLAR OIL

OIL SPILL CONTINGENCY PLAN

FOR

UMUSETI/IGBUKU MARGINAL OIL FIELD

JANUARY, 2018 (REV 05)

This document was prepared as contingency planning for
The prevention, control and combating of oil and hazardous substances spill in
Umuseti/Ugbuku Oil Field in accordance with ***PART VIII Article B of Environmental***
Guidelines and Standards for the Petroleum Industry in Nigeria
(EGASPIN) 2002, *of Department of Petroleum Resources (DPR).*

	NAME	DESIGNATION	SIGN. & DATE
Prepared by	ADUNN ETCHIE	Head, HSE	
Reviewed by	BABATUNDE M. OLAYINKA	Manager, Field Operations	
Endorsed by	OLUSEYE FADAHUNSI	Executive Director	
Approved by	SPENCER ONOSODE	Managing Director	

REVISION HISTORY

The following is a brief summary of revisions of this document first published in 2013. Details of all revisions are held on file by the issuing Health, Safety and Environment (HSE) department. On an annual basis, this plan shall be reviewed and activated.

Revision No.	Date	Author	Scope / Remarks
0	May 2014	AGBANI AKHAZE	First Draft Copy
01	May /June 2015	ADUNN ETCHIE	Reformatted, reviewed and updated. Please refer to addendum 1 for details
02	June, 2016	ADUNN ETCHIE	Reviewed and updated
03	March, 2017	ADUNN ETCHIE	Updated telephone numbers
04	June, 2017	ADUNN ETCHIE	Reviewed and updated
05	January, 2018	ADUNN ETCHIE	Revised to address DPR comments

AUTHORISATION

This 2018 edition of Pillar Oil Limited Oil Spill Contingency Plan has been prepared in line with Pillar Oil Limited corporate policy and statutory requirements. It is hereby formally approved for circulation and use.

Sign.

Manging Director,
SPENCER ONOSODE

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7	Pillar Oil Limited	Production Supervisors	1
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12	Department of Petroleum Resources	Director, Lagos	1
13	Department of Petroleum Resources	Delta State office	1
14	Federal Ministry of Environment	Hon. Minister of Environment	1
15	Federal Ministry of Environment	Delta State Controller	1
16	Delta State Environmental Protection Agency	Hon. Commissioner	1
17	National Oil Spill Detection and Response Agency	Director	1
18	Clean Nigeria Associates (CNA)	Delta State office	1
19	Oil Producers Trade Section - MAP	Lagos	1
20	Oil Spill Response Limited (OSRL)	West and Central Africa (WACAF) Regional office	1

Contents

EMERGENCY OPERATION CENTRE
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SECTION I

INTRODUCTION

1.1 Background Information

The Pillar Oil Limited (POL) *Oil Spill Contingency Plan (OSCP)* is prepared to provide an organised and predetermined course of actions to be pursued in the event of a spill in Umuseti/Ugbuku field. Prepared in accordance with *PART VIII B of Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) 2002,* the OSCP addressed areas of the operation where secondary containment is impracticable to counter oil spill.

The aim of this Oil Spill Contingency Plan is to define procedures and tactics for responding to discharges of oil into land and waters or adjoining facilities and communities. It describes the distribution of responsibilities and basic procedures for responding to an oil discharge and performing cleanup operations.

1.2 Purpose

The central objective of all countermeasures operations will be to minimize threat to human safety, terrestrial and marine ecosystems inter alia fisheries, ecologically sensitive zones, communities, inland water courses, groundwater reservoirs as well as other economically relevant features such as Pilar Oil facilities and other neighbouring amenities at risk.

The purpose of this plan is to establish an orderly procedure for timely response, oil containment and risk recovery from spill incident. The OSCP basically has the following objectives which are to:

- ensure oil spill incidents are proactively planed for in order to curb them and minimise their associated environmental, social and fiscal impacts
- ensure that environmental and property protection strategy is incorporated into the company's overall Emergency Response Plan

- ensure that manpower, equipment and funds are available to effectively contain and recover from oil spill incident
- ensure that good record-keeping is maintained and accurate information concerning an oil spill is disseminated to the public and government, and
- assures recovery from any loss and ensure business continuity

1.3 Scope of the Contingency Plan

This plan covers response to spill in Pillar Oil Limited's operational area located onshore within the Umuseti/Igbuku Field, OPL 283 (Ex-OML 56) and 7km delivery pipeline to the Umusadege Gas Gathering Facility (GGF) in the Ndokwa West & Ndokwa East Local Government Areas of Delta State. The Contingency Plan is prepared for Tier 1, 2 and 3 response levels.

1.4 Risk Assessment and Tiered Response System

The tiered response system is a risk assessment tool designed to assist the POL Incident Command System (ICS) to evaluate incidents that are beyond its own capability and thereby utilise the principle of mutual assistance. A tier level response model as generally used for oil spill is adopted for all assessed risks of POL operations. Tiers 1, 2 and 3 oil spill response capacity will be defined in terms of type of spill based on a risk assessment conducted. The risk is assessed based on size and area extent (as illustrated in ***Figure 1.1*** below).

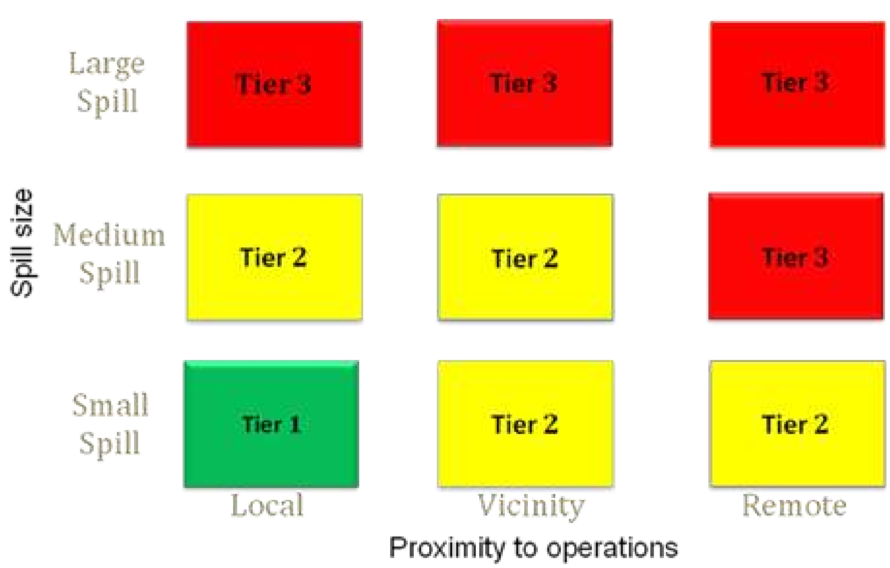


Figure 1.1: Risk-Based Corrective Action (RBCA) using a tiered approach to risk assessment (Source: International Petroleum Industry Environmental Conservation Association, IPIECA)

The principle of Tier or Level Response is based on volume of spill and corresponding response resources as described by DPR in *Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2002).*

- ***Tier 1:***

Operational type spills of volume between **0 – 25 barrels to inland waters** OR **0 – 250 barrels to land or coastal/ offshore waters** that may occur at or near a company's own facilities, as a consequence of its own activities. An individual company would typically and under *International Convention on Oil Pollution Prevention, Response and Cooperation (OPRC), 1990* be required to provide resources to response to this size of spill.

- ***Tier 2:***

A larger spill of volume **25 - 250 barrels to inland waters** OR **250 – 2500 barrels to land or coastal/ offshore waters** in the vicinity of a company's facilities. Resources from another company and possible government response agencies in the area can be called in on a mutual aid basis. The company will participate in local cooperative where each member pools their Tier 1 resources and has access to any equipment which has been jointly purchased by the cooperative such as Clean Nigeria Associates (CNA) or Oil Producers Trade Section (OPTS).

- ***Tier 3:***

This is a major spill, **greater than 250 barrels to inland waters** OR **above 2500 barrels to land or coastal/ offshore waters** where substantial further resources will be required and support from a national (Tier 3) or international co-operative stock pile, like the West and Central African (WACAF) Region Oil Spill Response Limited (OSRL) may be necessary. It is likely that such operation would be subject to government controls or even direction. It is important to recognize that a spill which could receive a Tier 3 response may be close to, or remote from, company facilities. The basis of operator plans for handling Tier 3 spills shall be based on the Worst Case Scenario.

1.5 Policy, Legal and Administrative Framework

1.5.1 Federal Laws

The mandatory regulatory requirements for the preparation and implementation of Oil Spill Contingency Plan (OSCP) and related emergency plan are provided in Nigerian Petroleum Laws, Guidelines and Standards which include:

i. Section 17 (3) and 31 (c) of the Oil Pipeline Ordinance Cap 145 of 1956 as amended by the Oil Pipelines Act, 1965;
ii. Section 101 of the Petroleum Regulations Cap 150 of 1967;
iii. Oil in Navigable Waters Act 1968;
iv. Sections 8 (1) b (ii) of the Petroleum Act 1969;
v. Petroleum (Drilling and Production) Regulation 1969
vi. Petroleum (Drilling and Production) Regulation 1973
vii. Section 20, 21 and 23 of the Federal Environmental Protection Agency Decree 1988;
viii. Mineral Oils (Safety) Regulations 1997
ix. Part VIIIB of the Environmental Guidelines and Standards for the Petroleum Industry in Nigeria 2002 (DPR);
x. Part III, Chapter 2, of the National Interim Guidelines and standards for Industrial Effluents, Gaseous Emissions and Hazardous Wastes Management in Nigeria (FEPA).

Other contingency arrangements for the higher level response include:

i. The Clean Nigeria Associates (CNA), which was formed in October, 1981, by oil and gas operating companies in Nigeria to "establish and maintain capacity to combat spills of liquid hydrocarbons or pollution in general, in addition to any capability maintained by any individual member";
ii. The National Oil Spill Contingency Plan and National Oil Spill Detection and Response Agency, which are still in their formative stages;
iii. Further assistance may be required overseas from Oil Spill Response Limited (OSRL) established in Southampton-UK in 1985; which has its West and Central African (WACAF) operational base in Accra Ghana. This may be required in worst case spill scenario.
iv. National Oil Spill Contingency Plan, 2010 Revision

1.5.2 International Conventions

Nigeria is a signatory to the following international laws since joining the International Maritime Organization in 1980.

a) Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal.
b) London Convention 1972, Convention on the Prevention of Marine Pollution by Dumping of Waste and other Matter, 1972, as amended.
c) International Convention on Oil Pollution Prevention, Response and Cooperation (OPRC) 1990.

1.6 Description of the Facility and Operations Covered by the OSCP

1.6.1 Pillar Oil Limited Safety and Environment Statement

''It is the philosophy, policy and goal of Pillar Oil Limited to conduct its activities in accordance with industry best practice and regulatory standards for the safety of its staff, contractors, communities, third parties and the environment in which operations are carried out.

Pillar Oil is fully committed to prevention of industrial accidents and our resources shall be deployed to loss control and mitigation efforts, in case of an undesired accidental occurrence.

All Pillar Oil staff and her contractors shall work in line with this policy. An employee must suspend any job if it undermines, in any way, this central philosophy of the company and must report such to his/her immediate supervisor without delay''.

1.6.2 Process and Export Facilities

POL exploration and production activities are located onshore within Umuseti/Igbuku Field, OPL 283 (Ex-OML 56) in the Ndokwa West & Ndokwa East Local Government Areas of Delta State ***(Figure 1.2).*** The currently operational well at Umuseti-4 & Umuseti-6 location are located in Kwale, Delta State. Umuseti-4 is hooked up through 2 x 4inch flow lines to the Umuseti 3 Production Facility and the processed crude oil produced is transported via a 7km x 6inch delivery pipeline to the Umusadege Group Gathering Facility (GGF) located within the Midwestern Oil and Gas Company Plc location and from where it is then exported, in combination with other GGF cluster members crude oil production, through the Nigerian Agip Oil Company's ("NAOC's") Ob-Ob manifold/pumping station via Okpai/Kwale Flowstation and finally to the Brass Terminal in Bayelsa State.

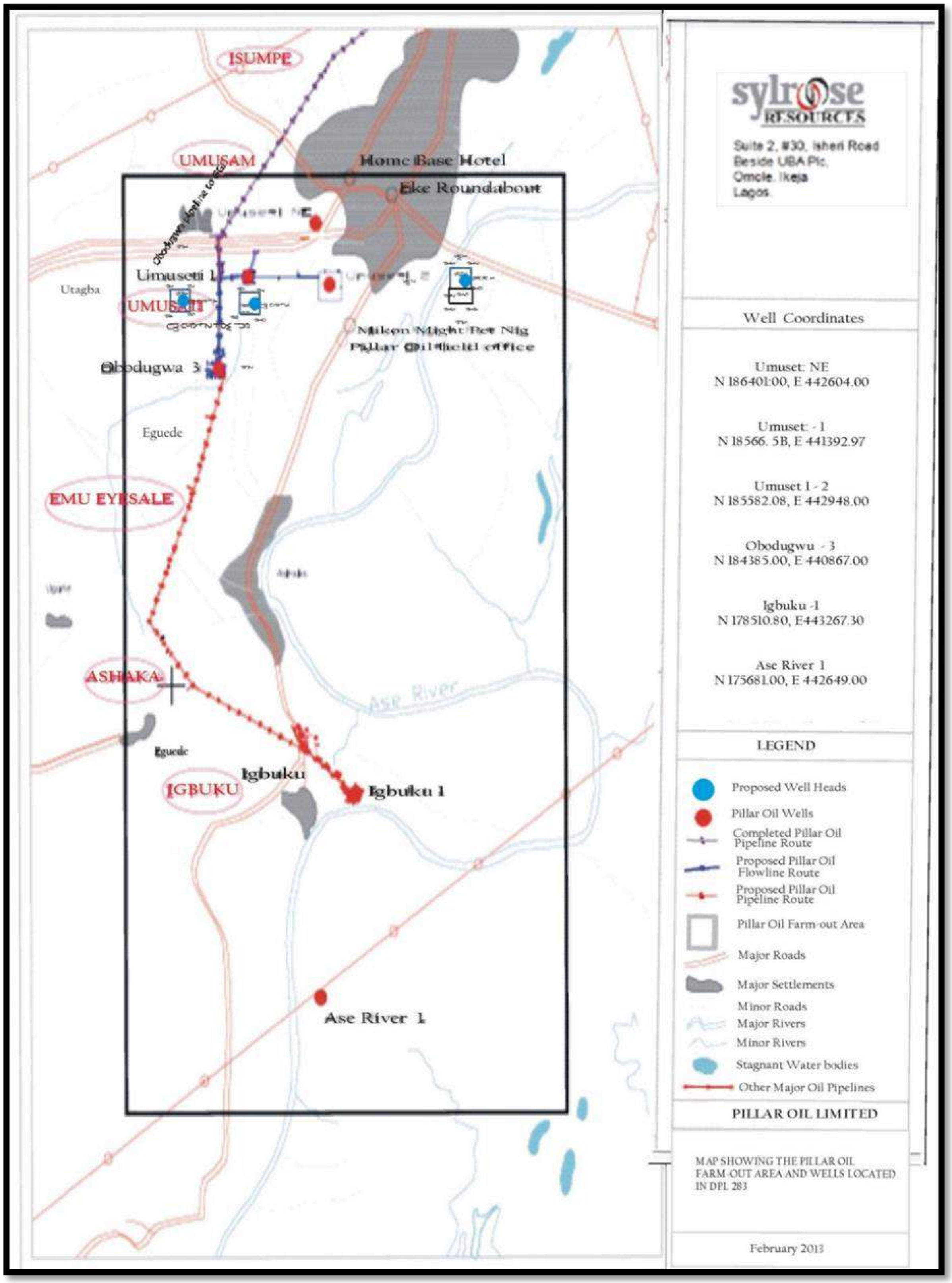


Figure 1.2: Umuseti/Ugbuku Field

The physical and social description of the environment is shown in ***Table 1.1*** below.

Table 1.1: Pillar Oil facilities

S/No	Facility	Description of the Environment
I	Umuseti – well 4 & 5, Umuseti – well 6 & Umuseti production facility	Located onshore and within a community. Umuseti-4 & 5 are nearer to communities while the EPF is located more than 3kms away from the host community. Farm land typically plantain, guava, palm trees farm with shrubs are in the immediate vicinity.
II	7km oil delivery pipeline	Oil delivery pipeline passes through four (4) host communities to arrive at the GGF.
II	LACT unit	Pillar Oil's LACT unit is located onshore at Midwestern Oil and Gas Company (MWO&G) station. It is less than 1.5km away from communities. Within its immediate surroundings are MWO&G facilities.

1.6.3 Operating Principles

It is noteworthy to recall that the design and construction of Pillar Oil Limited (POL) facilities incorporated standard safety mechanism, which reduces opportunities for failure induced spills. In addition, adequate controls have been built into the design for fail safe operations with sufficient devices to control and contain hydrocarbon release to the environment. Relief valves are provided on pressure vessels and piping system to protect equipment from catastrophic mechanical failure. Fusible plugs and instrument loops exist to shut down production in the event of fire. Pressure control, safety and shut down valves exist to protect facilities against over-pressure.

The pipelines have adequate corrosion allowance built into them in addition to cathodic protection system. In addition, routine turnaround maintenance and monitoring practice are also enshrined in the management system practice. However, potential spill scenarios are address below.

1.6.4 Identified Spill Sources

1.6.4.1 Major Spill Sources

Identified spill sources are shown in ***Table 1.2*** below.

Table 1.2: Spill Scenarios

S/N	Incident Scenario	Source	Areal Extent	Existing Control	Likelihood Of Occurrence	Consequence	Impact Significance
1	Blowout	Drilling and workover	Process facility, Communities	Use of blowout preventer and operational excellence	Low	Fire, fatality, injury, economic damage, damage to aquatic lives, and ecological disruption	High
2	Failure of storage tanks	Storage tanks	Within the field	Use of secondary containment/bund walls	Low	Fire, land pollution, surface water pollution	High
3	Pipeline rupture/ sabotage	Delivery and facility pipeline network	Within the field and communities	Surveillance of pipeline Right of Ways (RoW) to prevent acts of vandalism, Inspection and integrity check of the pipelines	Low	Fire, land, pollution, surface water pollution	High

1.6.4.2 Minor Spill Sources

Minor spill sources include eequipment leakage or failure. The entire principal product is located at Umuseti-6 / Umuseti-5 / Umuseti-4 well / Umuseti-3 Production facility and these are constantly manned. Hence, conditions are under regular monitoring and surveillance. In the event of any leakage or failure of any equipment, immediate shutdown and isolation will take effect to minimize the quantity of oil spill. See ***Table 1.3***.

Table 1.3: Potential source of minor spill

S/No	Potential Source of Spill	Likely Causes	Probable Estimate
1.	Wellhead	Valve leakage	Fire, damage to properties, personnel, environmental pollution, etc.
2.	Flow line/delivery pipeline	Leakage due to corrosion	Fire, oil spill, damage to environment, etc.
3.	Production Facility	Valve leakage, piping failure, process vessels failure, overflow, etc.	Fire, oil spill, damage to the environment, etc.
4	Crude Oil Storage Tanks	Tank shell/foundation collapse, bund wall damage	Fire, oil spill, damage to the environment, etc.

1.7 Description of the Environments

The baseline environmental characteristics of the area is necessary for emergency preparedness and response. The baseline description as presented here, was adapted from *Environmental Evaluation Study (EES) Based Environmental Impact Assessment (EIA) for Umuseti/ Igbuku Field Further Development (2013).*

1.7.1 Soil

The particle size analysis (expressed as fractions of sand, silt and clay) showed that sand sized particles dominate the soils of the study area (average values of 84.1% - 93.6%) followed by clay (4.5% - 8.6%) and silt (1.9% - 7.3%), making them mostly Sand/Loamy Sand (Textural graph by Holme and Mcinx, 1972). Sand of this characteristics easily allows percolation of oil contaminants which can in turn affects the shallow groundwater aquifer of the area. The pH values of top and sub soil samples collected from the study area in the dry season ranged respectively from 3.44 to 5.99 (average value of 5.04) and 3.66 to 5.67 (average value of 4.31) while that of the wet season ranged from 4.92 to 6.94 (average value of 5.82) and 4.73 to 6.52.

1.7.2 Hydrogeology and Hydrology

In addition to smaller surface water bodies, Ase River is in the area and located about 10km from the field. The entire area is characterized by relatively high water table of about 23.2m. The groundwater flow direction is southerly. The aquifer recharge depends on the rivers and streams in the area. Information obtained from existing boreholes sunk within the project site indicates depths ranging from 100ft to 120ft. Loggings of the Boreholes show that the formation underneath the project area is made up of fine – coarse sand. Sand dominated geologic formation of the area constituting over 90% of the total composition of the drill cuttings and the static water levels (SWL) of the boreholes within this area ranged from 30 – 40ft. Groundwater flow direction in the area is from the North-West to the South-East which conforms to the regional groundwater flow direction in the Niger Delta Basin.

1.7.3 Vegetation

The vegetation of the area covered under the OSCP is dominated by heavy shrubs and a few tree species in Umuseti. Similarly, the ecotype in Benecu community is dominated by tall shrubs and stratified tree structures comprising the Phanerophytes (woody plants) which include: Megaphanerophytes (Mgp) (trees over 30m high) (Terminalia superba, Khaya grandifoliola, Khaya ivorensis, Cleistopholis patens, Milicia excelsa, and Antiaris africana), Mesophanerophytes (Mep) (Trees from 8 – 300m high), Microphanerophytes (Mip) (Trees and shrubs 2 – 8m high) and Nanophanerophytes (Nanop) (Shrubs under 2m high). Other physiological groups of plant species include Epiphytes, Chamaephytes, Hemicrytophytes, Cryptophytes and Therophytes. This subsection discusses the vegetation ecotypes, floristic composition, forest resource usage, plant phytochemistry and pathology etc. of the Umuseti and Beneku communities.

1.7.4 Wildlife and Endangered Species

Four (4) species of primates have been reported in the area and include: Mona monkey, Pata monkey, White-nose monkey and Dwarf Galago. Non-game wildlife species such as Giant forest-Squirrel, Gambian giant-rat, Cane rat, Striped mouse, Brush - tailed porcupine etc. The wildlife species of the study area have been well documented (Ita 1984; Happold, 1987; Anadu and Green 1990; Powell 1993, 1995, 1997; Akani et al. 1999, 2004, 2008). The data shows that a total of 93 vertebrate wildlife species are presently resident in the area and its environs. This comprises: 36 mammalian, species; 36 avian species; and 21 reptilian species.

1.8 Oil Spill Trajectory Modelling

1.8.1 Umuseti/Ugbuku Field Oil Characteristics and Movement

Crude oil is generally a complex mixture of hydrocarbons of varying molecular weights and structure comprising three main chemical groups: paraffinic, naphthenic and aromatic. These hydrocarbons range from blend simple, highly volatile substances to complex waxes and asphaltic compounds, which cannot be distilled. Oils of many differing characteristics are produced from the field; however, they can best be described by the samples from the Gas Gathering System which can be taken as representative of crudest oil produced from the field. Thus, the properties of the oil are described below:

Composition of Zero Flashed Stock Tank Oil by Chromatography (Chromatogram)

(Sample In RFL Cylinder No. PH-023)

(Finger Print Umuseti 5 Resr 9060ft)

Component Carbon #	**Weight % of Total**	**Cumulative Weight %**	**Boiling Point (°F @ 1 Atm.)**
C6-	5.52	5.52	156
C7	3.64	9.16	209
C8	4.35	13.51	258
C9	4.20	17.71	303
C10	3.87	21.58	345
C11	4.54	26.12	385
C12	5.05	31.17	421
C13	6.01	37.18	456
C14	6.26	43.44	488
C15	5.21	48.65	519
C16	4.05	52.70	549
C17	3.94	56.64	576
C18	3.54	60.18	602
C19	3.53	63.71	627
C20	3.34	67.05	651
C21	3.28	70.33	674
C22	3.21	73.54	696
C23	3.22	76.76	716
C24	3.16	79.92	736
C25	3.08	83.00	755
C26	2.94	85.94	774

C27	2.67	88.61	792
C28	2.37	90.98	809
C29	1.98	92.96	825
C30+	7.04	100.00	>841

API Gravity of sample at 60^{o}F = 39.1

Specific Gravity at 60^{o}F = 0.8294

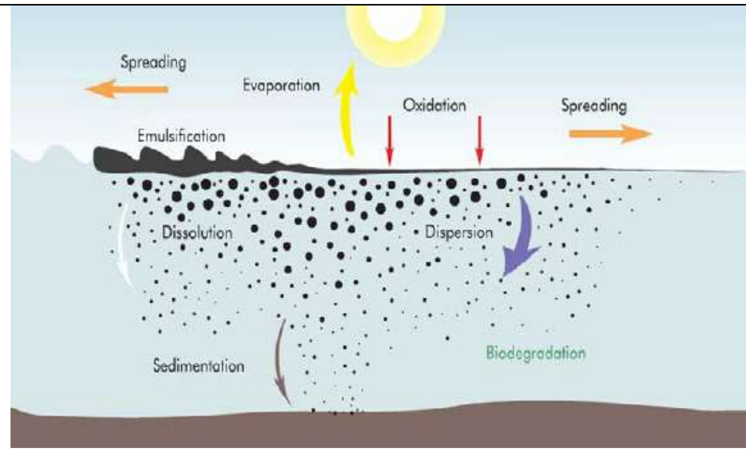
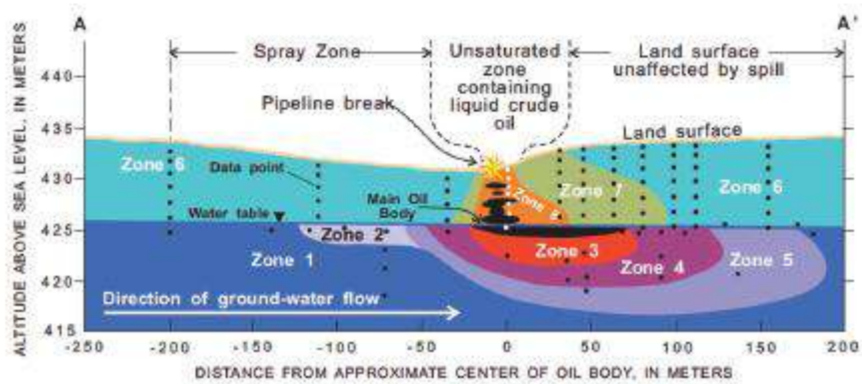
**Drilling mud contaminant represents approximately 6.90 % (or 9.10% of stock tank oil) by weight of total well stream*

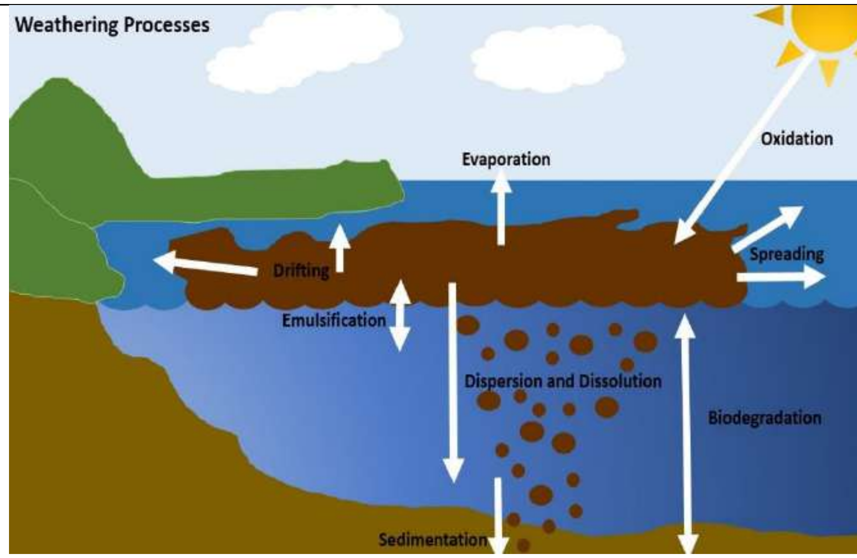
1.8.2 Fate of Oil Spill

The OSCP contains current oil spill trajectory modelling that applies to the POL's activity or events covered under the OSCP. It is understood that a spill may impact the environment and this is critical to ensure adequate response techniques are planned and implemented at the time of an incident.

The OSCP also include information that best represents the zone of potential impact and subsequent fate of a spill for all credible scenarios (including worst case) ***(Table 1.4).*** This representation demonstrates an understanding of the soil/sand type including soil infiltration rates, topography, and any other information that may influence the fate of a spill. This was used in determining the environment that may be affected, and therefore protection priorities and the most appropriate response actions. Response times for clean-up and removal can then be considered in order to minimise the potential environmental impacts. For example, the water table of the area is at a shallow depth and the soil has a high infiltration rate, the urgency to remove any surface spill of petroleum products will be greater than that in areas with a deep groundwater table and low infiltration rates.

Table 1.4: Fate of spilled oil

Oil fate and behaviour	Weathering	 *Weathering Processes acting on Spilled Oil (Source: International Tanker Owners Pollution Federation (ITOPF) Limited, 2002)*
	Drifting	Physical movement of surface oil from one location to another due to the combined effects of 100% current speed and direction and 3% wind speed and direction. Spill oil can move several km from high land to low land even to the surface water bodies beyond the Ase River into the Ethiope River and the Atlantic Ocean
	Spreading	Increase in the length and breadth of the oil slick as it spreads and thins on the land and water surfaces. 
	Evaporation	Evaporation of lighter hydrocarbons from the oil to the atmosphere. 25% of oil spilled evaporates *(British Petroleum, BP)*

		
	Oxidation	Oxidation is promoted by sunlight and may lead to the formation of soluble products or persistent tars. Its overall effect on dissipation is minor.
	Emulsification	Formation of water in oil emulsions, resulting in an increase in oil viscosity. Oils with a high asphaltene content are more likely to form stable emulsions.
	Dispersion	The formation of oil droplets due to breaking waves, resulting in transport of oil from the sea surface into the water column.
	Dissolution	Physical-chemical process resulting in oil from the oil slick or from suspended oil droplets dissolving into the water column.
	Sedimentation	Increase in density of oil due to weathering and interaction with suspended sediments or biological material. Tar balls may be formed, which could be deposited on the seabed.
	Biodegradation	Biological-chemical process altering or transforming hydrocarbons through the action of microbes and/or the ingestion by plankton and other organisms.
	Shoreline Stranding	Impact of oil on the shoreline where it may strand on the surface, or become buried in layers, or may re-float and move elsewhere. The rate of weathering of stranded oil depends on several factors, in particular the amount of exposure to waves.

1.9 Environmental Sensitivity Index (ESI) of the Area

The OSCP incorporating Environmental Sensitivity Index (ESI) is essential to the upstream sector operation in the nation's oil and gas industry/activities. However, environmental sensitivity of the area under this OSCP was identified based on literature review and expert experience.

1.9.1 Resources at risk

In worst case oil spill scenario, likely communities that could be impacted include Umuseti, Umusam, Isumpe and Umusadege. Other resources that could be impacted include surface water bodies (including Ase River and tributaries), farm land and other manmade features. The sensitive resources at risk and the likely impact magnitude are itemised in ***Table 1.5*** below.

Table 1.5: Summary of resources at risk in the event of oil spill incident

S/N	Description	Magnitude of Impact
i.	Economic trees: palm trees, plantain, etc.	Minor to Moderate
ii.	Agricultural crops: cassava	Minor to Moderate
iii.	Sediment, River shorelines sand and adjoining water bodies and tributaries. ▪ Quality ▪ Quantity ▪ Groundwater	 Major Major Minor to Moderate
iv.	Biological Resources ▪ Fisheries ▪ Zoo/phytoplankton ▪ Flora ▪ Wildlife	 Moderate to Major Moderate Minor to Moderate Minor

S/N	Description	Magnitude of Impact
v.	Socio-economic resources ▪ Fishing activity ▪ Economic trees ▪ Farm land (animal) ▪ Land use	 Moderate to Major Minor to Moderate Minor to Moderate Minor to Moderate
vi.	Other facilities (oil facilities, communities, schools, etc.)	Moderate to Major

1.9.2 Areas for Critical Protection

Areas of critical protection are provided in **Table 1.6** below.

Table 1.6: Areas of critical protection

Area	Location	Critical Period of Year
People	POL staff and nearby communities	Year-round
Industrial	POL and other oil and gas production facilities near Umuseti/Ugbuku marginal field	Year-round
Surface water ecology and fishing	*Ase River* and other smaller streams	Year-round
Communities	Human settlements	Year-round
Religious and Cultural	In communities	Year-round
Tourism	Recreational beaches/river bank	Year-round

1.9.3 Order of Protection

In the event of oil spill within the terrestrial and aquatic environment, the following assumptions are made:

a) The first priority will be safety and preservation of life of persons and personnel.
b) Early detection mechanism (fire alarms, smoke detectors, etc.) shall be utilized to determine source and size of the incident and to mount an early response.
c) For major spill, it is recognized that shoreline protection especially sensitive areas will be the next priority and precautionary shoreline treatment operations will be undertaken.
d) In the event of extensive oil spill impacts, a substantial logistical task would be required to organize and sustain the deployment of clean-up personnel and equipment.
e) The mounting of a labour-intensive and protracted cleaning operation would quickly absorb the available labour force so that external reinforcement of equipment and personnel would almost certainly be required as a contingency.
f) All of the oily residue and other waste associated with clean-up will be treated and disposed at approved site within Nigeria.

This Plan focuses on the provision of equipment and human resources locally. This plan also recognizes that external aid will be utilized early when it has been established by the Incident Commanders that local capabilities may be exhausted or unable to deal with problem at hand. Smaller amounts of oil resulting from minor incidents should be manageable by local resources.

SECTION II

STRUCTURE AND RESPONSIBILITY FOR THE OSCP

2.1 Introduction

This section presents the OSCP management organogram and responsibilities of the Incident Command Team (ICT).

2.2 Incident Command System (ICS) Organization

The POL ICS organization comprises five functional sections which include:

1) Incident command and the command staff section
2) Operations section
3) Logistics section
4) Planning section, and
5) Finance section

The "basic" and “detailed” ICS functions are shown in **Figures 2.1 and 2.2** receptively below.

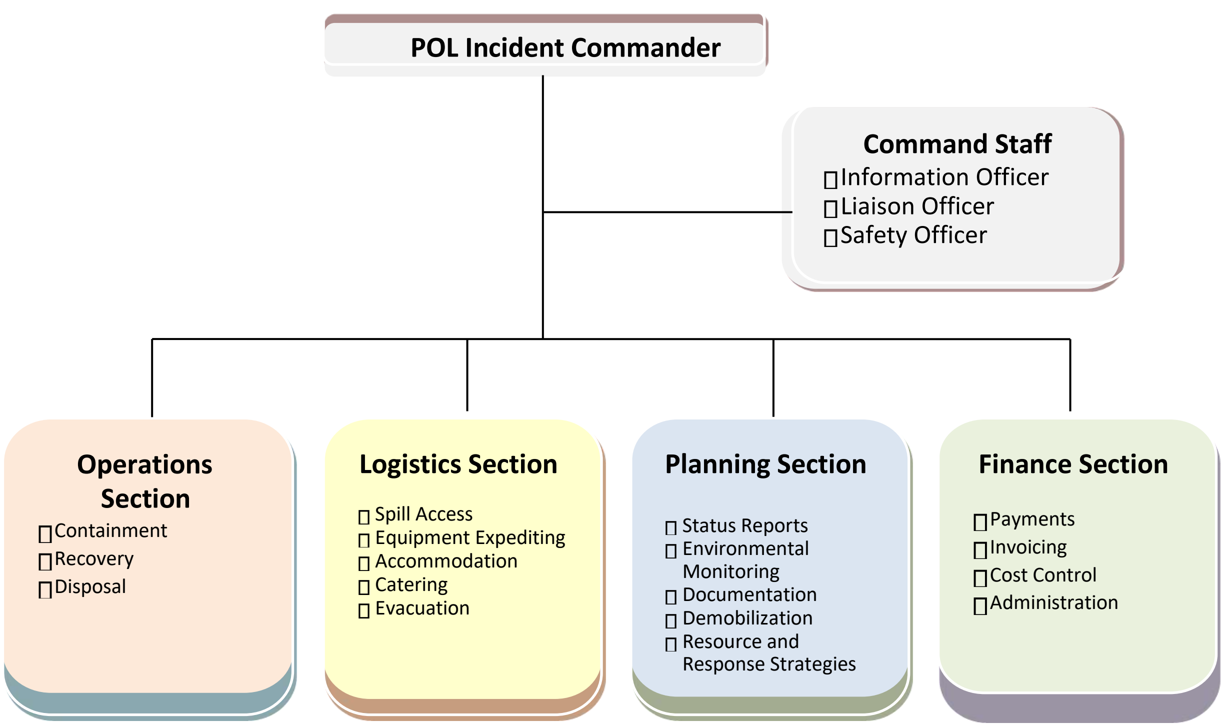


Figure 2.1: Basic incident command system (ICS) organogram

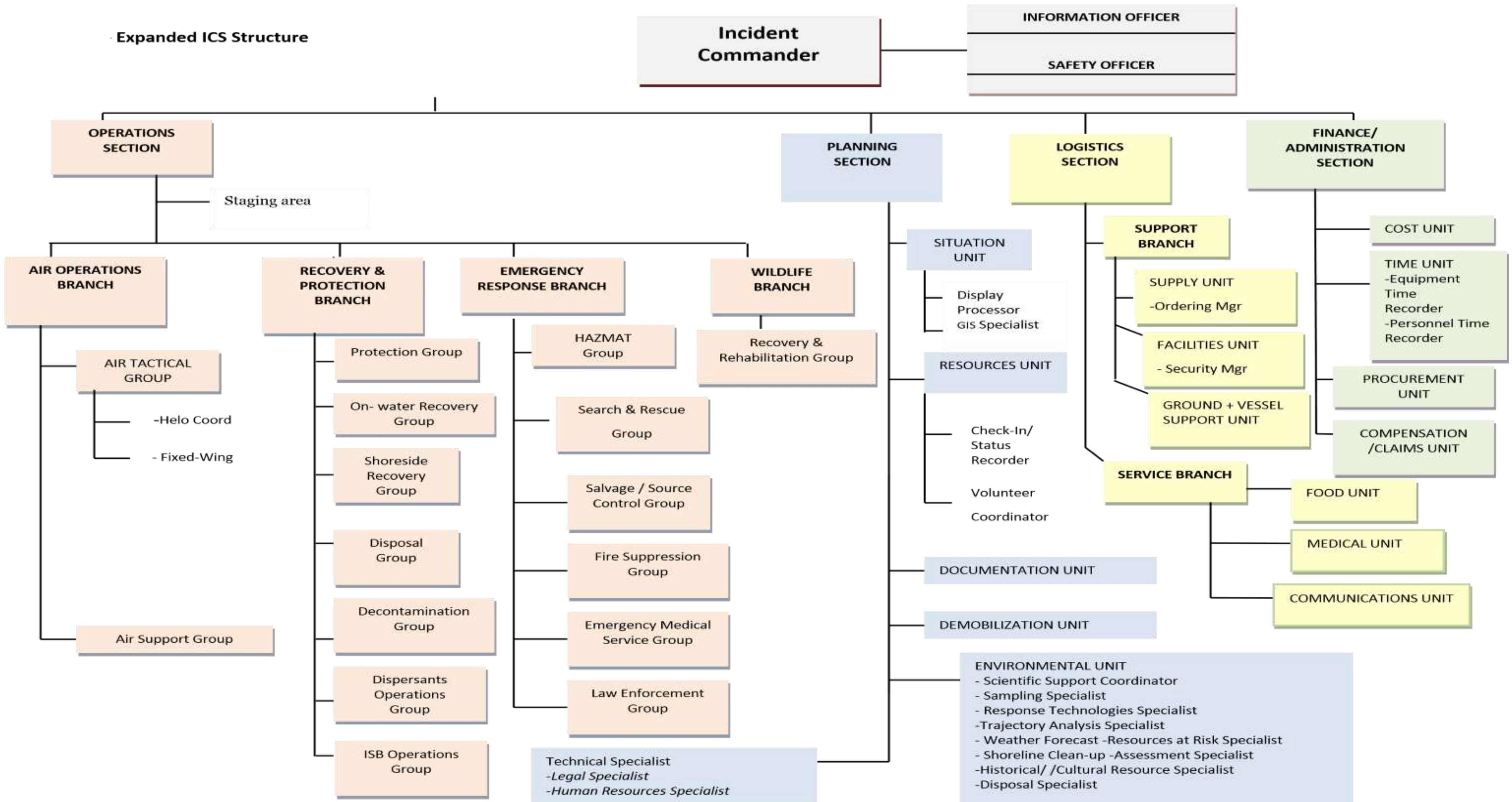


Figure 2.2: Expanded ICS structure showing detailed functions of the sections

2.3 Roles and Responsibilities

The OSCP identified the emergency response structure across all levels of incidents and provide information on the roles and responsibilities of all personnel that will play a role in the incident response. The structure, roles, and responsibilities will range from in-field personnel as the initial responders, to those roles and teams in other locations that may be contacted in the event of larger scale incidents. The command system provides information on how all roles interact, including details on the internal notification structure and process to demonstrate that appropriate lines of communication.

2.3.1 Incident Commander

In the event of oil spill, the Incident Commander (IC) is responsible for activating this OSCP. The Incident Commander has the overall responsibility for the response operations and must assemble the response team (including specialists if required). The Incident Commander is responsible for the following main functions under the Incident Command System (ICS).

a) The Incident Commander for a Tier 1 incident is the Responsible Party (RP) which is POL
b) The Incident Commander of a Tier 2 incident will utilize the unified command between the Responsible Party (POL), Oil Producers Trade Section (OPTS) and Clean Nigeria Associate (CAN).
c) The Incident Commander of a Tier 3 incident will utilize unified command among the Incident Commanders.

Following alarm, the appointed Incident Commander will confirm the significance of the incident and then activate the Emergency Operations Centre (EOC) and the personnel designated to chair the sections/units of the Centre (which are operations, planning, logistics and finance) will report for duty ***(Figure 1).*** The EOC is a unit of unit quipped for emergency response. Necessary administrative tools/equipment for the EOC is attached in ***APPENDIX V***.

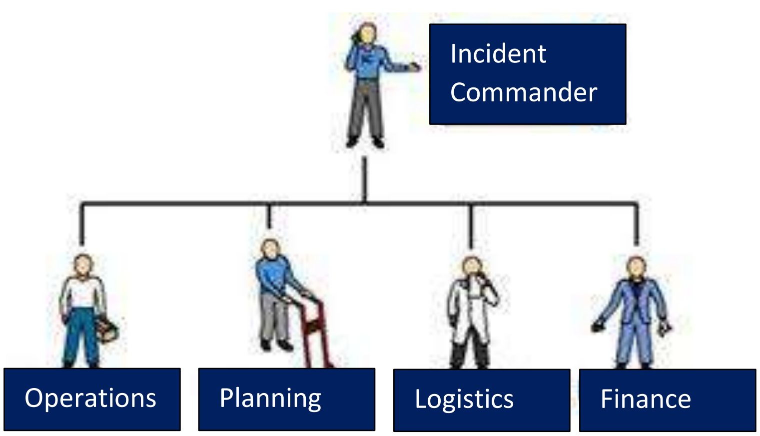


Figure 1: Alerting system

2.3.1.1 Information Officer

The Information Officer is responsible for developing and releasing information about the incident to the news media, to incident personnel, and to other appropriate agencies and organizations. Only one Information Officer will be assigned for each incident, including incidents operating under Unified Command and multi-jurisdictional incidents (i.e. Tiers 2 and 3). The Information Officer may have assistants, as necessary, and the assistants may also represent assisting agencies or jurisdictions.

2.3.1.2 Safety Officer

The Safety Officer is responsible for monitoring and assessing hazardous and unsafe situations and developing measures to assure personnel safety. The Safety Officer will correct unsafe acts or conditions through the regular line of authority. The Safety Officer may exercise emergency authority to prevent or stop unsafe acts when immediate action is required. The Safety Officer maintains awareness of active and developing situations, ensures Site Safety and Health Plan is prepared and implemented, and includes safety messages in each Incident Action Plan. Only one Safety Officer will be assigned for each incident, including incidents operating under Unified Command and multi-jurisdiction incidents. The Safety Officer will have assistants, as necessary, and the assistants may also represent assisting agencies or jurisdictions.

2.3.1.3 Liaison Officer

Incidents that are multi-jurisdictional (i.e. Tier 2 and Tier 3), or involve several agencies, may require the establishment of a Liaison Officer position on the Command Staff. The Liaison Officer is the point of contact for the assisting and cooperating Agency Representatives and stakeholder groups. Only one Liaison Officer will be assigned for each incident, including incidents operating under Unified Command and multi-jurisdiction incidents. The Liaison Officer may have assistants, as necessary, and the assistants may also represent assisting agencies or jurisdictions. The Responsible Party (POL) shall fulfil this responsibility.

2.3.2 Operations Section Chief

The Operations section shall be responsible for the following key activities. The techniques for afore mentioned operations are explained in detail in **Chapter 3** of this Plan.

I. Oil spill containment and recovery
II. Search and rescue
III. Waste disposal

The Operations Section Chief (OSC), a member of the general staff within Incident Command System (ICS), is responsible for the management of all operations directly applicable to the primary mission. The major responsibilities of the Operations Section Chief are:

a) Review Common Responsibilities
b) Develop operations portion of Incident Action Plan (IAP).
c) Brief and assign Operations Section personnel in accordance with the IAP.
d) Supervise Operations Section.
e) Determine need and request additional resources.
f) Review suggested list of resources to be released and initiate recommendation for release of resources.
g) Assemble and disassemble strike teams assigned to the Operations Section.
h) Report information about special activities, events, and occurrences to the IC.
i) Respond to resource requests in support of Natural Resource Damage Assessment (NRDAR) activities.
j) Maintain Unit/Activity Log

The Operations Section Chief role will be fulfilled by the POL to be supported by the CNA and NOSDRA (for multi-jurisdictional responses).

2.3.3 Planning Section Chief

The Planning Section Chief is responsible for collecting, evaluating, and disseminating the tactical information related to the oil spill incident, and for preparing and documenting Incident Action Plans (IAPs). The Planning Section Chief (PSC) is responsible for:

a) Status reporting
b) Environmental monitoring
c) Documentation
d) Demobilisation
e) Resource and report strategies.
f) Prepare alternative strategies for the incident

2.3.4 Logistics Section Chief

The Logistics Section Chief (LSC) is responsible for providing facilities, services, and material in support of the incident ***(Figure 2.3).*** The LSC participates in the development and implementation of the Incident

Action Plan (IAP) and activates and supervises the branches and units within the Logistics Section. The Logistics Section Chief coordinates communications and equipment, personnel and supply movements in a large spill, fire, explosion or any catastrophic event. The LSC activates a mobile command centre and ensures that its operational needs are met. Other duties include the following:

a) Spill access
b) Equipment expediting
c) Accommodation
d) Catering
e) Evacuation
f) Field Coordination and Communications (summon equipment, maintain field communications equipment, coordinate logistic support)
g) Arrange for technical and repair services

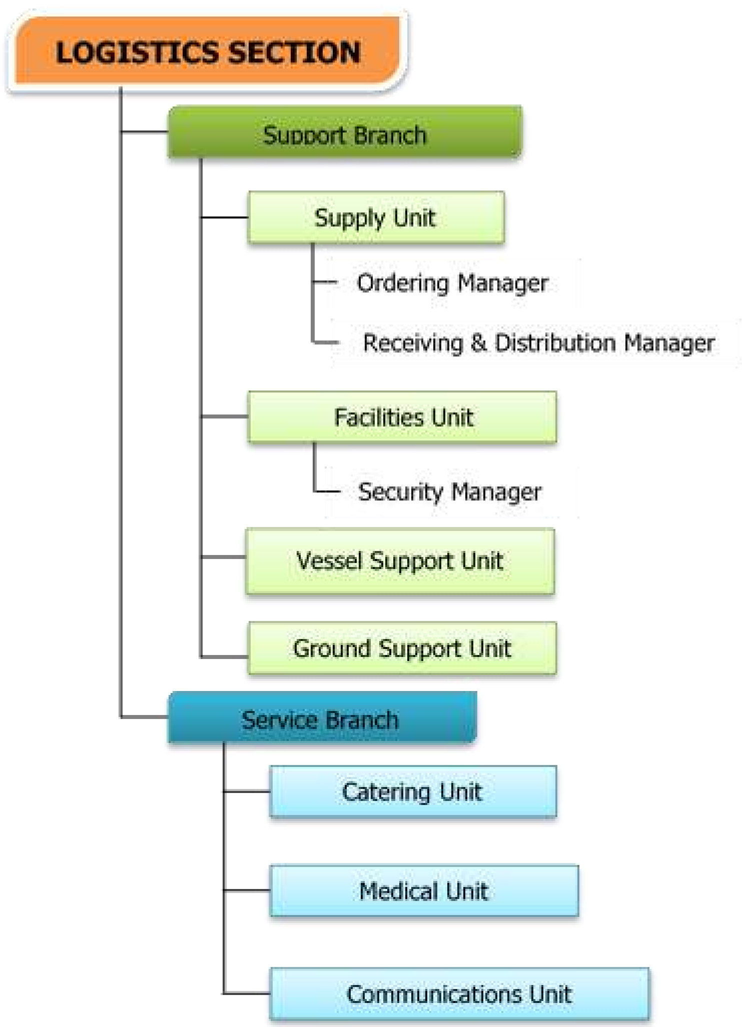


Figure 2.3: Logistics section functions

2.3.5 Finance Section Chief

The Finance Section Chief facilitates financial and other resources, arranges payments and controls invoicing (Figure 2.3). He ensures on-site cost and recovery accounting, and a chronological record is kept of spill control events. The Finance and Administrative Chief is responsible for:

a) Payments
b) Invoicing
c) Cost control, and
d) Administration

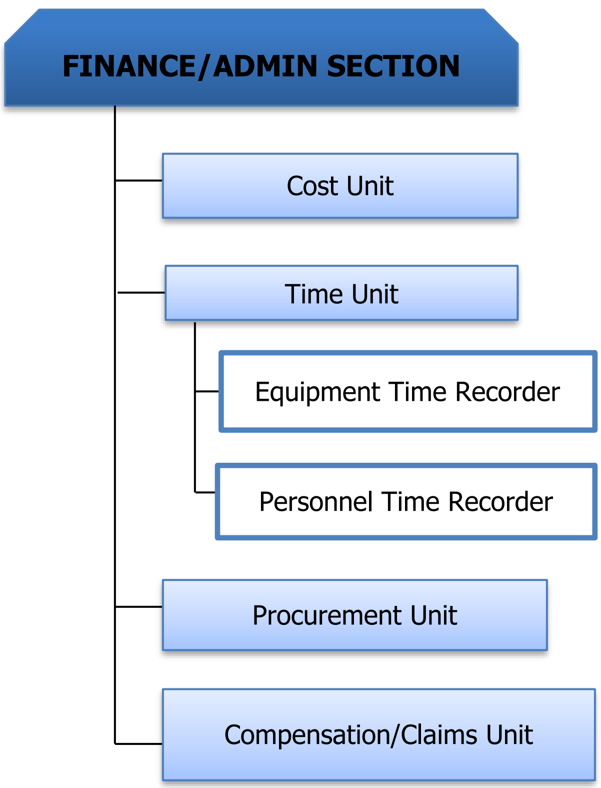


Figure 2.4: Finance section functions

2.4 Support Agencies and Companies

The support agencies and companies provide technical and advisory assistance for the Incident Command System (ICS) in the areas of planning, emergency services, infrastructure and social services. These resources (support agencies and companies) can be drawn from public institutions, private enterprise, consultants, Oil Producers Trade Section (OPTS), universities and non-governmental organisations (NGOs).

International agencies/organisations such as WACAF – OSRL can also be utilized to provide expert advice, equipment and personnel if necessary.

2.4.1 Interagency Agreements

The following agreements shown in ***Table 2.1*** below shall be firmed up for the POL OSCP

Table 2.1: Interagency agreement

Agreements	Year
OPTS	
CNA	
WACAF OSRL	

SECTION III

PREPAREDNESS

3.1 Background Information

This section demonstrates the OSCP manpower and equipment requirements, which shall also be reviewed continually as part of the contingency planning.

3.2 Training and Drills/Exercises

The ultimate test of any contingency plan is measured by performance in a real emergency. Therefore, the OSCP includes a continual programme to test the plan through realistic exercises. Training will be coordinated and administered through in house and external resources.

POL shall arrange for periodic exercises to ensure that reporting, alerting and communication systems function effectively and that those personnel assigned specific tasks under this Plan are familiar with them. The mobilization and deployment of equipment, personnel and materials to ensure availability and performance shall be exercised. Additionally, training programs for shoreline clean-up personnel and the Control and Command Teams will be developed. The training timetable is presented in ***Table 3.1*** below.

Table 3.1: Frequencies of Drills/Exercises

S/N	Type of Exercise	Minimum Frequency under Tier 1	Minimum Frequency under Tier 2
1	Function testing of dispersant spraying equipment, boom, skimmer, fire extinguishers, etc.	Quarterly	Quarterly
2	Deployment of dispersant spraying equipment, skimmer	1 per-year	2 per-year
3	Limited scale deployment of equipment	1 per-year	1 per-year
4	Offshore full scale deployment of oil recovery	1 per 2-year	1 every 2-year
5	Desktop exercise	2 per-year	4 per-year

S/N	Type of Exercise	Minimum Frequency under Tier 1	Minimum Frequency under Tier 2
6	New operations and after approval of the OSCP	Within 12 months	Within 12 months
7	Desktop Tier 1 Drill and bilateral/Tier 2 Drill with OPTS and CNA	6 months	1 per 2-year
8	Site Tier 1 Drill and bilateral/Tier 2 Drill with OPTS and CNA	1 – year	2 – year

Invitations will be sent to the relevant private and government agencies including DPR, NOSDRA, CNA, OPTS and National Emergency Management Agency (NEMA) to observe and/or participate in all of these events as required. The general training for POL Incident Command Team shall address the following:

- Individual roles and responsibilities
- Threat, hazards, and protective actions
- Notification, warning, and communications procedures
- Emergency response procedures
- Evacuation, shelter, and accountability procedures
- Location and use of common emergency equipment; and
- Emergency shutdown procedures.

3.2.1 General and Expert Courses to be Undertaking by the Incident Command Team

Identification of courses required for respond to an incident is provided in the OSCP. The onsite personnel shall be trained on oil spill response, cleanup, search and rescue, etc. Personnel not located on-site, but who may be allocated a role in the response, will be identified and shown to have the appropriate training to undertake the designated roles. As provided in the ***Table 3.2*** below, the OSCP provides information on the following:

- What training should be undertaken including courses, inductions, and exercises (desktop/field)
- The frequency that training is provided to ensure adequate skills are maintained
- Personnel required to participate in the training
- Any other relevant information to assist in satisfactorily demonstrating response personnel capability.

Table 3.2: General and Expert Courses

SN	Personnel	Task	Course Required	Frequency
1	All personnel	Evacuation procedure	Induction, desktop exercise	1 per year
2	Incident Command Team (Oil Spill Clean-up)	Oil spill clean up	Induction, desktop exercise, DPR approved oil spill clean-up course provided by external consultant	2 per year
3	Incident Command Team (Search and Rescue)	Search and rescue	Induction, desktop training, sea survival training, search and rescue training	2 per year
4	Incident Command Team (Waste Management)	External resources (DPR accredited waste management consultant)	As per requirement	1 per year
5	Incident Command Team (Offshore Safety)	Safety on water	Course to be performed at approved facility offsite	1 per 5 years

3.3 Response Equipment and Materials

The OSCP includes a list of equipment available on site for the activities/events covered under the OSCP. The OSCP also identified additional/external sources of equipment available for use in the event of an incident. Details on equipment location and mobilisation time is included for equipment stockpiles not located on site. This will assist in the planning of response strategies and demonstrating the capability and feasibility of implementing the proposed response strategies. As part of the training need, the equipment shall be tested periodically as presented in the OSCP training schedule. The list of response equipment for oil spill is attached in ***APPENDIX I.***

The response equipment and materials will be continually tested and stocked in line with DPR Guidelines for the Stocking and Listing of Response Equipment and Materials *according APPENDIX VIII- B l of EGASPIN (2002)*.

SECTION IV

RESPONSE

4.1 Background information

This section details the immediate and expanded response actions to be taken in the event of oil spill or an emergency occurrence that can trigger oil spill.

4.2 Spill Alerting and Notification System

4.2.1 Internal Alerting and Reporting System

The Emergency Call Sign **"ECHO – ECHO – ECHO"** is to be used **only** in cases of emergencies such as Blow out, Oil Spillage, etc. endangering human lives and properties and requiring urgent intervention. On hearing the call code – "ECHO – ECHO – ECHO" using UHF Radio, the OSCP Incident Commander will assess the spill and activate the OSCP. It is the responsibility of each employee to report any incident or any near miss to his/her duty supervisor, using Pillar Oil Limited's incident reporting procedures, who determines the necessary line of action as well as informs the Departmental Head.

The Head, Field Operations reports any oil spill and other incidents to the Managing Director and the HSE Department. Such reports are deliberated upon for strategic planning and management decisions.

4.2.2 External Alerting and Reporting System

Notification of any major incident/oil spill (all Tiers) shall be reported immediately to Director of DPR (Lagos) and DPR Warri Base by the POL Management Response Team (MRT) within 24 hours of occurrence (see ***APPENDIX IV*** for DPR and NOSDRA Notification Forms). A formal report will, following notification, be sent to DPR and NOSDRA using the Reporting Forms attached in ***APPENDIX IV.***

- In case the initial report was verbal; it shall be formalized by submitting a daily completed Oil Spillage/Leakage report to DPR***.***
- For spills larger than **25 bbls**, clean up progress and report on prescribed form shall be submitted within 14 days to DPR. The 14 days shall be extended if clean up takes longer.
- DPR shall be kept regularly informed of the latest development in any emergency.

In case of major oil spill affecting large number of people in any area, reports shall be made to the Local and State Government as soon as possible following discussion between POL Management Response Team (MRT) and DPR.

4.2.3 Contact Directory

POL will maintain an up-to-date contact directory (attached in ***APPENDIX III).*** All alert and communication shall follow the established communication procedure earlier discussed. The relevant contact details for the OSCP include the following:

- Key company personnel,
- Regulators (DPR, NOSDRA, FMEnv),
- Regional/local authorities for example, State Fire Service, NEMA, Police, etc.
- Equipment and resource contacts,
- Waste contractor and disposal sites,
- Other contractors and support services that may be contacted to assist in the event of an incident (CNA, OPTS, etc.)
- Media

4.3 Response Techniques

4.3.1 Use of Dispersants

It is the position of Federal Ministry of Environment (FMEnv) and Department of Petroleum Resources (DPR) to ensure that use of dispersants will cause no significant environmental harm from such use. It is therefore POL policy that when combating spilled oil within its territorial waters, the Incident Commander as authorized by the POL, will only use dispersants under the following conditions in line with regulatory requirements:

a) The area of application is not less than one nautical mile from any river bank, nor closer than three nautical miles up-current from important marine fishery ecosystems which are less than 20 feet from the water’s surface. Ase River and other smaller streams are less than 20ft wide, therefore, dispersant many not be used unless otherwise approved by FMEnv/DPR under certain conditions;

b) The water depth should exceed 10 meters (30 feet) in the area in which the dispersant will be applied. Ase River is less than 10m deep, therefore dispersant is not suitable for use in Ase River and its tributaries;

c) The method of application is one recommended by the manufacturer according to the safety data sheet (SDS);

PILLAR OIL

d) The rate of application is as recommended by the manufacturer;

e) The dispersants exhibits low toxicity.

The DPR and FMEnv are responsible for the approval of the use of dispersants in Nigerian waters in accordance with the criteria agreed for the Nigerian waters unless there are special overriding considerations at the time. It is noted, however, that for chemical dispersants to be effective, they must be applied on fresh oil in order to maximize the limited window of opportunity for their use – often within 24-48 hours following a spill. This window of opportunity may be expanded in some cases to 72-96 hours depending on the oil type and dispersant to be used. Dispersants shall not be used in sensitive areas as determined by the DPR, FMEnv and Fisheries and Wildlife Division.

It is further emphasized that only licensed and approved dispersants are permitted. This does not include commercial detergents - which will not be applied whether onshore or offshore. The decision-tree flowchart for dispersant use is shown in **Figure 3.1** below:

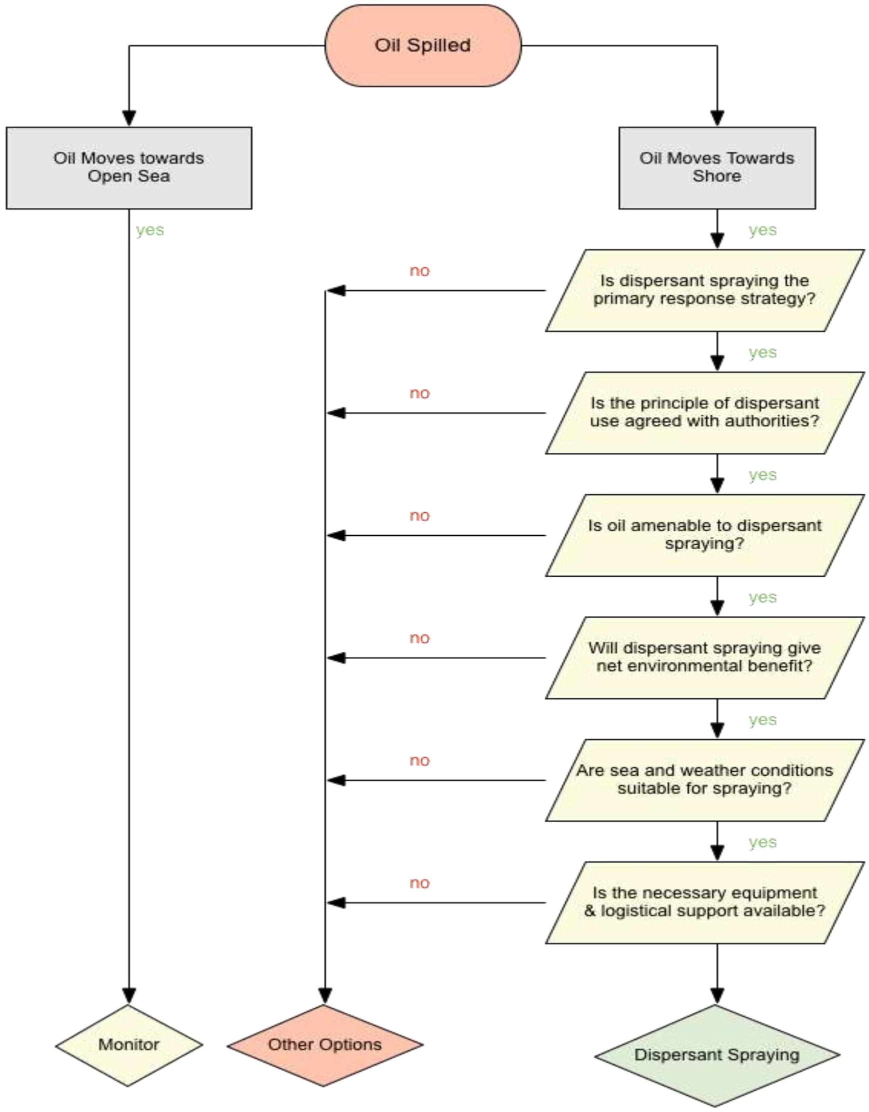


Figure 3.1: Dispersant use decision tree

4.3.2 Containment and Cleanup Procedures

4.3.2.1 Combating Oil Spill

Competent staff on site shall take immediate steps to asses and combat oil spill while mobilizing support from other competent persons. Actions to be taken include:

- Stop the source of spill e.g. well shut-in, facility shut-down, and isolation of the affected equipment or pipeline.
- Remove ignition and explosive sources.
- Evacuate people from endangered area and undertake first aid treatment for any injured person before moving them to a hospital.
- Mark area as an emergency zone and restrict movement of people from the zone.

- Mobilize appropriate anti-pollution control equipment, start containment and clean-up operations.
- Start the process of sending reports immediately to the appropriate relevant governmental agencies.

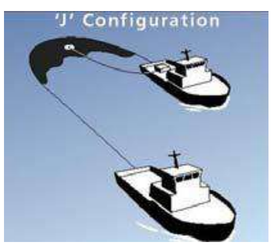
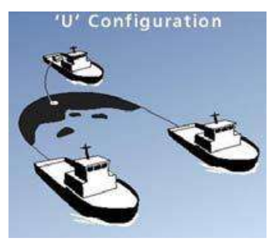
Spills within land can be contained by installing barricades in the direction of flow and then pump the spilled oil into containers. However, when the spill has migrated to surface water bodies, the spill will, be contained by boom. A spill that is fully contained by boom is best cleaned-up by a floating skimmer placed inside the boomed. The oil will tend to concentrate against the boom in the direction of the wind and current. The skimmer should be placed in this area and continually moved to skim the thickest area. This procedure is further discussed subsequent sections below.

4.3.2.2 Containment and Protection Technique

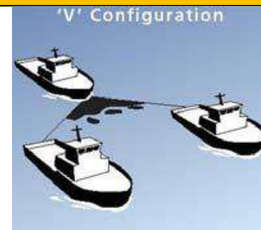
The appropriate containment actions depend upon the spill location and environmental conditions. The initial containment actions prescribed are to be implemented with regards to the spill volume and rate. Containment and/ or protection will be conducted promptly to avoid its spread to other sensitive areas. The containment and recovery technique is shown in ***Tables 4.1 – 4.3*** below.

Table 4.1: River Recovery

Spill Size	Technique/Equipment
Tier 1 Resources Available	i. For spill within water, skimmer 50 recovery system will be applicable. In absolute optimum conditions, where the River is calm and the spilled oil is of a sufficient thickness, the skimmer unit (Skimmer 50) could recover approximate $50m^3$ per hour. It must be emphasized that such a recovery rate could never be achieved offshore. ii. 500m Vikoma Sentinel 1100 boom will be used
Considerations	i. Ensure safety is first considered; stop any ignition sources and ensure gas monitoring is undertaken. ii. Effective offshore recovery requires trained operators, suitable equipment, well-maintained equipment, vessel logistics, aerial support, temporary storage, transportation and waste disposal. iii. In the event of a spill at sea, containment and recovery is the primary response option.

Spill Size	Technique/Equipment			
	iv. Aerial surveillance should be used to direct vessels to areas of thickest oiling. v. Even in the most ideal conditions recovery rates will never be 100% and are actually more likely to be around 10 – 20%. vi. The faster the response, the better the recovery rate as the spill will have had less time to spread and fragment. vii. Oil contained onshore within the tank farm should be protected as it presents fire risk. viii. Booming will be ineffective if the current speed at right angles to the face of the boom (due to water current or speed of towing vessels) exceeds 0.75 knots. Entrainment failure can be reduced by reducing the boom at an angle to the current, as described in the graph below. ix. Boom will fail if significant wave height exceeds 2m, with oil being washed over. Eddies behind the booms are an indication that they are being towed too fast. Oil lost under the boom will appear as globules or droplets rising 2-10m behind the boom. Sheens will often be present even when the boom is functioning well.			
Techniques		+ Only two boats required - Smaller encounter than three boats system		+ Wide encounter with oil - logistics - Difficult to coordinate Boats - Wide boom apex
		+ Logistics + Quick to deploy if available		+ Wide encounter + Tight apex aids recovery

<table>
<tr><th>Spill Size</th><th colspan="4">Technique/Equipment</th></tr>
<tr><td></td><td></td><td>+ Easy to maintain configuration when recovering

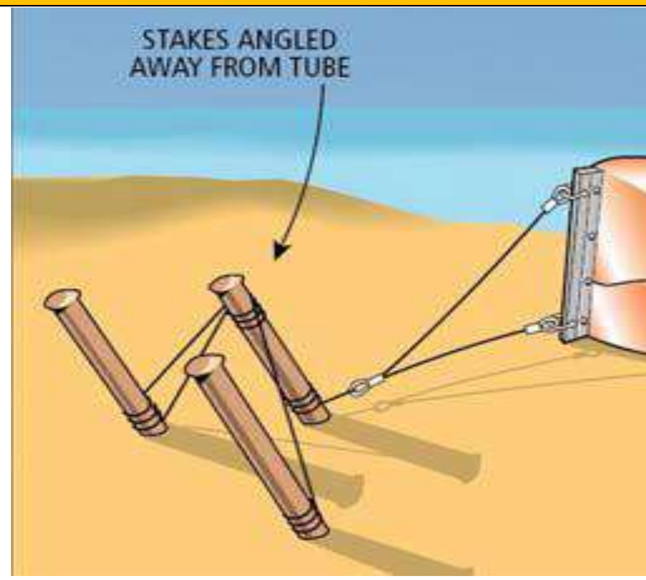
- Small encounter</td><td></td><td>- Specialist equipment required
- Skimmer vessel

- Logistics</td></tr>
<tr><td></td><td colspan="4">i. When towing a sectioned boom in a ‘U’ configuration, an odd number of sections of boom should be used to prevent having a join in the centre of the boom from which oil can more easily escape.
ii. To avoid sharp stress or snatching on a towed boom, lines between boom ends and the vessel should be of sufficient length. 50 metres or more would be appropriate for towing a 400m length of boom.
iii. Recovered oil could be pumped into the inflatable storage barge ($100m^3$ capacity Pollutant) or the recovery oil tank on the Bourbon Rhesos ($116m^3$ capacity).
iv. Very viscous oils or emulsions may need to be heated to pump.
v. Recovered oil should be pump onto the facility/ Harbour</td></tr>
</table>

Table 4.2: Inland and Streams- Containment and Recovery

Spill	Technique/Equipment
Tier 1 Resources Available	i. River booms ii. Skimmer systems iii. $7m^3$ Fastanks iv. Vacuum truck v. Hand tools (shovels, etc.)
Considerations	vi. Ensure safety is considered; stop any ignition sources and ensure gas monitoring is undertaken.

Spill		Technique/Equipment
	vii.	Fast flowing rivers will put high loads on the booms, making anchoring difficult.
	viii.	It is not always practical to boom the river with a single length of boom.
	ix.	Smaller boom may not be that durable and will be prone to damage from floating debris.
	x.	In currents over 2.5 knots the length of boom required to take account of current usually becomes unmanageable.
	xi.	Oil will escape from a boom laid perpendicular to the flow if the relative current strength is above 0.6 knots.
	xii.	Ensure the Boom is securely anchored to the bank either by it being staked to the ground or attached to a tree. Stakes should be angled away from the boom and secured to each other from the top of the bank stake to the bottom of the back stake, as in the opposite diagram.
	xiii.	There should be a good seal between the boom and the bank. Sorbents should be utilized to ensure oil does not escape.
	xiv.	If there is a no suitable Point for recovery, the bank can be excavated to create an area of calm, sufficiently deep water for recovery.
	xv.	For wider rivers, the use anchors may be required to keep the boom in the correct figuration
	xvi.	For currents between 0.6 and 2.5 knots the boom must be set at an angle to the water flow so that the oil will not escape but be reflected along the boom. Use the below graph as guidance.
	xvii.	For currents below 1.2 knots, the boom should 1.5 times the width of the river as a minimum.

Spill	Technique/Equipment
	 ***Stacking Method***
	xviii. For currents of 1.2 and 1.4 knots, the total length of boom will range from twice to approximately 4 times the river width. xix. It is more effective to boom at a wide slow position than on a narrow fast stretch of water. xx. Booms should be deployed to deflect oil from the faster outer-side of the river to the slower inner-side of the river for recovery. xxi. The boom should have a smooth profile and preferably have a bottom tension wire on which anchors can be placed. xxii. Once oil is pooled at the bank in an area of calm water, the skimmer should be used for recovery. xxiii. Debris, such as vegetation, can clog up skimmers / pumps and impede recovery, but this can be overcome by using screens / mesh around the skimmer / suction hose.

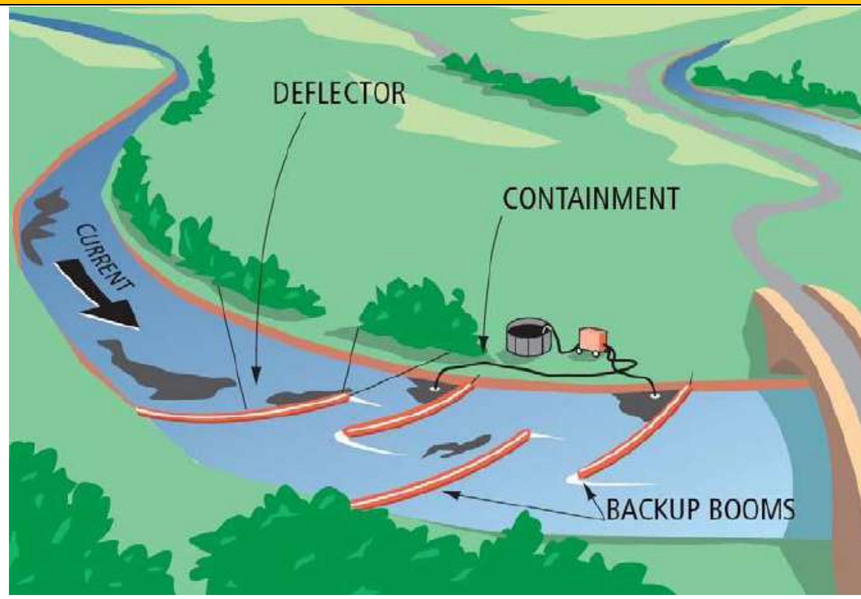
Spill	Technique/Equipment
	 ***Overview of Creek/River Booming***

Table 4.3: Inland: Containment and Recovery in Swamps

Spill	Technique/Equipment
Tier 1 Resources Available	i. River booms ii. Skimmer systems iii. $7m^3$ Fastanks iv. vacuum truck v. Hand tools (shovels, etc.)
Considerations	vi. Ensure safety is considered; stop any ignition sources and ensure gas monitoring is undertaken. vii. Swamp areas are characterized by thick vegetation and a network of water courses, the majority of which have limited flow and are more pond-like. Refer to sections 0 and 7.4.5 for strategies regarding ditches / streams and rivers. viii. Access is likely to be extremely limited. ix. Using a combination of response strategies will probably be required. x. To limit the impact, dam / boom any outlets from the polluted water body. xi. Vegetation and plant debris will inevitably become oiled, greatly increasing

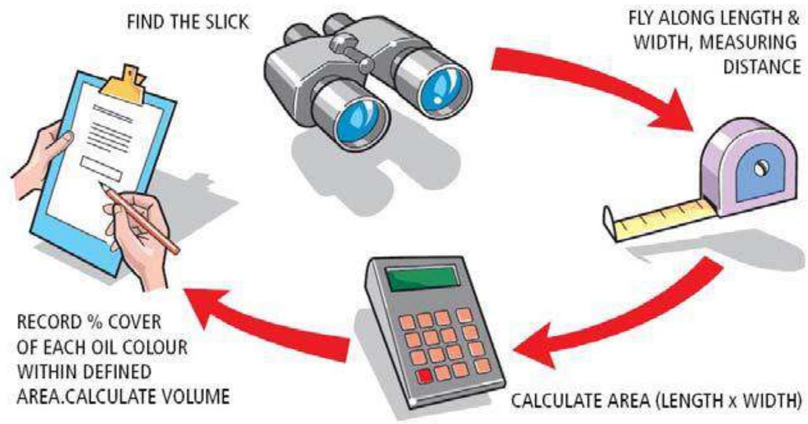
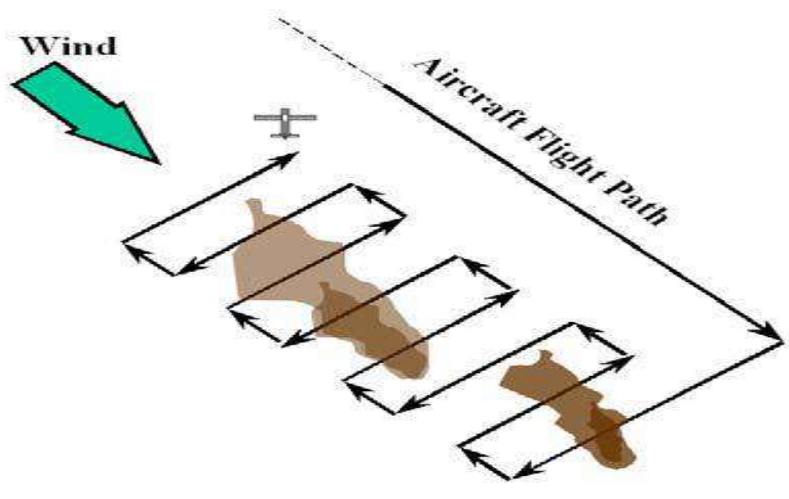
Spill	Technique/Equipment
	the volume of waste collected.
	xii. Shallow draft booms or sorbents can be dragged across the water to corral oil for recovery. xiii. Air or water jets can be applied horizontally to the water surface to generate a current for directing the oil to collection points. It is important not to create turbulence as it may cause some emulsification or cause further impact. xiv. Oil can be recovered by using sorbents, or skimmers if they can be carried to the site. xv. Impermeably lined temporary storage pits may be required to store oil. A series of pits may be required to transport recovered oil by pumping the contents from one pit to another especially for particularly remote areas. xvi. Debris, such as vegetation, can clog up skimmers / pumps and impede recovery, but this can be overcome by using screens / mesh around the skimmer / suction hose.

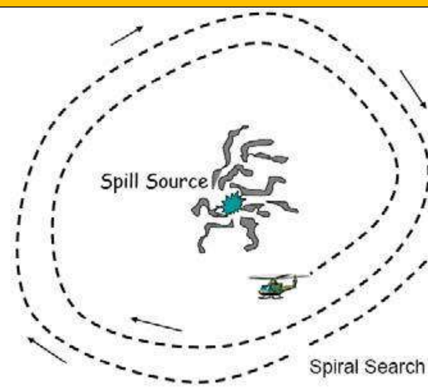
4.4 Spill Monitoring and Surveillance

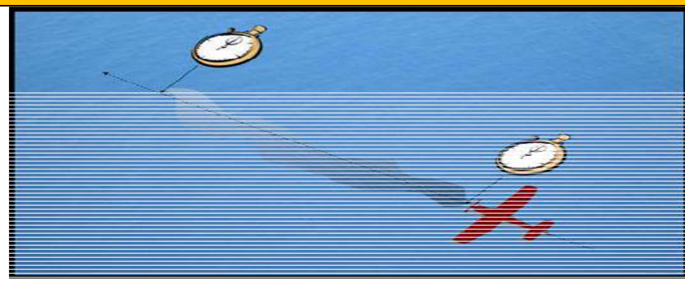
In the event of an oil spill or incident spreading beyond, the use of helicopter services may be considered for surveillance operations, private helicopter contractor companies such as Bristow Helicopters Nigeria will be engaged for this purpose. Ruptures of pipelines with potential to cause a spill incident can be detected by pressure monitoring. The key steps in Aerial surveillance is shown in ***Table 4.4*** below.

Table 4.4: Key Steps in Aerial Surveillance

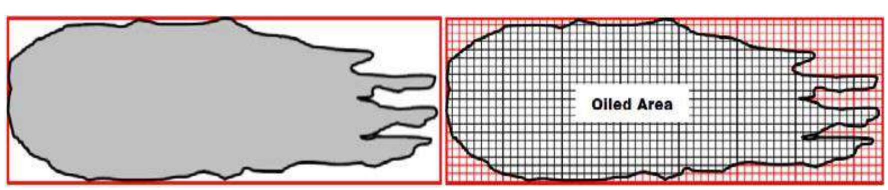
Spill	Technique

Spill	Technique
	 ***Key Steps in Aerial Surveillance***
Step 1: Find the Slick	i. A 'standard' ladder search pattern is used when it is considered that the oil spill may be anywhere in the search area to an equal probability. It is known as the "Parallel Track Search / Ladder Search" as pictured below. It is the most economical method of surveying an area. The spacing between tracks should be 6 to 10 nm. ii. If there is an uncertainty as to the exact location / extent of the spill, a spiral pattern can be used to investigate the area of interest. It should be noted that spiral searches can be difficult operationally in a fixed wing aircraft.  **a. *Ladder Search Pattern***

Spill	Technique
	 ***b. Spiral Search Pattern*** iii. The size of the search area should take into account possible errors in the initial release position, the navigational errors of the search units and the errors in the drift calculations. In general terms, 1 - 2 nm will account for any positional error. Drift error is expressed as a percentage of drift distance and 30% is normally used (drift distance x 0.3). iv. It is recommended that, where practical, the long search legs be aligned at 90° to the direction of the prevailing wind to increase the chances of oil detection as floating oil has a tendency to become elongated and aligned in long, narrow, strips called 'windrows' typically 30 to 50 metres apart and lying parallel to the direction of the wind. However, haze and dazzle reflected from the sea surface can often affect their visibility. Depending on the position of the sun it may be more beneficial to fly the search pattern with a different orientation. v. There is more chance of detecting targets at lower search speeds. Generally, the more difficult the target is to see because of size, colour, and light conditions etc., the lower the required search altitude. For lower altitudes, the track spacing will need to be closer and the search effectiveness will be reduced. An altitude of 1000 – 1500 feet is the usual range for daylight over water visual searches
Step 2: Fly along the Spill and Measure	i. Fly the length and width of the slick and record the time taken and the aircraft speed (note: 1 knot = 0.5m/second = 1.8 km/hour).

<table>
<tr><th>Spill</th><th>Technique</th></tr>
<tr><td></td><td>
Timing the Flight along the Length of the Slick

ii. Once the speed and times to fly the length and width are recorded, the area can then be calculated.</td></tr>
<tr><td>Step 3: Spill Area Calculation</td><td>i. Example – A helicopter flying at a ground speed of 120 knots (taken from the GPS or helicopter’s flight instrument) takes 260 seconds to fly along the length of the slick and 70 second to measure the width.
ii. Length = (260 seconds x 120 knots) /3600 seconds in one hour = 8.67 nm = 16.04km Width = (70 seconds x 120 knots) / 3600 seconds in one hour = 2.33nm = 4.31km Area = 16.04km (length) x 4.31km (width) = 69.13km^2</td></tr>
<tr><td>Step 4: % Cover and Volume Calculation</td><td>i. The area covered with oil is calculated by placing a rectangle around a ‘map’ of the slick equal to the overall length and width, and calculating or estimating the percentage of the overall area covered by the oil.
ii. It can be difficult estimating the percentage of the overall area covered with oil in flight. All visual assessments should be carefully checked after landing. The use of grid overlays should be used to obtain accurate measurements of overall slick area from the recorded images or maps.



Overall Area and Use of Grids to estimate Coverage – in this example, estimate of oil area is 80% and clear water 20%
i. Oiled Area = 69.13 km^2 (overall area) x 80% (oiled area) = 55.30 km^2</td></tr>
</table>

Spill	Technique
	i. The oiled area should be sub-divided into areas that relate to a specific oil appearance, see below, following the Bonn Agreement Oil Appearance Colour Code. ii. Care should be taken in the allocation of coverage to appearance, particularly the appearances that relate to higher thicknesses (Discontinuous True Colour and Continuous True Colour). iii. The assessment should be made in-flight and checked post flight using the grid overlay. Photographs, particularly those taken overhead using a digital camera and the visual assessment, should be used to verify data. iv. It is generally considered that 90% of the oil volume will be contained within 10% of the oiled area (normally the leading edge up wind side of the slick). v. In this example, 1% of the slick is continuous true colour, 5% metallic, 24% rainbow and 70% sheen. vi. The Bonn Agreement Colour Code can be used to estimate minimum and maximum thickness for each identified colour, and then the overall minimum and maximum slick volume can be estimated. *Full details are in the Bonn agreement Aerial Surveillance Handbook 2004 (http://www.bonnagreement.org).*

4.5 Control of Oil Spillages that Impact Underground Waters

When underground water is contaminated the following conditions shall apply. POL shall immediately activate an Initial Remedial Action (IRA) Plan, such as free oil/product removal, when applicable, to prevent contaminant migration. Such initial remedial action shall be approved by the Director, Petroleum Resources. Thereafter, the cleanup and groundwater quality monitoring procedures shall follow.

4.6 Mystery Spills (Spills of Unknown Origin)

POL will take prompt and adequate steps to contain, remove and dispose of mystery spill within its operational areas. Where POL has incurred costs in cleaning up a spill for which it is not responsible, POL shall be reasonably compensated, up to the extent of recovering all expenses incurred, including reimbursement of any payments for any damage caused by the spill, through funds established by the Government or the oil industry for that purpose.

For easy identification of oil spills POL shall further carry out finger printing of the spilled oil. The results of the finger printing shall be submitted to the Director of Petroleum Resources.

4.7 Disposal of Recovered Oil

It is fundamental that, as soon as an incident occurs, the right decisions are made and waste management contingency plans are set in motion. This will ensure a successful waste management operation and clean-up and will minimise costs. In any oil spill event, the handling of hazardous oily waste shall follow the "POL Waste Management Plan";

Objectives of waste management are:

i. Safe handling, transportation and storage.
ii. Prevention of secondary pollution.
iii. Reduction in volume of waste.
iv. Reuse of recovered oil.
v. Removal of waste from anywhere it could have an adverse effect on people or the natural environment.

Any oily waste, for example from an inland response or shoreline response, will be disposed in an acceptable manner with approval by DPR and FMEnv. T**able 4.5** below provides a synopsis of POL hazardous waste management procedure:

Table 4.5: Guidance on waste management considerations

Technique	Management procedure	Type of Waste
On water response options	Recovery operations will potentially give rise to a large quantity of waste oil and water for treatment. The type of oil spilled will have an effect on the resultant waste; viscous and waxy oils in particular will entrain debris and can create large volumes of waste. They can also present severe	Oiled equipment, Oiled personal protective equipment (PPE), Recovered oil / oily water, oiled vegetation Oiled sorbent materials Oiled flotsam and jetsam Animal carcasses

Technique	Management procedure	Type of Waste
	handling difficulties. Recovered waste oil will be treated and disposed by incineration or biochemical decomposition offsite	
Dispersant Application	Waste concentrations are minimal as the oil is suspended in the water column and allowed to biodegrade naturally. Debris equipment/tools will be recycled or disposed at approved site.	No hydrocarbon waste is generated, PPE, Empty dispersant drums
Inland/ Shoreline Cleanup	The type of spilled oil will often have a profound effect on the amount of oily waste generated. Waste segregation and minimisation techniques are critical to ensure an efficient operation. These will be established at the initial recovery site and maintained right through to the final disposal site otherwise waste volumes will spiral out of control. Waste sites will be managed in such a way as to prevent secondary pollution.	Oiled equipment/vessels Oiled PPE and workforce Recovered oil / oily water Oiled vegetation Oiled sorbent materials Oiled beach material: • Sand • Shingle • Cobbles Oiled flotsam and jetsam / debris, Animal carcasses, etc.

The clean-up will be conducted by workers mobilized by the Tier 1 and 2. Appeals may be made for volunteer groups to assist from qualified and recognized Non-Governmental Organisations (NGOs). Contaminated sand will be removed with appropriate equipment coordinated by the Tier 2 Base and safely transported to a designated disposal or remediation site. Non-oil stained debris can be managed by accredited Waste Contractor. Oil contaminated soil or sand can be placed in temporary storage cells at on-site locations as designated by the Planning Section Chief and then transported safety to an FMEnv-approved bioremediation site for remediation or incineration. Any liquid oil recovered will have to be placed in containers, treated and then forwarded to a waste oil collection system for recovery through a refining process or other similar system. A separate detailed document called "Waste Management Plan for the Umuseti/Ugbuku field will be utilised for this purpose.

4.8 Handling of External Resources

The handling of external reinforcements of personnel and equipment may impose considerable strain on POL internal arrangements. The following salient points deserve mention here:

a) Helicopter likely to be deployed will be a side-loading Jet Cargo Aircraft
b) An helideck will certainly be required for landing and unloading of certain helicopter and, for fuelling of the helicopter, POL helideck in Umuseti field will be utilised;
c) Availability and deployment of marine crafts;
d) Temporary jetty and cargo handling facilities and, where necessary, water transport;
e) Immigration, Port Health and Customs arrangements are required to be in place for bringing into the country emergency equipment and personnel rapidly (for Tier 3).

4.9 Public Relations

Effective public relations are an integral part of the OSCP. In the event of spillage, POL will make coordinated arrangements for an experienced public relations officer to disseminate pertinent information to the public and the media to ensure that those who need to know have a full and timely appreciation of the incident and of the actions taken and progress made during the response. The contact directories for media houses is attached in ***APPENDIX II.***

4.10 Health and Safety

Personnel health and safety are prime considerations during an incident response when safety issues can be more complex than those during regular industry duties. An oil spill recovery on a watercourse involves boat operations where personnel can potentially be exposed to drowning, toxic and flammable hazards. If an incident occurs, planning for safety of life is the highest priority and will never be compromised regardless of the environmental imperativeness. The Site Safety and Health Plan shall be implemented during incident. Appropriate personal protective equipment (PPE) must be worn by all responders in accordance with the potential risks as determined from risk assessment. All chemicals used shall be approved by the DPR and FMEnv and handled in accordance with the instructions of their corresponding Safety Data Sheet (SDS).

The following will be identified and discussed before commencement of operation:

a) Toxicity of any spilled product
b) Fire and explosion hazards / risk

c) Operations safety guidelines

d) Personal protective equipment

e) Site security

f) Personnel safety responsibilities

SECTION V

RISK RECOVERY

5.1 Background Information

The aftermath of oil spill is usually with losses ranging from financial loss, property damage, and environmental pollution to fatalities in many cases with multiplied effects which include compensation cost, penalties, reputation damage and legal tussles which could threaten the continuous existence of the organisation. Therefore, to ensure POL is able to recover and continue its business in the event of any major oil spill incident, an impact recovery strategy has been incorporated into this OSCP.

In line with regulatory requirement, a post incident environmental restoration and rehabilitation program shall be carried out with the aim of returning the environment to its original condition. Thereafter, necessary compensations and insurance processing are followed.

5.2 Environmental Restoration and Rehabilitation

Once clean-up operations are completed, it may be necessary to restore affected areas to their original condition. The degree of restoration will be determined by the Post Impact Evaluation Study using the appropriate local or internationally accepted standards for restoration. Consideration will be given, as necessary, to replacing contaminated soil, replanting economic trees and farmland, and restocking aqua-cultural projects such as fishing area along the rivers. The restorative process will attempt to achieve acceptable minimum oil content and other target values (quality levels ultimately aimed for) for BTEX, heavy metals and polycyclic aromatic hydrocarbon (PAHS) in the impacted environment (as stipulated in *PART VIII F of EGASPIN 2002).*

In areas identified as having high environmental sensitivity, consideration will be given to establishing a monitoring program to determine the long-term effects on flora and fauna. Concerning oiled wildlife rehabilitation, recovery and interment, the following system will be followed:

- Oiled wildlife shall be designated for rehabilitation by the Wildlife Section of the Forestry Division of Nigeria.
- All oiled wildlife and domestic animal (within the impacted communities) designated for rehabilitation shall be sent for treatment at a registered rehabilitation centre.

The Incident Commander will therefore:

- Liaise with all interested parties regarding the conduct of the operation and the level of cleanliness appropriate to each impacted location.
- Stand down equipment and order its removal to an appropriate location for cleaning and maintenance.
- Ensure that temporary storage sites are restored and other work areas are tidied up. On completion of the foregoing, the relevant Section Chief will:
    a. Ensure all relevant documentations are completed.
    b. Hold a debriefing session with relevant authorities
    c. Prepare final information bulletin.
    d. Ensure that consumed materials are reordered and that damaged equipment/tools are repaired or replaced.
    e. Consolidate costs;
    f. Regularize accounting procedures;
    g. Prepare financial report.
    h. Prepare a formal detailed report (to include time and date of termination).
    i. Address claims for clean-up costs and pollution damage.

5.3 Spill Cost Accounting and Preparation of Claims

In order that financial claims may be processed with minimum delay, it is essential that accurate records are maintained for each clean-up location and include details of all actions taken; the reason for such action; personnel and equipment deployed; and consumable materials used. All meetings shall be documented and receipts of purchases preserved for future reference and for preparation of claims. The Incident Command Team will have overall responsibility for ensuring that these very important records are maintained.

5.4 Post Spill Environmental Evaluation Studies (EES)

POL will conduct an Environmental Evaluation (Post Impact) Study of any adversely impacted environment, in accordance with *PART VIII-A, Article 2.0 of the Environmental Impact Assessment Process Guidelines of EGASPIN 2002.*

5.5 Compensation

In line with *Part B Sec 8.3.1 of EGASPIN 2012*, settlement for damages and compensation shall be determined by direct negotiation between responsible party and affected landlord(s)/communities.

5.6 Insurance Protection

In the event the spill is from POL, the International Oil Pollution Compensation (IOPC) Funds will be engaged at an early stage to ensure that restoration plans are in keeping with the IOPC Fund Guidelines. A comprehensive portfolio of market-leading insurance services for upstream oil and gas companies will be helpful in protecting POL business against a variety of risks present in its business. POL shall be indemnified by its insurance company in the event of oil spill or any disaster. This is expected to assist the company compensate for cost of response, compensation and site rehabilitation/restoration.

5.7 Post-Incident Reports

Following resolution of the incident and termination of the response, a debriefing section shall be held between the concerned parties. An After Action/ Closing Report shall then be submitted to the supporting agencies involved in the Incident Command System within 7 days of closing the particular response. The report shall also incorporate learning points. See DPR/NOSDRA Post Incident reporting format in ***APPENDIX IV***.

REFERENCES

https://dpr.gov.ng/

Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) (2012 Revised)

EES Based EIA for the Proposed Umuseti - Igbuku Oil Field Further Development Project in OML-56, Delta State (2013)

http://www.bonnagreement.org/

International Petroleum Industry Environmental Conservation Association http://www.ipieca.org/

Nigeria National Oil Spill Contingency Plan (2010 Revised)

ANNEXES

APPENDIX I

LIST OF POL SPILL RESPONSE EQUIPMENT AND MATERIALS

1. BOOMS

- Types:
- Total length:
- Draft/freeboard length and weight per unit:
- Design or intended use (e.g. use in open sea or sheltered water operations):
- Mobilization time Means of transportation required:
- Available transportation:
- Personnel for handling:
- Estimated procurement cost/meter:
- Estimated daily rental cost/meter:

2. SKIMMERS AND OTHER PICK-UP DEVICES

- Types, total numbers:
- Weight and size per unit:
- Design or intended use:
- Mobilization time:
- Means of transportation required:
- Available transportation:
- Personnel for handling:
- Estimated procurement cost:
- Estimated daily Rental Cost:

3. EQUIPMENT FOR STORAGE OIL

- Types, total numbers/capacity:
- Weight and size per/unit:
- Additional support equipment necessary:
- Design or intended use:
- Mobilization time:
- Means of transportation required:
- Available transportation:
- Personnel for handling:
- Estimated procurement cost:
- Estimated daily rental cost:

6 SPECIALIZED SHORELINE CLEAN-UP EQUIPMENT (WHEN APPLICABLE)

- Types:
- Weight and size per unit:
- Additional support equipment necessary:
- Design or intended use:
- Mobilization time:

- Means of transportation required:
- Available transportation:
- Personnel for handling:
- Estimated procurement cost:
- Estimated daily rental cost:

5. VESSELS (SPECIALIZED AND OTHERS)

- Type, length, breadth, speed:
- Onboard storage capacity:
- Application (open sea or sheltered waters):
- Mobilization time:
- Personnel for handling:
- Estimated daily rental cost:

6. AIRCRAFT (WHEN APPLICABLE)

- Type, -rotary/fixed wing:
- Operating speed:
- Load capacity:
- Mobilization time:
- Estimated daily rental cost:

7. DISPERSANTS

- Types, total stock of each type:
- System of storage:
- Method of Application:
- Approval Data (e.g. DPR approval reference/number):
- Toxicity, Efficiency and biodegradability data:
- Means of transportation:
- Available transportation:
- Estimated price:
- Expiration Date(s) per dispersant(s):

8. LIGHTERING EQUIPMENT

- Pumps; total stocks by type/capacity and weight including prime mover:
- Hoses; length, diameter and weight/section:
- Fenders; total stocks by type/size and weight 1:
- Personnel for handling:
- Estimated procurement cost:
- Estimated daily rental cost:

9. COMMUNICATIONS AND AUXILLARY EQUIPMENT

- Equipment on Board:
- Portable equipment (on bond and ashore):
- Frequencies:
- Types of emission:
- Power source:
- Signaling lamps:
- Estimated Procurement Cost:

- Estimated daily Rental Cost:

10. OTHERS.

- Lighting Equipment:
- Emergency Safety Equipment:
- First Aid Kits:

APPENDIX II
CONTACT DIRECTORIES

A: PILLAR'S INCIDENT COMMAND SYSTEM (INTERNAL CONTACTS)

ICS Position	Assignees	Present Designation	Phone No.	Mobile
Incident Commander	Spencer Onosode	Managing Director	01-2717071	08066750250
Deputy Incident Commander	Oluseye Fadahunsi	Executive Director	01-2717072	07034069335
Maintenance Chief	Babatunde Olayinka	Manager, Field Operations		08113894428
Health, Safety and Environmental Chief	Adunn Etchie	HSE Manager		08039625003
External Relations Chief	Jacob Ogbekene	Head of Admin/CFO		08052097837
Human Resources Personnel	Ugochukwu Oyita	Field Accountant		08034610066
Materials Chief	Alfred Toluhi	Head, Operations (Lagos)		08113894451
Finance Chief	Jacob Ogbekene	Chief Financial Officer		08052097837
Construction Chief	Anthony Aniekwena	Asset Manager		08186837924
Communications Chief	Adunn Etchie	Head HSE		08039625003
Security Chief	Humphrey Oseji	Security		08113894412
Documentation	Daniel Akpe	HSE Officer		08113894410

B. **PRINCIPAL CONTACTS FOR EXTERNAL NOTIFICATION PROCEDURES (GOVERNMENT/ REGULATORY AGENCIES)**

1. DEPARTMENT OF PETROLEUM RESOURCES (DPR)

LOCATION	NAME	TELEPHONE		EMAIL
		OFFICE	HOME/MOB	
DPR Lagos 7, Kofo Abayomi, Victoria Island Lagos	**M.D.B. LADAN** (Director)	01-2790000 Ext 3421 01-2617461 Ext. 3254	08058298815	
	Mrs O. C. Sibeudu (Head, Safety & Environment)		08056099183	
	Dr. M. M Zagi Assitant Director, Environment		08065506300	
	Mr. A. A. Balogun		08113952145	
DPR Warri 19 Warri/ Sapele Road P.M.B 1275 Warri	**Mr Olugbenga A. Koku** (Warri Zonal Operations Controller)	053-253242, 252601, 250479 053-253226 Ext 21308	08058298857	
	Mr. H. O. Obiora Head, HSE	053-253226 Ext 21308	08113952168	

2. FEDERAL MINISTRY OF ENVIRONMENT (FMENV)

LOCATION	NAME	TELEPHONE		EMAIL
		OFFICE	HOME	
Federal Ministry of Environment, Abuja Independence Way, South Central Area, P.M.B. 265, Garki, Abuja	**Mrs. Nana Fatima Mede** (Perm Sec.) **Mr Bayero** (Pollution Control & Env. Health) **Prof. P. A. Dickson** (Environmental Assessment) **Eneita, Ann** (Planning, Research and Statistics) **Mr. M. M. Omar** (Environmental Conservation)	09-5234119 FMEnv.Office 09-2342808, 2346596-7 - do - - do - - do -	 08033113755	
Federal Ministry of Environment, Lagos	Regional Controller **Mrs O.O Agbenla**	Tel/Fax: 01-5851570-1 01-5850120	08035489539	
Federal Ministry of Environment, Warri	**Mr Emeka Onyetenu** (Zonal Director)	053-256564 Ext. 50447	07081191775	

3. NATIONAL OIL SPILL DETECTION AND RESPONSE AGENCY (NOSDRA)

LOCATION	NAME	TELEPHONE		EMAIL
		OFFICE	HOME/MOB	
5TH Floor NAIC Building Plot 590 Zone A, Central Area, Garki	**Idris Olubola Musa** Director- Oil Field Assessment division **Okwechime, U. (Mrs)** (Director- F & A) **I.O Musa (Director)** (Oil Spill Detection and Response)	09-461-8691-9 09-6714928 09-4618693	08033153547 08033327873 08033153547	info@nosdra.org iomusa2003@yahoo.com
NOSDRA NOSDRA	**Mrs. Felicity Nwakwuushue** (Assistant Director, Warri) **Mrs Okunubi** Zonal Director, Lagos		08056401007 07063695958	

4. OIL PRODUCERS TRADE SECTOR (OPTS) MUTUAL ASSISTANCE PLAN COMMITTEE OFFICIALS

S/N	COMPANY	ADDRESS	NAME/POSITION	TELEPHONE NUMBERS	
				OFFICE	HOME
1	Total Petroleum (Nig.) Ltd.	Total Petroleum (Nig.) Ltd 35 Kofo Abayomi St. Victoria Island	Mr. J Marraud des Grottes (MD) Mr. Obi Iloanusi (GM HSE)	01-2623720 084-236310-23	08034024050
2	Chevron Nig. Ltd	2 Chevron Drive Lekki Peninsular, Lagos	Fred Nelson (MD) Charles Makoju (HSE)	01-3668800 01-2600600, 2668002 Ext.7737	
3	Mobil Producing Nig. Ltd	Mobil House Lekki Expressway V. I, Lagos	J.P.C. Chaptin (MD) C.A. Antaih carol.antaih @exxonmobil.com	01-2621714 Fax:01-2621733 2621640,2621660 Ext.6855 Fax:01-2621733	01-833592 08033000521
4	Nigerian Agip Oil Company	Plot PC 23, Engineering close V. I, Lagos	Mr. Victor Eke-Spiff	084-236400-0 or 01-2600100 08069496081	
5	Pan Ocean Oil Company Nig. Ltd	The Ark Towers Plot 17 Ligali Ayorinde V. I, Logos	Dr. F.A. Fadeyi (MD) Mr. Efe Ani Harris	01-4616030-9 Ext.2202 08023175091	01-2611851
6	Dubri Oil Company Ltd	"The Octagon" Plot 13A, A.J. Marinho Drive, Victoria Island, Lagos	Dr. U.J. Itsueli (MD) Mr. P. Ekhaesombi	01-7740426 01-2625220/ 01-2625226	
7	Conoco Philips Nig. Ltd	39C Ahmed Onibudo Street, Victoria Island, Lagos	Mr. R. Smith (MD) Mr. T. Folorunsho (Manager HSE)	4486868 4486800 08025015554	
8	Consolidated Oil Ltd	Plot 289 Ajose Adeogun Victoria Island, Lagos	Dr. M.E. Omatsola (MD) Mr. A.A. Baiyewu	01-263508 01-2612682	01-2696198

9	Addax Petroleum Development (Nigeria) Ltd.	10 Aboyade Cole Street Victoria Island Lagos 32, Ozumba Nbadiwe Street, Victoria Island Lagos	Vance B. Querio (MD) Amadi Grace (General Manager HSE)	01-2611941 01-2623584/ 07034127360	 01-8135570
10	Shell Pet. Dev. Co. (Nig) Ltd.	Freeman House, 21/22 Marina Lagos	Mr. Basil Omiyi (MD) Davidson Stewart	084.424000 234-844-22215	01-2691723
11	Shell Petroleum Exploration and Production Co. (Nig) Ltd.	P.M.B. 2418 Lagos	Steve Brigg	234(1)2601600 (17 lines)	
12	TOTAL Exploration Petroleum Nigeria Limited	Patrick.ngene @totalfinaelf. com.	Chairman: P.C. Ngene Environmental and Safety Sub-Committee	01-2623720/084-236310 Fax: 01-2621733	08033131150

B. CLEAN NIGERIA ASSOCIATES (CNA)

POL is aspiring to become a supporting member of Clean Nigeria Associates (CNA). In the event the spill magnitude exceeds POL's capabilities, the incident Commander will direct the HSE Chief to call CNA to assist. Below are the CNA phone directories:

HEAD OFFICE: SPDC, FIRE BUILDING, KIDNEY ISLAND, PORT HARCOURT:

1. GM - **CHIBUZOR NNUBIA** - 08033404705, 08056526027
2. ADMIN/ACCTS/MGT. SYSTEMS MANAGER - **RALPH UWHUMIAKPOR** - 08070227885, 08182427437, 08033135064

EASTERN BASE OPERATION:

1. OPS & MAINT MANAGER - **LANRE OGUNTOMOLE** - 08034272682
2. BASE SUPT. ONNE BASE - **UCHE NLEMADIM** - 08039123298, 08121932606
3. ENVR, SAFETY & TRAINING SUPT. - **JONAH SHEKWOLO** - 07036603988
4. EKET BASE SUPVR - **ALEX IHEWUOKWU** – 08037237916

WESTERN OPERATION:

1. OPS & MAINT MANAGER - **BEREMBO WARIBOKO** - 08033791555, 07034574703
2. BASE SUPT. WARRI - **MARK TIMIYAN** - 08037240489, 08058924940
3. BASE SUPT. BRASS - **GODWIN AMORIGHOYE** - 08036712361
4. ENVR, SAFETY & TRAINING SUPT. - **CHIKA UMAHI** - 08033340061, 08183934860

CENTRAL OPERATION:

1. BASE SUPERVISOR - ATLASCOVE LAGOS - **BAYO JOLAIYA** - 08065576233
2. BASE SUPERVISOR - KADUNA - **SULE ABRAHAM** - 08037247759
   SSB Radio Frequency 7414 kHz (main frequency)
3. Wariboko Berembo
4. Chika Umahi 08033340061

WARRI BASE
Telephone: 053-250607 (business hours only)
Advise CNA of the Incident, identify yourself to the dispatcher and provide list of equipment needed.

CNA TECHNICAL COMMITTEE MEMBERS

S/N	COMPANY	REPRESENTATIVE	ALTERNATE
1	AGIP ENERGY	**Mr. R.Orike** PC 23, Engineering Close, V/I, Lagos Tel.Office:084-236400-9 ext 4410, 012600100	**O. Hussein** Nigerian Agip Oil Company Port-Harcourt 08037551316
2	ADDAX	**Vance B. Querio** (Managing Director) Addax Petroleum Development Nigeria Limited. Lagos 01-2621914	**Grace Amadi** (General Manager, HSE) Addax Petroleum Development Nigeria Limited. Lagos 01-2623584
3	CHEVRON	**A. D ADEKUNLE** Manager. Environment & Regulatory Affairs, Chevron Nigeria Limited, Lagos. Tel. Office: 01-2600600 ext.8467 fax:7737 Home: 01-7780987	**TITILAYO AJOSE** HES Specialist, Chevron Nigeria Limited Lagos Tel.Office: 01-2600600 Ext.8596 Fax:7737
4	DUBRI	**Mr. U.Itsueli** Plot 13 A, A.J Marinho drive Victoria Island, Tel.Office: 01-774-4520; Fax:01-7740528	**Mr. P. O EKHAESOMHI** Production Manager Plot 13 A, A.J Marinho drive Victoria Island, Tel. Office: 01-774-4520;
5	ELF	**Mr.Obi Iloanusi** 35 Kofo Abayomi Street Victoria Island, Lagos Phone:084-236310 ext:3670 Obi.iloanusi@total.com	**P.C. Ngene (HSE GM)** Elf Petroleum Nigeria Ltd. 084-236310 Ext. 2777 08034024140
6	MOBIL	**Mr A.J Etuk** Mobil House, Lekki expressway Victoria Island , Lagos Phone : 01-2621704 e-mail: aniefiokj.etuk@exxonmobil.com	**Mrs. G.E ESSIEN** General Manager, Safety Health and Environment(SHE) Tel. Office: 01-2621640 Ext.1250 Fax:1115, Tel Office: D/L 01- Fax:01-2621733
7	NAOC/AGIP ENERGY	**Dr. F.A ANJU** Operations Manager, Port Harcourt, Tel.Office:084-236400-19; DL:084-234044 Tel Home084-334951	**Mr. J.ONYIA** Health Safety &Environment Manager, Port Harcourt, Tel Office:084-236400-9;

8	NNPC	**MR.E.C KALU** NNPC Towers Abuja Tel. Office: 09-2348234;Ext 82800	**Mr. J.ONYIA** Health Safety & Environment Manager, Port Harcourt,
9	PAN OCEAN	**Taiwo Odefunso** Operations Manager, Warri Tel Office:053-252247 ext:122 Mobile:	**Engr. Efe Ani Harris** Assistant Manager HSE , Lagos Plot17 Ligali Ayorinde Street, Victoia island Lagos. Tel Office:
10	**SHELL**	**Steve Brigg** Shell Nigeria Exploration and production Company LTD PMB 2418 Lagos – Nigeria Phone: 234(1)2601600 (17 lines)	**Philip Shekwolo** Tel. Office: 084-237210-35 084-422622 08034062833
11	**NAPIMS**	Group General Manager NAPIMS 01-7901215	**Mr. H. AKPAN** (Manager, Environment, Safety & Protection) NAPIMS, Lagos, Tel. Office: 01-4739335 01-7648898, 08064384245
12	**CAN**	**CHIEF C.NNUBIA** General Manager CNA, Kidney island, Port Harcourt, Tel.Office:084-234614, 08033404705	**Mr. O. OGUNTOMOLE** Maintenance Operations Coordinator, CNA Kidney Island, Port Harcourt, Tel Office: 084-575987, 08035250121

C. **MEDIA HOUSES**

NAME	**ADDRESS**	**TELEPHONE**	**CONTACT**
Daily Times, Sunday Times	3, 5, 7 Kakawa Street. Lagos/Lateef Jakande Road, Agidingbi, Ikeja, Lagos.	01-2661442 01-4977280-3 Fax: 01-4977284	Tayo Awodeju
The Guardian	Rutam House, Isolo, Lagos.	01-4529183 01-4524111 Fax: 01-521982	Eluem E. Izeze
The Punch	1, Kudeti Street. Onipetesi, Ikeja/208/212, Broad Street, Lagos.	01-4972815 Fax: 01-497286	Dickson, Akinwunmi
The statesman	3, Godwin Okigbo Street, off Alh. Masha, Surulere, Lagos.	01-662732 01-662742	

This Day	9, Yinusa Adeniji Street, off Unity Road, off Muslim Ave., Ikeja.	Tel/Fax: 4937779	Victor Ifijeh
Nigerian Television Authority (NTA 2)	N.T.A. Ahmadu Bello Way, Victoria Island, Lagos.		The Manager N.T.A. 2, Lagos.
Nigerian Television Authority Lagos	Tejuosho, Surulere, Lagos.		The Manager N.T.A. 2, Lagos.
Vanguard	Kirikiri Canal, Apapa	01-5871200 01-2645241 01-5875847	Gbenga Adefaye
NTA, Asaba	DBS Junction, Okpanam Road, Asaba	Tel. 56 282976, 08033950646	Nsan Aruk Gladys

APPENDIX III

OIL SPILL REGISTER

FORM 1

The oil spill register (as per attachment VI) serves as a log book for the updating of information on oil spill incidents. It comprises the following information:

Item 1	S/No.	……………………………………..
Item 2	Oil Spill Reference No.	……………………………………..
Item 3	PILLAR	
	Facility/Equipment	…………………………………….
Item 4	Location	……………………………………..
Item 5	LGA:	
Item 6	State	………………………………………
Item 7	Date/Time of spill	…………………………………….
Item 8	Cause of spill	…………………………………….
Item 9	Est. Qty. Spilled (bbls)	……………………………………..
Item 10	Area & date of Survey	………………………………………
Regulatory requirements & date of		
Compliance for items (11 – 17)		………………………………………
Item 11Contractor Name, Number & Value		………………………………………..

Item 12 Form A	The notification document prepared within 24 Hrs Of the Oil Spill / leakage incident.
Item 13 Form B	The document prepared within 14 days of the Oil Spill/Leakage incident after JIV and repairs
Item 14 Form C	The document prepared within 4 weeks of the Oil Spill Response/Clean-up exercise

Item 15 Joint Inspection Visit (JIV)	Joint investigation visit to ascertain the cause of Oil spill/Leakage incident with regulatory bodies and community representatives
Item 16 Clean-up status/Post Clean -up Insp. (PCI) Status	the progressive clean-up state/position of the contaminated area such as tender in progress, clean up in progress or clean-up completed/ Joint visual assessment visit to verify the status of clean-up with regulatory bodies and community representatives.
Item 17 Remark	The column where additional information is written example date of repairs facility (pipeline, flow line, etc.), date of evacuation where applicable, etc.

PILLAR OIL

FORM 2
OIL SPILL RESPONSE REGISTER/LOG
DETAILS:

Location of Spill ……………………………………………………………………………Date of spill ………/………../…………

Days of clean-up ………

Summary of work done

……

……

……

……

……

……

……

……

……

………

COST DATA

NAME	DESIGNATION	SOURCE	HOURS WORKED	EQUIPMENT RETURNED	PAID

PILLAR OIL

APPENDIX IV
DPR AND NOSDRA FORMS

ATTACHEMENT I

(DPR)

FORM 'A' OIL SPILLAGE /LEAKAGE NOTIFICATION REPORT

(To be submitted within 24 hours of Spill Incident)

The Director, From: Oil spill serial No **/20…**
Department of Petroleum Resources, Company:
7 Kofo Abayomi Street,
P.M.B. 12650, Address.
Victoria Island,
LAGOS. Ref: ………………….
Date: ……………………
Please be informed that an oil spillage/leakage has occurred.
1) Facility/Location:
2) Date/Time Observed:
3) Known extent of pollution:
....
4) Precautionary measures taken since the spillage/leakage occurred to prevent hazards that may arise:
....
....
....
5) Probable Cause(s):
....
6) Estimated Quantity Spilled:
Additional details about the spillage/leakage must be reported within 14 days of the spill on the oil Spillage/Leakage report (FORM B). The Oil Spillage response/clean-up report must be submitted within four (4) weeks.
Reporting Officer:
Signature: …………
Designation…

cc. Operations Controller of Appropriate Department of Petroleum Resources Field Office.

PILLAR OIL

(NOSDRA)
FORM A – OIL SPILLAGE/LEAKAGE NOTIFICATION REPORT
OIL SPILLAGE/LEAKAGE NOTIFICATION REPORT
(This report must be submitted within 24 hours of Spill incidence)

The Director General,
National Oil Spill Detection & Response Agency,
5th Floor NAIC Building,
P. M. B. 145,,
Garki,
Abuja.

Oil Spill Ref. No:______________
Ref: ________________________
Date: _______________________

1 **Company: ____**
2 **Incident Details**
(i) Date of Incident: _____________________ (ii) Time of Incident: _________________
(iii) Date of Observation: _____________________ (IV) Time of Observation: ________________
(v) Level of Impact

(a) ☐ No Impact (b) ☐ Slight Impact (c) ☐ Heavy Impact

(i) Estimated Quantity Spilled:

3 Co-ordinates:____

4 **Site /Details**
(i) Site/Location: ____

(ii) Spill Area:
(a) ☐ Land (b) ☐ Swamp (c) ☐ Freshwater

(d) ☐ Mangrove (e) ☐ Coastline (f) ☐ Nearshore

(g) ☐ Offshore (h) ☐ others (specify): _______________________
1
(iii) Containment Measures in Place:
(a) ☐ Boom ☐ Trenches ☐ Bund wall

(d) ☐ Sorbents (e) ☐ others (specify): _______________________

(iv) Type of Oil Containment:
(a) ☐ Crude Oil (b) ☐ Condensate (c) ☐ Chemicals
(d) Refined Products ☐ (e) others (specify): _________
(v) Facility:
(a) ☐ Pipeline (b) ☐ Flowline ☐ Well Head

(d) ☐ Manifold (e) ☐ Flow station (f) ☐ Rig

☐ ☐

(g) Storage tank (h) Compressor Plant

(i) ☐ Others (specify) ________________________________

(v) Properties at Risk:
(a) ☐ Farmland (b) ☐ Fish Pond (c) ☐ Vegetation

(d) ☐ Fishing Net (e) ☐ Surface water (f) ☐ Venerable Objects

(g) ☐ Others (specify):___________________________________

Reporting officer: ____
Designation:
Signature: ______________________________ **Date:** _________________

Reporting officer: ____
Designation: **E.D Technical**

Signature: ____________________________ Date: ________________________

CC: Zonal Director, NOSDRA, Warri
Oil shall be deemed to mean both crude and refined petroleum products.
**RBA Report must be submitted within 2 weeks of the Spill Incidence*

PILLAR OIL

ATTACHEMENT II
FORM B (DPR)

FORM B – OIL SPILLAGE/LEAKAGE REPORTING

Attachment II: OIL SPILLAGE/LEAKAGE REPORT

(To be submitted within fourteen (14) days of the spill incident)

The Director General,
Department of Pet. Resources,
Ministry of Pet. Resources, 7 Kofo Abayomi Street,
PMB 12650, Victoria Island,
Lagos.

Oil Spill Serial No: ___________________
Company: _________________________
Address: ____________________
Ref: ___________________________
Date: __________________________

1. Date/time of occurrence: ____
2. Date/time of observation: ____
3. Co-ordinates: ____

4(a) Facility: ______________________________

(i) OPL.OML No/Unit Desc: _____________

(ii) Nearest town: ______________________

(iii) State: _____________________________

4(b) Operational Area

(i) ☐ Land

(ii) ☐ Offshore

(iii) ☐ Coastland

(iv) ☐ Swamp

(v) ☐ Inland Waters

4(c) Type of spill/leak

(i) ☐ Crude Oil

(ii) ☐ Product (Specify)

(iii) ☐ Drilling Mud/Chemicals

(IV) ☐ Others (Specify)

4(d) Type of operation at spill site: ____

5. Cause of Leakage/Spillage

(a) ☐ Unknown (b) ☐ Blowout

(c) ☐ Equipment Failure (Specify) (d) ☐ Operator/Maintenance

Error ☐ ☐

(e) Corrosion (f) Sabotage

(g) ☐ Sand/Erosion/Wave (h) ☐ Accident

(i) ☐ Others (Specify)

6 Weather Conditions

(a) ☐ Bright & Sunny (b) ☐ Cloudy

(c) ☐ Rainy (d) ☐ Other (Specify)

(e) Wind direction: ______________________ (f) Wind speed: _________

7 Sea Conditions

(a) ☐ Calm (b) ☐ Rough (c) ☐ Not

Applicable

(d) Direction of Current: ____

(e) Strength of Current: ______________________________________

(f) Swell height: ____

(g) Tidal Condition ☐ High ☐ Low

8 Quantity Leaked

(a) Estimated quantity of oil/contaminant leaked: ______________________

(b) Detailed calculations: (attach additional sheets if necessary) ________

9 Quantity of crude oil/contaminant recovered as at time of reporting: _________

10 Details of immediate pollution to inland waters, beaches, farmland, etc.: ______

11 Steps being taken to prevent further pollution:

____

____

____

____

12 Any Casualties?

(a) [ ] Yes (b) [ ] No

If yes, give details:

____

____

____

Health, Safety & Environment Manager: __________________________________

E.D Technical ___________________________________

c.c. (2) Operations Controller of Appropriate Department of Petroleum Resources, Field Office

(3) The Group General Manager, NAPIMS, Lagos

(4) The Managing Director, ConocoPhillips Nig. Ltd., Lagos

Oil shall be deemed to mean both crude and refined petroleum product.

PILLAR OIL

FORM B (NOSDRA)

FORM B –OIL SPILLAGE/LEAKAGE REPORTING

RISK BASED ASSESSMENT (RBA) OF OIL SPILL INCIDENCE

(This report must be submitted within 2 weeks of the Spill Incidence)

The Director General,
National Oil Spill Detection & Response Agency,
5th Floor NAIC Building,
P. M. B. 145, Garki, Abuja.

Oil Spill Ref. No ______________________
Ref: ____________________________
Date: ____________________________

1 Company: ____

2 Date of Assessment: ____

3 Incident Details

(i) Date of Incident: _______________________ (ii) Date spill was stopped:_________

(iii) Co-ordinates: ____

(iv) Method Used:

(a) ☐ Clamping (b) ☐ Well Shut-in (c) ☐ F/Station shut down

(d) ☐ Others (specify): ____

(v) Estimated quantity Spilled: ____

(vi) Estimated quantity recovered: ____

(vii) Cause of Spill:

(a) ☐ Corrosion (b) ☐ Equipment failure

(c) ☐ Third Party Interference (d) ☐ Accident

☐ ☐

(e) Operational Error (f) others (specify): ______

4 **Site Details**

(i) Site/Location ____

(ii) Spill Area:

(a) ☐ Land (b) ☐ Swamp (c) ☐ Freshwater (d) ☐ Mangrove

(e) ☐ Coastline (f) ☐ Nearshore (g) ☐ Offshore

(h) ☐ Others (specify): ____

(iii) Facility:

(a) ☐ Pipeline (b) ☐ Flowline ☐ Well Head

(d) ☐ Manifold (e) ☐ Flow station (f) ☐ Rig

(g) ☐ Storage tank (h) ☐ Compressor Plant

(i) Others (specify): ____

5 **Site Characterization**

(i) Sea Conditions

(a) ☐ Calm (b) ☐ Rough (c) ☐ Not applicable

(d) ☐ Low Tide (e) ☐ High Tide

Current direction: ____

Swell Height: ____

Current Strength: ____

(ii) Weather Conditions

(a) ☐ Bright Sunny (b) ☐ Rough (c) ☐ Slight Rain

(d) ☐ Others (specify): ________________________________

Temperature: ____

Wind Direction: ____

Wind Speed: ____

Relative Humidity: ____

6 Visual Observation

(i) Any oil sheen on water ☐ Yes ☐ No ☐ N/A

(ii) Any soil wet with oil ☐ Yes ☐ No ☐ N/A

(iii) Any patches of oil on site ☐ Yes ☐ ☐ N/A

(iv) Any oil sheen on soil sediment when disturbed ☐ Yes ☐ No ☐ N/A

(v) Any oil stain on vegetation ☐ Yes ☐ No ☐ N/A

<u>Receptor Assessment</u>

Receptor	Pathway to Impacted Area (m^2)	Distance Impacted Area (m^2)	Estimated Area of Impact (m^2)	Receptor Impacted (Yes/No)	Remark
Farmland					
Fish Pond					

Vegetation					
Surface Water					
Ground Water					
Venerable Object					
Human Habitation					
Livestock					
Plantation					
Swamp					

7 Any Casualties Yes ☐ No ☐

If yes, Give details ____

____

8 Clean-up Program details

(a) Method of Clean-up ____

(b) Time frame for clean-up____

9 General Remarks

____

____

____

Reporting Officer: __________________________ **Signature:** ________________

Designation: **Health, Safety & Environment Manager** **Date:** _____________________

____

Reporting Officer: __________________________ **Signature:** ________________

Designation: **E.D Technical** **Date:** _____________________

c.c: Zonal Director, NOSDRA, Port Harcourt/ Warri.

Oil shall be deemed to mean both crude and refined petroleum products

Clean-up program report must be submitted within 4 weeks of spill incidence.

Attachment III

FORM C (DPR)

OIL SPILLAGE RESPONSE/CLEANUP REPORT FORM C

Attachment III: FORM C – OIL SPILLAGE RESPONSE/CLEAN UP REPORT

OIL SPILLAGE RESPONSE/ CLEANUP REPORT

(To be submitted within four (4) weeks of the spill incident)

The Director,

Department of Petroleum Resources,

Ministry of Petroleum Resources,

No. 7 Kofo Abayomi Street,

PMB 12650,

Victoria Island,

Lagos.

1 Date of spill: ______________________________ Oil Spill Ref. No.________________

2 Time: ___________________________________ Company: ____________________

3 Place of spill: ___________________________

____

4 Steps taken to clean up the spilled oil: Address:

____

____

____

____ Ref:

____

5 Cleanup party: ___________________________ Date:

____

____

____

6 Equipment/Containment Method Chemical Dispersants

(a) ☐ Bund walls (a) Type: ______________

(b) ☐ Booms (b) Quantity: _______________

(c) ☐ Sorbents (c) Not Applicable: _________

(d) Other (Specify) ____

8 Progress of clean-up (tick)

Not Started	**20%**	**40%**	**60%**	**80%**	**Completed**

9 Clean-up duration: ____

10 Man hours used:

____

11 Amount of crude oil/contaminant recovered

____

12 Damage to the Environment

(a) ☐ Land/Soil Media:

____

(b) ☐ Water Bodies:

____

(c) ☐ Air Media:

____

13 Rehabilitation plans for the impacted area:

____

____

____

14 Cost of Spill

(a) Naira loss due to oil spilled:

____

(b) Cleanup cost:

____

(c) Down time man hours lost:

____

(d) Repair work:

____

(e) TOTAL:

____

15 Compensation paid, if any :

____

16 Method of Settlement of Damage Claimed

(a) ☐ Arbitration (d) ☐ direct negotiation Between landlord and the company

(b) ☐ Court Settlement

(c) ☐ Other (Specify) (e) ☐ Not Applicable

17 Specify any follow-up studies:

____

____

____

18 Other remarks:

____

____

PILLAR OIL

Health, Safety &Environment Manager:

____

E.D Technical: ____

c.c: Operations Controller of Appropriate Department of Petroleum Resources, Field Office

**** Oil shall be deemed to mean both crude and refined petroleum product.***

FORM C (NOSDRA)

OIL SPILL RESPONSE/CLEANUP REPORT

SITE CLEAN-UP/REMEDIATION ASSESSMENT REPORT

(This report must be submitted within 2 weeks of the Spill Incidence)

The Director General,
National Oil Spill Detection & Response Agency,
5th Floor NAIC Building,
P. M. B. 145, Garki,
Abuja.

Oil Spill Ref. No:______________________
Ref: _____________________________
Date: ______________________________

1 Company:

____

2 Date of Assessment:

____

3 Site Details

(i) Site/Location:

____

(ii) Date/Time of incident:

____

(iii) Area & Depth of impact:

____

(iv) Contaminated Media:

(a) ☐ Vegetation (b) ☐ Soil (c) ☐ Sediment

(d) ☐ In-land surface water (e) ☐ Brackish Swamp surface water

(f) ☐ Offshore surface water ☐ Underground water

(i) ☐ Others (specify):______________________________________\

4.(i) Date clean-up programme

Commenced: ____

(ii) Method of Clean-up

(a) ☐ Low pressure wash (b) ☐ Manual (c) ☐ Mechanical

(d) ☐ Surface wash (e) ☐ Sorbents ☐ Chemical dispersant

(g) ☐ Vacuum skimming (h) ☐ others (specify): ____________________

(iii) Estimated quantity of oil/contaminant

Recovered: ____

(iv) Method of Oil Debris Disposal:

(a) ☐ Controlled incineration (b) ☐ Buried in lined pit

(c) ☐ Chemical Treatment (d) ☐ Sanitary Landfill

(e) ☐ Land farming (f) ☐ others (specify):_______

5. Site Visual Observation:

(i) Nature of Soil:

(a) ☐ Oil sheen present (b) ☐ No oil sheen present

(c) ☐ Others (specify):

____

(iii) Nature of Vegetation:

(a) ☐ Withered (b) ☐ Withering (c) ☐ Luxuriant

(iv) Site Photos ☐ Yes ☐ No

(v) Date site clean-up ended:

____

(vi) Samples collected after clean-up program:

(a) ☐ Soil (b) ☐ Sediment (c) ☐ Water

(d) ☐ Others (specify):

____

6. Results of Laboratory Analysis of Samples collected Pre/Post Remediation

Parameter	Sample	Test Method	Result	
			Pre-Remediation	**Post-Remediation**
TPH				
Trace Metals				
Arsenic				
Barium				
Cadmium				
Chromium				
Cobalt				
Copper				
Mercury				
Lead				
Nickel				
Zinc				
Total Dissolved Solid				
Total Suspended Solids				

7 Does site require remediation ☐ Yes ☐ No

If Yes,

(i) Date site remediation commenced:

____

(ii) Method of Remediation;

(a) ☐ Land farming (b) ☐ Biopile (c) ☐ Bio venting

(d) ☐ Air Sparging (e) ☐ Chemical Oxidation (f) ☐ Washing/Leading

(g) ☐ Phyto remediation (h) ☐ Enhanced natural attenuation

(i) ☐ Monitoring enhanced natural attenuation ☐ Thermal desorption

(k) ☐ Others (specify):

____

(iii) Is remediation method (a) ☐ In situ (b) ☐ Ex situ

(iv) Details of remedial method (*attach as an annex*)

8. Details of rehabilitation plan for impacted population (*attach as an annex*)

9. Cost of spill:

(a) Clean-up cost:

____

(b) Cost of remediation:

____

(c) Cost of repair works:

____

(d) Naira loss due to oil spilled:

____

(e) Lost man Hours:

____

Total: ____

10. Compensation paid, if any:

____

11. Method of Settlement of Claim:

(a) ☐ Arbitration/Mediation ☐ Direct negation b/w Landlord & Operator

(b) ☐ Court Settlement (d) ☐ Not applicable

(e) ☐ Others (specify): ____

12. Date/Time of visit by Regulators: ____

13. Remarks by any third party:

____

____

____

14 General Remarks:

____

____

____

15. NOTE: Officials of NOSDRA must be present when samples are collected and when analyses begin.

Reporting Officer:	________________________________	**Signature:** ____________	
Designation:	**Health, Safety & Environment Manager**	**Date:**	_______________

Reporting Officer:	________________________________	**Signature:** ____________	
Designation:	**E.D Technical**	**Date:**	______________

Cc: Zonal Director, NOSDRA, Port Harcourt/Warri.

Oil shall be deemed to mean both crude and refined petroleum products

Clean-up program report must be submitted within 4 weeks of spill incidence.

PILLAR OIL

ATTACHMENT IV

OIL SPILL SITE INSPECTION REPORT

Attachment IV: OIL SPILL SITE JOINT INVESTIGATION VISIT REPORT

SPILL REFERENCE NO_______

SUMMARY SHEET

Date of Spill: …………………………. **Location of Spill:** ………………………………………………………

Extent of Contaminated Area: ………………………………………………………………………………….

(i) PILLAR OIL Property……………………………………………………………………………….

(ii) Other: ……………………………………………………………………………….

Cause of Spill: Operational Error ☐ Equipment Failure ☐ Structure Failure ☐

Sabotage ☐ Corrosion ☐ Others

(Specify)…………………………..

Quantity Spilled: ……………………………………………. **Time of Inspection** …………………………..

Spill site Coordinates: ……………………………………………………………………………………………

Community Allowed Access: NO ☐ YES ☐

Reason: ………………………………………………………………………………………………………

Class of Spill: Minor ☐ Medium Major

N/A

APPENDIX V

EMERGENCY OPERATION CENTRE

The Emergency Operations Centre (EOC) or Incident Command Post provides several key elements:

- A known sheltered place where supervisory personnel can meet and discuss management issues relating to response and clean-up.
- Communications equipment, both internal and external, including direct links to vessels, helicopters, and vehicles.
- Storage of reference materials such as charts, computerized sensitivity maps, and spill trajectory modelling systems.
- Possible first aid care.
- Dealing with the media

Types of Incident/Onsite Command Posts

Type of Command Post	**Furnishings**	**Equipment**
Incident Command Post		
Existing Buildings or Operations Rooms	Tables, chairs, sleeping facilities, white board, flip charts	Telephones, TVs, Video links, Computers, Projectors Mobile Radios, Power Generator, Photocopier
	Conference Table Chairs, Kitchen, White Board	Screen, Projectors, Power Generator, Photocopying
	Conference Table Chairs, Kitchen, White Board	Telephone, Screen, Projectors, Fax, Power Generator, Photocopying

	Conference Table Chairs, Kitchen, white board, flip charts	Meteorological feed, Screen, Whiteboard, Telephone, Internet, Projectors, Mobile Radios, Fax, Photocopying, TV, Scanner, Plotter
	Tables, chairs, sleeping facilities, white board, flip charts	Telephones, TVs, Computers, Projectors Mobile Radios, Power Generator, Weather stations, emergency water supply, VHF repeaters, VHF Handheld Radios, Desk Dispatch Radio Phone, Satellite video, Photocopier
On-site Command Post		
Self-contained Mobile Facility: Buses, Vans and Trucks	Tables, chairs, white board, flip charts	Phones, TVs, Video, Computers, Projectors, Mobile Radios, Generator, Copiers

Appendix 4.1a-Chain of Custody-Dry Season

JENNEOBY
ENVIRONMENTAL & LABORATORY SERVICES LTD

Jenneoby Environmental and Laboratory Services Limited
LABORATORY DEPARTMENT
13 Chief Albert Iyorah Street, off Babatunde Anjose Street, Off Admiralty Way,Lekki Phase 1, Lagos Nigeria.
+2348115706631; +2348124461879
jenneobyng@gmail.com, info@jenneoby.com

INSITU DATA SHEET

I. Ensure proper container packaging.
II. Ensure samples are properly preserved.
III. Ship samples promptly following collection.

Company Name: Pillar Oil Limited
Sampler: Chemtek
Project Location/ Title: EIA of further field development of Umusebi-Igbuku, OML 56, Delta State.

DATA RESULT

Sample ID	Date	Time	pH	Temp (°C)	E.C (µS/cm)	Salinity (ppt)	Turbidity (NTU)	DO (mg/l)	Redox potential (mV)	TDS (mg/l)
POL GW1	26/02/2020		6.76	24.5	97.1	0.05	0.0	3.87	125.5	48.5
POL GW2	26/02/2020		6.94	24.5	49.2	0.03	0.0	3.94	141.2	24.6
POL GW3	26/02/2020		6.37	24.5	387	0.19	0.0	3.82	188.8	193.7
POL GWC	26/02/2020		7.38	24.6	45.7	0.03	0.0	3.90	123.3	22.8
POL SW1	26/02/2020		6.33	24.6	91.1	0.05	0.1	4.22	102.4	45.5
POL SW2	26/02/2020		6.38	24.6	72.9	0.04	1.8	4.40	92.2	36.5
POL SW3	26/02/2020		6.26	24.6	72.6	0.04	2.1	4.63	101.4	36.3
POL SWC	26/02/2020		6.07	24.6	69.8	0.04	2.4	4.56	119.2	34.9

Witnessed by / Sign:

Witnessed by / Sign:

Date: Time:

Delivered by / Sign: Mr. Tony

Received by / Sign: Ismail

Date: 27/02/2020 Time: 10:34am

Remark/Condition of Sample: Good Condition

JENNEOBY
ENVIRONMENTAL & LABORATORY SERVICES LTD

Jenneoby Environmental and Laboratory Services Limited
LABORATORY DEPARTMENT
13 Chief Albert Iyorah Street, off Babatunde Anjose Street, Off Admiralty Way,Lekki Phase 1,
Lagos Nigeria,
+2348115706631; +2348124461879
jenneobyng@gmail.com, info@jenneoby.com

CHAIN- OF -CUSTODY RECORD

i. **Ensure proper container packaging.**
ii. **Ensure samples are properly preserved.**
iii. **Ship samples promptly following collection.**

Company Name: Pillar Oil Limited
Sampler: Chemtek
Project Location/ Title: EIA of further field development of Umuseti-Igbuku, OML56, Delta State.

Sample ID	Sampling: Date	Sampling: Time	Container: Glass	Container: Plastic	Container: Teflon Bag/Foil paper	Preservation Method: HNO_3	Preservation Method: H_2SO_4	Preservation Method: CH_3OH	Preservation Method: Ice	Preservation Method: None	Sample Matrix: Water	Sample Matrix: Soil/Sediment	In-situ	Physiochemical	BOD/COD	Heavy Metals	Organics (TPH/THC/O&G, etc.)	Microbiology	Geographical Co-ordinate
DOL TS 1-17					Teflon				✓			Soil					✓		
DOL SS 1-17					✓				✓			✓					✓		
DOL TS C1-3					✓				✓			✓					✓		
DOL SS C1-3					✓				✓			✓					✓		
DOL SED 1					✓				✓			Sed.					✓		
DOL SED 2					✓				✓			✓					✓		
DOL SED 3					✓				✓			✓					✓		
DOL SED C					✓				✓			✓					✓		

Witnessed by / Sign:
Witnessed by / Sign:
Date: Time:

Delivered by / Sign: Mr. Tony
Received by / Sign: Ismail
Date: 27/02/2020 Time: 10:34am

Remark/Condition of Sample: Good Condition

CHAIN OF CUSTODY

Project Name: EIA OF FURTHER FIELD DEVELOPMENTOF UMUSETI IGBUKU FIELD, OML 56
Submitted By: AFRUITFUL ENV LTD
Received By: JENCDBY ENV LTD
Date of Sample Collection: 25/02/20
Date of Receipt of Samples: ______________
Sample Type: Surface Water (✓)

3. SURFACE WATER

S/N	Sample I.D	Sample Type	Analysis Required
1	SW 1	Surface water (downstream)	(1)Physico-chemistry (in 0.5L plastic bottle): DO, COD, TDS, turbidity, redox potential, salinity, acidity, hardness, electrical conductivity, sulphate, nitrate, phosphate, Percent Carbon, Oil and Grease, Available Phosphate, Total Nitrogen, Ammonium, Nitrate, Nitrite, Cation Exchange Capacity (CEC), Exchangeable cations - Na, K, Mg and Ca, etc.
2	SW 2	Surface water (midstream)	
3	SW 3	Surface water (upstream)	
4	SW C	Surface water (control)	
			(2)Organics and Oil & Grease (in clear silica bottle): PAH, TPH, THC, BTEX, Phenols, Oil and Grease, etc. (3) SW Microbiology: Total Heterotrophic Bacteria and Fungi. Hydrocarbon utilizing bacteria, Total Heterotrophic bacteria, Hydrocarbon, etc. (4) Heavy metals (in 100ml plastic bottle): Fe, Zn, Ar, As, Pb, Hg, V, Cr, Ba, Cu, Ni, Zn, and Cd etc. (5) BOD (amber bottles): BOD

Prepared By:	Transferred By:	Received By:	Regulator (FMENV):	Regulator (DPR):
AGBOOLA O.O.			Tuomukime Ruth	Ahmad, C.A
Date/Sign: 25/02/20	Date/Sign:	Date/Sign:	Date/Sign: 25-02-2020	Date/Sign: 26/02/20

Project Name: EIA OF FURTHER FIELD DEVELOPMENTOF UMUSETI IGBUKU FIELD, OML 56

Appendix 4.1b-Chain of Custody-Wet Season

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE: EIA OF FURTHER DEVELOPMENT OF UMUSEDI - IGBUKU FIELD, OML 56	COMPANY NAME: PILLAR OIL LTD	JACIO ENVIRONMENTAL LIMITED 3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.	METHOD OF PRESERVATION: Ice Chest Cooling

S/N	SAMPLED		COORDINATES		FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
	DATE	TIME	NORTHING	EASTING							
1	5/6/20	8:50			PO/EIA2/SED3			✓	Sediment	As Required in the COR	
2	✓	9:10			PO/EIA2/SED1			✓			
3	✓	9:40			PO/EIA2/SED2			✓			OK
4	✓	10:14			PO/EIA2/SED4			✓			

RELINQUISHED BY: Okoro N
SIGN: [signature]
DATE/TIME: 6/06/2020 8:52am

RECEIVED BY: Osazuwa Solomon
SIGN: [signature]
DATE/TIME: 6/06/2020 8:52am

COMMENTS: Samples were properly labelled and sampled

SAMPLER: (Please Print) Okoro N. [signature] 5/6/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020

FMENV REP. (NAME & SIGNATURE/DATE)

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE: EIA OF FURTHER DEVELOPMENT OF UMUSETI-IGBUKU FIELD, OML 56

COMPANY NAME: PILLAR OIL LTD

JACIO ENVIRONMENTAL LIMITED
3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.

METHOD OF PRESERVATION: Ice Chest Cooling, H_2SO_4, HNO_3

S/N	SAMPLED DATE	SAMPLED TIME	COORDINATES NORTHING	COORDINATES EASTING	FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
1	5/6/20	9:20			POL/EIA3/GW01	6	✓		Ground Water	As Required in the TOR	
2	✓	9:50			POL/EIA3/GW02	✓	✓				
3	✓	10:20			POL/EIA3/GWC	✓	✓				OK
4	✓	10:50			POL/EIA3/GW03	✓	✓				

RELINQUISHED BY: Okoro -N
SIGN: [signature]
DATE/TIME: 06/6/20

RECEIVED BY: OSAZUWA SOLOMON
SIGN: [signature]
DATE/TIME: 6/6/20

SAMPLER: (Please Print) Okoro N [signature] 5/6/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020

FMENV REP. (NAME & SIGNATURE/DATE)

COMMENTS: Samples were properly labelled and sampled prior to lab. analysis.

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE: EIA of Futher Development of Umuseti-Igbuku Fields OML 56

COMPANY NAME: PILLAR Oil LTD

JACIO ENVIRONMENTAL LIMITED
3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.

METHOD OF PRESERVATION: Ice Chest Cooling @ H_2SO_4 & HNO_3

S/N	SAMPLED DATE	SAMPLED TIME	COORDINATES NORTHING	COORDINATES EASTING	FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
1	5/6/20	8:50am			POL/EIA2/SW03	6	✓		Surface Wt		
2	✓	9:10am			POL/EIA2/SW01	✓	✓		Surface Water	As Required in the TOR	Satisfactory
3	✓	9:40am			POL/EIA2/SW02	✓	✓				
4	✓	10:11am			POL/EIA2/SWC	✓	✓				

RELINQUISHED BY: Okoro .N
SIGN: [signature]
DATE/TIME:

RECEIVED BY: Osa Zelina Solomon
SIGN: [signature]
DATE/TIME: 06/06/20

SAMPLER: (Please Print) Okoro Ndidi [signature] 5/06/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020

FMENV REP. (NAME & SIGNATURE/DATE)

COMMENTS: Sample were properly Preserved and labelled.

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE: EIA OF FURTHER DEVELOPMENT OF UMUSETI - IGBUKU FIELD, OML 56	COMPANY NAME: PILLAR OIL LTD	JACIO ENVIRONMENTAL LIMITED 3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.	METHOD OF PRESERVATION: Formaline

S/N	SAMPLED		COORDINATES		FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
	DATE	TIME	NORTHING	EASTING							
1	5/6/20	8:50			POL/EA2/BT03			✓	Benthos	As Required in the COR	
2	✓	9:10			POL/EA2/BT01			✓			OK
3	✓	9:40			POL/EA2/BT02			✓			
4	✓	10:14			POL/EA2/BTC			✓			

RELINQUISHED BY: Okoro N
SIGN: [signature]
DATE/TIME:

RECEIVED BY: OSAZUWA SOLOMON
SIGN: [signature]
DATE/TIME: 05/06/20

SAMPLER: (Please Print) Okoro Ndidi · [signature] 5/06/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020.

FMENV REP. (NAME & SIGNATURE/DATE)

COMMENTS:
Samples were properly labelled and sampled.

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE:	COMPANY NAME:		METHOD OF PRESERVATION
EIA of Further Development of Umusebli Igbuku Field OML 56	Pillar Oil Ltd	JACIO ENVIRONMENTAL LIMITED 3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.	

S/N	SAMPLED		COORDINATES		FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
	DATE	TIME	NORTHING	EASTING							
1	5/6/20	8:50am			POL/EIA2/PP03		✓		Plankton		
2	✓	9:10am			POL/EIA2/PP01		✓			As required	
3	✓	9:40am			POL/EIA2/PP02		✓			in the	
4	✓	10:14			POL/EIA2/PP/C		✓			TOR	

RELINQUISHED BY: Okoro N
SIGN: [signature]
DATE/TIME

RECEIVED BY: OSAZUWA SOLOMON
SIGN: [signature]
DATE/TIME: 06/06/20

SAMPLER: (Please Print) Okoro Nduka [signature] 5/6/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020.

FMENV REP. (NAME & SIGNATURE/DATE)

COMMENTS:
Samples were clearly labelled

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE: EIA OF FURTHER DEVELOPMENT OF UMUSETI –IGBUKU FIELD, OML 56	COMPANY NAME: PILLAR OIL LTD.	JACIO ENVIRONMENTAL LIMITED 3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.	METHOD OF PRESERVATION

S/N	SAMPLED DATE	SAMPLED TIME	COORDINATES NORTHING	COORDINATES EASTING	FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
1					POL/EIA$_2$/TS1	2			SOIL	Physico chemistry, MB, O & G	
2					POL/EIA$_2$/SS1	2					
3					POL/EIA$_2$/TS2	2					
4	–				POL/EIA$_2$/SS$_2$	2					
5					POL/EIA$_2$/TS3	2					OK
6					POL/EIA$_2$/SS3	2					
7					POL/EIA$_2$/TS4	2					
8					POL/EIA/SS4	2					
9					POL/EIA/TS5	2					
10					POL/EIA/SS5	2					
11					POL/EIA/TS6	2					
12					POL/EIA/SS6	2					
13					POL/EIA/TS7	2					
14					POL/EIA/SS7	2					

RELINQUISHED BY:
SIGN:
DATE/TIME

RECEIVED BY: OSAZUWA SOLOMON
SIGN: [signature]
DATE/TIME 05/06/20

COMMENTS: Samples were properly preserved prior for lab. analysis.

SAMPLER: (Please Print) ~~OKOROAFOR MADUEKE~~ Dr Dare Agboola [signature] 05/06/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020

FMENV REP. (NAME & SIGNATURE/DATE)

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE:	COMPANY NAME:		METHOD OF PRESERVATION
E/A OF FURTHER DEVELOPMENT OF UMUSETI-IGBUKU FIELD, OML 56	PILLAR OIL LIMITED	**JACIO ENVIRONMENTAL LIMITED** **3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.**	

S/N	SAMPLED		COORDINATES		FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
	DATE	TIME	NORTHING	EASTING							
29					POL/EIA/TS15	2			SOIL	Physicochemistry, MCB	
30					POL/EIA/SS15	2					
31					POL/EIA/TS16	2					
32	—				POL/EIA/SS16	2					Ok
33					POL/EIA/TS17	2					
34					POL/EIA/SS17	2					
35					POL/EIA/TSC1	2					
36					POL/EIA/SSC1	2					
37					POL/EIA/TSC2	2					
38					POL/EIA/SSC2	2					
39					POL/EIA/TSC3	2					
40					POL/EIA/SSC3	2					

RELINQUISHED BY:

SIGN:

DATE/TIME

RECEIVED BY: OSAZUWA SOLOMON

SIGN: [signature]

DATE/TIME 06/06/2020

COMMENTS: Samples were properly labelled and preserved.

SAMPLER: (Please Print) OMAMWAN NWOKEDI Dr Dave Agboola [signature] 05/06/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. [signature] 05/06/2020.

FMENV REP. (NAME & SIGNATURE/DATE)

FIELD CHAIN OF CUSTODY RECORD

JOB/PROJECT TITLE: EIA OF FURTHER DEVELOPMENT OF UMUSETI, IGBUKU FIELD, OML 56	COMPANY NAME: PILLAR OIL LIMITED	JACIO ENVIRONMENTAL LIMITED 3, AIROBOYI ESTATE, KM 2 REFINERY ROAD, EFFURUN, WARRI, DELTA STATE.	METHOD OF PRESERVATION

S/N	SAMPLED DATE	SAMPLED TIME	COORDINATES NORTHING	COORDINATES EASTING	FIELD SAMPLE ID	#OF CONTAINER	COMPOSITE	GRAB	SAMPLE MATRIX	ANALYSIS REQUIRED	REMARK
15					POL/EIA/TS8	2					
16					POL/EIA/SS8	2					
17					POL/EIA/TS9	2					
18					POL/EIA/SS9	2					OK
19					POL/EIA/TS10	2					
20					POL/EIA/SS10	2					
21					POL/EIA/TS11	2			SOIL	Physico chemistry & O&G, MB	
22					POL/EIA/SS11	2					
23					POL/EIA/TS12	2					
24					POL/EIA/SS12	2					
25					POL/EIA/TS13	2					
26					POL/EIA/SS13	2					
27					POL/EIA/TS14	2					
28					POL/EIA/SS14	2					

RELINQUISHED BY:

SIGN:

DATE/TIME

RECEIVED BY: OSAZUWA SOLOMON

SIGN:

DATE/TIME 6/6/2020

SAMPLER: (Please Print) Dr Dave Agboola 05/06/20

DPR REP. (NAME & SIGNATURE/DATE) Salihu, B.S. 05/06/2020.

FMENV REP. (NAME & SIGNATURE/DATE)

COMMENTS: Samples were properly stored and transported

Appendix 4.3a_Dry_Season Results 2020

APPENDIX 4.3A

Table 1: Sampling Georeferenced Point for all Environmental Parameters

Sample ID	Sample	Longitude	Latitude
Soil and Vegetation			
1	Soil & Veg	6.39851	5.66711
2	Soil & Veg	6.39741	5.66533
3	Soil & Veg	6.39747	5.66713
4	Soil & Veg	6.39862	5.66594
5	Soil & Veg	6.39743	5.66622
6	Soil & Veg	6.39816	5.66593
8	Soil & Veg	6.39785	5.66643
9	Soil & Veg	6.39707	5.67041
10	Soil & Veg	6.40060	5.66876
11	Soil & Veg	6.40599	5.66273
12	Soil & Veg	6.41092	5.66029
13	Soil & Veg	6.40678	5.65371
14	Soil & Veg	6.41224	5.61530
15	Soil & Veg	6.41550	5.61560
16	Soil & Veg	6.41440	5.61374
17	Soil & Veg	6.41070	5.61935
	Control - Soil & Veg	6.42287	5.67347
	Control - Soil & Veg	6.43925	5.62267
	Control - Soil & Veg	6.37664	5.64060
Air Quality and Noise Level			
1	Air Quality & Noise	6.41199	5.6087
2	Air Quality & Noise	6.41171	5.60876
3	Air Quality & Noise	6.41082	5.60944
4	Air Quality & Noise	6.41074	5.60766
5	Air Quality & Noise	6.40991	5.6129
6	Air Quality & Noise	6.40944	5.6130
8	Air Quality & Noise	6.41771	5.61217
9	Air Quality & Noise	6.41819	5.61225
10	Air Quality & Noise	6.41156	5.61652
11	Air Quality & Noise	6.41683	5.61284
12	Air Quality & Noise	6.40758	5.61861
13	Air Quality & Noise	6.3977	5.6233
14	Air Quality & Noise	6.38978	5.62489
15	Air Quality & Noise	6.38851	5.62861
16	Air Quality & Noise	6.39625	5.63488
17	Air Quality & Noise	6.39806	5.63603
18	Air Quality & Noise	6.40019	5.63861
19	Air Quality & Noise	6.40088	5.63974

20	Air Quality & Noise	6.413297	5.68315
21	Air Quality & Noise	6.42312	5.69247
22	Air Quality & Noise	6.42367	5.68282
23	Air Quality & Noise	6.39620	5.67916
24	Air Quality & Noise	6.39816	5.68052
25	Air Quality & Noise	6.40449	5.688179
26	Air Quality & Noise	6.41389	5.68274
27	Air Quality & Noise	6.40283	5.68556
28	Air Quality & Noise	6.40564	5.68720
29	Air Quality & Noise	6.40610	5.69228
30	Air Quality & Noise	6.40699	5.69482
31	Air Quality & Noise	6.41389	5.68274
32	Air Quality & Noise	6.41055	5.68650
33	Air Quality & Noise	6.40389	5.69040
34	Air Quality & Noise	6.40686	5.69474
35	Air Quality & Noise	6.40862	5.69672
36	Air Quality & Noise	6.41483	5.69884
37	Air Quality & Noise	6.41875	5.70283
38	Air Quality & Noise	6.421214	5.70442
39	Air Quality & Noise	6.42326	5.70827
40	Air Quality & Noise	6.42688	5.71236
	Control-Air Quality & Noise	6.40625	5.68317
	Control-Air Quality & Noise	6.41606	5.6930
Surface water and Sediment			
1	Surface water & Sediment	6.41144	5.60872
2	Surface water & Sediment	6.41071	5.60769
3	Surface water & Sediment	6.41806	5.61111
	Control - Surface water & Sediment	6.41288	5.62403
Groundwater			
1	Groundwater	6.41091	5.60936
2	Groundwater	6.40941	5.61292
3	Groundwater	6.42573	5.71114
	Control - Groundwater	6.41655	5.66884

AIR QUALITY/NOISE LEVEL AND MICROCLIMATIC DATA

Table 2: Field Findings of Air Quality Parameters, Noise and Microclimates

S/N	Sample ID	Sampling Coordinate		Toxic Gases, GHGs and Particulates									Noise dB(A)		Microclimates			
		N	E	SOx (ppm)	VOC (ppm)	NOx (ppm	NH_3 (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	SPM(10) (μg/m³)	SPM(2.5) (μg/m³)	Min	Max	Temp (°C)	RH (%)	WS (m/s)	WD
1	AQ1	5.6087	6.41199	<0.01	228	0.063	<0.01	0.7	2.6	40	720.0	492.1	48.3	77.3	29.6	74.7	0.0	NE
2	AQ2	5.60876	6.41171	<0.01	163	<0.01	<0.01	0.6	2.9	40	387.0	317.8	31.2	64.7	29.4	75.5	0.0	NE
3	AQ3	5.60944	6.41082	<0.01	152	<0.01	<0.01	0.6	3.5	40	515.5	409.5	44.6	76.7	29.4	76.0	0.6	NW
4	AQ4	5.60766	6.41074	<0.01	113	<0.01	<0.01	0.6	2.5	30	687.5	519.4	37.9	76.9	30.1	75.8	0.0	NE
5	AQ5	5.6129	6.40991	<0.01	188	<0.01	<0.01	0.5	<0.01	50	150.6	106.2	37.4	65.4	34.8	56.7	0.0	SW
6	AQ6	5.6130	6.40944	<0.01	160	<0.01	<0.01	0.5	<0.01	40	137.8	111.3	46.2	74.3	35.4	53.4	2.8	NW
7	AQ7	5.61217	6.41771	<0.01	154	<0.01	<0.01	0.2	0.6	40	149.8	83.6	34.3	72.2	34.9	50.8	1.1	NE
8	AQ8	5.61225	6.41819	<0.01	161	<0.01	<0.01	0.6	<0.01	50	120.5	77.7	34.0	50.3	34.2	54.9	0.8	SW
9	AQ9	5.61652	6.41156	<0.01	150	<0.01	<0.01	0.6	<0.01	50	68.9	48.7	44.1	72.2	33.6	61.5	0.0	NE
10	AQ10	5.61284	6.41683	<0.01	152	<0.01	<0.01	0.6	<0.01	50	81.9	52.0	45.2	64.9	33.2	66.5	0.0	NE
11	AQ11	5.61861	6.40758	<0.01	139	<0.01	<0.01	0.6	<0.01	40	164.7	123.1	38.9	65.1	32.8	63.1	0.2	NW
12	AQ12	5.6233	6.3977	<0.01	165	<0.01	<0.01	0.5	<0.01	40	188.4	64.2	32.2	62.5	36.0	42.8	0.0	NW
13	AQ13	5.62489	6.38978	<0.01	168	<0.01	<0.01	0.5	<0.01	50	176.2	72.1	38.7	65.1	37.6	39.1	0.4	NW

14	AQ14	5.62861	6.38851	<0.01	148	<0.01	<0.01	0.6	<0.01	50	155.5	70.4	37.9	63.8	36.9	46.2	0.3	NE
15	AQ15	5.6324	6.38762	<0.01	152	<0.01	<0.01	0.5	<0.01	40	80.3	293.1	43.2	87.6	35.8	42.7	0.0	NW
16	AQ16	5.63488	6.39625	<0.01	218	<0.01	<0.01	0.5	<0.01	60	620	220.4	45.2	69.7	34.9	44.2	0.0	NW
17	AQ17	5.63603	6.39806	<0.01	189	<0.01	<0.01	0.4	<0.01	60	145.6	64.8	41.9	70.5	35.8	44.6	0.0	SW
18	AQ18	5.63861	6.40019	<0.01	175	<0.01	<0.01	0.5	<0.01	50	138.2	92.0	39.7	68.3	36.3	42.0	0.2	SW
19	AQ19	5.63974	6.40088	<0.01	182	<0.01	<0.01	0.5	<0.01	60	131.6	73.1	38.9	72.1	35.7	42.5	0.0	SW
20	AQ20	5.68315	6.413297	<0.01	195	<0.01	<0.01	0.4	<0.01	80	152.1	56.5	41.3	60.8	35.6	38.6	0.0	NE
21	AQ21	5.69247	6.42312	<0.01	173	<0.01	<0.01	0.5	<0.01	60	148.3	53.1	42.6	73.8	35.7	40.3	0.2	NW
22	AQ22	5.68282	6.42367	<0.01	178	<0.01	<0.01	0.5	<0.01	100	132.7	65.3	39.1	69.3	36.8	41.1	0.0	NW
23	AQ23	5.67916	6.39620	<0.01	150	<0.01	<0.01	0.5	<0.01	80	155.6	89.3	48.4	71.2	35.6	34.2	0.0	NE
24	AQ24	5.68052	6.39816	<0.01	130	<0.01	<0.01	0.5	<0.01	30	143.1	54.0	50.7	70.4	36.4	33.8	0.2	NW
25	AQ25	5.688179	6.40449	<0.01	121	<0.01	<0.01	0.4	<0.01	100	193.8	72.5	43.0	68.9	36.7	32.5	2.8	NE
26	AQ26	5.68274	6.41389	<0.01	108	<0.01	<0.01	0.4	<0.01	100	174.2	65.6	56.7	72.3	37.0	34.3	0.6	NE
27	AQ27	5.68556	6.40283	<0.01	84	<0.01	<0.01	0.5	<0.01	100	215.7	68.7	44.0	62.8	37.4	30.0	2.1	NW
28	AQ28	5.68720	6.40564	<0.01	88	<0.01	<0.01	0.5	<0.01	200	166.3	66.2	38.2	69.8	37.3	31.2	1.4	NE
29	AQ29	5.69228	6.40610	<0.01	82	<0.01	<0.01	0.4	<0.01	100	348.5	110.4	40.1	70.3	37.4	32.2	0.8	NE
30	AQ30	5.69482	6.40699	<0.01	102	<0.01	<0.01	0.4	<0.01	100	505.1	80.4	44.4	68.5	37.7	31.9	0.5	NE
31	AQ31	5.68274	6.41389	<0.01	152	<0.01	<0.01	0.5	<0.01	100	143.1	59.0	50.7	70.4	36.4	33.8	0.0	NE
32	AQ32	5.68650	6.41055	<0.01	118	<0.01	<0.01	0.5	<0.01	100	152.3	62.1	44.6	75.9	36.8	35.7	0.2	NW
33	AQ33	5.69040	6.40389	<0.01	121	<0.01	<0.01	0.5	<0.01	100	181.5	57.8	42.1	69.3	36.5	33.8	0.2	SW

34	AQ34	5.69474	6.40686	<0.01	116	<0.01	<0.01	0.4	<0.01	100	161.5	75.1	37.9	65.3	36.3	34.5	0.0	SW
35	AQ35	5.69672	6.40862	<0.01	114	<0.01	<0.01	0.4	<0.01	100	148.7	60.1	41.3	64.7	36.2	39.8	0.6	SW
36	AQ36	5.69884	6.41483	<0.01	120	<0.01	<0.01	0.3	<0.01	200	190.2	58.6	50.5	72.1	36.3	34.2	0.2	NW
37	AQ37	5.70283	6.41875	<0.01	115	<0.01	<0.01	0.4	<0.01	200	181.7	81.5	47.3	69.8	36.7	36.0	0.0	NW
38	AQ38	5.70442	6.421214	<0.01	124	<0.01	<0.01	0.4	<0.01	200	158.2	57.3	38.3	68.5	36.5	35.8	0.0	NE
39	AQ39	5.70827	6.42326	<0.01	117	<0.01	<0.01	0.3	<0.01	100	162.3	65.0	36.5	70.2	36.9	36.2	0.6	NE
40	AQ40	5.71236	6.42688	<0.01	110	<0.01	<0.01	0.4	<0.01	100	143.6	73.9	38.3	58.9	36.7	35.7	0.8	NW
41	AQ41	5.68317	6.40625	<0.01	124	<0.01	<0.01	0.4	<0.01	200	155.5	78.3	46.7	72.0	36.6	36.6	0.0	NW
42	AQ42	5.6930	6.41606	<0.01	138	<0.01	<0.01	0.5	<0.01	200	160.2	83.7	48.9	68.1	36.9	35.3	1.4	NW
Min				<0.01	82	<0.01	<0.01	0.2	<0.01	30	68.9	48.7	38.9	50.3	29.6	30	0	NW
Max				<0.01	228	0.063	<0.01	0.7	3.5	200	720	519.4	56.7	87.6	37.7	76	2.8	NW
Average				<0.01	155	0.0315	<0.01	0.45	1.75	115	394.45	284.05	47.8	68.95	33.65	53	1.4	NE
DPR Limits				**0.04 – 0.06**	**160**	**0.08**	**-**	**-**	**10**	**400 - 500**	**250**	**150**	**90**	**90**				

GROUND WATER SAMPLES

Table 3: Physico-chemical

Sample	Colour	Alkalinity	Conductivity	pH	Temp.	Total Hardness	COD	BOD	DO	Salinity	TSS	TDS	Turbidity	Redox Potential
	Pt/Co	mg/L	µs/cm		⁰C	mg/L	mg/L	mg/L	mg/L	psu	mg/L	mg/L	NTU	mV
POL GW 1	1	Nil	76.6	6.7	24.5	20.00	8.00	1.80	3.87	0.05	ND	38.3	<0.01	125.5
POL GW 2	1	Nil	51.2	6.9	24.5	16.00	8.00	1.91	3.94	0.03	ND	25.6	<0.01	141.2
POL GW 3	1	Nil	387	6.3	24.5	95.00	16.0	1.77	3.82	0.19	ND	193.7	<0.01	188.8
POL GW C	1	Nil	65.6	7.3	24.6	16.00	8.00	1.85	3.90	0.04	ND	32.8	<0.01	123.3
Min	**1**	**Nil**	**51.2**	**6.3**	**24.5**	**16**	**8**	**1.77**	**3.82**	**0.03**	**ND**	**25.6**	**<0.01**	**125.5**
Max	**1**	**Nil**	**387**	**6.9**	**24.5**	**95**	**16**	**1.91**	**3.94**	**0.19**	**ND**	**193.7**	**<0.01**	**188.8**
Average	**1**	**Nil**	**219.1**	**6.6**	**24.5**	**55.5**	**12**	**1.84**	**3.88**	**0.11**	**ND**	**109.6**	**<0.01**	**157.15**

Table 4: Exchangeable Cations and Anions

Sample ID	Phosphate	Sulphate	Nitrate	Chloride	Calcium	Ammonium	Potassium	Sodium	Carbonate	Magnesium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL GW 1	0.163	6.713	1.339	12.55	4.81	0.353	0.814	8.14	Nil	2.90
POL GW 2	0.172	2.823	1.384	8.37	3.21	0.371	0.621	5.43	Nil	1.94
POL GW 3	0.157	8.912	1.321	62.7	22.04	0.311	1.720	40.68	Nil	13.31
POL GW C	0.156	5.143	1.304	10.46	3.21	0.277	0.714	6.79	Nil	1.94
Min	**0.157**	**2.823**	**1.321**	**8.37**	**3.21**	**0.311**	**0.621**	**5.43**	**Nil**	**1.94**
Max	**0.172**	**8.912**	**1.384**	**62.7**	**22.04**	**0.371**	**1.72**	**40.68**	**Nil**	**13.31**
Average	**0.1645**	**5.8675**	**1.3525**	**35.535**	**12.625**	**0.341**	**1.1705**	**23.055**	**Nil**	**7.625**

Table 5: Heavy Metals

Sample ID	Iron	Manganese	Zinc	Copper	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL GW 1	0.321	0.144	0.211	0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL GW 2	0.300	0.127	0.195	0.014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL GW 3	0.287	0.113	0.188	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL GW C	0.292	0.122	0.207	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Min	**0.287**	**0.113**	**0.188**	**0.014**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Max	**0.321**	**0.144**	**0.211**	**0.025**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Average	**0.304**	**0.1285**	**0.1995**	**0.0195**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 6: Organics

Sample ID	PAHs	TPH	Oil & Grease	THC
	mg/L	mg/L	mg/L	mg/L
POL GW 1	0.004	0.018	0.035	0.026
POL GW 2	0.009	0.020	0.044	0.037
POL GW 3	0.010	0.030	0.050	0.040
POL GWC	0.007	0.014	0.025	0.020
Min	**0.004**	**0.018**	**0.035**	**0.026**
Max	**0.01**	**0.03**	**0.05**	**0.04**
Average	**0.007**	**0.024**	**0.0425**	**0.033**

Table 7: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform
	cfu/ml $(x10^3)$	sfu/ml $(x10^2)$	cfu/ml $(x10^1)$	sfu/ml $(x10^1)$	MPN/100ML
POL GW 1	2.11	1.00	ND	ND	<1.8
POL GW 2	2.50	2.00	ND	ND	1.8
POL GW 3	3.00	1.50	ND	ND	1.8
POL GWC	2.00	1.00	ND	ND	<1.8
Min	**2.11**	**1**	**ND**	**ND**	**<1.8**
Max	**3**	**2**	**ND**	**ND**	**1.8**
Average	**2.555**	**1.5**	**ND**	**ND**	**1.8**

Table 8: SUMMARY OF GROUND WATER RESULT

		GW1	GW2	GW3	GW Control	Min	Max	Average	Stdev
Colour	Pt/Co	1	1	1	1	**1**	**1**	**1**	**0**
Alkalinity	mg/L	Nil	Nil	Nil	Nil	**Nil**	**Nil**	**Nil**	**0**
Conductivity	µs/cm	76.6	51.2	387	65.6	**51.2**	**387**	**219.1**	**167.9**
pH		6.76	6.94	6.37	7.38	**6.37**	**6.94**	**6.655**	**0.285**
Temp.	^0C	24.5	24.5	24.5	24.6	**24.5**	**24.5**	**24.5**	**0**
Total Hardness	mg/L	20	16	95	16	**16**	**95**	**55.5**	**39.5**
COD	mg/L	8	8	16	8	**8**	**16**	**12**	**4**
BOD	mg/L	1.8	1.91	1.77	1.85	**1.77**	**1.91**	**1.84**	**0.07**
DO	mg/L	3.87	3.94	3.82	3.9	**3.82**	**3.94**	**3.88**	**0.06**
Salinity	psu	0.05	0.03	0.19	0.04	**0.03**	**0.19**	**0.11**	**0.08**
TSS	mg/L	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
TDS	mg/L	38.3	25.6	193.7	32.8	**25.6**	**193.7**	**109.65**	**84.05**
Turbidity	NTU	<0.01	<0.01	<0.01	<0.01	**<0.01**	**<0.01**	**<0.01**	**0**
Redox Potential	mV	125.5	141.2	188.8	123.3	**125.5**	**188.8**	**157.15**	**31.65**
Phosphate	mg/L	0.163	0.172	0.157	0.156	**0.157**	**0.172**	**0.1645**	**0.0075**
Sulphate	mg/L	6.713	2.823	8.912	5.143	**2.823**	**8.912**	**5.8675**	**3.0445**
Nitrate	mg/L	1.339	1.384	1.321	1.304	**1.321**	**1.384**	**1.3525**	**0.0315**
Chloride	mg/L	12.55	8.37	62.7	10.46	**8.37**	**62.7**	**35.535**	**27.165**
Calcium	mg/L	4.81	3.21	22.04	3.21	**3.21**	**22.04**	**12.625**	**9.415**
Ammonium	mg/L	0.353	0.371	0.311	0.277	**0.311**	**0.371**	**0.341**	**0.03**
Potassium	mg/L	0.814	0.621	1.72	0.714	**0.621**	**1.72**	**1.1705**	**0.5495**
Sodium	mg/L	8.14	5.43	40.68	6.79	**5.43**	**40.68**	**23.055**	**17.625**
Carbonate	mg/L	Nil	Nil	Nil	Nil	**Nil**	**Nil**	**Nil**	**0**
Magnesium	mg/L	2.9	1.94	13.31	1.94	**1.94**	**13.31**	**7.625**	**5.685**
Iron	mg/L	0.321	0.3	0.287	0.292	**0.287**	**0.321**	**0.304**	**0.017**
Manganese	mg/L	0.144	0.127	0.113	0.122	**0.113**	**0.144**	**0.1285**	**0.0155**
Zinc	mg/L	0.211	0.195	0.188	0.207	**0.188**	**0.211**	**0.1995**	**0.0115**
Copper	mg/L	0.025	0.014	0.017	0.016	**0.014**	**0.025**	**0.0195**	**0.0055**
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**

Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Vanadium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Nickel	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Barium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
PAHs	mg/L	0.004	0.009	0.01	0.007	**0.004**	**0.01**	**0.007**	**0.003**
TPH	mg/L	0.018	0.02	0.03	0.014	**0.018**	**0.03**	**0.024**	**0.006**
Oil & Grease	mg/L	0.035	0.044	0.05	0.025	**0.035**	**0.05**	**0.0425**	**0.0075**
THC	mg/L	0.026	0.037	0.04	0.02	**0.026**	**0.04**	**0.033**	**0.007**
THB	cfu/ml ($x10^3$)	2.11	2.5	3	2	**2.11**	**3**	**2.555**	**0.445**
THF	sfu/ml ($x10^2$)	1	2	1.5	1	**1**	**2**	**1.5**	**0.5**
HUB	cfu/ml ($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
HUF	sfu/ml ($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
Feacal coliform	MPN/100ML	<1.8	1.8	1.8	<1.8	**<1.8**	**1.8**	**1.8**	**0**

SURFACE WATER SAMPLES

Table 9: Physico-chemical

Sample	Colour	Alkalinity	Conductivity	pH	Temp.	Total Hardness	COD	BOD	DO	Salinity	TSS	TDS	Turbidity	Redox Potential
	Pt/Co	mg/L	µs/cm		^0C	mg/L	mg/L	mg/L	mg/L	psu	mg/L	mg/L	NTU	mV
POL SW 1	1	Nil	91.1	6.33	24.6	25.0	8.00	1.83	4.22	0.06	0.06	45.5	0.1	45.5
POL SW 2	1	Nil	72.9	6.38	24.6	20.0	8.00	1.95	4.40	0.05	0.95	36.5	1.8	36.5
POL SW 3	1	Nil	72.6	6.26	24.6	20.0	8.00	2.21	4.63	0.04	1.10	36.3	2.1	36.3
POL SW C	1	Nil	69.8	6.07	24.6	16.0	8.00	2.10	4.56	0.04	1.24	34.9	2.4	34.9
Min	**1**	**Nil**	**72.6**	**6.26**	**24.6**	**20**	**8**	**1.83**	**4.22**	**0.04**	**0.06**	**36.3**	**0.1**	**36.3**
Max	**1**	**Nil**	**91.1**	**6.38**	**24.6**	**25**	**8**	**2.21**	**4.63**	**0.06**	**1.1**	**45.5**	**2.1**	**45.5**
Average	**1**	**Nil**	**81.85**	**6.32**	**24.6**	**22.5**	**8**	**2.02**	**4.425**	**0.05**	**0.58**	**40.9**	**1.1**	**40.9**

Table 10: Exchangeable Cations and Anions

Sample ID	Phosphate	Sulphate	Nitrate	Chloride	Calcium	Ammonium	Potassium	Sodium	Carbonate	Magnesium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL SW 1	0.168	6.452	1.832	16.73	4.81	0.509	1.358	10.86	Nil	2.90
POL SW 2	0.164	6.974	1.364	12.55	4.81	0.341	1.202	8.14	Nil	2.90
POL SW 3	0.175	6.432	1.370	8.37	3.21	0.346	1.148	5.43	Nil	1.94
POL SW C	0.176	4.718	1.869	6.27	3.21	0.564	1.031	4.07	Nil	1.94
Min	**0.164**	**6.432**	**1.364**	**8.37**	**3.21**	**0.341**	**1.148**	**5.43**	**Nil**	**1.94**
Max	**0.175**	**6.974**	**1.832**	**16.73**	**4.81**	**0.509**	**1.358**	**10.86**	**Nil**	**2.9**
Average	**0.1695**	**6.703**	**1.598**	**12.55**	**4.01**	**0.425**	**1.253**	**8.145**	**Nil**	**2.42**

Table 11: Heavy Metals

Sample ID	Iron	Zinc	Manganese	Copper	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL SW 1	0.621	0.410	0.214	0.147	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SW 2	0.578	0.431	0.233	0.135	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SW 3	0.419	0.478	0.219	0.132	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SW C	0.522	0.422	0.217	0.133	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Min	**0.419**	**0.41**	**0.214**	**0.132**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Max	**0.621**	**0.478**	**0.233**	**0.147**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Average	**0.52**	**0.444**	**0.2235**	**0.1395**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 12: Organics

Sample ID	PAHs	TPH	Oil & Grease	THC
	mg/L	mg/L	mg/L	mg/L
POL SW 1	0.036	0.065	0.104	0.095
POL SW 2	0.028	0.049	0.070	0.058
POL SW 3	0.024	0.045	0.062	0.053
POL SWC	0.015	0.037	0.050	0.044
Min	**0.024**	**0.045**	**0.062**	**0.053**

Max	**0.036**	**0.065**	**0.104**	**0.095**
Average	**0.03**	**0.055**	**0.083**	**0.074**

Table 13: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform
	cfu/ml ($x10^3$)	sfu/ml ($x10^2$)	cfu/ml ($x10^1$)	sfu/ml ($x10^1$)	MPN/100ML
POL SW 1	4.11	2.15	ND	ND	3.6
POL SW 2	3.24	2.00	ND	ND	3.6
POL SW 3	3.18	1.87	ND	ND	2.0
POL SWC	3.11	134	ND	ND	2.0
Min	**3.18**	**1.87**	**ND**	**ND**	**2**
Max	**4.11**	**2.15**	**ND**	**ND**	**3.6**
Average	**3.645**	**2.01**	**ND**	**ND**	**2.8**

Table 14: SUMMARY OF SURFACE WATER DATA

Sample		**POL SW 1**	**POL SW 2**	**POL SW 3**	**POL SW C**	**Min**	**Max**	**Average**	**Stdev**
Colour	Pt/Co	1	1	1	1	**1**	**1**	**1**	**0**
Alkalinity	mg/L	Nil	Nil	Nil	Nil	**Nil**	**Nil**	**Nil**	**0**
Conductivity	µs/cm	91.1	72.9	72.6	69.8	**72.6**	**91.1**	**81.85**	**9.25**
pH		6.33	6.38	6.26	6.07	**6.26**	**6.38**	**6.32**	**0.06**
Temp.	^0C	24.6	24.6	24.6	24.6	**24.6**	**24.6**	**24.6**	**4.35E-15**
Total Hardness	mg/L	25	20	20	16	**20**	**25**	**22.5**	**2.5**
COD	mg/L	8	8	8	8	**8**	**8**	**8**	**0**
BOD	mg/L	1.83	1.95	2.21	2.1	**1.83**	**2.21**	**2.02**	**0.19**
DO	mg/L	4.22	4.4	4.63	4.56	**4.22**	**4.63**	**4.425**	**0.205**
Salinity	psu	0.06	0.05	0.04	0.04	**0.04**	**0.06**	**0.05**	**0**
TSS	mg/L	0.06	0.95	1.1	1.24	**0.06**	**1.1**	**0.58**	**0.52**
TDS	mg/L	45.5	36.5	36.3	34.9	**36.3**	**45.5**	**40.9**	**0**
Turbidity	NTU	0.1	1.8	2.1	2.4	**0.1**	**2.1**	**1.1**	**1**

Redox Potential	mV	45.5	36.5	36.3	34.9	**36.3**	**45.5**	**40.9**	**4.6**
Phosphate	mg/L	0.168	0.164	0.175	0.176	**0.164**	**0.175**	**0.1695**	**0.0055**
Sulphate	mg/L	6.452	6.974	6.432	4.718	**6.432**	**6.974**	**6.703**	**0.271**
Nitrate	mg/L	1.832	1.364	1.37	1.869	**1.364**	**1.832**	**1.598**	**0.234**
Chloride	mg/L	16.73	12.55	8.37	6.27	**8.37**	**16.73**	**12.55**	**4.18**
Calcium	mg/L	4.81	4.81	3.21	3.21	**3.21**	**4.81**	**4.01**	**0.8**
Ammonium	mg/L	0.509	0.341	0.346	0.564	**0.341**	**0.509**	**0.425**	**0.084**
Potassium	mg/L	1.358	1.202	1.148	1.031	**1.148**	**1.358**	**1.253**	**0.105**
Sodium	mg/L	10.86	8.14	5.43	4.07	**5.43**	**10.86**	**8.145**	**0**
Carbonate	mg/L	Nil	Nil	Nil	Nil	**Nil**	**Nil**	**Nil**	**0**
Magnesium	mg/L	2.9	2.9	1.94	1.94	**1.94**	**2.9**	**2.42**	**0.48**
Iron	mg/L	0.621	0.578	0.419	0.522	**0.419**	**0.621**	**0.52**	**0.101**
Zinc	mg/L	0.41	0.431	0.478	0.422	**0.41**	**0.478**	**0.444**	**0.034**
Manganese	mg/L	0.214	0.233	0.219	0.217	**0.214**	**0.233**	**0.2235**	**0.0095**
Copper	mg/L	0.147	0.135	0.132	0.133	**0.132**	**0.147**	**0.1395**	**0**
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Cadmium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Mercury	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Vanadium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Nickel	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Barium	mg/L	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
PAHs	mg/L	0.036	0.028	0.024	0.015	**0.024**	**0.036**	**0.03**	**0.006**
TPH	mg/L	0.065	0.049	0.045	0.037	**0.045**	**0.065**	**0.055**	**0.01**
Oil & Grease	mg/L	0.104	0.07	0.062	0.05	**0.062**	**0.104**	**0.083**	**0.021**
THC	mg/L	0.095	0.058	0.053	0.044	**0.053**	**0.095**	**0.074**	**0.021**
THB	cfu/ml ($x10^3$)	4.11	3.24	3.18	3.11	**3.18**	**4.11**	**3.645**	**0.465**
THF	sfu/ml ($x10^2$)	2.15	2	1.87	134	**1.87**	**2.15**	**2.01**	**0.14**
HUB	cfu/ml ($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
HUF	sfu/ml ($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
Feacal coliform	MPN/100ML	3.6	3.6	2	2	**2**	**3.6**	**2.8**	**0.8**

SOIL SAMPLES

Table 15: Physico-chemical

Sample ID	pH	Temp.	Cond.	Redox Pot.	TOC	Soil Characterization				
						Colour	Permeability	Texture	Grain size	Porosity
	-		µs/cm	mV	%	Visual		-	mm	%
POL SS1 (0-15cm)	5.58	26.4	75.45	100.2	1.25	Brown	Moderate	Sandy	0.1-2	67
POL SS1 (15-30cm)	5.80	25.9	79.50	105.5	1.31	Brown	Moderate	Sandy	0.1-2	68
POL SS2 (0-15cm)	6.10	25.8	83.50	109.4	1.15	Light Brown	Moderate	Sandy	0.1-2	66
POL SS2 (15-30cm)	6.05	26.0	60.20	110.8	1.22	Light Brown	Moderate	Sandy	0.1-2	66
POL SS3 (0-15cm)	5.30	26.1	74.50	113.5	0.93	Brown	Moderate	Sandy	0.1-2	67
POL SS3 (15-30cm)	5.10	26.1	90.05	114.0	1.04	Brown	Moderate	Sandy	0.1-2	67
POL SS4 (0-15cm)	5.60	25.9	62.50	110.5	1.84	Brown	Moderate	Sandy	0.1-2	66
POL SS4 (15-30cm)	5.73	25.8	60.10	120.0	1.87	Brown	Moderate	Sandy	0.1-2	66
POL SS5 (0-15cm)	6.00	25.7	65.35	140.2	1.29	Brown	Moderate	Sandy	0.1-2	66
POL SS5 (15-30cm)	6.10	26.0	80.10	130.5	1.37	Brown	Moderate	Sandy	0.1-2	67
POL SS6 (0-15cm)	6.30	26.2	82.20	110.2	1.49	Brown	Moderate	Sandy	0.1-2	66
POL SS6 (15-30cm)	6.20	25.9	80.40	116.0	1.62	Brown	Moderate	Sandy	0.1-2	66
POL SS7 (0-15cm)	5.72	25.8	70.50	120.0	1.60	Brown	Moderate	Sandy	0.1-2	63
POL SS7 (15-30cm)	5.90	25.6	81.0	112.5	1.66	Brown	Moderate	Sandy	0.1-2	64
POL SS8 (0-15cm)	5.80	25.7	55.10	151.5	1.29	Brown	Moderate	Sandy	0.1-2	68
POL SS8 (15-30cm)	5.70	25.7	60.25	140.5	1.76	Brown	Moderate	Sandy	0.1-2	69
POL SS9 (0-15cm)	6.01	25.8	65.70	120.5	1.84	Brown	Moderate	Sandy	0.1-2	65
POL SS9 (15-30cm)	6.10	25.6	63.45	119.0	1.95	Brown	Moderate	Sandy	0.1-2	64
POL SS10 (0-15cm)	6.01	25.7	51.37	110.0	1.26	Brown	Moderate	Sandy	0.1-2	64
POL SS 10 (15-30cm)	6.20	25.8	55.89	120.0	1.38	Brown	Moderate	Sandy	0.1-2	63
POL SS11 (0-15cm)	5.90	25.8	62.19	115.5	1.11	Brown	Moderate	Sandy	0.1-2	66
POL SS11 (15-30cm)	5.85	25.9	65.00	118.2	1.69	Brown	Moderate	Sandy	0.1-2	64
POL SS12 (0-15cm)	5.80	25.7	53.16	129.8	1.16	Brown	Moderate	Sandy	0.1-2	67
POL SS12 (15-30cm)	5.69	25.5	57.20	137.5	1.24	Brown	Moderate	Sandy	0.1-2	66

Sample ID	pH	Temp.	Cond.	Redox Pot.	TOC	Soil Characterization				
						Colour	Permeability	Texture	Grain size	Porosity
	-		µs/cm	mV	%	Visual		-	mm	%
POL SS 13 (0-15cm)	5.90	25.6	78.50	140.5	1.04	Brown	Moderate	Sandy	0.1-2	68
POL SS 13 (15-30cm)	6.10	25.7	87.00	139.0	13.1	Brown	Moderate	Sandy	0.1-2	66
POL SS 14 (0-15cm)	6.01	25.8	64.00	115.0	1.84	Brown	Moderate	Sandy	0.1-2	65
POL SS 14 (15-30cm)	6.10	25.8	68.20	113.5	1.87	Brown	Moderate	Sandy	0.1-2	67
POL SS 15 (0-15cm)	5.90	26.0	61.35	120.0	1.22	Brown	Moderate	Sandy	0.1-2	66
POL SS 15 (15-30cm)	5.95	26.1	65.90	125.7	1.32	Brown	Moderate	Sandy	0.1-2	66
POL SS 16 (0-15cm)	5.80	25.9	50.10	130.2	0.93	Brown	Moderate	Sandy	0.1-2	68
POL SS 16 (15-30cm)	5.68	25.9	52.10	135.5	1.04	Brown	Moderate	Sandy	0.1-2	69
POL SS 17 (0-15cm)	6.10	25.8	50.50	114.0	1.13	Brown	Moderate	Sandy	0.1-2	67
POL SS 17 (15-30cm)	6.20	26.0	63.40	118.2	1.87	Brown	Moderate	Sandy	0.1-2	68
POL SS C1 (0-15cm)	5.78	26.1	62.50	120.5	1.84	Brown	Moderate	Sandy	0.1-2	65
POL SS C1 (15-30cm)	5.92	25.8	61.90	122.0	1.95	Brown	Moderate	Sandy	0.1-2	69
POL SS C2 (0-15cm)	5.80	26.2	64.00	133.0	1.37	Brown	Moderate	Sandy	0.1-2	64
POL SS C2 (15-30cm)	5.67	25.8	78.50	139.0	1.29	Brown	Moderate	Sandy	0.1-2	68
POL SS C3 (0-15cm)	5.80	25.9	65.00	140.0	1.25	Brown	Moderate	Sandy	0.1-2	65
POL SS C3 (15-30cm)	5.90	25.8	67.20	130.0	1.31	Brown	Moderate	Sandy	0.1-2	69

Table 16: Exchangeable Cations and Anions

Sample ID	Sulphate	Phosphate	Total-Nitroge	Nitrate	Nitrite	Carbonate	Ammonium	Sodium	Potassium	Calcium	Magnesium	CEC
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS1 (0-15cm)	74.44	0.953	21.21	10.08	0.079	89.10	11.05	32.57	3.458	32.06	19.36	87.45
POL SS1 (15-30cm)	81.00	1.027	23.12	10.56	0.075	89.18	12.48	32.57	3.421	24.05	14.52	74.56
POL SS2 (0-15cm)	55.03	1.184	24.10	12.05	0.060	59.90	11.99	43.42	3.201	24.05	14.52	85.19
POL SS2 (15-30cm)	64.36	1.014	22.31	10.63	0.069	58.02	11.61	21.71	3.545	16.03	9.68	50.97
POL SS3 (0-15cm)	90.17	1.401	20.09	9.520	0.050	59.10	10.52	32.57	4.658	24.05	14.52	75.80
POL SS3 (15-30cm)	83.55	1.343	23.77	11.28	0.035	60.00	12.45	43.42	3.089	24.02	14.52	85.50
POL SS4 (0-15cm)	52.37	0.958	26.69	12.82	0.085	58.10	13.78	32.57	2.254	32.06	19.36	86.24
POL SS4 (15-30cm)	55.86	0.892	21.73	9.125	0.105	59.10	12.50	32.57	3.054	24.05	14.52	74.19
POL SS5 (0-15cm)	95.29	1.069	23.67	10.10	0.070	88.30	13.50	21.71	3.410	16.03	9.68	50.83
POL SS5 (15-30cm)	90.07	1.032	26.45	13.92	0.070	89.02	12.46	32.57	2.842	24.05	14.52	73.98
POL SS6 (0-15cm)	105.1	1.037	29.90	14.33	0.084	58.01	15.49	32.57	3.314	24.05	14.52	74.45
POL SS6 (15-30cm)	96.94	1.099	28.23	13.72	0.095	60.00	14.41	43.42	2.656	24.05	14.52	84.65
POL SS7 (0-15cm)	75.40	0.982	23.75	12.69	0.065	59.10	10.99	32.57	2.915	24.05	14.52	74.06
POL SS7 (15-30cm)	71.19	1.031	26.02	13.80	0.079	88.20	12.14	43.42	3.129	32.06	19.36	97.97
POL SS8 (0-15cm)	59.22	1.095	27.66	14.41	0.050	89.50	13.20	21.71	2.022	8.02	4.84	36.59
POL SS8 (15-30cm)	64.56	1.012	22.37	10.52	0.060	89.72	11.79	32.57	2.045	8.02	4.84	47.48
POL SS9 (0-15cm)	88.09	0.935	24.07	11.78	0.094	89.18	12.20	32.57	2.345	24.05	14.52	73.49
POL SS9 (15-30cm)	89.47	0.966	24.47	11.89	0.094	89.30	12.49	32.57	2.267	16.03	9.68	60.55
POL SS10 (0-15cm)	76.94	0.869	25.56	12.12	0.089	88.10	13.35	21.71	2.842	16.03	9.68	50.26
POL SS 10 (15-	88.07	0.913	25.70	11.96	0.084	89.02	13.66	32.57	2.626	8.02	4.84	48.06
POL SS11 (0-15cm)	85.09	1.018	23.03	10.47	0.070	59.05	12.49	32.57	3.454	24.05	14.52	74.59
POL SS11 (15-	79.36	0.979	26.43	12.83	0.079	58.10	13.52	32.57	2.140	32.06	19.36	86.13
POL SS12 (0-15cm)	84.26	0.978	26.45	14.25	0.103	60.00	12.10	21.71	2.325	8.02	4.84	36.90
POL SS12 (15-	75.77	0.903	26.08	13.02	0.099	58.87	12.96	21.71	2.584	8.02	4.84	37.15
POL SS13 (0-15cm)	85.69	1.208	26.30	12.24	0.090	59.09	13.97	43.42	2.304	24.05	14.52	84.29
POL SS13 (15-	91.05	1.134	24.05	10.11	0.100	60.00	13.84	54.28	2.879	24.05	14.52	95.73
POL SS 14 (0-15cm)	65.33	0.950	24.31	11.55	0.119	88.14	12.64	32.51	3.014	32.06	19.36	86.94
POL SS 14 (15-	57.35	1.059	23.19	10.21	0.104	89.45	12.88	32.57	2.924	24.05	14.52	74.06
POL SS 15 (0-15cm)	81.33	0.898	20.59	9.542	0.094	60.00	10.95	32.57	3.250	24.05	14.52	74.39
POL SS 15 (15-	76.43	0.853	22.19	10.69	0.079	59.45	11.42	21.71	3.008	16.03	9.68	50.43
POL SS 16 (0-15cm)	73.37	0.927	25.25	12.98	0.074	58.95	12.20	21.71	2.256	16.03	9.68	49.68
POL SS 16 (15-	80.46	0.973	22.69	10.74	0.089	58.10	11.86	32.57	2.102	24.05	14.52	73.24
POL SS 17 (0-15cm)	86.33	0.957	26.48	13.85	0.110	59.62	12.52	32.57	2.223	24.05	14.52	73.36

Sample ID	Sulphate	Phosphate	Total-Nitroge	Nitrate	Nitrite	Carbonate	Ammonium	Sodium	Potassium	Calcium	Magnesium	CEC
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS 17 (15-	90.26	1.016	26.16	12.47	0.129	60.00	13.56	21.71	2.521	16.03	9.68	49.94
POL SS C1 (0-15cm)	109.6	1.015	27.69	13.51	0.158	89.20	14.02	32.57	2.143	24.05	14.52	73.28
POL SSC1 (15-	110.2	0.994	23.51	10.58	0.179	88.67	12.75	32.51	2.317	32.06	19.36	86.25
POL SSC2 (0-15cm)	81.22	0.954	22.14	10.65	0.095	90.00	11.39	32.51	1.982	24.05	14.52	73.06
POL SSC2 (15-	75.44	0.882	23.53	11.07	0.104	89.47	12.36	43.42	2.199	24.05	14.52	84.19
POL SSC3 (0-15cm)	64.08	0.941	20.95	9.958	0.085	89.89	10.91	32.57	1.875	24.05	14.52	73.02
POL SSC3 (15-	69.84	0.897	22.89	10.60	0.105	88.74	12.18	32.51	2.145	24.05	14.52	73.23

Table 17: Heavy Metals

Sample ID	Iron	Zinc	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS1 (0-15cm)	1.802	0.177	0.065	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS1 (15-30cm)	1.995	0.161	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS2 (0-15cm)	1.824	0.128	0.047	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS2 (15-30cm)	2.708	0.179	0.054	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS3 (0-15cm)	2.601	0.167	0.048	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS3 (15-30cm)	2.675	0.179	0.067	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS4 (0-15cm)	2.584	0.154	0.061	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS4 (15-30cm)	1.794	0.184	0.058	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS5 (0-15cm)	1.841	0.147	0.043	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS5 (15-30cm)	1.947	0.161	0.057	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS6 (0-15cm)	1.510	0.180	0.046	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS6 (15-30cm)	2.724	0.186	0.072	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS7 (0-15cm)	1.814	0.164	0.063	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS7 (15-30cm)	2.614	0.168	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS8 (0-15cm)	1.988	0.132	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS8 (15-30cm)	2.704	0.174	0.059	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS9 (0-15cm)	1.968	0.169	0.037	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Sample ID	Iron	Zinc	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS9 (15-30cm)	2.214	0.171	0.035	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS10 (0-15cm)	1.780	0.165	0.066	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 10 (15-30cm)	1.994	0.171	0.064	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS11 (0-15cm)	2.621	0.174	0.044	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS11 (15-30cm)	2.871	0.180	0.057	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS12 (0-15cm)	1.621	0.151	0.050	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS12 (15-30cm)	1.884	0.163	0.055	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 13 (0-15cm)	1.628	0.167	0.050	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 13 (15-30cm)	1.914	0.170	0.061	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 14 (0-15cm)	1.701	0.171	0.076	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 14 (15-30cm)	1.910	0.190	0.084	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 15 (0-15cm)	1.617	0.165	0.062	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 15 (15-30cm)	1.716	0.182	0.072	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 16 (0-15cm)	1.671	0.154	0.068	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 16 (15-30cm)	1.801	0.169	0.071	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 17 (0-15cm)	2.599	0.156	0.076	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 17 (15-30cm)	2.743	0.175	0.081	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C1 (0-15cm)	2.143	0.153	0.058	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C1 (15-30cm)	2.440	0.168	0.063	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C2 (0-15cm)	1.875	0.155	0.062	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C2 (15-30cm)	1.794	0.162	0.067	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C3 (0-15cm)	1.641	0.157	0.058	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C3 (15-30cm)	2.104	0.165	0.069	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 18: Organics

Sample ID	TPH(total)	BTEX	THC
	mg/Kg	mg/Kg	mg/Kg
POL SS1 (0-15cm)	0.387	<0.001	0.453
POL SS1 (15-30cm)	0.470	<0.001	0.506
POL SS2 (0-15cm)	0.600	<0.001	0.632
POL SS2 (15-30cm)	0.730	<0.001	0.798
POL SS3 (0-15cm)	0.798	<0.001	0.834
POL SS3 (15-30cm)	1.001	<0.001	1.004
POL SS4 (0-15cm)	0.400	<0.001	0.452
POL SS4 (15-30cm)	0.625	<0.001	0.665
POL SS5 (0-15cm)	1.120	<0.001	1.157
POL SS5 (15-30cm)	1.189	<0.001	1.203
POL SS6 (0-15cm)	1.043	<0.001	1.072
POL SS6 (15-30cm)	1.101	<0.001	1.125
POL SS7 (0-15cm)	0.956	<0.001	0.984
POL SS7 (15-30cm)	1.230	<0.001	1.313
POL SS8 (0-15cm)	0.801	<0.001	0.809
POL SS8 (15-30cm)	1.201	<0.001	1.211
POL SS9 (0-15cm)	0.295	<0.001	0.312
POL SS9 (15-30cm)	0.380	<0.001	0.400
POL SS10 (0-15cm)	0.597	<0.001	0.605
POL SS 10 (15-30cm)	0.801	<0.001	0.817
POL SS11 (0-15cm)	0.700	<0.001	0.736
POL SS11 (15-30cm)	0.940	<0.001	0.961
POL SS12 (0-15cm)	1.180	<0.001	1.205
POL SS12 (15-30cm)	1.410	<0.001	1.433
POL SS 13 (0-15cm)	0.960	<0.001	0.995
POL SS 13 (15-30cm)	0.745	<0.001	0.782
POL SS 14 (0-15cm)	0.635	<0.001	0.675
POL SS 14 (15-30cm)	0.800	<0.001	0.810
POL SS 15 (0-15cm)	0.910	<0.001	0.940

Sample ID	TPH(total)	BTEX	THC
	mg/Kg	mg/Kg	mg/Kg
POL SS 15 (15-30cm)	1.100	<0.001	1.124
POL SS 16 (0-15cm)	1.047	<0.001	1.085
POL SS 16 (15-30cm)	1.210	<0.001	1.234
POL SS 17 (0-15cm)	0.905	<0.001	0.935
POL SS 17 (15-30cm)	1.030	<0.001	1.048
POL SS C1 (0-15cm)	0.810	<0.001	0.843
POL SS C1 (15-30cm)	1.210	<0.001	1.229
POL SS C2 (0-15cm)	1.157	<0.001	1.183
POL SS C2 (15-30cm)	1.190	<0.001	1.202
POL SS C3 (0-15cm)	1.128	<0.001	1.146
POL SS C3 (15-30cm)	1.267	<0.001	1.287

Table 19: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	(cfu/g) $x10^4$	(sfu/g) $x10^3$	cfu/g $x10^1$	sfu/g $x10^1$	MPN/100ML	(cfu/g) $x10^1$
POL SS1 (0-15cm)	6.70	5.00	ND	ND	13	ND
POL SS1 (15-30cm)	5.50	3.00	ND	ND	11	ND
POL SS2 (0-15cm)	8.00	3.00	ND	ND	14	ND
POL SS2 (15-30cm)	6.00	5.00	ND	ND	17	ND
POL SS3 (0-15cm)	3.05	2.00	ND	ND	12	ND
POL SS3 (15-30cm)	4.95	3.00	ND	ND	17	ND
POL SS4 (0-15cm)	5.00	2.05	ND	ND	13	ND
POL SS4 (15-30cm)	7.30	5.00	ND	ND	11	ND
POL SS5 (0-15cm)	3.40	1.50	ND	ND	17	ND
POL SS5 (15-30cm)	3.50	1.00	ND	ND	20	ND
POL SS6 (0-15cm)	5.30	3.50	ND	ND	11	ND

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	(cfu/g) x10^{4}	(sfu/g) x10^{3}	cfu/g x10^{1}	sfu/g x10^{1}	MPN/100ML	(cfu/g) x10^{1}
POL SS6 (15-30cm)	7.50	3.00	ND	ND	14	ND
POL SS7 (0-15cm)	7.05	4.05	ND	ND	13	ND
POL SS7 (15-30cm)	6.50	4.50	ND	ND	14	ND
POL SS8 (0-15cm)	6.00	4.50	ND	ND	17	ND
POL SS8 (15-30cm)	6.05	3.00	ND	ND	25	ND
POL SS9 (0-15cm)	7.50	1.05	ND	ND	11	ND
POL SS9 (15-30cm)	7.00	5.00	ND	ND	25	ND
POL SS10 (0-15cm)	8.10	3.05	ND	ND	17	ND
POL SS 10 (15-30cm)	8.50	3.00	ND	ND	13	ND
POL SS11 (0-15cm)	5.05	2.15	ND	ND	11	ND
POL SS11 (15-30cm)	3.90	2.50	ND	ND	26	ND
POL SS12 (0-15cm)	3.95	2.05	ND	ND	21	ND
POL SS12 (15-30cm)	2.05	1.05	ND	ND	17	ND
POL SS 13 (0-15cm)	4.60	3.50	ND	ND	21	ND
POL SS 13 (15-30cm)	6.40	2.15	ND	ND	11	ND
POL SS 14 (0-15cm)	6.00	5.40	ND	ND	14	ND
POL SS 14 (15-30cm)	5.50	2.50	ND	ND	17	ND
POL SS 15 (0-15cm)	3.50	1.00	ND	ND	11	ND
POL SS 15 (15-30cm)	4.10	2.00	ND	ND	15	ND
POL SS 16 (0-15cm)	5.50	2.50	ND	ND	11	ND
POL SS 16 (15-30cm)	5.00	2.50	ND	ND	26	ND
POL SS 17 (0-15cm)	4.50	2.00	ND	ND	11	ND
POL SS 17 (15-30cm)	5.00	4.00	ND	ND	20	ND
POL SS C1 (0-15cm)	5.00	4.80	ND	ND	17	ND
POL SS C1 (15-30cm)	5.35	3.30	ND	ND	13	ND
POL SS C2 (0-15cm)	4.00	2.85	ND	ND	21	ND

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	(cfu/g) x10^4	(sfu/g) x10^3	cfu/g x10^1	sfu/g x10^1	MPN/100ML	(cfu/g) x10^1
POL SS C2 (15-30cm)	1.45	3.00	ND	ND	17	ND
POL SS C3 (0-15cm)	2.00	1.50	ND	ND	11	ND
POL SS C3 (15-30cm)	7.00	2.00	ND	ND	25	ND

Table 20: SUMMARY TOP SOIL RESULT

	POL SS1 (0-15cm)	**POL SS2 (0-15cm)**	**POL SS3 (0-15cm)**	**POL SS4 (0-15cm)**	**POL SS5 (0-15cm)**	**POL SS6 (0-15cm)**	**POL SS7 (0-15cm)**	**POL SS8 (0-15cm)**	**POL SS9 (0-15cm)**	**POL SS10 (0-15cm)**	**POL SS11 (0-15cm)**	**POL SS12 (0-15cm)**	**POL SS 13 (0-15cm)**	**POL SS 14 (0-15cm)**	**POL SS 15 (0-15cm)**	**POL SS 16 (0-15cm)**	**POL SS 17 (0-15cm)**	**Control**	**Min**	**Max**	**Average**	**St Dev**
pH	5.58	6.1	5.3	5.6	6	6.3	5.72	5.8	6.01	6.01	5.9	5.8	5.9	6.01	5.9	5.8	6.1	5.79	5.1	6.2	5.65	0.55
Temp.	26.4	25.8	26.1	25.9	25.7	26.2	25.8	25.7	25.8	25.7	25.8	25.7	25.6	25.8	26	25.9	25.8	25.96	25.5	26.1	25.8	0.3
Cond.	75.45	83.5	74.5	62.5	65.35	82.2	70.5	55.1	65.7	51.37	62.19	53.16	78.5	64	61.35	50.1	50.5	66.38	52.1	90.05	71.075	18.975
Redox Pot.	100.2	109.4	113.5	110.5	140.2	110.2	120	151.5	120.5	110	115.5	129.8	140.5	115	120	130.2	114	130.9	105.5	140.5	123	17.5
TOC	1.25	1.15	0.93	1.84	1.29	1.49	1.6	1.29	1.84	1.26	1.11	1.16	1.04	1.84	1.22	0.93	1.13	1.54	1.04	13.1	7.07	6.03
Colour	Brown	Light Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	0
Permeability	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	0
Texture	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	0
Grain size	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0
Porosity	67	66	67	66	66	66	63	68	65	64	66	67	68	65	66	68	67	66.2	63	69	66	3
Sulphate	74.44	55.03	90.17	52.37	95.29	105.1	75.4	59.22	88.09	76.94	85.09	84.26	85.69	65.33	81.33	73.37	86.33	88.11	55.86	96.94	76.4	20.54

Phosphate	0.953	1.184	1.401	0.958	1.069	1.037	0.982	1.095	0.935	0.869	1.018	0.978	1.208	0.95	0.898	0.927	0.957	0.96	0.853	1.343	1.098	0.245
Total-Nitrogen	21.21	24.1	20.09	26.69	23.67	29.9	23.75	27.66	24.07	25.56	23.03	26.45	26.3	24.31	20.59	25.25	26.48	23.56	21.73	28.23	24.98	3.25
Nitrate	10.08	12.05	9.52	12.82	10.1	14.33	12.69	14.41	11.78	12.12	10.47	14.25	12.24	11.55	9.542	12.98	13.85	11.15	9.125	13.92	11.5225	2.3975
Nitrite	0.079	0.06	0.05	0.085	0.07	0.084	0.065	0.05	0.094	0.089	0.07	0.103	0.09	0.119	0.094	0.074	0.11	0.12	0.035	0.129	0.082	0.047
Carbonate	89.1	59.9	59.1	58.1	88.3	58.01	59.1	89.5	89.18	88.1	59.05	60	59.09	88.14	60	58.95	59.62	89.45	58.02	89.72	73.87	15.85
Ammonium	11.05	11.99	10.52	13.78	13.5	15.49	10.99	13.2	12.2	13.35	12.49	12.1	13.97	12.64	10.95	12.2	12.52	12.29	11.42	14.41	12.915	1.495
Sodium	32.57	43.42	32.57	32.57	21.71	32.57	32.57	21.71	32.57	21.71	32.57	21.71	43.42	32.51	32.57	21.71	32.57	34.72	21.71	54.28	37.995	16.285
Potassium	3.458	3.201	4.658	2.254	3.41	3.314	2.915	2.022	2.345	2.842	3.454	2.325	2.304	3.014	3.25	2.256	2.223	2.1	2.045	3.545	2.795	0.75
Calcium	32.06	24.05	24.05	32.06	16.03	24.05	24.05	8.02	24.05	16.03	24.05	8.02	24.05	32.06	24.05	16.03	24.05	25.65	8.02	32.06	20.04	12.02
Magnesium	19.36	14.52	14.52	19.36	9.68	14.52	14.52	4.84	14.52	9.68	14.52	4.84	14.52	19.36	14.52	9.68	14.52	15.49	4.84	19.36	12.1	7.26
CEC	87.45	85.19	75.8	86.24	50.83	74.45	74.06	36.59	73.49	50.26	74.59	36.9	84.29	86.94	74.39	49.68	73.36	77.96	37.15	97.97	67.56	30.41
Iron	1.802	1.824	2.601	2.584	1.841	1.51	1.814	1.988	1.968	1.78	2.621	1.621	1.628	1.701	1.617	1.671	2.599	1.98	1.716	2.871	2.2935	0.5775
Zinc	0.177	0.128	0.167	0.154	0.147	0.18	0.164	0.132	0.169	0.165	0.174	0.151	0.167	0.171	0.165	0.154	0.156	0.16	0.161	0.19	0.1755	0.0145
Chromium	0.065	0.047	0.048	0.061	0.043	0.046	0.063	0.073	0.037	0.066	0.044	0.05	0.05	0.076	0.062	0.068	0.076	0.06	0.013	0.084	0.0485	0.0355
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Nickel	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Barium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0

TPH(total)	0.387	0.6	0.798	0.4	1.12	1.043	0.956	0.801	0.295	0.597	0.7	1.18	0.96	0.635	0.91	1.047	0.905	1.1	0.38	1.41	0.895	0.515
BTEX	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
THC	0.453	0.632	0.834	0.452	1.157	1.072	0.984	0.809	0.312	0.605	0.736	1.205	0.995	0.675	0.94	1.085	0.935	1.12	0.4	1.433	0.9165	0.5165
THB	6.7	8	3.05	5	3.4	5.3	7.05	6	7.5	8.1	5.05	3.95	4.6	6	3.5	5.5	4.5	3.56	2.05	8.5	5.275	3.225
THF	5	3	2	2.05	1.5	3.5	4.05	4.5	1.05	3.05	2.15	2.05	3.5	5.4	1	2.5	2	3.09	1	5	3	2
HUB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0
HUF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0
Feacal coliform	13	14	12	13	17	11	13	17	11	17	11	21	21	14	11	11	11	15.8	11	26	18.5	7.5
SRB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0

Table 21: SUMMARY SUB SOIL RESULT

	POL SS1 (15-30cm)	**POL SS2 (15-30cm)**	**POL SS3 (15-30cm)**	**POL SS4 (15-30cm)**	**POL SS5 (15-30cm)**	**POL SS6 (15-30cm)**	**POL SS7 (15-30cm)**	**POL SS8 (15-30cm)**	**POL SS9 (15-30cm)**	**POL SS 10 (15-30cm)**	**POL SS11 (15-30cm)**	**POL SS12 (15-30cm)**	**POL SS 13 (15-30cm)**	**POL SS 14 (15-30cm)**	**POL SS 15 (15-30cm)**	**POL SS 16 (15-30cm)**	**POL SS 17 (15-30cm)**	**Control**	**Min**	**Max**	**Average**	**Std ev**
pH	5.8	6.05	5.1	5.73	6.1	6.2	5.9	5.7	6.1	6.2	5.85	5.69	6.1	6.1	5.95	5.68	6.2	5.81	5.1	6.2	5.65	0.55
Temp.	25.9	26	26.1	25.8	26	25.9	25.6	25.7	25.6	25.8	25.9	25.5	25.7	25.8	26.1	25.9	26	25.91	25.5	26.1	25.8	0.3
Cond.	79.5	60.2	90.05	60.1	80.1	80.4	81	60.25	63.45	55.89	65	57.2	87	68.2	65.9	52.1	63.4	67.16	52.1	90.05	71.075	18.975
Redox Pot.	105.5	110.8	114	120	130.5	116	112.5	140.5	119	120	118.2	137.5	139	113.5	125.7	135.5	118.2	132.48	105.5	140.5	123	17.5
TOC	1.31	1.22	1.04	1.87	1.37	1.62	1.66	1.76	1.95	1.38	1.69	1.24	13.1	1.87	1.32	1.04	1.87	1.45	1.04	13.1	7.07	6.03
Colour	Brown	Light Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	Brown	0
Permeability	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	0
Texture	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	Sandy	0
Grain size	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0.1-2	0

Porosity	68	66	67	66	67	66	64	69	64	63	64	66	66	67	66	69	68	66.87	63	69	66	3
Sulphate	81	64.36	83.55	55.86	90.07	96.94	71.19	64.56	89.47	88.07	79.36	75.77	91.05	57.35	76.43	80.46	90.26	81.48	55.86	96.94	76.4	20.54
Phosphate	1.027	1.014	1.343	0.892	1.032	1.099	1.031	1.012	0.966	0.913	0.979	0.903	1.134	1.059	0.853	0.973	1.016	0.94	0.853	1.343	1.098	0.245
Total-Nitrogen	23.12	22.31	23.77	21.73	26.45	28.23	26.02	22.37	24.47	25.7	26.43	26.08	24.05	23.19	22.19	22.69	26.16	22.76	21.73	28.23	24.98	3.25
Nitrate	10.56	10.63	11.28	9.125	13.92	13.72	13.8	10.52	11.89	11.96	12.83	13.02	10.11	10.21	10.69	10.74	12.47	10.67	9.125	13.92	11.5225	2.3975
Nitrite	0.075	0.069	0.035	0.105	0.07	0.095	0.079	0.06	0.094	0.084	0.079	0.099	0.1	0.104	0.079	0.089	0.129	0.12	0.035	0.129	0.082	0.047
Carbonate	89.18	58.02	60	59.1	89.02	60	88.2	89.72	89.3	89.02	58.1	58.87	60	89.45	59.45	58.1	60	89.37	58.02	89.72	73.87	15.85
Ammonium	12.48	11.61	12.45	12.5	12.46	14.41	12.14	11.79	12.49	13.66	13.52	12.96	13.84	12.88	11.42	11.86	13.56	11.98	11.42	14.41	12.915	1.495
Sodium	32.57	21.71	43.42	32.57	32.57	43.42	43.42	32.57	32.57	32.57	32.57	21.71	54.28	32.57	21.71	32.57	21.71	34.71	21.71	54.28	37.995	16.285
Potassium	3.421	3.545	3.089	3.054	2.842	2.656	3.129	2.045	2.267	2.626	2.14	2.584	2.879	2.924	3.008	2.102	2.521	2.1	2.045	3.545	2.795	0.75
Calcium	24.05	16.03	24.02	24.05	24.05	24.05	32.06	8.02	16.03	8.02	32.06	8.02	24.05	24.05	16.03	24.05	16.03	25.65	8.02	32.06	20.04	12.02
Magnesium	14.52	9.68	14.52	14.52	14.52	14.52	19.36	4.84	9.68	4.84	19.36	4.84	14.52	14.52	9.68	14.52	9.68	15.49	4.84	19.36	12.1	7.26
CEC	74.56	50.97	85.5	74.19	73.98	84.65	97.97	47.48	60.55	48.06	86.13	37.15	95.73	74.06	50.43	73.24	49.94	77.95	37.15	97.97	67.56	30.41
Iron	1.995	2.708	2.675	1.794	1.947	2.724	2.614	2.704	2.214	1.994	2.871	1.884	1.914	1.91	1.716	1.801	2.743	1.97	1.716	2.871	2.2935	0.5775
Zinc	0.161	0.179	0.179	0.184	0.161	0.186	0.168	0.174	0.171	0.171	0.18	0.163	0.17	0.19	0.182	0.169	0.175	0.16	0.161	0.19	0.1755	0.0145
Chromium	0.073	0.054	0.067	0.058	0.057	0.072	0.013	0.059	0.035	0.064	0.057	0.055	0.061	0.084	0.072	0.071	0.081	0.06	0.013	0.084	0.0485	0.0355
Lead	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Cadmium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Mercury	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Vanadium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0

Nickel	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
Barium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
TPH(total)	0.47	0.73	1.001	0.625	1.189	1.101	1.23	1.201	0.38	0.801	0.94	1.41	0.745	0.8	1.1	1.21	1.03	1.18	0.38	1.41	0.895	0.515
BTEX	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0
THC	0.506	0.798	1.004	0.665	1.203	1.125	1.313	1.211	0.4	0.817	0.961	1.433	0.782	0.81	1.124	1.234	1.048	1.19	0.4	1.433	0.9165	0.5165
THB	5.5	6	4.95	7.3	3.5	7.5	6.5	6.05	7	8.5	3.9	2.05	6.4	5.5	4.1	5	5	3.89	2.05	8.5	5.275	3.225
THF	3	5	3	5	1	3	4.5	3	5	3	2.5	1.05	2.15	2.5	2	2.5	4	2.62	1	5	3	2
HUB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0
HUF	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0
Feacal coliform	11	17	17	11	20	14	14	25	25	13	26	17	11	17	15	26	20	17.13	11	26	18.5	7.5
SRB	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	0

SEDIMENT SAMPLES

Table 22: Physico-chemical

Sample ID	Conductivity	pH	Redox Potential	TOC	Salinity	Particle Size		
						Soil	Clay	Silt
	µs/cm		mV	%	psu	%	%	%
POL SED 1	135	6.02	120.1	1.23	0.09	87	8	5
POL SED 2	139	6.19	113.5	1.19	0.09	90	7	3
POL SED 3	87.6	5.70	125.0	1.06	0.06	88	8	4
POL SED C	131	5.52	151.5	1.76	0.09	90	7	3
Min	**87.6**	**5.7**	**113.5**	**1.06**	**0.06**	**87**	**7**	**3**
Max	**139**	**6.19**	**125**	**1.23**	**0.09**	**90**	**8**	**5**
Average	**113.3**	**5.945**	**119.25**	**1.145**	**0.075**	**88.5**	**7.5**	**4**

Table 23: Exchangeable Cations and Anions

Sample ID	Phosphate	Sulphate	Nitrate	Chloride	Ammonium	Calcium	Potassium	Sodium	Carbonate	Magnesium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SED 1	1.209	134.6	14.85	50.20	15.49	16.03	3.777	32.57	90.00	9.68
POL SED 2	1.042	139.6	14.01	50.20	14.64	24.05	4.214	32.57	89.47	14.52
POL SED 3	1.112	120.0	14.16	33.47	15.43	40.08	5.451	43.42	89.89	24.20
POL SED C	1.078	97.22	14.20	50.20	15.85	32.06	5.147	32.57	88.74	19.36
Min	**1.042**	**120**	**14.01**	**33.47**	**14.64**	**16.03**	**3.777**	**32.57**	**89.47**	**9.68**
Max	**1.209**	**139.6**	**14.85**	**50.2**	**15.49**	**40.08**	**5.451**	**43.42**	**90**	**24.2**
Average	**1.1255**	**129.8**	**14.43**	**41.835**	**15.065**	**28.055**	**4.614**	**37.995**	**89.735**	**16.94**

Table 24: Heavy Metals

Sample ID	Iron	Zinc	Copper	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SED 1	2.147	0.542	0.141	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SED 2	2.125	0.413	0.121	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SED 3	2.146	0.487	0.107	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SED C	2.201	0.461	0.112	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Min	**2.125**	**0.413**	**0.107**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Max	**2.147**	**0.542**	**0.141**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
Average	**2.136**	**0.4775**	**0.124**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**

Table 25: Organics

Sample ID	PAHs	BTEX	Oil & Grease	THC	Phenols
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SED 1	0.180	<0.001	1.435	1.390	<0.001
POL SED 2	0.155	<0.001	1.369	1.347	<0.001
POL SED 3	0.140	<0.001	1.324	1.305	<0.001
POL SED C	0.132	<0.001	1.284	1.245	<0.001

Min	**0.14**	**<0.001**	**1.324**	**1.305**	**<0.001**
Max	**0.18**	**<0.001**	**1.435**	**1.39**	**<0.001**
Average	**0.16**	**<0.001**	**1.3795**	**1.3475**	**<0.001**

Table 26: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	cfu/g (x10^3)	sfu/g(x10^2)	cfu/g (x10^1)	sfu/g(x10^1)	MPN/100ML	cfu/g (x10^1)
POL SED 1	4.30	2.00	ND	ND	11	ND
POL SED 2	5.00	3.30	ND	ND	12	ND
POL SED 3	5.00	4.30	ND	ND	8.2	ND
POL SED C	8.05	1.05	ND	ND	9.1	ND
Min	**4.3**	**2**	**ND**	**ND**	**8.2**	**ND**
Max	**5**	**4.3**	**ND**	**ND**	**12**	**ND**
Average	**4.65**	**3.15**	**ND**	**ND**	**10.1**	**ND**

Table 27: SUMMARY OF SEDMENT RESULT

Sample ID			**POL SED 1**	**POL SED 2**	**POL SED 3**	**POL SED C**	**Min**	**Max**	**Average**	**Stdev**
Conductivity	µs/cm		135	139	87.6	131	**87.6**	**139**	**113.3**	**25.7**
pH			6.02	6.19	5.7	5.52	**5.7**	**6.19**	**5.945**	**0.245**
Redox Potential	mV		120.1	113.5	125	151.5	**113.5**	**125**	**119.25**	**5.75**
TOC	%		1.23	1.19	1.06	1.76	**1.06**	**1.23**	**1.145**	**0.085**
Salinity	psu		0.09	0.09	0.06	0.09	**0.06**	**0.09**	**0.075**	**0.015**
Particle Size	Soil	%	87	90	88	90	**87**	**90**	**88.5**	**1.5**
	Clay	%	8	7	8	7	**7**	**8**	**7.5**	**0.5**
	Silt	%	5	3	4	3	**3**	**5**	**4**	**1**
Phosphate	mg/Kg		1.209	1.042	1.112	1.078	**1.042**	**1.209**	**1.1255**	**0.0835**
Sulphate	mg/Kg		134.6	139.6	120	97.22	**120**	**139.6**	**129.8**	**9.8**

Nitrate	mg/Kg	14.85	14.01	14.16	14.2	**14.01**	**14.85**	**14.43**	**0.42**
Chloride	mg/Kg	50.2	50.2	33.47	50.2	**33.47**	**50.2**	**41.835**	**8.365**
Ammonium	mg/Kg	15.49	14.64	15.43	15.85	**14.64**	**15.49**	**15.065**	**0.425**
Calcium	mg/Kg	16.03	24.05	40.08	32.06	**16.03**	**40.08**	**28.055**	**12.025**
Potassium	mg/Kg	3.777	4.214	5.451	5.147	**3.777**	**5.451**	**4.614**	**0.837**
Sodium	mg/Kg	32.57	32.57	43.42	32.57	**32.57**	**43.42**	**37.995**	**5.425**
Carbonate	mg/Kg	90	89.47	89.89	88.74	**89.47**	**90**	**89.735**	**0.265**
Magnesium	mg/Kg	9.68	14.52	24.2	19.36	**9.68**	**24.2**	**16.94**	**7.26**
Iron	mg/Kg	2.147	2.125	2.146	2.201	**2.125**	**2.147**	**2.136**	**0.011**
Zinc	mg/Kg	0.542	0.413	0.487	0.461	**0.413**	**0.542**	**0.4775**	**0.0645**
Copper	mg/Kg	0.141	0.121	0.107	0.112	**0.107**	**0.141**	**0.124**	**0.017**
Chromium	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Lead	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Cadmium	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Mercury	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Vanadium	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Nickel	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Barium	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
PAHs	mg/Kg	0.18	0.155	0.14	0.132	**0.14**	**0.18**	**0.16**	**0.02**
BTEX	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
Oil & Grease	mg/Kg	1.435	1.369	1.324	1.284	**1.324**	**1.435**	**1.3795**	**0.0555**
THC	mg/Kg	1.39	1.347	1.305	1.245	**1.305**	**1.39**	**1.3475**	**0.0425**
Phenols	mg/Kg	<0.001	<0.001	<0.001	<0.001	**<0.001**	**<0.001**	**<0.001**	**0**
THB	cfu/g ($x10^3$)	4.3	5	5	8.05	**4.3**	**5**	**4.65**	**0.35**
THF	sfu/g($x10^2$)	2	3.3	4.3	1.05	**2**	**4.3**	**3.15**	**1.15**
HUB	cfu/g ($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
HUF	sfu/g($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**
Feacal coliform	MPN/100ML	11	12	8.2	9.1	**8.2**	**12**	**10.1**	**1.9**
SRB	cfu/g ($x10^1$)	ND	ND	ND	ND	**ND**	**ND**	**ND**	**0**

Note:

LOD= limit of Detection; C= Control; ND=Not Detected

Appendix 4.3b_Wet_Season Results 2020

APPENDIX 4.3B

Table 1: Sampling Georeferenced Point for all Environmental Parameters

Sample ID	Sample	Longitude	Latitude
Soil and Vegetation			
1	Soil & Veg	6.41199	5.6087
2	Soil & Veg	6.41171	5.60876
3	Soil & Veg	6.41082	5.60944
4	Soil & Veg	6.41074	5.60766
5	Soil & Veg	6.40991	5.6129
6	Soil & Veg	6.40944	5.613
8	Soil & Veg	6.41771	5.61217
9	Soil & Veg	6.41819	5.61225
10	Soil & Veg	6.41156	5.61652
11	Soil & Veg	6.41653	5.61284
12	Soil & Veg	6.40758	5.61861
13	Soil & Veg	6.3977	5.6233
14	Soil & Veg	6.38978	5.62489
15	Soil & Veg	6.38851	5.62861
16	Soil & Veg	6.38762	5.6824
17	Soil & Veg	6.39625	5.63488
	Control - Soil & Veg	6.39806	5.63603
	Control - Soil & Veg	6.40019	5.63861
	Control - Soil & Veg	6.40088	5.63974
Air Quality and Noise Level			
1	Air Quality & Noise	6.41199	5.6087
2	Air Quality & Noise	6.41171	5.60876
3	Air Quality & Noise	6.41082	5.60944
4	Air Quality & Noise	6.41074	5.60766
5	Air Quality & Noise	6.40991	5.6129
6	Air Quality & Noise	6.40944	5.613
8	Air Quality & Noise	6.41771	5.61217
9	Air Quality & Noise	6.41819	5.61225
10	Air Quality & Noise	6.41156	5.61652
11	Air Quality & Noise	6.41653	5.61284
12	Air Quality & Noise	6.40758	5.61861
13	Air Quality & Noise	6.3977	5.6233
14	Air Quality & Noise	6.38978	5.62489
15	Air Quality & Noise	6.38851	5.62861
16	Air Quality & Noise	6.38762	5.6824
17	Air Quality & Noise	6.39625	5.63488
18	Air Quality & Noise	6.39806	5.63603
19	Air Quality & Noise	6.40019	5.63861

20	Air Quality & Noise	6.40088	5.63974
21	Air Quality & Noise	6.415277	5.68315
22	Air Quality & Noise	6.42312	5.69241
23	Air Quality & Noise	6.42367	5.68287
24	Air Quality & Noise	6.3962	5.69916
25	Air Quality & Noise	6.39816	5.68052
26	Air Quality & Noise	6.40448	5.68818
27	Air Quality & Noise	6.41359	5.68274
28	Air Quality & Noise	6.40253	5.68556
29	Air Quality & Noise	6.40564	5.6872
30	Air Quality & Noise	6.40649	5.69228
31	Air Quality & Noise	6.40649	5.69452
32	Air Quality & Noise	6.41389	5.61861
33	Air Quality & Noise	6.41055	5.6865
34	Air Quality & Noise	6.40384	5.6904
35	Air Quality & Noise	6.40685	5.69474
36	Air Quality & Noise	6.40862	5.70283
37	Air Quality & Noise	6.41483	5.70442
38	Air Quality & Noise	6.41875	5.70827
39	Air Quality & Noise	6.41214	5.71236
40	Air Quality & Noise	6.42326	5.68317
	Control-Air Quality & Noise	6.40625	5.68317
	Control-Air Quality & Noise	6.41606	5.693
Surface water and Sediment			
1	Surface water & Sediment	6.41159	5.60877
2	Surface water & Sediment	6.41083	5.60760
3	Surface water & Sediment	6.41815	5.61117
	Control - Surface water & Sediment	6.41299	5.62410
Groundwater			
1	Groundwater	6.41091	5.60936
2	Groundwater	6.40941	5.61292
3	Groundwater	6.42573	5.71114
	Control - Groundwater	6.41655	5.66884

AIR QUALITY/NOISE LEVEL AND MICROCLIMATIC DATA

Table 2: Field Findings of Air Quality Parameters, Noise and Microclimates

S/N	Sample ID	Sampling Coordinate			Toxic Gases, GHGs and Particulates												
															Microclimates		
		N	E	SOx (ppm)	VOC (ug/m³)	NOx (ppm	NH_3 (ppm)	H_2S (ppm)	CO (ppm)	CO_2 (ppm)	SPM (ug/m³)	SPM (ug/m³)	Noise Level		Temp (°C)	RH (%)	WS (m/s)
													Min	Max			
1	AQ1	5.6087	6.41199	0	0.1	<0.01	<0.01	0	<0.01	230	20.5	15.9	38.8	41.2	34.3	61.7	1.6
2	AQ2	5.60876	6.41171	0	0.2	<0.01	<0.01	0	<0.01	200	22	16	40.1	52.3	34	62	2
3	AQ3	5.60944	6.41082	0	0.3	<0.01	<0.01	0	<0.01	200	21.5	21.3	39.1	51.4	34.9	60.1	4.1
4	AQ4	5.60766	6.41074	0	0.2	<0.01	<0.01	0	<0.01	150	45.7	46	42	59.3	34.4	62	2.3
5	AQ5	5.6129	6.40991	0	0.3	<0.01	<0.01	0	<0.01	200	83.4	22.6	41.6	53.2	35.7	59.8	2.5
6	AQ6	5.613	6.40944	0	0.4	<0.01	<0.01	0	<0.01	234	86.8	23.1	40.2	54.6	35.9	60.1	0.9
7	AQ7	5.61217	6.41771	0	1	<0.01	<0.01	0	<0.01	200	31.5	17.2	50.32	57.7	40.7	40.9	1.2
8	AQ8	5.61225	6.41819	0	2	<0.01	<0.01	0	<0.01	100	32	16.9	53.1	61	41	52	2.4
9	AQ9	5.61652	6.41156	0	1.5	<0.01	<0.01	0	<0.01	100	29.4	16.6	41.8	55.2	39.4	42.5	2.3
10	AQ10	5.61284	6.41653	0	1	<0.01	<0.01	0	<0.01	120	29.2	16.7	39.3	45.6	40.1	60.2	1.2
11	AQ11	5.61861	6.40758	0	1.1	<0.01	<0.01	0	<0.01	211	35.6	16.8	49.3	55.9	38.5	63.1	1.4
12	AQ12	5.6233	6.3977	0	0.3	<0.01	<0.01	0	<0.01	300	36.2	35.6	52.7	60.2	40.9	64	1.6
13	AQ13	5.62489	6.38978	0	1.1	<0.01	<0.01	0	<0.01	90	76.6	20.1	45.3	57.8	37.6	62.9	0.1
14	AQ14	5.62861	6.38851	0	1.2	<0.01	<0.01	0	<0.01	80	75.9	22.1	42.5	61.2	39.6	59.8	2.1
15	AQ15	5.6824	6.38762	0	2	<0.01	<0.01	0	<0.01	100	107.4	27.2	42.4	69.4	40.5	56.9	1.6
16	AQ16	5.63488	6.39625	0	1.2	<0.01	<0.01	0	<0.01	221	94.6	26.9	46.8	56.7	40.4	57	1.7
17	AQ17	5.63603	6.39806	0	0.3	<0.01	<0.01	0	<0.01	200	82.1	27.2	44.8	54.6	40.2	58	1.2
18	AQ18	5.63861	6.40019	0	0.6	<0.01	<0.01	0	<0.01	200	76.4	29.4	40.1	52.4	41	57.9	1.4
19	AQ19	5.63974	6.40088	0	1	<0.01	<0.01	0	<0.01	200	49.7	29.9	44.3	52	41	58.1	1.3
20	AQ20	5.68315	6.415277	0	0.9	<0.01	<0.01	0	<0.01	200	50.8	30.2	39.8	53.1	40.8	59	1.9

21	AQ21	5.69241	6.42312	0	2	<0.01	<0.01	0	<0.01	200	15.9	15.5	41.1	41.8	34.3	56.7	0.1
22	AQ22	5.68287	6.42367	0	2.1	<0.01	<0.01	0	<0.01	200	10.2	13.5	43.1	41.7	34	51.4	0.2
23	AQ23	5.69916	6.3962	0	2.2	<0.01	<0.01	0	<0.01	200	16.4	13.4	52	59.6	34.9	51.5	1.4
24	AQ24	5.68052	6.39816	0	2.3	<0.01	<0.01	0	<0.01	200	16.6	13.3	44.6	49.1	37.4	57.2	2.6
25	AQ25	5.68818	6.40448	0	2.1	<0.01	<0.01	0	<0.01	222	49.4	17.8	43.2	63.4	36.1	50.1	1.7
26	AQ26	5.68274	6.41359	0	2	<0.01	<0.01	0	<0.01	200	49.5	16.9	50.2	60.5	36.8	51.3	2.3
27	AQ27	5.68556	6.40253	0	1.4	<0.01	<0.01	0	<0.01	202	15.7	9.5	33.1	48.7	36.7	52.2	1
28	AQ28	5.6872	6.40564	0	1.5	<0.01	<0.01	0	<0.01	200	16.2	10.2	39.8	51.3	37	52.1	1.2
29	AQ29	5.69228	6.40649	0	0.4	<0.01	<0.01	0	<0.01	200	152.4	44.2	45.3	46.4	37.1	50.1	2.4
30	AQ30	5.69452	6.40649	0	0.5	<0.01	<0.01	0	<0.01	200	130.3	45.2	39.3	62.5	33.1	50.2	3.2
31	AQ31	5.61861	6.41389	0	0.6	<0.01	<0.01	0	<0.01	190	55.4	20.5	42.7	63.4	37.6	48.1	1.6
32	AQ32	5.6865	6.41055	0	0.1	<0.01	<0.01	0	<0.01	200	56	21.2	55.3	62.2	37.5	52.9	1.7
33	AQ33	5.6904	6.40384	0	1	<0.01	<0.01	0	<0.01	210	54.2	20.1	42.5	51.6	37.5	52.1	0.1
34	AQ34	5.69474	6.40685	0	0.9	<0.01	<0.01	0	<0.01	210	53.4	22.4	40.4	52.9	37.1	51.6	2
35	AQ35	5.70283	6.40862	0	1	<0.01	<0.01	0	<0.01	215	45.2	17.6	45.8	51.6	36.7	52.1	1.6
36	AQ36	5.70442	6.41483	0	1.1	<0.01	<0.01	0	<0.01	200	46	16.9	54.8	52.6	36.7	53.1	2.8
37	AQ37	5.70827	6.41875	0	1	<0.01	<0.01	0	<0.01	200	47	17.2	38.1	51.7	36.6	52.2	1.6
38	AQ38	5.71236	6.41214	0	1	<0.01	<0.01	0	<0.01	180	47.1	17.1	44.3	51.8	36.5	52.3	4.2
39	AQ39	5.68317	6.42326	0	1.2	<0.01	<0.01	0	<0.01	187	55.4	16.5	39.8	46.7	36.6	52.1	6.1
40	AQ40	5.71236	6.42668	0	1.4	<0.01	<0.01	0	<0.01	189	57.2	15.2	41.5	48.5	37.7	79.2	3.2
	Min			0	0.1	<0.01	<0.01	0	<0.01	80	10.2	9.5	33.1	41.2	33.1	40.9	0.1
	Max			0	2.3	<0.01	<0.01	0	<0.01	300	152.4	46	55.3	69.4	41	79.2	6.1
	Mean			0	1.2	<0.01	<0.01	0	<0.01	190	81.3	27.75	44.2	55.3	37.05	60.05	3.1
	CC1	5.68317	6.40625	0	1	<0.01	<0.01	0	<0.01	201	54.5	20.1	46.2	59.7	37.1	51.1	1.6
	CC2	5.693	6.41606	0	1.4	<0.01	<0.01	0	<0.01	205	55.6	21.3	48	60.2	37	52	2

GROUND WATER SAMPLES

Table 3: SUMMARY OF GROUND WATER RESULT

Parameters	Unit	GW 1	GW 2	GW 3	Min	Max	Mean	StDev	GW Control
Physiochemical:									
pH		6.12	6.02	5.79	5.79	6.12	5.96	0.17	6.10
Electrical Conductivity	μS/cm	48	25	91	25	48	36.5	11.50	17
TDS	mg/L	19	9	35	9	35	22	13.00	6
ORP	mV	31	45	55	31	55	43	12.00	32
Temp	^0C	30.8	29.6	29.4	29.4	30.8	30.1	0.70	29.9
Colour	TCU	5	4	8	4	8	6	2.00	3
Salinity	ppt	0.01	0.01	0.02	0.01	0.02	0.01	0.00	0.01
TSS	mg/L	0.32	0.37	0.25	0.25	0.37	0.31	0.06	0.14
Nitrite	mg/L	<0.01	<0.01	0.01	0.01	0.01	0.01	0.00	0.01
DO	mg/L	6.6	7.1	6.9	6.6	7.1	6.9	0.25	7.0
Turbidity	NTU	1.15	0.92	1.80	0.92	1.80	1.36	0.44	0.61
BOD_5	mg/L	3.7	4.0	3.3	3.3	4.0	3.7	0.35	1.4
COD	mg/L	8.87	7.73	9.93	7.73	9.93	8.83	1.10	4.67
THC	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.00	<0.01
Ammonium	mg/L	0.16	0.12	0.15	0.12	0.16	0.14	0.02	0.11
Chloride	mg/L	8.55	6.49	18.50	6.49	18.50	12.50	6.01	5.00
Nitrate	mg/L	0.41	0.34	0.47	0.34	0.47	0.40	0.07	0.31
Phosphate	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.00	<0.01
Sulphate	mg/L	1.84	1.16	3.67	1.16	3.67	2.41	1.25	0.86
Total hardness	mg/L as $CaCO_3$	11.0	9.0	7.0	7.0	11.0	9.0	2.00	8.0
Carbonates	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Total Alkalinity	mg/L as $CaCO_3$	10.0	4.0	6.0	4.0	10.0	7.0	3.00	4.0
Heavy Metals:									
Cu	mg/L	0.009	0.005	0.014	0.005	0.014	0.010	0.00	0.005
Fe	mg/L	1.029	0.635	0.828	0.635	1.029	0.832	0.20	0.956
Ni	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Zn	mg/L	<0.001	0.14	<0.001	<0.001	0.14	0.142	0.00	<0.001
Pb	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Mn	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Cd	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Cr	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Ba	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
V	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00	<0.001
Cations:									
Na	mg/L	4.54	2.75	10.32	2.75	10.32	6.53	3.78	1.97
K	mg/L	0.36	0.41	0.21	0.21	0.41	0.31	0.10	0.16
Ca	mg/L	2.71	2.34	1.44	1.44	2.71	2.08	0.63	1.26
Mg	mg/L	0.98	0.84	0.71	0.71	0.98	0.85	0.13	0.65
Organics:								0.00	
TPH	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	0.00	BDL
PAH	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	0.00	BDL
BTEX	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	0.00	BDL
Microbiological Test:									
THB	cfu/ml	2.3×10^3	2.1×10^3	2.2×10^3	2.1×10^3	2.3×10^3	2.2×10^3	0.10	1.7×10^3
THF	cfu/ml	1.2×10^2	1.0×10^2	1.4×10^2	1.0×10^2	1.4×10^2	1.2×10^2	0.20	1.3×10^2
HUB	cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil	0.00	Nil

HUF	cfu/ml	Nil	Nil	Nil	Nil	Nil	Nil	0.00	Nil
Feacal Coliform	MPN/100ml	Nil	Nil	Nil	Nil	Nil	Nil	0.00	Nil
BDL = Below Detection Limit									

SURFACE WATER SAMPLES

Table 4: SUMMARY OF SURFACE WATER DATA

Parameters	Unit	SW 1	SW 2	SW 3	Min	Max	Mean	StDev	SW Control
Physiochemical:									
pH		7.10	6.50	7.14	6.50	7.14	6.82	0.31	7.32
Electrical Conductivity	µS/cm	36	42	102	36	102	69	31.51	96
TDS	mg/L	14	17	39	14	39	27	11.83	37
ORP	mV	19	30	33	19	33	26	6.47	23
Temp	^{0}C	30.8	30.8	31.8	30.8	31.8	31.3	0.49	30.8
Colour	TCU	6	5	7	5	7	6	0.89	4
Salinity	ppt	0.01	0.01	0.03	0.01	0.03	0.02	0.01	0.02
TSS	mg/L	0.63	0.81	1.06	0.63	1.06	0.85	0.19	0.75
Nitrite	mg/L	0.01	0.01	0.02	0.01	0.02	0.01	0.01	0.01
DO	mg/L	4.20	4.40	4.70	4.20	4.70	4.45	0.22	5.50
Turbidity	NTU	1.77	1.82	1.88	1.77	1.88	1.825	0.05	1.63
BOD_5	mg/L	8.7	9.6	8.7	8.7	9.6	9.2	0.44	8.4
COD	mg/L	23.5	26.7	22.4	22.4	26.7	24.5	1.96	20.3
THC	mg/L	1.00	0.77	0.20	0.20	1.00	0.60	0.36	0.05
Ammonium	mg/L	0.15	0.17	0.31	0.15	0.31	0.23	0.08	0.23
Chloride	mg/L	6.49	5.00	15.49	5.00	15.49	10.25	4.94	9.49
Nitrate	mg/L	0.46	0.51	0.68	0.46	0.68	0.57	0.1	0.56
Phosphate	mg/L	0.01	0.04	0.07	0.01	0.07	0.04	0.03	0.01
Sulphate	mg/L	1.50	1.84	4.58	1.50	4.58	3.04	1.46	4.24

Total hardness	mg/L as $CaCO_3$	12.0	16.0	24.0	12.0	24.0	18.0	5.43	18.0
Carbonates	mg/L	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
Total Alkalinity	mg/L as $CaCO_3$	10.0	6.0	14.0	6.0	14.0	10.0	3.58	16.0
Heavy Metals:									
Cu	mg/L	0.032	0.054	0.046	0.032	0.054	0.043	0.01	0.028
Fe	mg/L	1.698	3.267	1.545	1.545	3.267	2.406	0.82	1.862
Ni	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Zn	mg/L	0.140	0.060	0.113	0.060	0.140	0.100	0.04	0.089
Pb	mg/L	0.012	0.016	0.008	0.008	0.016	0.012	0	0.006
Mn	mg/L	0.058	0.094	0.073	0.058	0.094	0.076	0.02	0.035
Cd	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Cr	mg/L	0.010	0.007	0.004	0.004	0.010	0.007	0	<0.001
Ba	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
V	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Hg	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Cations:									
Na	mg/L	4.43	5.89	4.74	4.43	5.89	5.16	0.68	5.54
K	mg/L	0.70	0.65	0.28	0.28	0.70	0.49	0.2	0.42
Ca	mg/L	2.04	1.85	1.76	1.76	2.04	1.90	0.13	1.31
Mg	mg/L	0.68	0.57	0.52	0.52	0.68	0.60	0.07	0.37
Organics:									
TPH	mg/L	0.853	0.439	0.181	0.181	0.853	0.517	0.3	0.035
PAH	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	0	BDL
BTEX	mg/L	BDL	BDL	BDL	BDL	BDL	BDL	0	BDL
Microbiological Test:									
THB	cfu/ml	5.3×10^3	6.2×10^3	4.7×10^3	4.7×10^3	6.2×10^3	5.5×10^3	1.06	5.8×10^3
THF	cfu/ml	3.6×10^2	4.4×10^2	3.9×10^2	3.6×10^2	4.4×10^2	4.0×10^2	0.57	5.0×10^2

HUB	cfu/ml	1.0 x 10^2	2.1 x 10^2	1.8 x 10^2	1.0 x 10^2	2.1 x 10^2	15.5 x 10^2	0.78	0.7 x 10^2
HUF	cfu/ml	0.4 x 10^1	0.3 x 10^1	0.7 x 10^1	0.3 x 10^1	0.7 x 10^1	0.5 x 10^1	0.28	Nil
Feacal Coliform	MPN/100ml	22	18	32	18	32	25	7	24
BDL = Below Detection Limit									

SOIL SAMPLES

Table 5: SUMMARY TOP SOIL RESULT TOP SOIL

Parameters	**TS1**	**TS2**	**TS3**	**TS4**	**TS5**	**TS6**	**TS7**	**TS8**	**TS9**	**TS10**	**TS11**	**TS12**	**TS13**	**TS14**	**TS15**	**TS16**	**TS17**	**Min**	**Max**	**Mean**	**StDev**	**TS C1**	**TS C2**	**TS C3**
Physiochemical:																								
pH (1:1, soil to water)	4.38	4.12	4.70	4.53	4.40	4.88	5.08	5.41	4.93	4.83	5.00	4.52	4.92	5.30	5.16	5.15	4.14	5.16	4.12	4.84	0.459852	5.20	5.57	4.12
Electrical Conductivity	108	64	41	44	41	50	85	53	27	39	66	853	109	48	69	65	119	109	27	73	75.73379	76	41	100
Temperature	27.2	27	27.1	26.8	27	27	26.9	27.1	27.1	26.9	27.1	26.8	26.9	27	27.2	27	26.9	27.1	26.8	26.98	0.129615	27.1	26.9	26.9
Nitrite	0.052	0.036	0.046	0.075	0.066	0.049	0.052	0.066	0.082	0.105	0.069	0.072	0.046	0.095	0.082	0.046	0.043	0.082	0.036	0.052	0.016439	0.046	0.049	0.039
Chloride	10.64	3.55	1.77	3.55	7.09	3.55	7.09	7.09	7.09	1.77	7.09	159.53	10.64	3.55	7.09	7.09	17.73	10.64	1.77	9.57	20.12239	7.09	3.55	10.64
Sulphate	13.15	5.27	2.64	5.27	10.52	5.27	10.52	7.89	10.52	2.64	789.00	233.86	13.15	5.27	7.89	7.89	18.41	18.41	2.64	11.4	21.11173	7.89	5.27	13.15
TOC	1.64	1.37	0.90	0.98	0.96	0.43	0.94	0.59	0.35	1.21	1.09	1.13	1.09	0.27	0.66	0.47	0.94	1.21	0.27	0.58	0.377	1.05	0.20	1.05
Total Phosphorous	0.019	0.013	0.016	0.026	0.023	0.017	0.019	0.023	0.028	0.040	0.024	0.025	0.016	0.033	0.028	0.016	0.015	0.028	0.013	0.018	0.005409	0.016	0.017	0.014
Ammonium	0.21	0.14	0.18	0.30	0.26	0.19	0.21	0.26	0.32	0.41	0.27	0.28	0.18	0.37	0.32	0.18	0.17	0.32	0.14	0.2	0.064499	0.18	0.19	0.16
Nitrate	0.71	0.49	0.62	1.02	0.88	0.66	0.71	0.88	1.11	1.41	0.93	0.97	0.62	1.28	1.11	0.62	0.58	1.11	0.49	0.7	0.221317	0.62	0.66	0.53
Total Nitrogen	0.16	0.11	0.14	0.23	0.20	0.15	0.16	0.20	0.25	0.32	0.21	0.22	0.14	0.29	0.25	0.14	0.13	0.25	0.11	0.16	0.050066	0.14	0.15	0.12
Oil & Grease	1.29	1.13	0.85	0.99	0.85	0.57	0.99	0.71	0.43	1.12	0.99	0.99	0.99	0.43	0.71	0.57	0.85	1.12	0.43	0.56	0.334592	0.99	0.16	0.99
Phenols	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Bulk density	1.42	1.66	2.17	2.27	2.07	2.10	1.99	1.93	2.32	2.31	1.92	1.82	2.29	1.98	2.05	2.10	1.84	2.29	1.42	2.05	0.22526	1.92	2.13	1.88
Porosity	25.3	37.4	18.1	14.3	21.9	20.8	24.9	27.2	12.5	12.8	27.5	31.3	13.2	25.3	22.6	20.8	30.6	30.6	12.5	21.9	7.12131	27.5	19.6	29.1

THC	0.86	0.63	0.47	0.61	0.39	0.32	0.76	0.42	0.27	0.78	0.49	0.60	0.40	0.17	0.51	0.34	0.49	0.76	0.17	0.32	0.204273	0.51	0.13	0.73
Percent Carbon	1.26	1.05	0.69	0.75	0.74	0.33	0.72	0.45	0.27	0.93	0.84	0.87	0.84	0.21	0.51	0.36	0.72	0.93	0.21	0.43	0.291527	0.81	0.15	0.81
CEC	13.84	10.59	8.85	11.95	10.24	5.74	9.20	9.86	15.33	13.96	7.48	13.31	17.57	9.04	10.41	14.44	12.92	9.20	10.24	12.06	2.968301	13.04	13.31	17.21
Particle Size Distribution:																								
Sand	2	5	79	75	79	84	84	82	79	80	84	84	79	81	83	81	86	84	2	72.12	25.15762	81	86	78
Silt	85	77	14	18	13	9	7	10	12	8	4	6	9	9	7	7	4	4	85	17.56	23.13626	8	6	11
Clay	13	18	7	7	8	7	9	8	9	12	12	10	12	10	10	12	10	7	18	10.32	4.115532	11	8	11
Heavy Metals:																								
Cu	6.21	7.89	5.69	9.43	10.53	6.43	3.29	5.47	0.86	2.45	3.64	2.31	1.10	0.69	2.05	3.52	0.46	0.46	10.53	3.39	3.044775	1.90	0.75	1.03
Fe	12651	17605	9533	9760	7465	9438	8778	6463	3658	7489	5109	7134	6182	6340	6562	33615	7160	3658	33615	7866	5972.799	3149	4999	5563
Ni	4.45	7.32	1.12	2.64	0.55	0.52	0.23	0.21	0.40	1.94	2.45	2.10	0.57	1.44	3.40	1.56	0.64	1.56	7.32	1.44	1.669898	1.26	0.55	0.63
Zn	20.18	15.39	21.45	13.25	17.70	23.42	13.22	30.10	21.45	13.20	29.45	20.11	30.84	19.60	34.25	26.49	19.58	13.20	34.25	20.66	7.054775	18.88	17.80	15.35
Pb	2.19	2.85	1.45	1.32	4.57	0.86	3.86	0.75	2.11	3.29	1.46	2.10	2.18	3.26	1.74	0.77	2.15	0.75	4.57	1.98	1.185974	3.25	0.89	0.73
Mn	28.40	39.35	59.75	12.31	7.03	20.43	9.40	12.77	6.60	8.16	16.40	16.84	10.86	14.33	12.19	7.43	11.03	6.60	59.75	14.93	11.82064	14.28	10.10	7.11
Cd	0.86	0.23	0.30	0.12	1.07	0.60	0.78	0.55	0.16	1.25	0.46	1.32	0.45	0.30	0.79	1.10	1.07	0.12	1.32	0.56	0.392458	0.32	0.25	0.26
Cr	0.90	2.75	1.00	0.80	1.35	2.35	1.68	2.30	1.26	2.59	3.39	3.09	1.86	1.67	2.58	3.11	0.54	0.54	3.39	1.73	0.971006	1.00	1.97	0.99
Ba	1.18	2.15	1.30	1.86	0.34	1.52	0.95	1.24	0.42	1.35	1.44	2.65	0.88	2.65	1.32	1.04	0.85	0.34	2.65	1.28	0.690994	1.00	0.78	0.86
V	<0.001	0.14	0.06	<0.001	0.14	0.12	<0.001	0.09	0.17	<0.001	<0.001	<0.001	0.07	0.13	<0.001	<0.001	0.20	<0.001	0.20	0.11	0.031241	<0.001	<0.001	<0.001
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Cations:																								
Na	2.36	1.78	1.59	1.80	1.98	2.98	2.44	1.12	0.91	1.24	1.93	0.53	1.06	1.50	0.85	0.60	0.71	0.53	2.98	1.26	0.690754	0.54	1.21	1.89
K	1.01	0.36	1.19	0.43	0.19	1.20	0.10	0.33	0.22	0.23	1.18	0.12	0.41	0.47	0.18	1.11	0.25	0.10	1.20	0.62	0.481811	0.18	0.46	0.34
Ca	4.46	3.64	2.86	2.21	5.86	1.22	3.89	2.20	2.91	2.23	3.99	1.90	4.86	2.16	2.35	2.57	3.76	1.22	5.86	3.48	1.236175	4.24	3.44	5.77

Mg	2.01	1.81	3.21	1.51	2.21	2.34	2.77	1.21	1.29	1.26	1.38	0.76	1.24	0.91	1.03	1.16	1.20	1.38	3.21	1.63	0.742356	1.08	1.20	2.21
Organics:																								
TPH	0.658	0.558	0.419	0.520	0.342	0.275	0.429	0.367	0.148	0.736	0.440	0.582	0.350	0.157	0.456	0.286	0.465	0.148	0.736	0.246	0.158234	0.475	0.125	0.432
PAH	0.120	0.170	0.060	0.090	BDL	0.060	0.090	0.070	BDL	0.130	0.060	0.190	BDL	BDL	0.050	BDL	0.060	0.000	0.130	0.07	0.040825	0.090	BDL	BDL
Benzene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.000	0.000	0	0	BDL	BDL	BDL
Microbiological Test:																								
THB	6.5 x 10^4	7.6 x 10^4	9.7 x 10^4	5.2 x 10^4	6.4 x 10^4	7.3 x 10^4	5.8 x 10^4	6.6 x 10^4	10.1 x 10^4	6.8 x 10^4	4.5 x 10^4	6.4 x 10^4	3.2 x 10^4	5.7 x 10^4	6.1 x 10^4	4.0 x 10^4	6.8 x 10^4	10.1	9.7	9.4	0.351188	4.8 x 10^4	4.9 x 10^4	7.6 x 10^4
THF	4.3 x 10^3	5.3 x 10^3	6.2 x 10^3	3.2 x 10^3	7.0 x 10^3	6.8 x 10^3	5.6 x 10^3	5.3 x 10^3	3.2 x 10^3	4.6 x 10^3	3.3 x 10^3	3.7 x 10^3	4.8 x 10^3	3.6 x 10^3	4.0 x 10^3	5.2 x 10^3	7.6 x 10^3	3.2	7.6	5.4	2.2	4.0 x 10^3	4.0 x 10^3	4.0 x 10^3
HUB	1.2 x 10^2	1.0 x 10^2	0.4 x 10^2	1.5 x 10^2	1.4 x 10^2	1.3 x 10^2	1.6 x 10^2	1.4 x 10^2	0.8 x 10^2	1.7 x 10^2	1.0 x 10^2	1.0 x 10^2	1.7 x 10^2	0.2 x 10^2	1.2 x 10^2	0.7 x 10^2	2.0 x 10^2	0.2	2	1.1	0.9	2.2 x 10^2	0.2 x 10^2	1.7 x 10^2
HUF	0.4 x 10^2	0.7 x 10^2	Nil	0.5 x 10^2	0.6 x 10^2	1.0 x 10^2	1.0 x 10^2	1.0 x 10^2	0.2 x 10^2	1.1 x 10^2	0.7 x 10^2	0.6 x 10^2	1.0 x 10^2	Nil	0.4 x 10^2	0.3 x 10^2	1.1 x 10^2	0	1.1	0.55	0.55	1.4 x 10^2	Nil	0.9 x 10^2

Table 6: SUMMARY SUB SOIL RESULT SUB SOIL

Parameters	**SS1**	**SS2**	**SS3**	**SS4**	**SS5**	**SS6**	**SS7**	**SS8**	**SS9**	**SS10**	**SS11**	**SS12**	**SS13**	**SS14**	**SS15**	**SS16**	**SS17**	**Min**	**Max**	**Mean**	**StDev**	**SSC1**	**SSC2**	**SSC3**
Physiochemical:																								
pH	4.43	4.08	4.64	4.54	4.30	5.12	5.15	5.24	4.64	4.81	5.14	4.54	4.82	5.29	5.21	5.34	4.50	4.08	5.34	4.86	0.63592	5.34	5.46	4.19
EC	69	68	43	42	42	30	39	127	27	49	46	421	58	35	51	45	75	27	421	113	207.162	90	32	72
Temperature	26.8	27.1	26.9	27	27	26.8	26.7	27.1	27	26.8	27.1	26.9	27	26.9	27.1	27.2	27.1	26.7	27.2	27.00833	0.25226	27.1	27.1	27
Nitrite	0.049	0.030	0.043	0.059	0.062	0.043	0.049	0.062	0.059	0.089	0.059	0.052	0.043	0.092	0.069	0.036	0.039	0.03	0.092	0.059	0.03102	0.039	0.043	0.033
Chloride	7.09	7.09	7.09	1.77	1.77	1.77	1.77	17.73	3.55	3.55	3.55	106.35	7.09	1.77	3.55	3.55	7.09	1.77	106.35	17.21	56.4525	10.64	1.77	7.09
Sulphate	7.89	7.89	7.89	2.64	2.64	2.64	2.64	18.41	5.27	5.27	5.27	110.37	7.89	2.64	5.27	5,27	10.52	2.64	5.27	3.96	1.315	10.52	2.64	7.89
TOC	0.98	1.13	0.78	0.23	0.39	0.16	0.47	0.23	0/16	1.17	0.94	1.01	0.51	0.23	0.39	0.16	0.43	0.16	0.98	0.79	0.42922	0.31	0.08	0.47

Total Phosphorous	0.018	0.011	0.015	0.021	0.022	0.015	0.017	0.022	0.021	0.030	0.021	0.019	0.015	0.031	0.024	0.013	0.014	0.011	0.031	0.021	0.01	0.014	0.015	0.012
Ammonium	0.19	0.12	0.17	0.23	0.25	0.17	0.19	0.25	0.23	0.35	0.23	0.21	0.17	0.36	0.27	0.14	0.16	0.12	0.36	0.23	0.12014	0.16	0.17	0.13
Nitrate	0.66	0.40	0.58	0.80	0.84	0.58	0.66	0.84	0.80	1.19	0.80	0.71	0.58	1.24	0.93	0.49	0.53	0.4	1.24	0.79	0.42036	0.53	0.58	0.44
Total Nitrogen	0.15	0.09	0.13	0.18	0.19	0.13	0.15	0.19	0.18	0.27	0.18	0.16	0.13	0.28	0.21	0.11	0.12	0.09	0.28	0.18	0.09504	0.12	0.13	0.10
Oil & Grease	0.99	0.99	0.71	0.16	0.43	0.16	0.57	0.16	0.16	0.99	0.85	0.85	0.71	0.16	0.43	0.16	0.57	0.16	0.99	0.73	0.42454	0.43	0.16	0.57
Phenols	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Bulk density	1.54	1.92	2.37	2.03	2.09	2.18	2.08	2.15	2.34	2.15	1.94	2.20	1.88	2.41	2.13	2.12	2.02	1.54	2.15	2.02	0.3213	1.99	2.12	1.96
Porosity	41.9	27.5	10.6	23.4	21.1	17.1	21.5	18.7	11.7	18.7	26.8	17.0	29.1	9.10	19.6	20.0	23.8	9.1	41.9	23.3	16.4491	24.9	20.0	26.0
THC	0.55	0.53	0.45	0.09	0.24	0.11	0.35	0.08	0.13	0.52	0.38	0.44	0.33	0.06	0.25	0.04	0.36	0.04	0.55	0.43	0.26665	0.23	0.11	0.43
Percent Carbon	0.75	0.87	0.60	0.18	0.30	0.12	0.36	0.18	0.12	0.90	0.72	0.78	0.39	0.18	0.29	0.12	0.33	0.12	0.9	0.57	0.39154	0.24	0.06	0.36
CEC	14.16	8.95	9.58	9.84	12.61	6.98	7.50	10.69	15.47	10.73	8.24	16.50	15.27	12.78	11.23	15.06	10.20	6.98	16.5	12.11	4.76479	10.54	15.89	16.20
Particle Size Distribution:																								
Sand	3	11	63	80	76	85	85	85	81	78	85	87	76	82	84	82	84	3	87	75.21	45.4776	78	83	84
Silt	76	74	29	15	15	12	9	8	10	3	5	2	16	8	8	8	5	2	76	14.13	39.6884	11	7	4
Clay	21	15	8	5	9	3	6	7	9	19	10	11	8	10	8	10	11	3	21	10.33	9.0515	11	10	12
Heavy Metals:																								
Cu	4.84	8.46	7.99	6.84	8.83	5.83	2.85	4.10	0.56	1.99	5.82	3.16	0.97	1.68	2.11	0.87	1.58	0.56	8.83	3.36	4.20622	0.86	0.27	0.54
Fe	13303	11965	10973	8591	8310	9390	6230	7520	6463	8108	4362	9925	7921	4198	4958	2759	8640	2759	13303	8088	5272.1	3064	3988	4991
Ni	2.68	5.48	0.79	2.02	0.37	0.18	0.47	0.23	0.18	1.02	1.94	0.43	1.85	0.26	2.57	1.52	0.33	0.18	5.48	1.57	2.74804	1.84	0.40	0.20
Zn	19.67	14.00	22.81	10.84	15.39	19.67	15.35	33.92	15.77	34.39	18.50	15.72	28.76	21.48	35.83	23.30	20.22	10.84	35.83	20.82	12.5791	16.35	18.62	16.49
Pb	3.00	0.97	0.87	3.28	2.99	0.94	4.00	0.80	3.25	2.91	2.00	1.26	1.90	2.80	1.32	1.06	1.38	0.8	4	2.04	1.61344	3.17	1.09	0.40
Mn	33.65	32.80	28.35	9.69	10.55	18.36	5.30	11.40	7.32	10.10	14.52	12.66	8.59	15.07	8.52	8.08	9.95	5.3	33.65	15.24	14.3843	12.38	9.46	8.56
Cd	0.54	0.33	1.20	0.53	1.33	0.21	0.32	0.18	0.37	0.84	0.19	1.10	0.65	0.22	0.65	1.25	0.87	0.18	1.33	0.58	0.58381	0.47	0.31	0.19

Cr	0.79	2.54	1.95	0.94	1.60	3.00	1.74	3.20	1.32	4.20	2.16	2.50	2.00	0.90	2.17	0.78	0.86	0.78	4.2	1.83	1.75194	1.45	0.54	0.68
Ba	0.91	2.43	0.90	2.14	0.40	1.69	0.70	0.86	0.64	1.20	2.19	2.47	1.02	2.50	1.25	0.97	1.24	1.25	2.5	1.3	0.7077	1.20	0.63	0.92
V	<0.001	0.09	<0.001	0.12	0.08	0.11	<0.001	0.11	0.10	<0.001	<0.001	<0.001	0.10	0.10	<0.001	0.11	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Hg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001	<0.001	<0.001
Cations:																								
Na	2.73	1.45	1.63	0.76	1.14	2.74	0.97	1.21	0.81	1.66	0.85	1.09	1.79	0.92	0.72	0.66	0.58	0.58	2.74	1.36	1.0938	0.68	1.13	0.79
K	1.13	0.22	0.65	0.16	1.25	1.11	1.31	0.36	0.20	0.11	0.22	0.33	0.50	0.32	1.14	0.15	0.16	0.11	1.31	0.6	0.60335	1.13	1.57	1.28
Ca	4.33	3.99	4.98	3.28	4.94	2.02	2.06	2.87	3.12	4.40	1.68	2.87	3.79	2.28	2.41	2.32	3.81	1.68	4.98	3.33	1.65	2.54	4.87	3.86
Mg	1.97	2.29	2.32	1.64	1.28	1.11	1.16	3.25	1.34	2.56	0.49	2.21	0.19	1.26	0.96	1.20	1.65	0.19	3.25	1.58	1.53213	1.19	1.32	2.27
Organics:																								
TPH	0.316	0.217	0.388	0.075	0.190	0.104	0.301	0.063	0.113	0.328	0.314	0.259	0.311	0.053	0.235	0.027	0.333	0.027	0.388	0.358	0.20033	0.180	0.097	0.328
PAH	0.080	0.040	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0.080	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0	0.08	0.086	0.04801	BDL	BDL	BDL
Benzene	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	0	BDL	BDL	BDL
Microbiological Test:																								
THB	4.6×10^4	5.2×10^4	7.2×10^4	3.8×10^4	4.8×10^4	4.3×10^4	4.4×10^4	5.1×10^4	7.3×10^4	6.5×10^4	3.6×10^4	4.5×10^4	2.4×10^4	3.2×10^4	3.8×10^4	3.2×10^4	5.1×10^4	2.4	7.3	4.85	2.45	2.6×10^4	2.8×10^4	4.7×10^4
THF	3.2×10^3	3.8×10^3	4.1×10^3	3.0×10^3	5.3×10^3	4.2×10^3	3.8×10^3	4.2×10^3	5.0×10^3	5.2×10^3	4.2×10^3	5.6×10^3	2.2×10^3	2.9×10^3	2.8×10^3	4.6×10^3	5.2×10^3	2.2	5.6	3.9	1.7	6.8×10^3	5.6×10^3	2.2×10^3
HUB	0.6×10^2	0.7×10^2	1.0×10^2	0.3×10^2	0.8×10^2	0.6×10^2	0.7×10^2	0.2×10^2	1.0×10^2	1.3×10^2	1.2×10^2	1.8×10^2	0.8×10^2	Nil	0.9×10^2	Nil	0.8×10^2	0	1.8	0.9	0.9	0.5×10^2	1.3×10^2	0.7×10^2
HUF	0.2×10^2	0.2×10^2	0.8×10^2	Nil	0.2×10^2	Nil	0.2×10^2	Nil	0.8×10^2	1.0×10^2	0.7×10^2	1.2×10^2	0.2×10^2	Nil	0.3×10^2	Nil	0.3×10^2	0	1.2	0.6	0.6	0.2×10^2	0.4×10^2	0.3×10^2

SEDIMENT SAMPLES

Table 7: SUMMARY OF SEDIMENT RESULT

Parameters	**Unit**	**SED 1**	**SED 2**	**SED 3**	Min	Max	Mean	StDev	**SED Control**
Physiochemical:									
pH (1:1, sediment to water)		4.65	4.58	4.52	4.52	4.65	4.59	0.065	4.51
Redox Potential	mV	139	142	138	138	142	140	2	140
Electrical Conductivity	µs/cm	96	70	60	60	96	78	18	78
Temperature	°C	26.5	26.5	26.4	26.4	26.5	26.45	0.05	26.6
Nitrite	mg/kg	0.101	0.107	0.091	0.091	0.107	0.099	0.008	0.089
Chloride	mg/kg	21.27	24.82	17.73	17.73	24.82	21.28	3.545	21.27
Sulphate	mg/kg	23.66	28.92	21.03	21.03	28.92	24.98	3.945	23.66
TOC	%	2.03	1.76	1.87	1.76	2.03	1.9	0.135	1.71
Total Phosphorous	%	0.042	0.047	0.035	0.035	0.047	0.041	0.006	0.031
Ammonium	mg/kg	0.40	0.43	0.37	0.37	0.43	0.4	0.0315	0.35
Nitrate	mg/kg	1.41	1.50	1.28	1.28	1.50	1.39	0.1105	1.24
Total Nitrogen	%	0.24	0.28	0.25	0.24	0.28	0.26	0.02	0.28
Oil & Grease	mg/kg	1.54	1.26	1.40	1.26	1.54	1.4	0.14	1.26
Phenols	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
THC	mg/kg	0.86	0.73	0.77	0.73	0.86	0.8	0.065	0.70
Percent Carbon	%	1.56	1.35	1.44	1.35	1.56	1.46	0.105	1.32
CEC	meq/100g	10.65	9.84	11.71	9.84	11.71	10.77	0.937	10.60
Particle Size Distribution:									
Sand	%	43	66	57	43	66	55	11.5	47
Silt	%	38	26	27	26	38	32	6	39
Clay	%	19	8	16	8	19	14	5.5	14
Texture	Texture Triangle	LOAM	SANDY LOAM	SANDY CLAY LOAM					LOAM
Heavy Metals:									
Cu	mg/kg	4.00	1.65	2.50	1.65	4.00	2.83	1.175	2.50
Fe	mg/kg	1303.50	1841.20	1184.00	1184.00	1841.20	1512.6	328.6	1356.50
Ni	mg/kg	2.64	1.56	0.67	0.67	2.64	1.66	0.985	2.44

Zn	mg/kg	19.11	12.60	22.64	12.60	22.64	17.62	5.0175	25.63
Pb	mg/kg	1.24	0.87	1.03	0.87	1.24	1.06	0.185	0.76
Mn	mg/kg	12.46	9.82	21.99	9.82	21.99	15.91	6.085	17.18
Cd	mg/kg	0.14	0.15	<0.001	<0.001	0.15	0.08	0.0745	<0.001
Cr	mg/kg	0.43	0.51	0.85	0.51	0.85	0.68	0.17	0.42
Ba	mg/kg	0.38	0.21	0.47	0.21	0.47	0.34	0.13	0.28
V	mg/kg	0.12	<0.001	0.09	<0.001	0.12	0.061	0.0595	<0.001
Hg	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0	<0.001
Cations:									
Na	meq/100g	2.17	1.90	2.04	1.90	2.17	2.04	0.132	2.00
K	meq/100g	1.22	0.88	1.56	0.88	1.56	1.22	0.34	1.47
Ca	meq/100g	2.69	4.04	3.84	2.69	4.04	3.37	0.6735	4.85
Mg	meq/100g	4.56	3.01	4.27	3.01	4.56	3.79	0.7755	2.27
Organics:									
TPH	mg/kg	0.743	0.616	0.675	0.616	0.743	0.68	0.0635	0.518
PAH	mg/kg	0.210	0.140	0.180	0.140	0.210	0.175	0.035	0.080
Benzene	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	0	BDL
Microbiological Test:									
THB	(cfu/g)	8.3×10^4	6.7×10^4	9.2×10^4	6.7×10^4	9.2×10^4	7.95	1.25	5.3×10^4
THF	(cfu/g)	5.8×10^3	4.7×10^2	4.9×10^3	4.7×10^2	5.8×10^3	5.25	0.55	3.6×10^3
HUB	(cfu/g)	1.3×10^2	1.7×10^2	2.1×10^2	1.3×10^2	2.1×10^2	1.7	0.4	1.5×10^2
HUF	(cfu/g)	1.0×10^2	1.2×10^2	1.3×10^2	1.0×10^2	1.3×10^2	1.15	0.15	1.4×10^2
BDL = Below Detection Limit									

Appendix 4.3c - Raw Data_Pillar_Oil_Dry_Season

CERTIFICATE OF ANALYSIS

2020

DATE	**29/05/2020**
CLIENT	**PILLAR OIL LIMITED.**
PROJECT TITLE	**EIA of further field development of Umuseti-Igbuku, OML 56, Delta State.**
REFERENCE	**JELS LAB RST 020 20032020**
LOCATION	**LAGOS STATE**
DATE RECEIVED	**20/02/2020**
DATE OF ANALYSES	**20/02/2020 – 27/03/2020**

SUMMARY

Jenneoby laboratory received Forty (40) soil samples including three (3) controls at 0-15cm and 15-30cm depths, four (4) sediment samples including one control, four (4) surface water samples including one control and four (4) ground water samples including one (1) control. The samples were documented and stored in a refrigerator at a temperature of 4 degrees Celsius, to preserve the integrity of the samples prior to sample preparation and analysis. All analyses were performed at Jenneoby Environmental and Laboratory Services Ltd.

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Contents

GROUND WATER SAMPLES

Table 1: Physico-chemical

Sample	Colour	Alkalinity	Conductivity	pH	Temp.	Total Hardness	COD	BOD	DO	Salinity	TSS	TDS	Turbidity	Redox Potential
	Pt/Co	mg/L	µs/cm		^{0}C	mg/L	mg/L	mg/L	mg/L	psu	mg/L	mg/L	NTU	mV
POL GW 1	1	Nil	76.6	6.7	24.5	20.00	8.00	1.80	3.87	0.05	ND	38.3	0.0	125.5
POL GW 2	1	Nil	51.2	6.9	24.5	16.00	8.00	1.91	3.94	0.03	ND	25.6	0.0	141.2
POL GW 3	1	Nil	387	6.3	24.5	95.00	16.0	1.77	3.82	0.19	ND	193.7	0.0	188.8
POL GW C	1	Nil	65.6	7.3	24.6	16.00	8.00	1.85	3.90	0.04	ND	32.8	0.0	123.3

Table 2: Exchangeable Cations and Anions

Sample ID	Phosphate	Sulphate	Nitrate	Chloride	Calcium	Ammonium	Potassium	Sodium	Carbonate	Magnesium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL GW 1	0.163	6.713	1.339	12.55	4.81	0.353	0.814	8.14	Nil	2.90
POL GW 2	0.172	2.823	1.384	8.37	3.21	0.371	0.621	5.43	Nil	1.94
POL GW 3	0.157	8.912	1.321	62.7	22.04	0.311	1.720	40.68	Nil	13.31
POL GW C	0.156	5.143	1.304	10.46	3.21	0.277	0.714	6.79	Nil	1.94

Table 3: Heavy Metals

Sample ID	Iron	Manganese	Zinc	Copper	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL GW 1	0.321	0.144	0.211	0.025	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL GW 2	0.300	0.127	0.195	0.014	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL GW 3	0.287	0.113	0.188	0.017	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL GW C	0.292	0.122	0.207	0.016	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 4: Organics

Sample ID	PAHs	TPH	Oil & Grease	THC
	mg/L	mg/L	mg/L	mg/L
POL GW 1	0.004	0.018	0.035	0.026
POL GW 2	0.009	0.020	0.044	0.037
POL GW 3	0.010	0.030	0.050	0.040
POL GWC	0.007	0.014	0.025	0.020

Table 1:Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform
	cfu/ml ($x10^3$)	sfu/ml ($x10^2$)	cfu/ml ($x10^1$)	sfu/ml ($x10^1$)	MPN/100ML
POL GW 1	2.11	1.00	ND	ND	<1.8
POL GW 2	2.50	2.00	ND	ND	1.8
POL GW 3	3.00	1.50	ND	ND	1.8
POL GWC	2.00	1.00	ND	ND	<1.8

SURFACE WATER SAMPLES

Table 6: Physico-chemical

Sample	Colour	Alkalinity	Conductivity	pH	Temp.	Total Hardness	COD	BOD	DO	Salinity	TSS	TDS	Turbidity	Redox Potential
	Pt/Co	mg/L	µs/cm		^{0}C	mg/L	mg/L	mg/L	mg/L	psu	mg/L	mg/L	NTU	mV
POL SW 1	1	Nil	91.1	6.33	24.6	25.0	8.00	1.83	4.22	0.06	0.06	45.5	0.1	45.5
POL SW 2	1	Nil	72.9	6.38	24.6	20.0	8.00	1.95	4.40	0.05	0.95	36.5	1.8	36.5
POL SW 3	1	Nil	72.6	6.26	24.6	20.0	8.00	2.21	4.63	0.04	1.10	36.3	2.1	36.3
POL SW C	1	Nil	69.8	6.07	24.6	16.0	8.00	2.10	4.56	0.04	1.24	34.9	2.4	34.9

Table 7: Exchangeable Cations and Anions

Sample ID	Phosphate	Sulphate	Nitrate	Chloride	Calcium	Ammonium	Potassium	Sodium	Carbonate	Magnesium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL SW 1	0.168	6.452	1.832	16.73	4.81	0.509	1.358	10.86	Nil	2.90
POL SW 2	0.164	6.974	1.364	12.55	4.81	0.341	1.202	8.14	Nil	2.90
POL SW 3	0.175	6.432	1.370	8.37	3.21	0.346	1.148	5.43	Nil	1.94
POL SW C	0.176	4.718	1.869	6.27	3.21	0.564	1.031	4.07	Nil	1.94

Table 8: Heavy Metals

Sample ID	Iron	Zinc	Manganese	Copper	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
POL SW 1	0.621	0.410	0.214	0.147	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SW 2	0.578	0.431	0.233	0.135	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SW 3	0.419	0.478	0.219	0.132	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SW C	0.522	0.422	0.217	0.133	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Table 9: Organics

Sample ID	PAHs	TPH	Oil & Grease	THC
	mg/L	mg/L	mg/L	mg/L
POL SW 1	0.036	0.065	0.104	0.095
POL SW 2	0.028	0.049	0.070	0.058
POL SW 3	0.024	0.045	0.062	0.053
POL SWC	0.015	0.037	0.050	0.044

Table 10: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform
	cfu/ml ($x10^3$)	sfu/ml ($x10^2$)	cfu/ml ($x10^1$)	sfu/ml ($x10^1$)	MPN/100ML
POL SW 1	4.11	2.15	ND	ND	3.6
POL SW 2	3.24	2.00	ND	ND	3.6
POL SW 3	3.18	1.87	ND	ND	2.0
POL SWC	3.11	134	ND	ND	2.0

SOIL SAMPLES

Table 11: Physico-chemical

Sample ID	pH	Temp.	Cond.	Redox Pot.	TOC	Soil Characterization				
						Colour	Permeability	Texture	Grain size	Porosity
	-		µs/cm	mV	%	Visual		-	mm	%
POL SS1 (0-15cm)	5.58	26.4	75.45	100.2	1.25	Brown	Moderate	Sandy	0.1-2	67
POL SS1 (15-30cm)	5.80	25.9	79.50	105.5	1.31	Brown	Moderate	Sandy	0.1-2	68
POL SS2 (0-15cm)	6.10	25.8	83.50	109.4	1.15	Light Brown	Moderate	Sandy	0.1-2	66
POL SS2 (15-30cm)	6.05	26.0	60.20	110.8	1.22	Light Brown	Moderate	Sandy	0.1-2	66
POL SS3 (0-15cm)	5.30	26.1	74.50	113.5	0.93	Brown	Moderate	Sandy	0.1-2	67
POL SS3 (15-30cm)	5.10	26.1	90.05	114.0	1.04	Brown	Moderate	Sandy	0.1-2	67
POL SS4 (0-15cm)	5.60	25.9	62.50	110.5	1.84	Brown	Moderate	Sandy	0.1-2	66
POL SS4 (15-30cm)	5.73	25.8	60.10	120.0	1.87	Brown	Moderate	Sandy	0.1-2	66
POL SS5 (0-15cm)	6.00	25.7	65.35	140.2	1.29	Brown	Moderate	Sandy	0.1-2	66
POL SS5 (15-30cm)	6.10	26.0	80.10	130.5	1.37	Brown	Moderate	Sandy	0.1-2	67
POL SS6 (0-15cm)	6.30	26.2	82.20	110.2	1.49	Brown	Moderate	Sandy	0.1-2	66
POL SS6 (15-30cm)	6.20	25.9	80.40	116.0	1.62	Brown	Moderate	Sandy	0.1-2	66
POL SS7 (0-15cm)	5.72	25.8	70.50	120.0	1.60	Brown	Moderate	Sandy	0.1-2	63
POL SS7 (15-30cm)	5.90	25.6	81.0	112.5	1.66	Brown	Moderate	Sandy	0.1-2	64
POL SS8 (0-15cm)	5.80	25.7	55.10	151.5	1.29	Brown	Moderate	Sandy	0.1-2	68
POL SS8 (15-30cm)	5.70	25.7	60.25	140.5	1.76	Brown	Moderate	Sandy	0.1-2	69
POL SS9 (0-15cm)	6.01	25.8	65.70	120.5	1.84	Brown	Moderate	Sandy	0.1-2	65
POL SS9 (15-30cm)	6.10	25.6	63.45	119.0	1.95	Brown	Moderate	Sandy	0.1-2	64
POL SS10 (0-15cm)	6.01	25.7	51.37	110.0	1.26	Brown	Moderate	Sandy	0.1-2	64
POL SS 10 (15-30cm)	6.20	25.8	55.89	120.0	1.38	Brown	Moderate	Sandy	0.1-2	63
POL SS11 (0-15cm)	5.90	25.8	62.19	115.5	1.11	Brown	Moderate	Sandy	0.1-2	66
POL SS11 (15-30cm)	5.85	25.9	65.00	118.2	1.69	Brown	Moderate	Sandy	0.1-2	64
POL SS12 (0-15cm)	5.80	25.7	53.16	129.8	1.16	Brown	Moderate	Sandy	0.1-2	67

Sample ID	pH	Temp.	Cond.	Redox Pot.	TOC	Soil Characterization				
						Colour	Permeability	Texture	Grain size	Porosity
	-		µs/cm	mV	%	Visual		-	mm	%
POL SS12 (15-30cm)	5.69	25.5	57.20	137.5	1.24	Brown	Moderate	Sandy	0.1-2	66
POL SS 13 (0-15cm)	5.90	25.6	78.50	140.5	1.04	Brown	Moderate	Sandy	0.1-2	68
POL SS 13 (15-30cm)	6.10	25.7	87.00	139.0	13.1	Brown	Moderate	Sandy	0.1-2	66
POL SS 14 (0-15cm)	6.01	25.8	64.00	115.0	1.84	Brown	Moderate	Sandy	0.1-2	65
POL SS 14 (15-30cm)	6.10	25.8	68.20	113.5	1.87	Brown	Moderate	Sandy	0.1-2	67
POL SS 15 (0-15cm)	5.90	26.0	61.35	120.0	1.22	Brown	Moderate	Sandy	0.1-2	66
POL SS 15 (15-30cm)	5.95	26.1	65.90	125.7	1.32	Brown	Moderate	Sandy	0.1-2	66
POL SS 16 (0-15cm)	5.80	25.9	50.10	130.2	0.93	Brown	Moderate	Sandy	0.1-2	68
POL SS 16 (15-30cm)	5.68	25.9	52.10	135.5	1.04	Brown	Moderate	Sandy	0.1-2	69
POL SS 17 (0-15cm)	6.10	25.8	50.50	114.0	1.13	Brown	Moderate	Sandy	0.1-2	67
POL SS 17 (15-30cm)	6.20	26.0	63.40	118.2	1.87	Brown	Moderate	Sandy	0.1-2	68
POL SS C1 (0-15cm)	5.78	26.1	62.50	120.5	1.84	Brown	Moderate	Sandy	0.1-2	65
POL SS C1 (15-30cm)	5.92	25.8	61.90	122.0	1.95	Brown	Moderate	Sandy	0.1-2	69
POL SS C2 (0-15cm)	5.80	26.2	64.00	133.0	1.37	Brown	Moderate	Sandy	0.1-2	64
POL SS C2 (15-30cm)	5.67	25.8	78.50	139.0	1.29	Brown	Moderate	Sandy	0.1-2	68
POL SS C3 (0-15cm)	5.80	25.9	65.00	140.0	1.25	Brown	Moderate	Sandy	0.1-2	65
POL SS C3 (15-30cm)	5.90	25.8	67.20	130.0	1.31	Brown	Moderate	Sandy	0.1-2	69

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Table 12: Exchangeable Cations and Anions

Sample ID	Sulphate	Phosphate	Total-Nitrogen	Nitrate	Nitrite	Carbonate	Ammonium	Sodium	Potassium	Calcium	Magnesium	CEC
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS1 (0-15cm)	74.44	0.953	21.21	10.08	0.079	89.10	11.05	32.57	3.458	32.06	19.36	87.45
POL SS1 (15-30cm)	81.00	1.027	23.12	10.56	0.075	89.18	12.48	32.57	3.421	24.05	14.52	74.56
POL SS2 (0-15cm)	55.03	1.184	24.10	12.05	0.060	59.90	11.99	43.42	3.201	24.05	14.52	85.19
POL SS2 (15-30cm)	64.36	1.014	22.31	10.63	0.069	58.02	11.61	21.71	3.545	16.03	9.68	50.97
POL SS3 (0-15cm)	90.17	1.401	20.09	9.520	0.050	59.10	10.52	32.57	4.658	24.05	14.52	75.80
POL SS3 (15-30cm)	83.55	1.343	23.77	11.28	0.035	60.00	12.45	43.42	3.089	24.02	14.52	85.50
POL SS4 (0-15cm)	52.37	0.958	26.69	12.82	0.085	58.10	13.78	32.57	2.254	32.06	19.36	86.24
POL SS4 (15-30cm)	55.86	0.892	21.73	9.125	0.105	59.10	12.50	32.57	3.054	24.05	14.52	74.19
POL SS5 (0-15cm)	95.29	1.069	23.67	10.10	0.070	88.30	13.50	21.71	3.410	16.03	9.68	50.83
POL SS5 (15-30cm)	90.07	1.032	26.45	13.92	0.070	89.02	12.46	32.57	2.842	24.05	14.52	73.98
POL SS6 (0-15cm)	105.1	1.037	29.90	14.33	0.084	58.01	15.49	32.57	3.314	24.05	14.52	74.45
POL SS6 (15-30cm)	96.94	1.099	28.23	13.72	0.095	60.00	14.41	43.42	2.656	24.05	14.52	84.65
POL SS7 (0-15cm)	75.40	0.982	23.75	12.69	0.065	59.10	10.99	32.57	2.915	24.05	14.52	74.06
POL SS7 (15-30cm)	71.19	1.031	26.02	13.80	0.079	88.20	12.14	43.42	3.129	32.06	19.36	97.97
POL SS8 (0-15cm)	59.22	1.095	27.66	14.41	0.050	89.50	13.20	21.71	2.022	8.02	4.84	36.59
POL SS8 (15-30cm)	64.56	1.012	22.37	10.52	0.060	89.72	11.79	32.57	2.045	8.02	4.84	47.48
POL SS9 (0-15cm)	88.09	0.935	24.07	11.78	0.094	89.18	12.20	32.57	2.345	24.05	14.52	73.49
POL SS9 (15-30cm)	89.47	0.966	24.47	11.89	0.094	89.30	12.49	32.57	2.267	16.03	9.68	60.55
POL SS10 (0-15cm)	76.94	0.869	25.56	12.12	0.089	88.10	13.35	21.71	2.842	16.03	9.68	50.26
POL SS 10 (15-30cm)	88.07	0.913	25.70	11.96	0.084	89.02	13.66	32.57	2.626	8.02	4.84	48.06
POL SS11 (0-15cm)	85.09	1.018	23.03	10.47	0.070	59.05	12.49	32.57	3.454	24.05	14.52	74.59
POL SS11 (15-30cm)	79.36	0.979	26.43	12.83	0.079	58.10	13.52	32.57	2.140	32.06	19.36	86.13
POL SS12 (0-15cm)	84.26	0.978	26.45	14.25	0.103	60.00	12.10	21.71	2.325	8.02	4.84	36.90
POL SS12 (15-30cm)	75.77	0.903	26.08	13.02	0.099	58.87	12.96	21.71	2.584	8.02	4.84	37.15
POL SS13 (0-15cm)	85.69	1.208	26.30	12.24	0.090	59.09	13.97	43.42	2.304	24.05	14.52	84.29
POL SS13 (15-30cm)	91.05	1.134	24.05	10.11	0.100	60.00	13.84	54.28	2.879	24.05	14.52	95.73
POL SS 14 (0-15cm)	65.33	0.950	24.31	11.55	0.119	88.14	12.64	32.51	3.014	32.06	19.36	86.94
POL SS 14 (15-30cm)	57.35	1.059	23.19	10.21	0.104	89.45	12.88	32.57	2.924	24.05	14.52	74.06
POL SS 15 (0-15cm)	81.33	0.898	20.59	9.542	0.094	60.00	10.95	32.57	3.250	24.05	14.52	74.39
POL SS 15 (15-30cm)	76.43	0.853	22.19	10.69	0.079	59.45	11.42	21.71	3.008	16.03	9.68	50.43
POL SS 16 (0-15cm)	73.37	0.927	25.25	12.98	0.074	58.95	12.20	21.71	2.256	16.03	9.68	49.68
POL SS 16 (15-30cm)	80.46	0.973	22.69	10.74	0.089	58.10	11.86	32.57	2.102	24.05	14.52	73.24

Sample ID	Sulphate	Phosphate	Total-Nitrogen	Nitrate	Nitrite	Carbonate	Ammonium	Sodium	Potassium	Calcium	Magnesium	CEC
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS 17 (0-15cm)	86.33	0.957	26.48	13.85	0.110	59.62	12.52	32.57	2.223	24.05	14.52	73.36
POL SS 17 (15-30cm)	90.26	1.016	26.16	12.47	0.129	60.00	13.56	21.71	2.521	16.03	9.68	49.94
POL SS C1 (0-15cm)	109.6	1.015	27.69	13.51	0.158	89.20	14.02	32.57	2.143	24.05	14.52	73.28
POL SSC1 (15-30cm)	110.2	0.994	23.51	10.58	0.179	88.67	12.75	32.51	2.317	32.06	19.36	86.25
POL SSC2 (0-15cm)	81.22	0.954	22.14	10.65	0.095	90.00	11.39	32.51	1.982	24.05	14.52	73.06
POL SSC2 (15-30cm)	75.44	0.882	23.53	11.07	0.104	89.47	12.36	43.42	2.199	24.05	14.52	84.19
POL SSC3 (0-15cm)	64.08	0.941	20.95	9.958	0.085	89.89	10.91	32.57	1.875	24.05	14.52	73.02
POL SSC3 (15-30cm)	69.84	0.897	22.89	10.60	0.105	88.74	12.18	32.51	2.145	24.05	14.52	73.23

Table 13: Heavy Metals

Sample ID	Iron	Zinc	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS1 (0-15cm)	1.802	0.177	0.065	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS1 (15-30cm)	1.995	0.161	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS2 (0-15cm)	1.824	0.128	0.047	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS2 (15-30cm)	2.708	0.179	0.054	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS3 (0-15cm)	2.601	0.167	0.048	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS3 (15-30cm)	2.675	0.179	0.067	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS4 (0-15cm)	2.584	0.154	0.061	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS4 (15-30cm)	1.794	0.184	0.058	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS5 (0-15cm)	1.841	0.147	0.043	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS5 (15-30cm)	1.947	0.161	0.057	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS6 (0-15cm)	1.510	0.180	0.046	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS6 (15-30cm)	2.724	0.186	0.072	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS7 (0-15cm)	1.814	0.164	0.063	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS7 (15-30cm)	2.614	0.168	0.013	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS8 (0-15cm)	1.988	0.132	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS8 (15-30cm)	2.704	0.174	0.059	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Sample ID	Iron	Zinc	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SS9 (0-15cm)	1.968	0.169	0.037	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS9 (15-30cm)	2.214	0.171	0.035	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS10 (0-15cm)	1.780	0.165	0.066	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 10 (15-30cm)	1.994	0.171	0.064	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS11 (0-15cm)	2.621	0.174	0.044	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS11 (15-30cm)	2.871	0.180	0.057	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS12 (0-15cm)	1.621	0.151	0.050	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS12 (15-30cm)	1.884	0.163	0.055	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 13 (0-15cm)	1.628	0.167	0.050	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 13 (15-30cm)	1.914	0.170	0.061	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 14 (0-15cm)	1.701	0.171	0.076	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 14 (15-30cm)	1.910	0.190	0.084	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 15 (0-15cm)	1.617	0.165	0.062	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 15 (15-30cm)	1.716	0.182	0.072	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 16 (0-15cm)	1.671	0.154	0.068	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 16 (15-30cm)	1.801	0.169	0.071	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 17 (0-15cm)	2.599	0.156	0.076	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS 17 (15-30cm)	2.743	0.175	0.081	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C1 (0-15cm)	2.143	0.153	0.058	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C1 (15-30cm)	2.440	0.168	0.063	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C2 (0-15cm)	1.875	0.155	0.062	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C2 (15-30cm)	1.794	0.162	0.067	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C3 (0-15cm)	1.641	0.157	0.058	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SS C3 (15-30cm)	2.104	0.165	0.069	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

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Table 14: Organics

Sample ID	TPH(total)	BTEX	THC
	mg/Kg	mg/Kg	mg/Kg
POL SS1 (0-15cm)	0.387	<0.001	0.453
POL SS1 (15-30cm)	0.470	<0.001	0.506
POL SS2 (0-15cm)	0.600	<0.001	0.632
POL SS2 (15-30cm)	0.730	<0.001	0.798
POL SS3 (0-15cm)	0.798	<0.001	0.834
POL SS3 (15-30cm)	1.001	<0.001	1.004
POL SS4 (0-15cm)	0.400	<0.001	0.452
POL SS4 (15-30cm)	0.625	<0.001	0.665
POL SS5 (0-15cm)	1.120	<0.001	1.157
POL SS5 (15-30cm)	1.189	<0.001	1.203
POL SS6 (0-15cm)	1.043	<0.001	1.072
POL SS6 (15-30cm)	1.101	<0.001	1.125
POL SS7 (0-15cm)	0.956	<0.001	0.984
POL SS7 (15-30cm)	1.230	<0.001	1.313
POL SS8 (0-15cm)	0.801	<0.001	0.809
POL SS8 (15-30cm)	1.201	<0.001	1.211
POL SS9 (0-15cm)	0.295	<0.001	0.312
POL SS9 (15-30cm)	0.380	<0.001	0.400
POL SS10 (0-15cm)	0.597	<0.001	0.605
POL SS 10 (15-30cm)	0.801	<0.001	0.817
POL SS11 (0-15cm)	0.700	<0.001	0.736
POL SS11 (15-30cm)	0.940	<0.001	0.961
POL SS12 (0-15cm)	1.180	<0.001	1.205
POL SS12 (15-30cm)	1.410	<0.001	1.433
POL SS 13 (0-15cm)	0.960	<0.001	0.995
POL SS 13 (15-30cm)	0.745	<0.001	0.782
POL SS 14 (0-15cm)	0.635	<0.001	0.675

Sample ID	TPH(total)	BTEX	THC
	mg/Kg	mg/Kg	mg/Kg
POL SS 14 (15-30cm)	0.800	<0.001	0.810
POL SS 15 (0-15cm)	0.910	<0.001	0.940
POL SS 15 (15-30cm)	1.100	<0.001	1.124
POL SS 16 (0-15cm)	1.047	<0.001	1.085
POL SS 16 (15-30cm)	1.210	<0.001	1.234
POL SS 17 (0-15cm)	0.905	<0.001	0.935
POL SS 17 (15-30cm)	1.030	<0.001	1.048
POL SS C1 (0-15cm)	0.810	<0.001	0.843
POL SS C1 (15-30cm)	1.210	<0.001	1.229
POL SS C2 (0-15cm)	1.157	<0.001	1.183
POL SS C2 (15-30cm)	1.190	<0.001	1.202
POL SS C3 (0-15cm)	1.128	<0.001	1.146
POL SS C3 (15-30cm)	1.267	<0.001	1.287

Table 15: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	(cfu/g) x10^4	(sfu/g) x10^3	cfu/g x10^1	sfu/g x10^1	MPN/100ML	(cfu/g) x10^1
POL SS1 (0-15cm)	6.70	5.00	ND	ND	13	ND
POL SS1 (15-30cm)	5.50	3.00	ND	ND	11	ND
POL SS2 (0-15cm)	8.00	3.00	ND	ND	14	ND
POL SS2 (15-30cm)	6.00	5.00	ND	ND	17	ND
POL SS3 (0-15cm)	3.05	2.00	ND	ND	12	ND
POL SS3 (15-30cm)	4.95	3.00	ND	ND	17	ND
POL SS4 (0-15cm)	5.00	2.05	ND	ND	13	ND
POL SS4 (15-30cm)	7.30	5.00	ND	ND	11	ND
POL SS5 (0-15cm)	3.40	1.50	ND	ND	17	ND

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	(cfu/g) $x10^4$	(sfu/g) $x10^3$	cfu/g $x10^1$	sfu/g $x10^1$	MPN/100ML	(cfu/g) $x10^1$
POL SS5 (15-30cm)	3.50	1.00	ND	ND	20	ND
POL SS6 (0-15cm)	5.30	3.50	ND	ND	11	ND
POL SS6 (15-30cm)	7.50	3.00	ND	ND	14	ND
POL SS7 (0-15cm)	7.05	4.05	ND	ND	13	ND
POL SS7 (15-30cm)	6.50	4.50	ND	ND	14	ND
POL SS8 (0-15cm)	6.00	4.50	ND	ND	17	ND
POL SS8 (15-30cm)	6.05	3.00	ND	ND	25	ND
POL SS9 (0-15cm)	7.50	1.05	ND	ND	11	ND
POL SS9 (15-30cm)	7.00	5.00	ND	ND	25	ND
POL SS10 (0-15cm)	8.10	3.05	ND	ND	17	ND
POL SS 10 (15-30cm)	8.50	3.00	ND	ND	13	ND
POL SS11 (0-15cm)	5.05	2.15	ND	ND	11	ND
POL SS11 (15-30cm)	3.90	2.50	ND	ND	26	ND
POL SS12 (0-15cm)	3.95	2.05	ND	ND	21	ND
POL SS12 (15-30cm)	2.05	1.05	ND	ND	17	ND
POL SS 13 (0-15cm)	4.60	3.50	ND	ND	21	ND
POL SS 13 (15-30cm)	6.40	2.15	ND	ND	11	ND
POL SS 14 (0-15cm)	6.00	5.40	ND	ND	14	ND
POL SS 14 (15-30cm)	5.50	2.50	ND	ND	17	ND
POL SS 15 (0-15cm)	3.50	1.00	ND	ND	11	ND
POL SS 15 (15-30cm)	4.10	2.00	ND	ND	15	ND
POL SS 16 (0-15cm)	5.50	2.50	ND	ND	11	ND
POL SS 16 (15-30cm)	5.00	2.50	ND	ND	26	ND
POL SS 17 (0-15cm)	4.50	2.00	ND	ND	11	ND
POL SS 17 (15-30cm)	5.00	4.00	ND	ND	20	ND
POL SS C1 (0-15cm)	5.00	4.80	ND	ND	17	ND

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	(cfu/g) x10^4	(sfu/g) x10^3	cfu/g x10^1	sfu/g x10^1	MPN/100ML	(cfu/g) x10^1
POL SS C1 (15-30cm)	5.35	3.30	ND	ND	13	ND
POL SS C2 (0-15cm)	4.00	2.85	ND	ND	21	ND
POL SS C2 (15-30cm)	1.45	3.00	ND	ND	17	ND
POL SS C3 (0-15cm)	2.00	1.50	ND	ND	11	ND
POL SS C3 (15-30cm)	7.00	2.00	ND	ND	25	ND

SEDIMENT SAMPLES

Table 16: Physico-chemical

Sample ID	Conductivity	pH	Redox Potential	TOC	Salinity	Particle Size		
						Soil	Clay	Silt
	µs/cm		mV	%	psu	%	%	%
POL SED 1	135	6.02	120.1	1.23	0.09	87	8	5
POL SED 2	139	6.19	113.5	1.19	0.09	90	7	3
POL SED 3	87.6	5.70	125.0	1.06	0.06	88	8	4
POL SED C	131	5.52	151.5	1.76	0.09	90	7	3

Table 17: Exchangeable Cations and Anions

Sample ID	Phosphate	Sulphate	Nitrate	Chloride	Ammonium	Calcium	Potassium	Sodium	Carbonate	Magnesium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SED 1	1.209	134.6	14.85	50.20	15.49	16.03	3.777	32.57	90.00	9.68
POL SED 2	1.042	139.6	14.01	50.20	14.64	24.05	4.214	32.57	89.47	14.52
POL SED 3	1.112	120.0	14.16	33.47	15.43	40.08	5.451	43.42	89.89	24.20
POL SED C	1.078	97.22	14.20	50.20	15.85	32.06	5.147	32.57	88.74	19.36

Table 18: Heavy Metals

Sample ID	Iron	Zinc	Copper	Chromium	Lead	Cadmium	Mercury	Vanadium	Nickel	Barium
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SED 1	2.147	0.542	0.141	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SED 2	2.125	0.413	0.121	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SED 3	2.146	0.487	0.107	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
POL SED C	2.201	0.461	0.112	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

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Table 18: Organics

Sample ID	PAHs	BTEX	Oil & Grease	THC	Phenols
	mg/Kg	mg/Kg	mg/Kg	mg/Kg	mg/Kg
POL SED 1	0.180	<0.001	1.435	1.390	<0.001
POL SED 2	0.155	<0.001	1.369	1.347	<0.001
POL SED 3	0.140	<0.001	1.324	1.305	<0.001
POL SED C	0.132	<0.001	1.284	1.245	<0.001

Table 19: Microbiology

Sample ID	THB	THF	HUB	HUF	Feacal coliform	SRB
	cfu/g ($x10^3$)	sfu/g($x10^2$)	cfu/g ($x10^1$)	sfu/g($x10^1$)	MPN/100ML	cfu/g ($x10^1$)
POL SED 1	4.30	2.00	ND	ND	11	ND
POL SED 2	5.00	3.30	ND	ND	12	ND
POL SED 3	5.00	4.30	ND	ND	8.2	ND
POL SED C	8.05	1.05	ND	ND	9.1	ND

Note:
LOD= limit of Detection
C= Control
ND=Not Detected

Appendix 4.3d - Raw Data_Pillar_Oil_Wet_Season

CLIENT: PILLAR OIL LIMITED
PROJECT TITLE: ENVIRONMENTAL IMPACT ASSESSMENT
LOCATION: UMUSETI-IGBUKU FIELD, OML 56
SAMPLE MATRIX: SOIL
DATE RECEIVED: 06/06/2020
PERIOD OF ANALYSIS: 6th June - 15th July, 2020
NUMBER OF SAMPLE: 40

PILLAR OIL LTD EIA SOIL RESULT

Parameters	Unit	TS1	SS1	TS2	SS2	TS3	SS3	TS4
Physiochemical:								
pH (1:1, soil to water)		4.38	4.43	4.12	4.08	4.70	4.64	4.53
Electrical Conductivity	µs/cm	108	69	64	68	41	43	44
Temperature	^oC	27.2	26.8	27	27.1	27.1	26.9	26.8
Nitrite	mg/kg	0.052	0.049	0.036	0.030	0.046	0.043	0.075
Chloride	mg/kg	10.64	7.09	3.55	7.09	1.77	7.09	3.55
Sulphate	mg/kg	13.15	7.89	5.27	7.89	2.64	7.89	5.27
TOC	%	1.64	0.98	1.37	1.13	0.90	0.78	0.98
Total Phosphorous	%	0.019	0.018	0.013	0.011	0.016	0.015	0.026
Ammonium	mg/kg	0.21	0.19	0.14	0.12	0.18	0.17	0.30
Nitrate	mg/kg	0.71	0.66	0.49	0.40	0.62	0.58	1.02
Total Nitrogen	%	0.16	0.15	0.11	0.09	0.14	0.13	0.23
Oil & Grease	mg/kg	1.29	0.99	1.13	0.99	0.85	0.71	0.99
Phenols	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Bulk density	g/cm^3	1.42	1.54	1.66	1.92	2.17	2.37	2.27
Porosity	%	25.3	41.9	37.4	27.5	18.1	10.6	14.3
THC	mg/kg	0.86	0.55	0.63	0.53	0.47	0.45	0.61
Percent Carbon	%	1.26	0.75	1.05	0.87	0.69	0.60	0.75
CEC	meq/100g	13.84	14.16	10.59	8.95	8.85	9.58	11.95
Particle Size Distribution:								

Sand	%	2	3	5	11	79	63	75
Silt	%	85	76	77	74	14	29	18
Clay	%	13	21	18	15	7	8	7
Texture	Texture Triangle	SILTY LOAM	SILTY LOAM	SILTY LOAM	SILTY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM
Heavy Metals:								
Cu	mg/kg	6.21	4.84	7.89	8.46	5.69	7.99	9.43
Fe	mg/kg	12651	13303	17605	11965	9533	10973	9760
Ni	mg/kg	4.45	2.68	7.32	5.48	1.12	0.79	2.64
Zn	mg/kg	20.18	19.67	15.39	14.00	21.45	22.81	13.25
Pb	mg/kg	2.19	3.00	2.85	0.97	1.45	0.87	1.32
Mn	mg/kg	28.40	33.65	39.35	32.80	59.75	28.35	12.31
Cd	mg/kg	0.86	0.54	0.23	0.33	0.30	1.20	0.12
Cr	mg/kg	0.90	0.79	2.75	2.54	1.00	1.95	0.80
Ba	mg/kg	1.18	0.91	2.15	2.43	1.30	0.90	1.86
V	mg/kg	<0.001	<0.001	0.14	0.09	0.06	<0.001	<0.001
Hg	mg/kg	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cations:								
Na	meq/100g	2.36	2.73	1.78	1.45	1.59	1.63	1.80
K	meq/100g	1.01	1.13	0.36	0.22	1.19	0.65	0.43
Ca	meq/100g	4.46	4.33	3.64	3.99	2.86	4.98	2.21
Mg	meq/100g	2.01	1.97	1.81	2.29	3.21	2.32	1.51
Organics:								
TPH	mg/kg	0.658	0.316	0.558	0.217	0.419	0.388	0.520
PAH	mg/kg	0.120	0.080	0.170	0.040	0.060	BDL	0.090
Benzene	mg/kg	BDL	BDL	BDL	BDL	BDL	BDL	BDL
Microbiological Test:								
THB	(cfu/g)	6.5×10^4	4.6×10^4	7.6×10^4	5.2×10^4	9.7×10^4	7.2×10^4	5.2×10^4
THF	(cfu/g)	4.3×10^3	3.2×10^3	5.3×10^3	3.8×10^3	6.2×10^3	4.1×10^3	3.2×10^3
HUB	(cfu/g)	1.2×10^2	0.6×10^2	1.0×10^2	0.7×10^2	0.4×10^2	1.0×10^2	1.5×10^2
HUF	(cfu/g)	0.4×10^2	0.2×10^2	0.7×10^2	0.2×10^2	Nil	0.8×10^2	0.5×10^2

BDL = Below Detection Limit; TS = Top Soil (0-15cm); SS = Sub Soil (15-30cm)

PREDOMINANT BACTERIA ISOLATES IDENTIFIED IN PILLARS SOIL
Streptococcus spp., Bacillus spp, Pseudomonas spp. Lactobacillus spp, Mycobacterium spp, Arthrobacter spp,

PREDOMINANT FUNGI ISOLATES IDENTIFIED IN PILLARS SOIL

Aspergillus spp., Mucor spp, Fusarium spp, Candida spp, Cladosporium spp, Rhodotorula spp, Penicillium spp.

SS4	TS5	SS5	TS6	SS6	TS7	SS7	TS8	SS8	TS9	SS9	TS10
4.54	4.40	4.30	4.88	5.12	5.08	5.15	5.41	5.24	4.93	4.64	4.83
42	41	42	50	30	85	39	53	127	27	27	39
27	27	27	27	26.8	26.9	26.7	27.1	27.1	27.1	27	26.9
0.059	0.066	0.062	0.049	0.043	0.052	0.049	0.066	0.062	0.082	0.059	0.105
1.77	7.09	1.77	3.55	1.77	7.09	1.77	7.09	17.73	7.09	3.55	1.77
2.64	10.52	2.64	5.27	2.64	10.52	2.64	7.89	18.41	10.52	5.27	2.64
0.23	0.96	0.39	0.43	0.16	0.94	0.47	0.59	0.23	0.35	0/16	1.21
0.021	0.023	0.022	0.017	0.015	0.019	0.017	0.023	0.022	0.028	0.021	0.040
0.23	0.26	0.25	0.19	0.17	0.21	0.19	0.26	0.25	0.32	0.23	0.41
0.80	0.88	0.84	0.66	0.58	0.71	0.66	0.88	0.84	1.11	0.80	1.41
0.18	0.20	0.19	0.15	0.13	0.16	0.15	0.20	0.19	0.25	0.18	0.32
0.16	0.85	0.43	0.57	0.16	0.99	0.57	0.71	0.16	0.43	0.16	1.12
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2.03	2.07	2.09	2.10	2.18	1.99	2.08	1.93	2.15	2.32	2.34	2.31
23.4	21.9	21.1	20.8	17.1	24.9	21.5	27.2	18.7	12.5	11.7	12.8
0.09	0.39	0.24	0.32	0.11	0.76	0.35	0.42	0.08	0.27	0.13	0.78
0.18	0.74	0.30	0.33	0.12	0.72	0.36	0.45	0.18	0.27	0.12	0.93
9.84	10.24	12.61	5.74	6.98	9.20	7.50	9.86	10.69	15.33	15.47	13.96

80	79	76	84	85	84	85	82	85	79	81	80
15	13	15	9	12	7	9	10	8	12	10	8
5	8	9	7	3	9	6	8	7	9	9	12
LOAM SAND	SANDY LOAM	SANDY LOAM	LOAM SAND	LOAM SAND	LOAM SAND	LOAM SAND	LOAM SAND	LOAM SAND	LOAM SAND	LOAM SAND	SANDY LOAM
6.84	10.53	8.83	6.43	5.83	3.29	2.85	5.47	4.10	0.86	0.56	2.45
8591	7465	8310	9438	9390	8778	6230	6463	7520	3658	6463	7489
2.02	0.55	0.37	0.52	0.18	0.23	0.47	0.21	0.23	0.40	0.18	1.94
10.84	17.70	15.39	23.42	19.67	13.22	15.35	30.10	33.92	21.45	15.77	13.20
3.28	4.57	2.99	0.86	0.94	3.86	4.00	0.75	0.80	2.11	3.25	3.29
9.69	7.03	10.55	20.43	18.36	9.40	5.30	12.77	11.40	6.60	7.32	8.16
0.53	1.07	1.33	0.60	0.21	0.78	0.32	0.55	0.18	0.16	0.37	1.25
0.94	1.35	1.60	2.35	3.00	1.68	1.74	2.30	3.20	1.26	1.32	2.59
2.14	0.34	0.40	1.52	1.69	0.95	0.70	1.24	0.86	0.42	0.64	1.35
0.12	0.14	0.08	0.12	0.11	<0.001	<0.001	0.09	0.11	0.17	0.10	<0.001
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
0.76	1.98	1.14	2.98	2.74	2.44	0.97	1.12	1.21	0.91	0.81	1.24
0.16	0.19	1.25	1.20	1.11	0.10	1.31	0.33	0.36	0.22	0.20	0.23
3.28	5.86	4.94	1.22	2.02	3.89	2.06	2.20	2.87	2.91	3.12	2.23
1.64	2.21	1.28	2.34	1.11	2.77	1.16	1.21	3.25	1.29	1.34	1.26
0.075	0.342	0.190	0.275	0.104	0.429	0.301	0.367	0.063	0.148	0.113	0.736
BDL	BDL	BDL	0.060	BDL	0.090	BDL	0.070	BDL	BDL	BDL	0.130
BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
3.8×10^4	6.4×10^4	4.8×10^4	7.3×10^4	4.3×10^4	5.8×10^4	4.4×10^4	6.6×10^4	5.1×10^4	10.1×10^4	7.3×10^4	6.8×10^4
3.0×10^3	7.0×10^3	5.3×10^3	6.8×10^3	4.2×10^3	5.6×10^3	3.8×10^3	5.3×10^3	4.2×10^3	3.2×10^3	5.0×10^3	4.6×10^3
0.3×10^2	1.4×10^2	0.8×10^2	1.3×10^2	0.6×10^2	1.6×10^2	0.7×10^2	1.4×10^2	0.2×10^2	0.8×10^2	1.0×10^2	1.7×10^2
Nil	0.6×10^2	0.2×10^2	1.0×10^2	Nil	1.0×10^2	0.2×10^2	1.0×10^2	Nil	0.2×10^2	0.8×10^2	1.1×10^2

SS10	TS11	SS11	TS12	SS12	TS13	SS13	TS14	SS14	TS15	SS15	TS16	SS16
4.81	5.00	5.14	4.52	4.54	4.92	4.82	5.30	5.29	5.16	5.21	5.15	5.34
49	66	46	853	421	109	58	48	35	69	51	65	45
26.8	27.1	27.1	26.8	26.9	26.9	27	27	26.9	27.2	27.1	27	27.2
0.089	0.069	0.059	0.072	0.052	0.046	0.043	0.095	0.092	0.082	0.069	0.046	0.036
3.55	7.09	3.55	159.53	106.35	10.64	7.09	3.55	1.77	7.09	3.55	7.09	3.55
5.27	789.00	5.27	233.86	110.37	13.15	7.89	5.27	2.64	7.89	5.27	7.89	5,27
1.17	1.09	0.94	1.13	1.01	1.09	0.51	0.27	0.23	0.66	0.39	0.47	0.16
0.030	0.024	0.021	0.025	0.019	0.016	0.015	0.033	0.031	0.028	0.024	0.016	0.013
0.35	0.27	0.23	0.28	0.21	0.18	0.17	0.37	0.36	0.32	0.27	0.18	0.14
1.19	0.93	0.80	0.97	0.71	0.62	0.58	1.28	1.24	1.11	0.93	0.62	0.49
0.27	0.21	0.18	0.22	0.16	0.14	0.13	0.29	0.28	0.25	0.21	0.14	0.11
0.99	0.99	0.85	0.99	0.85	0.99	0.71	0.43	0.16	0.71	0.43	0.57	0.16
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
2,15	1.92	1.94	1.82	2.20	2.29	1.88	1.98	2.41	2.05	2.13	2.10	2.12
18.7	27.5	26.8	31.3	17.0	13.2	29.1	25.3	9.10	22.6	19.6	20.8	20.0
0.52	0.49	0.38	0.60	0.44	0.40	0.33	0.17	0.06	0.51	0.25	0.34	0.04
0.90	0.84	0.72	0.87	0.78	0.84	0.39	0.21	0.18	0.51	0.29	0.36	0.12
10.73	7.48	8.24	13.31	16.50	17.57	15.27	9.04	12.78	10.41	11.23	14.44	15.06

78	84	85	84	87	79	76	81	82	83	84	81	82
3	4	5	6	2	9	16	9	8	7	8	7	8
19	12	10	10	11	12	8	10	10	10	8	12	10
SANDY LOAM	LOAM SAND	LOAM SAND	LOAM SAND	LOAM SAND	SANDY LOAM	SANDY LOAM	SANDY LOAM	SANDY LOAM	LOAM SAND	LOAM SAND	SANDY LOAM	LOAM SAND
1.99	3.64	5.82	2.31	3.16	1.10	0.97	0.69	1.68	2.05	2.11	3.52	0.87
8108	5109	4362	7134	9925	6182	7921	6340	4198	6562	4958	33615	2759
1.02	2.45	1.94	2.10	0.43	0.57	1.85	1.44	0.26	3.40	2.57	1.56	1.52
34.39	29.45	18.50	20.11	15.72	30.84	28.76	19.60	21.48	34.25	35.83	26.49	23.30
2.91	1.46	2.00	2.10	1.26	2.18	1.90	3.26	2.80	1.74	1.32	0.77	1.06
10.10	16.40	14.52	16.84	12.66	10.86	8.59	14.33	15.07	12.19	8.52	7.43	8.08
0.84	0.46	0.19	1.32	1.10	0.45	0.65	0.30	0.22	0.79	0.65	1.10	1.25
4.20	3.39	2.16	3.09	2.50	1.86	2.00	1.67	0.90	2.58	2.17	3.11	0.78
1.20	1.44	2.19	2.65	2.47	0.88	1.02	2.65	2.50	1.32	1.25	1.04	0.97
<0.001	<0.001	<0.001	<0.001	<0.001	0.07	0.10	0.13	0.10	<0.001	<0.001	<0.001	0.11
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
1.66	1.93	0.85	0.53	1.09	1.06	1.79	1.50	0.92	0.85	0.72	0.60	0.66
0.11	1.18	0.22	0.12	0.33	0.41	0.50	0.47	0.32	0.18	1.14	1.11	0.15
4.40	3.99	1.68	1.90	2.87	4.86	3.79	2.16	2.28	2.35	2.41	2.57	2.32
2.56	1.38	0.49	0.76	2.21	1.24	0.19	0.91	1.26	1.03	0.96	1.16	1.20
0.328	0.440	0.314	0.582	0.259	0.350	0.311	0.157	0.053	0.456	0.235	0.286	0.027
0.080	0.060	BDL	0.190	BDL	BDL	BDL	BDL	BDL	0.050	BDL	BDL	BDL
BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6.5×10^{4}	4.5×10^{4}	3.6×10^{4}	6.4×10^{4}	4.5×10^{4}	3.2×10^{4}	2.4×10^{4}	5.7×10^{4}	3.2×10^{4}	6.1×10^{4}	3.8×10^{4}	4.0×10^{4}	3.2×10^{4}
5.2×10^{3}	3.3×10^{3}	4.2×10^{3}	3.7×10^{3}	5.6×10^{3}	4.8×10^{3}	2.2×10^{3}	3.6×10^{3}	2.9×10^{3}	4.0×10^{3}	2.8×10^{3}	5.2×10^{3}	4.6×10^{3}
1.3×10^{2}	1.0×10^{2}	1.2×10^{2}	1.0×10^{2}	1.8×10^{2}	1.7×10^{2}	0.8×10^{2}	0.2×10^{2}	Nil	1.2×10^{2}	0.9×10^{2}	0.7×10^{2}	Nil
1.0×10^{2}	0.7×10^{2}	0.7×10^{2}	0.6×10^{2}	1.2×10^{2}	1.0×10^{2}	0.2×10^{2}	Nil	Nil	0.4×10^{2}	0.3×10^{2}	0.3×10^{2}	Nil

TS17	SS17	TS C1	SS C1	TS C2	SS C2	TS C3	SS C3
4.14	4.50	5.20	5.34	5.57	5.46	4.12	4.19
119	75	76	90	41	32	100	72
26.9	27.1	27.1	27.1	26.9	27.1	26.9	27
0.043	0.039	0.046	0.039	0.049	0.043	0.039	0.033
17.73	7.09	7.09	10.64	3.55	1.77	10.64	7.09
18.41	10.52	7.89	10.52	5.27	2.64	13.15	7.89
0.94	0.43	1.05	0.31	0.20	0.08	1.05	0.47
0.015	0.014	0.016	0.014	0.017	0.015	0.014	0.012
0.17	0.16	0.18	0.16	0.19	0.17	0.16	0.13
0.58	0.53	0.62	0.53	0.66	0.58	0.53	0.44
0.13	0.12	0.14	0.12	0.15	0.13	0.12	0.10
0.85	0.57	0.99	0.43	0.16	0.16	0.99	0.57
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
1.84	2.02	1.92	1.99	2.13	2.12	1.88	1.96
30.6	23.8	27.5	24.9	19.6	20.0	29.1	26.0
0.49	0.36	0.51	0.23	0.13	0.11	0.73	0.43
0.72	0.33	0.81	0.24	0.15	0.06	0.81	0.36
12.92	10.20	13.04	10.54	13.31	15.89	17.21	16.20

86	84	81	78	86	83	78	84
4	5	8	11	6	7	11	4
10	11	11	11	8	10	11	12
LOAM SAND	LOAM SAND	SANDY LOAM	SANDY LOAM	LOAM SAND	LOAM SAND	SANDY LOAM	SANDY LOAM
0.46	1.58	1.90	0.86	0.75	0.27	1.03	0.54
7160	8640	3149	3064	4999	3988	5563	4991
0.64	0.33	1.26	1.84	0.55	0.40	0.63	0.20
19.58	20.22	18.88	16.35	17.80	18.62	15.35	16.49
2.15	1.38	3.25	3.17	0.89	1.09	0.73	0.40
11.03	9.95	14.28	12.38	10.10	9.46	7.11	8.56
1.07	0.87	0.32	0.47	0.25	0.31	0.26	0.19
0.54	0.86	1.00	1.45	1.97	0.54	0.99	0.68
0.85	1.24	1.00	1.20	0.78	0.63	0.86	0.92
0.20	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
0.71	0.58	0.54	0.68	1.21	1.13	1.89	0.79
0.25	0.16	0.18	1.13	0.46	1.57	0.34	1.28
3.76	3.81	4.24	2.54	3.44	4.87	5.77	3.86
1.20	1.65	1.08	1.19	1.20	1.32	2.21	2.27
0.465	0.333	0.475	0.180	0.125	0.097	0.432	0.328
0.060	BDL	0.090	BDL	BDL	BDL	BDL	BDL
BDL	BDL	BDL	BDL	BDL	BDL	BDL	BDL
6.8×10^4	5.1×10^4	4.8×10^4	2.6×10^4	4.9×10^4	2.8×10^4	7.6×10^4	4.7×10^4
7.6×10^3	5.2×10^3	4.0×10^3	6.8×10^3	4.0×10^3	5.6×10^3	4.0×10^3	2.2×10^3
2.0×10^2	0.8×10^2	2.2×10^2	0.5×10^2	0.2×10^2	1.3×10^2	1.7×10^2	0.7×10^2
1.1×10^2	0.3×10^2	1.4×10^2	0.2×10^2	Nil	0.4×10^2	0.9×10^2	0.3×10^2

Appendix 4.4a Interview Guide

INTERVIEW GUIDE ON SOCIO-ECONOMIC INDICATORS

1. Age: ……………………………………………………………………………………….
2. Marital Status):………………………………………… ………………………..
3. Ethnic Group: ………………………………………………………………………
4. Religion: ……………………………………………………………………………..
5. Highest Qualification: ………………………………………………………………
6. Number of Children had: ………………………………………………………….
7. How many persons are there in your household? (probe for sex and age composition)
8. For how long have you lived in this settlement? (Probe to know whether or not respondent hails from the settlement)
9. What do you do for a living? (probe to know respondent's nature of occupation and average monthly income). **Probe for the major economic activities in the settlement.**
10. Please describe the ownership of your apartment (probe further to know the nature of respondent's apartment; whether respondent has a personal room; number of persons living in a room; the nature of the building; the monthly rent (in naira); toilet facilities and the roofing. **Take picture where necessary.**
11. How and where do you source for water? (Probe to know the quality of water consumed by respondent). **Take picture where necessary.**
12. Tell us about source(s) of energy for cooking. (Interviewer should probe to know why community members prefer that source and whether they are willing to embrace modern sources). **You may need to take pictures of the cooking environment.**
13. Please tell us how you manage your domestic wastes. (Probe to know if respondent benefits from governmental agencies responsible for waste management).
14. Please describe the nature and conditions of health facilities in your community. (Probe for the number of health centres/clinics/hospitals and their proximity; accessibility to health facilities; affordability, and friendliness of health workers. Also probe for the use of traditional medicine).

15. Please tell us about the culture, festivals, deities and sacred places in this community. (Probe deeply to understand the cultural dynamics of the people, and to know if there are cultural practices that may be affected by the project).
16. What do you consider to be the development challenges in this community? (probe for availability of good roads, markets, schools and so on).
17. What is your perception of this project? What kinds of businesses and properties do you think would be affected by this project and how will it affect them?

Appendix 4.4b Questionnaire

QUESTIONNAIRE FOR THE ASSESSMENT OF SOCIO-ECONOMIC CHARACTERISTICS

Dear respondent,

We are conducting a study on the socio-economic characteristics of residents in this community. You have been selected to participate by completing a questionnaire. Please note that your participation is strictly voluntary. You may choose to terminate your participation at any point or refuse to participate at all. I assure you that any information you supply shall be treated anonymously.

SOCIO-ECONOMIC AND HEALTH ASSESSMENT QUESTIONNAIRE

Name of Settlement/Community: ……………………………

L.G.A/State: …………………………………………………

Interviewer: ……………………………………………….

Date: ………………………………………………………….

Please tick as appropriate response where applicable

DEMOGRAPHIC CHARACTERISTICS OF RESPONDENTS

QUESTIONS	RESPONSE		Write the number here
1. Sex	1) Male	2) Female	
2. Actual Age	……………………………………………		
3. Education	1) No formal education 2) Primary 3) Secondary 4) OND/NCE	5) HND/B.Sc 6) Postgraduate degree(s)	
4. Religion	1) None 2) Christianity 3) Islam	4) Traditional 5) Others (pls specify)	
5a. Marital Status	1) Never married 2) Married	3) Separated/Divorced 4) Widowed	
5b. If married, what is the marriage type?	1) Monogamy (only one spouse) 2) Polygyny (one man with two or more wives)	3) Polyandry (One woman with two or more husbands)	
6. Ethnic Group	1) Hausa 2) Igbo 3) Igala	4) Igbira 5) Yoruba 4) Others (pls specify)	
7. What is the nature of the apartment wherein you stay?	1) A single room 2) Room and parlour	3) Flat 4) Duplex 5) Others (pls specify)	
8. How many people including you stay in your household?	…………………………………………………		

9. Why are you in this community?

Purpose in the community	Please Tick
Living in the community	
Working in the community	
Living and working in the community	
Other (specify)	

10. For how long have you been living in the community?

………………………………………………………………………

11. Residency Status

Status of Resident	Please tick the option that applies to you
Landlord	
Tenant	
Living in family house without rent payment	
Other (specify)	

12. Income Source

INCOME SOURCE		₦
Agriculture	Crop farming	
	Livestock sales	
	Crop, vegetable, fruit sales	
	Animal products' sales	
	Other (specify)	
Employment (non-farm)	Civil service	
	Private sector	
	Self-employment: petty trading (hairdresser, seamstress, carpenter etc), sale of handicrafts	
Other income sources	Pensions	
	Housing and land rent	
	Other income sources (specify) ………..	
ESTIMATED TOTAL MONTHLY INCOME		

13A. Buildings/structures (more than one option/material is possible)

Building Type	Frequency	Number
Which of the followings describe the type of building wherein you live?	1) Mud wall un-plastered with thatch roof 2) Mud wall un-plastered & zinc roof 3) Mud wall plastered with cement & zinc roof 4) Cement block wall un-plastered & zinc roof 5) Cement block wall plastered & zinc roof	

13B. Toilet facilities:

Kindly indicate the toilet type in your house	Please tick
No toilet	
Pit latrine	
Water Closet toilet	

14. Expenditure

Indicate the effect of the following expenditure items on your family income over the past year (Multiple options are allowed)

Item	Very strong effect	Strong effect	Minor effect	No effect
Food				
Education				
Health				
Transport				
Hire of labour				
Other (specify)				

15. Which ailments have persons in your household suffered from in the past 1 year? (Multiple options are allowed)

Illness	Please Tick
Malaria	
Cough / lung problems	
Diarrhea	
Skin infection	
Sexually transmitted disease	
Eye disease	
Tooth ache	
Cholera	
Fever	
Birth complications (women)	
Other (specify) …………………………………………	

16. Where do you normally seek help when a member of your household is sick?

Facility	Please Tick
Government hospital	
Private health facility	
Traditional healer	
Chemist / pharmacy	
Self-medication(orthodox or herbs)	

17. Where does your household get water from? ***(more than one answer may be given)***

Source	Drinking/Cooking,	Washing, / Others
Borehole		
Well		
Rain collected at homestead		
River /spring		
Water sold by other people		
Other (specify) ……………………………….		

18. Source of fuel or energy for cooking

Source	Please
Electricity	
Gas	
Charcoal	
Wood	
Other (specify) …………………………………………………..	

Appendix 8.1-Pillar Oil DAP

DECOMMISSIONING AND ABANDONMENT PLAN

FOR
UMUSETI/IGBUKU MARGINAL OIL FIELD

JANUARY, 2018

*This document was prepared according to **Part VIIIG Articles A&B of Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN 2002)** in fulfilment of requirement of Department of Petroleum Resources (DPR). It addressed the DPR comments on the Environmental Evaluation Study (EES) Based Environmental Impact Assessment (EIA) Report for the Umuseti - Igbuku Marginal Oil Field Further Development Project in OML-56, Delta State.*

	NAME	DESIGNATION	SIGN. & DATE
Prepared by	ADUNN ETCHIE	Head, HSE	
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REVISION HISTORY

Revision No.	Date	Author	Scope / Remarks
0	January, 2018	AGBANI AKHAZE	First Draft Copy

AUTHORISATION

This Decommissioning and Abandonment Plan document has been prepared in line with Pillar Oil Limited corporate policy and statutory requirements. It is hereby formally approved for use.

Sign.

Manging Director,

SPENCER ONOSODE

Contents

List of Abbreviations and Acronyms

API	-	American Petroleum Institute
DAP	-	Decommissioning and Abandonment Plan
DPR	-	Department of Petroleum Resources
EES	-	Environmental Evaluation Study
EGASPIN	-	Environmental Guidelines and Standards for the Petroleum Industry in Nigeria
EIA	-	Environmental Impact Assessment
LSA	-	Low Specific Activity
NORM	-	Naturally Occurring Radioactive Material
POL	-	Pillar Oil Limited
RP	-	Recommended Procedure

Glossary

Assets:	Includes installations and structures onshore Umuseti/Igbuku field owned by Pillar Oil Limited
The Field:	Umuseti/Igbuku marginal field
DAR	(Decommissioning, Abandonment and Restoration): The dismantling and removal of onshore installations or structures, following facility shutdown, depressurisation and decontamination of vessels, piping and process equipment as well as the cleanup and restoration of sites in accordance with the approved Decommissioning and Abandonment program.
The Authority:	The Department of Petroleum Resources, Federal Ministry of Environment or such other Government department or corporate entity to which is delegated the authority from time to time to administer and regulate the provisions under these Guidelines.
The Company:	Pillar Oil Limited that owns or operates the oil and gas installations or structures in Umuseti/Igbuku field

SECTION I

INTRODUCTION

1.1 Background Information

This Decommissioning and Abandonment Plan (DAP) outlines the Pillar Oil Limited's (POL) management approach for the suspension, decommissioning, demolition and/or abandonment of assets within the Umuseti/Igbuku marginal field project area.

This document was prepared according to *Part VIIIG Articles A&B of Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN 2002)* to provide a context for undertaking decommissioning, abandonment and restoration (DAR) activities in project area.

1.2 Purpose

POL has both legal and social responsibility to decommission (including demolition) and / or abandon assets associated within the Umuseti/Igbuku field development project. This DAP has been prepared to satisfy these obligations and complements the overarching POL Environment, Health and Safety Policy. The purpose of the Plan, therefore, is to provide a framework to:

- Undertake the decommissioning and/or abandonment of assets in a manner that complies with legislative requirements and POL Project operating license requirements;

- Undertake decommissioning and/or abandonment activities in a manner that meets stakeholder expectations;
- Leave a landform which is safe, stable and non-polluting and compatible with the intended post-closure land use and enable effective transfer to third parties, such as landholders; and
- Provide for the retention and beneficial reuse of infrastructure constructed by POL to third parties (e.g. other production companies), where there is an appropriate agreement in place and regulatory authorities are satisfied.

1.3 Scope

This DAP provides an overview of the POL approach to manage decommissioning and/or abandonment activities. Specifically, this DAP:

- Identifies the types of activities/equipment to be decommissioned and/or abandoned across the Umeseti/Igbuku field project area;
- Describes the general approach to decommissioning and/or abandonment of these activities;
- Describes general measures to minimise or manage potential adverse impacts associated with decommissioning and/or abandonment of the activities.

This DAP is to be implemented by all POL Project personnel responsible for the demolition, decommissioning and/or abandonment of the project infrastructure during the decommissioning and restoration phases of the Project.

This DAP is Umuseti/Igbuku site specific. The POL Project Area consists of Umuseti/Igbuku field comprising the production wells, process plant, and export line as illustrated in ***Figure 1.1.***

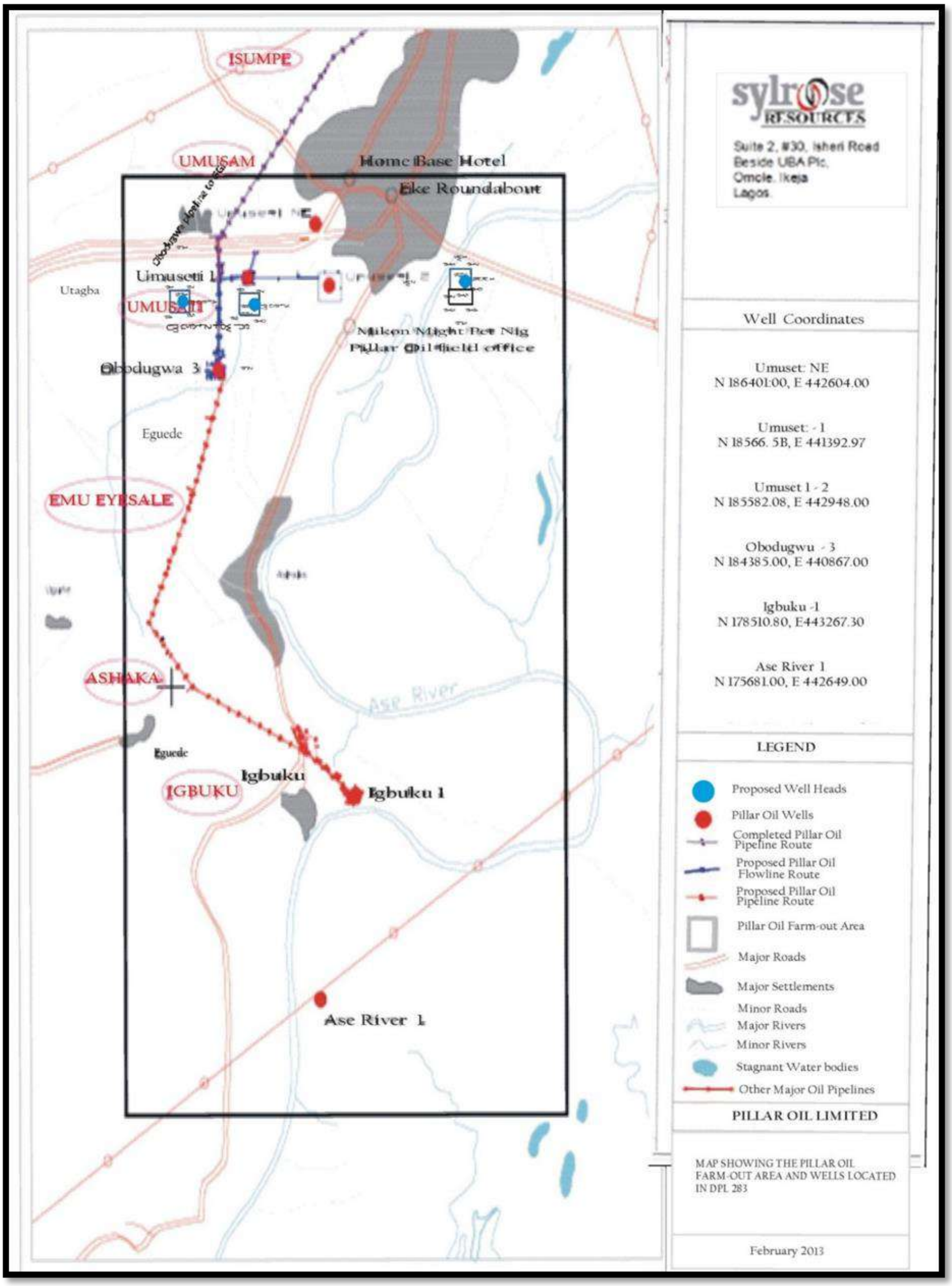
ISUMPE
UMUSAM
Home Base Hotel
Eke Roundabout
Umuseti 1
Utagba
Miikon Might Ret Nig
Pillar Oil field office
Obodugwa 3
Eguede
EMU EYESALE
ASHAKA
Ase River
Igbuku
IGBUKU
Igbuku 1
Ase River 1
sylrose RESOURCES
Suite 2, #30, Isheri Road
Beside UBA Plc,
Omole, Ikeja
Lagos.
Well Coordinates
Umuset: NE
N 186401:00, E 442604.00
Umuset: - 1
N 18566. 5B, E 441392.97
Umuset 1 - 2
N 185582.08, E 442948.00
Obodugwu - 3
N 184385.00, E 440867.00
Igbuku -1
N 178510.80, E443267.30
Ase River 1
N 175681.00, E 442649.00
LEGEND
Proposed Well Heads
Pillar Oil Wells
Completed Pillar Oil Pipeline Route
Proposed Pillar Oil Flowline Route
Proposed Pillar Oil Pipeline Route
Pillar Oil Farm-out Area
Major Roads
Major Settlements
Minor Roads
Major Rivers
Minor Rivers
Stagnant Water bodies
Other Major Oil Pipelines
PILLAR OIL LIMITED
MAP SHOWING THE PILLAR OIL FARM-OUT AREA AND WELLS LOCATED IN DPL 283
February 2013

Figure 1.1: POL assets within Umuseti/Igbuku marginal field project area (Source: Project EIA, 2014)

1.4 Abandonment Timeline

With the current production rate, the economic viability of the Umuseti/Igbuku marginal field is not expected in the next twenty-five (25) years.

1.5 Legal and other Requirements

Pollution control regulations in the oil and gas operations are governed by the Principal legislation of Petroleum Act 1969. The regulations are made pursuant to section 8(i) b (iii) of the Petroleum Act 1969 which empowers the Minister of Petroleum Resources to make regulations for the prevention of pollution of water courses and the atmosphere. The Umuseti/Igbuku marginal field shall be decommissioned in accordance with the prevailing national regulations, international standards and license requirements. Some of the specific regulations include:

- the Petroleum (Drilling and Production) Regulations 1969, Sections 25 and 36;
- the Mineral Oils (Safety) Regulation, 1963, Part III Section 7 and Part IV Sections 44 and 45;
- the Petroleum Regulations 1967; the Oil in Navigable Waters Decree No.34/Regulations 1968;
- the Oil Pipeline Ordinance Cap 145 of 1956 as amended by the Oil Pipeline Act 1965, Section 17(3);
- the Petroleum Refining Regulations 1974, Section 43;
- the Environmental Guidelines and Standards for Petroleum Industry in Nigeria (EGASPIN, 2002 Revision)

1.5 Roles and Responsibilities

In relation to the safety and environmental risks of decommissioning and/or abandonment of plant and equipment, a Management of Change (MoC) proposal shall be developed and submitted to the relevant company's Asset Manager for review and approval prior to the commencement of physical work. The relevant management of change proposal must address the matters listed in Project's global Risk Assessment document.

POL project personnel are responsible for the environmental performance of their activities, for complying with relevant approval/permit requirements and for ensuring that all environmental objectives associated with the work are achieved. POL project personnel shall also be mindful of the General Environmental Duty as outlined in the project Environmental Impact Assessment (EIA) Report and in line with the National Environmental Protection (Effluent Limitations) Regulations of 1991 which also states that "a person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practical measures to prevent or minimise the harm."

Roles, responsibilities and accountability under the DAP will be assigned in accordance with the POL responsibility and accountability policy.

1.6 Pillar Oil Limited Safety and Environment Statement

''It is the philosophy, policy and goal of Pillar Oil Limited to conduct its activities in accordance with industry best practice and regulatory standards for the safety

of its staff, contractors, communities, third parties and the environment in which operations are carried out.

Pillar Oil is fully committed to prevention of industrial accidents and our resources shall be deployed to loss control and mitigation efforts, in case of an undesired accidental occurrence.

All Pillar Oil staff and her contractors shall work in line with this policy. An employee must suspend any job if it undermines, in any way, this central philosophy of the company and must report such to his/her immediate supervisor without delay''.

SECTION II

DECOMMISSIONING, ABANDONMENT AND RESTORATION (DAR)

2.1 Introduction

Prior to site Decommissioning, Abandonment and Restoration (DAR), a Decommissioning Plan Report, detailing the intent of the Company, shall be prepared and submitted to DPR for approval. Thereafter, the standard DAR procedure shall follow.

2.2 Decommissioning Plan Report

Once the project's EIA has been prepared prior to its execution and approved by DPR (in 2014), at the decommissioning and abandonment phase, only Decommissioning Plan Report shall be submitted for approved by DPR as stipulated in *Section 1.1.2 of Part VIIIG, Article A of EGASPIN 2002.*

Decommissioning, abandonment and demolition activities will be undertaken in accordance with the POL Environmental Management Plans listed below, so as to ensure any associated impacts to the environment are minimised as far as practicable:

- Waste Management Plan
- Erosion and Sediment Control Management Plan
- Land Release Management Plan;
- Noise Management Plan; and
- Chemical and Fuel Management Plan

- Project's Environmental Management Plan (EMP)

2.2.1 Format of the Decommissioning Plan Report

The Decommissioning Plan Report shall as a minimum contain:

a) Peculiarity of the project.

b) The degree of abandonment (partial/wholly).

c) Methods to be used for the removal of the structure (explosives, mechanical cutting, touches, high pressure jetting, etc.)

d) Verification of method(s), when used.

e) Disposal of removed structures, debris and associated wastes (all materials radioactivity shall for verified for LSA/NORM).

f) A synopsis of the project's environmental protection/monitoring report (EIA and/or, EER, Restoration and Remediation plans).

2.3 Decommissioning and Abandonment Flowchart

Decommissioning, Abandonment and Restoration (DAR) of the field will typically involve dismantling and removal of onshore installations or structures, following facility shutdown, depressurisation and decontamination of vessels, piping and process equipment as well as the cleanup and restoration of sites in accordance with the approved procedures. The DAR decision procedure is illustrated in ***Figure 2.1*** below.

Decommissioning activities (for facilities completely shut down and/or abandoned) shall commence at least one year after abandonment and be completed within six months to one year.

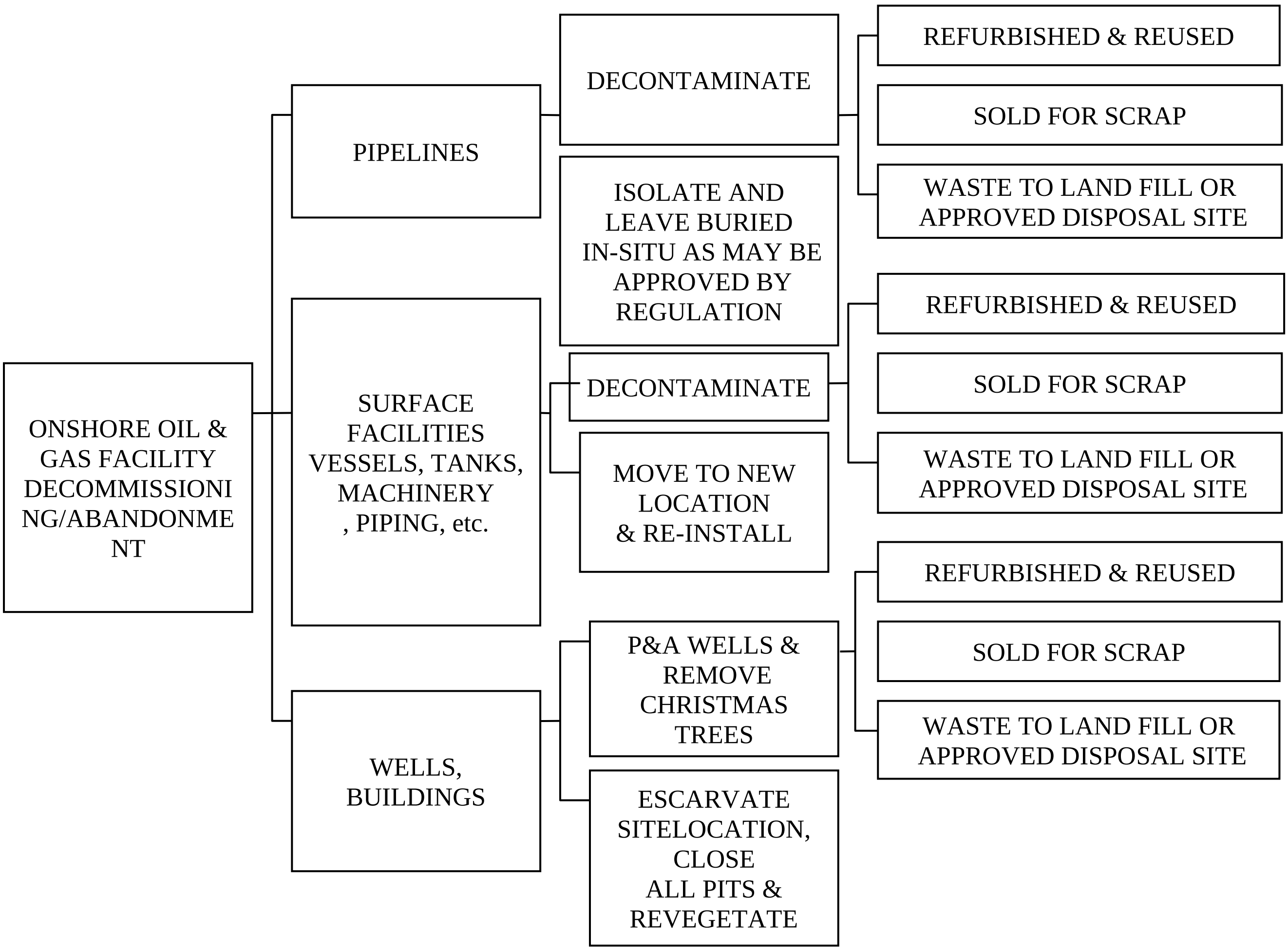

Figure 2.1: DAR Flowchart

2.4 Surface and Subsurface Asset Abandonment/Decommissioning

Administrative process on property acquisition and divestiture shall be complied, with and where possible, affected communities shall be consulted as part of the POL community affairs policy. All surface and buried installations shall be removed entirely and the well site returned to their original land conditions in line with standard practice.

The following sections provide an overview of typical decommissioning and abandonment activities that will apply to common infrastructure types across the project area. As described above, specific methods for decommissioning of infrastructure will be determined at the time of the works and in accordance with the up-to-date regulatory requirements, guidelines and standards.

2.4.1 Production Well Abandonment Strategy

2.4.1.1 Preliminary Decommissioning

Prior to the final decommissioning and/or abandonment of an asset, preliminary decommissioning of assets may be required. Preliminary decommissioning typically occurs when an asset is no longer required for production or unlikely to return to production, however final decommissioning is not yet practicable. The activities are undertaken as required to manage health, safety and environmental risks. Preliminary decommissioning is most commonly associated with production well infrastructure but can also apply to other assets such as produced water treatment facility.

Preliminary decommissioning involves the full isolation of a production well and/or surface equipment and generally involves one or more of the activities:

- Wellhead infrastructure positively isolated from surface equipment;
- Surface infrastructure and piping electrically and mechanically isolated;
- Surface infrastructure depressurised, purged and drained;
- Flow-lines disconnected from the wellhead and depressurised;

- Well integrity verified such that the well is suitable to be left in a suspended state;
- Annulus pressure monitoring and potential bleed off of pressure;
- Removal of well lease surface equipment for recycling or disposal;
- Satisfy other conditions as in American Petroleum Institute Recommended Practice (API – RP) well completion, servicing, workover, and plug and abandonment operations.
- Removal of fuels and lubricants for recycling/sale or disposal;
- Collection and removal of chemicals, wastes, sludge and fluids for recycling or disposal;
- Routine inspections, patrols and / or monitoring;

2.4.1.2 Final Decommissioning, Demolition and Abandonment

Once the production capacity of the reservoir resource has been realised, final decommissioning activities can commence, including abandonment and/or demolition activities. All decommissioning activities will be documented as required and be subject to routine inspections, patrols and/or monitoring to ensure health, safety and environmental issues are minimised and managed as appropriate. See ***Figure 2.1*** for typical decommissioned well.

Decommissioning and abandonment of wells may comprise:

- Isolation of gas reservoirs and aquifers by suitable barriers (where required)
- Placement of a surface cement plug
- Disconnection and de-pressurisation of flow lines and relevant gathering-lines

- Removal of well surface equipment, such as generators, separators, tanks, metering skid and water transfer equipment
- Removal of well casing and tubing to below ground level
- Removal, storage or disposal of all casing risers, flow loops, or other pipe work attached to the wellhead (but not parts of downstream production flow-lines or facilities)
- Cutting off of screw piles associated with the well site foundations below ground level and abandoned
- Backfilling of remaining excavations (if present) such as from drilling, work-over or production operations
- Marking of well locations
- Transferring to third parties remaining well-bores (e.g. water bores) and responsibility for their ongoing maintenance in accordance with appropriate regulatory authorities, permit requirement, and ensuring the recipient of any infrastructure is properly instructed in the safe operating methods and appropriate maintenance of equipment.

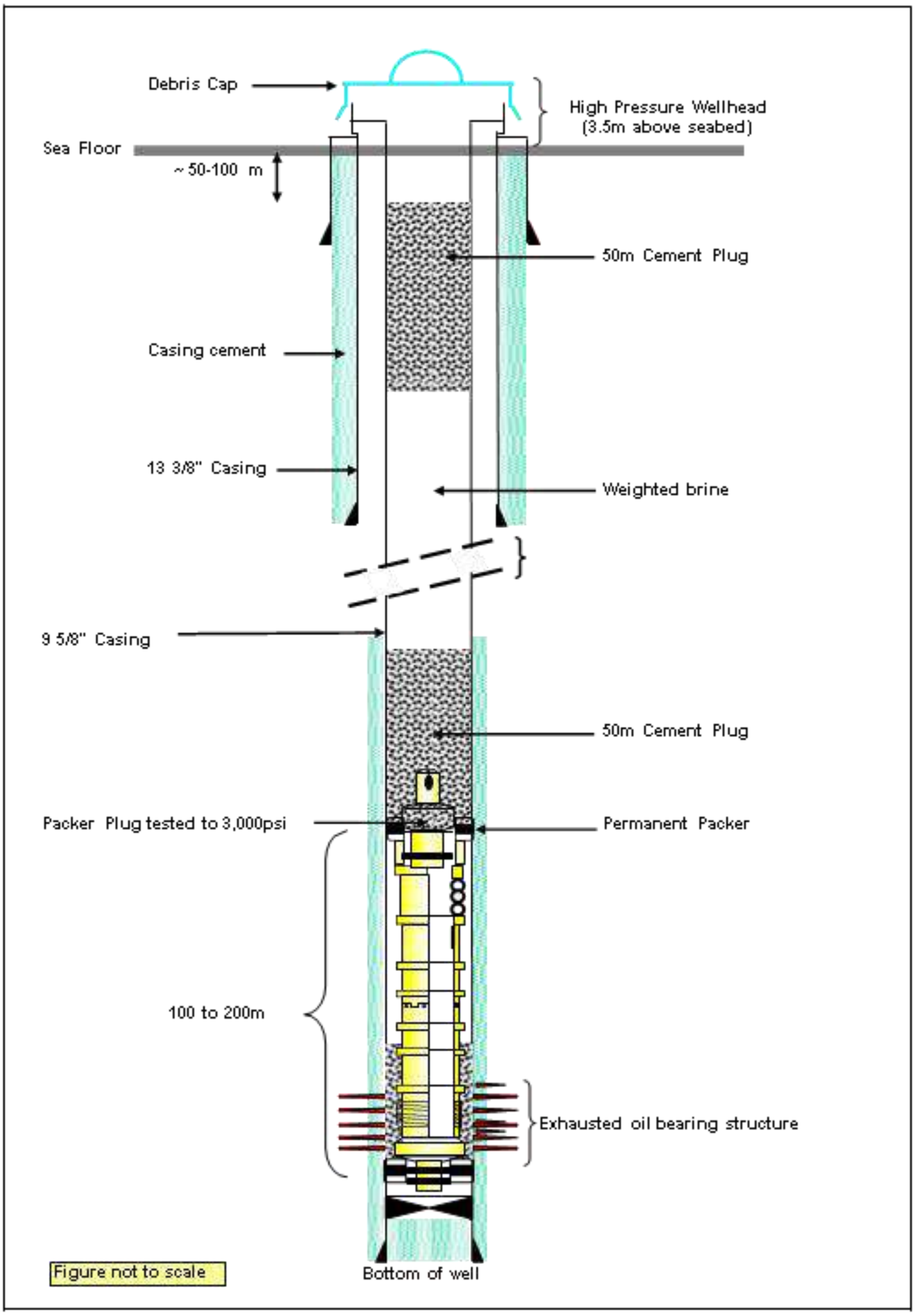

Figure 2.1: Cross-section of typical decommissioned well (Adapted from Jubilee field, Ghana, EIA Report, 2009)

2.4.2 Hub Facilities, Laydown Areas and Camps

Hub Facilities (comprising compressor stations and/or water treatment systems), camps (temporary or permanent) and laydown areas may be comprised of a combination of pad-mounted, modular structures and onsite fabricated structures. Examples of these buildings may include offices, accommodation units, storage, kitchens, warehousing, switch rooms, maintenance facilities, tanks, sewage treatment plants and power generation.

Modular type structures are generally able to be disassembled and removed intact, where re-use or sale is practicable. Where removal is not practicable, then they may be demolished and recycled or disposed of. Fabricated type structures typically require demolition activities and comprise partial or complete removal of surface infrastructure, with piping and other structural elements such as screw piling, cut off and/or capped below grade.

A number of other large structures may be present, at compression stations such as hub and nodal compressors, alternators and gas turbines. For these large structures disassembly for relocation and reuse may not be a practicable alternative and they may be demolished for scrap recycling or disposal. Other process facilities to be decommissioned include Hydro-processing Reactors and Separators, Ammonia Converters and Urea Reactors, Process Separators, Utility Pressure Vessels and Drums, Process tanks , Pig Launchers & Receivers, Air Coolers, Process Skids and Packages. Decommissioning and abandonment activities may comprise:

- Removal of fuels, lubricants, chemicals and wastes, for recycling or disposal;

- Demolition of the building structures (roof, siding and structural materials) for recycling or disposal recycled or disposed;
- Demolition of concrete pads and foundations of the building and infrastructure (where practicable) or abandonment in-situ;
- Concrete crushed and steel rebar segregated for recycling or disposal;
- Abandonment in-situ of underground utilities or piping;
- Removal of gravel pathways, pavements or hardstand areas; and
- Concrete crushed and steel rebar segregated for recycling or disposal.

2.4.3 Pipelines

It is likely that abandonment of pipelines will occur in-situ. Where practicable, pipelines (export line) may be transferred to a third-party for on-going beneficial use. Decommissioning and abandonment activities may comprise:

- Disconnection from and disposal of all aboveground structures such as pigging stations
- Disconnection of the cathodic protection systems
- Cutting and filling critical sections (such as rail crossings) with a stable material (e.g. concrete) to prevent potential future subsidence due to corrosion or breakage
- Cutting and capping at defined locations to prevent the pipe from acting as a conduit for water and / or contaminants
- Minimize conflict with available land use.

2.4.4 Electrical and Communication Lines

Underground electrical and communication lines that are no longer required will be decommissioned in accordance with legislative requirements applicable at that time. Decommissioning and abandonment activities may comprise:

- De-energising and isolating lines;
- Arc flash precautions (as required);
- Removal and recycling or disposal of electrical and communication lines (where practicable) or abandonment in-situ;
- Removal and recycling or disposal of all surface equipment such as transformers, switchyards, substations and communication towers/masts;
- Demolition of concrete pads and foundations such as for switchyards, substations, transformers and communication towers (where practicable) or abandonment in-situ;
- Concrete crushed and steel rebar segregated for recycling or disposal; and
- Demolition and recycling or disposal of transmission poles which may involve cutting off poles below grade.

2.4.5 Roads and Access Tracks

Where practicable, roads and access tracks may be transferred to a third-party for on-going beneficial use. In the event that a road or access track is to be decommissioning and removed, activities may comprise the removal and recycling or disposal of pavements such as asphalt and gravel (if present) and grading of the surface to form a stable landform.

2.4.6 Borrow Pits and Flare Site

Where practicable, borrow pits and quarries may be transferred to a third-party for on-going beneficial use. In the event that a borrow pit or flare site is to be decommissioned, activities may comprise:

- Removal and recycling or disposal of surface infrastructure such as pumps, screening and washing facilities;
- Filling voids with acceptable material to form a safe landform;

- Ensuring drainage is adequate to minimise pollution run-off; and
- Stabilising area of disturbance.

2.5 Site Remediation and Restoration

Site remediation and restoration will entail:

a) A survey of the decommissioned site for contamination as part of a Conceptual Site Model and Strategy Plan;
b) Initial conclusions on the hydrology and geology;
c) Preparation of a Site Assessment Action Process Flow Sheet to be approved by DPR as in *VIII-F1 in EGASPIN*; and
d) Interim action or remediation designed to confirm applicability and feasibility of one or more potential remedial options: such as application of dispersants or biological treatment using petroleum degrading bacteria or by aeration process.

Finally, the site will be monitored for compliance and performance to confirm effectiveness of remedial measures. At the end of the site abandonment, the following useful documentation will be reviewed:

a) The initial DAP (this document)
b) The abandonment operations conducted in the field, along with changes to plan necessitated by field conditions
c) The configuration and lengths of casing and tubing remaining in the well
d) The location and length of plugs, including pumping duration and cement volumes as applicable
e) Test reports for each plug.

2.6 Discharges and Waste Management

Discharges that occur during the decommissioning phase, such as produced water and sewage, will meet the same discharge criteria that applied to the operational phase of the project. Waste generated during the decommissioning phase will be managed as per the project Waste Management Plan, which will be updated through the life of the project. Generally, the waste management will follow the principle of waste reuse, recycling and finally, responsible disposal which is the least considered option.

Existing contract with the company's waste contractors will be reviewed against their engagement for disposal of the wastes associated with the decommissioning process. All hazardous wastes will be disposed at approved sites in Warri, necessary waste notes documenting volume, weight and the waste types will be completed.

SECTION III

EVALUATION AND REVIEW

3.1 Evaluation

The implementation and effectiveness of this plan will be regularly assessed to ensure:

- POL is demonstrating compliance with legal and social obligations;
- The overall management strategy remains relevant and up to date; and
- The issue is being adequately managed.

Effectiveness will be assessed by a number of methods as shown in ***Table 3.1***

Table 3.1: Methods to assess effectiveness

Assessment Tool	Description
Checklists – POL Compliance Management System	• Checklists, developed to reflect legal and procedural requirements / outcomes may be used by individual POL Departments to assess and manage compliance. The results of the checklists will be evaluated for trending non- compliances that may be resolved as a result of a procedural change or by implementing another measure or process.
Audits	• Conduct internal and third party audits to formally assess the level of compliance with both regulatory requirements and with POL procedures. • Audit outcomes are used to develop corrective

Assessment Tool	Description
	actions which may include changes to procedures.
Review of Incidents	• A review of internal incidents, near misses or hazards will be undertaken to identify recurrences of similar incident types. This may highlight a requirement for a change in an existing procedure, require the development of a new procedure or by implementation of another measure or process to address the recurring issue.
Review of Data	• Analyse all relevant data collected for negative and/or undesirable trends that may be prevented by procedural changes or by implementing another measure or process.

3.2 Review

The DAP is a living document and shall be reviewed at least every three years or sooner if any of the following occur:

- The plan is found to be inadequately to manage the issue;
- Legislative requirements change;
- The area of activity changes; and/or
- Significant changes to decommissioning activities occur.

Reviews and changes to the DAP will be communicated to relevant POL project personnel and the concerned regulatory authority.

3.3 Risk – Based Corrective Action for Contaminated Sites

The site shall be subjected to risk assessment to determine any contamination (as illustrated in ***Figure 3.1*** below). Any suspected contamination shall be reviewed and a Risk Based Corrective Action (RBCA) performed. The traditional method for assessing the need and extent for remediating contaminated land is to determine the level of contamination through site investigation and to then compare the contaminant levels measured with soil and groundwater quality standards or criteria defined by legislation. The RBCA report shall, at a minimum, include the following:

- A site description;
- A summary of the site ownership and use;
- A summary of the past releases or potential source areas;
- A summary of current and completed site activities;
- A description of regional hydrogeologic conditions;
- A description of site – specific hydrogeologic condition;
- A summary of beneficial use;
- A summary and discussion of the risk assessment (hazard identification, dose response assessment, exposure assessment, and risk characterization),

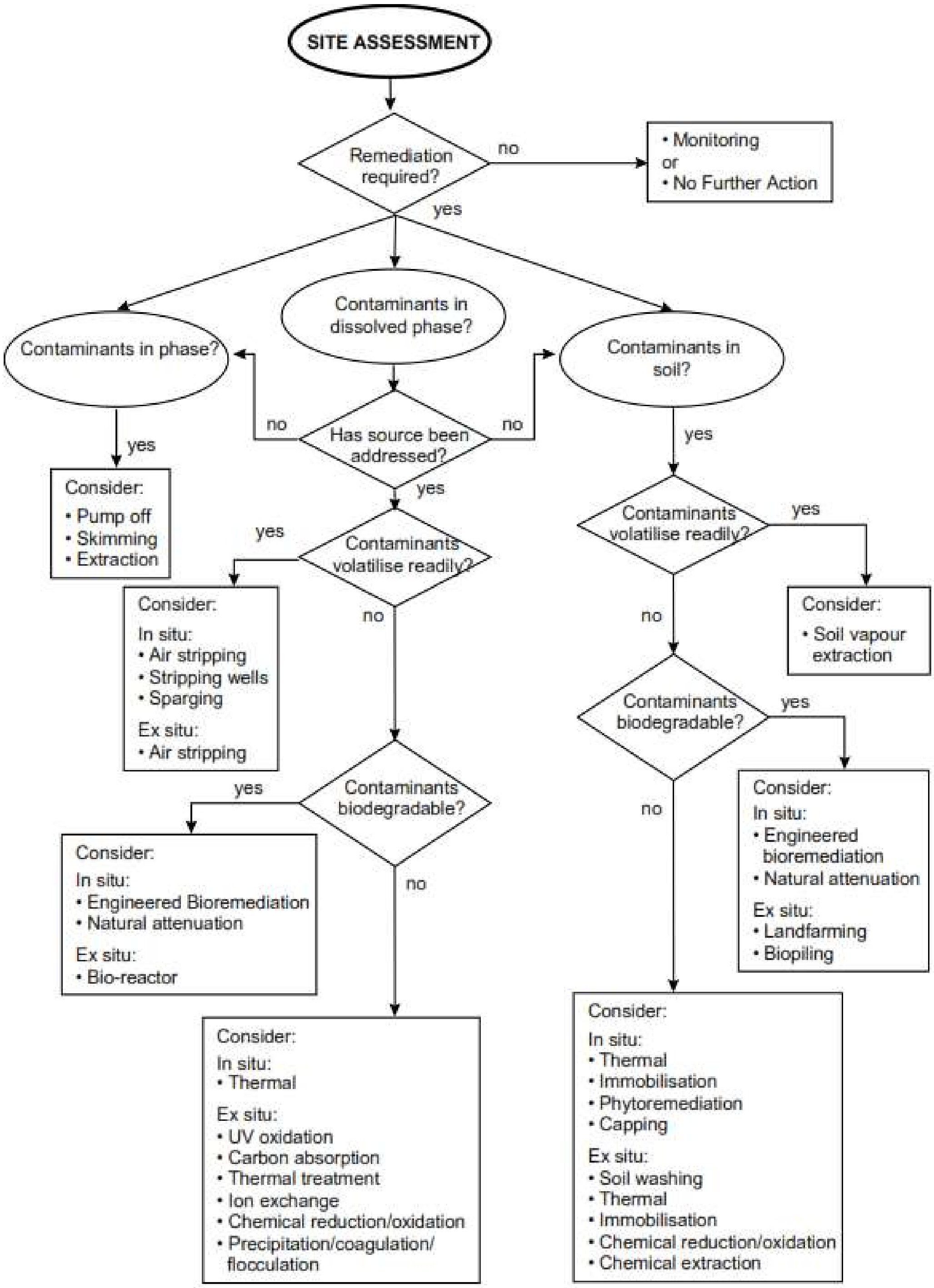

Figure 3.1: Site assessment process

3.3.1 Monitoring and Site Maintenance

Upon completion of the RBCA process, POL shall establish a monitoring programme which shall demonstrate the effectiveness of implemented remedial action measures or to confirm that current conditions persist or improve with time.

3.3.2 Remedial Action and Site Closure

When RBCA has been demonstrated to be suitable, institutional controls (if any), and monitoring and site maintenance are no longer required to ensure that conditions persists, then no further action shall be necessary, except to ensure that institutional controls (if any) remain in place. POL shall formally request for Decommissioning Certificate to be issued by DPR following completion of the decommissioning process.

References

Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (2002 Revision)

Environmental Evaluation Study (EES) Based Environmental Impact Assessment (EIA) Report for Further Development of Umuseti/Igbuku Field (2013)

Jubilee Field, Ghana, Environmental Impact Assessment Report, 2009, Chapter Eight.

Protection, Guideline for Contaminated Land Professionals at http://www.ehp.qld.gov.au/licences-permits/contaminated-land/documents/guideline-contaminated-land

Santos GLNG Upstream Decommissioning and Abandonment Management Plan, Australia, 2013

White Paper on Sustainable Closure and Decommissioning of Onshore and Offshore Oil and Gas Assets in Nigeria, 2015

World Petroleum Congress (1997). Environmental Technologies Related to Production and Exploration (Topic 19) proceeding of the fifteenth World Petroleum