Indorama Eleme Fertilizer & Chemicals Limited

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Environmental and Social Impact Assessment (ESIA) for the Proposed IEFCL – Train 3 Project

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Acronyms and Abbreviations

Name	Description
AoI	Project Area of Influence
AQS	Air Quality Standards
ATA	Agriculture Transformation Agenda
NMPSSAN	Non-Metallic Senior Staff Association
CMIP	Shared Socio-economic Pathways
CR&D	Community Relations and Development Department
DM	Demineralised Water
EAD	Environmental Assessment Department
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EPA	Environmental Protection Agency
EPCL	Eleme Petrochemicals Company Limited
ERM	Environmental Resources Management Southern Africa (Pty) Ltd
ESCL	Environmental & Chemical Services Limited
ESIA	Environmental and Social Impact Assessment
ESMMP	Environmental and Social Management and Monitoring Plan
ESMS	Environmental and Social Management System
FIRS	Federal Inland Revenue Service
FMenv	Federal Ministry of Environment
GBVH	Gender Based Violence and Harassment
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GMP	Grievance Management Procedure
GTG	Gas Turbine Generators
Ha	Hectares
HR	Human Resources
ICOMOs	International Council on Monuments and Sites
IEFCL	Indorama Eleme Fertilizer & Chemicals Limited
IFC	International Finance Corporation
IFT	Industrial Training Fund
IHR	International Health Regulation
ILO	International Labour Organization
IPCC	Intergovernmental Panel on Climate Change
IPs	Indigenous Peoples
IR	Industrial Relations
KPI	Key Performance Indicator
LGA	Local Government Area
MMSCF	Million Standard Cubic Feet
MoU	Memorandum of Understanding
MTPD	Metric Tons Per Day

Name	Description
NCCC	National Council on Climate Change
NESREA	The National Environmental Standards and Regulations Enforcement Agency
NGOs	Non-Governmental Organisations
NIMET	Nigerian Meteorological Agency
NMDPRA	Nigerian Midstream and Downstream Petroleum Regulatory Authority
NNPC	Nigeria National Petroleum Company
NSITF	Nigeria Social Insurance Trust Fund
NSR	Noise Sensitive Receptor
OSH	Occupational Safety and Health
PAC	Project Advisory Committee
PAYE	Pay As You Earn (Tax)
PC	Process Contribution
PEC	Predicted Environmental Concentration
PET	Polyethylene Terephthalate
PM	Particulate Matter
PPE	Personal Protective Equipment
PS	Performance Standards
RIWAMA	Rivers State Waste Management Agency
RSEPA	Rivers State Environmental Protection Agency
RSESA	Rivers State Environmental Sanitation Authority
RSMENV	Rivers State Ministry of Environment
SEP	Stakeholder Engagement Plan
SOP	Standard Operating Procedures
SSA	Sub-Saharan Africa
SSPS	Shared Socio-economic Pathways
TMP	Transportation Management Plan
ToR	Terms of Reference
VAPP	The Violence against Persons (Prohibition) Act
VPSHR	Voluntary Principles on Security and Human Rights
WBG	World Bank Group
WHO	World Health Organization

EXECUTIVE SUMMARY

Introduction

Environmental Resources Management Southern Africa (Pty) Ltd ('ERM') was commissioned by Indorama Eleme Fertilizer & Chemicals Limited ('IEFCL' or 'Proponent' or the 'Client') to undertake an Environmental and Social Impact Assessment (ESIA) for the proposed Indorama Eleme Fertilizer and Chemicals Limited (IEFCL) Ammonia and Urea Train 3 Project at Port Harcourt, Nigeria (hereafter referred to as the Project).

The Project will consist of the development of an additional ammonia and urea train, with a design capacity of 2,300 metric tons per day (MTPD) of ammonia and 4,000 MTPD of urea. The total footprint of the Project is 80ha. It must be noted that the Project is a direct replica of the existing (operational) Train 1 and Train 2 lines, which both independently also produce 2,300 and 4,000 MTPD of ammonia and urea respectively. An ESIA was commissioned for Train 2 in 2017 and subsequently approved by the FMEnv and the IFC.

Objective

This ESIA study has been conducted in line with the National EIA Procedural and Sectoral Guidelines, as well as ensuring consideration of relevant best practices, international standards, and guidelines. A detailed description of the policy, legal and institutional framework is provided in *Chapter 2* of this report. The ESIA study involved a number of key activities carried out in a stepwise manner. These included: scoping, literature review, baseline data gathering, stakeholder engagement, impact identification and evaluation, development of mitigation measures and an Environmental, Social Management and Monitoring Plan (ESMMP), and Report writing. Each of these activities/processes is explained in detail in Chapter 5 of this Report.

The specific objectives of the ESIA study are to:

- Provide a detailed description of the proposed Project (including relevant alternatives) in terms of the planned activities and the expected environmental and social aspects associated with the activities.
- Establish the existing state of the environmental and socio-economic conditions and to identify any sensitive resources and receptors.
- Identify and assess the associated and potential environmental and socio-economic impacts and risks of the Project, including potential secondary and cumulative impacts.
- Recommend appropriate mitigation measures (adopting the Mitigation Hierarchy, which is a set of guidelines that aim to achieve no overall negative impacts through the avoid, minimise, restore and offset sequential steps) to address the identified impacts of the Project.
- Develop an appropriate ESMMP to detail how mitigation measures will be implemented and how environmental performance will be managed for the project throughout the Project's life cycle.
- Prepare and submit a detailed ESIA Report presenting clear and concise information on the findings of the ESIA study.

Justification for the Project

The likely positive benefits associated with the Project include: improving domestic urea and ammonia production, promoting the setting up of downstream blending plants, enhancement of supply/distribution networks and the provision of new employment opportunities for the growing demand from the young Nigerian population. With all three units (Train1, 2 & 3) in operation, IEFCL will be able to produce 4.2 million tonnes of urea annually. Overall, the Project will help improve the share of agriculture in the Country's GDP and derive valuable foreign exchange from the export of urea, as well as improve the local economy in the immediate Project Area

In terms of Project alternatives, the availability of reliable natural gas feedstock at the broader Indorama Complex together with the efficiencies being realized through sharing of infrastructure and personnel from existing operations favours the selected Project location. In terms of technological alternatives, the evaluation of alternate raw materials for production (such as coal and biomass) concluded that such options would not be environmentally preferred or economically viable. In view of the above, the availability of raw material (i.e. – natural gas), the location of the Project in relation to existing Indorama /IEFCL operations is critical to the overall feasibility of the Project, and as such has been selected as the preferred option for this ESIA. A detailed description of the justification for the Project and an analysis of alternatives is proved in Chapter 3.

Project Description

Project Location

The proposed IEFCL Train 3 Project is proposed to be located within a 250ha plot adjacent of the IEFCL Plants situated in the Eleme Local Government Area, Rivers State, Nigeria. The Project area borders the existing Indorama Complex on the south and undeveloped land to the north, west, and east. The total footprint of the Project is 80ha. The coordinates of the Project site are Latitude $4^0$50’3” to $4^0$50’52” N and Longitude $7^0$6’29” to $7^0$6’55” E.

Project Design

The equipment design, process flow sheets, layout etc. of the proposed IEFCL Train 3 Project will be identical to Train 2. IEFCL has already engaged Engineering, Procurement and Construction (EPC) Contractors for the Project.

Project design is such that the Project will have an operational lifespan of 30 years, with a planned shutdown for maintenance purposes at every 4 years. Design capacity is such that the plant will operate 330 days/year.

The Project will consist of the following key infrastructure (refer to Figure 0-3):

- An Ammonia Plant (with a capacity of 2,300 MTPD). The key infrastructure associated with the Ammonia Plant includes:
  - The Compressor Unit
  - Stacks associated with the Reforming and Steam Boiler
- A Urea Plant (with a capacity of 4,000 MTPD). Key infrastructure associated with the Urea Plant includes:
  - The Granulation Unit and associated stack
- Internal Road Network (with a width that varies between 8 to 10 meters)
- Watch Towers (situated along the boundary wall)
- Boundary Wall and Fence
- Truck Parking Facilities
- Workshops and other Administrative Buildings
- A Fire Station
- Urea Product Handling and Bulk Loading Area
- Bulk Urea Storage Facilities
- Two Cooling Towers

Construction Phase

The construction phase cannot commence prior to the approval of the associated ESIA study. It is assumed that construction will continue for a duration of approximately 32 months. Activities during the construction phase will typically involve establishment of the boundary wall and fence, clearance of vegetation and grading of land and civil/construction works. It should be noted that no construction activities will be undertaken during the night.

Operational Phase

A summary of the operational process flow is as follows:

- The ammonia plant is a single train plant consisting of the following key process stages (also refer to Figure 4-7):
  - Feed and fuel gas supply
  - Feed gas desulfurization
  - Primary reforming
  - Process air compression
  - Secondary reforming
  - CO shift conversion, HTS and LTS (High and Low Temperature Shift) conversion
  - CO_2 removal
  - Methanation
  - Syngas drying
  - Cryogenic Purification
  - Synthesis gas compression
  - Ammonia synthesis
  - Ammonia refrigeration system
  - Loop Purge Ammonia Recovery
  - Process condensate stripping

  The ammonia plant is designed to produce 2,300 MTPD of ammonia. Ammonia will be delivered to the urea plant in pipes. The plant will also deliver produced liquid ammonia to an atmospheric storage tank in the event that the urea plant be shutdown.

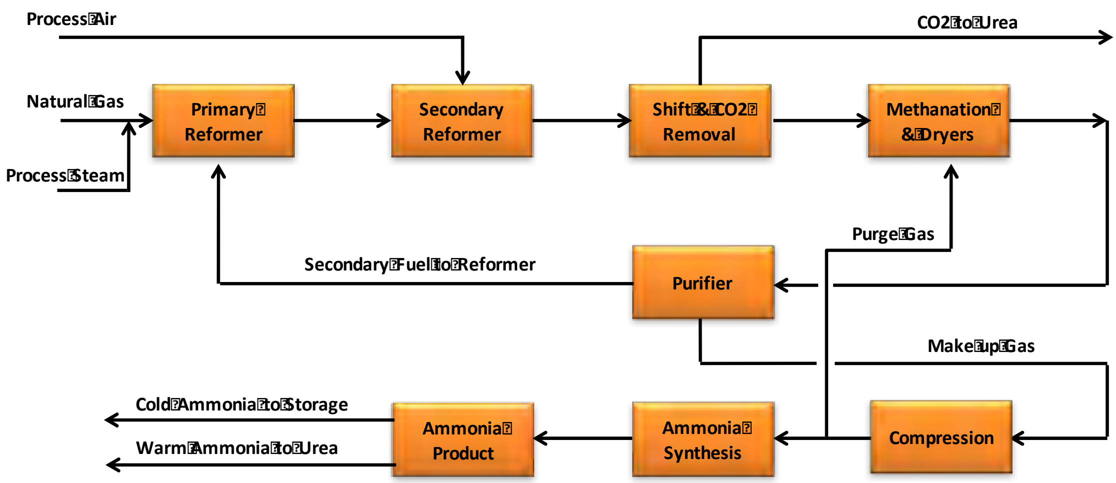


Figure 0-1 Block Diagram of Ammonia Plant

- The urea plant consists of the following main process stages (also refer to Figure 4-9):
  - Urea synthesis, whereby ammonia and CO_2 react to produce a urea solution.
  - Urea solution purification and recovery.
  - Conversion of the urea solution to granules (employing spout bed fluid granulation technology).

  The urea plant is designed to produce 4,000 MTPD of urea. Urea granules produced will be sent to storage either for bagging or bulk shipment.

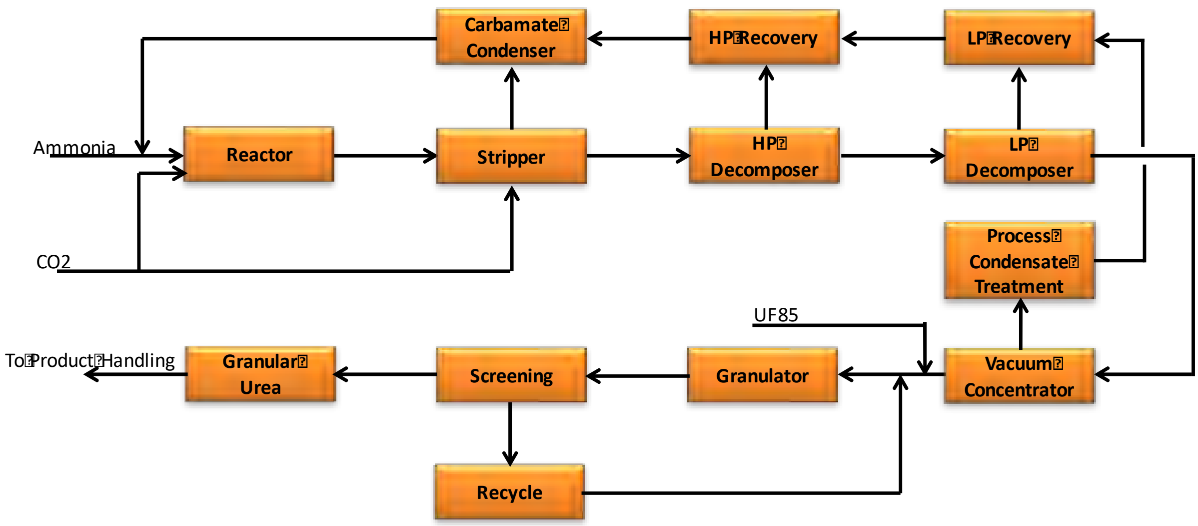


Figure 0-2 Block Diagram of Urea Plant

Decommissioning Phase

Activities during the decommissioning phase will involve demolition and site clean-up, disposal of waste, demobilisation of the workers, and a final site review. Decommissioning will take place years from now, and the baseline conditions associated with the Project and surrounds are likely to be significantly different to what it is today. When the IEFCL Train 3 Project reaches end of life and should decommissioning be required then this would need to be assessed under a separate ESIA process and a separate ESMMP should be developed in this regard.

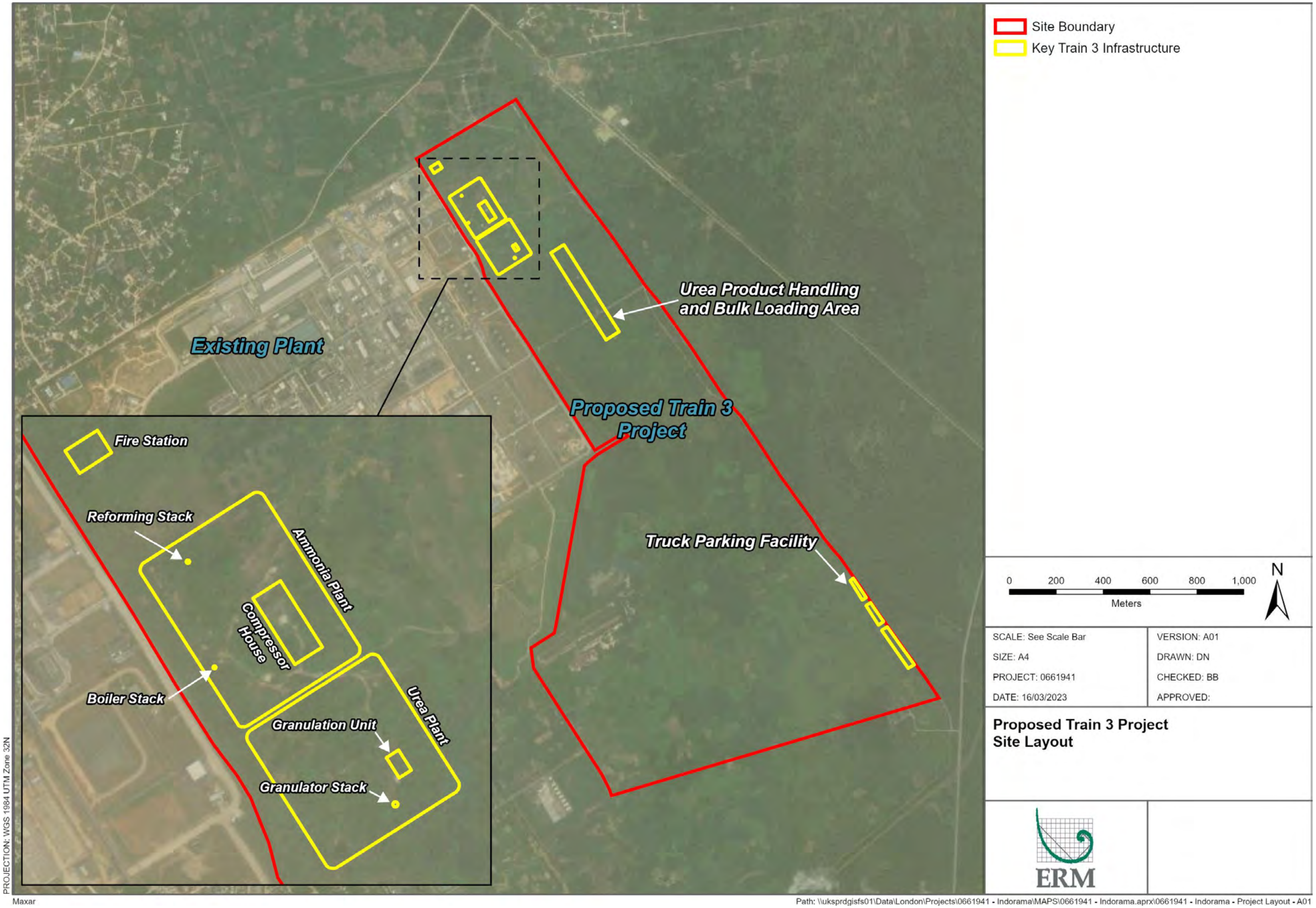


Figure 0-3 Siting and Layout of Key Infrastructure associated with the Train 3 Project

Key Sensitivities

Key physical, biophysical and socio-economic sensitivities identified in the Study Area include:

Key Physical Environmental Sensitivities

- In terms of climatic hazards, the broader Project Area is susceptible to extreme heat; water stress and drought; and increased flooding events and wildfires.
- Given the relatively high permeability of the shallow unconfined aquifer, as well as the shallow depth to groundwater (<7.5m), the aquifer is a sensitive resource towards potential contamination from surface sources. This is likely to be experienced by the seven communities surrounding the Site.
- Soils in the Project Area are sensitive to compaction and will increase surface runoff during rainfall events. Further, the local community also rely on the soils for subsistence farming. Therefore, contamination of the soils can impact not only on the quality of water, but also the field carrying capacity for livestock and crop production.
- The Okulu River is located directly downstream of the existing and planned plants. Pollutants from the effluent plant have the potential to be transported from Project Site to the River, resulting in the potential for impact (specifically the potential for a large release related to failure of plant due to flood, retention pond wall failure, or continual undetected release of untreated effluent).

Key Biophysical Sensitivities

- **Terrestrial Biodiversity** – the terrestrial biodiversity of the site has been impacted upon by anthropogenic disturbances, but still retains both plants and animals that form an integral part of the community's ecosystem services. The loss of the area to be cleared for the proposed IEFCL Train 3 Project could directly affect the surrounding ecosystem through siltation and pollutants, alien invasive species introduction, and changes to the functionality of the systems.
- **Aquatic Biodiversity** – while little to no direct impact is predicted to occur to the aquatic biodiversity of the site, the possibility exists that effluent discharge could lead to contamination of these systems is thus a reduction in aquatic biodiversity, which is already under threat from a number of anthropogenic impacts. Most of the threatened species observed are associated with aquatic habitats.
- **Ecosystem Services** – the ecosystem services of the study area are most likely to be affected by the direct removal of natural systems from the footprint of the Project, as well as the loss of functionality that accompanies the loss of biodiversity noted above.
- **Critical Habitat** – potential critical habitat triggering species appear to be associated with wetland/stream habitats (including seasonally flooded areas), and denser forest/thicket vegetation.

Key Socio-economic Sensitivities

- **Proximity of communities to site**:
  - The construction phase could result in disruption to nearby communities to the north and north-west. The access to the site (roads and entrances) should be considered to minimise impacts to adjacent communities.
  - Construction noise, dust, traffic must be managed to prevent impacts on nearby communities.
  - Air quality was raised as a perceived issue from the current Indorama facility – and should be considered in the ESIA – i.e., to what extent does the current facility impact on local air quality and what is the potential for this to change with the proposed Project.

- **Labour**:
  - There is an ongoing influx of people from outside the immediate area moving into Port Harcourt seeking employment and business opportunities. Whereas majority of the workforce (80% - 90%) have been living within the vicinity of Port Harcourt, the proposed Project is likely to create expectations around employment and opportunities. This must be managed through effective and ongoing stakeholder engagement (adjacent communities and the broader public).
  - Sourcing of labour for construction must be done in a manner that is open and transparent, and through reputable organisations or structures.
  - IEFCL needs to outline the number and skill levels of employees and contractors required during construction and operation and how labour will be sourced, or provide a commitment statement to this effect, before stakeholder engagement commences.
- **Community Investment**:
  - Currently Indorama have agreements (MoUs) with the host communities (Akpajo, Njuru, Okerewa, Aleto, Agbonchia, Wakoahu Family). The expectation from the communities is likely to be that these will be reinstated with new terms and/or amounts to be paid. With the expansion of the Indorama site, it is likely that communities will expect an increased level of social investment. However, it is noted that the 2023-2025 MoUs will run through the construction phase of Train 3 and include commitments to the host communities.
  - The ESIA team (stakeholder engagement team) needs to be clear about the intentions around community investment prior to engagement with these communities.
- **Town Planning and Development**:
  - The Port Harcourt area has historically suffered from rapid and uncontrolled physical expansion. This trend is likely to continue, with human settlement densifying in adjacent communities and further surrounding the Project site.
  - The cumulative impact of population influx can be expected to exacerbate high-density, unplanned human settlement in the Greater Port Harcourt area with little to no provision of basic services albeit on a smaller scale given the labour will be sourced locally.
- **Traffic**:
  - There is congestion on the East West Road, which connects south-eastern Nigeria to Port Harcourt, resulting from increases in peak hour traffic, increases in large vehicle traffic, as well as turning movements at the Indorama Complex access road.
  - There are also congestion and safety concerns at the intersection of the Indorama Complex access road and the East West Road due to lack of traffic controls (traffic signals or signage) and the volume of vehicle turning movements at this intersection.
  - Congestion on the route from the port at Onne to the East West Road is due to increased truck traffic.
  - The impact of higher traffic volumes and more truck traffic is felt on residents, businesses, and other road users of the Uzaku Alese Road within and near Eleme and nearby towns.

Key Impacts Findings and Recommendations

The ESIA process undertaken identified and assessed a range of potential impacts to the physical, biological, and social environment. Where impacts have been identified, appropriate mitigation measures have been provided in the ESIA. It should be noted that for many of the impacts identified, the proposed mitigation measures will reduce the significance of the impacts to a minor or negligible level. However, for some impacts, even with mitigation, residual impacts will remain. Those impacts that have a moderate to major post-mitigation (residual) significance, and which will require careful and consistent ongoing management, include:

- Impacts on soils and geology during the construction phase of the Project, as a result of soil erosion and loss of topsoil from site preparation, de-vegetation, and associated increased surface run-off during rainfall events.
- Impacts associated with changes to the soil-water balance, which can occur due to surface soil compaction, which can lead to flooding due to reduced recharge into the soil.

Moreover, gaps remain in the understanding of the baseline for aquatic biodiversity. In this respect, the following additional post-ESIA baseline studies will need to be undertaken, ideally prior to the commencement of the construction phase of the Project[1]:

- **Aquatic Biodiversity** – in order to address the aquatic biodiversity impacts related to potential spillage, water quality issues and increased stormwater discharge, a dry-season aquatic biomonitoring campaign will need to be conducted in all aquatic habitats supporting flowing water that may be affected by spills and discharge from the Project site prior to the commencement of construction. In this respect, established South African aquatic monitoring protocols will be applied, such as VEGRAI for monitoring the riparian vegetation, SASS5 and MIRAI methods for monitoring of invertebrates and FRAI for monitoring fish populations. Data will be consolidated to develop comprehensive assessments of the Present Ecological State of aquatic ecosystems. Preconstruction Aquatic Ecology baselines will be established and will be included as an addendum to this ESIA. Post construction Aquatic Ecology baselines will be established and compared against data from the preconstruction baselines.

As additional baseline data is gathered, a greater level of certainty regarding the impacts of the Project will emerge. The ESIA process should therefore not stop with the submission of this ESIA amendment report and associated ESMMP to the FMEnv. Upon submission, there will be need for continued work to address data gaps highlighted in the ESIA Report. Where any changes are proposed, these will be assessed in terms of their potential to alter the ESIA findings. Some changes may not result in a material change to the ESIA findings; however, as additional baseline data is gathered, a greater level of certainty regarding the impacts of the Project will emerge. As additional baseline data and any further changes to Project scope should be re-evaluated in terms of the influence on impact significance, and if necessary, mitigation / management measures included in the ESMMP will be amended to ensure negative impacts are mitigated and positive impacts enhanced. Typically, such substantive changes will be submitted as an addendum to this ESIA.

To provide the vehicle for the integrated management of the potential impacts identified in the ESIA (both positive and negative) an ESMS will need to be implemented. The ESMS provides a mechanism for ensuring that mitigation measures identified in the ESIA and associated ESMMP are adequately implemented. Moreover, the ESMS provides a framework for monitoring, compliance auditing and inspection programmes, which assist the Project in meeting its commitments, as stipulated in Nigerian regulations, lender standards (primarily the IFC PSs), and as required by the Contractor.

Provided that all the social and environmental mitigation / management measures provided in this ESIA and associated ESMMP are implemented, and provided that the gaps associated with the baselines for biodiversity are fully addressed, it is the opinion of ERM that there are no environmental or social fatal flaws which inhibit authorisation of the proposed IEFCL Train 3 Project. Moreover, the positive benefits of the proposed Project also need to be considered in the authorisation decision.

[1] Ideally, the undertaking these post-ESIA studies would commence prior to the start of the construction phase, so as to obtain a true and representative baseline that is not influenced by construction / operational activities associated with the proposed IEFCL Train 3 Project.

1. INTRODUCTION

1.1 Project Overview and Background

Environmental Resources Management Southern Africa (Pty) Ltd ('ERM') was commissioned by Indorama Eleme Fertilizer & Chemicals Limited ('IEFCL' or 'Proponent' or the 'Client') to undertake an Environmental and Social Impact Assessment (ESIA) for the proposed Indorama Eleme Fertilizer and Chemicals Limited (IEFCL) Ammonia and Urea Train 3 Project at Port Harcourt, Nigeria (hereafter referred to as the Project).

IEFCL is a major producer of urea fertilizer situated on a site of approximately 51hectares (ha) within the 361 ha Indorama manufacturing complex at Eleme. The proposed Train 3 expansion Project is proposed to be located within a 250ha land situated in the Eleme Local Government Area, Rivers State, Nigeria (refer to Figure 1.1). The Project area borders the existing Indorama Complex on the South and undeveloped land to the East and North as outlined in Figure 1.1.

The proposed Train 3 expansion will consist of the development of an additional ammonia and urea train, with a design capacity of 2,300 metric tons per day (MTPD) of ammonia and 4,000 MTPD of urea. The total footprint of the Project is 80ha. It must be noted that the Train 3 Project is a direct replica of the existing (operational) Train 1 and Train 2 lines, which both independently also produce 2,300 and 4000 MTPD of ammonia and urea respectively. It should be noted that an ESIA was commissioned for Train 2 in 2017 and subsequently approved by the FMEnv and the IFC.

The Indorama Complex consists also of an Olefins plant, Polyethylene / Butene and Polypropylene Plants, acquired by Indorama from erstwhile Eleme Petrochemicals. Subsequent to the acquisition from NNPC, the plant commenced production in October 2006, and thereafter commenced domestic sales as well as exports to Europe, Asia and parts of Africa in March 2007. A solid-state polymerization plant to convert amorphous polyethylene terephthalate (PET)[2] to PET resin was commissioned in the complex in July 2012, followed by the commissioning of the aforementioned Train 1 and 2 production lines in 2016 and 2021 respectively.

There is a legislative requirement to undertake an Environmental Impact Assessment (EIA) study for the proposed Train 3 Project based on the provisions of the Nigeria EIA Act No 86 of 1992 (now codified as the EIA Act CAP E12 Law of the Federation of Nigeria, 2004). In September 2021, through Official Gazette No. 105, Vol 108, the Federal Republic of Nigeria published S.I. No. 109, Environment Impact Assessment (EIA) Procedures and Charges Regulations. This ESIA has considered these regulations which outline the National EIA process. The ESIA[3] has also considered the requirements of the International Finance Corporation's (IFC) Performance Standards (PSs) on Environmental and Social Sustainability (2012), the World Bank Group's (WBG) General as well as relevant industry-sector Environmental, Health and Safety (EHS) guidelines and Indorama's Health, Safety and Environment (HSE) policy statements. These standards include a requirement to assess the Environmental, Social and Health impacts of any development during all phases (planning, construction and operation), so that adequate control measures can be undertaken to mitigate negative effects and enhance positive impacts.

[2] A type of plastic that is used to make different types of products, including, but not limited to, containers, clothing, and soda bottles.

[3] The use of the term ESIA as opposed to EIA is to emphasise that the process will not only assess environmental impacts but will also assess potential socio-economic impacts of the proposed Project.

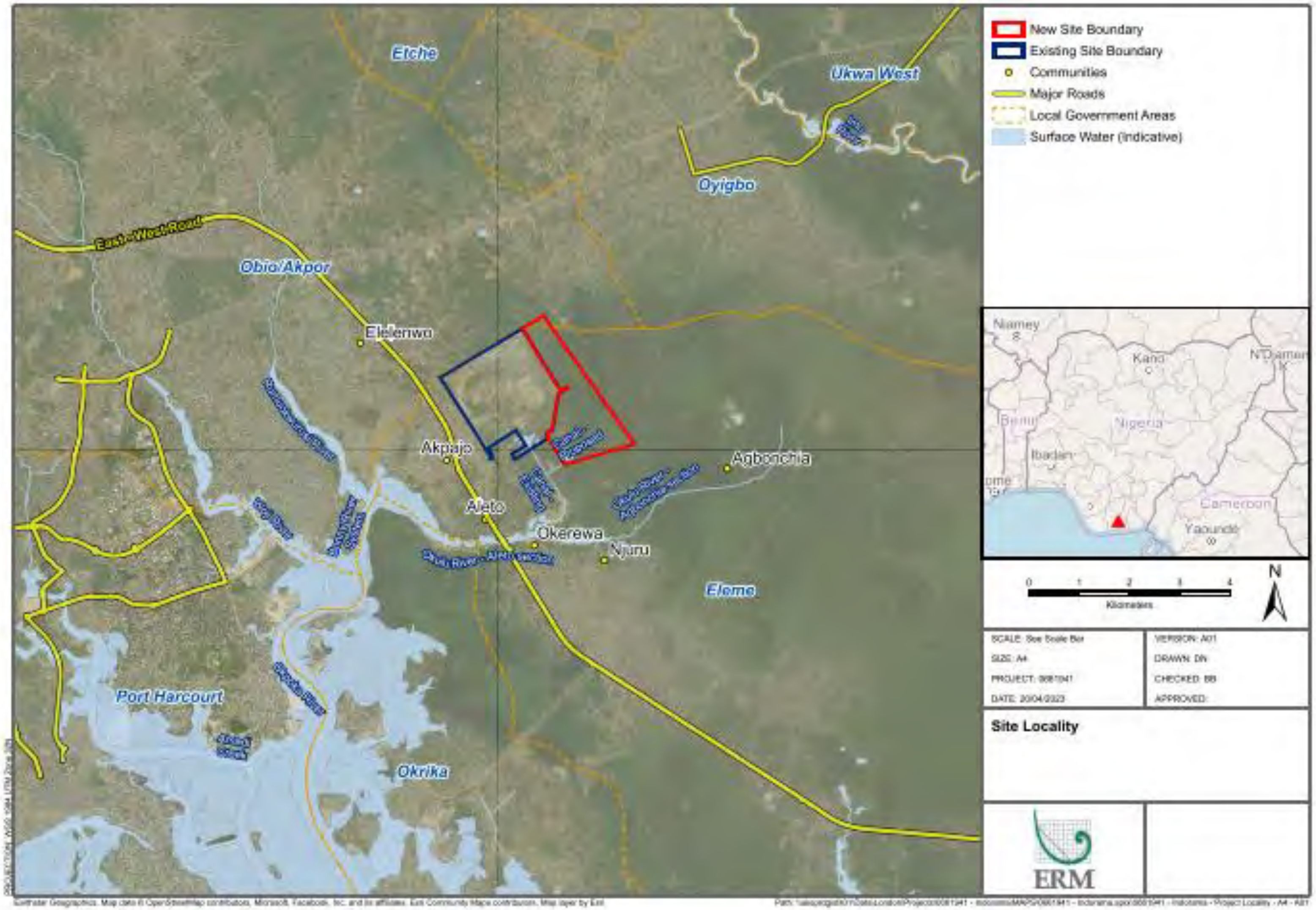


Figure 1.1 Project Locality Map

In July 2021, IEFCL commissioned an accredited Nigerian E&S Consultant "Environmental & Chemical Services Limited "(ESCL) to kick start the ESIA approval process. In August 2021, post site verification, FMEnv categorized project in category one (1) with one season baseline data gathering in line with international best practices vide letter reference number FMEnv/EA/EIA/6063/Vol.1/68 dated 5th August 2021. With this letter FMEnv also advised to conduct scoping workshop involving relevant stakeholders and regulators. In September 2021, IEFCL compiled an ESIA Terms of Reference (ToR)/Scoping report for the Project in consultation with ESCL, which was submitted and approved by the Federal Ministry of Environment (Environmental Assessment Department) (FMEnv) on 05 October 2021 (Ref: FMEnv/EA/EIA/6063/Vol.1/160). In the approval letter, the FMEnv informed IEFCL to proceed to the next phase of the overall EIA Phase, in line with Best Practices. In October 2021, IEFCL commissioned 'Environmental & Chemical Services Limited' (ECSL), a Nigerian E&S Consultant to undertake to collect infield wet season baseline data in supervision of FMEnv / RSME and Local Government representatives. Wet season baseline data collected includes –

- Meteorology.
- Air Quality, which includes stack emissions.[4]
- Noise.
- Geology / soil.
- Hydrogeology/Groundwater.
- Surface water & sediments, which includes treated effluent quality of operating plants.
- Aquatic biodiversity.
- Terrestrial biodiversity.
- Ecosystems services.
- Socio-economics.
- Traffic.
- Cultural Heritage.

In addition to ECSL, IEFCL commissioned ERM to guide the ESIA development process and ensure quality assurance so that the ESIA process is in compliance with International best practices as well as IFCs Performance Standards.

As a first step, ERM undertook a review and gap analysis of the wet season baseline data collected back in October 2021. The gap analysis was undertaken against the requirements of the IFC PSs, with the intention of identifying whether further action is required to address any gaps. The gap analysis identified a range of gaps. Majority of the gaps were addressed through clarification / provision of additional information from IEFCL. Moreover, the ESIA has been undertaken in compliance with the FMEnv requirements and guidelines and the FMEnv approved ToR for the Project. There however remains certain gaps per the requirements of the IFC PSs. This ESIA notes these gaps, and actions to close out these gaps have been included as a post-ESIA commitments in the Environmental and Social Management and Monitoring Plan (ESMMP) (refer to Chapter 10).

1.2 Project Proponent

The Project proponent is Indorama Eleme Fertilizer & Chemicals Limited, Eleme, Rivers State, Nigeria. It is the proponent's intent to establish the Train 3 Project, and required associated facilities, from concept to construction and subsequent commissioning & operation in line with the National Guidelines on manufacturing sector and in accordance with international best practice.

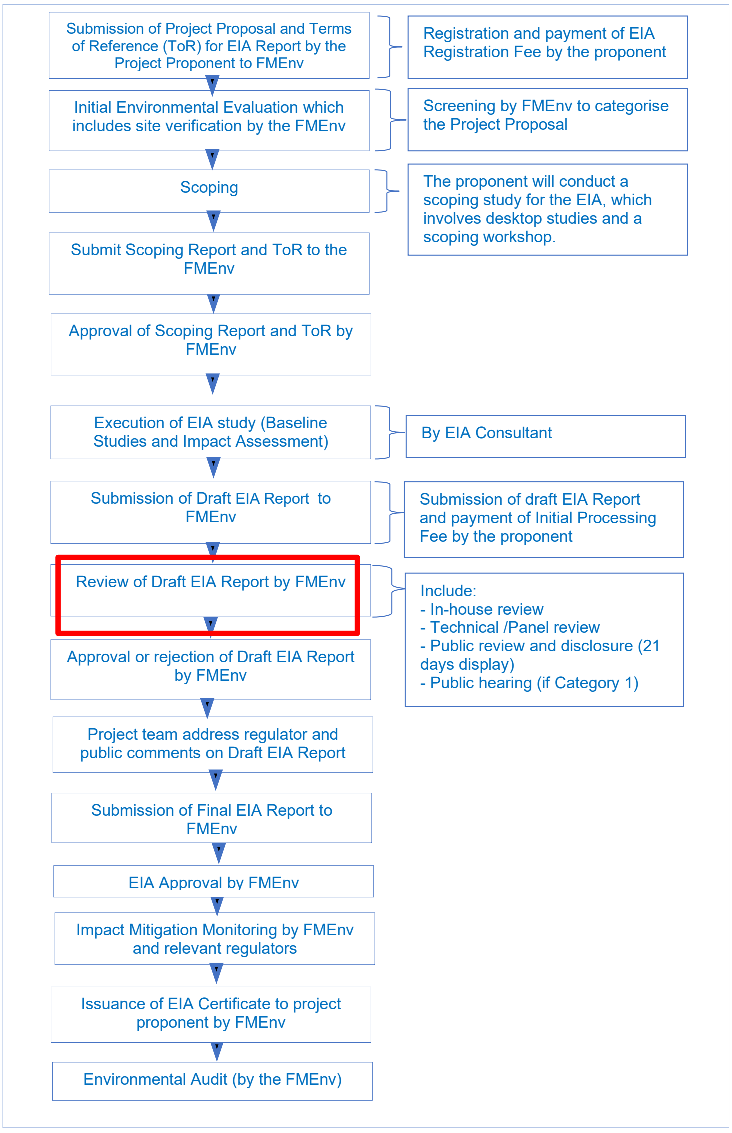
[4] The baseline Air Quality data provided includes monthly data for a period of 4 years (2019-2020). In June 2020 data was not captured due to the Covid 19 Pandemic.

1.3 Objectives of the ESIA Process

As previously mentioned, this ESIA study has been conducted in line with the National EIA Procedural and Sectoral Guidelines, as well as ensuring consideration of relevant best practices, international standards, and guidelines. The FMEnv ESIA study process is summarised in Figure 1.2. The ESIA study involves a number of key activities carried out in a stepwise manner. These included: scoping, literature review, baseline data gathering, stakeholder engagement, impact identification and evaluation, development of mitigation measures and ESMMP, and Report writing. Each of these activities is explained in detail in the subsequent chapters of this Report.

The specific objectives of the ESIA study are to:

- Provide a detailed description of the proposed Project (including relevant alternatives) in terms of the planned activities and the expected environmental and social aspects associated with the activities.
- Establish the existing state of the environmental and socio-economic conditions and to identify any sensitive resources and receptors.
- Identify and assess the associated and potential environmental and socio-economic impacts and risks of the project, including potential secondary and cumulative impacts.
- Recommend appropriate mitigation measures (adopting the Mitigation Hierarchy, which is a set of guidelines that aim to achieve no overall negative impacts through the avoid, minimise, restore and offset sequential steps) to address the identified impacts of the project.
- Develop an appropriate ESMMP to detail how mitigation measures will be implemented and how environmental performance will be managed for the project throughout the Project’s its life cycle.
- Prepare and submit a detailed ESIA Report presenting clear and concise information on the findings of the ESIA study.



Red box shows current stage

Figure 1.2 The Nigerian Environmental Impact Assessment Process

1.4 Scope of the ESIA Study and Report

As discussed in Section 1.1, the technical scope associated with the proposed IEFCL Train 3 Project is an exact replica of the IEFCL Train 2 Project. Furthermore, the ESIA study has been conducted in line with the Terms of Reference (ToR) already approved by FMEnv. In order to achieve the ESIA objectives highlighted in Section 1.3 above, the following activities have been completed:

- Review of applicable national and international laws, regulations, agreements and industry codes;
- Submission and subsequent approval of the Project ToR by the FMEnv;
- Literature review of relevant information pertaining to the Project Area of Influence (AoI) and the wider study area;
- Consideration of Project alternatives;
- Description of all actions/activities that will be carried out in the course of the Project;

- Wet season baseline data gathering through review of secondary data and direct environmental and socio-economic surveys and subsequent identification of any baseline gaps and subsequent resolutions;
- Identification and evaluation of potential impacts of the project;
- Recommendation of appropriate mitigation measures (including any further post-ESIA E&S studies), including the development of an ESMMP; and
- Response to the queries from stakeholders, Host Communities, regulators, and other interested parties.

1.5 Report Structure

In line with the FMEnv Procedural Guidelines, this ESIA Report has been organised into 12 Chapters (refer to Table 1-1).

Table 1-1 Structure of the ESIA Report

Chapter	Description
Chapter 1: Introduction	Introduction containing an overview of the Project, the objectives and scope of the ESIA study
Chapter 2: Legal and Administrative Framework	Describes the legislative, policy and administrative requirements, as well as international good practise requirements applicable to the Project.
Chapter 3: Project Justification	Contains a rationale for the Project, as well as the analysis of Project alternatives.
Chapter 4: Project Description	A description of the Project containing the technical elements applicable to the ESIA.
Chapter 5: Environmental and Social Impact Assessment Process	Describes the ESIA process followed for the Project and the associated impact assessment methodology employed.
Chapter 6: Stakeholder Engagement	Summarises the stakeholder engagement activities associated with the Project and ESIA process.
Chapter 7: Description of the Environment	Provides a baseline assessment of the receiving physical, biophysical and socio-economic environments in the AoI and surrounds.
Chapter 8: Associated and Potential Environmental and Social Impacts	Assessment of all relevant environmental and socio-economic risks and impacts of the project, including associated and cumulative impacts.
Chapter 9: Mitigation Measures	Presents the mitigation measures for the identified environmental and socio-economic impacts and a discussion of residual impacts.
Chapter 10: Environmental and Social Management and Monitoring Plan	Presents the ESMMP for the Project, which is attached as Appendix C.
Chapter 11: Conclusions and Recommendations	Summarises the key findings of the ESIA.
Chapter 12: References	Contains a list of references used in compiling this ESIA Report.

The ESIA report is supported by the following Appendices:

- Appendix A: ESIA ToR Approval by FMEnv
- Appendix B: Stakeholder Engagement Plan (SEP)
- Appendix C: Environmental and Social Management and Monitoring Plan (ESMMP)

2. LEGAL AND ADMINISTRATIVE FRAMEWORK

2.1 Introduction

This Chapter details the legislative and international good practice environmental and social requirements for the proposed IEFCL Train 3 Project. National (Nigerian) laws deemed relevant for the successful implementation of all environmental and social components of the Project are presented in this Chapter. Furthermore, the applicable standards of international lending organisations are provided, and their applicability discussed.

PLEASE NOTE:

Whilst this Chapter has been prepared with all due care by ERM, it does not constitute legal advice and should not be construed as such. Furthermore, the Nigerian regulatory environment may be subject to changes to both regulatory instruments and authorities during the projected Project life cycle. It is therefore recommended that the regulatory framework is reviewed and assessed periodically.

The sourcing of legislation was limited to a desktop survey (ERM's EHS database and other available online sources) and reliance on in-country contacts.

2.2 Institutional Framework

A summary of other authorities with the mandate to implement aspects of Nigerian legislation over aspects relating to the Project are provided in this Section.

2.2.1 Federal Ministry of Environment (FMEnv)

FMEnv is the principal authority for the regulation and enforcement of environmental laws in Nigeria. The EIA Act, established by the Ministry, which ensures that all development and industrial activities, operations and emissions are within the limits prescribed in the national guidelines and standards and comply with relevant regulations for environmental pollution management in Nigeria as and when these are released by the Ministry. Further to the Mandate, FMEnv developed laws/ guidelines on various sectors of the national economy including the Environmental Impact Assessment (EIA Act CAP E12, LFN 2004) Act and procedures for evaluating EIA reports. Furthermore, in September 2021, through Official Gazette No. 105, Vol 108, the Federal Republic of Nigeria published S.I. No. 109, Environment Impact Assessment Procedures and Charges Regulations. This ESIA has considered these regulations, which outlines the EIA procedure from project conception to commissioning and describes the requisite follow up activities. FMEnv consults with State Ministries of Environment and their Environmental Protection Agencies during the EIA permitting process.

In addition, other regulatory agencies/authorities with oversight over specific industries have also issued guidelines to regulate the impact of such industries on the environment.

2.2.2 National Environmental Standards and Regulation Enforcement Agency (NESREA)

The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established in 2007 by the Federal Government of Nigeria as an Agency of FMEnv. The Agency is charged with the responsibility of enforcing the environmental laws, guidelines, standards, and regulations in Nigeria, specifically during the operational phase of development projects.

2.3 National Regulatory Framework

The national policies and regulations included in Table 2-1 have E&S implications that pertain to the Project and associated ESIA study.

Table 2-1 National Policies and Regulations and the Applicability Thereof

Governing Documents	Description	Applicability
	National Policies	
National Policy on the Environment, 1989	The National Policy on the Environment, 1989 (revised 1999 and 2017), provides a national mechanism for routine coordination and consultation among various tiers of local, state, and federal government to improve the development and implementation of environmental policy as well as establish effective relationships. In doing so, this Policy aims to achieve sustainable development through conserving the environment and natural resources, raising public awareness between environmental resources development, maintaining, and enhancing ecosystem processes, and co-operating with other countries, organisations, and agencies to reduce transboundary environmental degradation.	In line with the aims of the policy, this ESIA study includes an assessment of impacts to the physical, biological and socio-economical environments related with the different phases of the Project. Moreover, this ESIA includes mitigation measures and an associated Environmental and Social Management and Monitoring Plan (ESMMP) that aim to avoid /minimise/manage the severity of identified impacts. Once the ESIA is approved by the FMEnv, IEFCL will need to implement the commitments included and conduct periodic audits to ensure continuous improvement.
National Policy on Climate Change, 2013	The mission of the National Policy on Climate Change, 2013 is to strengthen national initiatives to adapt to and mitigate climate change and involve all sectors of society, including the poor and other vulnerable groups (e.g., women, elderly, youth etc.) within the overall context of advancing sustainable socio-economic development. Its main objectives are to: ■ Implement mitigation measures that will promote low carbon as well as sustainable and high economic growth; ■ Strengthen national capacity to adapt to climate change; ■ Raise climate change-related science, technology, and research and development to a new level that will enable the country to better participate in international scientific and technological co-operation on climate change;	In line with the National Policy on Climate Change, 2013 and the Climate Change Act, 2021, this ESIA has considered the climate change adaptation requirements for the Project and management relating to GHG emissions during all Project phases.

Governing Documents	Description	Applicability
	■ Significantly increase public awareness and involve the private sector in addressing the challenges associated with climate change; and ■ Strengthen national institutions and mechanisms (policy, legislative and economic) to establish a suitable and functional framework for climate change governance.	
Climate Change Act, 2021	The Climate Act 2021 provides a framework for achieving low greenhouse gas emission (GHG), inclusive green growth and sustainable economic development. The Act applies to the Ministries, Departments and Agencies (MDAs) of the Federal Government of Nigeria, and to public and private entities within boundaries of Nigeria for the development and implementation of mechanism geared towards fostering low carbon emission, environmentally sustainable and climate resilient society. Its main objectives are to: ■ Ensure that Nigeria formulates programmes for achieving its long-term goals on climate change mitigation and adaptation; ■ Facilitate the coordination of climate change action needed to achieve long-term climate objectives; ■ Mainstream climate change actions in line with national development priorities; ■ Facilitate the mobilization of finance, and other resources necessary to ensure effective action on climate change; ■ Ensure that climate change policies and actions are integrated with other related policies for promoting socio-economic development and environmental integrity;	

Governing Documents	Description	Applicability
	■ Setting a target for year 2050-2070 for the attainment of a net zero GHG emission, in line with Nigeria's international climate change obligations; ■ Identify risks and vulnerabilities, building resilience and strengthening existing adaptive capacities to the impacts of climate change; ■ Implement mitigation measures that promote low carbon economy and sustainable livelihood; and ■ Ensure that private and public entities comply with stated climate strategies, targets, and National Climate Change Action Plan.	
The National Gender Policy, 2021	The National Gender Policy, 2021 presents a set of minimum standards to meet the mandate for gender equality, good governance, accountability, and being socially responsive to the needs of vulnerable groups. The policy builds on the revision of the NGP, 2007 to respond to emerging issues across the sectors since 2006 and to incorporate current gender gaps to fulfil Nigeria's commitment to such global agenda as the SDGs. The strategic policy objectives are to bridge gender/social inclusion gaps, achieve parity in all spheres, to protect women's human rights, and mitigate sexual and gender-based violence through appropriate buffers and related services.	This ESIA process has (and continues) to be undertaken to ensure effective, transparent, and timely stakeholder engagement. Moreover, it has been structured such that all stakeholder engagement activities will take into consideration in gender sensitivities, particularly when engaging with local communities. Moreover, the ESIA considers gender equality in recruitment and that no employee or job applicant discriminated against on the basis of his or her gender, marital status, nationality, ethnicity, age, religion or sexual orientation.
National Policy on Occupational Safety and Health, 2021	The Occupational Safety and Health policy strengthens the National Labour Policy and extant labour legislations, provisions Cap 126, the workmen's Compensation Act Cap 470, Trade Union Act Cap 126, Trade Dispute Act Cap 432, wages Board and Industrial Councils Act 466 and the Labour Act Cap 198, and other relevant Laws of the Federation of Nigeria. The goal of the policy is to facilitate improvement of occupational safety and health performance by providing the framework for participative occupational safety and health protection of	The safety, health and welfare of all the workers associated with the Project will need to be addressed in line with all the provisions of this Policy throughout the Project lifecycle (construction, operational and decommissioning phases).

Governing Documents	Description	Applicability
	workers including the most vulnerable groups in all sectors of economic activities.	
National Policy on Solid Waste Management, 2022	The National Policy on Waste Management 2022 provides a guidance for efficient and sustainable solid waste management in Nigeria. The policy objective is to provide a national direction on solid waste management for the Federal, States, Local governments, private sector, and all stakeholders. In doing so, the policy aims to promote a healthy and aesthetically satisfactory environment by ensuring effective, sustainable, safe, and sanitary solid waste management.	The Project, during the construction, operational and decommissioning phases, will generate wastes, which will need to be disposed of as per the guidelines in this Policy. The ESMMP has considered these regulations and includes a section on solid waste management.
National Environmental Sanitation Policy, 2005 (revised 2018)	This Policy serves as the instrument for securing sustainable quality environment for good health and social wellbeing of present and future generations.	This ESIA process has undertaken to cover events that could impinge on sanitation, hygiene, and health.
The Agriculture Promotion Policy, 2016	The Agriculture Promotion policy builds on achievement of Agriculture Transformation Agenda (ATA), 2011-2015 and was readjusted to solve challenges faced by implementation of ATA and highlight Federal government (in partnership with State Government) priorities in the agricultural sector.	In line with this policy, IEFCL is required to abide to climate change and environmental sustainability in its operation and participation in agricultural promotion.
General Environmental		
Environmental Impact Assessment Act 86 of 1992 (amended by EIA Act CAP E12 LFN 2004) and regulation 2021	This is the primary governing Act for EIA in Nigeria. The Act establishes a procedure and methodology to be followed to undertake an EIA study. Section 2 (2) of the Act requires that an EIA study must be undertaken in accordance with the Act when the extent, nature, or location of the proposed project or activities is likely to affect the environment significantly.	As the proposed Project will entail the construction of a fertilizer Plant for Ammonia and Urea production, an ESIA study in line with the provisions of the EIA Act is therefore required prior to the project commencing. Accordingly, an ESIA study is currently being carried out in line with the requirements of this Act and has further considered the Environment Impact Assessment Procedures and Charges Regulation, 2021, IEFCL shall be required to commit to implementing the commitments included in the ESMMP laid out in this ESIA Report and any other conditions as laid out by FMEnv, should an ESIA licence be issued for the Project.

Governing Documents	Description	Applicability
National Environmental Impact Assessment Procedural and Sectoral Guidelines, 1994	FMEnv developed the National EIA Procedural Guidelines in response to the establishment of the EIA Act. The Procedural Guidelines assists proponents in conducting detailed E&S assessments by providing an overview of the baseline information, key issues, impacts, mitigation, and management plans to be considered as part of the EIA study.	An ESIA study is currently being undertaken for the Project. This ESIA has been undertaken to comply with the requirements of these Guidelines. IEFCL shall be required to commit to implementing the ESMMP laid out in this ESIA and any other conditions stipulated by FMEnv.
The National Environmental (permitting & Licensing System) Regulation, 2009	The purpose of these regulation is to enable consistent application of Environmental Laws, Regulations and Standards in all sectors of the economy and geographical regions.	In line with these regulations, this ESIA has considered the Environmental Laws, guidelines, standards, and regulations in Nigeria during all Project phases.
Waste and Pollution		
National Environmental (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations, 1991, S.I.9	These Regulations impose restrictions on the release of toxic substances into the environment and stipulate requirements for pollution monitoring units, machinery for combating pollution, and contingency plans to be implemented by industries.	The Project, during the construction, operational and decommissioning phases, will generate wastes, which will need to be disposed of as per the guidelines in these Regulations. The ESMMP has considered these regulations and includes a section on the management of both non-hazardous and hazardous wastes.
National Environmental Protection (Effluent Limitation) Regulation 1991, S.I.8	The National Effluent Limitation Regulation, S.1.8 of 1991 (No. 42, Vol. 78, August 1991) makes it mandatory for industries such as waste generating facilities (including research institutes, clinics, hotels etc.) to install pollution prevention and pollution abatement equipment on site. The regulation is specific for each category of a waste generating facility with respect to limitations of solid and liquid discharges or gaseous emissions into the ecosystem. Appropriate penalties for contraventions are also specified in the regulation.	The Project, during the construction, operational and decommissioning phases, will generate waste effluent, which will need to be managed per the guidelines in these Regulations. This regulation requires the Project to install anti-pollution equipment for the detoxification of effluent and chemical discharges emanating from its activities and specify selected wastewater parameters for the industries in the First Schedule to the Regulations.
National Environmental (Management of Solid and Hazardous Wastes) Regulations, 1991, S.I.15	This instrument regulates the collection, treatment, and disposal of solid and hazardous waste streams from municipal and industrial sources. It gives a comprehensive list of chemicals and chemical waste by toxicity categories. The regulation requires the project proponent to practice waste segregation (at source) and engage the services of a	The Project, during the construction, operational and decommissioning phases, will generate wastes, which will need to be managed and disposed of as per the guidelines in these Regulations. The ESMMP has considered these regulations and

Governing Documents	Description	Applicability
	government-approved waste management agents for appropriate waste disposal throughout the project's life cycle.	includes a section on the management of both non-hazardous and hazardous wastes.
National Environmental (Sanitation and Wastes Control) Regulations, 2009, S.I.28	This Regulation aims to adopt sustainable and environment-friendly practices in environmental sanitation and waste management to minimise pollution.	The provisions included in this Regulation have been considered as part of the Project ESMMP.
Soils and Water		
National Environmental (Soil Erosion and Flood Control) Regulations, 2011, S.I.12	The overall objective of this Regulation is to ensure that projects developed on sites that are vulnerable to flooding, including facilities that serve such projects, are protected against flooding by appropriate design at the time of initial construction.	The provisions included in these Regulations will need to be considered by IEFCL as part of Project Engineering designs.
National Environmental (Surface and Groundwater Quality Control) Regulations, 2011, S.I.22	The purpose of these Regulations is to enhance and preserve the physical, chemical and biological integrity and to maintain existing use of groundwater and surface water resources. The standards contained herein provide for the protection of surface and ground water from pollutants so that the waters shall be protected, used, developed, conserved, managed, and controlled in ways that take into account: ▪ Citizens right of access to clean water and sanitation; ▪ Protection of aquatic ecosystems and long term sustainability of water resources ; and ▪ Reduction and prevention of pollution and degradation of surface water resources and recognition of preventive, precautionary, and polluter-pays-principles.	The Project will be associated with waste generation, more specifically solid and effluent wastes, which should be managed and disposed of in an environmentally friendly manner to avoid any form of pollution, including water pollution. This ESIA and associated ESMMP has considered these regulations.
Water Resources Act, CAP W2 LFN, 2004	This Act is aimed at promoting the optimum planning, development, and use of Nigeria's water resources; ensuring the coordination of activities that are likely to influence the quality, quantity; distribution, use, and management of water; providing the application of appropriate	In line with the requirements of this Act, IEFCL will need to safeguard the integrity water systems within and surrounding the Project area throughout the implementation of the Project. This includes implementing proper waste management to prevent water

Governing Documents	Description	Applicability
	standards and techniques for the investigation, use, control, protection, and management of water resources; and facilitating technical assistance and rehabilitation for water supplies.	pollution during the construction, operational and decommissioning phases.
Climate Change		
Climate Change Act, 2021	The Climate Change Act provides a legal and institutional framework for reducing GHG emissions in Nigeria. The objective of the law is to establish a framework for reducing GHG emissions and to embed climate change actions into national plans and programmes. The Act establishes the National Council on Climate Change (NCCC), which has been delegated the authority to make policies and decisions on all matters relating to climate change in Nigeria. The NCCC is directed to collaborate with the Federal Inland Revenue Service (FIRS) to develop a carbon tax in Nigeria. The proceeds from the carbon tax will go to the Climate Change Fund established under the Act. The Fund is to be used for the administration and general operation of the NCCC, the funding of innovative climate change mitigation and adaptation projects, conducting assessments of climate change impacts on vulnerable communities, and incentivizing the transition to clean energy. The law is the first stand-alone comprehensive climate change legislation in West Africa. The Climate Change Act seeks to achieve net-zero GHG emissions in Nigeria between 2050 and 2070. It further provides a framework to help achieve Nigeria's NDCs and mandates the Ministry of Environment, in consultation with the Federal Ministry for Budget and National Planning, to set a carbon budget to keep the average increase in global temperature to within 2°C, and to help keep to 1.5°C rise above pre-industrial levels. The Act also requires the NCCC to collaborate with the FIRS to develop and implement a mechanism for carbon emission trading and empowers the Ministries to periodically revise the carbon	In line with the requirements of this Act, this ESIA has considered the climate change adaptation requirements for the Project and management relating to GHG emissions during all Project phases.

Governing Documents	Description	Applicability
	budget, in line with Nigeria's NDCs with a view to complying with Nigeria's international obligations. The Climate Change Act also requires the preparation of a National Climate Change Action Plan (every five-years) to ensure that the carbon budgets are being met, and that climate change mitigation actions are identified and are being actively applied.	
Air Quality		
National Environmental (Air Quality and Control) Regulations, 2021, S.I.88	The objective of the Regulations is for the prevention, control, and reduction of air pollution to ensure clean and healthy ambient air. It provides for the establishment of emission standards for various sources such as mobile sources (e.g. vessels, motor vehicles) and stationary sources (e.g. industries). Emission limits for different areas and facilities have been set. The regulations make provision for designating controlled areas and the setting of objectives of air quality management plans for these areas.	The Project, during the construction, operational and decommissioning phases, will generate air emissions. As part of this ESIA process, an air quality study has been undertaken. The primary objective of the air quality study is to consider and assess the potential impacts which the Project may have upon existing air quality, during both construction and operational phases. The assessment of construction impacts focuses on the potential effect of construction dust and construction-related combustion emissions (including vehicles) at existing sensitive receptor locations immediately adjacent to the Project. The assessment of operational impacts focuses on the potential negative effects of pollutants from a variety of sources. Impacts of emissions on air quality have been quantified by comparison of the predicted maximum concentrations with the Project applicable air quality standards (which have considered these Regulations). Moreover, the ESMMP includes specific controls to mitigate air quality emissions.
Noise		
National Environmental (Noise Standards and Control) Regulations, 2009, S.I.35	The Regulation highlights the permissible noise levels to which a person may be exposed, control and mitigate noise, permits for noise emissions above acceptable levels and enforcement maximum permissible noise levels a facility or activity to which a person may be exposed to.	The Project, during the construction, operational and decommissioning phases, will generate noise. As part of this ESIA process, a noise study has been undertaken. The study has considered noise emissions at the potentially most affected noise sensitive receiver (NSR) locations in proximity to the Project. The

Governing Documents	Description	Applicability
		Project will be required to comply with these Regulations to promote a healthy and safe working environment throughout all Project phases. Noise impacts have been quantified by comparison of the predicted maximum concentrations with the Project applicable noise standards (which have considered these Regulations). Moreover, the ESMMP includes specific controls to mitigate noise emissions.
Biodiversity		
National Environmental (Control of Alien and Invasive Species) Regulations, 2013, S.I.32	This regulation seeks to prevent the decline and minimise the modification and destruction of the ecosystem and human health caused by alien and invasive species.	This ESIA and associated ESMMP has considered a range of potential ecological impacts associated with the Project, including the control of invasive alien plants in the immediate Project area and surrounds.
Endangered Species Act CAP E9 LFN, 2004 as amended 2016	This Act prohibits, except under a valid license, the hunting, capture, or trade-in animal species, either presently or likely being in danger of extinction, and defines the liability of any offender under this Act. It also provides for regulations to be made necessary for environmental prevention and control regarding the purposes of this Act.	These regulations have been considered in the biodiversity study for the ESIA and associated ESMMP.
Health and Safety and Labour		
Employment Laws and Regulations Nigeria 2023	The Employment Laws and Regulation 2023 strengthens employment laws as stated in the constitution of the Federal Republic 1999, the Labour Act 2004, Federal and State laws that relate to labour and employment, and international conventions, treaties and protocols relating to labour and employment, industrial relations or matters connected therewith that have been ratified by Nigeria.	IEFCL will be bound to abide to Nigeria labour and employment laws and regulation during its Project lifecycle.
Factories Act, CAP F1 LFN 2004	The Factories Act 1990 (amended in 2004) is the primary law regulating the health, safety and welfare of workers in the country's factories. The Law holds management and staff personally responsible for violations of the provisions in the Act.	The safety, health, and welfare of all the workers associated with the Project will need to be addressed in line with all the provisions of this Act throughout the Project lifecycle.

Governing Documents	Description	Applicability
Labour Act, CAP L1 LFN 2004	Nigeria has ratified all core International Labour Organisation Conventions. The Labour Act 1990 (amended in 2004) is the primary law protecting the employment rights of individual workers. The Act covers protection of wages, contracts, employment terms and conditions, and recruitment; and classifies types of workers and special workers.	IEFCL will be bound by this Act to abide to its stipulation on employee management and remuneration during its construction and operational phases.
Trade Unions Act, 2005	This Act contains provisions with respect to the formation, registration, and organization of trade unions. It includes stipulation of 'equal pay for equal workers without discrimination on account of sex, or any other ground whatsoever'.	The Proponent will respect workers' rights to join (or not join) unions of their choice and to engage with those unions which workers are members of in relation to collective bargaining, disciplinary proceedings, and retrenchment of workers.
National Minimum Wage Act, 2019	The Act prescribes the national minimum wage and provides for a legal framework for a seamless review of the stated national wage.	IEFCL will abide to the stipulation of this Act on employee remuneration during the Project lifecycle.
Employee Compensation Act, 2010	This Act repeals the Workmen's Compensation Act W6 LFN 2004 and makes comprehensive provisions for payment of compensation to employees that suffer from occupational diseases or suffer injuries from accident at workplace or in the course of the employment.	The safety, health, and welfare of all the workers associated with the Project will need to be addressed in line with all the provisions of this Act throughout the Project lifecycle.
Pension Reform Act, 2014	This Act makes provision for the contributory pension scheme for public and private sectors in Nigeria.	IEFCL will be bound by this Act to abide to its stipulation on employee remuneration during all Project phases.
Violence against Persons (Prohibition) Act, 2005	The Violence against Persons (Prohibition) Act (VAPP) was passed into law in May 2015. The Act was necessitated as a result of agitations for the protection of persons against different forms of violence. The Act has strengthened advocacy against rape, female genital mutilation, partner battery, stalking, harmful widowhood practices while prohibiting all forms of violence, including physical, sexual, psychological, domestic, harmful traditional practices and discrimination against persons. It also provides maximum protection and effective remedies for victims and punishment of offenders.	The safety, health, and welfare of all the workers and communities associate with the Project will need to be addressed in line with all the provisions of this Act throughout the Project lifecycle.

Governing Documents	Description	Applicability
Land		
Land Use Act CAP L5 LFN, 2004	Land Use Act No. 6 was enacted in 1978 (revised in 1990 and 2004). The Act vests all land in the territory of each State (except land vested in the Federal Government or its agencies) solely in the Governor of the State, who holds such land in trust for the people and is solely responsible for the allocation of land in all areas, to individual resident in the State and to organizations for residential, agricultural, and commercial purposes.	IEFCL have legally secured rights to the land associated with development of the Project.
Other		
National Environmental (Ozone Layer Protection) Regulations, 2009, S.I.32	This regulation prohibits the use, emission, storage, and disposal of stratospheric ozone-depleting substances (ODS) and articles which contain those substances.	IEFCL will need to ensure that equipment containing ODS's will either not be used on site or, if currently being used, will need to be phased out.
National Environmental (Construction Sector) Regulations (S.I No. 19), 2011	The purpose of these Regulations is to prevent and minimize pollution from construction, decommissioning and demolition activities applicable to Nigerian projects. It stipulates that new projects in the construction sector shall apply cost-effective, up-to-date, efficient, use best available technology, to minimize pollution to the barest degree practicable.	This ESIA considers a variety of potential impacts that may result in pollution to the environment during the construction and decommissioning phases of the Project. IEFCL shall be required to commit to implementing the ESMMP laid out in this ESIA and any other conditions stipulated by FMEnv.
Harmful Waste (Special Criminal Provisions) Act CAP H1 LFN, 2004	The Harmful Waste (Special Criminal Provisions) Act CAP H1 LFN, 2004 prohibits and declares unlawful activities relating to the purchase, sale, importation, transit, transportation, deposit, and storage of harmful wastes. Appropriate penalties for infringement are prescribed.	The Project is not anticipated to generate any harmful waste, ESMMP has considered these regulations and includes a section on the management of both non-hazardous and hazardous wastes.
The Standards Organization of Nigeria (SON) ACT NO. 14, 2015	The Standards Organisation of Nigeria was established by Act. No.56 of 1971 which vested it with the authority for: Standards elaboration, Specifications, Quality assurance system of commodities, manufactured industrial and imported products and services generally. The Act No. 14 of 2015 amended the previous SON Act, 2004, and was enacted for the purpose of providing additional functions for the	IEFCL shall be required to commit the quality standards as certified by SON throughout its operation.

Governing Documents	Description	Applicability
	Standards Organisation of Nigeria, increasing penalty for violations; and for related matters.	
Criminal Code of 1990 (now CAP 38 LFN, 2004)	The Act contains the primary criminal law offences related to environmental damage, public health, and natural resources. Some environmental crimes include causing a public nuisance, fouling the water of any spring, stream, well, or reservoir of a place, and violating the atmosphere in any position to make it harmful to the health of persons.	IEFCL shall be required to commit to implementing the ESMMP laid out in this ESIA and any other conditions stipulated by FMEnv.

2.4 State Laws and Administrative Institutions on Environmental Protection

Section 20 of the 1999 constitution of the Federal Republic of Nigeria, states that, "The State shall protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria". Furthermore, the EIA Act No. 86 of 1992 recommends the setting up of state environmental agencies to support the efforts of the FMEnv in regulating the consequences of project development on their environment.

2.4.1 Rivers State Ministry of Environment

Since the inauguration of the present democratic administration, Rivers State Government has established a full-fledged Ministry of Environment (RSMENV) headed by a commissioner. The Ministry was created from the Rivers State Environmental Protection Agency (RSEPA). RSMENV was empowered by the decree that set up the repealed FEPA (Decree 58 of 1988, as amended by Decree 59 of 1992), which encourages State governments to set up their own Environmental Protection Agencies.

Consequently, RSMENV is charged with the protection of the environment of Rivers State and operates with Edict No. 2 of 1994. In 2002, RSMENV published the Interim Guidelines and Standards on Environmental Pollution Control and Management in Rivers State which was revised in 2013. The guidelines seek to:

- Regulate the generation, handling, storage, disposal, and management of all wastes of whatever origin in Rivers State.
- Regulate physical development in compliance with the principle of sustainable development.
- Enhance and where possible, restore the quality of the environment and protect the biodiversity of the flora and fauna of Rivers State.

2.4.2 Rivers State Waste Management Agency (RIWAMA)

The Rivers State Waste Management Agency (RIWAMA) is responsible for the enhancement of the environment but is also mandated to positively change the living conditions and reduce diseases and health problems in the state. It was created in 2013 by the Rivers State House of Assembly and was assented by the state governor in July 2014. Prior to this, the agency functioned as the "Rivers State Environmental Sanitation Authority (RSESA)".

2.4.3 Rivers State Noise Control Edict, No. 20, 1985

The law targets reducing occupational noise exposure of workers to noise from factories/industrial machines and exposure of the neighbouring population to noise from nearby factories. It also sets limits for other sources of noise including aircrafts, loud music and public address systems and recommends daily noise exposure limits for industry workers and communities.

2.4.4 Rivers State Environmental Protection and Management Law, CAP A42, 2019

The objective of law is to exploit, develop and manage resources to achieve a higher quality of life by ensuring sustainable development. The law prescribing and listing activities that require environmental permits both in manufacturing and non-manufacturing sectors. The law also specifies terms for registration of environmental consultants in the state and conditions for issuance or renewal of the accreditation certificates / permits.

2.5 International Conventions, Protocols and Agreements

Nigeria is a signatory to several international conventions and agreements targeted toward the conservation and protection of the environment to ensure sustainable development. The relevant international conventions and regulations most applicable to the project are highlighted below in Table 2-2.

Table 2-2 List of Relevant International Conventions and Regulations

Conventions	Year Adopted	Overview
The Paris Accord	2015	The Paris Accord is a legally binding international treaty on climate change. It was adopted by 196 Parties at the United Nations Climate Change Conference, COP 21 in Paris, on 12 December 2015 and entered into force on 4 November 2016. The Paris Accord's long-term temperature goal is to keep the rise in mean global temperature to well below 2 °C (3.6 °F) above pre-industrial levels, and preferably limit the increase to 1.5 °C (2.7 °F), recognizing that this would substantially reduce the impacts of climate change. Emissions should be reduced as soon as possible and reach net-zero in the second half of the 21st century. It aims to increase the ability of parties to adapt to climate change impacts and mobilize sufficient finance. Under the Agreement, each country must determine, plan, and regularly report on its contributions.
International Health Regulations (IHR)	2005	The IHR is an international legal instrument that is binding on 196 countries across the globe, including all the Member States of World Health Organisation (WHO). This binding instrument of international law was first adopted in 1969, revised in 2005 and entered into force on 15 June 2007. The purpose and scope are "to prevent, protect against, control and provide a public health response to the international spread of disease in ways that are commensurate with and restricted to public health risks and which avoid unnecessary interference with international traffic and trade".
International Labour Organization (ILO): ILO-OSH, 2001 - Guidelines on Occupational Safety and Health (OSH) Management	2001	These guidelines call for coherent policies to protect workers from occupational hazards and risks while improving productivity. The guidelines present practical approaches and tools for assisting organisations, competent national institutions, employers, workers, and other social partners in establishing, implementing and improving occupational safety and health management systems, with the aim of reducing work-related injuries, ill health, diseases, incidents and deaths.

Conventions	Year Adopted	Overview
		At the organisational level, the guidelines encourage the integration of OSH management system elements as an important component of overall policy and management arrangements. Organizations, employers, owners, managerial staff, workers, and their representatives are motivated in applying appropriate OSH management principles and methods to improve OSH performance. Nigeria ratified the guidelines in 2001.
The United Nations Convention on Biological Diversity	1994	The Convention was adopted in 1994. The objectives of the Convention include the conservation of biological diversity, the sustainable use of its components and the fair and equitable sharing of benefits arising out of the utilization of genetic resources.
The Rio Declaration on Environment and Development	1992	The Declaration was made in 1992 in Rio de Janeiro, reaffirming the declaration of the United Nations Conference on Human Environment adopted at Stockholm in 1972. The principle works towards international agreement which respects the interest of all and protects the integrity of the global environment and development. The principles of the declaration relevant to the proposed project include: Principle 4: In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it. Principle 17: EIA as a national instrument shall be undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.
The United Nations Framework Convention on Climate Change	1992	The Convention on Climate Change was adopted in 1992 during the Rio Earth Summit in Rio De Janeiro, Brazil and entered into force in 1994 to limit Greenhouse Gas (GHG) emissions which cause global warming.
International Convention on Oil Pollution Preparedness, Response, and Co-operation (OPRC)	1990	Parties to the International Convention on OPRC are required to establish measures for dealing with pollution incidents, either nationally or in co-operation with other countries. Parties to the convention are required to provide assistance to

Conventions	Year Adopted	Overview
		others in the event of a pollution emergency and provision is made for the reimbursement of any assistance provided. Ships and operators are required to carry a shipboard oil pollution emergency plan, oil pollution emergency plans or similar arrangements which must be coordinated with national systems for responding promptly and effectively to oil pollution incidents.
The Montreal Protocol on Substances that deplete the Ozone Layer. Adopted on September 16, 1987.	1987	The Protocol was adopted on 16 September 1987 as an international treaty to eliminate ozone depleting chemicals production and consumption.
Vienna Convention for the Protection of the Ozone Layer.	1985	The Vienna Convention was adopted in 1985 and entered into force on 22 September 1988. It places general obligations on countries to make appropriate measures to protect the environment against adverse effects resulting from human activities which tend to modify the ozone layer.
Protocol Concerning Cooperation in Combating Pollution in Cases of Emergency in the West and Central African Region	1981	The objective of the protocol is to protect the marine environment, the coastal zones and the related internal waters falling within the jurisdiction of the States of the West and Central African region against pollution in cases of emergency. The Parties undertake to cooperate in all matters relating to the protection of their respective coastline and related interests from the threat and effects of pollution resulting from marine emergencies, especially by exchanging relevant information (arts. 4, 5, 6, 7, 8 and 10). They agree to assist each other, on demand, in cases of marine emergencies (art. 8). Finally, they are to endeavor to maintain and promote marine emergency contingency plans (art. 9) and take appropriate measures to prevent, reduce, combat and control the effects of pollution (art. 10).
Convention on the Conservation of Migratory Species of Wild Animals, 1979	1979	This Convention, also known as the Bonn Convention, was adopted in 1979 and entered into force in 1983. It stipulates actions for the conservation and management of migratory species including habitat conservation. <u>West African Aquatic Mammals Memorandum of Understanding (MoU), 2008</u> This MoU concerns the conservation of the manatee and small cetaceans of Western Africa

Conventions	Year Adopted	Overview
		and Macaronesia. It is a Multilateral Environmental MoU and entered into effect on 3 October 2008 under the auspices of the Convention on the Conservation of Migratory Species of Wild Animals. The MoU aims to protect these species at a national, regional, and global level. MoU concerning Conservation Measures for Marine Turtles of the Atlantic Coast This MoU requires signatories to endeavour to put in place measures for the conservation and, where necessary and appropriate, strict protection of marine turtles at all stages of their life cycle (including eggs, hatchlings, juveniles, sub-adults and adults. It came into effect in 1999 and is an agreement under Article IV, paragraph 4, of the Convention on the Conservation of Migratory Species of Wild Animals.
African Convention on the Conservation of Nature and Natural Resources	1968	The African Convention on the Conservation of Nature and Natural Resources was adopted in Algiers, Algeria, on 15 September 1968, and entered into force on 16 June 1969. The Convention stipulates that the contracting States shall undertake to adopt the measures necessary to ensure conservation, utilization and development of soil, water, flora and fauna resources in accordance with scientific principles and with due regard to the best interests of the people.

2.6 International *Best Practice Standards and Guidelines*

2.6.1 *Equator Principles (EPIV)*

The Equator Principles provide a set of 10 principles of voluntary standards that present a credit risk management framework for determining, assessing and managing social and environmental risk in Project financing. The Equator Principles are based on the IFC Performance Standards on social and environmental sustainability and on the World Bank Group EHS Guidelines. The Project has committed to complying with this set of principles, which together with the IFC Performance Standards and the EHS Guidelines will be used as a benchmark for IBP.

Details of the applicability of the Equator principles to the Project ESIA process are provided in Table 2-3.

Table 2-3 Applicability of the Equator Principles to the Project ESIA Process

Principle	Relevance to Project
1: Review and Categorisation	Category A project.

Principle	Relevance to Project
2: Social and Environmental Assessment	IEFCL are currently undertaking an internationally compliant ESIA for the Project.
3: Applicable Social and Environmental Standards	The ESIA and associated ESMMP has been undertaken in accordance with standards and recommendations of IFC Performance Standards and EHS Guidelines.
4: Action Plan and Management System	At this stage, IEFCL have a number of environmental, social, occupational health and safety and human resource plans, policies and procedures. These plan, policies and procedures relate to all IEFCL's operations in Port Harcourt. Over the life of all of IEFCL's operations, the vehicle by which the commitments set out in the ESMMP related to this ESIA and other plans, policies and procedures should be developed into specific actions which can be implemented through an overarching Environmental and Social Management System (ESMS).
5: Consultation and Disclosure	On-going stakeholder engagement, community consultation and disclosure are being undertaken (refer to Chapter 6 and SEP).
6. Grievance Mechanism	A Project's Grievance Mechanism has been developed and is being implemented (refer to Chapter 6 and SEP).
7. Independent Review	The Project lenders will need to appoint an independent review panel to review all Project documentation.
8. Covenants	Relevant Nigerian legislation is being complied with. IEFCL employees and activities will need to comply with commitments included in the ESMMP. Annual reports will need to be prepared documenting actions and activities demonstrating these commitments.
9. Independent Monitoring and Reporting	The Project lenders will need to appoint an independent review panel to review all Project documentation.
10. Equator Principle Founding Institute (EPFI) Reporting	Not IEFCL's responsibility.

2.6.2 International Finance Corporation Performance Standards on Environmental and Social Sustainability, 2012 (IFC PSs)

IFC's Sustainability Framework (International Finance Corporation, World Bank Group) articulates the Corporation's strategic commitment to sustainable development and is an integral part of IFC's approach to risk management. The Sustainability Framework comprises IFC's Policy and Performance Standards (PSs) on Environmental and Social Sustainability, and IFC's Access to Information Policy.

The Policy on Environmental and Social Sustainability describes IFC's commitments, roles, and responsibilities related to environmental and social sustainability. IFC's Access to Information Policy reflects IFC's commitment to transparency and good governance on its operations and outlines the Corporation's institutional disclosure obligations regarding its investment and advisory services.

The PSs are directed towards clients, providing guidance on how to identify risks and impacts, and are designed to help avoid, mitigate, and manage risks and impacts as a way of doing business in a sustainable way, including stakeholder engagement and disclosure obligations of the client in relation to project-level activities.

IFC requires its clients to apply the PSs to manage environmental and social risks and impacts so that development opportunities are enhanced.

The IFC PSs are outlined in Box 2.1.

Box 2.1 International Finance Corporation Performance Standards

Performance Standards:

- PS 1: Assessment and Management of Environmental and Social Risks and Impacts.
- PS 2. Labour and Working Conditions
- PS 3. Resources Efficiency and Pollution Prevention
- PS 4. Community, Health, Safety and Security
- PS 5. Land Acquisition and Involuntary Resettlement
- PS 6. Biodiversity Conservation and Sustainable Management of Living Natural Resources
- PS 7. Indigenous Peoples
- PS 8. Cultural Heritage

The requirements of each of the eight IFC PSs, and their relevance to the Project, are presented in Table 2-4.

Table 2-4 IFC PSs and the Relevance to the Project

Performance Standards	Key Requirement	Relevance to the Project
IFC PS1: Assessment and Management of Environmental and Social Risks and Impacts	This PS relates to integrating and managing E&S performance throughout the life of a project in line with national regulations and international standards. The standard requires the development of an Environmental and Social Management System (ESMS) that entails a structured approach to managing environmental and social risks and impacts. Moreover, the PS describes how E&S issues are to be handled in project development and serves as the core around which the other standards are framed. This standard requires that nearby communities be appropriately engaged on issues that could potentially affect them. Key requirements include: • Conducting an informed consultation and participation process with affected communities; • Working in an inclusive and culturally appropriate manner;	The Project poses a number of E&S risks and impacts, which will need to be appropriately managed. Appropriate management measures have been included in the ESMMP. Moreover, as part of the ESIA process stakeholders at the State and Local Government and Community level have been consulted and engaged, and will continue being engaged during the ESIA process and post-ESIA. At this stage, IEFCL have a number of environmental, social, occupational health and safety and human resource plans, policies and procedures. These plan, policies and procedures relate to all IEFCL's operations in Port Harcourt. Over the life of all of IEFCL's operations, the vehicle by which the commitments set out in the ESMMP

Performance Standards	Key Requirement	Relevance to the Project
	• Addressing the needs of disadvantaged or vulnerable groups; and • Making available an effective grievance management system.	related to this ESIA and other plans, policies and procedures should be developed into specific actions which can be implemented through an overarching Environmental and Social Management System (ESMS).
IFC PS2: Labour and Working Conditions	This standard aims to ensure that the Proponent establishes, maintains and improves a worker-management relationship that promotes the fair treatment, non-discrimination and equal opportunity of workers, and compliance with national labour and employment laws and international standards (as defined by the International Labour Organisation (ILO). In particular, PS2 addresses child labour and forced labour, and promotes safe and healthy working conditions, and protecting and promoting the health of workers by recognising the role of employees.	Project workers (for all Project phases) will need to be provided with fair labour and working conditions. This will apply to all categories of workers irrespective of whether directly engaged by IEFCL or Contractor (direct workers), engaged through third parties (contracted workers), and workers engaged by the client's primary suppliers (supply chain).
IFC PS 3: Resource Efficiency and Pollution Preventions	This PS aims to abate pollution to air, water, and land that may threaten people and the environment at the local, regional, and global levels. This Performance Standard promotes the ability of private sector companies to adopt such technologies and practices where feasible.	Development of the Project will require a number of resources, which have the potential to cause some negative E&S impacts. All required resources will need to be used efficiently and all wastes managed in accordance with the waste management hierarchy, where avoidance of waste generation is the priority.
IFC PS 4: Community, Health, Safety and Security	The role of this PS is to anticipate and avoid adverse impacts on the health and safety of the affected communities throughout the life of the project as a result of routine and non-routine events. The PS also requires an assessment of how use of security by the project to safeguard personnel and property could impact on community security taking into account considerations of human rights.	Implementation of the Project will need to ensure that the health, safety and security of all Project affected communities are not compromised.
IFC PS5: Land Acquisition and Involuntary Resettlement	PS5 refers to the management of physical and economic displacement resulting from project-related land acquisition through resettlement and livelihood restoration processes. Objectives are to: • Avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs.	IEFCL have legally secured rights to the land associated with development of the Project. The securing of land and access restrictions to surrounding communities will need be in line with the requirements of PS5.

Performance Standards	Key Requirement	Relevance to the Project
	• Avoid forced eviction. • Anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use by: - Providing compensation for loss of assets at replacement cost; and - Ensuring that resettlement activities are implemented with appropriate disclosure of information, consultation, and the informed participation of those affected. • Improve, or restore, the livelihoods and standards of living of displaced persons. • Improve living conditions among physically displaced persons through the provision of adequate housing with security of tenure at resettlement sites.	
IFC PS6: Biodiversity Conservation and Sustainable Management of Living Natural Resources	This PS aims to protect and conserve biodiversity based on the Convention on Biological Diversity. It divides habitat into three categories, modified, natural, and critical. For projects in natural habitat, mitigation measures should be designed to achieve no net loss of biodiversity where feasible. For projects in critical habitats, the project's mitigation strategy should be described in a Biodiversity Action Plan and be designed to achieve net gains of those biodiversity values for which the critical habitat was designated.	Assessment of the proposed Project's impacts on biodiversity has been carried out in line with the requirements of this PS.
IFC PS7: Indigenous Peoples	This PS deals with safeguarding Indigenous Peoples. The aim of this PS is to protect the interests of Indigenous Peoples (IPs) during project implementation. On a broader scale, it requires project implementation to avoid adverse impacts on Indigenous Peoples as well as ensuring their participation and consent.	No recognized IPs are impacted by this Project, hence PS7 is not triggered.

Performance Standards	Key Requirement	Relevance to the Project
IFC PS8: Cultural Heritage	Cultural heritage, according to this PS, refers to tangible forms of cultural heritage, such as tangible movable or immovable objects, property, sites, structures, or groups of structures, having archaeological (prehistoric), paleontological, historical, cultural, artistic, and religious values; unique natural features or tangible objects that embody cultural values, such as sacred groves, rocks, lakes, and waterfalls; and certain instances of intangible forms of culture that are proposed to be used for commercial purposes, such as cultural knowledge, innovations, and practices of communities embodying traditional lifestyles.	As part of this ESIA process a cultural heritage impact assessment (considering both tangible and intangible forms of cultural heritage) has been undertaken.

2.6.3 The World Bank Group (WBG) Environmental, Health and Safety (EHS) Guidelines

The World Bank Group (WBG) Environmental, Health and Safety (EHS) Guidelines (1991 and updated in 2007) are a set of technical reference materials that provide pollution related limits and standards. In general, the Guidelines seek to avoid, minimize and control environmental, health and safety (EHS) impacts during the construction, operation and decommissioning phase of a project or facility and are applicable to this Project. The EHS Guidelines serve as a technical reference source to support the implementation of the IFC PSs.

General EHS Guidelines exist, which contain information on cross-cutting EHS issues potentially applicable to all industry sectors; these are listed in Box 2.2 below.

Box 2.2 IFC General EHS Guidelines

General EHS Guidelines

1. Environmental
1.1 Air Emissions and Ambient Air Quality
1.2 Energy Conservation
1.3 Wastewater and Ambient Water Quality
1.4 Water Conservation
1.5 Hazardous Materials Management
1.6 Waste Management
1.7 Noise
1.8 Contaminated Land

2. Occupational Health and Safety
2.1 General Facility Design and Operation
2.2 Communication and Training
2.3 Physical Hazards
2.4 Chemical Hazards
2.5 Biological Hazards
2.6 Radiological Hazards
2.7 Personal Protective Equipment (PPE)
2.8 Special Hazard Environments
2.9 Monitoring

3. Community Health and Safety
3.1 Water Quality and Availability
3.2 Structural Safety of Project Infrastructure
3.3 Life and Fire Safety (L&FS)
3.4 Traffic Safety
3.5 Transport of Hazardous Materials
3.6 Disease Prevention
3.7 Emergency Preparedness and Response

4. Construction and Decommissioning
4.1 Environment
4.2 Occupational Health and Safety
4.3 Community Health and Safety

Where applicable, the abovementioned EHS Guidelines were considered in this ESIA process; however, the Air Emission and Ambient Air Quality Guideline (1.1); the Wastewater and Ambient Water Quality Guideline (1.3); the Water Conservation Guideline (1.4); and the Noise Guideline (1.7) are of particular importance to the proposed ESIA process. These are discussed in more detail in the Sections below.

IFC EHS Guidelines – 1.1 Air Emissions and Ambient Air Quality

The IFC recommend that the air quality guidelines as set out by the WHO be utilised in such an assessment. The WHO standards are divided into a number of stages, which have interim targets and a final guideline target. The WHO guidelines are recognised to be particularly conservative, as they make no consideration of the economic burden of achieving the stipulated guidelines. The WHO final guideline target is aspirational, and as such, this target should be progressively worked towards.

As mentioned in Section 2.3, the Nigerian Government has developed a list of environmental standards for the purpose of preventing significant industrial pollution. Nigerian ambient air quality standards are set out in Table 2-5.

Table 2-5 Nigerian Air Quality Standards

Pollutant	Averaging Period	Value (µg/m^3)
Nitrogen dioxide (NO_2)	Annual	80
	24 hours	120
	1 hour	200
Particulate Matter (PM_{10})	Annual	60
	24 hours	150
Particulate Matter ($PM_{2.5}$)	Annual	20
	24 hours	40
Ammonia (NH_3)	Annual	200
	24 hours	600

It must be noted that the IFC/WHO do not set guidelines for ammonia and therefore guidelines from the Environment Agency for England (EAE) are suggested. Table 2-6 provides the WHO/IFC and EAE ambient air quality guidelines for those pollutants included in the Nigerian air quality standards.

Table 2-6 WHO/IFC and EAE Ambient Air Quality Guidelines

Pollutant	Averaging Period	Value (µg/m^3)
NO_2	Annual mean	40
	1 Hour Maximum	200
PM_{10}	Annual mean	70 (interim target -1)
	24 Hour, 4th Highest (99th percentile)	150 (interim target-1)
$PM_{2.5}$	Annual mean	35 (interim target-1)

Pollutant	Averaging Period	Value ($\mu g/m^3$)
	24 Hour Maximum	75 (interim target-1)
NH_3	Annual Mean	180 [5]
	1 Hour Maximum	2,500 [1]

Taking the above into account, the Project specific guidelines (which consider Nigerian ambient air quality standards and air quality guidelines from the WHO/IFC and EAE) are presented in Table 2-7.

Table 2-7 Project Specific Guidelines

Pollutant	Averaging Period	Origin of Guideline	Value ($\mu g/m^3$)
NO_2	Annual mean	IFC	40
	1 Hour Maximum	IFC	200
PM_{10}	Annual mean	Nigeria	60
	24 Hour Maximum	Nigeria	150
$PM_{2.5}$	Annual mean	Nigeria	20
	24 Hour Maximum	Nigeria	40
NH_3	Annual Mean	EAE	180
	1 Hour Maximum	EAE	2,500

IFC EHS Guidelines – 1.3 Wastewater and Ambient Water Quality, 2007

IFC EHS Guideline 1.3 specifies that discharges should not result in contaminant concentrations in excess of local ambient water quality criteria or, in the absence of local criteria, other sources of ambient water quality. Receiving water use and assimilative capacity, taking other sources of discharges to the receiving water into consideration, should also influence the acceptable pollution loadings and effluent discharge quality.

The WBG EHS Guideline states that process wastewater should be consistent with the applicable Industry Sector EHS Guidelines and in compliance with national or local standards for wastewater discharge. As such, this ESIA process has considered the Industry Specific EHS Guideline for Nitrogenous Fertilizer Production (refer to Section 2.6.4) together with local Nigerian standards.

IFC EHS Guidelines – 1.4 Water Conservation, 2007

Mechanisms included in the water conservation guidelines include –

- The setting of targets for water use, and monitoring of water flows against these targets;

[5] NH_3 guidelines established from UK Guidance as IFC/WHO do not set guidelines for NH_3 [Air emissions risk assessment for your environmental permit - GOV.UK (www.gov.uk)]

- Water reuse where possible; and
- Reducing leaks and making more efficient use of water within the water reticulation system.

IFC EHS Guidelines – 1.7 Noise, 2007

The IFCs EHS Guidelines – *General EHS Guidelines: Environmental Noise Management 1.7 Noise* (IFC 1.7 Noise) is an internationally recognised guideline document containing information for the assessment and management of noise.

Table 2-8 presents the IFC noise guidelines that should not be exceeded at the nearest Noise Sensitive receptor (NSR) locations offsite. These guidelines are generally based on an interpretation of the relevant section of the WHO 1999 guidance concerning the effect of noise on people and implied potential health effects. They are designed to apply to noise emissions from facilities and stationary noise sources (such as factories).

In addition to the absolute values provided in Table 2-8, the IFC also requires that noise increase above existing (background) levels should not exceed 3 dB at the nearest receptor location off-site.

Table 2-8 IFC Noise Level Guidelines

Receptor	One Hour L_{Aeq} (dB(A))	
	Daytime (07:00 – 22:00)	Night (22:00 – 07:00)
Residential; institutional; educational	55	45
Industrial; commercial	70	70

LAeq = A-weighted equivalent sound levels over a measurement period, dB(A) = A-weighted decibel

IFC noise guidelines give no guidance on construction noise. As such, for the construction phase of the Project specifically, the ESIA process has adopted the Nigerian noise criteria included in the National Environmental (Noise Standards and Control) Regulations, 2009, S.I.35 (refer to Table 2-9).

Table 2-9 Nigerian Construction Noise Criteria

Receptor	Maximum noise level permitted L_{Aeq} dB(A)	
	Day time	Night-time
Hospitals, schools, institutions of higher learning, homes for the disabled, etc.	**60**	50
Buildings other than those prescribed above	**75**	65

Construction activities will take place only during the daytime, therefore the assessment of construction noise is based only on the daytime noise criteria (i.e. – those included in **bold** in Table 2-9).

In addition to construction noise specific criteria, the Nigerian Noise Standards and Control Regulation includes maximum permissible L_{Aeq} levels for a range of receptor types. These are presented in Table 2-10.

Table 2-10 Maximum Permissible Noise Levels in Nigeria

Receptor	Maximum noise level permitted L_{Aeq} dB(A)	
	Day time 06:00 – 22:00	Night-time 22:00 – 06:00
Any building used as hospital, convalescence home, home for the aged, sanatorium and institutes of higher learning, conference rooms, public library, environmental or recreational sites	45	35
Residential buildings	50	35
Mixed residential	55	45
Residential + industry or small-scale production+ commerce	60	50
Industrial (outside perimeter fence)	70	60

The NSRs in the proximity of the Project can be classified as "*residential + industry or small-scale production+ commerce*" according to the Nigerian standards; however, for this ESIA process the more stringent criteria for "*residential, institutional; educational*" receptors as prescribed by the IFC will be used.

As such, for Project activities during the operational phase to create a significant noise impact, the noise generated must be above the noise impact threshold levels, as summarised in Table 2-11.

Table 2-11 Project Noise Criteria for Operational Phase

Receptor	One Hour L_{Aeq} (dB(A))	
	Daytime (06:01 – 22:00)	Night (22:01 – 06:00)
Residential; institutional; educational	55	45

The daytime period will be based on the Nigerian criteria between 06:01 to 22:00 hours and the night-time period will be between 22:01 to 06:00 hours.

2.6.4 Industry Specific EHS Guidelines – Nitrogenous Fertilizer Production

In addition to the above General EHS Guidelines, the Guideline for Nitrogenous Fertilizer Production is also relevant to the Project. This Guideline expands on the general EHS Guidelines discussed in Section 2.6.3) and includes industry specific management guidance.

This Guideline includes information relevant to facilities that produce ammonia based nitrogenous fertilizers, including (amongst others) ammonia and urea. The Guideline has identified that potential environmental issues associated with nitrogenous fertilizer manufacturing include the following:

- Air Emissions
- Wastewater
- Hazardous Materials
- Wastes
- Noise

Air Emissions

Air emissions from nitrogenous fertilizer manufacturing facilities typically consist of greenhouse gases (GHGs – typically carbon dioxide and nitrous oxide), other gaseous inorganic compounds and particulate emissions, especially particulate matter less than 10 microns in aerodynamic diameter (PM_{10}) from prilling.

More specifically, process emissions for **Ammonia production plants** include - hydrogen (H_2), carbon dioxide (CO_2), ammonia (NH_3), and carbon monoxide (CO). Fugitive emissions of NH_3 from storage tanks, valves, flanges, and tubing may also occur, especially during transportation or transfer. Non-routine emissions associated with process upsets or accidents may contain natural gas, CO, H_2, CO_2, volatile organic compounds (VOCs), nitrogen oxide (NO_X), and NH_3.

For **Urea production plants**, emissions consist mainly of NH_3 and dust. Fugitive emissions of NH_3 from tanks, valves, flanges, and tubing may also occur. The production process proposed for the IEFCL Train 3 Project involves granulation of urea, which generates much less dust when compared with prilling towers.

Table 2-12 presents emission[6] guidelines specific to Nitrogenous Fertilizer Production. Guideline values for process emissions are indicative of good international industry practice as reflected in relevant standards of countries with recognised regulatory frameworks. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of good industry practice pollution prevention and control techniques.

Table 2-12 Air Emissions Levels for Nitrogenous Fertilizers Manufacturing Plants

Pollutant	Unit	Guideline Value
Ammonia Plants[1]		
NH_3	mg/Nm^3	50
NO_X	mg/Nm^3	300
PM	mg/Nm^3	50
Urea Plants		
Urea (prilling/granulation)	mg/Nm^3	50
NH_3 (prilling/granulation)	mg/Nm^3	50
PM	"	50
Notes: 1. NO_X in flue-gas from the primary reformer. The other emissions are from process, granulators etc. NO_X in all types of plants: temperature 273K (0°C), pressure 101.3 kPa (1 atmosphere), oxygen content 3% dry for flue gas.		

Wastewater

Process water discharges from nitrogenous fertilizer manufacturing plants are limited typically to acid wash from scheduled cleaning activities and purges, effluents from wet scrubbers, accidental releases,

[6] Note – these are ***Emission*** guidelines (i.e. – pollutant loadings at point source) as opposed to Ambient Air Quality Guidelines as is presented in Section 2.6.3

leaks of small quantities of liquids from product storage tanks, and acidic and caustic effluents from the boiler feed water preparation.

More specifically, effluents from **Ammonia production plants** may include releases of process condensates or scrubbing effluents of waste gases containing ammonia and other by-products. Process condensates typically arise from condensation between shift reactors and absorption of carbon dioxide, and from carbon dioxide overheads. Such condensates may contain ammonia, methanol, and amines (e.g., methylamines, dimethylamines, and trimethylamines). In partial oxidation, soot and ash removal may impact water discharges if not handled adequately.

For **Urea production plants**, significant amounts of process water containing NH_3, CO_2 and urea are generated. Other sources include ejector steam, flush, and seal water.

Table 2-13 presents effluent guidelines specific to Nitrogenous Fertilizer Production. Guideline values for effluents are indicative of good international industry practice as reflected in relevant standards of countries with recognised regulatory frameworks. These guidelines are achievable under normal operating conditions in appropriately designed and operated facilities through the application of good industry practice pollution prevention and control techniques.

Table 2-13 Effluents Levels for Nitrogenous Fertilizers Manufacturing Plants

Pollutant	Unit	Guideline Value
pH	S.U.	6-9
Temperature Increase	°C	<3
Ammonia Plants		
NH_3	mg/l	5
Total nitrogen	mg/l	15
TSS	mg/l	30
Urea Plants		
Urea(prilling/granulation)	mg urea/l	1
NH_3(prilling/granulation)	mg/l	5

Table 2-14 presents a comparison between the effluent guidelines specific to Nitrogenous Fertilizer Production and the Nigerian standards associated with process water discharge. The most stringent of these guidelines and standards are used for the Project ESIA process.

Table 2-14 Comparison of the Nigerian an IFC Values for Discharged Effluent

Parameter(s)	FMEnv Limits (Effluent Discharges)	IFC Nitrogenous Fertiliser plants (Ammonia Plants and Urea Plants)	Project Applicable limit
	Limit	Limit	Limit
pH	6.5 – 8.5	6-9	6.5 – 8.5

Parameter(s)	FMEnv Limits (Effluent Discharges)	IFC Nitrogenous Fertiliser plants (Ammonia Plants and Urea Plants)	Project Applicable limit
Appearance	-	-	-
Temperature Increase (°C)	-	<3	<3
Elect. Cond. (µs/cm)	-	-	-
TDS (mg/l)	2,000	-	2,000
Turbidity (NTU)	-	-	-
TSS (mg/l)	30	30	30
Total Hardness (mg/l)	-	-	-
Alkalinity (mg/l)	-	-	-
Chloride, Cl^-(mg/l)	600	-	600
Sulphate, SO_4^{2-}(mg/l)	500	-	500
Nitrate, NO_3^-(mg/l)	20	-	20
Phosphate, PO_4^{3-} (mg/l)	5.0	-	5.0
Cyanide CN^- (mg/l)	0.1	-	0.1
Ammonium NH_4^+ (mg/l)	5	5	5
Urea (prilling/ granulation) (mg/l)	-	1	1
Formaldehyde (mg/l)	-	-	-
Total Nitrogen (mg/l)	-	15	15
DO (mg/l)	>4.0	-	>4.0
BOD (mg/l)	30	-	30
COD (mg/l)	150	-	150
O & G (mg/l)	10	-	10
Sodium, Na (mg/l)	-	-	-
Potassium, K (mg/l)	-	-	-
Iron, Fe (mg/l)	5.0	-	5.0
Calcium, Ca (mg/l)	200	-	200
Magnesium, Mg (mg/l)	200	-	200
Zinc, Zn (mg/l)	1.0	-	1.0
Copper, Cu (mg/l)	1.0	-	1.0

Parameter(s)	FMEnv Limits (Effluent Discharges)	IFC Nitrogenous Fertiliser plants (Ammonia Plants and Urea Plants)	Project Applicable limit
Manganese, Mn (mg/l)	5.0	-	5.0
Chromium, Cr (mg/l)	1.0	-	1.0
Silver, Ag (mg/l)	0.1	-	0.1
Lead, Pb (mg/l)	1.0	-	1.0
Mercury, Hg (mg/l)	0.05	-	0.05
Cadmium, Cd (mg/l)	0.1	-	0.1
Nickel, Ni (mg/l)	1.0	-	1.0
Arsenic, As (mg/l)	0.1	-	0.1

Hazardous Materials

Nitrogenous fertilizer facilities use and manufacture significant amounts of hazardous materials, including raw materials and intermediate/final products.

The most common hazardous wastes produced by these facilities are spent catalysts after their replacement in scheduled turnarounds of ammonia plants, and urea plants. The most common non-hazardous wastes are nitrogen-containing dust particulates from prilling and granulators dust control systems.

Noise

Typical sources of noise emissions include large size rotating machines such as compressors and turbines, pumps, electric motors, air coolers, conveyors belts, fired heaters, and from emergency depressurization.

Occupational Health and Safety

The occupational health and safety issues that may occur during the construction and decommissioning of nitrogenous fertilizer facilities are similar to those of other industrial facilities. The most significant occupational health and safety hazards occur during the operational phase of a nitrogenous fertilizer facility and primarily include – process safety, chemical hazards, fire and explosion hazards and ammonia storage.

Community Health and Safety

The most significant community health and safety hazards during the operation of nitrogenous fertilizers facilities include – accidental leaks/release of toxic and flammable gases through management, storage, and shipping of hazardous products such as ammonia.

2.7 Project Specific EHS Policies and Standards

2.7.1 IEFCL Non-Discriminatory Policy, 2021

IEFCL is an equal opportunity employer and as per the Non-Discriminatory Policy does not and shall not discriminate against any employee or any applicant for employment on the basis of race, colour, religion (creed), gender expression, age, disability, military status, sexual orientation, and national origin in any of its activities or operations. These activities include but are not limited to employment – recruitment, selection, hiring, compensation, termination, upgrading, promotions, and other conditions of employment.

2.7.2 IEFCL Child Labour Prohibition Policy, 2021

IEFCL does not and shall not offer employment nor employ any person below the age of eighteen (18) years. The Company maintains zero tolerance towards the breach of this policy.

In line with the Policy, IEFCL shall maintain appropriate documents of all relevant details of employees including their age and these documents shall be open for verification by authorized personnel or the relevant statutory body. The Human Resources Department is responsible for the implementation of this Policy.

2.7.3 IEFCL Human Rights and Labour Policy, 2021

The IEFCL Human Rights Policy is guided by the International Human Rights Principles as enshrined in the Universal Declaration of Human Rights, the ILO Declaration on fundamental Principles of Rights at Work, and the African charter on Human Rights on the constitution of the Federal Republic of Nigeria 1999, as amended. Specifically, IEFCL employees shall have the following rights:

- Freedom of association
- Freedom of express
- Healthy work environment
- Safety at workplace
- Non-discrimination
- Freedom of worship
- Freedom from bullying, sexual harassment
- Right to fair hearing
- Any other such rights as necessary and recognized by the law of the Federal Republic of Nigeria.

2.7.4 IEFCL Independent Contractors' Policy, 2021

For the purpose of this Policy, independent contractors are workers working for IEFCL. IEFCL directs all independent contractors working with the Company to strictly comply with the guidelines on the following internal policies: Employee Hand Book, Grievance Handling and Management Policy, Anonymous Grievance Handling Mechanism, Child Labour Prohibition Policy, Human Rights Policy, Non-discriminatory Policy, Retrenchment Planning (Redundancy) as stipulated in the National Labour Law, Work Place Discipline Policy, Security and Safety Policy, Employee Compensation Policy and any other policy necessary for the wellbeing of the independent contractors and their employees.

2.7.5 IEFCL Gender Based Violence and Harassment Policy, 2021

IEFCL is committed to promote gender diversity in the organization and recognizes the potential risk of Gender Based Violence and Harassment (GBVH). IEFCL has a zero tolerance for GBVH and on continual basis endeavours to identify the risk areas, upgrade preventive measures; create awareness amongst both internal & external stakeholders, enhance capability building and increase effectiveness of grievance management system. The objective this Policy is to define a policy framework and define strategies for addressing the issue of GBVH. This Document also aims to provide an integrated framework for stakeholder engagement and grievance management system with a focus on GBVH at all states of business cycle.

2.7.6 IEFCL Anti-Retaliatory Policy, 2021

IEFCL is committed to providing access to effective grievance management systems for its employees, stakeholders, and local business partners. Further, IEFCL also expects from its local business partners working with the company to provide access to effective grievance management systems for its employees and stakeholders for freedom of expression and grievance redressal without any fear of Retaliation or victimisation. The objective of this Policy is to provide a framework, establish organisational commitment, assess risk, build organisation capabilities for preventative and mitigation measures, as well as proffer an effective grievance management system for safeguarding the human rights values.

2.7.7 IEFCL Community and Stakeholder Policy, 2021

IEFCL is committed to respecting the rights, cultures, customs, and values of employees and communities affected by its activities and will manage its businesses in a fair and equitable manner to meet its social responsibilities. The objective of the Policy is to ensure proactive engagement with key stakeholders on sustainable development challenges and opportunities in an open and transparent manner and to ensure effective grievance mechanisms are in place.

2.7.8 IEFCL Environmental & Climate Change Policy, 2022

IEFCL is committed to effective environmental management. The aim of this Policy is to minimise impacts on the environment and reduce impacts on climate change throughout its operations. The objective of the Policy is to ensure the development and implementation of Environmental Management Systems that are compliant with applicable national, regional, and local environmental regulations, and good international practice.

2.7.9 IEFCL Occupational Health, Safety & Wellbeing Policy, 2022

The Policy aims to promote the health and safety of employees, service providers, and any other person who is impacted by IEFCL operations. The goal of the Policy is zero harm as well as safe and healthy workplaces.

2.7.10 IEFCL Product Stewardship Policy, 2022

IEFCL is committed to the highest standards of product safety, quality, and business integrity to meet customer expectations and achieve customer delight. The Policy goal is to minimise the health, safety, environmental, and social impacts of their products.

2.7.11 IEFCL Responsible Business Policy, 2021

The Responsible Business Policy objective is to make positive contributions to the economic, environmental, and social progress at the locations where IEFCL operates. IEFCL is committed to promoting business practices that provide benefits to society, transparently and ethically, and address potential negative impacts associated with its operations.

2.7.12 IEFCL Social Media Policy, 2021

The IEFCL Social Media Policy provides a framework for use of social media for corporate or personal accounts to protect against damage to the organization. The policy objective is to provide practical ways to avoid issues that may arise from the improper use of social media.

2.7.13 IEFCL Confidential Reporting Policy, 2021

IEFCL is committed to high ethical standards and encourages reporting of any acts listed below by any employee irrespective of their position. The Policy prohibits anyone from retaliating against any person who in good faith raises or helps to resolve any of the acts below or any other ethical concern. Confidential reporting applies to:

- Any violation of Indorama's Code of Conduct.
- Any act that adversely affects the business interest of IEFCL.
- Any act that is illegal under local or international law.
- Any abuse of authority.

3. PROJECT JUSTIFICATION

3.1 Introduction

This Chapter presents the rationale for the Project. It also presents the alternatives (including locality, technology and no-go alternative considerations) considered for the Project.

3.2 Need for the Project and Associated Benefits

Presently, Indorama has two operating lines (Train 1 and Train 2), which both independently produce 2,300 MTPD Ammonia and 4000 MTPD urea fertilizers. All of the Ammonia produced is captively converted to approximately 2.8 million tonnes of Urea per year. IEFCL is currently selling approximately one million tonnes of fertilizer per year to meet the current local demand in Nigeria, whilst the remaining volume is exported to Latin America (mainly Brazil), West African countries, USA and India.

As such, the Urea produced by the proposed Train 3 Project will be primarily for export to Latin America, Europe, USA and West Africa. IEFCL is not currently selling ammonia as a standalone product; however, given the uses of ammonia as a hydrogen carrier, there could be opportunities in future to sell ammonia.

Global Urea demand is growing at a compound annual growth rate (CAGR) of 1.9% during 2021 to 2027[7]. Urea demand has reached to 180 million tonnes in 2022, driven by demand rise in NE Asia & South Asia. Considering continued increase in crop acreages in South America & Asia, Urea demand is likely to outstrip supply on longer term amid limited firm capacity announcements. The global outlook of Urea supply & demand balance is presented in Figure 3-1.[8]

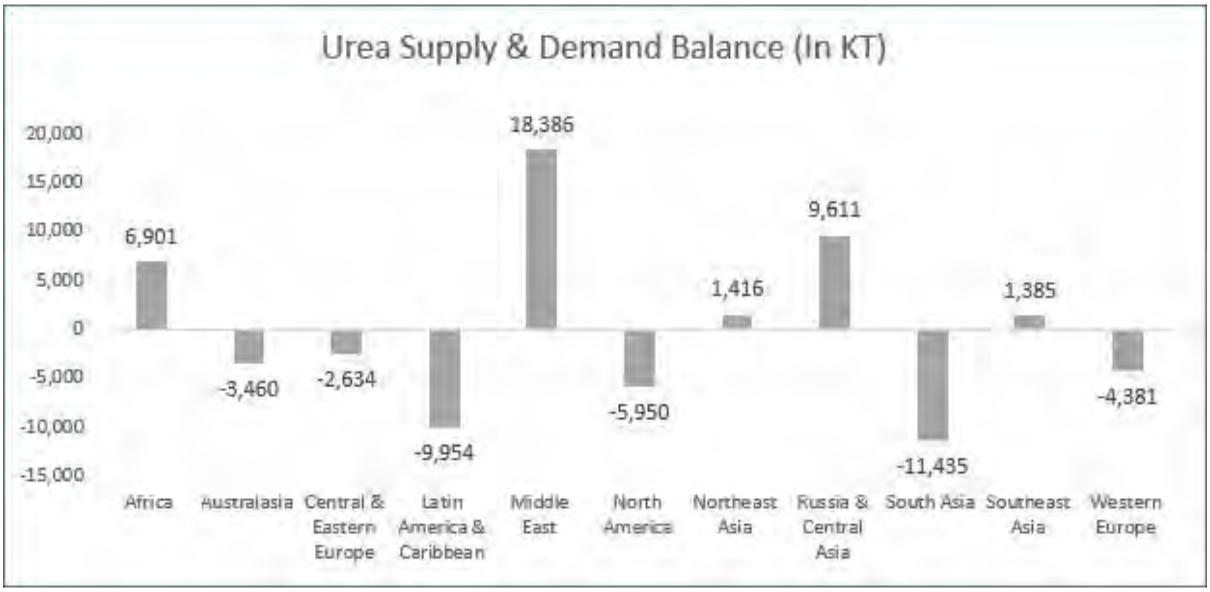


Figure 3-1 Urea Supply and Demand Balance (in KT)

The above being said, Sub-Saharan Africa (SSA) has the lowest nitrogen fertilizer usage in the world as outlined in Figure 3-2. Nigeria's national fertilizer consumption is only 20 kilograms (kgs) / hectare (ha) as of 2021[9][10] against the global average of approx. 120 kgs/ha. The targeted fertiliser consumption

[7] https://www.digitaljournal.com/pr/urea-fertilizers-market-global-analysis-2022-2027-expected-to-reach-usd-62180-million-and-exhibit-a-cagr-of-1-9-price-forecast-key-players-strategy-rising-demand-revenue-and-growth-rate-throu
[8] FAO, 2022-World fertilizer trends and outlook to 2022. Rome
[9] https://ifdc.org/2021/06/24/changing-the-data-landscape-the-vifaa-nigeria-dashboard/
[10] VIFAA Nigeria (africafertilizer.org)

in SSA is 50kg/ha. As such there is a substantial need for investment in the fertilizer sector to meet this consumption target.

Farming and livestock rearing is the main livelihood for approximately 70% of households in Nigeria. Agriculture remains predominately subsistence on small family owned plots in rural areas. The heavy reliance of subsistence crops as a source of food for majority of the population coupled with ever increasing population growth[11] and effects of climate change has exacerbated the food security crisis in Nigeria.

In the third quarter of 2021, agriculture contributed 29.94% to the nominal Gross Domestic Product (GDP) of Nigeria. The country is a global leader in various types of agricultural production, including (amongst others) for cocoa beans, sorghum, palm oils, etc. This being said, Nigeria's agricultural potential is far from being realised. Low fertiliser use is one of the major contributing factor for poor utilization of agricultural potential. The proposed Project therefore has the potential to significantly contribute to the provision of fertilizer for the local domestic market and other markets in West Africa. The projection that the use of nitrogen fertilizer per ha should increase from the current levels of 20 kg/ha to 50 kg/ha provides a robust justification for the Project.

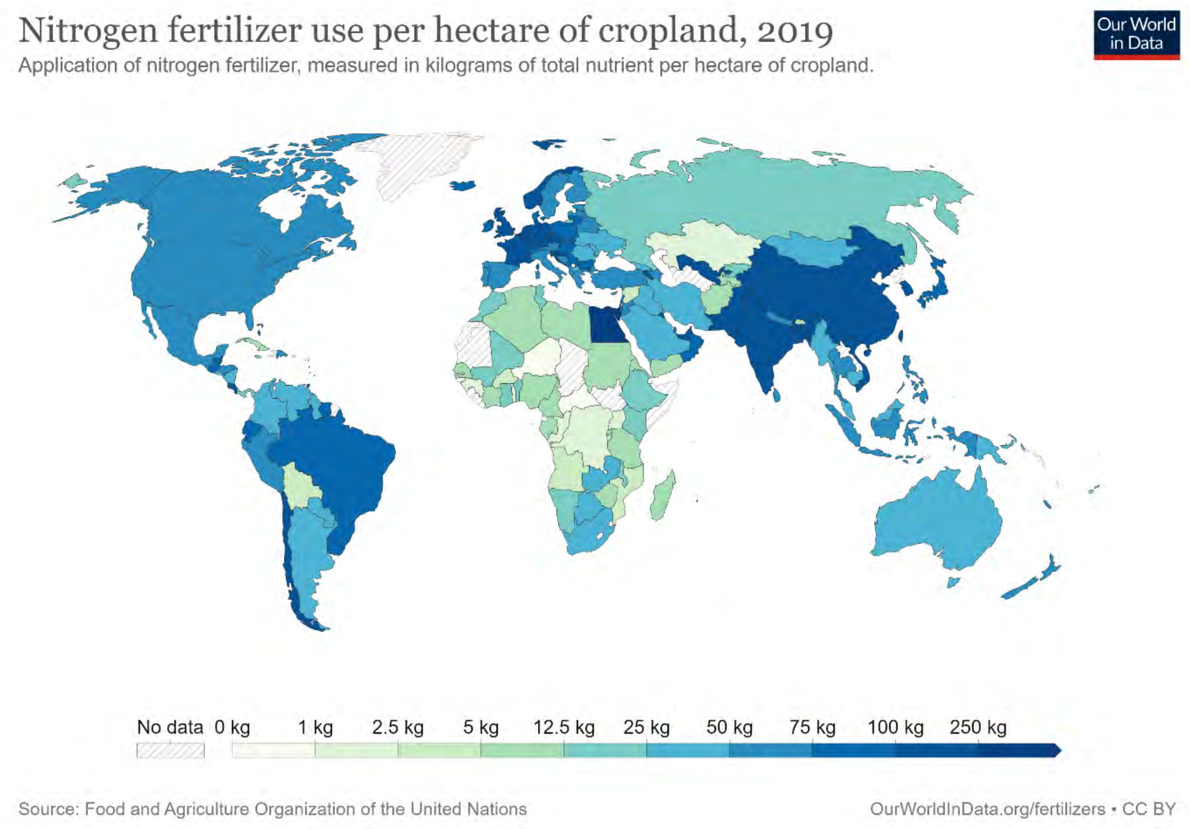


Figure 3-2 Nitrogen Fertilizer use per Ha of Cropland

IEFCL is currently using natural gas as a feedstock for ammonia and urea fertilizers production in Line 1 and Line 2. Natural gas will also be used for the proposed Line 3 Project. During the process, 80% of the gas is used as feedstock for fertilizer, while the remaining 20% is used for fuel and for Power generation.

The Petroleum Industry Act 2021, focused on increasing domestic gas supply and the reduction of gas flaring, while diversifying national revenues. The domestic gas market is gradually developing, with Gas

[11] The Nigerian population projected to rise to 262 million by 2030 and 398 million by 2050.

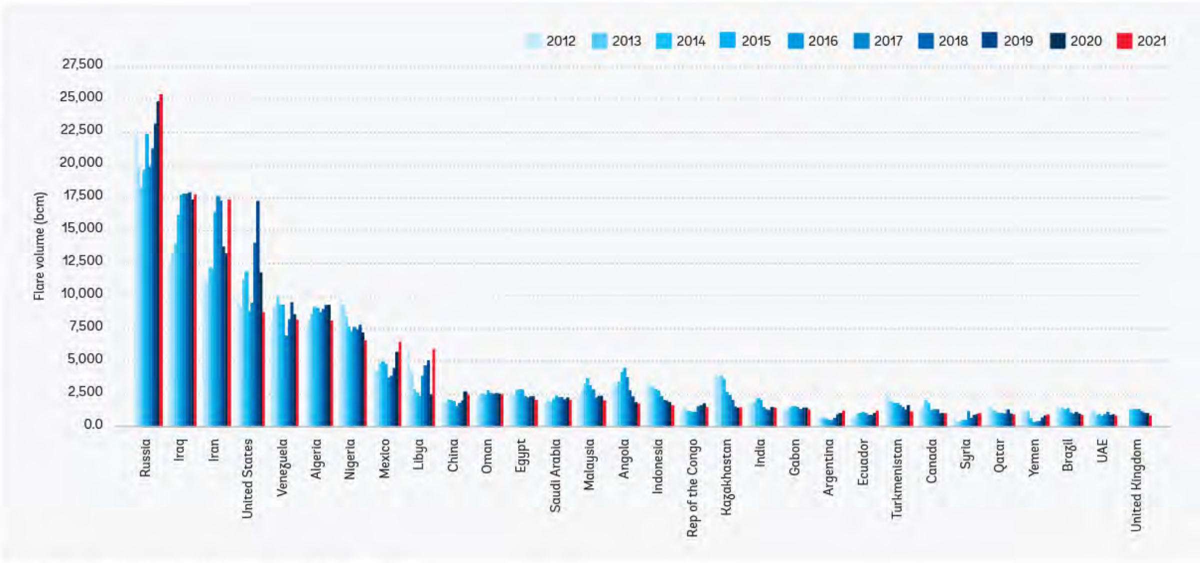
Based Industries and Power Sector being the main drivers of gas demand. To date, out of total gas production of 7.5 BCF/day, approximately 1.4 BCF/day is supplied to the domestic market, with 3.5 BCF/day for exports, 2.0 BCF/day for reinjection and 0.6 BCF/day being flared.

According to the Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA), as of March 2022, Nigeria's gas reserve was estimated at approximately 209 trillion cubic feet, the highest in all of Africa. Although Nigeria has abundant gas resources, not much of it has been harnessed, with the nation's primary focus being on crude oil production. The domestic gas market is generally underdeveloped, with only 664 and 930 million cubic feet consumed and exported respectively in 2015[12].

While the proposed Project targets efficient use of natural gas, it is to be noted that a significant volume of natural gas is still being flared in Nigeria. According to World Bank data obtained from the Global Gas Flaring Tracker Report (2022), approximately 600 million standard cubic feet (MMSCF) gas was flared daily on average in 2021. In comparison, a new fertilizer plant consumes about 90 MMSCF per day and hence project have potential to reduce approx. 3.4 MMTPA CO_2 eq. greenhouse gas. As such, the proposed Project has the potential to reduce flaring by an equivalent amount. The equivalent CO_2 emissions resulting from the flaring contribute significantly to global warming (World Bank, 2023)[13]. On top of CO_2 emissions, black carbon (otherwise known as soot) is another air pollutant resulting from flaring. Black carbon is produced through incomplete combustion of fossil fuels and despite remaining in the atmosphere for just a few days or weeks, it has the second-largest warming effect on the atmosphere, after carbon dioxide (World Bank, 2023). Flaring of natural gas is unproductive and the use of gas in the production of fertilizers (such as the proposed Line 3 Project) is key in reducing overall greenhouse gas (GHG) emissions in Nigeria.

As of 2022, Nigeria ranks 7th in the world in terms of gas flaring (Figure 3-3) despite Nigeria making significant progress in reducing flaring. Since 1996, flaring in Nigeria has been reduced by 68% (World Bank, 2022)[14].

[12] Yahya, B. and Nkwatoh, L. S. (2021). Testing the Long Run Relationship between Natural Gas Utilisation and Economic Activities in Nigeria. *Journal of Economics and Allied Research.* Vol. 6 (2). ISSN: 2536-7447. Available on https://jearecons.com/index.php/jearecons/article/download/163/161
[13] https://www.worldbank.org/en/programs/gasflaringreduction/gas-flaring-explained#:~:text=Assuming%20a%20'typical'%20associated%20gas,of%20CO2%20equivalent%20emissions%20annually.
[14] chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://thedocs.worldbank.org/en/doc/1692f2ba2bd6408db82db9eb3894a789-0400072022/original/2022-Global-Gas-Flaring-Tracker-Report.pdf



Source: NOAA, Payne Institute and Colorado School of Mines, GGFR

Figure 3-3 Flare Volumes for Top 30 Flaring Countries from 2012 to 2021 (sorted by 2021 volume, shown in red)

As part of the effort to curb gas flaring in the country, in December 2016, the Federal Government launched the Nigerian Gas Flare Commercialization Program (NGFCP). The NGFCP was designed to implement the Policy objectives of the Government for the elimination of gas flares through technically and commercially sustainable gas utilization projects. The proposed IEFCL Train 3 Project has the potential to significantly contribute to the strategic investment program to increase the use of natural gas and reduce flaring while simultaneously ensuring the availability of fertilizer to enable the Green Revolution in Nigeria to usher in food security for the long term.

3.3 Value of the Project

Previously, Indorama commissioned two trains of ammonia and urea productions, specifically Train 1 in 2016 and Train 2 in 2021 respectively. IEFCL Management further plans to set up a 3rd Train in the same location for ammonia and urea production. The investment is aimed at: improving domestic production, promoting the setting up of downstream blending plants, enhancement of supply/distribution networks and the provision of new employment opportunities for the growing demand from the young Nigerian population. With all three units in operation, Indorama will be able to produce 4.2 million tonnes Urea annually. Overall, the Project will be able to help improve the share of agriculture in the Country's GDP and derive valuable foreign exchange from the Urea that may be exported, as well as improve the local economy in the immediate Project area.

The envisioned capital cost of the Project is anticipated at around USD 1.3 Billion Envisaged Sustainability

3.3.1 Technical Sustainability

The proposed Project is expected to be technically sustainable due to the following reasons:

- Natural gas has more hydrogen compared with other feedstock. Additionally, heavier feedstock such as coal and oil are more complex to process & increases the GHG emissions.
- Ammonia and urea will be manufactured in the same plant resulting in more than 70% of the carbon dioxide byproduct from ammonia production being used to make urea.

- Both the operational IEFCL Train 1 and Train 2 projects employ the same technologies and have demonstrated a high degree of operability and reliability, while setting a benchmark in process safety. As such, the IEFCL Train 3 Project will employ the same technology as Trains 1 and 2.
- Engineering and construction of the Project will be undertaken by the same Contractors who engineered and constructed Trains 1 and 2.
- The Project Proponent will design, construct and operate the Project in strict adherence to internationally accepted codes, standards and best practices for engineering design and construction such as (but not limited to):
  - American National Standards Institute (ANSI)
  - American Society of Mechanical Engineers (ASME)
  - National Association of Corrosion Engineers (NACE)
  - National Fire Protection Association (NFPA)
  - International Electrotechnical Commission (ICE)
  - Institute of Electrical and Electronics Engineers (IEEE)
  - Institute of Electrical and Electronics Engineers (ISA)
  - Network Information Service (NIS)

It is important to mention that the successful construction and operation of Lines 1 and 2 are as a result of robust designs, safety, energy efficiencies and deployment of vigorous O&M Practices.

- The Project has secured the availability of natural gas for feed.
- IEFCL has technically competent personnel required for effective operation of the Project. These staff were / are involved in the construction, commissioning and operation activities of Lines 1 and 2.

3.3.2 Environmental Sustainability

Provided that all the E&S mitigation / management measures provided in this ESIA and associated ESMMP are implemented, and provided that the suggested ways forward are a condition of authorisation, it is the opinion of ERM that there are no environmental or social fatal flaws or red flags which inhibit authorisation of the Project. Moreover, the positive E&S benefits (refer to Section 3.2) of the Project also need to be considered in the authorisation decision.

The ESIA process does not stop with submission of the Project ESIA report to the FMEnv. Following submission of the ESIA, work will continue to address some of the acknowledged data gaps and detailed design of the Project will progress. As additional baseline data is gathered, a greater level of certainty regarding the impacts of the Project will emerge. Additional baseline data and any further changes to Project scope should be re-evaluated in terms of their influence on impact significance, and if necessary, mitigation / management measures included in the ESMMP should be amended to ensure negative impacts are mitigated and positive impacts enhanced.

3.3.3 Economic Sustainability

The strategy of the Federal Government to reduce the flaring of associated gas from the various oil fields provides the push to incentivize and make available the required natural gas for this Project, as well as for other similar industries. The Project contributes positively to the economic sustainability due to more than required gas supply contracts in place, sound technology, experienced contractors and operations staff, easy access to Port, and an established marketing and sales team.

In addition, the Project will help to correct the existing market imbalance in terms of supply and demand of urea fertilizer. Presently the per capita consumption of fertilizer is very low in Africa, and

Nigeria in particular. The projection that the use of fertilizer per ha should increase from the current levels of 20[15] kg/ha to 50 kg/ha provides a robust economic justification for the Project.

The Project will improve the following areas of the economy:

- The local economy and development of other downstream medium scale industries such as NPK blending.
- Valuable foreign exchange, if the product is exported.
- Direct and indirect employment of the local population.
- Substantial indirect employment for plant construction, transportation, and support services.

3.3.4 Social Sustainability

IEFCL is committed to meet the ever-increasing national level demand of fertilizer, which in turn is a key enabler to achieving food security in Nigeria. Moreover, the Project will provide employment opportunities during all phases (construction and operations).

The robust and all-inclusive engagement of the host communities by IEFCL Management has ensured a positive relationship between the Proponent and host communities. A detailed stakeholder consultation process has been implemented throughout the ESIA process to assist in ensuring that all relevant stakeholders have had the opportunity to provide input into the project planning process. IEFCL will ensure that the stakeholder consultation process is sustained throughout the life of the Project as set out in the SEP.

3.4 Project Alternatives

3.4.1 Introduction

In accordance with the Nigeria EIA Act No 86 of 1992 (now codified as the EIA Act CAP E12 Law of the Federation of Nigeria, 2004), an ESIA study should consider technically and economically feasible alternatives for carrying out a project, including an assessment of the environmental effects of alternatives. Additionally, the Federal Republic of Nigeria through Official Gazette No. 105, Vol 108 published S.I No. 109, Environment Impact Assessment Procedures and Charges Regulations in September 2021. These Regulations require that the alternatives be considered based on technology, site, energy and water requirements. The Project has therefore considered:

- Location Alternatives, and
- Technology Alternatives.

3.4.2 Location Alternatives

The proposed Project will be established adjacent to the existing Indorama complex. The land earmarked for the Project is within the industrial zone with no existing settlements and is therefore preferable from a social perspective as no physical resettlement will be required. Given the location of the proposed Project site in relation to existing operations, the site has access to key utilities such as power, water supply and wastewater treatment. In addition to utilities, the existing complex also has well established infrastructure and facilities such as roads that may be leveraged by the Project. Other major advantages to locating the Project adjacent to the existing complex includes:

- Good soil conditions similar to the existing Line 1 and 2 plots;
- E&S impacts can be adequately managed / controlled (i.e. – there are no fatal flaws or red flags);
- The relations with the host and neighbouring communities is positive;

[15] VIFAA Nigeria (africafertilizer.org)

- The existing Operations and Maintenance (O&M) support team associated with the existing operations are available during the construction and operations of the Project; and
- Proximity to the Proponent's Port at Onne with good marine conditions.

Consequently, although alternative location alternatives is reasonable, it is not a financially feasible option. Moreover, from an E&S perspective, there are no environmental or social fatal flaws or red flags associated with the location of the Project. As such, location alternatives will not be considered any further in this ESIA.

3.4.3 Technology Alternatives

As mentioned in Section 3.4.1, availability of raw material (i.e. – natural gas) is critical to the overall feasibility of the Project. Natural gas is considered to be more advantageous over other materials (like coal) for the following reasons:

- Natural gas will be available at the plant's battery limit. A separate authorization is in place to assure the delivery of the raw material.
- The reserve of the natural gas will suffice well above the life cycle of the Project (including for Train 1 and 2).
- The use of coal or biomass as a raw material for the Project would be capital intensive, as material would need to be transported to the proposed Project via road. Transportation of raw material via road for the life of the Project is also not favourable from a community or occupational health and safety perspective.
- Hydrogen production from biomass is either biochemical (anaerobic digestion or fermentation) or thermochemical. Anaerobic digestion to produce biogas can only process sewage sludge, agricultural, food processing and household waste, and some energy crops. Fermentation can process the non-edible cellulosic part of some plants; nevertheless, the volume of biomass required would be significantly high and cost prohibitive. The estimated amount of biomass (equivalent to 90 MMSCFD NG) required would be approximately 6,000 TPD. Further, the fermentation process results in CO_2 emissions. Preliminary assessments indicate that it would not be feasible to source such high volumes of biomass.
- Although gasification could potentially convert all organic matters to syn gas, the process produces a significant amount of CO_2. The operational efficiency of the gasification technology is poor, which may result in non-availability of syn gas, and the ammonia process needs to operate on 24/7 basis. There is also a challenge of the formation of tars in the gasification process, which can cause catalyst poisoning.
- The use of coal as feed stock for production of urea fertilizer would have significant environmental implications. The quantity of coal needed would be 4,500 TPD (1,642,500 tons/year), which would need to be imported. The gasification of coal produces significant amounts of CO_2, and hence is not a feasible option from a climate change perspective. The carbon intensity of hydrogen from natural gas is roughly half that of coal. Without Carbon capture, the CO_2 emission vide Natural Gas route is just about 9 kg /kg of H_2 while that from coal generates approx. 20 kg / kg of H_2. In summary, the reforming of Natural Gas is a much cleaner technology.
- The option of using coal or biomass would also demand land take, which can bring loss of vegetation, biodiversity and other natural resources.
- If coal or biomass were used as an alternative feed stock, the cost in developing the site to accommodate the use of such a feedstock would be more significant.
- The Project would not be complementing Nigeria's NGFCP, which aims to eliminate flaring of natural gas and rather using gas for commercially sustainable gas utilization projects (like the proposed Train 3 Project).

Moreover, as mentioned in Section 3.3.1, the proposed Train 3 Project will employ the same technology as operational Trains 1 and 2. Trains 1 and 2 have demonstrated a high degree of operability and reliability, while setting a benchmark in process safety.

As such, although technology alternatives in terms of a feedstock and process are reasonable, it is not financially or environmentally reasonable. As such, technology alternatives will not be considered any further in this ESIA.

3.4.4 No Project Alternatives

As per ESIA good practice, any comparative assessment of project alternatives must include a "No Project Alternative". For the purposes of this report, the No Project Alternative will be that the proposed Project is not established within any time period.

The key potential disadvantages associated with the no-go alternative include:

- Lost opportunity to supply an ever-increasing global demand for fertilizer.
- The world population has more than doubled in the last 50 years from 3.77 billion in 1971 to 7.89 billion in 2021[16]. As of 2023, the world population growth rate stands at approximately 0.88%[17] per year and fertilizer demand is proportionate to population growth. The population growth in Africa is higher than world growth and hence no project alternative would put significant impact on the food security of the world and Africa at large.
- Lost contribution to the provision of fertilizer to Nigeria and other West African countries, especially given the drive to increase Nigeria's fertilizer consumption from the current 20 kg/ha to 50 kg/ha.
- Long-terms loss of utilising natural gas in a commercially sustainable gas utilisation project and the associated environmental disadvantages of having to flare the equivalent of approximately 90 MMSCF per day. <u>This would in turn translate to approx. 3.4 MMTPA CO_2 eq. emissions at source and the release of unburnt CH_4 would have a greater impact on climate change.</u>
- Loss of opportunity of additional employment and development in the local area.
- Loss of additional revenue stream in Nigeria, which in turn will affect local, regional and national government revenues.
- Cumulative loss in fertilizer supply could potentially increase fertilizer prices locally (i.e. in Nigeria) and regionally (i.e. West Africa), therefore affecting future price stability for fertilizer and potentially agriculture food products[18].

The No Project Alternative is a feasible option; however, its selection would result in the above mentioned disadvantages which will be detrimental to society at large. As such, this alternative is not considered reasonable and will not be considered any further in this ESIA.

[16] Population, total - World | Data (worldbank.org)
[17] https://www.macrotrends.net/countries/WLD/world/population-growth-rate
[18] Mainstream demand for fertilizer is directly coupled with the demand for agricultural crops.

3.5 Conclusion

The availability of reliable natural gas feedstock at the broader Indorama Complex together with the efficiencies being realized by the sharing of infrastructure and personnel from existing operations favors the selected Project location. In terms of technological alternatives, the evaluation of alternate raw materials for production (such as coal and biomass) concluded that such options would not be environmentally preferred or economically viable. In view of the above, the availability of raw material (i.e. – natural gas), the location of the Project in relation to existing Indorama / IEFCL operations is critical to the overall feasibility of the Project, and as such has been selected as the preferred option for this ESIA.

4. PROJECT DESCRIPTION

4.1 Introduction

This Chapter provides a description of the proposed IEFCL Train 3 Project, related activities and ancillary infrastructure. This Project description formed the Terms of Reference for specialist studies associated with the ESIA.

In April 2016 and April 2021, IEFCL commissioned the Train 1 and Train 2 production lines respectively, which both independently produce 2,300 and 4000 MTPD of ammonia and urea. The proposed Train 3 Project will employ the same technology as operational Trains 1 and 2. Trains 1 and 2 have demonstrated a high degree of operational performance and reliability, while setting a benchmark in process safety.

The Plot Plan associated with the Train 3 Project is illustrated in Figure 4-2. The Plan provides a visual representation of the layout of Project infrastructure and associated auxiliary facilities. Table 4-1 lists the permanent and temporary infrastructural components associated with the Project.

Table 4-1 Permanent and Temporary Project Components

Particulars
New Permanent Project Components
Polisher, Wastewater treatment and Air Dryer Units
Ammonia Plant
Urea Plant
Cooling Towers and Package Boiler
Urea Warehouse for Bulk Storage
Urea Truck Loading facilities
Natural Gas (NG) Receipt Facilities
Raw Water and DM Water
Wastewater Recovery Plant
Sewage Treatment Plant
New Temporary Project Components (only required for the construction phase)
Temporary Office facilities. Laydown, Pre-fabrication, Construction warehouse area

4.2 Project Location

The proposed Train 3 expansion Project is proposed to be located within a 250ha plot that is adjacent to the IEFCL Plants, situated in the Eleme Local Government Area, Rivers State, Nigeria (refer to Figure 1.1). The Project area borders the existing Indorama Complex on the south and undeveloped land to the north, west and east.). The total footprint of the Project is 80ha. The coordinates of the project site are Latitude 4050’3” to 4050’52” N and Longitude 706’29” to 706’55” E.

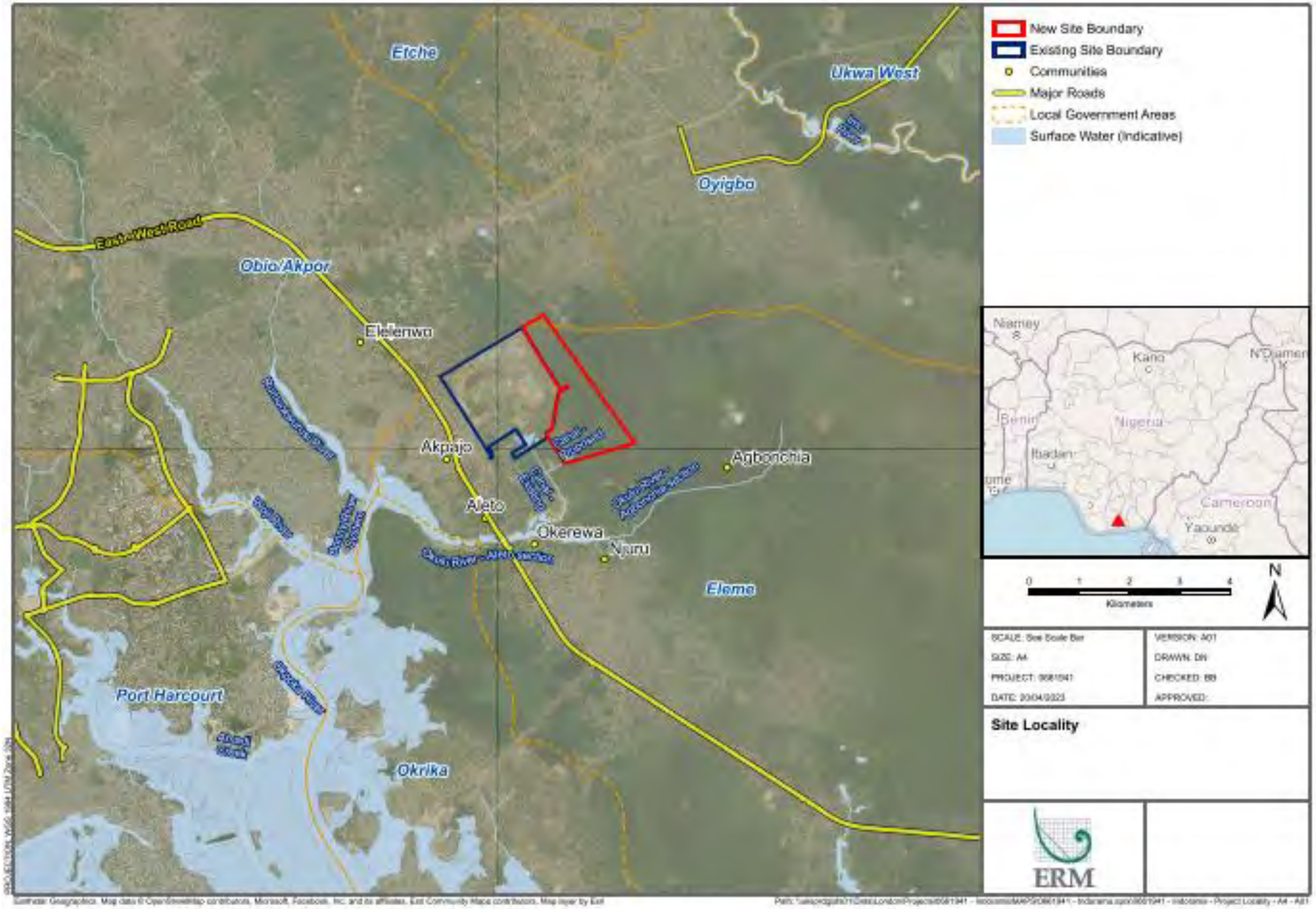


Figure 4-1 Site Locality Map

4.3 Project Phases

The proposed IEFCL Train 3 Project will be developed in the following set phases:

- Design Phase;
- Construction Phase;
- Operational Phase; and
- Decommissioning Phase.

Each of these four phases have a different combination of activities and the commencement of each phase is dependent on the outcome and success of its predecessor. It must be noted that the scope of the proposed Project, and the associated Project ESIA, relates to all four phases.

The above-mentioned Project phases are discussed in this Section.

4.3.1 Design Phase

At the end of the design phase, the proposed IEFCL Train 3 Project will be dimensionally correct, such that all the main components of the Project can be fully described. It is during this phase that the outcomes of the ESIA will influence how the proposed Project develops.

Project planning, decision-making and refinement of the Project will continue throughout the design phase, as a result of continued engineering studies, as well as per the findings of this ESIA and associated ESMMP, and through further post-ESIA environmental and social studies.

4.3.1.1 Current Design

The Project will be identical to the Line 2 Train, as the equipment design, process flow sheets, layout, etc. will be duplicates of Line 2. IEFCL has already engaged Engineering, Procurement and Construction (EPC) Contractors for the Project. For the purposes of this ESIA, the following regarding the Project is important to note:

- Project design is such that the Project will have an operational lifespan of 30 years, with a planned shutdown for maintenance purposes at every 4 years.
- Design capacity is such that the Plant will operate 330 days/year.

The IEFCL Train 3 Project will comprise of the following main infrastructure:

- An Ammonia Plant (with a capacity of 2,300 MTPD). The key infrastructure associated with the Ammonia Plant includes (Figure 4.2 and Figure 4.3):
  - The Compressor Unit (Figure 4.2 and Figure 4.3)
  - Stacks associated with the Reforming and Steam Boiler (Figure 4.2 and Figure 4.3)
- A Urea Plant (with a capacity of 4,000 MTPD). Key infrastructure associated with the Urea Plant includes (Figure 4.2 and Figure 4.3):
  - The Granulation Unit and associated stack (Figure 4.2 and Figure 4.3)
- Internal Road Network (with a width that varies between 8 to 10 meters) (Figure 4.2)
- Watch Towers (situated along the boundary wall) (Figure 4.2);
- Boundary Wall and Fence (Figure 4.2 and Figure 4.3);
- Truck Parking Facilities (Figure 4.2 and Figure 4.3);
- Workshops, material warehouse, chemical warehouse, Office buildings etc.
- A Fire Station (Figure 4.2 and Figure 4.3);

- Administration Buildings;
- Urea Product Handling and Bulk Loading Area; and
- Bulk Urea Storage Facilities, Two Cooling Towers for ammonia & Urea plant each.

Moreover, architectural plans for the Compressor House, Granulator Building and Urea Bulk Storage Area are presented in Figure 4.4 to Figure 4.6.

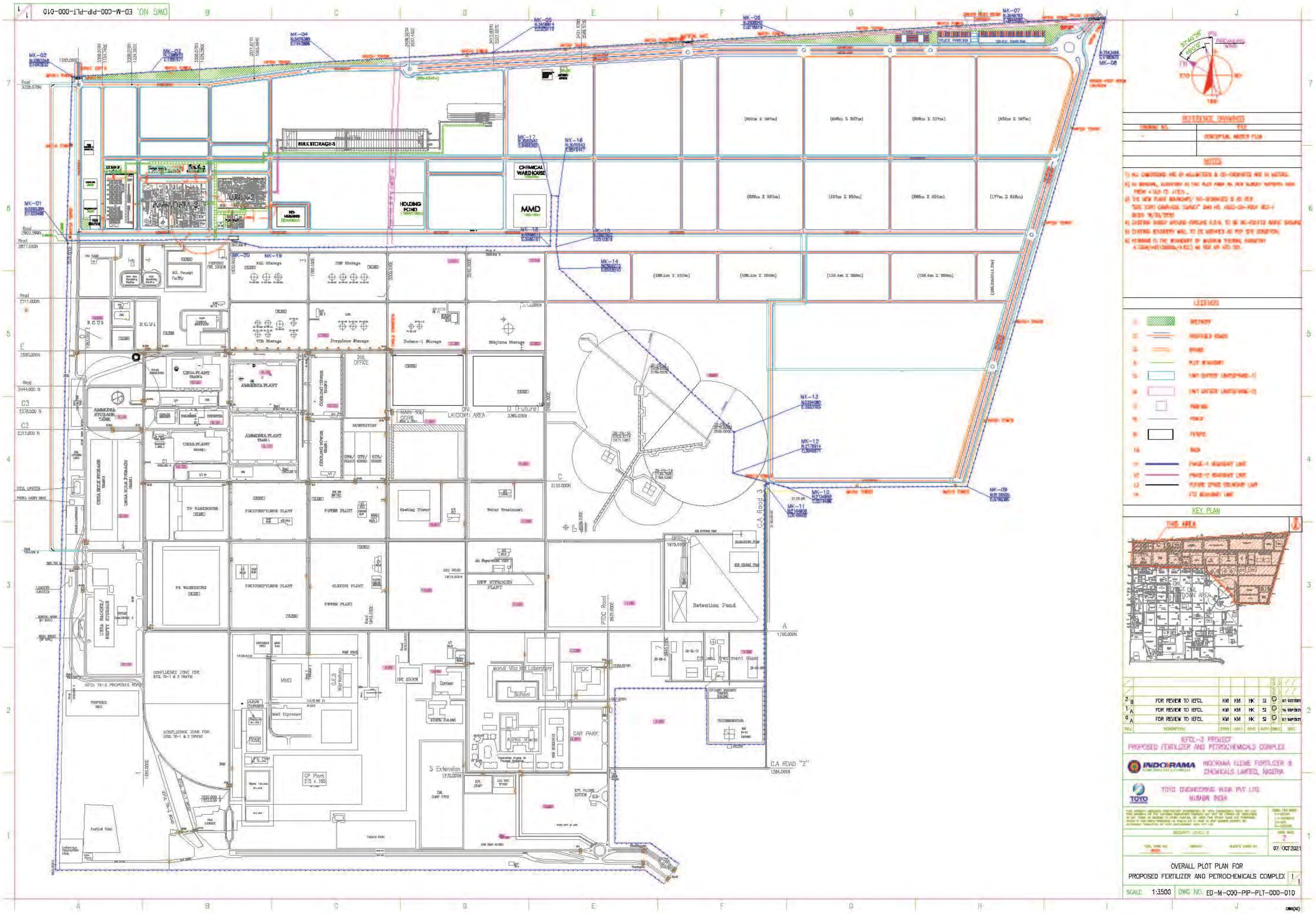


Figure 4-2 Detailed Layout of Train 3 Project in Relation to Existing Operations

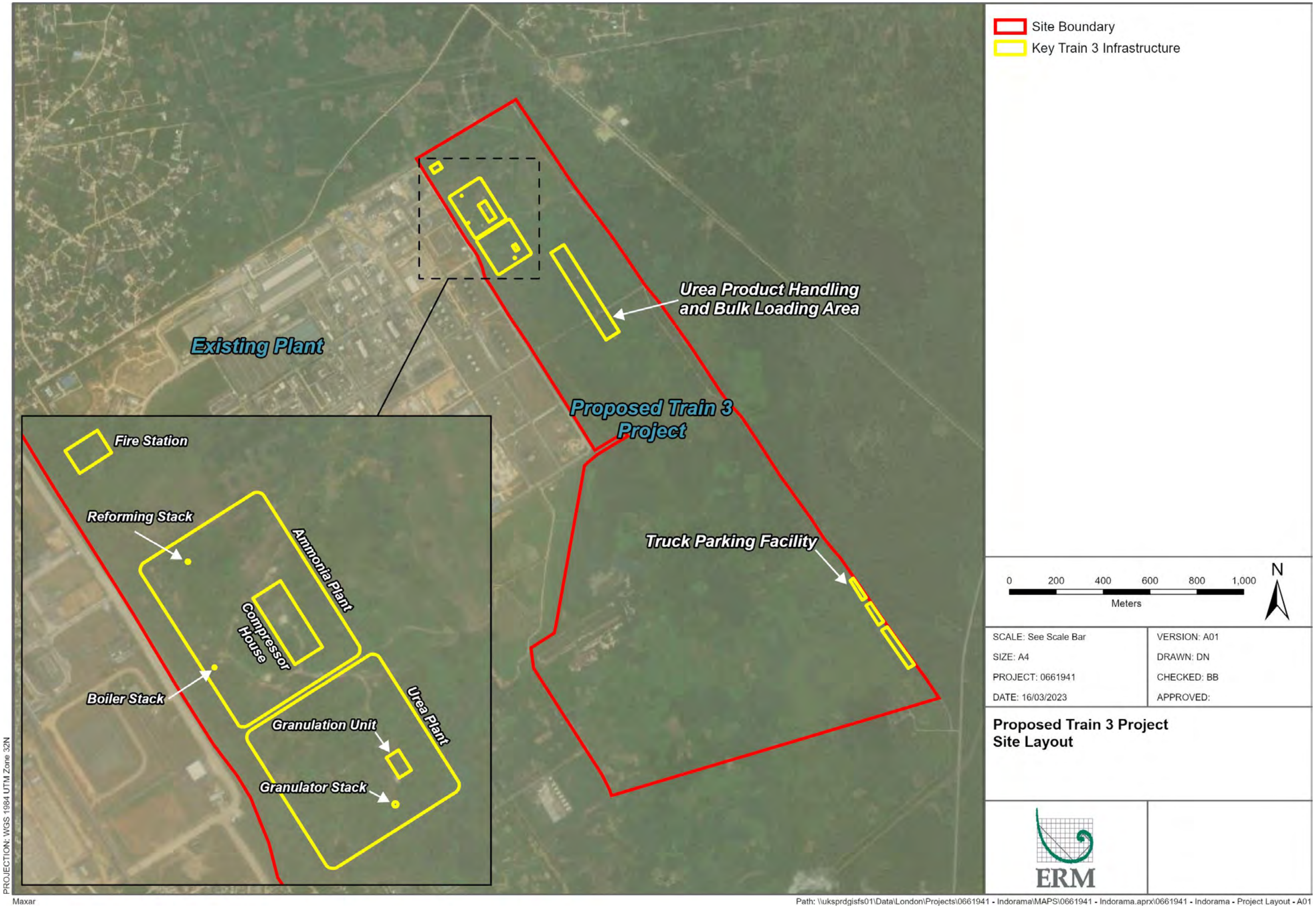


Figure 4-3 Siting and Layout of Key Infrastructure associated with the Train 3 Project

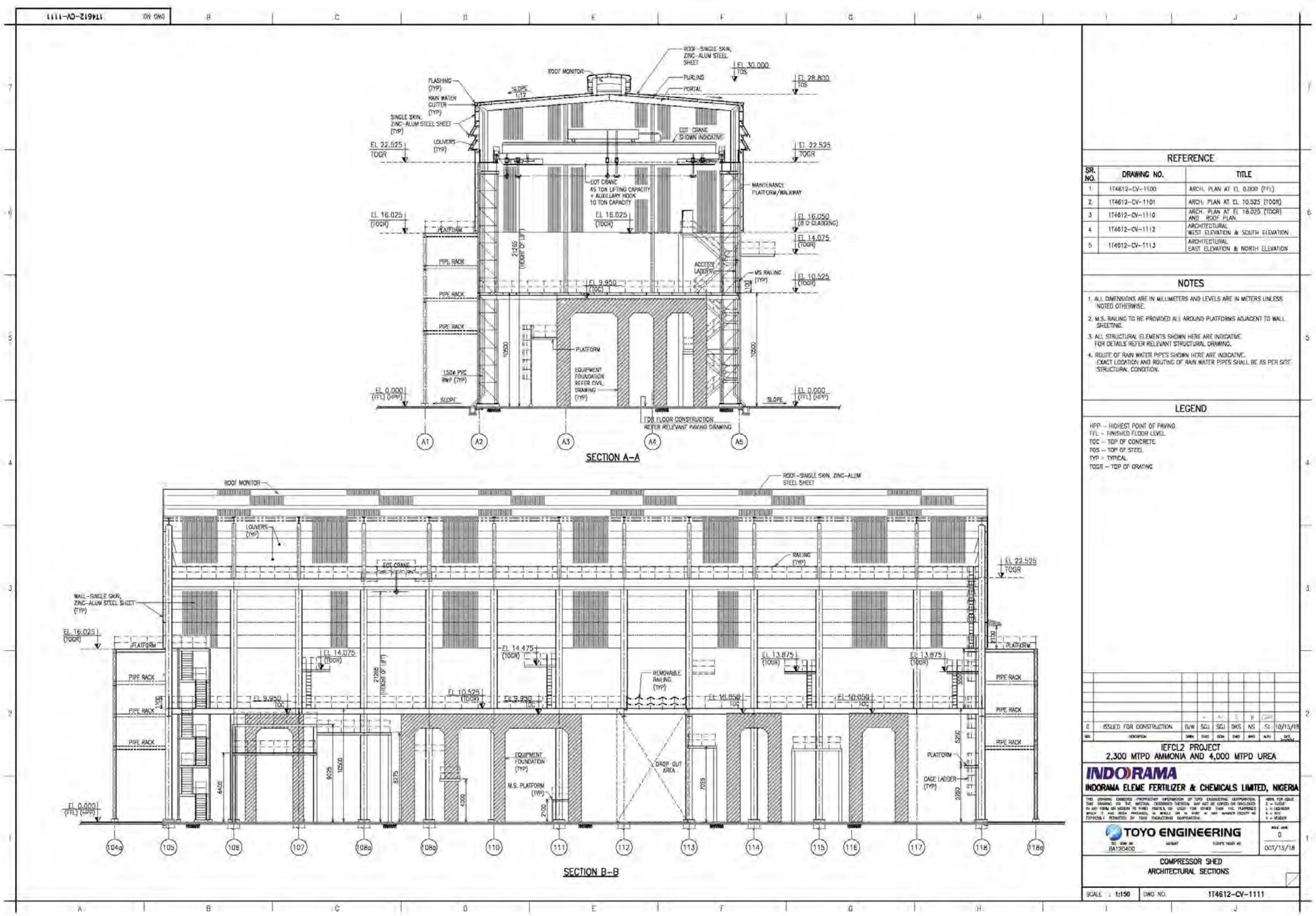


Figure 4-4 Compressor House Architectural Plan

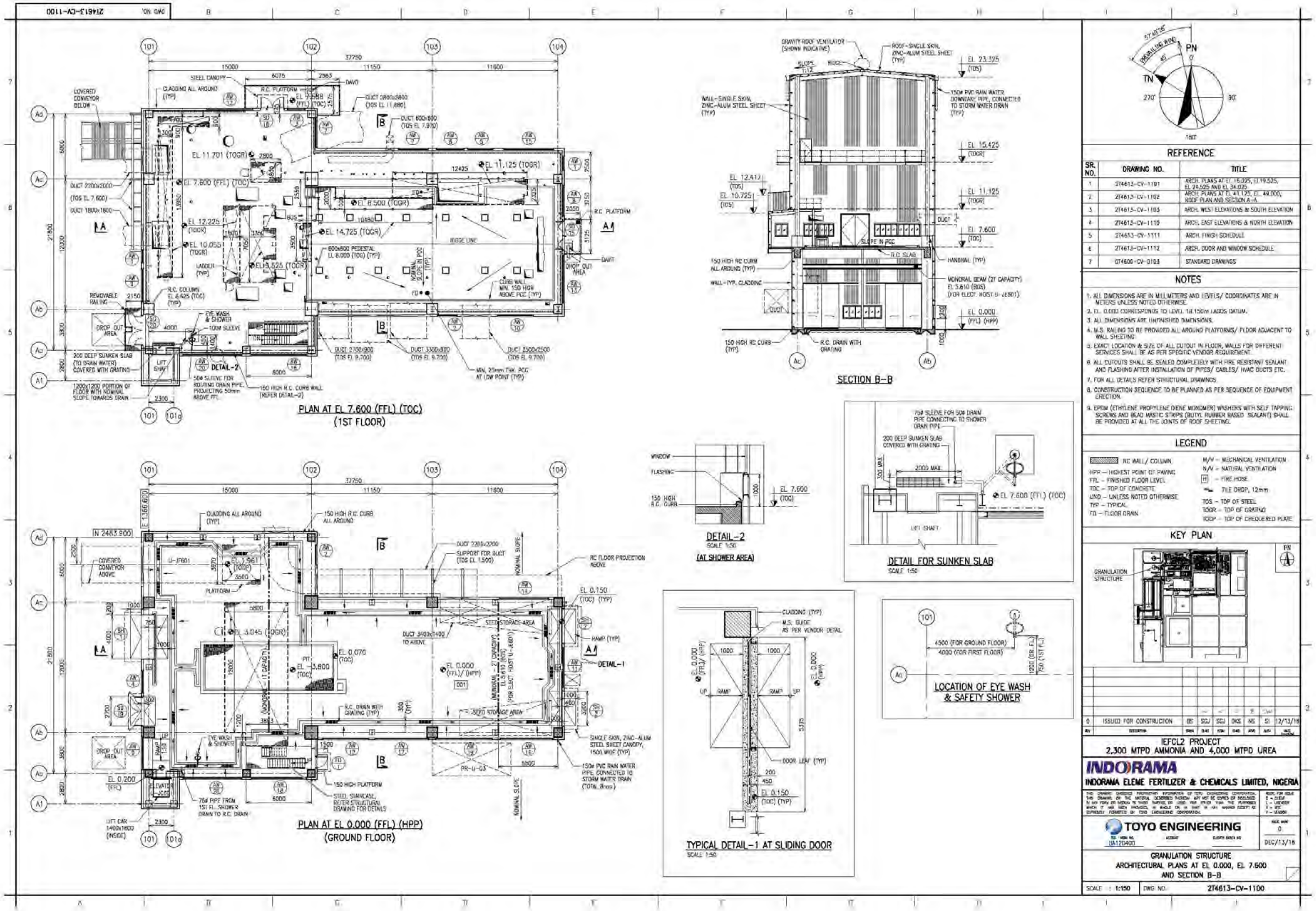


Figure 4-5 Granulator Building Architectural Plan

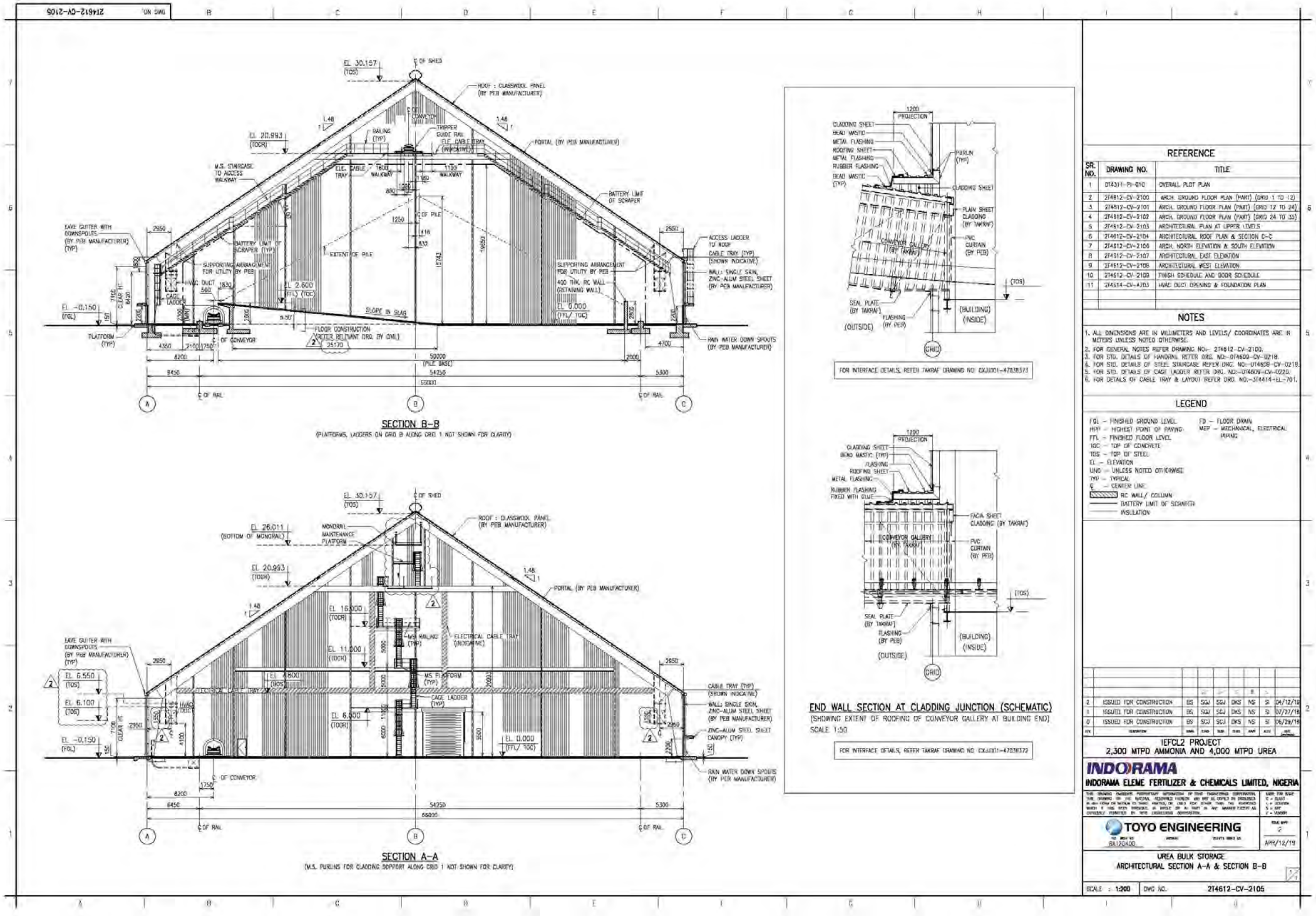


Figure 4-6 Urea Bulk Storage Architectural Plan

4.3.2 Construction Phase

The construction phase cannot commence prior to the approval of the associated ESIA study. It is assumed that construction will continue for a duration of approximately 32 months. Activities during the construction phase will typically involve establishment of the boundary wall and fence, clearance of vegetation and grading of land, civil works (specifically equipment foundations), installation of equipment, piping erection and establishment of the infrastructure mentioned in Section 4.3.1.

It should be noted that no construction activities will be undertaken during the night.

4.3.2.1 Construction Equipment

Construction activities will lead to increased traffic, due to movement of employees and construction equipment/materials. Vehicular movement during this phase will include trucks, buses, minibuses, and cars. Separate access and routes have been defined for movement of employees and materials. During construction period it is expected that additional average daily traffic of about 25 trucks/containers for the transport of equipment/ materials (logistics) and 100 buses average per day during peak manpower leading to a deployment of about 4,300 people.

It is proposed that the equipment, machinery and vehicles included in Table 4-3 will be used during the construction phase. It must be noted that the equipment, machinery and vehicles will be used intermittently during the day, i.e., all equipment, machinery and vehicles will not be used simultaneously.

4.3.2.2 Construction Utilities

It is anticipated that the following utilities will be required during the construction phase of the Project:

- **Water** – total consumption will be approximately 230,000 cubic meters (m^3), which will consist of treated water from the existing operation.
- **Diesel Consumption** – total consumption will be approximately 4,000 Kiloliters (KL), with an average consumption of approximately 46 KL/month for first 7 months and, and approximately 112 KL/month subsequently during the construction period.
- **Construction Power** – approximately 2 MWH power will be required during the construction phase and will be supplied from the existing power generating units.
- **Compressed air** – during construction, the compressed air shall be generated from portable air compressor.

4.3.2.3 Labour Requirements during Construction

The construction workforce will peak to 4,300 national staff and 617 expat staff. The 4,300 national staff will consist of skilled, semi-skilled and unskilled personnel. Employment of Nigerians will be prioritised, seeking local qualified and skilled Nigerian as a priority, The Project ambitions for recruitment of national staff during the construction phase is provided in Table 4-2.

Table 4-2 Recruitment Ambitions during the Construction Phase

Region Band	Skilled	Semi-skilled	Unskilled	Total
Eleme N'Delta	240	830	175	1,246
Rivers N'Delta	297	781	15	1,093
Othera N'Delta	630	903	15	1,548
Sub Total N'Delta	**1,167**	**2,515**	**205**	**3,887**

Region Band	Skilled	Semi-skilled	Unskilled	Total
Others	123	151	139	413
Total	**1,290**	**2,666**	**344**	**4,300**
Eleme N'Delta%	19%	31%	51%	29%
Rivers NDelta %	23%	29%	16%	26%
Other N'Delta	49%	34%	26%	38%
Others	9%	6%	7%	7%

Table 4-3 Equipment, Machinery and Vehicles Requirements during the Construction Phase (Month 1 to 35)

Equipment Description	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35
AUXILIARY EQUIPMENT																																			
AIR COMPRESSOR (UPPER 100 CFM)	-	2	3	3	3	4	3	3	4	5	6	6	6	6	7	8	8	8	8	8	8	8	8	-	8	9	9	8	9	9	8	7	5	4	-
FUEL TRUCK	1	1	1	1	1	1	1	1	1	-	1	1	1	2	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	1	1	-
GENERATOR (HEAVY)	2	2	2	2	1	2	1	-	-	2	-	-	-	-	-	-	-	-	-	1	2	2	2	-	2	2	2	2	2	2	6	7	5	5	-
MAN LIFT, STRAIGHT	5	4	2	2	2	2	1	1	5	3	5	6	6	7	8	8	8	11	13	15	16	15	15	-	-	-	-	-	-	-	-	11	9	9	7
WATER TRUCK	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	-	1	2	2	2	2	2	2	3	1	1	-
SCISSORS LIFT	2	3	3	3	2	3	2	1	1	-	2	2	2	2	3	3	3	3	3	3	3	3	3	-	-	-	-	-	-	-	-	-	-	-	-
SEWEGE TRUCK	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1	1	1	-
CIVIL EQUIPMENT																																			
BULL DOZER	1	1	-	-	-	-	1	-	-	2	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CONCRETE PUMP CAR	1	1	1	1	2	2	2	2	2	-	2	3	3	3	3	3	3	3	3	3	3	3	3	-	-	1	2	2	2	2	2	2	-	-	-
DUMP TRUCK	3	4	4	4	4	5	5	6	6	6	6	10	11	11	11	9	9	9	9	9	11	10	9	-	-	2	4	6	7	7	5	3	2	1	-
EXCAVATOR	6	7	6	8	8	9	11	16	16	13	14	13	13	13	15	15	15	15	15	15	16	16	15	-	1	4	4	6	8	7	9	7	1	1	-
MIXER TRUCK	3	3	3	3	3	3	4	4	4	-	3	6	6	6	6	6	6	6	6	6	6	6	6	-	-	2	2	2	2	2	3	2	-	-	-
MOTOR GRADER	1	1	1	1	1	1	1	2	2	-	1	1	1	2	2	2	2	2	2	2	2	2	2	-	-	-	-	1	1	1	-	1	-	-	-
SELF LOAD MIXER	-	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-
UNI LOADER	-	-	-	-	-	-	-	-	-	-	-	2	2	2	2	2	2	3	3	3	3	3	3	-	-	-	1	1	1	1	1	2	-	-	-
WHEEL LOADER	4	5	5	5	5	5	5	6	7	7	7	8	8	7	8	7	7	7	7	7	7	7	7	-	1	5	5	5	5	5	5	5	4	4	-

Equipment Description	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35
PILING																																			
PILING CRANE		3	3	3	4	5	5	4	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PICKAWAY TRUCK		1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WELDING MACHINE		2	2	2	4	5	5	5	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CRAWLER CRANE																																			
CRAWLER CRANE		2	2	2	2	3	4	6	8	13	14	15	15	17	20	20	20	20	21	20	21	20	20	2	9	16	18	17	15	16	10	7	6	5	-
HYD' CRANE																																			
HYD' CRANE (RT)	3	4	2	2	2	3	3	4	5	5	7	9	9	11	11	12	14	14	14	14	14	13	13	-	2	8	10	10	10	11	12	11	9	8	-
LIFTING EQUIPMENT																																			
FORK LIFT	1	2	2	2	1	1	2	4	4	5	5	6	6	6	9	8	8	10	10	10	10	10	10	-	1	8	9	9	9	9	10	11	10	10	-
FORK LIFT, TELESCOPIC	-	-	-	-	-	-	-	-	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	-	1	1	1	1	1	1	1	1	1	-
PAVING EQUIPMENT																																			
VIB ROLLER	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	-	-	1	1	1	1	1	1	1	-	-	-
PICK AWAY																																			
PICKAWAY TRUCK	2	2	2	2	2	3	4	5	5	5	6	7	7	7	7	7	8	9	9	9	9	9	9	-	2	8	9	9	9	9	9	9	7	7	-
PLANT																																			
BATCH PLANT	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	-	1	1	1	1	1	1	1	1	1	1	-
TRANSPORTATION																																			
CARGO TRUCK	3	3	3	3	3	3	3	3	3	2	3	3	3	3	4	4	4	4	4	4	4	4	4	-	-	2	3	3	3	3	3	3	3	3	-
MINI CARGO TRUCK (UNDER 4.0T)	6	7	6	8	7	7	6	6	8	8	8	7	8	7	8	8	8	8	8	8	8	8	8	6	7	9	10	10	10	10	9	10	10	10	-
TRAILER, HIGH BED	4	4	4	4	4	4	5	5	5	5	5	5	5	8	9	8	9	9	9	9	9	9	9	-	2	6	6	6	5	5	9	7	2	2	-

Equipment Description	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35
TRAILER, LOW BED	2	2	2	2	2	2	2	2	2	1	2	3	3	4	5	5	4	4	4	4	4	4	4	-	1	2	2	2	2	2	4	2	1	1	-
AUXILIARY M/C																																			
AIR COMPRESSOR (UNDER 100 CFM)/ENGIENEERIN G WELDING MACHINE	-	-	-	-	-	-	9	5	6	13	15	26	26	25	26	26	26	26	27	26	26	26	26	9	26	28	28	27	28	29	33	29	32	27	8
CIVIL M/C																																			
CONCRETE CUTTER	2	2	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CONCRETE SCREED MACHINE	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DRUM COMPACTOR	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HYD' BREAKER	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
MACHINE, DRILLING	2	2	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLATE COMPACTOR	4	4	3	6	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WATER PUMP	2	2	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
PLANT M/C																																			
MACHINE, LATHE	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SHOP M/C																																			
BAR BENDING M/C	1	2	1	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
BAR CUTTER M/C	1	1	1	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CAR. LIFT	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WELDING M/C																																			
ARC WELDING MACHINE	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ENGINE WELDING M/C	5	5	3	7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WELDER, ELECTRICAL DC, TIG/ARC	4	8	5	11	17	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Equipment Description	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15	M16	M17	M18	M19	M20	M21	M22	M23	M24	M25	M26	M27	M28	M29	M30	M31	M32	M33	M34	M35
BUS																																			
BUS	6	6	4	9	8	9	10	14	13	12	15	18	22	22	24	24	24	24	24	24	24	23	24	19	22	23	23	23	24	24	24	25	26	27	1
MINI BUS	4	4	3	5	4	4	4	4	5	8	5	6	6	6	6	6	6	6	6	6	6	6	7	5	5	5	6	6	6	6	6	6	6	6	-
EMERGENCY BUS																																			
AMBULANCE	1	1	1	1	1	1	1	1	1	2	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	-
JEEP																																			
JEEP	4	4	3	6	8	8	9	11	11	11	11	11	12	11	12	12	11	12	12	12	11	12	12	10	11	12	12	12	12	12	12	13	13	13	1
PICK UP																																			
PICK UP	6	7	5	10	8	9	12	14	14	24	21	21	21	23	26	25	26	26	27	26	25	26	26	17	23	25	25	25	25	25	25	28	29	29	1
TOTAL	**101**	**122**	**100**	**140**	**139**	**109**	**126**	**141**	**147**	**160**	**174**	**205**	**212**	**222**	**246**	**242**	**245**	**253**	**258**	**258**	**262**	**259**	**259**	**72**	**131**	**188**	**201**	**203**	**206**	**208**	**216**	**220**	**187**	**179**	**18**

4.3.3 Operational Phase

Early estimates indicate a potential life of the plant of approximately 30 years of operation. The *Sections* below provide a summary of the operational process flow:

4.3.3.1 Ammonia Plant

Process Flow

The ammonia plant is designed to produce 2,300 MTPD of ammonia. Ammonia will be delivered to the urea plant (refer to Section 4.3.3.2) in pipes. The plant will also deliver produced liquid ammonia to an atmospheric storage tank in the event that the urea plant be shutdown.

The ammonia plant is a single train plant consisting of the following main process stages (also refer to Figure 4-7):

- Feed and fuel gas supply
- Feed gas desulfurization
- Primary reforming
- Process Air compression
- Secondary reforming
- CO shift conversion, HTS and LTS (High and Low Temperature Shift conversion)
- CO_2 removal
- Methanation
- Syngas drying
- Cryogenic Purification
- Synthesis gas compression
- Ammonia synthesis
- Ammonia refrigeration system
- Loop Purge Ammonia Recovery
- Process condensate stripping

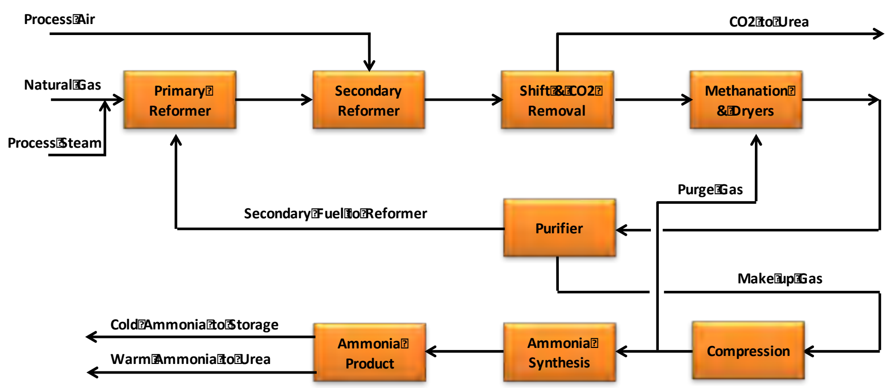


Figure 4-7 Block Diagram of Ammonia Plant

Further details of the operational process of the ammonia plant (as presented in Figure 4-7) are as follows:

- **Feed and Fuel** - the ammonia plant feed is natural gas (NG), which will be available at the plant battery limit [19] at approximately 48 kilogram force per square centimetre (kg/cm^2) and at a temperature of approximately15 degrees to 25 degrees Celsius (^{0}C). The fuel gas for the reforming and steam boiler will be part of the total natural gas delivered at the battery limit. The natural gas fuel for reforming will be supplemented by the waste gas generated within the ammonia plant.
- **Feed Gas Desulphurisation** – feed gas supplied at the battery limit will be directed through a slug catcher to separate the liquids entrained in the natural gas and thereafter processed in a desulphurization section to remove Sulphur. A small amount of hydrogen will then be added to the feed gas, following which it will be heated in the convection area of the reforming section of the plant. The gas will then pass through a bed of cobalt-molybdenum catalyst, which converts organic sulfur into Hydrogen Sulfide (H_2S). H_2S will then be absorbed to a zinc oxide bed. The desulphurised gas leaving the zinc-oxide bed contains less than 0.1 parts per million (ppm) of sulfur.
- **Primary Reforming** - the gas leaving the zinc oxide bed will then be mixed with medium pressure steam to maintain a specific steam-to-carbon molar ratio. The gas is subsequently heated in the convection zone of primary reformer, following which it is directed to the reformer catalyst tubes where the gas and steam react in the presence of a nickel base catalyst to form hydrogen and carbon oxides. Here partial reforming of the Natural gas occurs.
- **Process Air Compression** – the process air compressor provides process air for the secondary reforming. Process air is heated in the convection zone of the primary reformer and then fed to the secondary reformer along with partially reformed gas.
- **Secondary Reforming –** the process gas leaving the secondary reformer has a temperature of approximately 890 - 900°C. The gas is cooled to about 360°C in the Waste Heat Boiler, where saturated steam is produced. After cooling, the gas flows to the High Temperature CO converter.

  Saturated steam at 126 kg/cm^2 (g) will be superheated to 510°C in the coils of the waste heat section of the primary reformer. After superheating, the steam will be used in the high-pressure steam turbine that drives the air and other compressors.
- **Shift Conversion** – the CO leaving the secondary reformer will be further reacted with water over a catalyst to produce CO_2 and H_2. This conversion is accomplished in the following two steps – 1) the High Temperature Shift conversion (HTS) followed by 2) the Low Temperature Shift (LTS) conversion. Here the CO content is further reduced to less than 0.30 % vol. (dry).
- **CO_2 Removal** – the CO_2 removal is performed through preferential absorption in proprietary solvent. The rich solvent undergoes a two-stage regeneration process. The absorbent removes the CO_2 in the process gas. The recovered CO_2 is directed to the urea plant after compression.
- **Methanation** – the gas leaving the CO_2 removal section is heated and fed through Methanator Catalyst Beds where the remaining carbon oxides are transformed into methane and water. A reaction process that is opposite to reforming is used to eliminate carbon oxides from the gas stream, as these are harmful to synthesis catalyst. The syngas leaving the Methanator (methanator effluent gas) contains less than 5 parts per million by volume (ppmv) of carbon oxides (as CO + CO_2).

  The methanator effluent gas is then cooled. The chilled gas is then directed to the Molecular Sieve Driers. The driers contain solid desiccant. Each drier is sized to remove water, Ammonia, and carbon dioxide to less than 1ppmv.

[19] A separate authorization is in place to assure the delivery of natural gas.

- **Cryogenic Purification** – dried synthesis gas from the Molecular Sieve Drier is directed to the Purifier Expander, which is a turbo expander. At this stage of the process, pressure reduction energy from the gas is removed to develop the net refrigeration required for the Purifier. The removed energy is recovered as electricity in the Purifier Expander Generator. The effluent emanating from the expander is further cooled and partially condensed in the Purifier Feed / Effluent Exchanger. Process stream is then directed to the Purifier Rectifier, in which the molar ratio between hydrogen-to-nitrogen as needed for Ammonia synthesis is achieved.
- **Compression of Synthesis Gas** – purified synthesis gas will then be compressed to the synthesis loop pressure in the Synthesis Gas Compressor, which is a two-casing centrifugal compressor. The compressor will be driven by Steam Turbine that uses High Pressure (HP) steam produced in the Ammonia Plant (see below).
- **Ammonia Synthesis** – the syngas leaving the compressor is initially heated with the converter effluent, following which it will enter the syngas converter. Ammonia is produced in the three-bed converter, where the hydrogen and nitrogen react over an iron-based catalyst. The reaction is exothermic. Heat is recovered in the steam generator located in Synthesis loop to generate HP steam.
- **Ammonia Product** – from the syngas converter, compressed ammonia is condensed in a Refrigerant Condenser, which is then directed to the Refrigerant Receiver. From the Refrigerant Receiver, either cold ammonia or warm ammonia can be produced. Warm ammonia product is routed to the Urea Plant and cold ammonia is directed to an existing Train 1 ammonia storage tank in the event that the urea plant is under shutdown.

  The product ammonia (i.e. warm ammonia) has the following characteristics at the ammonia plant battery limits:

  - Ammonia: 99.90 wt % (min)
  - Water: 0.10 wt % (max)
  - Oil: 5 ppm (max)
- **Process Condensate Treatment** – process condensates produced in ammonia plant during process containing NH_3, CO_2 is treated in process condensate stripper to ensure that the condensate is free of all contaminants. Treated process condensate is sent to the Polisher Unit for further treatment and thereafter used as polished water.

Key Inputs and Outputs associated with Ammonia Production

The overall inputs / outputs associated with the ammonia plant are detailed in Figure 4-8.

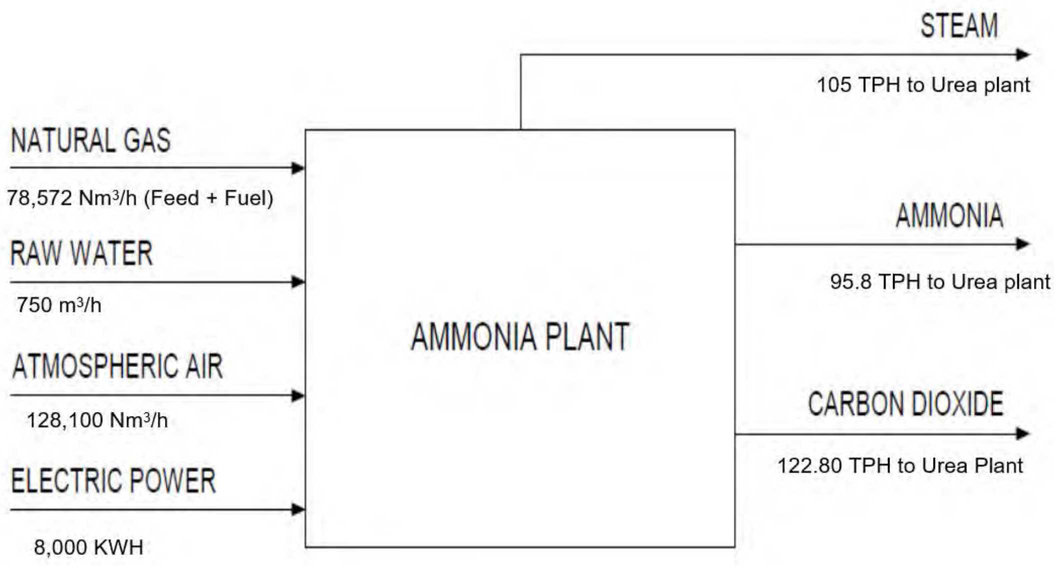


Figure 4-8 Key Inputs and Outputs associated with the Ammonia Plant

4.3.3.2 Urea Plant

Process Flow

The urea plant is designed to produce 4,000 MTPD of urea. The urea plant consists of the following main process stages (also refer to Figure 4-9):

- Urea synthesis, whereby ammonia and CO_2 react to produce a urea solution.
- Urea solution purification and recovery.
- Conversion of the urea solution to granules (employing spout bed fluid granulation technology).

The urea granules produced will be sent to storage either for bagging or bulk shipment.

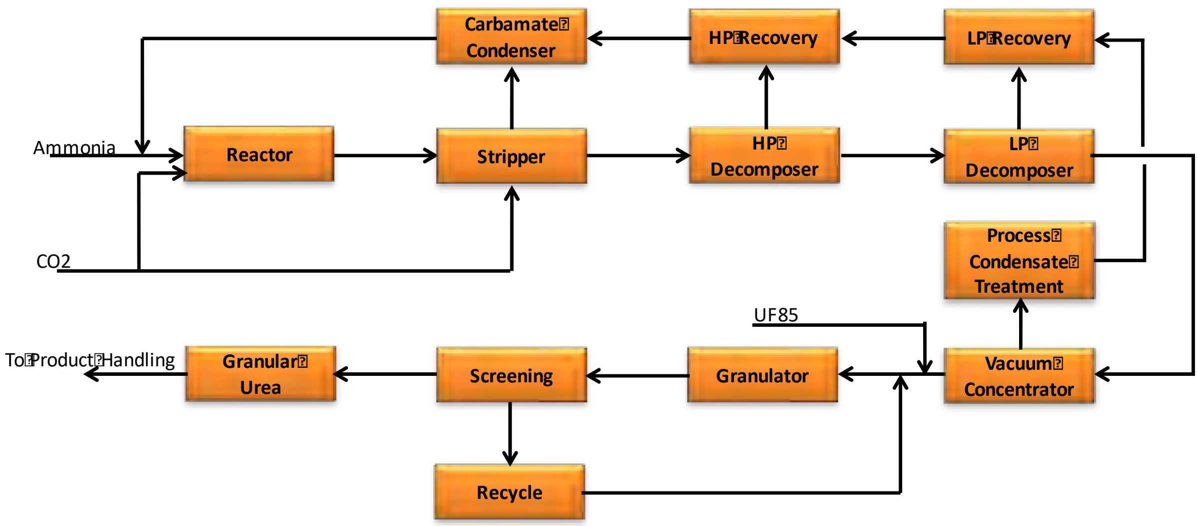


Figure 4-9 Block Diagram of Urea Plant

Further details of the operational process of the urea plant (as presented in Figure 4-9) are as follows:

- **Synthesis of Ammonia and CO_2** – urea is produced through the synthesis of ammonia and CO_2. Ammonia and CO_2 react to form ammonium carbamate, a portion of which dehydrates to urea and water.

  The fraction of ammonium carbamate that dehydrates is determined by: the ratios of various reagents, the operating temperature, pressure, and the residence time in the Reactor. The reaction products leaves the Reactor and is directed to a Stripper (a vertical in tube falling film stripper in which the liquid, distributed on the heating surface of tubes as a film, flows by gravity to the bottom of the tube).

  As the liquid film flows through the Stripper, it gets heated, resulting in the decomposition of carbamate Vapors (essentially ammonia and CO_2) are removed at the surface of the Stripper. The recovered vapor is condensed and recycled to the urea reactor by means of carbamate ejector.

- **Urea Purification** – urea purification and overhead vapors recovery takes place in two stages at decreasing pressures. The exchangers where urea purification occurs are called Decomposers. In this equipment, the residual carbamate decomposition takes place. The decomposed carbamate vapors are condensed and recycled back to the synthesis loop while the inerts are washed in the washing column before being sent to the flare stack. The urea solution exiting this section is purified to generate urea solution of 69-71 wt %.

- **Urea Concentration** – in order to granulate urea, concentrated urea solution is required. Urea concentration is achieved in the Vacuum Concentrator, whereby the concentrated urea solution (~97 % by wt.) is sent to the Granulator, after mixing with UF85 additive (Urea Formaldehyde Concentrate) as anti-caking agent.

- **Process Condensate Treatment** – process condensates containing NH_3, CO_2 and urea coming from the vacuum Concentrator is treated to ensure that the condensate is free of all contaminants. Treated process condensate is sent to the Polisher Unit for further treatment and thereafter used as polished water.

- **Granulation** - the concentrated urea solution is sprayed onto urea seeds in the Granulator through the use of multi spray nozzles. The water in the feed urea solution is evaporated in the Granulator. The enlarged granules are cooled to a suitable temperature by fluidizing air on the fluidized cooling beds in the granulator. Urea granules produced in the Granulator are screened to separate the product size granules from over and under size granules through the double deck screen. Smaller granules are recycled back to the Granulator as the seed and oversized granules are crushed and also recycled back to the Granulator. Exhaust air from the Granulator and cooler is scrubbed to recover urea dust and ammonia. Water used in the dust scrubber is also recycled back into the urea plant.

- **Urea Storage** – from the granulator, urea product will be transported by belt conveyor to new storage buildings. The new storage area will be capable of holding 80,000 metric tons of urea. Storage building will be equipped with air handling units to control ambient air temperature & humidity inside the storage building to avoid lump formation of the product. Portal scraper reclaimer will be used to reclaim the product onto a belt conveyor for export to bulk truck loading system.

Key Inputs and Outputs associated with Urea Production

The overall inputs / outputs associated with the urea plant are detailed in Figure 4-10.

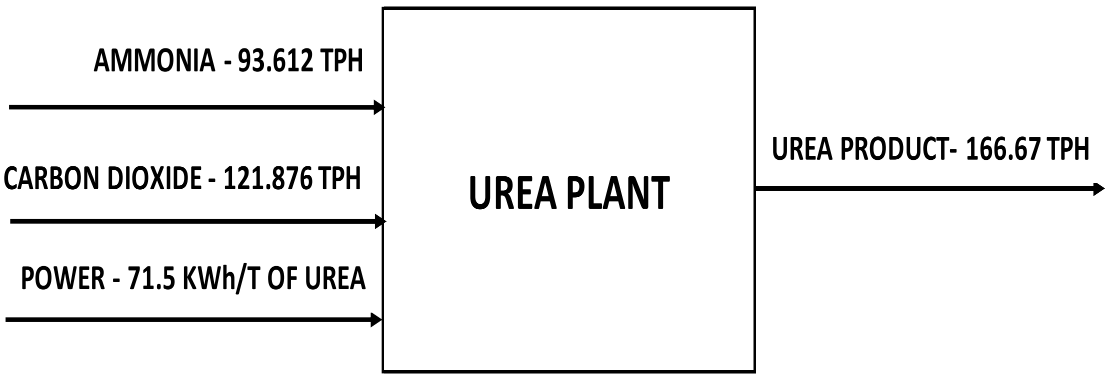


Figure 4-10 Key Inputs and Outputs associated with the Urea Plant

It must be noted that for safety purposes, all relief valves and pressure control devices associated with the ammonia and urea plant are designed for worst cases and connected to dedicated flare.

4.4 Decommissioning Phase

Activities during the decommissioning phase will involve demolition and site clean-up, disposal of waste, demobilization of the workers, and a final site review. Decommissioning will take place years from now, and the baseline conditions associated with the Project and surrounds are likely to be significantly different to what it is today. When the IEFCL Train 3 Project reaches end of life and should decommissioning be required then this would need to be assessed under a separate ESIA process.

4.5 Process Utilities

4.5.1 Power Generation

Power for the construction and operational phases of the proposed IEFCL Train 3 Project will be provided by the existing captive power plant in the Indorama complex situated adjacent to the Train 3 Project. The existing power plant consists of six operating Gas Turbine Generators (GTG) and one additional GTG (GT-7) shall be installed for redundancy[20]. Each of the gas turbines can produce approximately 33 MWH of power. Hence total power generation capacity of total 7 GTG's is 231 MWH and the existing power consumption is about 112 MW. The Project is expected to consume an additional 30 MWH, thus total power consumption will be 142 MW. The Indorama power grid operates with no connection to the state grid. Therefore, in order to have stable and reliable power, Indorama operates the gas turbines on an N+1+1 operation philosophy. Therefore, if one turbine trips during the operations, there would not be any load shedding in the manufacturing complex. Thus, the installed capacity is more than sufficient to meet the power demand of the Project while ensuring high reliability.

In addition to the gas turbines, the existing IEPL complex is equipped with four emergency diesel generators to supply emergency power in the event of power outages. The complex has 12 MW of emergency power capacity. For the proposed IEFL Train 3 Project, the emergency power generators and distribution system will be augmented by installing additional emergency diesel generators and associated infrastructure.

4.5.2 Raw Water Treatment

Water for the Project will be supplied by existing boreholes, and two additional new boreholes that will be developed as a back-up to ensure uninterrupted raw water supply. The location of the two new

[20] The installation of one additional gas turbine generator is been managed through a separate ESIA process.

boreholes have been identified and the relevant groundwater supply studies have been undertaken by an independent agency appointed by IEFCL. The groundwater studies was carried by Ground Scan Services Nigeria Limited under supervision of Environmental & Chemical Services Limited (LC), Nigeria and eminent Professors in hydrology The study concluded that the aquifer recharge is unaffected with the operation of additional boreholes.

Under normal operating conditions, total water demand for the proposed IEFCL Train 3 Project will be approximately 710 m^3/hr.

Raw water will be treated through de-carbonator to remove dissolved CO_2. The decarbonated water will be treated further through filtration devices (to remove suspended solids) and will be used as filtered water, for consumption in cooling tower as make up and also as service water within the plant. Filtered water shall be fed to the demineralized (DM) plant for producing DM Water.

4.5.3 Demineralized Water & Condensate Polishing System

Demineralized Water System

The DM plant will produce ultra-pure water, which will be further de-aerated to produce Boiler Feed Water (BFW) suitable for high pressure steam generation (refer to Section 4.3.3.1).

The Project will have new DM plant to meet the requirements for the Project. The existing IEPL & IEFCL DM plants will be integrated with the new DM plant to improve reliability of supply.

Condensate Polishing System

The Project will include a condensate polishing system, which will consist of a mix of bed polisher units. The system will be used to treat process and steam condensates from the ammonia plant, urea plant and the steam turbine. Return condensates from these plants will be received and stored in a condensate storage tank. . Sulphur acid and caustic soda are used for regeneration of the polisher beds.

Wastewater Recovery Plant

With the introduction of the proposed IEFCL Train 3 Project, it is anticipated that the combined IEPL and IEFCL wastewater produced will be approximately 580 m^3/hr. As part of the Project, IEFCL will implement a wastewater recovery to reduce groundwater consumption (refer to Section 4.5.2) and reduce the amount of wastewater discharge. The water recovered shall be used as makeup for cooling towers.

The wastewater recovery plant is designed to treat 580 m^3/hr of wastewater with a recovery of 522 m^3/hr (90%).

Therefore, the net raw water consumption for the proposed IEFCL Train 3 Project will be 190 m^3/hr.

4.5.4 Steam Generation

Steam for the proposed IEFCL Train 3 Project shall be supplied from new package boiler within the battery limit of the ammonia plant. Moreover, IEPL are in the process of installing four nos. Heat Recovery Steam Generators (HRSG) to recover heat from exhaust gasses from the operational Gas GTGs (refer to Section 4.5.1) to generate medium pressure steam.

It is proposed that the existing steam generators from the existing IEPL and IEFCL operations will be integrated with the Project package boiler through a common network to ensure for overall integration.

Steam is mainly used to drive turbines associated with compressors in the ammonia and urea plants, as well as in the reforming and CO shift processes.

4.5.5 Cooling Tower

Two new cooling towers having capacity of 26,000 and 16,000 m^3/hr shall be installed to supply cooling water for ammonia and urea plant respectively. Make-up water associated with the cooling towers shall be supplied partly from the water recovery plant and partly from filtered water.

A continuous blow-down from Ammonia & Urea circulating cooling water network is provided in order to maintain concentration of dissolved salts, turbidity and other key parameters of circulating water within acceptable to avoid deposition and corrosion in piping / equipment.

4.5.6 Natural Gas System

The Project requires natural gas as a feed for ammonia production and as a fuel for heat /power generation. IEFCL receives natural gas from two suppliers through an existing underground pipeline. From these suppliers, the natural gas is received in a station consisting of slug catcher, filters, ultrasonic gas flow measurement skid and distribution network. The present surplus capacity of natural gas receiving station and pipeline is adequate to meet the proposed IEFCL Train 3 Project feed and fuel gas requirement.

Natural gas required for the proposed IEFCL Line 3 Project facilities will be supplied by one of the existing Indorama suppliers and as such, there is no need to build pipeline for this Project. The pipeline having a carrying capacity of 235 mmscfd has a sufficient margin to accommodate the gas requirement of the proposed Line 3 Project.

4.5.7 Wastewater

Liquid wastes are generated from the boiler blow downs, air compressor intercoolers, turbine condensates, steam condensates, process condensate, and oily effluent from the various processing units in the ammonia and urea plants. Some waste streams will be individually treated in the ammonia and urea plants before being channeled into condensate polisher unit for reprocessing and reuse as boiler feed water (refer to Section 4.5.3). The various treatment approaches of wastewater / effluent streams are as follows (also refer to Figure 4.11):

- **Boiler Blow Down** – routed to the cooling tower basin as make-up water.
- **Turbine Condensate** – sent to the polishing unit and shall be reused as boiler feed water after polishing. If effluent is off specification it will be transferred to the water treatment system.
- **Steam Condensate** - sent to the polishing unit and reused as boiler feed water after polishing. If effluent is off specification it will be transferred to the water treatment system.
- **Process Condensates** – process condensate generated in the ammonia plant is treated in a dedicated Stripper and treated condensate is sent to the polishing unit and reused as boiler feed water after polishing. In case the process condensate is off specification, condensate shall be stored in a tank in the ammonia plant and gradually treated in the process condensate Stripper or transferred to the water treatment system.

  Process condensate generated in urea plant is treated in dedicated hydrolyser and Stripper unit. Treated condensate is sent to the polishing unit and reused as boiler feed water after polishing. In case the process condensate is off specification, condensate shall be stored in a tank in the urea plant and gradually treated in the hydrolyser / stripper or transferred to the water treatment system.
- **Oily Water** – collected in a dyke or an oil trap at each potential source of oily water. Oil is skimmed manually at each pit periodically and further removed in oily water separator (such as a CPI separator) prior to discharging to the to the water treatment system.
- **Chemical Drain** – a chemical drain will be constructed around the boiler to direct any effluent to an existing neutralization pit.

- **Floor-washing Water in the Urea Synthesis Area** – spilled process fluid on the surface of the paving or equipment is washed by steam condensate and collected in dedicated pits inside the urea plant. The collected water is treated in hydrolyser and stripper and the treated stream is sent to the water treatment system.
- **Floor-washing Water in the Granulation Area** – the granulation area is designed in such way that wash water containing urea is collected in a dissolving pit and recovered to the urea plant. Any spilled process fluid on the surface of the paving or equipment is washed by steam condensate and sent to the dissolving pit. There is no discharge to wastewater system from granulation area.
- **Sewage** – sewage generated by the proposed IEFCL Train 3 Project will be collected and treated in an existing sewage treatment plant located outside the battery limit of the Project. The sewage will be routed to the existing sewage treatment plant through underground network of piping, lifting pits and pumps. The treated sewage will be transferred to an existing IEPL holding pond for further disposal.

Wastewater from the Project will be collected and sent to the wastewater recovery plant mentioned in Section 4.5.3 for further treatment and recovery. Hence, there will be no wastewater disposal from the proposed IEFCL Train 3 Project during normal operation.

Existing IFL1/IFL2 equalization and holding ponds will be utilized to treat the IFL3 plant waste water in the event that the wastewater recovery plant (see Section 4.5.3) is not operational. The treated wastewater from the existing holding pond will be discharged to the retention pond in a controlled manner, once the quality has been confirmed. At the retention pond, the treated wastewater from holding pond will be mixed with rainwater streams from the new plot (refer to Section 4.5.11) and discharged to the Okulu River. It is important to note that the discharge from the Retention Pond will only be carried out when the pond is full and not discharged daily.

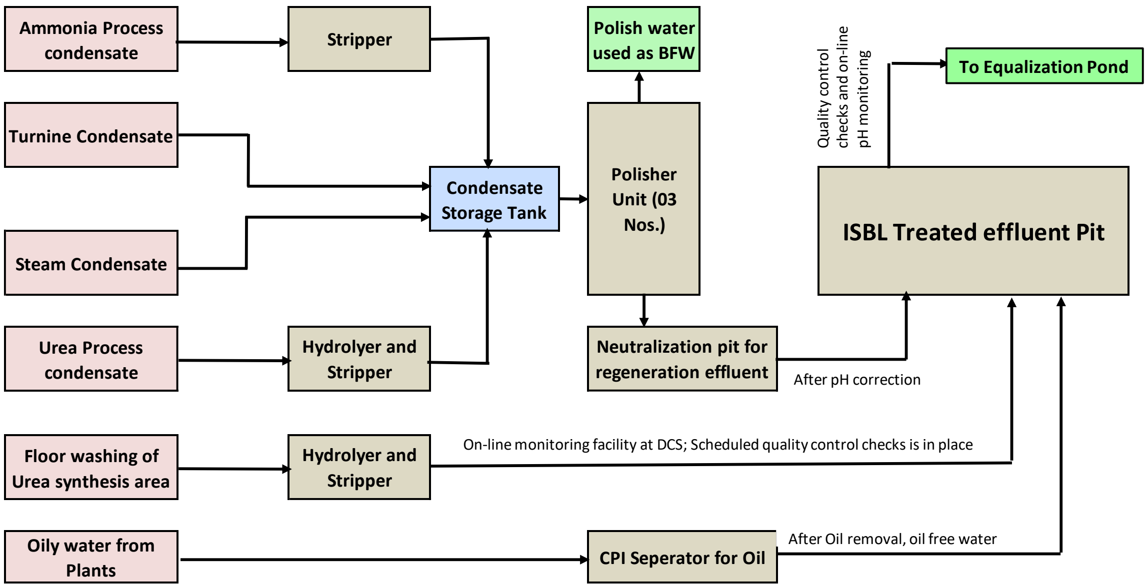


Figure 4.11 Flow Diagram of Effluent Treatment associated with the Project

4.5.8 Gaseous Emissions and Air Quality Management

4.5.8.1 Sources of Gaseous Emissions for the Ammonia Plant

The ammonia plant is designed to minimise gaseous emissions during normal and startup operations. Design features are as follows:

- **Process Heater (Primary Reformer)** – in the Primary Reformer, purge gas and flash gas are burned along with natural gas to supply the energy for the reforming reaction. Purge gas and flash gas contain ammonia, which is an emission source of nitrogen oxides. In order to reduce nitrogen oxides discharged from the Primary Reformer stack, the following inbuilt controls have been included:
  - Ammonia in the purge and flash gas is completely recovered in the Ammonia Recovery Unit. Treated gas is used as a fuel gas, which is sufficient to restrict nitrogen oxide emission from the Primary Reformer.
  - The low nitrogen oxides gas burners have been selected.
- **Package Boiler** – natural gas is used as the fuel without sulphur) for the package boiler, which is a relatively cleaner fuel thus reducing Sulphur Dioxide emissions. Furthermore, nitrogen oxides emissions are reduced by selecting the most advanced designed low nitrogen oxides burners.
- **Flare Stack and Venting** – flare stack and process vents can also be source of gaseous emissions in plant during upset conditions. Each flare stack is designed for complete burning of hydrocarbons even at the highest discharges in upset conditions. This is carried out during normal operations of the plant, hence there is no emission and no flaring of gas.

4.5.8.2 Sources of Gaseous Emissions for the Urea Plant

Major emissions from the urea plant are ammonia and urea. These emissions are caught and recycled back to process in an efficient manner, reducing emissions of pollutants to the atmosphere. The urea plant is designed to minimise such gaseous emissions during normal and startup operations. Design features are as follows:

- **Exhaust Air from the Granulator** – urea dust and ammonia contained in the exhaust air from the granulator can be a source of air pollution in urea plant. A unique dust recovery system proven in many commercial plants has been incorporated to reduce both urea dust and ammonia content in the exhaust to less than 50 mg/Nm^3-air.

4.5.8.3 Gaseous waste

A flare system will be established as part of the Project to control gaseous waste in the new plants. The flare system has been designed to dispose hydrocarbons and other gases safely during normal operation, start up, and shut down and in case of emergency in complex.

4.5.9 Solid Waste Management

Wastes generated from Project activities can be categorised as non-hazardous or hazardous according to their types and associated risks. The definitions of waste categories are as follows:

- **Non-hazardous Wastes** – wastes that do not exhibit any hazardous properties and are relatively low risk to human health and the environment. This category would include a range of materials that may be recycled or can safely be disposed of in a landfill.
- **Hazardous Wastes** – wastes that exhibit one or more characteristics which mean that the wastes are potentially harmful to human health and/or can cause damage to the environment (air, land, and/or water) or natural ecosystems. For example, the waste may be corrosive, reactive, toxic, mutagenic, teratogenic, infectious, carcinogenic, ecotoxic, flammable, or explosive.

Waste types and estimated quantities during the construction phase are shown in Table 4-4. The duration of construction activities up to mechanical completion is estimated at about 35 months.

Table 4-4 Waste Types and Estimated Quantities during the Construction Phase

Activity	Description	Waste Category	Quantity	Destination
Site preparation / ton/year Foundations	Cement / concrete – concrete debris, soil containing cement	Non-hazardous	3000-3500 ton/year	Land fill
	Scrap metal / wire – strips of metal, metal supports, pieces of wire	Non-hazardous	200-500 ton/year	Resale
Construction activities	Scrap plastic / PVC	Non-hazardous	20-30 ton/year	Recycle
Maintenance operations	Paints and solvents – traces of paint, solvents, etc.	Hazardous	0.3-0.5 ton/year	Approved waste management facility
	Light bulbs, fluorescent light fittings; Equipment which can contain traces of neon and tungsten	Hazardous	0.2 ton/year	Approved waste management facility
Personal Protective Equipment (PPE) from work activities	Used PPE – goggles, gloves, etc.	Hazardous	5 ton/year	Existing Incinerator or Approved waste management facility
Lube oil and seal flushing of machinery skid (Pre-Commissioning phase)	Lube and seal oil – oil containing weld splatter, chips, welding flux deposits, powered metal oxides	Hazardous	1.3-1.8 ton/year	Approved waste management facility
Camps, kitchen, offices operations	Cooking organic wastes	Non-hazardous	10-20 ton/year	Municipal/Approved dump side
	Mixed urban wastes	Non-hazardous	150-200 ton/year	Municipal/Approved dump side
	Medical wastes	Hazardous	0.05-0.10 ton / year	Existing Incinerator
	Wastewaters (drinking, washing, shower, sanitary)	Hazardous	150 lt/day per worker	New STP

During the operational phase, wastes contributed by the proposed IEFCL Train 3 Project will form part of the existing waste management system associated with the existing IEPL and IEFCL operations. To this end, IEFCL will update their Waste Management Plan to accommodate operational aspects of the Project.

The Project will adopt the 4R principle for solid waste management, which includes (in order or priority) to:

- **Refuse** single use plastics as much as possible
- **Reduce** the use of non-recyclable products
- **Reuse** solid wastes where possible to convert it into other useful products
- **Recycle** all wastes where possible

4.5.10 Hazardous Substance

The hazardous substances used during all Project phases are provided in Table 4-5.

Table 4-5 Hazardous materials to be used on site during construction/operations

Phase	Material	Quantity
Construction	Diesel fuel	3,600 ton during construction
	Gasoline	525 ton during construction
Operation	MDEA (Methyl diethanolamine)	3.0 Kg/hr
	UF-85	1,250 kg/hr
	Sulphuric acid	85 kg/hr

The hazardous materials included in Table 4-5 will be handled as per SOP (Standard operating procedures) for that specific material and under proper supervision and the guidance as per MSDS (material safety data sheet).

Moreover, IEFCL will ensure the proper labelling of containers, display of MSDS and availability of secondary containment and provision of spill control equipment. In the event of sulphuric acid spill, the spill will be washed with sufficient quantities of water, following which water will be routed to effluent treatment facility.

Any spillage of MDEA and UF-85 will be collected and reused. During construction minor spill during transfer of diesel/gasoline will be collected in secondary containment and reused. It should be noted that existing refueling facilities in the operational IEFCL and IEPL will be used.

4.5.11 Energy Management

The technology selected for the proposed IEFCL Train 3 Project is proven with respect to specific energy consumption and has the lowest energy requirements among the technologies available in the world for ammonia and urea production. The specific energy consumption for urea production will be 20.53 MMBTU/MT.

IEFCL have also considered the guidelines included in the IFC General EHS Guidelines (Energy Conservation) and Industry Specific Guidelines.

4.5.12 Stormwater Management

Stormwater will be managed following recommendations indicated by “IFC General EHS Guidelines, Ed. April 30th, 2007 – Wastewater and Ambient Water Quality”.

Stormwater includes any surface runoff and flows resulting from precipitation, drainage, or other sources. In order to reduce the need for stormwater treatment, the following principles, in compliance with IFC guidelines on Wastewater and Ambient water quality will be applied for the Project (Table 3.12).

- Stormwater will be separated from process and sanitary wastewater streams in order to reduce the volume of wastewater to be treated prior to discharge.
- Surface runoff from process areas or potential sources of contamination will be prevented. Where this approach is not practical, runoff from process and storage areas will be segregated from potentially less contaminated runoff.
- Runoff from areas without potential sources of contamination should be minimised (e.g., by minimising the area of impermeable surfaces) and the peak discharge rate should be reduced (e.g., by using vegetated swales and retention ponds).
- Where stormwater treatment is deemed necessary to protect the quality of receiving water bodies, priority will be given to managing and treating the first flush of stormwater runoff where the majority of potential contaminants tend to be present. Normal case will consider the disposal of neutralized wastewater and of de-oiled storm water to the existing plant pond.
- Oil water separators and grease traps will be installed and maintained as appropriate at refuelling facilities, workshops, parking areas, fuel storage and containment areas. Oil Skimmer has been foreseen inside each first rain sump to remove the majority of the oil, while the remaining will be removed through a Coalescing Plate Separator.
- Sludge from stormwater catchments or collection and treatment systems may contain elevated levels of pollutants and should be disposed in compliance with local regulatory requirements, in the absence of which disposal has to be consistent with protection of public health and safety, and conservation and long-term sustainability of water and land resources. Organic sludge will be incinerated in existing incinerators following existing SOP and ash will be analyzed as TCLP (Toxicity characteristics leaching procedure). Any spent catalyst containing zinc Sulphide will be handled by competent person as per the guidelines of MSDS HSE (Health safety and Environment) procedure.

4.6 Employment

In addition to the workforce required during the construction phase (refer to Section 4.3.2.3), the Project is anticipated to require an additional 57 and 115 expat and national staff during the operational phase of the Project. Employment of Nigerians will be prioritised.

4.7 Working Hours

The established normal working hours in IEFCL is 40 hours per week and 176 hours per month as stipulated in Nigerian Labour Laws and Internal Labour Organisation (ILO) conventions.

4.8 Project Schedule

It is anticipated that the mechanical completion will be achieved in 32 months and overall Project completion in 35 months.

5. THE ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT (ESIA) PROCESS

5.1 Introduction

As mentioned in Chapter 1, the ESIA process for the proposed IEFCL Train 3 has been undertaken in compliance with Nigerian legislation, specifically S.I. No. 109, Environment Impact Assessment Procedures and Charges Regulations, 2021. The ESIA has also considered the requirements of the IFC Performance Standards on Environmental and Social Sustainability (2012), the World Bank Group General as well as relevant industry-sector EHS guidelines and Indorama's Health, Safety and Environment (HSE) policy statements.

The purpose of the ESIA is to examine how the Project will lead to a measurable difference in the quality of the environment and the quality of life of impacted individuals and communities. Over the past decades, environmental impact assessments have expanded to include social impact assessments as well as public consultation/stakeholder engagement in the planning and decision-making process to avoid, reduce, or mitigate adverse impacts and to maximise the benefits of the project proposed. More recently, the emphasis has moved to the ESIA producing robust social and environmental management plans, which can effectively implement the recommended mitigation measures (developed in partnership with the Project proponent) identified in the ESIA during the life of the project. In addition, and as part of the environmental approval process for the proposed IEFCL Train 3 Project, a simple and easy to implement Environmental and Social Management and Monitoring Plan (ESMMP) has been developed to address the issues identified in the ESIA. The ESMMP is included in Appendix C of this Report.

The key stages for this ESIA process are:

- Scoping;
- Terms of Reference (ToR) approval;
- Wet season baseline data collection;
- Gap assessment of wet season baseline data collected and establishment of scope to fill/resolve the identified gaps with additional information / data collection;
- Assessment of impacts and mitigation;
- Interaction with design and decision-making processes;
- Management system integration;
- Stakeholder engagement; and
- Change management.

It must be noted that these key stages do not follow a linear process, but several stages are carried out in parallel. Many assumptions are revisited and modified as data becomes available and as the Project and ESIA progresses.

5.2 Scoping

The purpose of the scoping stage was to identify key sensitivities and those activities with the potential to contribute to, or cause, potentially significant impacts to environmental and socio-economic receptors and resources, and to evaluate siting, layout and alternatives for the Project. The key objectives of scoping are to:

- Identify the potentially most significant impacts;
- Obtain stakeholder views through consultation; and

- Develop the ToR for the ESIA through consultation to ensure that the ESIA process and associated reporting output are focused on the key issues.

In August 2021, post site verification, FMEnv categorized the Project as Category One with a requirement for one season of baseline data collection in line with international best practice, vide a letter dated 5th August 2021 (Ref: FMEnv/EA/EIA/6063/Vol.1/68). In the letter FMEnv also advised the Proponent to conduct a scoping workshop that included the relevant stakeholders and regulators. In September 2021, IEFCL compiled an ESIA Terms of Reference (ToR) / Scoping Report for the Project in consultation with ESCL, which was submitted and approved by the FMEnv on 05 October 2021 (Ref: FMEnv/EA/EIA/6063/Vol.1/160) (refer to Appendix A). In the approval letter, the FMEnv informed IEFCL to proceed to the next phase of the overall EIA Phase in line with Best Practice.

5.3 Wet Season Baseline Data Collection

One of the main objectives of any ESIA process is to collect suitable data on the physical, biophysical and social environment, so as to understand what receptors and resources have the potential to be *significantly* affected by a project. Chapter 7 of this ESIA provides description of the baseline conditions that have been used to make the assessment of physical, biological, and social impacts (impact assessments are presented in Chapters 8 and 9). The description of baseline aims at providing sufficient detail to meet the following objectives:

- Identify the key conditions and sensitivities in areas potentially affected by the Project;
- Provide a basis for extrapolation of the current situation, and development of future scenarios without the Project;
- Provide data to aid in the prediction and evaluation of possible impacts of the Project;
- Identify data collected by others to aid in the prediction and evaluation of possible impacts of the Project;
- Understand stakeholder concerns, perceptions and expectations regarding the Project;
- Allow the Project to develop appropriate mitigation measures as part of the ESIA process; and
- Provide a benchmark to assess future changes and to assess the effectiveness of mitigation measures.

It must be noted that In October 2021, IEFCL commissioned ECSL, a FMEnv accredited Nigerian E&S Consultant to undertake and collect infield wet season baseline data under the guidance of FMEnv and the Rivers State Ministry of Environment (RSMEnv) representatives. Wet season baseline data collected includes –

- Meteorology.
- Air Quality, which included stack emissions of operating plants.[21]
- Noise.
- Geology / soil.
- Hydrogeology/Groundwater.
- Surface water & sediments, which includes treated effluent quality of operating plants.
- Aquatic biodiversity.
- Terrestrial biodiversity.
- Ecosystems services.

[21] The baseline Air Quality data provided includes monthly data for a period of 4 years (2019-2020). In June 2020 data was not captured due to the Covid 19 Pandemic.

- Socio-economics.
- Traffic.
- Cultural Heritage.

5.4 Gap Assessment

As a part of the overall ESIA process, ERM undertook a review and gap analysis of the wet season baseline collected back in October 2021. The gap analysis was undertaken against the requirements of the IFC PSs, with the intention of identifying whether further action is required to address any gaps. The gap analysis identified a range of gaps. Majority of the gaps were addressed through clarification / provision of additional information from IEFCL. The actions to close out remaining gaps have been included as Project commitments in this ESIA and associated ESMMP and will need to be completed post-ESIA. These include:

- Additional surface water baseline surveys (the addition of an additional sampling location; surveying flow rates at surface water sample sites; and undertaking a flood risk appraisal).
- Adequately cataloguing the location of possible sources of anthropogenic sediment sources.
- Additional leachate tests to adequately document the condition of the riverine sediment is required. This leach test should follow recognised international methodology for Toxicity Characteristic Leaching Procedure (TCLP) testing. The recognised method is SW-846 Test Method 1311 as described by the United States Environmental Protection agency (EPA). The test is designed to determine the mobility of both organic and inorganic analytes present in solid and multiphasic waste. The collected riverine sediment will be dried in the laboratory before being subjected to the test, and therefore, the test can be done during dry season data collection.
- Analysis of groundwater and soils for ammonium and urea.
- Undertaking a water balance (to detect leakage) for the Project. The water balance will be undertaken during operational phase of the project.
- Ongoing sampling of all treated effluent ponds associated with the existing operations.
- Flow volumes of final effluent associated with the Project needs to be quantified during operation phase.
- Additional aquatic and terrestrial studies will be required.

Dry season data collection (which is currently underway) may potentially close-out some / if not all of the gaps mentioned above. ERM will assess dry season data collected against the identified gaps for adequacy, and at this stage determine whether the gap can be closed. If for whatever reason ERM be of the opinion that any gaps remain further actions will be provided to close out these gaps.

It must be noted that data presented by the wet season baseline assessments mentioned in Section 5.3 have been cross-referenced with publicly available online data where possible.

5.5 Impacts Assessment and Mitigation Methodology

5.5.1 Introduction

The impact assessment stage comprises a number of steps that collectively assess the manner in which the Project will interact with elements of the physical, biological, cultural or human environment to produce impacts to resources/receptors. The steps involved in the impact assessment stage are described in greater detail below.

NOTE:

The environmental and social impact assessment detailed below is an approach that combines *Impact Magnitude* and *Receptor Sensitivity* to determine **Impact Significance** (refer to methodology included in Section 5.5.2). For determination of air quality and noise impacts however, one can usually predict emission levels quantitatively and compare them against Impact Assessment Standards that take into account Receptor Sensitivity and/ or the source of noise or air contaminants to develop suitable criteria. For example, the IFC EHS Guidelines standard sets different noise levels for industrial areas than for residences. Other standards can be more prescriptive, offering numerical guidance to determine criteria and assessment of impacts, and can also be source specific. For example, industrial noise is different to road traffic noise, as is, rail traffic and aircraft noise. Thus, the impact assessment process for air quality and noise will be different to that detailed in Section 5.5.2 below. The air quality and noise impact assessment methodologies are detailed in Section 5.5.3 and Section 5.5.3 respectively.

Furthermore, the significance of potential key climate-related risks on the Project have been determined through a high-level scenario analysis, which has assessed the impact of climate change on physical climate-related risks associated with a full list of hazard types assessed to be applicable to the Project. The climate change assessment methodology is detailed in Section 0.

5.5.2 Impact Assessment

5.5.2.1 Impact Prediction

Introduction

The impact assessment process predicts and describes impacts that are expected to occur for different phases of the Project. Where possible, impacts are quantified to the extent practicable, which may include hectares of land affected; increase in noise or air pollution levels above acceptable standards; volume of waste or water discharged, number of graves affected, etc.

For each impact, its significance is evaluated by defining and evaluating two key aspects:

- The **magnitude** of the impact, and
- The **sensitivity** of the feature or receptor that will be impacted.

Impact Magnitude

Magnitude essentially describes the intensity of the change that is predicted to occur in the resource/receptor as a result of the impact. A magnitude rating tends to reflect a combination of the size of an area that may be affected, the duration over which the aspect may be altered, and the size, degree or scale of that change. In essence, magnitude is a descriptor for the degree of change that is predicted to occur in the resource or receptor.

For positive impacts (which are mostly socio-economic impacts) magnitude is generally categorised as 'Positive' unless sufficient information is available to support a more robust characterisation and to assign the degree of magnitude as Small, Medium or Large. For instance, if the number of jobs to be assigned to local community members is confirmed or if the size or value of the contribution to the national, regional or district economy is known then a magnitude rating can be assigned. If not, then the significance rating is assigned based on the sensitivity of the feature impacted by a specific activity or change.

The term '**magnitude'** therefore encompasses all the characteristics of the predicted impact including:

- Extent;
- Duration;
- Scale;

- Frequency; and
- Likelihood (only used for unplanned events).

The definitions for characteristics of magnitude used during the impact assessment are summarised in Table 5-1.

Table 5-1 Impact Characteristic Terminology

Characteristic	Definition	Designations
Type	A descriptor indicating the relationship of the impact to the Project (in terms of cause and effect).	Direct Indirect Induced
Extent	The "reach" of the impact (e.g., confined to a small area around the Project Footprint, projected for several kilometres, etc.).	Local Regional International
Duration	The time period over which a resource / receptor is affected.	Temporary Short-term Long-term Permanent
Scale	The size of the impact (e.g., the size of the area damaged or impacted, the fraction of a resource that is lost or affected, etc.).	[no fixed designations; intended to be a numerical value]
Frequency	A measure of the constancy or periodicity of the impact.	[no fixed designations; intended to be a numerical value]

The evaluation of pre-mitigation impact significance takes into account control measures that are already part of or embedded within the Project design. This avoids the situation where an impact is assigned a magnitude based on a hypothetical version of the Project that considers none of the embedded controls that are defined as part of the Project description. Examples of embedded controls could include acoustic reduction measures around noisy equipment or servitude and buffer requirements the development is obliged to implement and is part of the layout. Additional mitigation measures aimed at further reducing the significance of impacts are proposed where necessary or appropriate and are assessed as part of the 'residual' impact significance rating.

In the case of ***type***, the designations are defined universally (i.e., the same definitions apply to all resources/receptors and associated impacts). For these universally defined designations, the definitions are provided in Table 5-2.

Table 5-2 Designation Definitions

Designation	Definition
Type	
Direct	Impacts that result from a direct interaction between the Project and a resource/receptor (e.g., between occupation of a plot of land and the habitats which are affected).

Designation	Definition
Indirect	Impacts that follow on from the direct interactions between the Project and its environment as a result of subsequent interactions within the environment (e.g., viability of a species population resulting from loss of part of a habitat as a result of the Project occupying a plot of land).
Induced	Impacts that result from other activities (which are not part of the Project) that happen as a consequence of the Project (e.g., influx of camp followers resulting from the importation of a large Project workforce).
Extent	
Local	Impacts that affect an area in proximity to the development area within an area defined on a resource/receptor-specific basis.
Regional	Impacts occurring at a regional scale as determined by administrative boundaries or which affect regionally important resources or ecosystems.
International	Impacts that extend across international boundaries or affect resources such as features, resources or areas protected by international conventions.
Duration	
Temporary	Impacts are predicted to be of short duration (in the order of days) and/or intermittent/occasional.
Short-term	Impacts that are predicted to last only for the duration of the construction period (i.e. – 8 years).
Medium-term	Impacts that will continue for a period of 5 to 10 years following the completion of the construction phase e.g., where the impact may reverse or affected resources or receptors recover within this period of time.
Long-term	Impacts that will continue for the life of the Project, but will either cease when the Project stops operating or is decommissioned, or where the impact may reverse or the affected resource / receptor recovers or reverts to a near-natural state after 10 or within 20 years following the completion of the construction phase.
Permanent	Impacts that cause a permanent change in the affected receptor or resource (e.g., removal or destruction of ecological habitat) that endures substantially beyond 20 years following the completion of the construction phase.

In the case of ***scale*** and ***frequency***, these characteristics are not assigned fixed designations, as they are typically numerical measurements (e.g., number of acres affected, number of times per day, etc.).

The terminology and designations are provided to ensure consistency when these characteristics are described in an impact assessment deliverable. However, it is not a requirement that each of these characteristics be discussed for every impact identified.

For unplanned events (e.g., accidental release of hazardous materials) the ***likelihood*** of the impact occurring is taken into consideration in deriving the magnitude rating. The likelihood of an impact occurring as a result of an unplanned event is expressed as a probability and is designated using a qualitative scale (or semi-quantitative, where appropriate data are available), according to the attributes described in Table 5-3.

Table 5-3 Definitions for Likelihood Designations (only used for unplanned events)

Likelihood	Definition
Unlikely	The event is unlikely but may occur at some time during normal operating conditions.
Possible	The event is likely to occur at some time during normal operating conditions.
Likely	The event will occur during normal operating conditions (i.e., it is essentially inevitable).

Likelihood is estimated on the basis of experience and/or evidence that such an outcome has previously occurred.

It is important to note that likelihood is a measure of the degree to which the unplanned event is expected to occur, *not* the degree to which an impact or effect is expected to occur as a result of the unplanned event. The latter concept is referred to as *uncertainty*, and this is typically dealt with in a contextual discussion in the impact assessment deliverable, rather than in the impact significance assignment process.

In the case of impacts resulting from unplanned events, the same resource/receptor-specific approach to concluding a magnitude designation is utilised, but the 'likelihood' factor is considered, together with the other impact characteristics, when assigning a magnitude designation. There is an inherent challenge in discussing impacts resulting from (planned) Project activities and those resulting from unplanned events. To avoid the need to fully elaborate on an impact resulting from an unplanned event prior to discussing what could be a very low likelihood of occurrence for the unplanned event, this methodology incorporates likelihood into the magnitude designation (i.e., in parallel with consideration of the other impact characteristics), so that the "likelihood-factored" magnitude can then be considered with the resource/receptor sensitivity/vulnerability/importance in order to assign impact significance. Rather than taking a prescriptive (e.g., matrix) approach to factoring likelihood into the magnitude designation process, it is recommended that this be done based on professional judgment, possibly assisted by quantitative data (e.g., modelling, frequency charts) where available.

Once the impact characteristics are understood, these characteristics are used (in a manner specific to the resource/receptor in question) to assign each impact a *magnitude*. In summary, magnitude is a function of the following impact characteristics:

- Extent;
- Duration;
- Scale;
- Frequency; and
- Likelihood.

Magnitude essentially describes the degree of change that the impact is likely to impart upon the resource/receptor. As in the case of extent and duration, the magnitude designations themselves (i.e., negligible, small, medium, large) are universally used and across resources/receptors, but the definitions for these designations will vary on a resource/receptor basis, as is discussed further below. The universal magnitude designations are:

- Positive;
- Negligible;

- Small;
- Medium; and
- Large.

The magnitude of impacts takes into account all the various dimensions of a particular impact in order to make a determination as to where the impact falls on the spectrum (in the case of adverse impacts) from *negligible* to *large*. Some impacts will result in changes to the environment that may be immeasurable, undetectable or within the range of normal natural variation. Such changes can be regarded as essentially having no impact, and should be characterised as having a *negligible* magnitude.

5.5.2.2 Sensitivity

In addition to characterising the magnitude of impact, the other principal step necessary to assign significance for a given impact is to define the sensitivity/vulnerability/importance of the impacted resource/receptor to the type of activity proposed (e.g., habitat clearance, topsoil removal, etc.) or the consequences of a Project activity (e.g., dust, noise, water pollution, or induced population influx). This requires a range of physical, biological, cultural or human factors to be taken into account and may also need to include other factors such as legal protection, government policy, stakeholder views and economic value.

Characterisation of sensitivity for a physical or biological resource or receptor (e.g., a water feature or parameter, cliff, vegetation type) will take into account its conservation status and importance (on a local, national and international scale), its vulnerability to disturbance, and its resilience to recover or withstand a specific impact or type of impact. Where the receptor is human or cultural, the value of that social and cultural heritage receptor/s and its vulnerability to the impact is considered, taking into account the receptor's resilience, including ability to adapt to change or use alternatives where available.

As in the case of magnitude, the sensitivity/vulnerability/importance designations themselves are universally consistent, but the definitions for these designations will vary on a resource/receptor basis. The universal sensitivity/vulnerability/importance designations are:

- Low;
- Medium; and
- High.

5.5.2.3 Evaluating Significance

Once magnitude of impact and sensitivity/vulnerability/importance of resource/receptor have been characterised, the significance of the impact is assigned using the impact significance matrix shown in Table 5-4.

For impacts resulting from unplanned events (typically accidents, such as a major oil spill or other event that cannot be reasonably foreseen), the above methodology is applied but likelihood is also considered when assigning the magnitude designation, as classified in Table 5-3.

Table 5-4 Impact Significances

Evaluation of Significance		Sensitivity/Vulnerability/Importance of Resource/Receptor		
		Low	**Medium**	**High**
	Negative Impacts			
Magnitude of Impact	**Negligible**	Negligible	Negligible	Minor
	Small	Negligible	Minor	Moderate
	Medium	Minor	Moderate	**Major**
	Large	Moderate	**Major**	**Critical**

The matrix applies universally to all resources/receptors, and all impacts to these resources/receptors, as the resource/receptor- or impact-specific considerations are factored into the assignment of magnitude and sensitivity designations that enter into the matrix.

Box 5.1 provides a context for what the various impact significance ratings signify.

An impact of ***Negligible*** significance is one where a resource/receptor (including people) will essentially not be affected in any way by a particular activity or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.

An impact of ***Minor*** significance is one where a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small (with or without mitigation) and/or the resource/receptor is of low sensitivity/ vulnerability/ importance. In either case, the magnitude should be well within applicable standards.

An impact of ***Moderate*** significance has an impact magnitude that is within applicable standards, but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit. Clearly, to design an activity so that its effects only just avoid breaking a law and/or cause a major impact is not best practice. The emphasis for moderate impacts is therefore on demonstrating that the impact has been reduced to a level that is as low as reasonably practicable (ALARP). This does not necessarily mean that impacts of moderate significance have to be reduced to minor, but that moderate impacts are being managed effectively and efficiently.

An impact of ***Major*** significance is one where an accepted limit or standard may be exceeded, or large magnitude impacts occur to highly valued/sensitive resource/receptors. An aim of IA is to get to a position where the Project does not have any major residual impacts, certainly not ones that would endure into the long term or extend over a large area. However, for some aspects there may be major residual impacts after all practicable mitigation options have been exhausted (i.e. ALARP has been applied). An example might be the visual impact of a facility. It is then the function of regulators and stakeholders to weigh such negative factors against the positive ones, such as employment, in coming to a decision on the Project.

An impact of ***Critical*** significance after all feasible mitigation measures have been identified and assessed warrants the highest level of attention and concern. As with residual impacts of major significance, the regulators and stakeholders will need to closely evaluate whether the positive impacts of the project outweigh residual negative impacts of critical significance. In many cases residual critical impacts can be considered as potential fatal flaw of the project.

Box 5.1 Context of Impact Significances

5.5.2.4 Mitigation of Impacts

Once the significance of a given impact has been characterised using the above mentioned methodologies, the next step is to evaluate what mitigation measures are warranted. In keeping with the Mitigation Hierarchy, the priority in mitigation is to first apply mitigation measures to the source of the impact (i.e., to avoid or reduce the magnitude of the impact from the associated project activity), and then to address the resultant effect to the resource/receptor via abatement or compensatory measures or offsets (i.e., to reduce the significance of the effect once all reasonably practicable mitigations have been applied to reduce the impact magnitude).

It is important to have a solid basis for recommending mitigation measures. The role of any given ESIA is to help develop a consentable project, and to help clients meet their business objectives in a responsible manner. Impact assessment is about identifying the aspects of a project that need to be managed, and demonstrating how these have been appropriately dealt with. As key influencers in the decision making process, the role of the impact assessment is not to stop development or propose every possible mitigation or compensatory measure imaginable, but rather to make balanced judgements as to what is warranted, informed by a high quality evidence base.

Additional mitigation measures should not be declared for impacts rated as not significant, unless the associated activity is related to conformance with an ‘end of pipe’ applicable requirement. Further, it is important to note that it is not an absolute necessity that all impacts be mitigated to a not significant level; rather the objective is to mitigate impacts to an as low as reasonably possible (ALARP) level.

As previously mentioned, embedded controls (i.e., physical or procedural controls that are planned as part of the project design and are not added in response to an impact significance assignment) are considered as part of the project (prior to entering the impact assessment stage of the impact assessment process).

5.5.2.5 Residual Impact Assessment

Once mitigation measures are declared, the next step in the impact assessment process is to assign residual impact significance. This is essentially a repeat of the impact assessment steps discussed above, considering the assumed implementation of the additional declared mitigation measures.

5.5.2.6 Cumulative Impacts/Effects

Cumulative impacts and effects are those that arise as a result of an impact and effect from the Project interacting with those from another activity to create an additional impact and effect. These are termed cumulative impacts and effects.

The approach for assessing cumulative impacts is influenced by the availability of information about the impact of the other activity, and whether or not it already exists or is only proposed. Cumulative impacts of the Project are identified and briefly described in a qualitative manner in the context of other existing or planned development Projects.

5.5.2.7 Dealing with Uncertainty

Even with a final design and an unchanging environment, impacts are difficult to predict with certainty. Uncertainty stemming from on-going development of the Project design is inevitable, and the environment is typically variable from season to season and year to year. Where such uncertainties are material to ESIA findings, they will be clearly stated and conservatively approached (‘the precautionary approach’) in order to identify the broadest range of likely residual impacts and necessary mitigation measures.

Potential impacts may be assessed using tools ranging from quantitative techniques such as mathematical modelling to qualitative techniques based on expert judgment and historical information. The accuracy of these assessment tools depends on the quality of the input data and available information. Where assumptions have been made, the nature of any uncertainties associated with the assumption is discussed. For qualitative predictions/assessments, some uncertainty is removed through consultation.

5.5.2.8 Management and Monitoring

Management and monitoring measures are defined in the Environmental and Social Management and Monitoring Plan (ESMMP) in order to identify whether:

- Impacts or their associated Project components remain in conformance with applicable standards or performance targets;
- Mitigation measures are effectively ameliorating impacts to the extent predicted or an acceptable level; and
- Additional mitigation or management measures or other investigations are required to further ameliorate project impacts.

The ESMMP identifies the designated responsibility for implementing mitigation measures, the performance targets to be achieved, and the assurance mechanisms and protocols required to verify the proper implementation of the mitigation measures.

5.5.3 Air Quality Impact Assessment

The Nigerian National Environmental (Air Quality Control) Regulations, 2021 were set out under section 34 of the National Environmental Standards and Relations Enforcement Agency (Establishment) Act, 2007, "*to improve control of the nation's air quality such an extent would enhance the protection of flora and fauna, human health and other resources affected by air quality deteriorations".* In the majority of cases, the IFC EHS General Guidelines are substantially more stringent than the Nigerian Air Quality Standards; however, it is acknowledged that the IFC/WHO Guidelines do not consider the economic factors affecting guideline attainment.

Within the assessment, both the relevant Nigerian and IFC standards and guidelines have been used.

Baseline air quality typically varies across any area. In essence, the baseline can be considered in the following components:

- **Natural Baseline** – this represents the pollution concentrations that are ubiquitous in the region due to sources other than human activity. This primarily influences PM_{10} / $PM_{2.5}$ concentrations. Naturally occurring NO_x and SO_2 are typically minimal.
- **Regional Sources** – this represents the pollution concentrations that arise from large point or non-point sources that will affect substantial areas.
- **Local Sources** – this represents pollutant concentrations that vary on a small spatial scale, but may be substantially elevated on a local level. An example of such sources includes road traffic and in the middle of towns where there are vehicles, industry and multiple small-scale sources. These sources can lead to elevated pollutant concentrations on a localised scale, for the pollutants of interest.

The assessment uses dispersion modelling to identify the increase in air pollutants at ground level attributable to the emissions. With due consideration of the baseline, the potential for future significant impacts are assessed.

The predicted change in ground level concentrations of pollutants from the Project is referred to as the 'Process Contribution' (PC).

To consider the significance of potential impacts, the existing baseline also needs to be taken into consideration. The sum of the PC and the existing baseline is described as the 'Predicted Environmental Concentration' (PEC).

The IFC differentiate the significance of impacts using a risk-based approach, which is based upon the existing baseline air quality in the vicinity of the project. The magnitude of the impact can therefore be defined on the basis of two functions:

- **Process Contribution (PC)**, this is the impact associated with emissions from the Project only; and
- **Predicted Environmental Concentration (PEC)**, this is the impact associated with PC added to the existing background conditions.

The significance of potential impacts, using both the PC and PEC, is assessed following WBG guidance as described below.

The WBG General EHS Guidelines state:

> *"Projects with significant sources of air emissions, and potential for significant impacts to ambient air quality, should prevent or minimize impacts by ensuring that:*
>
> *Emissions do not result in pollutant concentrations that reach or exceed relevant ambient quality guidelines and standards by applying national legislated standards, or in their absence, the current WHO Air Quality Guidelines, or other internationally recognized sources.*

and that:

> *Emissions do not contribute a significant portion to the attainment of relevant ambient air quality guidelines or standards. As a general rule, this Guideline suggests 25 percent of the applicable air quality standards to allow additional, future sustainable development in the same airshed [i.e., in an undegraded airshed]".*

In general, the '25% threshold' is being applied as a rule rather than a guideline.

The WBG also states that:

> *"An airshed should be considered as having poor air quality [degraded] if nationally legislated air quality standards or WHO Air Quality Guidelines are exceeded significantly".*

and:

> *"Facilities or projects located within poor quality airsheds, and within or next to areas established as ecologically sensitive (e.g., national parks), should ensure that any increase in pollution levels is as small as feasible, and amounts to a fraction of the applicable short-term and annual average air quality guidelines or standards as established in the project-specific environmental assessment."*

In general, the WBG guidelines are interpreted such that where air quality standards are exceeded, then the airshed is described as 'degraded'.

The criteria presented in Table 5.5 have been used in the Project ESIA to assess the significance of effects on sensitive human receptors. The process is in two stages:

- First stage to determine the **magnitude** of impacts of the PC as a percentage of the air quality standard or guideline; and
- Second stage, to determine the **significance** of effects in terms of the magnitude of impacts identified from the screening stage, considered alongside the PEC.

Table 5.5 Definition of Magnitude Criteria for Air Pollutants

Magnitude of impact	Un-degraded airshed (i.e. baseline < AQS)	Degraded airshed (i.e. baseline > AQS)
Negligible	PC <25% of AQS	PC <10% of AQS

Magnitude of impact	Un-degraded airshed (i.e. baseline < AQS)	Degraded airshed (i.e. baseline > AQS)
Small	PC between 25% and 50% of AQS and PEC <100% of AQS	PC between 10% and 30% of AQS
Medium	PC between 50% and 100% of AQS, and PEC <100% AQS; or	PC between 30% and 50% of AQS
	PC between 25% and 50% of AQS, and PEC >100% of AQS	
Large	PC > 100% of AQS; or	PC > 50% of AQS
	PC > 50% of AQS, and PEC >100% of AQS	
PC: Process Contribution PEC: Predicted Environmental Concentration AQS: Air Quality Standard		

Classification as to whether a site or location is deemed to be undegraded or degraded (i.e. where ambient pollutant concentrations meet or exceed local or IFC standards, respectively), is generally ascertained through a review of local air quality monitoring data. It should be noted that an airshed can be classified as degraded for one pollutant and not for another, thus setting out different levels of criteria based on the potential significance of difference pollutant emissions.

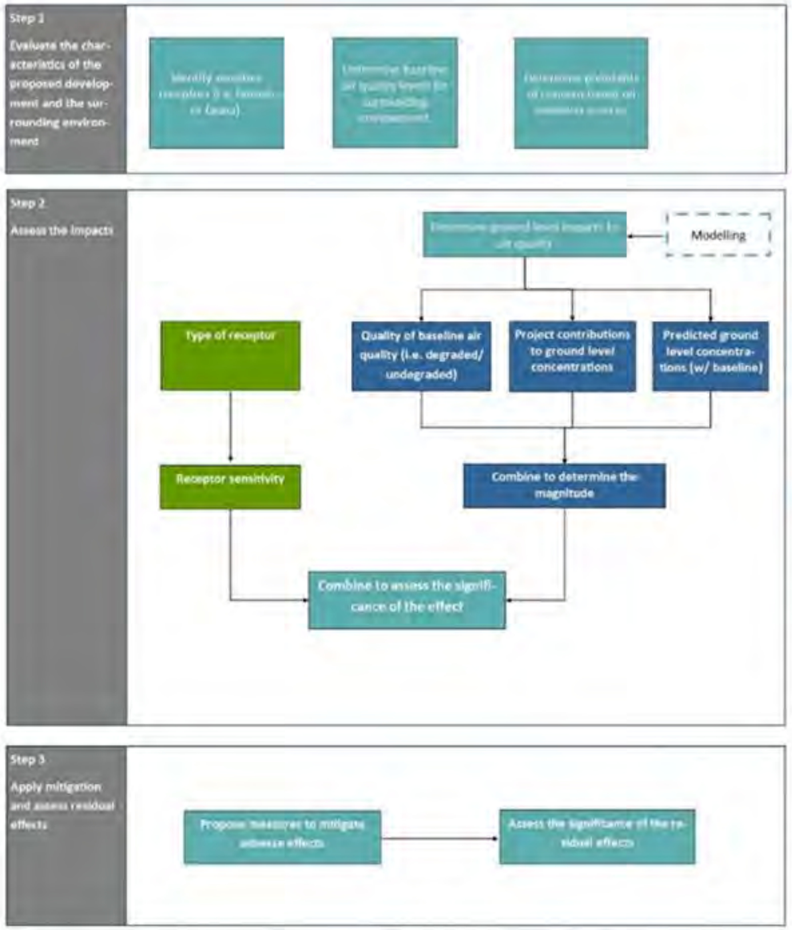
When determining the level of significance, consideration of the sensitivity of receptors also needs to be given. In particular, there is growing evidence [22] that the elderly, children and those with cardiovascular and/or respiratory disease are more susceptible to the harm from air pollution. The following sensitivity definitions have therefore been derived to take into account the potential receptor variability:

- **High Sensitivity**: Locations where particularly vulnerable individuals (for example elderly, very young or infirm) are present, which include hospitals and schools.
- **Medium Sensitivity**: Locations where the general population are present for large periods of the year, for example residential areas, towns and villages.
- **Low Sensitivity**: Locations where humans are transient or present for short periods only, such as agricultural areas or fishing areas.

The potential impact significance is therefore determined by considering both the magnitude of impacts and the receptor sensitivity. The criteria for the definition of significance are the same as those set out in Table 5-4 on Page 89.

The method for identifying significance of impacts of operational activities is set out in Figure 5.1.

[22] Defra & PHE (2017). Air Quality - A briefing for Directors of Public Health. Department for Environment, Food and Rural Affairs, and Public Health England, March 2017.



Receptor Sensitivity

The sensitivity of ecological receptors is defined on the basis of their designated importance as an ecological resource. Any significant ecology impacts from air quality on non-designated sites will be assessed qualitatively as part of the Ecology assessment. This is typically determined on the basis of the statutory protection conferred on a receptor (for example, under the Ramsar convention). The table below provides receptor sensitivity with respects to human health. Sensitivity criteria for ecological receptors is as defined in the biodiversity methodology.

Sensitivity	Human	Ecology
Negligible	N/A	Non-designated habitats
Low	N/A	Locally designated sites
Medium	General population	Nationally designated sites
High	Particularly vulnerable individuals, e.g. a hospital with intensive care ward	Internationally designated sites

Magnitude of Change

The results of the air dispersion modelling are compared to the relevant air quality standards or guidelines (either for human health or ecology). Different standards/ guidelines will apply depending on the pollutant of concern and the averaging period. To determine magnitude, the Project's Contributions (PCs) to ground level pollutant concentrations are assessed in tandem with the total Predicted Environmental Contributions (PECs), where the PEC is the sum of the baseline concentration and the PC for a particular pollutant. The criteria used is presented below. Where national guidance exists for impact magnitude levels, this should take precedent to the value provided below.

PC as % of AQS	Magnitude
Undegraded Airsheds Where PEC < Air Quality Standards/Guidelines	
<10%	***Negligible***
10-25%	***Small***
25-75%	***Medium***
>75%	***Large***
Degraded Airsheds, i.e. Where PEC > Air Quality Standards/Guidelines	
<5%	***Negligible***
5-10%	***Small***
10-25%	***Medium***
>25%	***Large***

Note that in some countries a site-specific methodology is required to assess ecology impacts from air emissions (e.g. acid deposition and eutrophication). In such cases, an additional assessment would be required using site-specific ecology criteria.

Assessing Air Quality Impacts from Industrial Sources

Figure 5.1 Assessment Methodology Operational Activities

5.5.4 Assessment Methodology

5.5.4.1 Construction Phase

Construction Dust

The process for the air quality assessment for construction dust impacts is based on the methodology shown in Figure 5.2. The method indicates the key steps in determining the significance of dust generation.

The magnitude of dust generation was determined by the following:

1. Earthworks expected to be 'Large' as per the IAQM guideline and this is determined by the size of the plant which will be greater than 10 000m^2.
2. The number of vehicles on the internal unpaved roads is more than 10 per day; and
3. Material volume handling likely to be more than 100 000 tonnes (estimated).

Based on the above parameters the construction phase dust and PM_{10} and $PM_{2.5}$ generation is determined to be of large magnitude (having the potential to exceed dust and PM_{10} and $PM_{2.5}$ AQS). Therefore, this impact is considered to be of major significance.

Monitoring and mitigation measures will be implemented to minimize dust nuisance. These measures are outlined in mitigation section. An Air Quality Management Procedure will also be required within the construction occupational health, safety & environment plan which should include construction phase dust management commitments.

With correct implementation of the required dust mitigation, the residual impacts could be negligible.

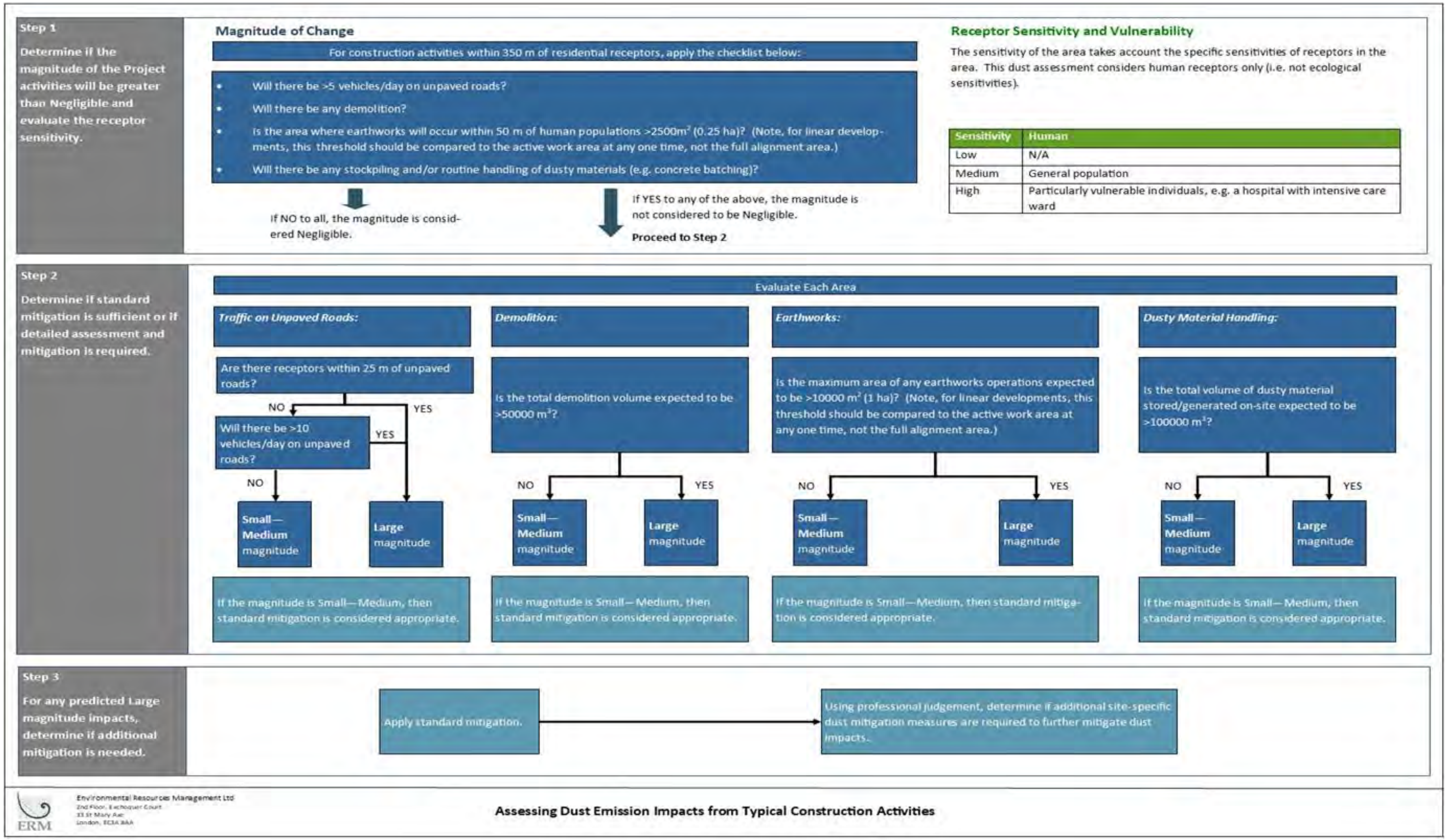


Figure 5.2 Dust Infographic for Air Quality Assessments

Construction Traffic

The process for the air quality assessment for traffic related impacts is based on the methodology as shown in the infographic Figure 5.3.

The screening method is based upon the UK Highways Agency Design Manual for Roads and Bridges (DMRB) and IFC guidelines adapted for the traffic fleet likely to be in place in Nigeria. DMRB is a semi-quantitative method that utilises traffic emission factors, and a dispersion factor derived from ADMS-Roads model for a typical road to estimate roadside concentrations at increments away from the roadside. This approach provided a set of traffic screening criteria corresponding to thresholds for Minor, Moderate and Major Impacts. These screening thresholds can be used in the future to identify the potential for significant impacts to arise. This approach is proposed as it does not rely upon traffic flow data which will not be available, or detailed modelling which will be highly uncertain. When the amount of traffic is known, this needs to be compared to these thresholds and in the case of moderate or major impacts, mitigation needs to be considered. It should be noted that this method applies to road traffic exhaust emissions. Dust emissions from vehicle operation on unpaved roads is covered in the subsequent section on construction dust.

As traffic flows associated with the Project are unknown, at this stage the significance of traffic related impacts cannot be determined.

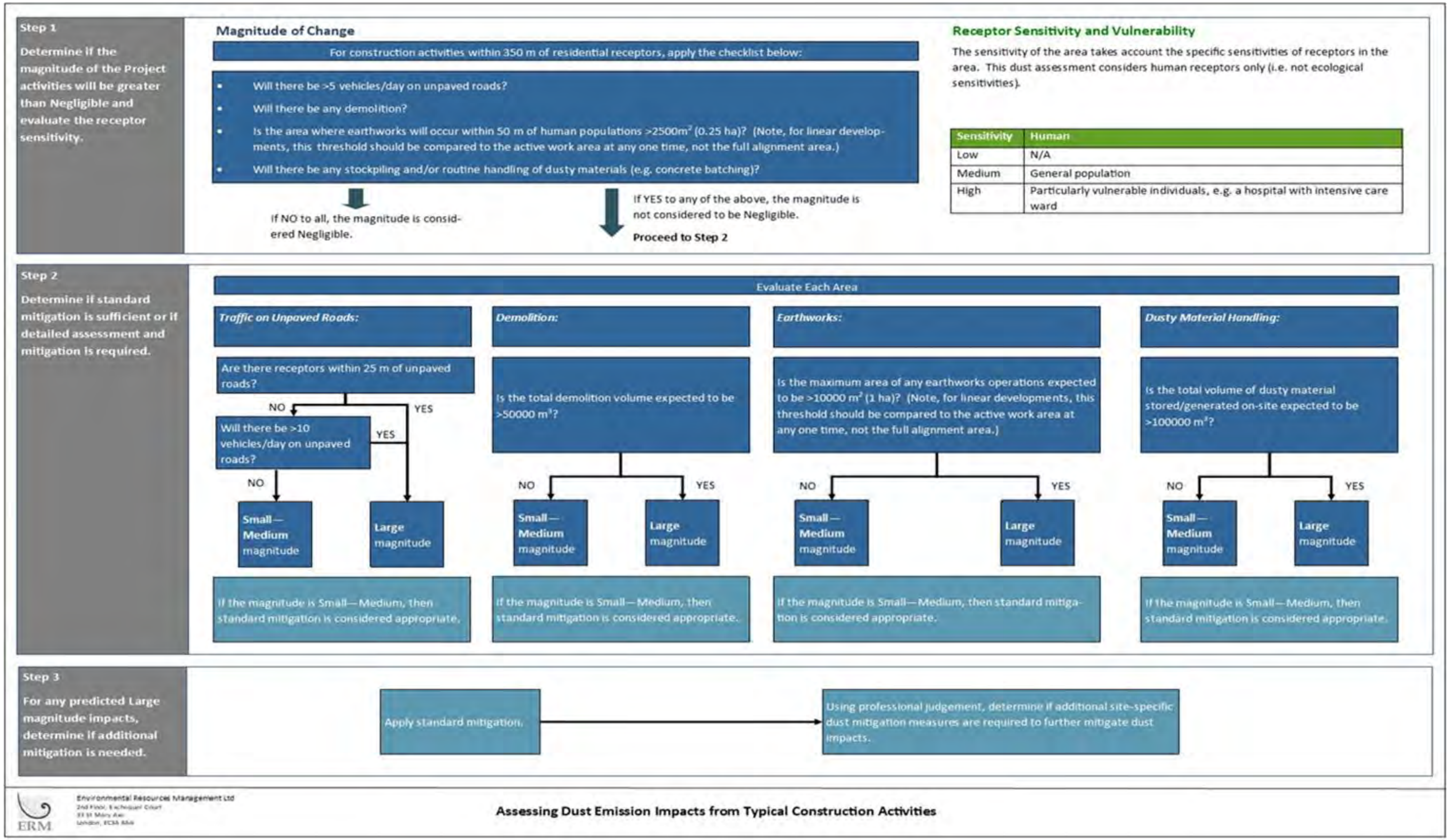


Figure 5.3 Traffic Infographic for Air Quality Assessments

Operational Impacts

For this ESIA, ERM used the air dispersion modelling software called AERMOD, which is a is a steady-state plume dispersion model for simulating transport and dispersion from point, area, or volume sources based on an up-to-date characterization of the atmospheric boundary layer. AERMOD fully incorporates the PRIME building downwash algorithms, advanced depositional parameters, local terrain and urban heat island effects, and advanced meteorological turbulence calculations. Moreover, ERM used the software AERMAT to prepare meteorological data, which is required for modelling. AERMET uses standard meteorological measurements and surface parameters representative of the modelling domain to compute boundary layer parameters.

The assumptions and parameters used when undertaking air dispersion modelling are provided in Table 5.6. The emissions data for Train 3 is based upon emissions monitoring undertaken on Train 1 and 2, noting that the processes are identical. The emission monitoring data are within IFC emission limits. Details of the emissions monitoring undertaken on train 1 and 2 and used to inform the Train 3 emissions are provided in Appendix D.

Table 5.6 Air Quality Model Inputs

Parameter	Approach	Notes
Dispersion model	USEPA Aermod 18081	
Number of sources	Project: 3	Refer to Figure 5.4
Model domain	10km x 10km	
Receptor grid resolution	50m within 1,000m 100m 1,000m – 10,000m	Environment Agency for England guidance [23] (cited by WBG) states that the grid resolution is no greater than 1.5 times the stack height
Buildings	Included	
Terrain	Not included	The terrain elevation is not significant, with no peaks in excess of 100m above mean sea level (AMSL) within 5km of the site. There are no sustained gradients of 1:10 or greater in the vicinity of the Project and therefore terrain was not included in the model.
Albedo	0.14 – 1.00	
Bowen Ratio	9.82 – 9.96	
Surface Roughness	0.80 – 0.80	
Meteorological data	Weather Research and Forecasting (WRF) data for Project site, sourced from Lakes Environmental 2018 to 2022	5 years hour-sequential data.
NO_x to NO_2 conversion ratio	Short-term concentrations: 35% Long-term concentrations: 70%	Environment Agency guidance.

Parameter	Unit	Pack Boiler Stack	Reformer Stack	Urea Granulator
Stack height actual	m	40	34.5	55

[23] Environment Agency (2012) Dispersion Modelling Frequently Asked Questions

Parameter	Unit	Pack Boiler Stack	Reformer Stack	Urea Granulator
Flue diameter	m	2.2	3.65	5
Emission velocity	m/s	12.1	11.0	17.1
Volume flow rate (nominal)	Nm^3/s	39.5	65.3	307
Volume flow rate (nominal)	Am^3/s	46	115	336
Emission temperature (actual)	K	403	406	329
NO_x (emission limit)	mg/Nm^3	300	300	
NH_3 (emission limit)	mg/Nm^3			50
PM_{10} (emission limit)	mg/Nm^3	50	50	50
NO_x (modelled emission)	mg/Nm^3	98.9	85.8	
NH_3 (modelled emission)	mg/Nm^3			47.1
PM_{10} (modelled emission)	mg/Nm^3	2.3	2.4	15.8
NO_x (modelled emission)	g/s	3.82	5.60	0
NH_3 (modelled emission)	g/s	0	0	14.5
PM_{10} (modelled emission)	g/s	0.0889	0.157	4.86

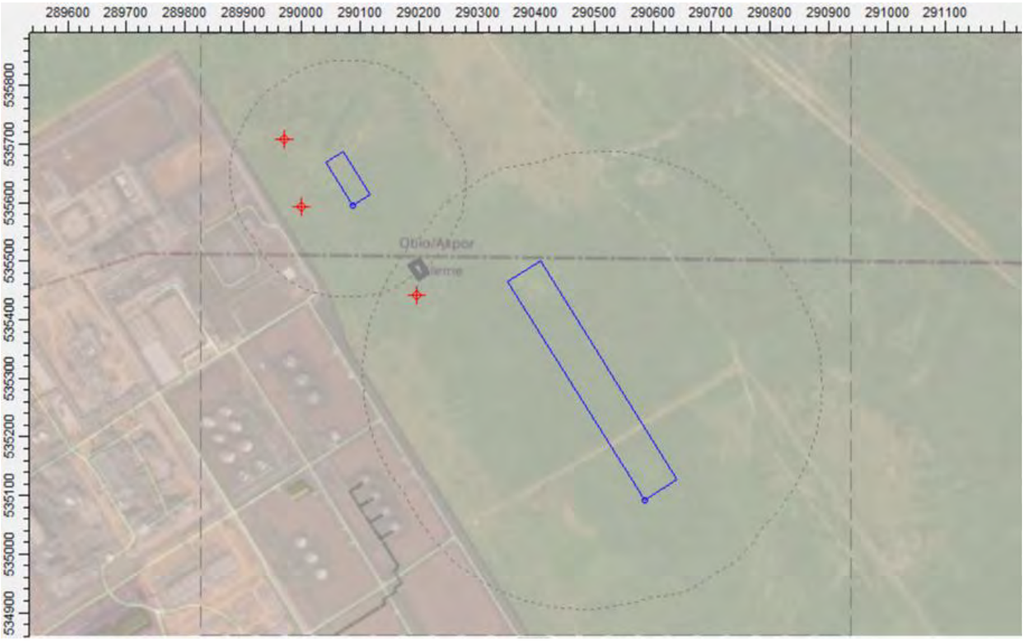


Figure 5.4 Modelling Points

5.5.5 Noise Impact Assessment

Many numerical noise standards are noise source-specific (e.g., industrial noise is different from aircraft noise), some refer to baseline levels (i.e., allowable increases above baseline), and there can be a number of other factors that are relevant to determining Impact Significance.

Rather than applying a two-dimensional matrix for noise impact significance, the process for noise instead considers the type of receptor, draws on relevant standards or guidance to determine impact magnitude, and then considers other factors to determine significance.

5.5.5.1 Project Noise Criteria – Construction Phase

To evaluate the impact of temporary construction activities it is necessary to establish criteria above which significant adverse effects are likely be experienced. International best practice has been followed and thresholds above which a significant construction noise impact is considered to occur have been based on Nigerian criteria for construction (refer to Chapter 2).

When assessing the significance of a noise impact, the process is slightly different to most other topics in this ESIA. The significance of an impact is derived from assessing the magnitude of the impact, but it also takes into consideration other factors like the duration of that specific construction activity, how well the infrastructure associated with the Noise Sensitive Receptors (NSR) can attenuate noise, etc.

Moreover, the sensitivity of the receptor is also considered in the assessment of impact magnitude. For example, NSRs sensitive to daytime noise are only assessed on the criteria associated with daytime activities, while those NSRs sensitive during the night-time are assessed using the criteria that consider the impact of noise on sleep disturbance.

For Project activities during the construction phase to create a significant noise impact, the noise generated must be above the noise impact threshold levels, as summarised in Table 5-7.

Table 5-7 Project Noise Criteria for Construction Phase

Receptor	Maximum noise level permitted L_{Aeq} dB(A)	
	Day time	Night-time
Hospitals, schools institutions of higher learning, homes for the disabled, etc.	**60**	50
Buildings other than those prescribed above	**75**	65

Construction activities will take place only during the day time, therefore the assessment of construction noise is based only on the daytime noise criteria (i.e. – those included in **bold** in Table 5-7).

The Project noise criteria used to assess the magnitude and significance of construction noise effects are included in **Table 5-8**.

Table 5-8 Magnitude and Significance of Construction Noise Effects

Exceedance of criteria, dBA	Magnitude of predicted impact	Other relevant factors	Resulting Significance of effect
5 or more below the criteria	Negligible	Factors which may influence significance of effects, e.g. duration of construction activity	Negligible
> 5 below, up to the criteria	Small		Minor
Up to 5 dB above the criteria	Medium		Moderate
> 5 above the criteria	Large		Major

The classification of significance refers to Negligible, Minor, Moderate and Major. Impacts rated as Moderate or Major should be mitigated where practicable, feasible and reasonable with proportionately more emphasis on the Major items. Mitigation may not fully eliminate an impact, but would be expected to reduce its severity.

5.5.5.2 Project Nosie Criteria – Operational Phase

For Project activities during the operational phase to create a significant noise impact, the noise generated must be above the noise impact threshold levels, as summarised in **Table 5-9** and **Table 5-10**.

Table 5-9 Project Noise Criteria for Operational Phase at Receptors

Receptor	One Hour L_{Aeq} (dB(A))	
	Daytime (06:01 – 22:00)	Night (22:01 – 06:00)
Residential; institutional; educational	55	45

The Project noise criteria used to assess the magnitude and significance of operational noise effects are included in **Table 5-10**. Existing noise baseline data are above the IFC absolute criteria for day and night time, and therefore the assessment for operational noise is based on the absolute IFC criteria for day and night time.

Table 5-10 Magnitude and Significance of Operational Noise Effects

Exceedance of criteria, dBA	Magnitude of predicted impact	Other relevant factors	Resulting Significance of effect
> 5 below, up to the criteria	Negligible	Factors which may influence significance of effects, e.g., how well NSR infrastructure can attenuate noise	Negligible
Up to 5 dB above the criteria	Small		Minor
> 5 to 10 dB above the criteria	Medium		Moderate
> 10 dB above the criteria	Large		Major

5.5.5.3 Assessment of Potential Nosie Impacts (Modelling)

ERM conducted Project specific noise modelling scenarios for both the construction and operational phases of the Project. These models were used to estimate Project induced noise levels at nearby NSRs due to construction and operation of IEFCL Train 3 Project. Predictor V2022.11 (by SoftNoise) noise modelling software package has been utilised to calculate noise emissions from the Project using *ISO 9613-2:1996 (ISO9613:2) - Acoustics* - Attenuation of Sound during Propagation Outdoors - Part 2: General Method of Calculation noise propagation algorithms (international method for general purpose, 1/1 octaves).

The Predictor software package allows topographic details to be combined with ground regions, water, foliage, significant building structures etc. and receptor locations, to create a detailed and accurate representation of the site and surrounding area. The noise model allowed for the quantification of noise levels from multiple sources, based on the sound characteristics (overall level, frequency data etc.)

emitted from each source to predict the contributed noise levels the Project would have at the nearest potentially affected receivers for various operating scenarios.

The inputs and assumptions used in the predictive noise modelling are outlined below:

- Ground factor of 0.5 was applied for the study area (0 is acoustically hard or reflective, 1.0 is soft);
- Temperature 20˚C; and
- Relative Humidity of 60%.

All noise levels were predicted at a height of 1.5m, are presented in decibels, dB(A) and rounded to the nearest whole integer or decimal place where necessary.

All Sound Pressure Levels (LP) values are expressed as dB(A) re: 2 x 10^{-5} Pascals (Pa) and all Sound Power Level (LW) values are expressed as dB(A) re: 10 $^{-12}$ Watts (W).

5.5.5.4 Modelling Assumptions

This Section details the assumptions that have been incorporated into the construction and operational phase noise models

For the Construction phase modelling:

- Construction activity will take place during day time for approximately 32 months;
- The worst scenario chosen was based on the number of equipment and its sound power level (SWL) especially for the heavy equipment;
- Construction activity of earthworks and site clearance has been assumed to have the greatest noise emissions; and
- The noise sources have been modelled as a source area on the footprint of the operational plant.

For each item of equipment, a SWL value has been determined for the purposes of noise modelling. The determination of the source noise level is based on the type and maximum number of items, and is show in **Table 5-11**. Sound power levels have been derived by the BS 5228 database.

Table 5-11 Earthworks Construction Equipment

Equipment	Quantity	BS5228 Reference	Sound Power Level, dB(A)	Sum Sound Power Level, dB(A)
Air compressor (upper 100 cfm)	8	D.7.9	102	111
Generator (heavy)	2	D.7.48	98	101
Man lift, straight	16	C.4.38	113	125
Water truck	3	D.11.52	117	122
Concrete pump car	3	D.6.16	109	114
Dump truck	11	D.3.60	110	120
Excavator	16	D.8.15	103	115
Mixer truck	6	D.6.5	102	110
Motor grader	2	D.3.75	112	115
Self-load mixer	1	C.4.20	108	108
Wheel loader	7	D.3.3	102	110

Equipment	Quantity	BS5228 Reference	Sound Power Level, dB(A)	Sum Sound Power Level, dB(A)
Crawler crane	21	C.4.50	99	112
Hydraulic crane (rt)	14	C.4.43	98	109
Forklift	10	D.7.94	116	126
Forklift, telescopic	1	C.2.35	99	99
Vibratory roller	2	D.3.116	106	109
Batch plant	1	D.6.10	106	106

ERM based on data from the client, March 2023

The overall sound power level of the construction activities is estimated to be 131 dB(A).

For Operational phase modelling:

- Plant will be operating 24 hours per day, seven days per week;
- Equipment located outdoors has been modelled as point sources;
- Only Ammonia equipment located indoors has been modelled as emitting facades and roof;
- A reduction index of 15 dB has been assumed for all walls and roofs as a conservative approach; and
- The noise calculations assume that all operational equipment is facing directly the facades and the roof of the building, representing a worst-case scenario, as it does not take into account the noise reduction due to other rooms between the operational equipment and the emitting facades, nor the ceiling between the operations equipment and emitting roofs.

Noise sources related to the operation are presented **Table 5-12**, **Table 5-13** and **Table 5-14**.

Table 5-12 Ammonia Plant Noise Sources

ID	Description source	Quantity	Sound Pressure Level at 1m, dB(A)	Location
A-101-J	Air Compressor	1	85	Indoor Comp Building
A-102-J F	Feed gas Compressor	1	85	Indoor Comp Building
A-103-J	Synthesis Gas Compressor	1	85	Indoor Comp Building
A-105-J	Ammonia Refrigerant Compressor	1	85	Indoor Comp Building
A-101-JT	Steam Turbine for 101-J (101-J package)	1	85	Indoor Comp Building
A-103-JT	Turbine for 103-J (103-J package)	1	85	Indoor Comp Building
A-105-JT	Turbine for 105-J (105-J package)	1	85	Indoor Comp Building
A-107-JAHT	Hydraulic Turbine for 107-JA	1	85	Outdoor
A-104-JA/JB/JC	HP BFW Pumps	2	85	Outdoor
A-107-JA,JB,JC	Semi-Lean Solution Pump	2	85	Outdoor

ID	Description source	Quantity	Sound Pressure Level at 1m, dB(A)	Location
A-108-J,JA	Lean Solution Pump	1	85	Outdoor

ERM based on data from the client, March 2023

Table 5-13 Urea Plant Noise Sources

ID	Description source	Quantity	Sound Pressure Level at 1m, dB(A)	Location
U-GB-101	CO2 Compressor	1	85	Indoor Comp Building*
U-GB701	N2 Compressor	1	85	Outdoor
U-GT-101	Turbine for CO2 Compressor	1	85	Indoor Comp Building*
U-GA101A, B	Ammonia Feed Pump	1	85	Outdoor
U-GA102A, B	Carbamate Feed Pump	1	85	Outdoor
U-GB604	Dust Collection Blower	1	85	Indoor Granulation Building*
*Has been modelled as outdoors				

ERM based on data from the client, March 2023

Table 5-14 Plant Periphery Noise Sources

ID	Description source	Quantity	Sound Pressure Level at 1m, dB(A)	Location
B-GA 1301A,B	BFW Pump for Package Boiler	1	85	Outdoor
C-GA 6001A,B,C	Cooling Water Pump for Ammonia	2	85	Outdoor
W-GB-1001A,B	Mixing Blower (In Polisher Unit)	1	85	Outdoor

ERM based on data from the client, March 2023

The predicted noise levels for during the construction and operational phases were compared against the Project noise criteria referenced in Section 5.5.5.1 and Section 5.5.5.2 respectively.

5.5.6 Climate Change Risk Assessment

5.5.6.1 Aim and Objectives

The aim of the Climate Change Risk Assessment (CCRA) is to assess the potential impact of climate change on the Project. This high-level CCRA considers the potential impact climate events may have on the Project during its construction and operational phases.

The objectives of the CCRA are to:

- Review the potential existing extreme weather that may affect the Project;

- Undertake a high-level assessment of the way in which these physical hazards may become more intense and/or frequent as a result of climate change; and
- Identify the high-level climate-related risks and opportunities facing the Project over the construction and operational periods.

5.5.6.2 Context

Climate change, and the associated political and social response, is already presenting material risks and opportunities to business and industrial sectors. These risks and opportunities have grown in prominence over the last five to ten years and are expected to increase significantly in scale and coverage in the next decade.

The physical impacts of climate change pose a threat to business operations and may have financial consequences, through impacts of extreme weather events such as storms, floods, and droughts. The effect of these changes could result in business interruption through damage to physical assets. Understanding the nature of these risks will support sites in increasing their resilience against climate change.

5.5.6.3 Climate Scenarios

Scenarios are plausible descriptions of how the future may develop, based on a coherent and set of assumptions about driving forces, e.g., rate of greenhouse gas emissions or changes in land use. They are not predictions nor forecasts. Scenario analysis is a useful approach for assessing the exposure of sites to climate-related risks and opportunities in an uncertain future world.

ERM utilises the latest climate projections data available from world-leading scientific organisations when assessing the impact of climate change on physical climate hazards for any given location. The Intergovernmental Panel on Climate Change (IPCC) has set out a series of Shared Socio-economic Pathways (SSPs) that vary on the basis of projected greenhouse gas (GHG) emissions over the next century. With increasing projected GHG emissions, there is the potential for a change in the climatic conditions at any given area, e.g., temperature and/or precipitation changes. This can vary depending on the concentration of projected emissions associated with each SSP and chosen timeframe. SSPs are used in this assessment to indicate the impact of varying degrees of warming on the risk associated with each climate hazard. As is standard practice when undertaking climate risk assessments, scenarios are selected on the basis of their appropriateness for any given assessment being undertaken. The SSPs selected for this assessment are:

- **SSP1-2.6**: lower emissions outcome most closely aligned with the Paris Agreement.
- **SSP5-8.5**, which describes a ‘business-as-usual’ scenario, where global emissions continue to rise unabated. Implied warming may increase by 4.4°C by end of 21st century, with many physical climate risks (e.g., cyclones) increasing in frequency and severity.

Where such uncertainties are material to ESIA findings, they are clearly stated and are approached conservatively (‘the precautionary approach’), to identify the broadest range of likely residual impacts.

5.5.6.4 Time Horizons

The time horizons used within this assessment have been selected to best align with the expected schedule of the construction and operation phases (**Table 5-15**). These time horizons reflect the technical view of the assessment team in terms of identifying periods that provide best insight to climate-related trends. Climate data is available for specific future time horizons – typically in 5- or 10-year intervals. For physical climate risk, it is recommended to review trends over generally longer timeframes as it provides a clearer indication of possible emerging issues. The 2030-time horizon is therefore provided as an insight to the possible climate trends for the construction stage and beginnings of the operation stage, whereas 2050 are used to provide insight to the climate trends towards the later stages of the operational phase.

Table 5-15 Time Horizons included within the CCRA

Future Time Horizons Included within this Assessment	Justification
2030	Provides insight to the possible climate trends for the construction period and start of operation phase.
2050	Provides insight as to the climate trends for the operation phase

5.5.6.5 Data and Sources

The projections data collated by ERM for use within this assessment originates from a range of providers, determined to be the best available for demonstrating the change in the hazards included within the assessment.

The main data source is the IPCC, the UN's leading body for assessing the science related to climate change. It releases Assessment Reports (AR), which provide information about the state of scientific, technical, and socio-economic knowledge on climate change, its impacts and future risks, and options for trying to reduce the rate at which climate change is taking place. With each new AR comes a new round of climate models and data developed by the IPCC and Coupled Model Intercomparison Project (CMIP). The last AR (AR6) was published in 2021, marking the latest round of finalized, fully reviewed, and fully published climate data (CMIP6) by the IPCC and CMIP.

5.5.6.6 Approach

The CCRA is conducted through two key steps, namely:

- High-level Physical Screening;
- High-Level Assessing of the Climate Risks of the Projects.

High-Level Physical Screening

Step 1 involves a high-level screening assessment to review and document the anticipated climate change impacts within the Project region, including:

- Existing and projected climate, weather extremes and any resultant climate-related risks.
- How climate change is likely to amplify or diminish these climate-related risks.

There are a wide range of climate hazards that have the potential to impact any given Project. ERM has undertaken a high-level scenario-based screening exercise, which involves reviewing the exposure of assets included as a part of the Projects against a range of climate hazards. ERM primarily relied on data provided by its proprietary Climate Impact Platform by ERM and supplemented that data with its propriety Climate Data Tool (CDT) data where necessary and appropriate to produce baseline (aka. Current) and future climate data associated with the Project. The predominant source of data has been global, reputable sources such as NASA, World Bank and the IPCC.

High-Level Risk Review

Based on the results of the high level physical screening, this step involves conducting a review of the climate data, which has been collected for each hazard included within this assessment. This includes the analysis of baseline and future projected trends for each climate hazard included a review of the potential materiality of any risk present under baseline conditions, and how this risk could potentially change in the future according to any key trends identified within the climate data. Each climate hazard will be assessed in relation to the Project using a mixture of climate data and some qualitative research, which is sourced from industry-leading academic and governmental sources.

ERM collects a series of data variables for each climate hazard included within this assessment. This climate data is collected primarily using Climate Impact Platform by ERM and Global Climate Database (GCD) and is supplemented by any climate data provided by the client as well as the best available online sources of data.

Once the climate data is collected, the trends associated with each variable are assessed for each climate hazard. Following this, ERM undertakes a high-level review of the potential risks posed to the Project in relation to each climate hazard. This section provides an overview of any impacts (associated with specific hazards), which are identified as being potentially material to specific risk areas associated with the Project (called Site Receptors).

Climate data is collected and discussed in relation to two time periods (2030 and 2050) - 'Risk Materiality Categories' (refer to **Table 5-16**) are assigned to all of these two time-periods, representing the start (baseline & construction) and its operations and possible end of operations (till 2050). These two time periods have been selected with an aim to identify the potential change in the level risk posed to the Project by the end of operations, in comparison to the baseline level of risk.

Table 5-16 Risk Materiality Categories and associated Definitions

Risk Materiality Category		Definition
Unlikely material		Impacts with this category (such as those related to operational, financial, or other types of impacts) are unlikely to be material. This means that, for example, (a) operational impacts could be expected to be short term, impacting a limited proportion of the overall asset and its operations, or (b) financial impacts would be expected to be minimal relative to the Project's overall revenue and/or costs.
Likely material	**Low to moderate**	Impacts with this category (such as those related to operational, financial, or other types of impacts) are likely to be of low-moderate materiality. This means that, for example, (a) operational impacts could be expected to be short to medium term, impacting a low to moderate proportion of the overall asset and its operations, or (b) financial impacts would be expected to be small to moderate relative to the Project's overall revenue and/or costs.
	High	Impacts associated with this category (such as those related to operational, financial, or other types of impacts) are likely to be of high materiality. This means that, for example, (a) operational impacts could be expected to be medium to long term, impacting a low to moderate proportion of the overall asset and its operations, or (b) financial impacts would be expected to be moderate to high relative to the Project's overall revenue and/or costs.

5.5.6.7 Climate Impact Platform by ERM

ERM's proprietary Climate Impact Platform by ERM provides an indication of climate trends at site locations. It provides data for key climate physical hazards, such as extreme temperatures, flooding, storms, precipitation-induced landslides, wildfires, and water stress and drought. The platform uses the best available global data sources to provide baseline and future projected results for each climate hazard. The climate data includes the latest round of IPCC and CMIP climate data (CMIP6), amongst other industry-leading sources of data. **Figure 5-5** below outlines the methodology followed by the Platform to complete a screening of physical risks relevant to a single asset or a scope of assets. The goal of a risk screening is to identify assets that have exposure to one or more climate Hazards, and to gain insight on the scale of the magnitude of that exposure.

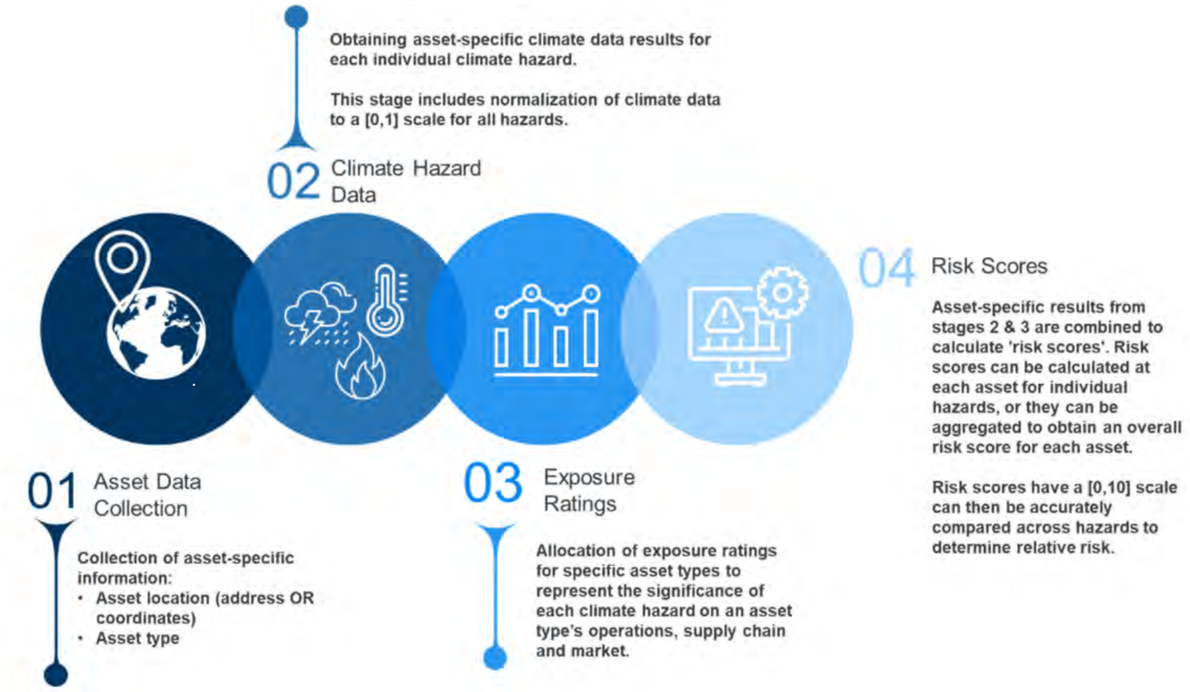


Figure 5-5 Climate Impact Platform

5.5.6.8 Assumptions and Limitations

The CCRA presented in this ESIA provides a high-level review of the possible risks posed to the Project. As a result, this CCRA aims to identify risks and aspects of the Project's design that ERM believes should be assessed further as the Project and its operations progress. There are limitations and assumptions that accompany this type of approach, which should be recognised when interpreting the results of this assessment:

- This is a fully desk-based assessment, meaning that ERM's team has not conducted any on-site visits associated with this physical CCRA, and thus assessments of the exposure of each asset are based upon information provided by the Client and ERM's research.
- ERM has not sought to verify the accuracy of any information provided by the Client (for example design specifications, observational data provided etc.).
- This assessment uses projected outputs from Global Climate Models (GCMs). This means that GCM data has not been regionally downscaled and validated for the region where the Project is located (no downscaling specific to Nigeria has been undertaken).
- According to IEFCL, the Project site can be considered as UCB Zone 0, which means that there is no Seismic activity in the Project Area. As such, this ESIA does not include an assessment of the potential impact of seismic activity (e.g., earthquakes) on the Project and its operations as these events are associated with, and induced by, seismic activity and therefore not considered a physical climate change event/hazard.
- The Project team has mainly used existing reports and existing Project design reports to gather baseline and future climate data of the Project area. For future climate data, the team uses global data sources from Climate Impact Platform and other sources.
- ERM has made assumptions and limitations where there may be data gaps, e.g., related to the site itself.

6. STAKEHOLDER ENGAGEMENT

6.1 Introduction

This Chapter presents a summary of the stakeholder engagement activities planned as part of the Project ESIA process. It also serves as a summary of a more detailed Stakeholder Engagement Plan (SEP), which presents the engagement approach and identifies stakeholders and the mechanisms through which stakeholders have been engaged. The complete SEP is included in Appendix B.

The engagement process has been designed to meet both Nigerian ESIA regulations for public participation and international requirements for engagement as outlined in the IFC PSs. More specifically, IFC PS1 requirements place an emphasis on broad engagement and disclosure of findings to stakeholders and require that a SEP be developed.

The SEP has been developed for the life of the proposed Project and provides an implementation framework for post-ESIA engagement (i.e., from the remainder of the feasibility and permitting phases, through construction, operation, and decommissioning).

Stakeholder engagement is an inclusive and culturally appropriate process, which involves sharing information and knowledge, seeking to understand the concerns of others and building relationships based on collaboration. It assists stakeholders in understanding Project risks, impacts and opportunities to avoid, minimise or mitigate negative outcomes, and maximise positive outcomes.

6.2 Objectives and Principles of Stakeholder Engagement

The key objectives of stakeholder engagement for this Project are to:

- To understand the interests, influence, and concerns of various Project stakeholders.
- To ensure effective, transparent, and timely communication between the Project and its stakeholders, to engender an environment of trust and mutual respect.
- To engage stakeholders on their concerns regarding the Project, and appropriately address these through dialogue and corrective actions.
- To establish effective means of communication to disseminate information from the Project to stakeholders.
- To design stakeholder engagement mechanisms and standards that respect local traditions and cultural norms.
- To effectively manage the expectations of stakeholders regarding socio-economic benefits derived from the Project.
- Establish the appropriate management mechanisms and identify necessary capacity building and training requirements for the effective implementation of the SEP.

The key principles guiding the Project's approach to stakeholder engagement are as follows:

- **Transparency**: to be open and transparent with stakeholders.
- **Accountability**: to be willing to accept responsibility as a corporate citizen and to account for impacts associated with the Project activities.
- **Trust**: to have a relationship with stakeholders that is based on mutual commitment to acting in good faith.
- **Mutual Respect**: to respect stakeholders' interests, opinions, and aspirations.
- **Collaboration**: to work cooperatively with stakeholders to find solutions that meet common interests.
- **Responsiveness**: to coherently respond in good time to stakeholders.

- **Proactiveness**: to act in anticipation of the need for information or potential issues.
- **Fairness**: to engage with stakeholders such that they feel they are treated fairly, and their issues and concerns are afforded fair consideration.
- **Accessibility**: to be within reach of stakeholders so that they feel heard and to provide meaningful information as needed.
- **Inclusivity**: to proactively anticipate, identify and include all relevant stakeholders.

These principles have informed the Project's approach to stakeholder engagement.

6.3 Identification of Stakeholders

A stakeholder is defined as any individual or group who is potentially affected by the Project, or who has an interest in the Project and its potential impacts.

Different issues are likely to concern different stakeholders, so stakeholders have been grouped based on their connections to the Project. Given that the Project is an expansion of an existing operational site, the identification of stakeholders for Train 3 has leveraged and built on the stakeholders engaged for Trains 1 and 2. The stakeholders for the Project have therefore been extracted from the existing stakeholder database for Trains 1 and 2 and are presented in Table 6-1 below. It should be noted that the stakeholder identification, mapping, and engagement will be a continuous process throughout the Project lifecycle.

It is noted that no new stakeholders have been identified during the stakeholder engagement for Train 3.

Table 6-1 Stakeholder Identification[24]

Stakeholder Category	Stakeholder Groups	Stakeholders	Connection to Project
Government	• Federal Ministry of Environment • Rivers State Ministry of Environment • Rivers State Ministry of Chieftaincy and Community Affairs • Eleme Local Government	• Director, Environment Assessment Department, Federal Ministry of Environment • Director, Pollution Control & Environment Health Department, Federal Ministry of Environment • Rivers State Commissioner of Ministry of Environment • Director, Pollution Control Department, Rivers State Ministry of Environment • Director, Environment Assessment Department, Rivers State Ministry of Environment • DG, National Environmental Standards and Regulations Enforcement Agency (NESREA) • Director, Planning & Policy analysis, National Environmental Standards and Regulations Enforcement Agency (NESREA) • Rivers State Commissioner of Chieftaincy & Community Affairs • Supervisor to Environment, Eleme Local Government	Environmental Regulatory bodies are of primary importance in terms of establishing policy, granting permits or other approvals for the Project, and monitoring and enforcing compliance with Nigerian law throughout all stages of the Project life cycle. Regional and Local Governments may input into the permitting process and may have a role in monitoring the implementation of Project commitments included in the ESMMP.
Traditional Rulers and Community Leaders	• Eleme Council of Traditional Rulers • Clan Heads	• King of Eleme • Emere Nchia	Local community leaders as representatives of their local community.

[24] A full database of all stakeholders should be maintained separately from the SEP and should be updated as new stakeholders are identified, or at least on an annual basis.

Stakeholder Category	Stakeholder Groups	Stakeholders	Connection to Project
	• Community Development Committees	• Clan Heads of following six (6) Host Communities: Aleto Okerewa Agbonchia Njuru Akpajo Elelenwo (Wakoahu Family)	Traditional rulers play vital role in community development, civil administration, and socio-economic wellbeing in their domain by interfacing with the government. Traditional rulers are custodian of cultures, customary territorial rights, and privileges of people in their communities. Traditional rulers preside over civil and customary grievance / dispute resolution processes. Traditional rulers represent and protect the socio – economic interest of the communities before government and external agencies. Traditional rulers participate in Public Forum discussions and Technical Panel review as part of ESIA. Traditional rulers' interface with IEFCL for MOU and its implementation. Management of communication in the communities with respect to project.
Directly Impacted Communities	• Communities originally impacted with the acquisition of land to construct the initial petrochemicals facility.	• Project Advisory Committee (PAC) • Six (6) host communities as given below: – Aleto – Okerewa – Agbonchia – Njuru – Akpajo – Elelenwo (Wakoahu Family)	Originally the land was acquired by Rivers State Government in the year 1984. Government has paid compensation to all impacted communities. Since then, communities are not carrying out any socio-economic activities in the said 250 hectares of land. However, there will be social, environmental, and economic impacts connected to project construction and operation of manufacturing facility. PAC is entrusted with the responsibility to interface with IEFCL on behalf of communities for the following: • Participation in ESIA Public forums to discuss positive / negative impacts of the project and the mitigation measures. • Participation in ESIA Technical Panel review to observe the evaluation process of mitigation measures set out to address the adverse impacts be social / economic / environmental impacts by experts and regulatory authorities. • Manage communications in the communities regarding the outcome of public forums and technical panel review. • Memorandum of Understanding (MOU) • Monitoring implementation of MOU for the following: a. Community Development Projects

Stakeholder Category	Stakeholder Groups	Stakeholders	Connection to Project
			b. Contracts and supplies c. Employment during construction and operation phase. d. Scholarship programmes for youth studying in universities. e. Micro Grant for women for micro business f. Skill development programme for young men and women.
Vulnerable Groups	• Women • Youth	• Eleme Women Leaders • Eleme Youth Council • Host Community Youth Forum	Women have representation in PAC and Host Community Youth Forum as representative body participate in the discussion and decision-making process of ESIA public forum, technical panel review, adverse impacts / mitigation measures, MOU, community development projects, employment, skill acquisition programme, subcontracts & supplies and grievance management process during ESIA / construction / operation phase of the project. Women leaders exclusively participate in discussion and decision-making process of Micro Grant Scheme. Host Community Youth Forum exclusively participates for discussion and implementation MOU for the Youth. Eleme Youth Council exclusive participates for extension of benefits such as office upkeep, subcontracts, surveillance contracts, employment etc.
Civil Society and Interest Groups	• Community-Based Organisations / Association • Non-Governmental Organisations (NGOs)	• Eleme Fishing Association • Eleme Hunters Association • Eleme Graduate Forum	Indigenes have advanced to modern methods of fish farming, poultry, piggery etc. These groups participate in skill development programmes and receive financial assistance under Youth Entrepreneurship Scheme in collaboration with PAC. Eleme Graduate Forum is a Non-Government Organisation (NGO) which in general represent the interest of members for employment
Employment and Business Associations	• Workers Unions • Employment Forums • Business Forums	• Welders and Fitters Association • Indigenous Suppliers Forum	Elected representatives of unions participate in collective bargaining agreements for betterment of condition of service, discussion on betterment of working condition, grievance management process, disciplinary management process, conflict and dispute resolution process during the construction and operation phase of the project.

Stakeholder Category	Stakeholder Groups	Stakeholders	Connection to Project
	• Business Associations		Elected / nominated members of Indigenous Suppliers represent their members for access to information with regards to contracts, supplies, grievance management dispute / conflict resolutions.
Other stakeholders	• Academia • Media	• Professors / teachers • Radio and Print media	Linkage between theory and practical thru industrial training, new skill development and recruitment and funding for research and development. Information from source via direct meeting or site visit, coverage of CSR events via invitation to events

6.4 Approach to Stakeholder Engagement

It is not practical, and not necessary, to engage with all stakeholder groups with the same level of intensity all of the time. Analysing and prioritising stakeholders is important to determine appropriate engagement methods. Given the dynamic nature of stakeholder and community contexts, stakeholder analysis will be revisited throughout the Project lifecycle.

Given that the Train 3 Project is in the same locality, and designed in the same manner, as Train 2, ERM has adopted elements of the stakeholder analysis previously conducted for the construction and operation of Train 2 in 2021. Stakeholder engagement conducted thus far for the ESIA process of Train 3 have also been analysed to update previous analysis. The broad groups of stakeholders identified in Table 6-1 have been further analysed below in terms of potential influence on Project activities and level of support for the Project (Table 6-2). An engagement approach is also suggested for each category of stakeholder (Table 6-3).

Table 6-2 Impact-Support Matrix

Stakeholder Cluster	Influence Level	Support Level	Engagement Approach
Environmental and Permitting Authorities	**High**	**High**	Work Together
Regional Government	**High**	**High**	Work Together
Local Government	**High**	**Medium**	Keep Engaged
Traditional Leaders	**High**	**Medium**	Keep Engaged
Community Leaders	**High**	**Medium**	Keep Engaged
Directly Affected Communities	**Medium**	**Medium**	Keep Engaged
Women	**Low**	**Medium**	Keep Informed
Youth	**Medium**	**Medium**	Keep Informed
Existing Natural Resource Users	**Low**	**Low**	Keep Informed
Civil Society Groups	**Low**	**Medium**	Keep Informed

Table 6-3 Summary of Potential Engagement Approaches

Engagement Approach	Process
Work Together	• Share information. • Consult on key Project issues. • Collaborate on Project delivery.
Keep Engaged	• Share information. • Consult on key Project issues.
Keep Informed	• Share information.
Show Consideration	• Share information. • Consult on key Project issues.

Priority should be given to stakeholders that are highly influential including those that are both supportive and unsupportive.

Engaging stakeholders who are unsupportive and influential, or those with deep-rooted challenges, requires engagement with pro-active and hands on approach. Effective engagement typically combines approaches - from informing to activities such as consultation or collaboration. In analysing these stakeholders and developing an approach to engagement, consideration has also been given to:

- Level of interest in the Project construction/operation;
- Anticipated impact of the Project on the stakeholder;
- Vulnerability status of the stakeholder; and
- Relationships with high influence stakeholders, including their ability to influence these stakeholders.

Stakeholders that have low influence but are unsupportive should be monitored closely, with a particular focus on their ability to influence, and their relationships with, other stakeholders. Less intensive forms of engagement such as monitoring or disseminating information will be adequate for engaging less influential, supportive stakeholders. Individual stakeholders can share a collective voice and access to legal guidance and resources thereby becoming more influential. Considering the outcomes of the stakeholder analysis, the high priority stakeholders for this Project are:

- Environmental and Permitting Authorities;
- Federal government;
- State government
- Local government;
- Traditional leaders; and
- Community leaders.

6.5 Summary of Previous Engagement

As the Project is an extension of an existing operational site, stakeholder engagement by Indorama has been ongoing since 2007. Relational contexts, ways of working, and perceptions of the existing operations will all influence the perceptions of the Project, and should be taken into consideration when implementing the SEP.

In terms of engagements specific to the IEFCL Train 3 Project, Table 6-4 highlights what has taken place to date.

Table 6-4 Summary of Previous Engagements

Date	Stakeholder	Purpose	No. of attendees
14 July 2021	• Environment Assessment Department (EAD) of Federal Ministry of Environment	Discuss proposed IEFCL Train 3 Project and draft Terms of Reference for Institutional Consultation	10
26 July 2021	• Federal Ministry of Environment • Rivers State Ministry of Environment	Site verification required for Project categorization	7
20 August 2021	• Federal Ministry of Environment • Rivers State Ministry of Environment • Eleme Local Government Area • Directly Affected Communities • Traditional Leaders and Community Leaders • Vulnerable Groups • Civil Society and Interest Groups	Scoping workshop for ESIA, Terms of Reference and Scope of Work	89

Date	Stakeholder	Purpose	No. of attendees
10 November 2021	Agbonchia community stakeholders: • The Paramount Ruler of Agbonchia • Community Chairman • Youth President and Executives • Women group • Youth Rep. of Eleme Youth Council • Agbonchia Community Members	Inform participants of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Discuss possible impacts of the Project and obtain community perspectives (expectations, benefits, perceptions etc.).	77
11/12 November 2021	Njuru and Akpakpan community stakeholders: • The Paramount Chief • Community Chairman • Security Guards • Youth President/Leader • Women Leader and women groups	Inform participants of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Discuss possible impacts of the Project and obtain community perspectives (expectations, benefits, perceptions etc.).	100
9 November 2021	Okerewa community stakeholders: • The Paramount Ruler Chief of Okerewa Community • Community Chairman • Youth President and Executives • Women Leader and Executives • Representative of Youths from Eleme Youth Council • Cross section of Okerewa Community Members	Inform participants of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Discuss possible impacts of the project and obtain community perspectives (expectations, benefits, perceptions etc.).	99
8 November 2021	Aleto community stakeholders: • The Paramount Ruler of Aleto Community • Aleto Community Development (CDC) Chairman • Fishermen and Hunters Association • Host Community Youth President • Women Leaders and Executives • Cross section of Aleto Community	Inform participants of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Discuss possible impacts of the Project and obtain community perspectives (expectations, benefits, perceptions etc.).	65
5 November 2021	Akpajo community stakeholders: • The Paramount Ruler of Akpajo • Community Development Committee (CDC) Chairman • Fishermen and Hunters • Host Community Youth President • Women Leader	Inform participants of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Discuss possible impacts of the Project and obtain community perspectives (expectations, benefits, perceptions etc.).	102
15 November 2021	Elelenwo (Wakoahu Family) Stakeholders: • Community Development Committee (CDC) Chairman	Inform participants of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Discuss	94

Date	Stakeholder	Purpose	No. of attendees
	• Host Community Youth President • Women Leader • Cross section of Wakoahu community • Wakoahu Youth Leader and Executive • Wakoahu PAC member	possible impacts of the Project and obtain community perspectives (expectations, benefits, perceptions etc.).	
7 December 2021	Project Advisory Committee (PAC)	Inform the PAC of the proposed Train 3 Project scope; environmental, social, economic and health aspects. Clarify the roles and responsibilities of the PAC with regards to the Project.	21
13 January 2023	FMEnv, RSMEnv, Eleme LGA and King of Eleme Kingdom with Council of Chiefs, Paramount Rulers of respective Communities, Elders, Women and women leaders, Youths, NGOs, Civil societies, Farmers, Traders, Fishers, students etc.	A broader engagement to further educate participants on the proposed Train 3 project scope, environmental, social, economic and health aspects. Possible impacts of the project and community perspective (expectation, benefits, and perception etc.)	121

6.6 Existing Stakeholder Concerns

The following high-level stakeholder concerns have been captured based on engagements conducted thus far for Train 3.

- **Increase in Traffic Volumes:** Further deterioration of already poor roads due to increased traffic volumes.
- **Population Influx:** Increase in migrant workers and jobseekers.
- **Environmental Impacts:** Negative impacts on the natural environment and biodiversity such as groundwater, surface water, and air pollution.
- **Socioeconomic Benefits:** Distribution of employment, procurement, and corporate social investment benefits between communities, effective implementation of MOU and a perceived insufficiency of such interventions given the scale of need in the area
- **Ongoing Engagement:** A perceived lack of sufficient ongoing engagement between Indorama and host communities.

6.7 ESIA Engagement

This phase involves engagement activities related to the completion of the ESIA process, and subsequent disclosure of the ESIA findings. Engagement activities include:

- **Public Involvement in Scoping Workshop** – as per Nigerian environmental regulations, a public hearing may be requested during the scoping phase to adequately determine the Terms of

Reference of the ESIA. This requirement was made known to IEFCL by the FMEnv, and the workshop in question was held on 21 August 2021 with 89 stakeholders.

- **Further Public Participation and Stakeholder Engagement** – where the ESIA process has identified information gaps or further public participation requirements, these must be completed by IEFCL prior to the completion of the ESIA and records and findings should be attached as an addendum to the ESIA document. This should be conducted as per the FMEnv requirements. Stakeholder Engagement was carried out during the ESIA study as shown in Table 6-4.
- **ESIA Disclosure** – following the completion of the ESIA, findings should be disclosed to all stakeholders. In compliance with the EIA Act CAP E12, LFN 2004 and S.I. No. 109, Environment Impact Assessment Procedures and Charges Regulations, 2021, once the ESIA is under review by the FMEnv the ESIA documents may be requested by the FMEnv to be disclosed publicly for 21 working days. Locations to display the documents should include:
  - Eleme Local Government Area offices;
  - Rivers State Ministry of Environment Offices;
  - The Federal Ministry of Environment, Rivers State (Zonal) Office; and
  - The Federal Ministry of Environment Headquarters.
- **ESIA Comment and Objection** – IEFCL must make reasonable opportunity available to stakeholders to comment or object to the ESIA findings. This will be conducted in compliance with EIA Act of 1992 (amended 2004) and will include advertisements in local newspapers and the radio to invite the public to participate in the ESIA review process, where necessary. Where the comments or objections are deemed reasonable and eligible, IEFCL will endeavour to address them through an updated Project design or through further engagement with the objecting stakeholders.

6.8 Post-ESIA Engagement

A summary of post ESIA engagement activities is presented in Table 6-5. For a more detailed overview of post-ESIA engagement please refer to the SEP (Appendix B). It should be noted that the plan for post-ESIA engagement will be updated should the need arise for more intensive engagement with certain stakeholder groups or should there be a substantial change to the Project plan.

Table 6-5 Stakeholder Engagement Phases and Activities

Engagement Phase	Engagement Activities
Pre-Construction	Monitor implementation of subsisting MOU 2023 – 2025
	Quarterly engagement with PAC
	Provide quarterly project updates
	Engagement with employment sub committee
	Engagement with PAC sub committees on employment, community development projects, grievance management, skill acquisition programme, scholarship, micro grant etc.
	Review of grievance and grievance tracking
	Engage local authorities, traditional rulers and community leaders for briefing the completion of ESIA process and commencement of construction phase of the project
Construction Phase	Provide monthly project updates
	Quarterly engagement with PAC
	Monthly engagement with youth
	Monitoring of grievances

Engagement Phase	Engagement Activities
	Engagement with PAC sub committees on employment, community development projects, grievance management, skill acquisition programme, scholarship, micro grant, etc.
Operational Phase	Quarterly engagement with PAC
	Provide broader project updates as required
	Monitoring of grievances
	Engagement with PAC sub committees on employment, community development projects, grievance management, skill acquisition programme, scholarship, micro grant etc
Decommissioning Phase	Announcement of intended decommissioning
	Quarterly engagement with PAC
	Provide broader decommissioning updates as required
	Monitoring of grievances
	Engagement with PAC sub committees on employment, community development projects, grievance management, skill acquisition programme, scholarship, micro grant etc

7. DESCRIPTION OF THE ENVIRONMENT

7.1 Introduction

It is important to gain an understanding of the physical, biological and social attributes of the area in which the IEFCL Train 3 Project is proposed and its surroundings. The description of the baseline environment is essential in that it represents the conditions before the construction of the proposed Project. The description of the baseline environment therefore provides a description of the current or status quo environment against which social and environmental impacts of the proposed IEFCL Train 3 Project are assessed and future changes monitored.

7.2 Study Area and Area of Influence

For the characterisation of the physical, biological and socio-economic baselines and associated impact assessments presented in Chapter 8, the definitions applicable to the Project Area are as follows –

- **Project Area** – defined as the IEFCL Train 3 Project, which will be sited on 80 ha of land within a 250ha portion situated in the Eleme Local Government Area, Rivers State, Nigeria. The Project area borders the existing Indorama Complex on the South and undeveloped land to the east, west and north.
- **Study Area** - the Study Area (or Area of Influence) can be defined as the area likely to be affected by the Project activities during construction, operational and decommissioning phases of the Project. The Study Area includes:
  - The primary Project site and related facilities that IEFCL develops or controls.
  - Additional areas in which aspects of the environment could conceivably experience significant impacts.
  - Areas potentially affected by cumulative impacts resulting from other potential or known developments at the time of the ESIA, further planned phases of the Project or any other existing circumstances.
  - Areas potentially affected by impacts from predictable (but unplanned) developments as a result of the Project (i.e., induced activities), occurring at a later stage or at a different location.

The study specific definitions for Study Area are provided in each aspect investigated (viz. air quality, noise, biodiversity, socio-economic, etc.).

7.3 Baseline Data Acquisition Methods

The information relating to this Chapter has been sourced from infield wet season baseline data commissioned by IEFCL in October 2021 and undertaken by ECSL, an FMEnv accredited Nigerian E&S consultant under the supervision of FMEnv. As mentioned in Chapter 5, as ERM undertook a review and gap analysis of the wet season baseline collected back in October 2021. The gap analysis was undertaken against the requirements of the IFC PSs, with the intention of identifying whether further action is required to address any gaps. The gap analysis identified a range of gaps. Majority of the gaps were addressed through clarification / provision of additional information from IEFCL. However, given the timeframes associated with the overall Project, it was not possible to address certain baseline data gaps as part of the ESIA process. As such, actions to close out such gaps have been included as Project commitments in this ESIA and associated ESMMP and will need to be completed post-ESIA.

Data presented by the wet season baseline assessments have been cross-referenced with publicly available online data where possible.

The Sections included in this Chapter are organised into a description of physical environment (Section 7.4), Biophysical environment (Section 7.5), Socio-economic Environment (including health) (Section 7.6), Cultural Heritage (Section 7.7) and Traffic (Section 7.8).

7.4 Physical Environment

This Section provides the baseline environmental conditions for the physical environment. It covers meteorology and climate, air quality, Greenhouse Gases (GHG) emissions, surface and groundwater, noise, geology, and soils.

7.4.1 Meteorology and Climate

7.4.1.1 Overview of the Climate

Nigeria is characterised by four distinct climate zones: a tropical wet climate in the south, a tropical savannah climate for most of the central regions, and a Sahelian hot and semi-arid climate in the north of the Country. This leads to a gradient of declining precipitation from south to north. Figure 7-1 shows a breakdown of the climatic classification in Nigeria. The Project falls within the 'tropical monsoon climate' classification, highlighted in dark blue representing monsoon climate (Am). Nigeria is broken down into nine diverse ecological zones (extending from an arid north to a tropical south), the Project falls within the south.

The rainfall pattern in the Country varies by region and season. In the south, rainfall is experienced throughout the year with less rainfall between December and March.

Nigeria's mean annual temperature ranges between 17°C to 37°C in the south. During the dry season, Harmattan winds bring dry air from the Sahara Desert to Nigeria, while during the rainy season moist air is brought from the Atlantic Ocean (USAID, 2019).

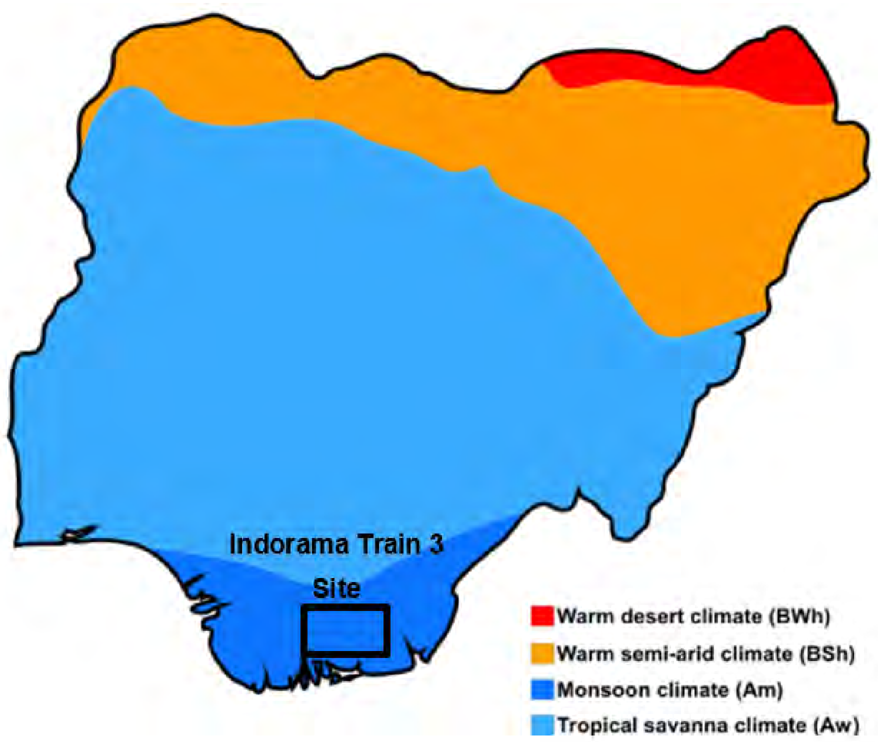


Figure 7-1 Map of Nigeria's Climate Classification

Source: Beck et al., 2018

7.4.1.2 Rainfall Pattern

The Project Area falls within the monsoon climatic zone (Figure 7-1). The annual distribution of rainfall in this climatic zone is characterised by two distinct seasons: wet season that runs from mid-March through to November and a dry season that runs from December through to March. The mean annual rainfall for the Study Area is above 2,300 mm. The highest precipitation is experienced in September at 374.5 mm, while the lowest is experienced in January at 17.2 mm (refer to Figure 7-2).

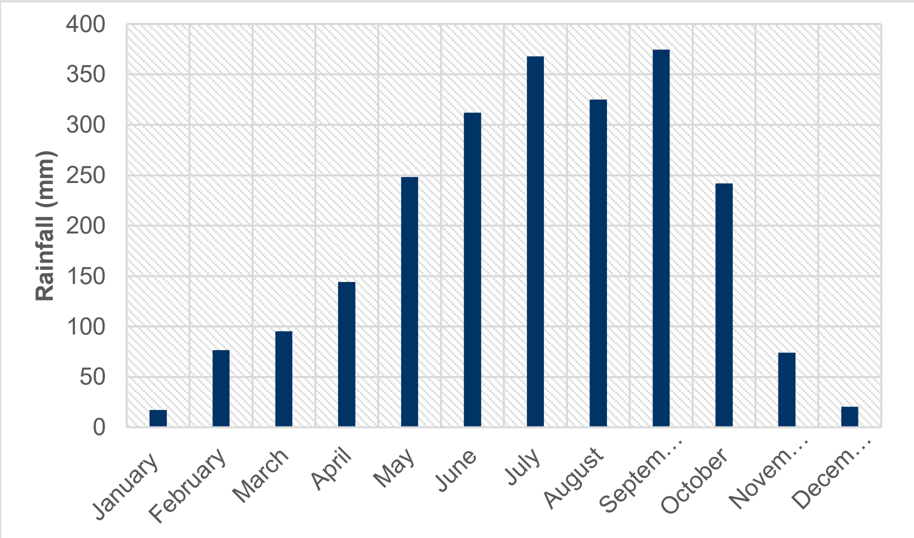


Figure 7-2 Monthly Rainfall Distribution in the Study Area

Source: Average Weather Trend for Port Harcourt (1990-2020), NIMET[25], Port Harcourt

7.4.1.3 Air Temperature

The most significant temperature difference in Nigeria is between the coastal areas and its interior as well as between the plateau and the lowlands. On the plateau, the mean annual temperature varies between 21°C and 27°C, whereas in the interior lowlands, temperatures are generally over 27°C. The coastal fringes have lower means than the interior lowlands. Seasonal mean temperatures are consistently over 20°C throughout the country and diurnal variations are more pronounced than seasonal ones. Highest temperatures occur during the dry season and vary little from the coast to inland areas.

For the Project Area, Figure 7-3 below indicates that the months of July to September recorded lower temperatures (28°C) due to rainy periods, while the months of November to March recorded higher temperatures (32-34°C)[26], due to increased solar radiation with low cloud cover dominant during the dry season. The Study Area is bounded to the east and south by open vegetation which creates a microclimate. During hotter days, the evapotranspiration creates a cooling effect that lowers surface temperature.

[25] Home - Nigerian Meteorological Agency (nimet.gov.ng)

[26][26]7.4.1 IEFCL Train 3: Meteorology / Climate Report (Wet Season Baseline October 2021)

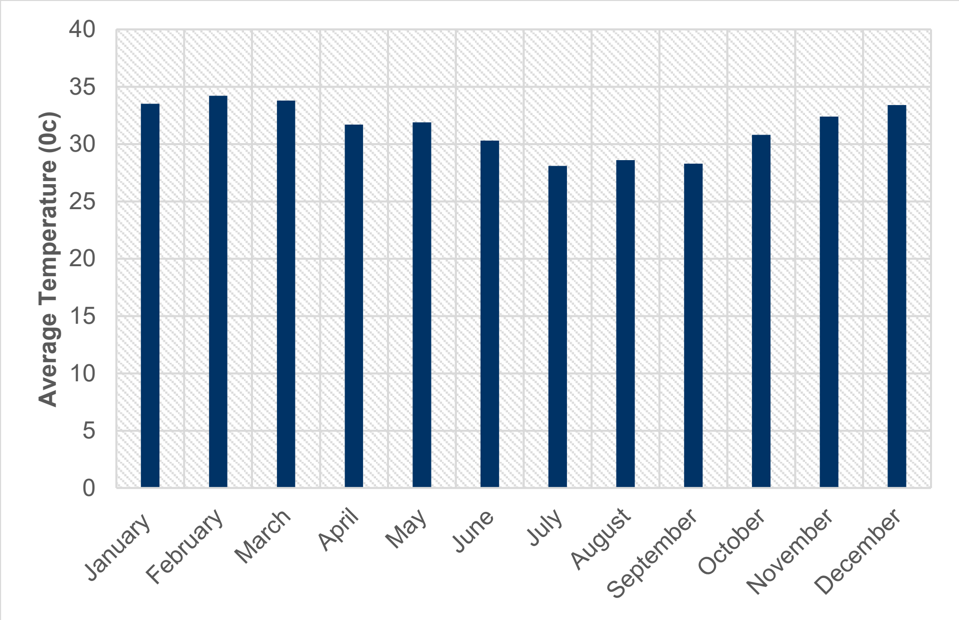


Figure 7-3 Mean Monthly Average Temperature

Source: Average Weather Trend for Port Harcourt (1990-2020), NIMET[27], Port Harcourt

7.4.1.4 Relative Humidity

According to the diurnal data obtained from field measurements carried out in the Project Area in October 2021, the maximum relative humidity (RH) is observed between 2-am and 7-am while the lowest RH was observed between 2-3pm. It can be noted that the highest RH corresponds with the coldest period with the lowest temperature at about 24^0C, while the lowest RH corresponds to the periods with the highest temperature at about 30^0C.

According to 30 year (1990-2020) average weather data obtained from Nigerian Meteorological Agency (NIMET) for Port Harcourt, July, August and September typically experience the highest relative humidity (92%), which corresponds to the highest atmospheric pressure at 1,010 millibar (mbar). Conversely, the periods that experience low atmospheric pressure correspond to low relative humidity with the lowest observed in December at 73% (refer to Figure 7-4). The high humidity and pressure at the Project Area is attributed to its proximity to a large water body hence moist air mass.

[27] Home - Nigerian Meteorological Agency (nimet.gov.ng)

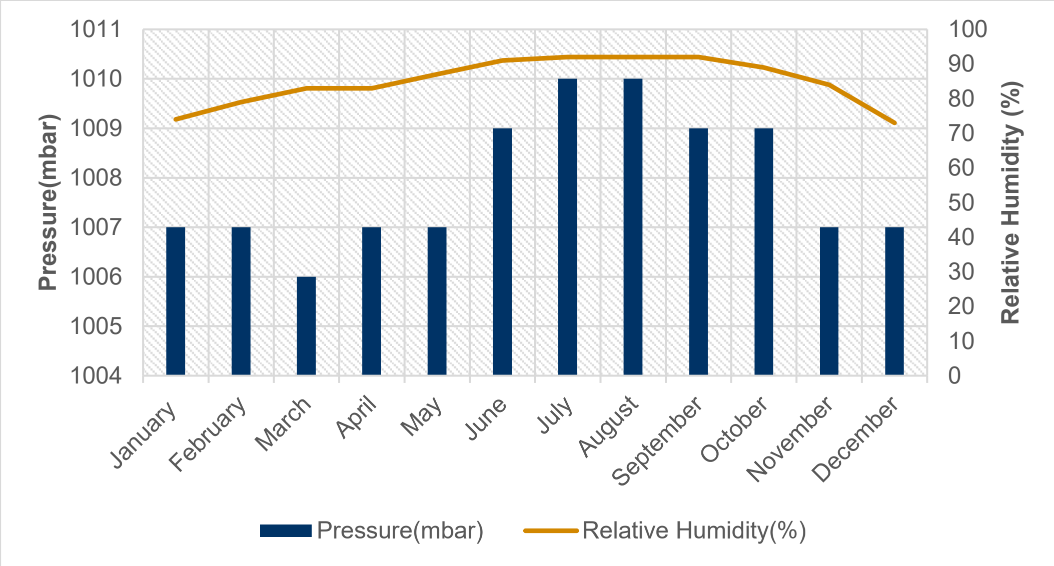


Figure 7-4 Average Relative Humidity and Pressure for Port Harcourt

Source: Average Weather Trend for Port Harcourt (1990-2020), NIMET[28], Port Harcourt

7.4.1.5 Wind Speed and Direction

According to diurnal weather measurements obtained from the Project site, the Project Area experiences moderate wind speeds during the periods of afternoons/evenings and lower wind speeds at dawn. The dominant direction of the wind during both the wet and dry season indicates the intrusion of the moist laden air mass from the Atlantic Ocean that characterises the Port Harcourt coastal domain during the dry season.

The prevailing wind direction observed during the October 2021 field investigation was south westerly and south easterly direction (Figure 7-5 and Figure 7-7), therefore implying that in the event of air emissions from the Project Area, the pollutants in the air will be driven north-east and north-west direction where there exists un-developed land with open vegetation. Wind speed range in the Project Area from 0.5 -2.1m/s constituted over 45.8% while the range 5.7-8.8m/s constituted about 29.2% (Figure 7-6). A 30 year mean average for the project area depicts an average wind speed of 3.58 m/s signifying a moderate dispersive potential of the boundary layer atmosphere as shown in Figure 7-8.

[28] Home - Nigerian Meteorological Agency (nimet.gov.ng)

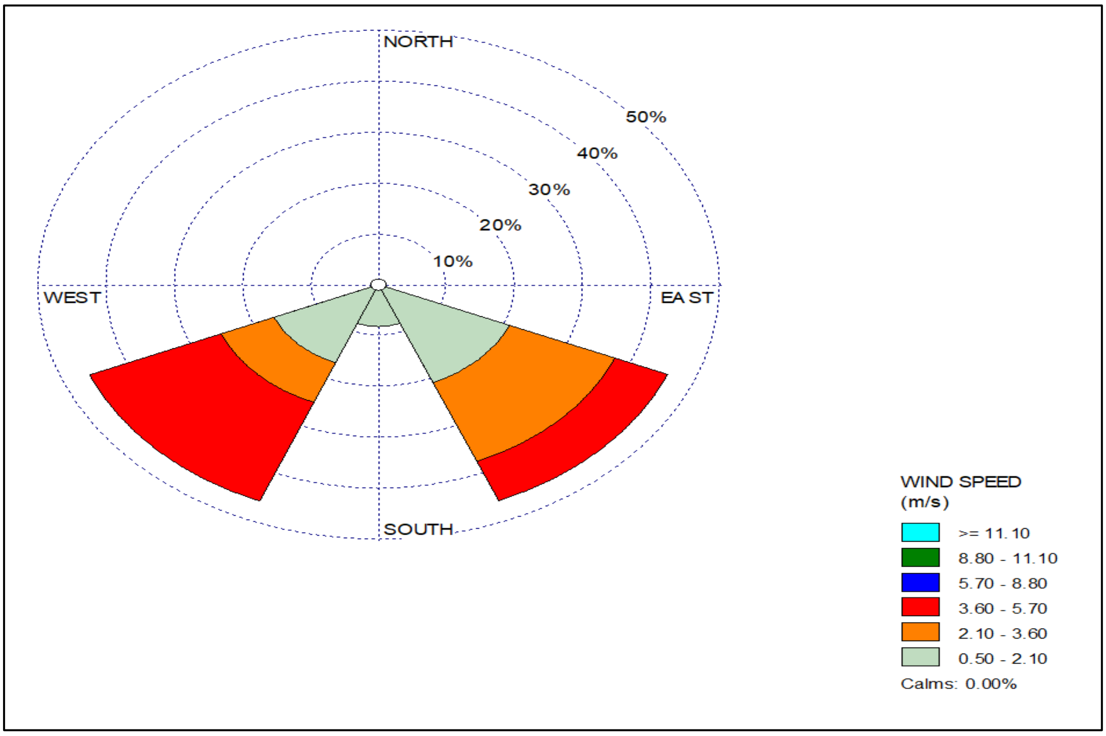


Figure 7-5 Diurnal Wind Rose Pattern for the Project Area

Source: Wet Season Baseline, October 2021[29]

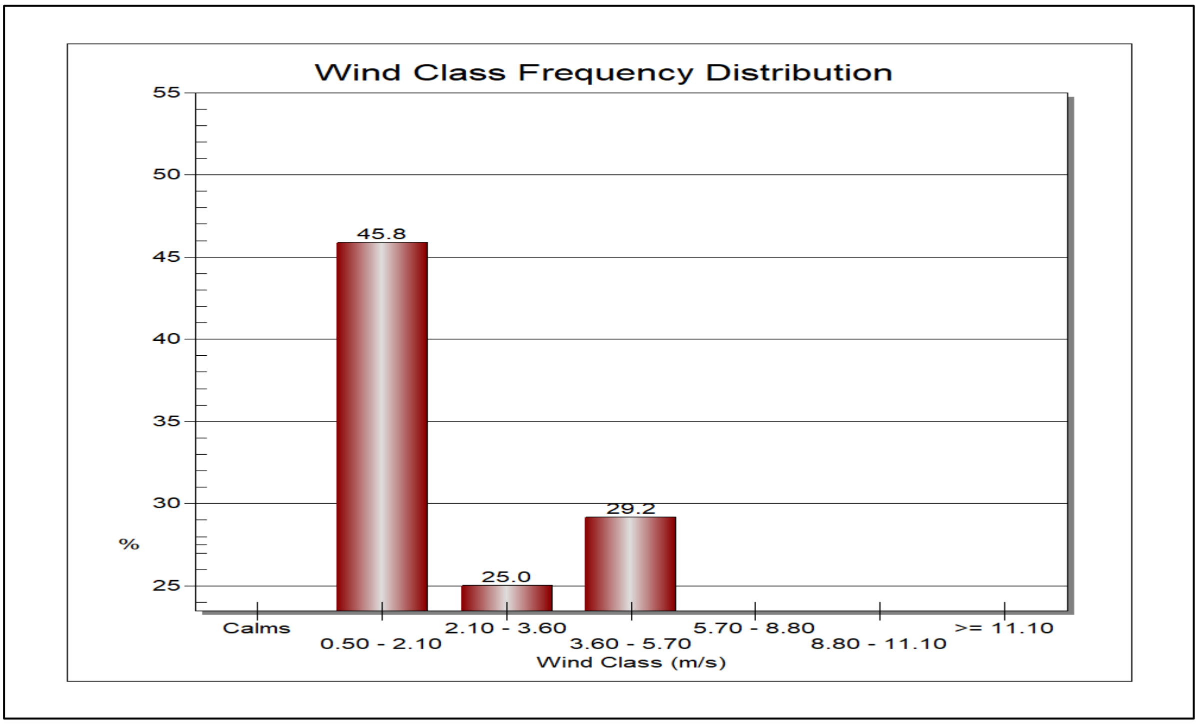


Figure 7-6 Diurnal Wind Speed for the Project Area

Source: Wet Season Baseline, October 2021

[29] IEFCL Train 3: Meteorology / Climate Report (Wet Season Baseline October 2021)

Figure 7-7 Satellite image of five (5) Years Hourly Wind Rose Pattern for the Project Area

Source: Wet Season Baseline, October 2021[30]

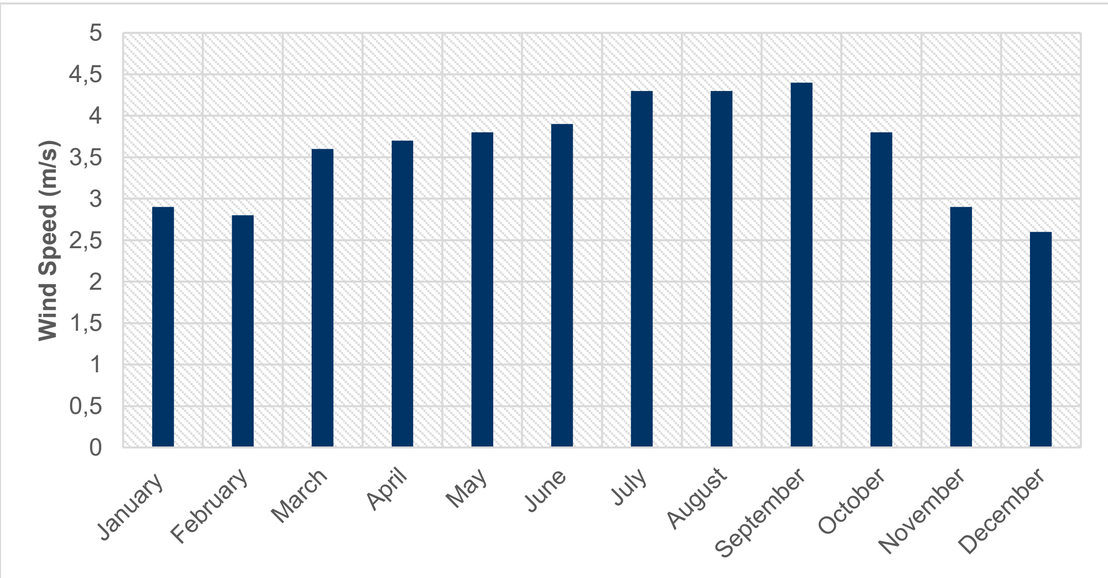


Figure 7-8 Average Wind speed for Port Harcourt

Source: Average Weather Trend for Port Harcourt (1990-2020), NIMET[31]*, Port Harcourt*

[30] NASA (https://power.larc.nasa.gov/data-access-viewer)

[31] Home - Nigerian Meteorological Agency (nimet.gov.ng)

7.4.1.6 Cloud Cover

According to the 30-year weather data for Port Harcourt, the Study Area depicts a cloud cover of over 6 oktas across the year (NIMET, 1990-2020) (Figure 7-9). Typically, sky conditions are estimated in terms of how many eighths of the sky are covered in cloud, ranging from 0 oktas (completely clear sky) through to 8 oktas (completely overcast). Therefore, with an average of over 6 oktas, the Study Area depicts a high rate of rising moist air mass due to the abundant water content, which gives rise to convective clouds. High amounts of cloud cover inhibit instability[32], which decreases the dispersion of plumes and lower amounts of cloud cover promote unstable conditions which enhance atmospheric dispersion of plumes. Cloud cover is prominent during rainy periods and minimal during dry seasons.

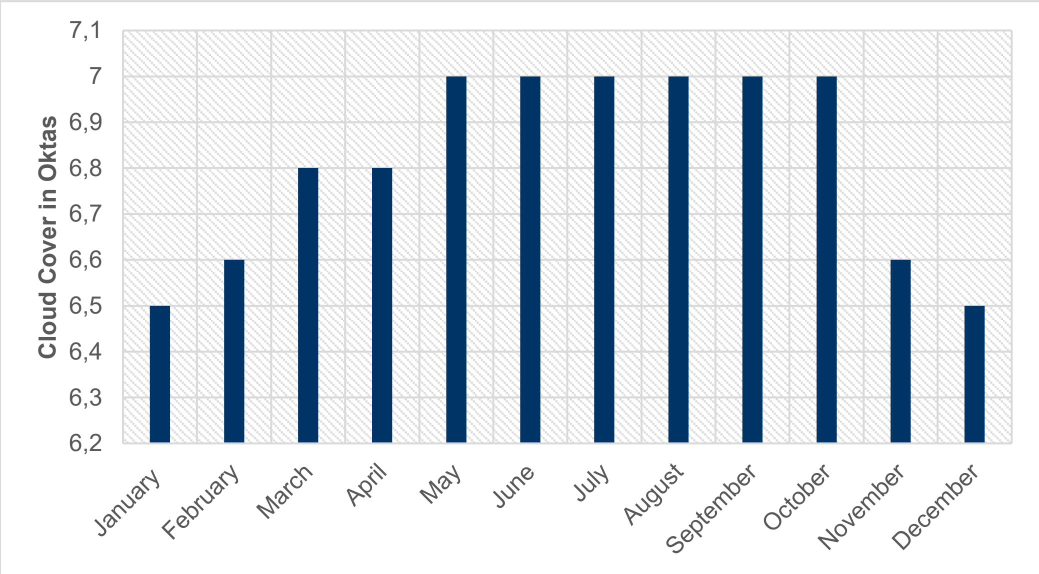


Figure 7-9 Average Monthly Cloud Cover in the Project Area

Source: Average Weather Trend for Port Harcourt (1990-2020), NIMET[33], Port Harcourt

7.4.2 Climate Risks

7.4.2.1 Introduction

The potential physical impacts that climate change could have on the Project have been considered in this Section.

This has been undertaken through a high-level scenario analysis, which has assessed the impact of climate change on physical climate-related risks associated with a full list of ERM's identified hazard types (extreme heat, extreme cold, flooding, landslides, wildfires, coastal flooding, water stress & drought and tropical cyclones) in relation to the proposed Project. Only those hazards deemed applicable to the Project have been assessed.

The scenario analysis has utilised a range of the Intergovernmental Panel On Climate Change (IPCC) climate change scenarios under a range of future projected time horizons (2030 and 2050) – which have been selected based upon their relevance to the Project and in alignment with the guidance set

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32 https://www.vincivilworld.in/air-pollution-meteorology-plume-types/#Atmospheric_Stability

33 [Home - Nigerian Meteorological Agency (nimet.gov.ng)](https://nimet.gov.ng)

out by the Task Force on Climate-Related Financial Disclosures (TCFD). This includes SSP1-2.6[34], which is most closely aligned with the targets made under the Paris Agreement (to aim to keep temperatures increases by 2100 at 2 deg. C or lower) and SSP5-8.5[35], which is a higher emissions scenario, also referred to as the Business as Usual scenario. As a part of this scenario analysis, climate-related risks have been identified under future projected timeframes and scenarios.

7.4.2.2 Literature Review

According to research conducted by USAID in 2019, Nigeria's average temperatures may increase between 1.1°C and up to 2.5°C by 2060, with higher rates of warming in the north. Rainfall variability and extreme rainfall events are also projected to increase across most of the Country. Coastal areas are also expected to experience an increase of 0.4 -1.0 metre (m) in mean sea level by 2100. In addition, there is a projection that the number of cold nights will decrease drastically, even with a projection of close to zero by 2090 while the number of extreme heat days is projected to increase by 2100 to 260 days (it was 10 days in 1990).

The World Bank Group (WBG) (2021) projects that temperatures will increase across the Country progressively through to the end of the century, with a potential increase in temperatures of between 2.9°C to 5.7°C, coupled with an increase in low temperatures and average temperatures are also expected to increase. Night-time temperatures are expected to increase by 4.7°C. By the 2100s, it is expected that the duration of heat waves will increase by an additional 8 to 55 days.

Additionally, there is a projection of heavy rainfall intensifying, in particular during the summer period. This in addition to an increase in the intensity and frequency of droughts may lead to an increase in natural disasters. Precipitation quantities are most likely to increase from the end of the rainy season up until the start of the dry season, which will be from September up until December (WBG, 2021).

"*Nigeria is at risk to numerous natural hazards and prone to floods, storms, ocean surges, droughts and wildfires. Nigeria's coastal states face extensive risks from storm surge along the entire coast, and inland flooding and wildfires in the Niger Delta region, and negative rainfall anomalies in the southeast*" (WBG, 2021, pg 11).

The Project Area falls within High Risk for both aspects of flooding and wildfires (Figure 7-10).

[34] Shared Socio-economic Pathways (SSPs) are scenarios of projected socio-economic global changes up to the year 2100. These scenarios are used to derive greenhouse gas emissions scenarios with different climate policies. SSP1-2.6 is a scenario that assumes low GHG emissions (i.e. CO_2 emissions are reduced to net zero by 2075).

[35] SSP5-8.5 scenario assumes very high GHG emissions (i.e. – that CO_2 emissions will triple by 2075).

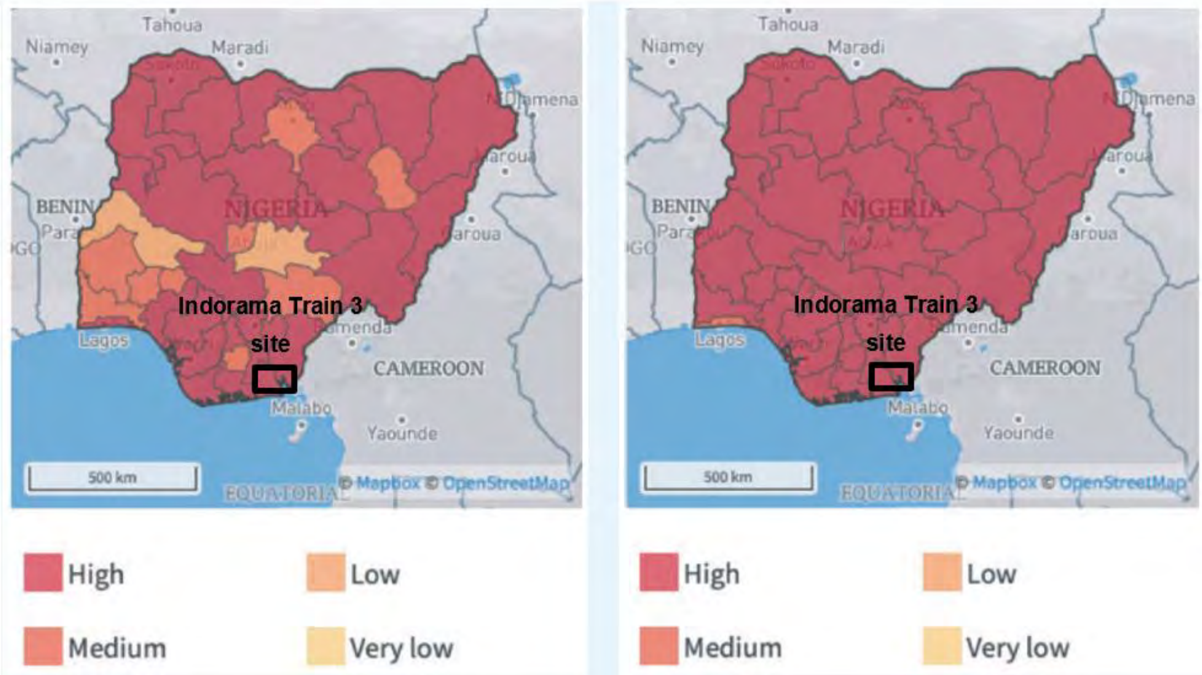


Figure 7-10 Nigeria's Risk of Urban Flood (left) and Risk of Wildfire (right)

Source: WBG, 2021

Moreover, the WRI Aqueduct offer projections to 2040 under a pessimistic[36] scenario. Results for the Project for drought risk / the projected change in water stress[37] is shown in Table 7-1 and Figure 7-11.

Table 7-1 Projected Water Stress for the Project

Climate Variable / Event	Projection
Drought Risk / Water Stress	Low to medium (10-20%) water stress

[36] *The "pessimistic" scenario represents a fragmented world with uneven economic development, higher population growth, lower GDP growth, and a lower rate of urbanization, all of which potentially affect water usage; and steadily rising global carbon emissions, with CO_2 concentrations reaching ~1370 ppm by 2100 and global mean temperatures increasing by 2.6–4.8°C relative to 1986–2005 levels.*

[37] *Water stress is an indicator of competition for water resources and is defined informally as the ratio of demand for water by human society divided by available water." (WRI Aqueduct 2015)*

Figure 7-11 Projected Water Stress for the Project Area

Source: WRI (Aqueduct 2015)

7.4.2.3 Risk Scores

Asset Risk Score

Climate impacts on the Project are considered based on scenario SSP1-2.6 and SSP5-8.5. Figure 7-12 and Figure 7-13 provide the 'Asset Risk Score' that identifies the potential change in risk profile for the Project. The Project Area is projected to experience a minimal increase in risk as a result of climate change across both scenarios and for both time horizons (2030 and 2050).

	Asset	Baseline	2030	2050
1	Indorama Train-3	0.44, Minimal Asset Risk	0.68, Minimal Asset Risk	0.74, Minimal Asset Risk

Where:

Figure 7-12 Asset Risk Score, SSP1-2.6

	Asset	Baseline	2030	2050
1	Indorama Train-3	0.44, Minimal Asset Risk	0.64, Minimal Asset Risk	0.66, Minimal Asset Risk

Where:

Figure 7-13 Asset Risk Score, SSP5-8.5

Risk Score Composition

In addition to the above, the key climate change hazards deemed applicable to the Project under scenario **SSP1-2.6** are as follows (also refer to hazard distribution in for the 2030 and 2050 time horizons in Figure 7-14 and Figure 7-15 respectively):

- **Extreme Heat**: the biggest change from the baseline to 2030 and 2050 is a visible increase in extreme heat, with a baseline risk score of 0.24 and then an increase in risk by 2.28 for 2030 and 2.46 for 2050.
- **Extreme Cold**: extreme cold decreases quite drastically from the baseline (2.08) risk score to 2030 by -0.68 and for 2050 by -0.96.
- **Wildfires**: at the baseline wildfires are at a risk score of 0.88, it increases for 2030 by 0.24 and for 2050 by 0.08.
- **Water Stress and Drought**: increases quite a bit from the baseline risk score which is at 0.40 to 0.64 in 2030 and increases to 1.36 in 2050.
- **Extreme Rainfall Flooding**: increases by 0.08 for both 2030 and 2050 from the baseline risk score of 0.40.

The key climate change hazards deemed applicable to the Project under scenario **SSP5-8.5** are as follows (also refer to hazard distribution in for the 2030 and 2050 time horizons in Figure 7-16 and Figure 7-17 respectively):

- **Extreme Heat**: the same as in the previous scenario, the biggest change from the baseline to 2030 and 2050 is a significant increase in extreme heat, with a baseline risk score of 0.24 and then an increase in risk to 2.76 for 2030 and 4.44 for 2050.
- **Extreme Cold**: there is a significant decrease in extreme cold from a 2.08 risk score at the baseline to a 1.04 risk score for 2030 and no risk score for 2050.
- **Wildfires**: same as above, wildfires baseline risk score is 0.88, it increases for 2030 by 0.16, while 2050 has no risk score.
- **Water Stress & Drought**: for baseline has a risk score of 0.40 and 2030, it increases by 0.16 for 2030 and by quite a bit by 0.64 in 2050.
- **Extreme Rainfall Flooding**: is the same for baseline and 2030 with risk score of 0.40, it then increases by 0.08 in 2050.

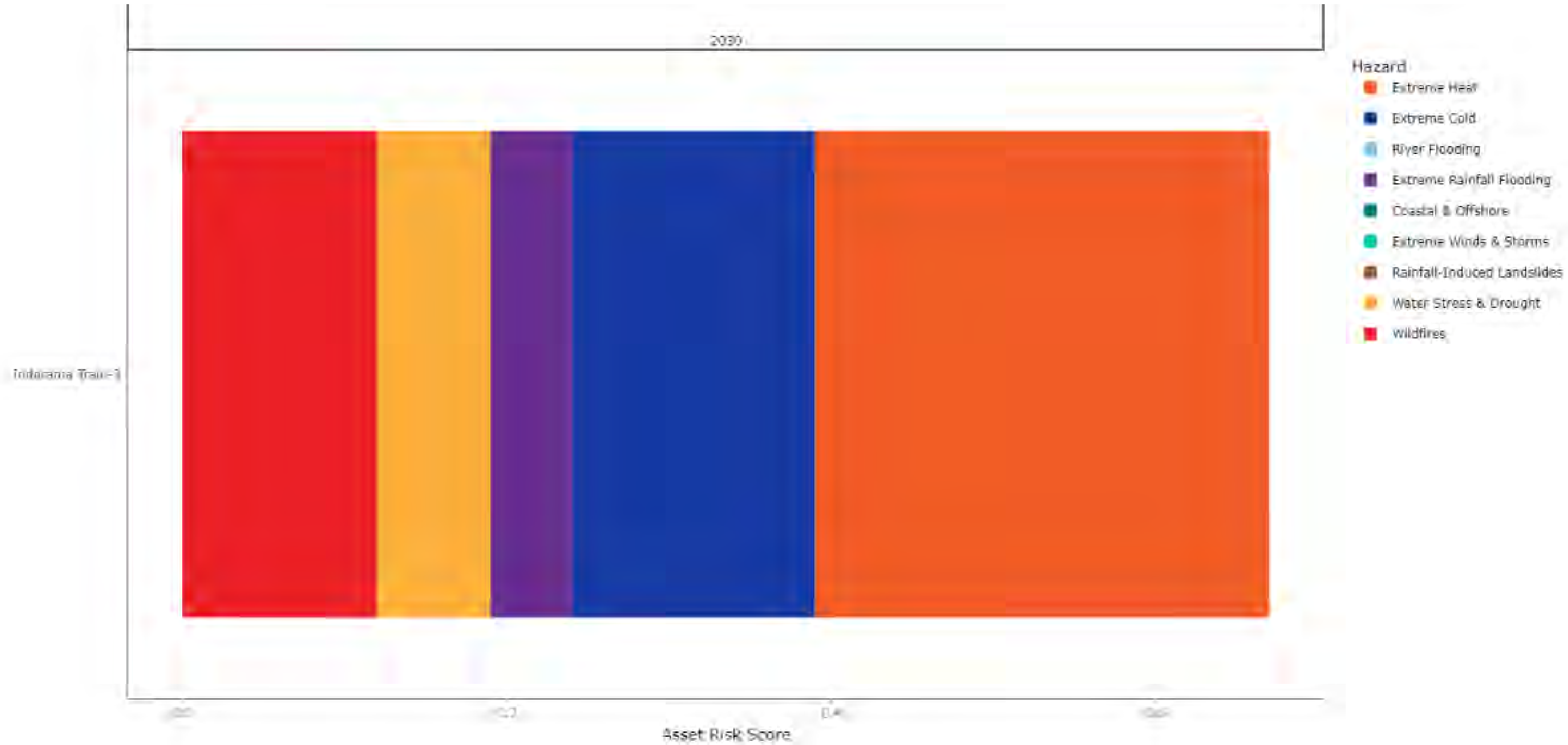


Figure 7-14 Projection Risk Score Composition: SSP1-2.6, 2030

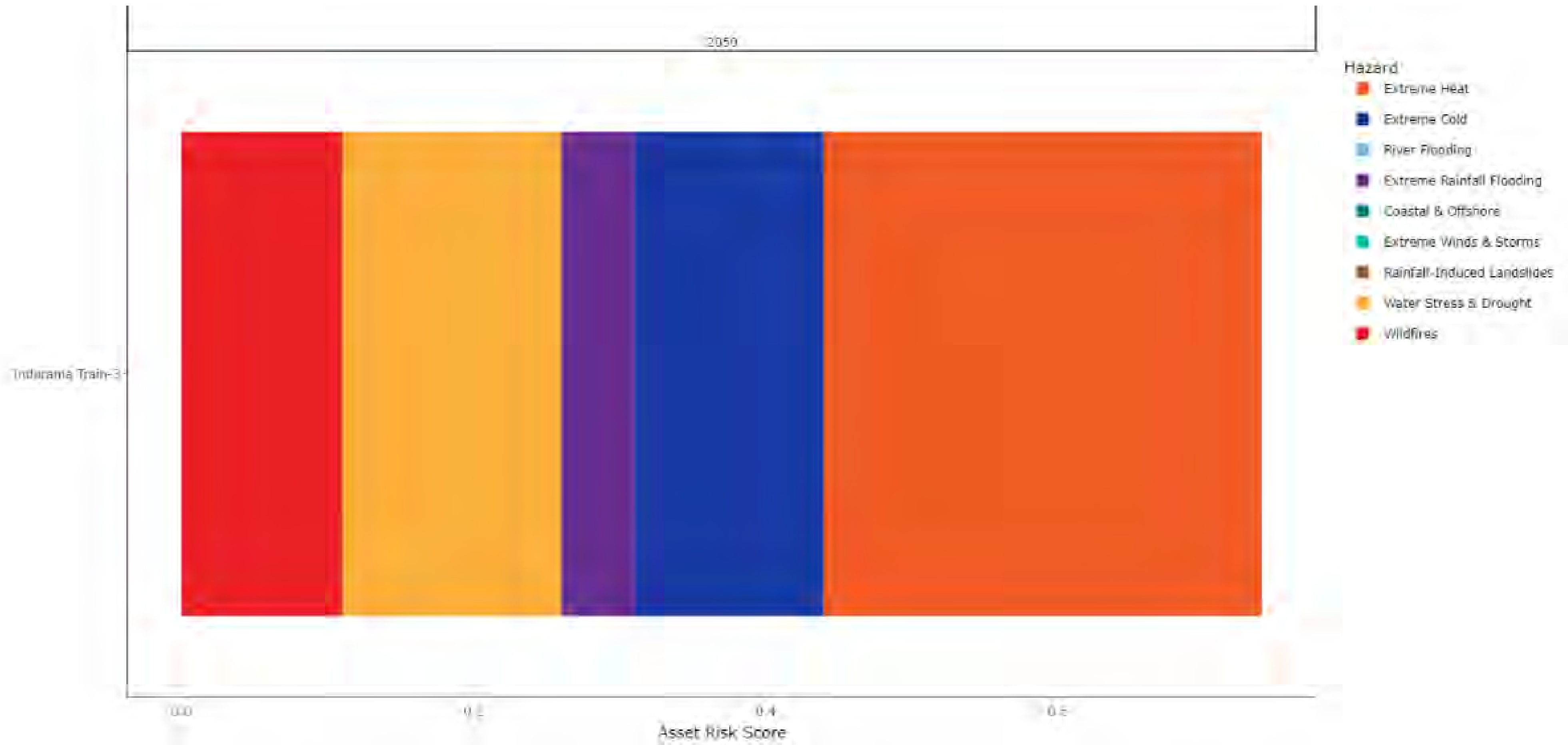


Figure 7-15 Projection Risk Score Composition: SSP1-2.6, 2050

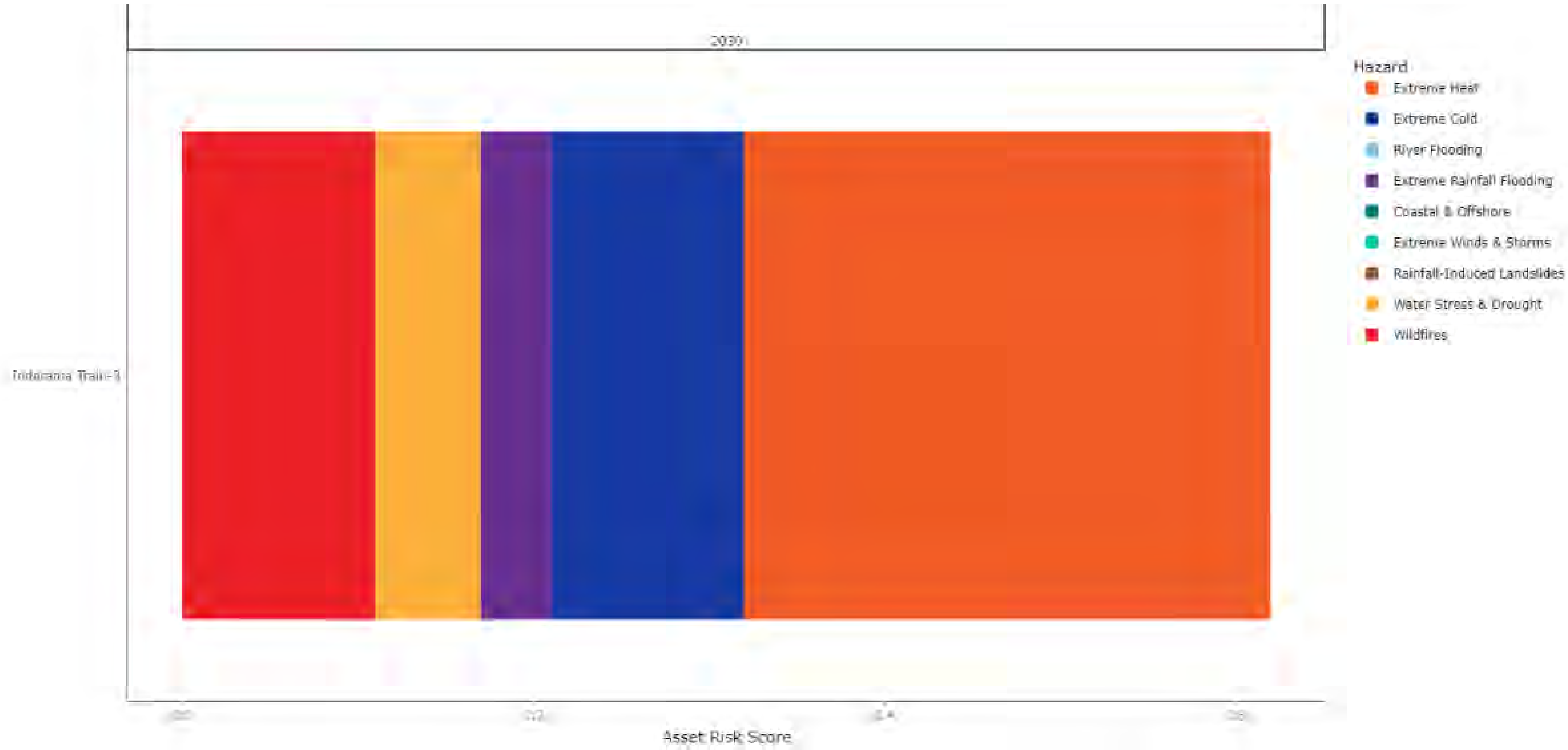


Figure 7-16 Projection Risk Score Composition: SSP5-8.5, 2030

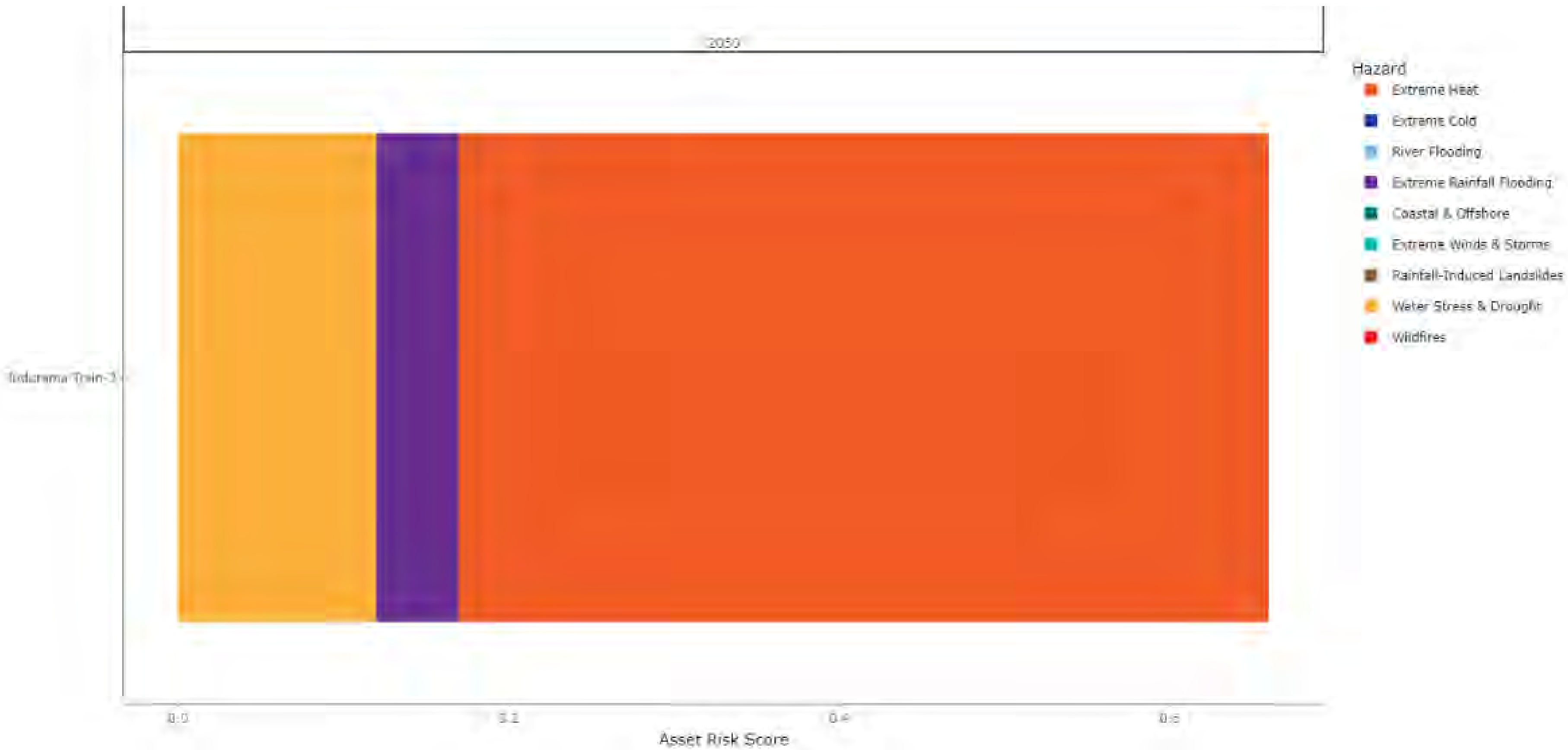


Figure 7-17 Projection Risk Score Composition: SSP5-8.5, 2050

7.4.2.4 Summary of Key Climate Change Hazards Applicable to the Project

Table 7-2 presents a summary of the potentially material hazards for the Project. Material hazards include:

- Increased extreme heat;
- Increased water stress and drought; and
- Increase in both flooding and wildfire events.

Table 7-2 Summary of Prominent Hazards for Baseline and Projections

Asset: Indorama Train 3	Period									
	Baseline					Projection				
	Prominent Hazards									
SSP1-2.6 & SSP5-8.5										
SSP1-2.6 - 2030							I			I
SSP1-2.6 - 2050							I			
SSP5-8.5 - 2030							I			I
SSP5-8.5 - 2050							I	I		I

Key:

Wildfires	Water Stress and Drought	Extreme Rainfall Flooding	Extreme Cold	Extreme Heat

I – Increase in Hazard for 2030 and 2050

Note – although wildfires and flooding events have been flagged as a potentially material hazard for the broader Project area it must be noted that the risk of wildfires is not material in that the actual Project site is situated in an area where year round relative humidity is in excess of 70% and in an area that has a high annual rainfall (above 2,300 mm). Moreover, although portions of the broader Study Area will be susceptible to risks of flooding, the Project area is located at a higher elevation (approximately 15m) from the Okulu River. As such, the risk associated with flooding of the Project area is not considered a material risk.

7.4.3 Air Quality

7.4.3.1 Air Quality Study Area

The Study Area is defined in terms of areas where direct and indirect impacts may occur as a result of the construction, operation or decommissioning of the proposed Project. In terms of air quality, the study considers only direct impacts to sensitive receptors. As such, the Study Area is based on the following distances from the infrastructure design:

- Construction phase:

- 500 m from any construction activities, as this is the maximum distance downwind that dust will travel as a precautionary approach; and
- 200 m from construction access routes.

- Operational phase:
  - 4 km from the proposed IEFCL Train 3 Plant.

The pollutants of interest are:

- Oxides of nitrogen (NO_x), and by association nitrogen dioxide (NO_2) arising from combustion sources;
- Particulate matter as PM_{10} and $PM_{2.5}$ arising from combustion and production; and
- Ammonia (NH_3) arising from production sources.

7.4.3.2 Baseline Environment

The location of the proposed IEFCL Train 3 Project is characterised by flat or slightly contoured landscape. Towards the western section of the Project Area lies an urban area, and to the north-east of the Project Area lies undeveloped land.

As mentioned in Section 7.4.1, the climate in the Study Area is characterised by two major seasons i.e., dry, and wet seasons, with the wet season from mid-March through to November and a dry season that runs from December through to March. The amount and distribution of rainfall in the Study Area plays an important role in moving pollutants from the atmosphere to other spheres of the environment. The Study Area experiences prevailing wind direction observed during the October 2021 field investigation was south westerly and south easterly direction, therefore implying that in the event of air emissions from the Project Area, the pollutants in the air will be driven north-east and north-west direction where there exists un-developed land with open vegetation.

At present, the Project Area lies adjacent to the operational Indorama Complex. As a result, the existing conditions are not a true baseline, but are influenced by the presence of these activities within the Study Area.

The baseline environmental conditions vary across the Study Area considering the natural baseline, regional and local pollutant sources as described in Chapter 5 of this report. Within the Study Area, the main sources of air pollution are:

- Nearby residential areas that include household heating fires, cooking;
- Agriculture;
- Dust from nearby paved and unpaved roads;
- Existing Ammonia Plant at the Indorama Complex; and
- Urban Traffic.

7.4.3.3 Summary of the Ambient Air Monitoring Campaign

As previously mentioned, in October 2021, IEFCL commissioned ECSL to undertake and collect infield E&S wet season baseline data for the IEFCL Train 3 Project. Baseline data collection included an air quality monitoring campaign.

Air quality sampling was undertaken for between 8 and 24 hours at multiple locations (refer to Figure 7-18 during October and November 2021 for wet season. The dry season data collection was undertaken during February and March 2023. It is important to note that sampling was undertaken for a single 8 to 24-hour period at each location as per the FMEnv guidelines and hence to present true reflection of baseline, the baseline data collected during wet and dry season are supported by the data of air quality monitoring campaign from 2019 to 2022, which is in practice and undertaken monthly at multiple locations (refer to Figure 7-19) as a part of environmental compliance monitoring program for operational plants.

The suspended particulate matter was monitored using battery operated mini-volume sampler, whereas PM_{10}, $PM_{2.5}$ and gases were monitored using Aeroqual 500 series monitors fixed with sensor heads. The details of the sensor heads used in the baseline survey are outlined in Table 7-3 below.

Table 7-3 Sensor Details

Sensor	Sensor type	Range	Minimum detection limit	Accuracy	Resolution
Nitrogen dioxide (NO_2)	GSE (Gas Sensitive Electrochemical)	0-1ppm	0.005ppm	<±0.02ppm 0-0.2ppm <±10% 0.2-1ppm	0.001ppm
Ammonia (NH_3)	GSE (Gas Sensitive Electrochemical)	0-25ppm	0.05ppm	<±0.5ppm 0-5ppm <±10% 5-25 ppm	0.01ppm
Particulate Matter ($PM_{2.5}$ & PM_{10})	LPC (Laser Particle Counter)	0.001-1000 mg/m^3	0.001mg/m^3	±0.005 mg/m^3 +15%f	0.001 mg/m^3

Ambient air quality was monitored inside and around the Project (the locations are shown in Figure 7-18). During the sampling period, the weather and wind direction measurements were taken at the East end of Project site (N4°49'30.00", E7°07'26.00") as provided in Table 7-4 and Table 7-5 for wet and dry season respectively. Table 7-6 and Table 7-7 indicate the baseline data for wet season and Table 7-8 and Table 7-9 presents the baseline data for dry season.

Table 7-10 indicate the data of air quality monitoring campaign from 2019 to 2022. The average of these data was used in the assessment (refer to Table 7-11).

Table 7-4 Mean Diurnal Weather Pattern during Fieldwork (Wet season 2021)

Local Time	Air Temp (°C)	RH (%)	Air Pressure (mbar)	Wind Speed (m/s)	Wind Direction	Cloud Cover
1:00 AM	24.7	90	1017	1.5	SE	Night-time
2:00 AM	24.3	91	1017	1.2	SW	Night-time
3:00 AM	24.0	91	1017	1.1	SE	Night-time
4:00 AM	23.9	91	1017	1.1	SE	Night-time
5:00 AM	23.9	91	1016	1.0	SW	Night-time
6:00 AM	24.2	91	1016	1.2	SW	6
7:00 AM	24.5	91	1017	2.1	SW	6

Local Time	Air Temp (ºC)	RH (%)	Air Pressure (mbar)	Wind Speed (m/s)	Wind Direction	Cloud Cover
8:00 AM	26.9	88	1017	2.1	SE	6
9:00 AM	27.8	87	1018	2.5	SE	6
10:00 AM	28.6	82	1018	2.8	SW	6
11:00 AM	29.5	81	1018	3.7	SE	5
12:00 PM	30.3	77	1018	3.9	SW	6
1:00 PM	30.5	77	1018	4.3	SW	6
2:00 PM	30.7	76	1018	4.5	SE	6
3:00 PM	30.7	76	1018	4.3	SW	6
4:00 PM	30.3	77	1018	3.6	SW	6
5:00 PM	29.6	77	1016	3.3	SW	6
6:00 PM	28.7	81	1016	3.7	SE	6
7:00 PM	27.9	85	1016	3.3	SE	6
8:00 PM	27.5	85	1016	2.6	SE	6
9:00 PM	27.1	87	1016	2.5	SE	Night-time
10:00 PM	26.8	88	1017	2.3	SW	Night-time
11:00 PM	26.2	89	1017	1.8	S	Night-time
12:00 PM	25.5	90	1017	1.8	S	Night-time
Mean	**27.3**	**84.9**	**1017**	**2.6**	**SE/SW**	**6**

Source: IEFCL Meteorology/climate data report of October 2021

Table 7-5 Mean Diurnal Weather Pattern during Fieldwork (Dry season 2023)

Local Time	Air Temp (ºC)	RH (%)	Air Pressure (mbar)	Wind Speed (m/s)	Wind Direction	Cloud Cover
1:00 AM	26.1	84	1013	1.0	NNE	Night-time
2:00 AM	26.5	81	1014	0.7	NE	Night-time
3:00 AM	22.2	94	1016	1.7	SSE	Night-time
4:00 AM	23.0	93	1014	0.7	NE	Night-time
5:00 AM	24.7	85	1013	0.7	NNE	Night-time
6:00 AM	26.0	81	1012	0.0	NE	1
7:00 AM	25.5	84	1011	0.0	ENE	2

Local Time	Air Temp (ºC)	RH (%)	Air Pressure (mbar)	Wind Speed (m/s)	Wind Direction	Cloud Cover
8:00 AM	26.0	81	1010	0.0	ENE	2
9:00 AM	27.3	77	1009	0.0	ENE	1
10:00 AM	27.2	80	1009	1.4	SW	1
11:00 AM	33.8	61	1013	3.1	W	0
12:00 PM	33.5	61	1013	3.4	SW	0
1:00 PM	29.3	79	1011	1.4	WSW	1
2:00 PM	28.9	83	1012	0.3	WSW	2
3:00 PM	28.8	82	1013	1.4	WSW	2
4:00 PM	29.0	81	1014	1.0	WSW	2
5:00 PM	28.9	82	1013	2.4	W	2
6:00 PM	28.7	82	1013	1.4	WSW	0
7:00 PM	28.0	85	1012	1.7	N	0
8:00 PM	26.9	80	1011	2.0	N	1
9:00 PM	25.2	84	1010	0.0	NNE	Night-time
10:00 PM	24.8	85	1011	0.7	NE	Night-time
11:00 PM	24.8	87	1011	0.7	NE	Night-time
12:00 PM	24.6	90	1012	0.0	NE	Night-time
Mean	**27.1**	**81.8**	**1012**	**1.1**		**1**

Source: IEFCL Meteorology/climate data report of March 2023

Table 7-6 Air Quality Data (Wet season 2021)

Parameter	AQ 1	AQ 2	AQ 3	AQ 4	AQ 5	AQ 6	AQ 7	AQ 8	AQ 9	AQ 10	AQ 11	AQ 12	AQ 13	Project Guideline	IFC
NO_2 (µg/m^3)	24.83	25.02	24.83	22.57	20.35	24.83	27.17	24.45	25.21	23.41	25.84	29.78	24.61	40	40**
NH_3 (µg/m^3)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	200	-
PM_{10} (µg/m^3)	20.90	20.60	23.20	21.82	22.91	19.70	21.39	21.06	20.50	20.33	21.37	21.67	20.67	60	70
$PM_{2.5}$ (µg/m^3)	11.10	10.70	10.40	12.27	10.09	12.10	11.17	11.29	10.90	11.11	11.47	11.56	11.25	20	35

LOD – Limit of Detection

Table 7-7 Air Quality Data (Wet season 2023)

Parameter	AQ 14	AQ 15	AQ 16	AQ 17	AQ 18	AQ 19	AQ 20	AQ 21	AQ 22	AQC 1	AQC2	Project Guideline	IFC
NO_2 (µg/m^3)	28.22	24.92	23.11	28.01	27.19	21.95	26.10	23.73	24.32	24.45	22.70	40	40**
NH_3 (µg/m^3)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	200	-
PM_{10} (µg/m^3)	20.38	21.08	21.64	22.00	22.36	21.08	22.38	20.69	21.07	22.77	20.80	60	70
$PM_{2.5}$ (µg/m^3)	11.38	11.33	11.57	12.78	11.91	11.67	11.25	11.08	10.71	11.08	10.67	20	35

Table 7-8 Air Quality Data (Dry season 2023)

Parameter	AQ 1	AQ 2	AQ 3	AQ 4	AQ 5	AQ 6	AQ 7	AQ 8	AQ 9	AQ 10	AQ 11	AQ 12	AQ 13	Project Guideline	IFC
NO_2 ($\mu g/m^3$)	28.41	27.72	28.40	29.42	29.09	28.39	29.54	30.16	30.67	28.45	28.18	31.00	28.31	40	40**
NH_3 ($\mu g/m^3$)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	200	-
PM_{10} ($\mu g/m^3$)	37.66	31.28	34.20	32.83	31.79	30.87	36.24	34.33	34.88	28.90	27.44	31.85	28.90	60	70
$PM_{2.5}$ ($\mu g/m^3$)	16.61	14.16	13.17	15.61	13.86	12.29	16.98	15.71	17.03	11.20	11.52	15.47	13.93	20	35

Table 7-9 Air Quality Data (Dry season 2023)

Parameter	AQ 14	AQ 15	AQ 16	AQ 17	AQ 18	AQ 19	AQ 20	AQ 21	AQ 22	AQC 1	AQC2	Project Guideline	IFC
NO_2 ($\mu g/m^3$)	30.29	27.87	27.96	30.89	28.43	28.35	26.78	27.29	27.66	29.23	30.14	40	40**
NH_3 ($\mu g/m^3$)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	200	-
PM_{10} ($\mu g/m^3$)	32.15	30.35	28.81	34.28	27.96	27.07	27.19	26.77	28.92	28.93	34.08	60	70
$PM_{2.5}$ ($\mu g/m^3$)	12.29	11.61	11.78	18.41	12.81	11.05	12.20	10.76	10.99	11.97	12.53	20	35

Table 7-10 Air Quality Data (2019 to 2022)

Parameter	Stat. 1	Stat. 2	Stat. 3	Stat. 4	Stat. 5	Stat. 6	Stat. 7	Stat. 8	Stat. 9	Stat. 10	Average	Project Guideline	IFC
NO_2 (µg/m^3)	29.28	28.97	28.86	27.64	27.12	28.32	26.94	25.00	27.50	27.39	27.70	40	40
NH_3 (µg/m^3)	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	<LOD	200	
PM_{10} (µg/m^3)	28.28	24.60	25.30	25.21	24.70	26.01	25.85	27.18	26.18	25.32	25.86	60	70
$PM_{2.5}$ (µg/m^3)	15.78	14.71	14.91	14.99	14.52	14.72	15.86	15.37	15.09	15.82	15.18	20	35

Station 1 = Near Main Gate

Station 2 = Near W/Bridge

Station 3 = Near Flare Stack

Station 4 = Near AGIP Mete. St

Station 5 = Near Urea Bagging (D/S of Fert. Plant)

Station 6 = Near Workshop (U/S of Fert. Plant)

Station 7 = Axis of Akpajo /Elelenwo

Station 8 = Axis of Aleto /Agbonchia

Station 9 = Agbonchia Area

Station 10 = Aleto Area

Table 7-11 Baseline used in the Air Quality Assessment for this ESIA

Parameter	Baseline used (µg/m^3)
NO_2 (µg/m^3)	27.15
NH_3 (µg/m^3)	<LOD
PM_{10} (µg/m^3)	26.12
$PM_{2.5}$ (µg/m^3)	13.32

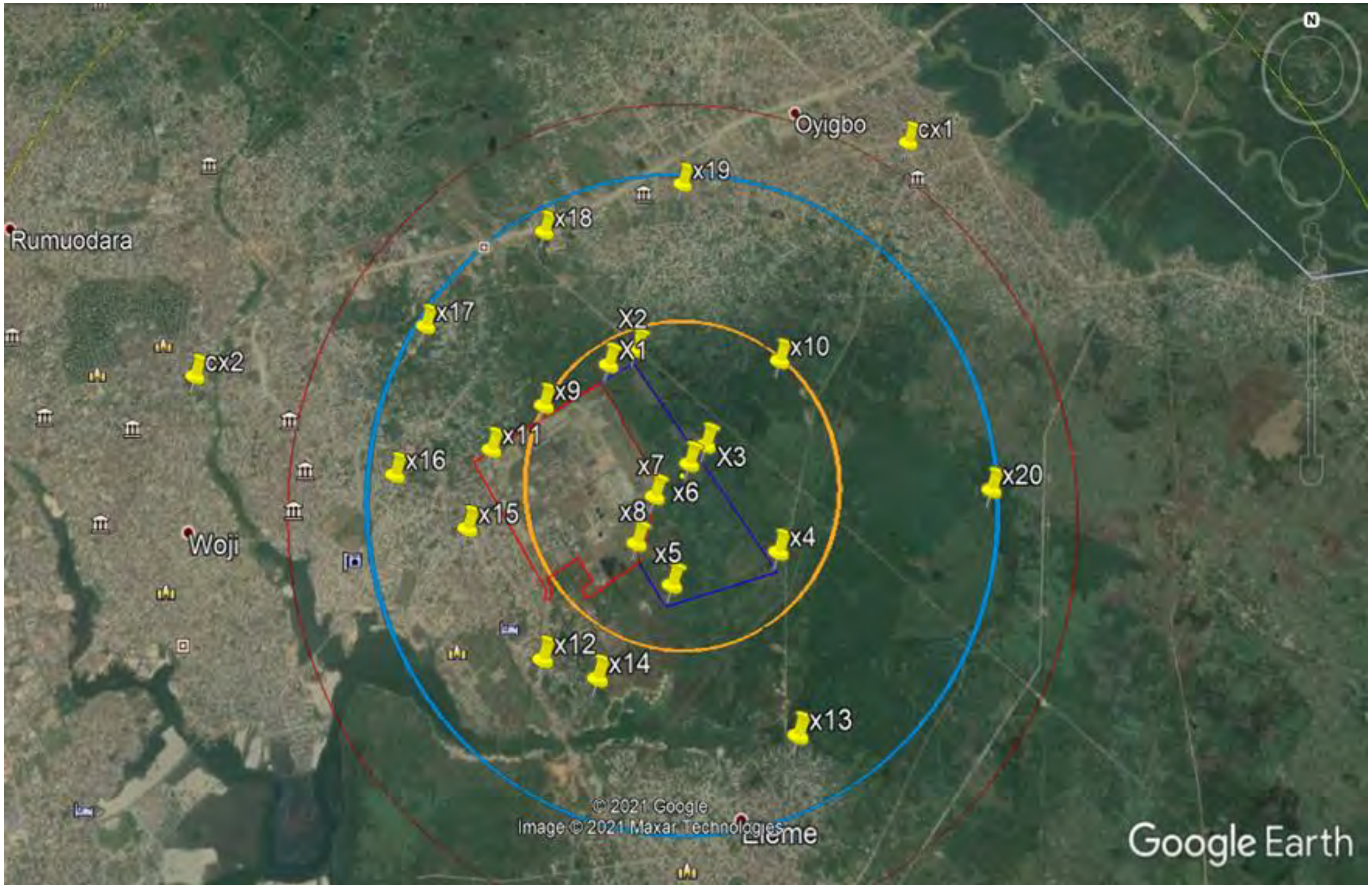


Figure 7-18 Ambient Air Quality Monitoring Stations

Figure 7-19 Monthly Ambient Air Quality Monitoring Stations

7.4.4 Noise

7.4.4.1 Introduction

An important part of the noise assessment is the quantification and understanding of the existing acoustic environment, including the identification of baseline noise levels at potentially Noise Sensitive Receptors (NSRs). The baseline environment can be defined as the conditions that would prevail in the absence of the proposed IEFCL Train 3 Project.

This Section presents the results of the baseline noise survey undertaken by ECSL appointed by IEFCL between the period 19 to 24 February 2023. The quantification of baseline noise levels provides the basis for the assessment of potential noise impacts at NSR's as a result of the Project. Noise measurement locations were chosen to achieve a representative understanding of the noise baseline at NSRs in the vicinity of the Project.

7.4.4.2 Noise Monitoring Locations

Noise baseline measurements were proposed to be conducted at four locations. These four locations were representative of the acoustic environment around the vicinity of the Project. Noise monitoring locations were selected before the finalisation of the Project's design. Noise measurement locations are provided in Table 7-12 and Figure 7-20.

Table 7-12 Noise Measurement Locations

Noise Monitoring Location	Description	Coordinates	
		Northing	Easting
L1	Within Indorama facilities and close to residential areas	288432	535153
L2	Residential	288839	535716
L3	Residential	290556	536221
L4	Within Indorama facilities and close to residential areas	289457	533228

Figure 7-20 Noise Measurement Locations

7.4.4.3 Noise Monitoring Results

The results of measurements recorded at the long-term noise-monitoring locations are summarised in Table 7-13. The measurements were undertaken between 07:00 to 18:00 hours for daytime period and 22:00 to 07:00 hour for night-time period.

The overall L_{Aeq} levels are the logarithmic average of the $L_{Aeq,15min}$ values, representing the equivalent energy average noise level for the period. The $L_{A90,period}$ is considered to be representative of the typical background noise level for the daytime and night-time periods. For this ESIA, the L_{Aeq} is the metric that is used to assess Project noise impacts since L_{Aeq} is referred to in the Nigerian noise regulations and IFC's Guidelines.

Table 7-13 Long Term Unattended Noise Monitoring Results

ID	Period (T)	Time	Measurement Parameter, dB(A)				
			L_{Aeq}	L_{A90}	L_{A10}	L_{Amax}	L_{Amin}
L1	Day-time	09:01 ~ 17.01	**43**	37	44	60	37
	Night-time	01:01 ~ 02.01	**41**	38	40	54	37
L2	Day-time	07:51 ~ 15.51	**46**	33	49	63	30
	Night-time	06:00 ~ 07.00	**58**	38	57	71	33
L3	Day-time	08:10 ~ 16.10	**48**	37	51	61	26
	Night-time	06:00 ~ 07.00	**56**	27	42	73	25
L4	Day-time	08:50 ~ 16.50	**50**	33	53	63	32
	Night-time	02:30 ~ 03.30	**39**	31	44	50	31
Period T = 10 hours for Daytime (07:00 - 18:00) and 8 hours for night-time (23:00–07:00) as per Nigerian criteria.							

Daytime noise levels (L_{Aeq}) comply IFC guideline of 55 dB at all measured locations. Night-time noise levels (L_{Aeq}) comply IFC guidelines of 45 dB at locations L1 and L4. For locations L2 and L3 exceedance is up to 13 and 11 dB respectively, however night time measurements at these two locations were undertaken during the commuting period where traffic noise and human activities are highly increased. Therefore, for these two locations, night time noise levels have been assumed to be similar to location L1 and L4, approx. 40 dB.

7.4.5 Geology

This Section presents the regional and local geological setting for the Project Area.

7.4.5.1 Regional Geology

Regionally, the Project Area is situated within the greater Niger Delta. The formation of the present-day Niger Delta started in the early Palaeocene era and resulted in the build-up of fine-grained sediments eroded and transported by River Niger and its tributaries. A regional geological map of the Niger Delta is shown in Figure 7-21 with a description of the various lithological units discussed below.

The subsurface geology of the Niger Delta consists of three lithostratigraphic units (Akata, Agbada and Benin Formations), which are in turn overlain by various types of quaternary deposits. The Benin Formation, which is the continental mega-facies of the tertiary Niger Delta, comprises about 6,000 m thick successions of unconsolidated sands with thin clay and lignite interbeds. The Benin formation grade very gently downwards into the paralic delta front mega-facies, represented by the Agbada Formation. The unit consists of an interbedded sequence of sands and shales about 3,150 m thick on the average. All the hydrocarbon reserves of the Niger Delta accumulate in the sands of the Tertiary Niger Delta. Consequently, it is dominated by shales of more than 1,380 m thick. Sands constitute the major aquiferous layer in the Niger Delta and is dominated by sands, and gravelly sands.

The overlying Quaternary deposits (40-150 m thick) generally consist of rapidly alternating sequences of sand and silt/clay with the latter becoming increasingly more prominent seawards. The Quaternary (neogene) and Tertiary stratigraphy of parts of the Niger Delta is shown in Table 7-14.

Geomorphologically, the Niger Delta can be subdivided into three major inter-gradational units from land to sea (north to south), these are:

- Dry deltaic plain with rare freshwater swamps;
- Extensive freshwater swamps and meander belts; and
- Saltwater mangrove swamps, estuaries, creeks and lagoons.

The dry deltaic plain is a geographically extensive low-lying area dominated by fluvial systems, some with braided characteristics. Few meander belts occur within this deltaic plain. Raffia palms dominate flood plains while palm trees are most common in the inter-fluvial settings. Extensive lateritic soil (approximately 12 m in thickness) underlies this unit.

Table 7-14 Geological and Lithological Units of the Niger Delta

Geologic Unit	Lithology	Age
Alluvium	Gravel, sand, clay silt	Quaternary
Freshwater back-swamp	Sand, clay, some silt, and gravel	
Meander belt		
Mangrove and salt Water/backswamps	Medium-fine sand, clay and some silt	
Active/abandoned beach ridges	Sand, clay and some silt	
Benin Formation (Coastal Plain Sand)	Coarse to medium sand with Subordinate silt and clay lenses	Tertiary
Agbada Formation	Mixture of sand, silt and shale	
Akata Formation	Shale, sandy in some places	

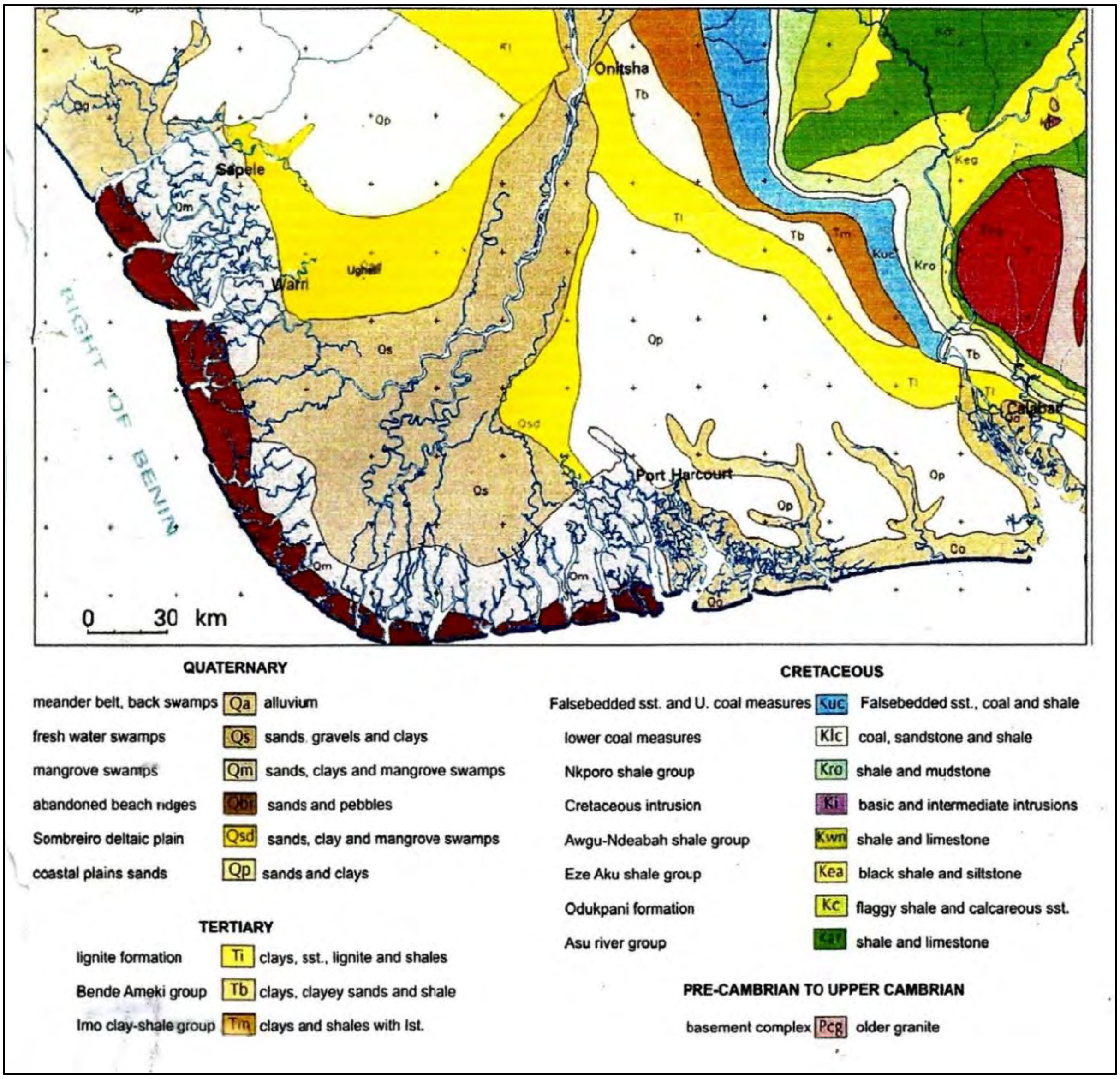


Figure 7-21 Geological Characteristics of the Niger Delta

7.4.5.2 Local Geology

The local geology has been defined based on the geological logs obtained from the three (3) boreholes drilled within the Project Area. The local lithologies identified are indicated on Figure 7.22 and discussed in more detail below.

Locally, the geology is predominantly composed of sandy clay as topsoil. The thickness of the sandy clay unit ranges from 5.0 – 6.0 m. The sandy clay is predominantly dark brown in colour and are firm in structure. This unit is underlain by a thick layer of fine to medium grained sand which ranges between 14 – 19 m in thickness. This fine to medium grained sand layer is host to the shallow aquifers in the area. Underlying this layer is a clayey sand which has a thickness between 9.0 – 13 m. The clayey sand is light brown to yellow in colour.

The lithologies underlying the clayey sands are fine to coarse grained sands and coarse to gravelly sands which extend from 32 – 70 mbgl across the Project Area. These lithologies are also regarded as being significant aquiferous rocks due to their relatively high hydraulic conductivities. The local lithologies observed within the proposed project area are characteristic of the typical lithologies across the Niger Delta.

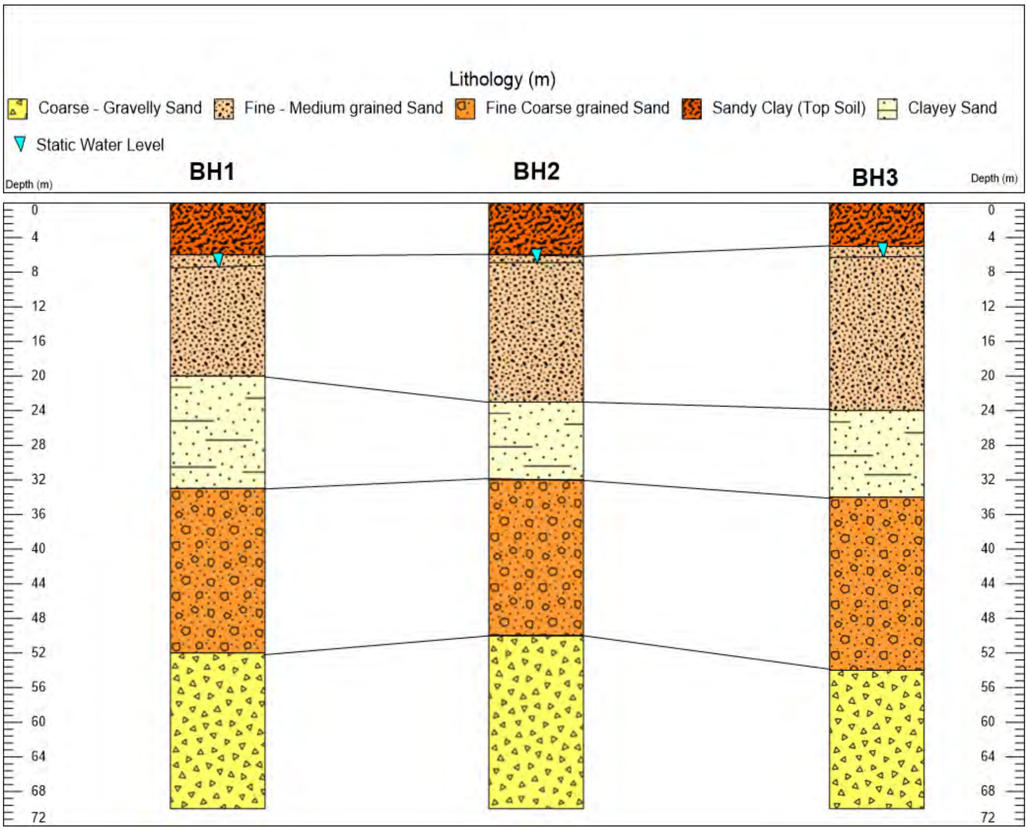


Figure 7.22 Lithostratigraphy of the Project Area

7.4.6 Soils

This Section presents the baseline / existing soil conditions in the Project Area and provides a benchmark of the conditions against any potential future impacts associated with the Project.

The existing soil conditions were assessed through a wet season field sampling campaign undertaken by ECSL appointed by IEFCL in October 2021 and laboratory analysis of the collected soil samples.

7.4.6.1 Soil Sampling Locations

Soil samples were collected from 24 sampling positions situated both within the Project Area as well as from off-site locations within the larger Study Area. At each sampling location, two samples were collected, which included a topsoil sample (0 – 15 cm) and a sub-soil sample (15 – 30 cm).

Table 7-15 provides a description of the various soil sampling locations, which are shown on Figure 7-23.

Table 7-15 Soil Sampling Positions

Station	Sample Location Description	GPS Coordinates	
		North (N)	East (E)
X1	West end of the Project site (Proposed Project Area)	4°50’40.20”	7°06’18.00”

Station	Sample Location Description	GPS Coordinates	
		North (N)	East (E)
X2	North End of the Project Site (Proposed Project Area)	4°50'48.80"	7°06'29.00"
X3	Between North & East End of the Project Site (Proposed Project Area)	4°50'08.60"	7°06'57.60"
X4	East End of the Project Site (Proposed Project Area)	4°49'30.00"	7°07'26.00"
X5	South End of the Project Site (Proposed Project Area)	4°49'16.80"	7°06'43.50"
X6	Centre of the Project Site (Proposed Project Area)	4°50'5.30"	7°06'49.70"
X7	Flare area of Indorama Complex	4°49'54.20"	7°06'37.00"
X8	ETP Area of Indorama Complex	4°49'32.20"	7°06'30.50"
X9	Down-wind of Urea Warehouse within Indorama Complex	4°50'25.20"	7°05'49.80"
X10	Vegetation area towards North of the Project Site (Proposed Project Area)	4°50'45.50"	7°07'35.80"
X11	IRC within Indorama Complex	4°50'10.70"	7°05'27.00"
X12	Main gate of Indorama Complex (Close to East-West Expressway)	4°48'47.00"	7°05'52.00"
X13	Agbonchia Community	4°48'20.00"	7°07'31.60"
X14	Aleto Community	4°48'40.00"	7°06'09.80"
X15	Akpajo Community	4°49'44.50"	7°05'17.60"
X16	Elelenwo Community	4°50'15.00"	7°04'43.00"
X17	Steel Market	4°51'10.00"	7°05'01.60"
X18	Axis of Iriebe Market	4°51'45.00"	7°05'47.00"
X19	Axis of Iriebe area	4°52'09.00"	7°06'58.00"
X20	Between Edutex and farming settlement	4°50'14.50"	7°08'53.50"
X21	Njuru	4°48'14.65"	7° 07'13.96"
X22	Okerewa	4°48'22.77"	7° 06'26.71"
CX1	GSS – Oyigbo	4°52'43.00"	7°08'23.00"
CX2	Rumuokwurusi	4°50'23.00"	7°03'32.00"

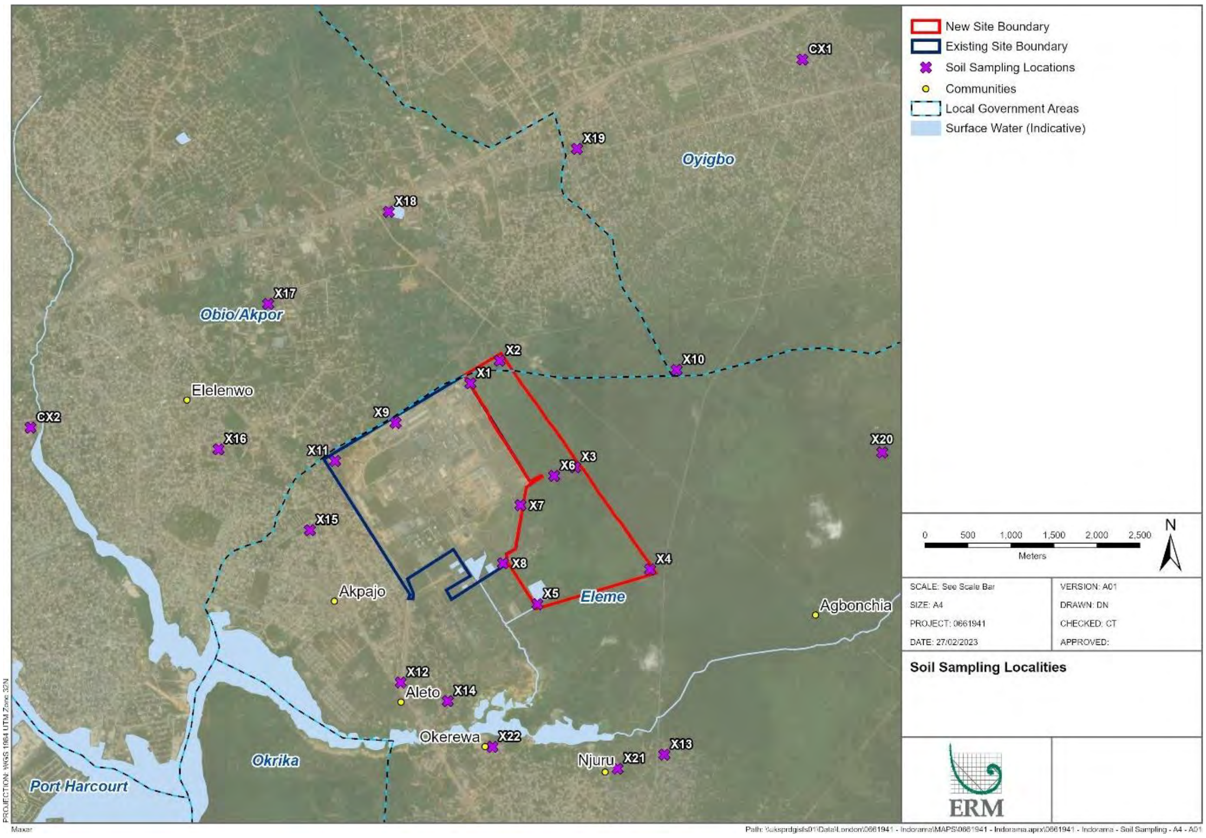


Figure 7-23 Soil Sampling Localities

7.4.6.2 Soil Sampling Methodology

International best practices for soil collection were adopted during the soil sampling campaign. A summary of the sampling methodology applied is discussed below.

A stainless-steel soil sampling augur was used to collect the samples. At each sampling position, a topsoil sample was collected at depths of between 0 – 15 cm while a second sample representing the subsoil was collected between 15 – 30 cm down the soil profile.

Each collected sample was placed into a plastic bag before being wrapped in aluminium foil and packed into a UV resistant container. Each sample bag was labelled at the point of collection with the correct station ID, depth and date of sampling.

The morphological and physical properties of the soils were noted based on visual observations and in-situ pH measurements were recorded for each soil sample.

7.4.6.3 Physical Description of the Soils

Morphologically, the soils of the Project Area are classified as coastal plain sand (ultisoil), friable when dry and sticky when wet. The soils are moderately well drained and loose with soil aggregates largely dominated by high sand percentage ranging from 77 - 86% and 76 – 87% for topsoil and subsoil respectively (refer to the laboratory results in Table 7-16); followed by clay percentage ranging from 10 – 17% and 12 – 18% for topsoil and subsoil respectively. The silt is the least dominating soil aggregate ranging from 2 – 8% and 1.5 – 7% for topsoil and subsoil respectively.

The bulk density and porosity results indicate moderately aerated soil, non-compacted soil and well drained. The soils are also predominantly dark brown indicating soil rich in organic matter with thick vegetation in some area within the Study Area.

7.4.6.4 Soil Chemistry Results

The physico-chemical results of the soil samples within and around the proposed Project area, as well as at two control points (CX1 and CX2) are presented in Table 7-16. The minimum, maximum and average values obtained from the soils within the Project area and the greater Project AoI are presented separately and compared to the values obtained from the two control stations. The table includes the results for both the subsoil and topsoil samples.

As there are no Nigerian specific standards for soil qualities, the two control points were used as a reference for comparative purposes.

The soils are generally characteristic of low pH values with high concentrations of manganese, nickel, chromium, iron, copper, zinc, and total hydrocarbon content. It is however noted that when comparing the soils within the proposed Project area and the soils within the greater Project AoI to the control samples, there is no significant difference in physical properties of the soil or the chemistries. There is also no notable difference in physical or chemical properties between the topsoil and the underlying subsoil samples.

Table 7-16 Summary Results of Physico-chemical Properties of Soil within the Study Area

Parameters	Control Samples		Soils within the Proposed Project Area			Soils within the Property AoI		
	CX1	CX2	Min	Max	Ave	Min	Max	Ave
Topsoil Samples (0-15cm)								
Sand (%)	85	82	79	86	82	77	86	82
Silt (%)	1.4	2.0	1.6	4.4	3.0	1.8	8.2	4.0
Clay (%)	14	16	12	17	15	10	16	14
Bulk Density (g/cm3)	1.5	1.4	1.2	1.5	1.3	1.2	1.6	1.3
Permeability (cm/sec)	0.14	0.15	0.14	0.17	0.16	0.14	0.18	0.16
Moisture Content (%)	18	13	15	19	17	15	25	19
Porosity	0.41	0.40	0.39	0.41	0.40	0.38	0.41	0.40
pH	5.5	4.6	3.6	4.9	3.9	3.1	5.5	4.3
Sulphide, S2- (mg/kg)	<0.01	<0.01	0.0	0.0	<0.01	0.0	0.0	<0.01
Sulphate, SO42- (mg/kg)	0.0	1.0	0.0	5.0	2.5	0	4.0	1.4
Nitrate, NO3- (mg/kg)	<0.01	0.1	0.1	1.7	0.84	0.1	1.3	0.45
Phosphate, PO43- (mg/kg)	0.25	0.2	0.08	0.96	0.47	0.03	0.75	0.28

Parameters	Control Samples		Soils within the Proposed Project Area			Soils within the Property AoI		
	CX1	CX2	Min	Max	Ave	Min	Max	Ave
Manganese, Mn (mg/kg)	64	46	36	130	107	7.7	142	51
Vanadium, V (mg/kg)	<0.001	<0.001	0.02	0.02	0.02	0.06	0.84	0.36
Nickel, Ni (mg/kg)	<0.001	<0.001	0.09	0.33	0.21	0.13	18	5.7
Chromium, Cr (mg/kg)	6.8	3.8	1.9	6.2	3.4	0.16	8.6	3.0
Iron, Fe (mg/kg)	2947	2277	2032	3712	2988	1081	4296	2305
Lead, Pb (mg/kg)	4.8	<0.001	0.51	42	15	0.54	16	6.4
Copper, Cu (mg/kg)	4.6	2.0	1.73	20	5.8	0.22	115	10
Zinc, Zn (mg/kg)	26	3.1	3.41	9.9	6.9	2.83	100	20
Mercury, Hg (mg/kg)	<0.001	<0.001	0.0	0.0	<0.001	0.0	0.0	<0.001
Arsenic, As (mg/kg)	0.040	0.020	0.020	0.18	0.055	0.01	1.1	0.10
THC (mg/kg)	12	<0.01	0.0	0.0	<0.01	10	38	24
THB (CFU/g)	320000	1600000	290000	1500000	866667	240000	3100000	1310000
THF (CFU/g)	170000	1100000	120000	1600000	636000	80000	1700000	448125
HUB (CFU/g) x 103	0.80	0.50	0.30	0.80	0.62	0.20	1.1	0.68
HUF (CFU/g) x 103	0.50	0.30	0.10	0.50	0.33	0.10	1.0	0.39
Subsoil Samples (15-30cm)								
Sand (%)	82	81	78	86	82	76	87	80
Silt (%)	2.6	3.2	1.5	5.0	3.1	1.6	7.3	4.9
Clay (%)	16	16	12	18	15	12	18	15
Bulk Density (g/cm3)	1.4	1.4	1.2	1.4	1.3	1.2	1.4	1.3
Permeability (cm/sec)	0.15	0.16	0.15	0.17	0.16	0.10	0.17	0.15
Moisture Content (%)	15	14	17	22	19	10	21	17

Parameters	Control Samples		Soils within the Proposed Project Area			Soils within the Property AoI		
	CX1	CX2	Min	Max	Ave	Min	Max	Ave
Porosity	0.40	0.40	0.39	0.41	0.40	0.37	0.41	0.39
pH	5.0	5.0	3.7	5.1	4.0	3.7	5.4	4.5
Sulphide, S2- (mg/kg)	<0.01	<0.01	0.0	0.0	<0.01	0.0	0.0	<0.01
Sulphate, SO42- (mg/kg)	0.0	0.0	0.0	3.0	1.5	0.0	3.0	1.0
Nitrate, NO3- (mg/kg)	<0.01	0.10	0.10	0.80	0.42	0.10	1.0	0.38
Phosphate, PO43- (mg/kg)	0.10	0.12	0.070	0.72	0.33	0.020	0.68	0.22
Manganese, Mn (mg/kg)	67	12	41	130	89	6.0	146	44
Vanadium, V (mg/kg)	<0.001	<0.001	0.040	0.060	0.050	0.020	0.12	0.07
Nickel, Ni (mg/kg)	<0.001	<0.001	0.060	1.2	0.71	0.090	2.5	1.0
Chromium, Cr (mg/kg)	7.3	3.0	1.5	6.4	4.2	1.1	13	3.2
Iron, Fe (mg/kg)	2835	1198	1789	4220	3451	1362	3875	2381
Lead, Pb (mg/kg)	2.8	57	0.30	19	7.3	0.30	6.7	2.9
Copper, Cu (mg/kg)	4.4	25	2.0	10	4.6	0.20	23	3.6
Zinc, Zn (mg/kg)	28	3.1	2.3	8.5	5.8	1.8	55	11
Mercury, Hg (mg/kg)	<0.001	<0.001	0.0	0.0	<0.001	0.0	0.0	<0.001
Arsenic, As (mg/kg)	0.040	0.23	0.020	0.090	0.043	0.010	0.22	0.036
THC (mg/kg)	7.7	<0.01	0.0	0.0	<0.01	4.3	25	15
THB (CFU/g)	210000	1000000	180000	330000	250000	100000	1700000	451250
THF (CFU/g)	60000	140000	40000	130000	90000	20000	1000000	165000
HUB (CFU/g) x 103	0.40	0.30	0.10	0.60	0.43	0.10	0.70	0.35
HUF (CFU/g) x 103	0.30	0.10	0.10	0.40	0.22	0.10	0.60	0.19

Overall, the soils are slightly to strongly acidic with soil pH values ranging between 3.6 – 4.9 within the Project Area; between 3.1 – 5.5 within the Study Area; and between 4.6 – 5.5 within the control samples. Soil pH value is a measure of the free hydrogen ion (H+) concentration of soil solution. The value of the free H+ concentration in a soil influences the availability of nutrients and biochemical reactions in the soil. In strongly acidic soils, basic cation uptake by plants roots is inhibited and phosphorus fixed due to its low solubility at low pH. In addition, important soil microorganisms can also become affected by soil acidity. Soil reaction is thus important for nutrients availability for plants uptake.

The soil pH values at each of the sampling location are presented in Figure 7-24.

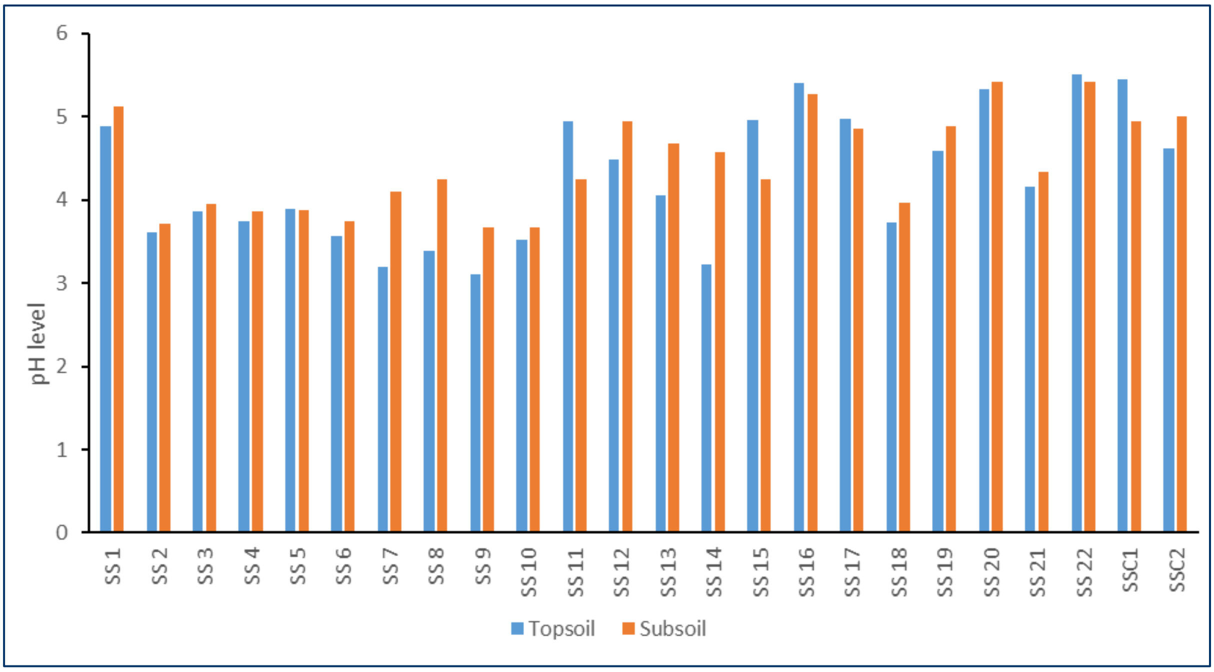


Figure 7-24 Distribution of Soil pH Values

The phosphate concentrations within the soils range between 0.070 – 0.96 mg/kg within the Project Area; between 0.020 - 0.75 mg/kg within the Study Area; and between 0.10 – 0.25 mg/kg within the control samples. The very low concentration of phosphate in the Project Area could be as a result of high soil acidity as recorded during this study.

As with phosphate, low sulphate concentrations are typical ranging between 0.0 – 5.0 mg/kg within the Project Area; between 0.0 – 4.0 mg/kg within the Study Area; and between 0.0 – 1.0 mg/kg within the control samples. Most soil sources of sulphur are in the organic matter (proteins, nucleic acids, and lipids) and are concentrated in the surface soil. Elemental Sulphur is not available to crops as they must be converted to the sulphate (SO_4^{2-}) form to become available. This conversion is performed by soil microbes (sulphur oxidising bacteria) and therefore requires soil conditions that are warm, moist, and well drained to proceed rapidly. The Sulphur form of S is an anion (negative charge), and therefore is leachable. Elemental sulphur concentrations were, however, found to be below the laboratory detection limits.

Hydrocarbon concentrations were assessed through Total Hydrocarbon Content (THC). THC concentrations were not detected within the soils in the Project Area, however concentrations of between 4.3 – 38.4 mg/kg were detected within the soils in the Study Area and up to 12 mg/kg within the control samples. The origin of the elevated THC concentrations observed are likely to be due to anthropogenic activities.

In terms of the heavy metals, concentrations of manganese, nickel, chromium, copper, and zinc were commonly detected within the soils collected from the Project Area and the Study Area, as well as from the control samples. The presence of heavy metals concentrations could be as a result of the low pH of the soils resulting in more favourable mobilisation of the metals, as opposed to more neutral or alkaline conditions.

Heavy metals are chemical substances that are required in trace or very small concentrations in soils for plants growth. However, these elements can become hazardous to humans and animals if absorbed in the food chain even in small concentrations as they usually can become biomagnified. The concern over the presence of heavy metals within the soils arises from the fact that they cannot easily be broken down into non-toxic forms. Thus, once ecosystems are contaminated by heavy metals; they remain a potential threat for many years.

The mean distribution of heavy metals within the topsoil and subsoil samples are indicated in Figure 7-25.

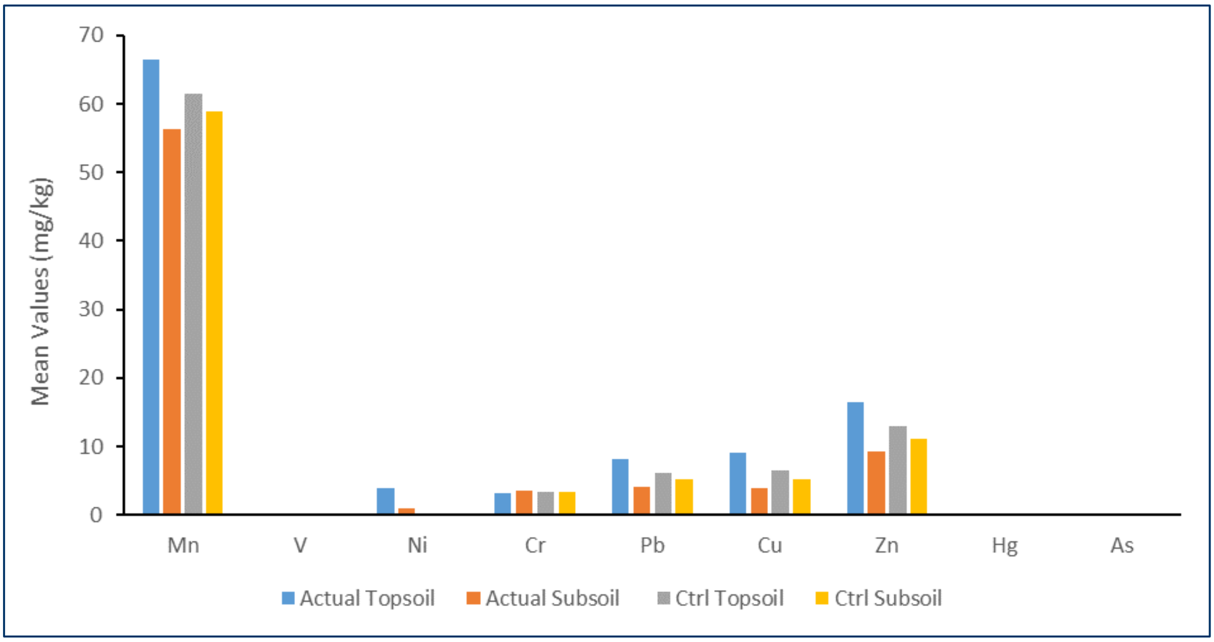


Figure 7-25 Mean Distribution of Heavy Metal Concentrations within the Soil Samples

In terms of the microbiological constituents within the soils, the sampling results (presented in Table 7-16) indicate the presence of total heterotrophic bacteria (THB) across all sampling areas including the control samples. THB counts ranged between 1.3 – 4.3x10^5 cfu/g within the topsoil, and between 1.0 – 3.3 x10^5 cfu/g within the subsoil samples.

Furthermore, hydrocarbon utilizing bacteria (HUB) population ranged from 0.2 – 1.1 x 10^3 cfu/g within the topsoil and 0.1 – 0.7 x 10^3 cfu/g within the subsoil. Total heterotrophic Fungi (THF) ranged from 0.1 – 2.6 x 10^5 cfu/g within the topsoil and 0.2 – 1.3x10^5 cfu/g within the subsoil. Hydrocarbon utilising Fungi (HUF) population ranged from 0.1 – 1.0 x 10^3 cfu/g within the topsoil and 0.1 – 0.6 x 10^3 cfu/g within the subsoil.

It is noted that in general, the population of THB and HUB were slightly higher in the soil surface (topsoil) than the subsurface (subsoil) most likely due to higher concentration of oxygen and organic matter at the soil surface. The HUB accounted for about 1% of the heterotrophic species, indicating non-pollution from petroleum sources. It is also noted, based on historical sampling across the Project Area, that the population of bacteria was generally higher in the wet season that then dry season, most likely due to more availability of oxygenated water in the pores of the soil during the wet season.

7.4.6.5 Land Use

Land use changes occur constantly and at many scales and can have specific and cumulative effects on air and water quality, watershed function, generation of waste, extent and quality of wildlife habitat, climate, and human health.

A regional land use study covering the greater Eleme Local Government Area (LGA) has been performed. Table 7-17 presents the land changes within the Eleme LGA based on a survey carried out between 2006 and 2019. It is no surprise that as the population has grown over the period 2006 – 2019, the largest change in land use has been the built-up area (increasing from approximately 19km^2 in 2006 to 49km^2 in 2019). Figure 7-26 shows how the built-up area has expanded between 1986 and 2015. The increase in built-up land area has resulted in a decrease in land area covered by vegetation from approximately 93 km^2 in 2006 to 60 km^2 in 2019 (combine light and thick vegetation area).

Table 7-17 Population Growth and Land Use Change trend (2006 – 2019)

Year	Population Growth	Built-up Area (km^2)	Farmland (km^2)	Light Vegetation (km^2)	Thick Vegetation (km^2)	Water Body (km^2)
2006	6,273	18.67	24.3	76.79	16.09	2.25
2007	6,467	20.805	24.653	75.213	15.146	2.105
2008	6,686	23.12	25.006	73.636	14.202	1.96
2009	6,914	25.435	25.359	72.059	13.258	1.815
2010	7,149	27.75	25.712	70.482	12.314	1.67
2011	7,392	30.065	26.065	68.905	11.37	1.525
2012	7,643	32.38	26.418	67.328	10.426	1.38
2013	7,903	34.695	26.771	65.751	9.482	1.235
2014	8,172	37.01	27.124	64.174	8.538	1.09
2015	8,450	39.325	27.48	62.59	7.594	0.945
2016	8,737	41.64	27.83	61.013	6.65	0.8
2017	9,034	43.955	28.183	59.436	5.706	0.655
2018	9,341	46.27	28.536	57.859	4.762	0.51
2019	9,659	48.585	28.889	56.282	3.818	0.365

Source: Obende et al. 2020

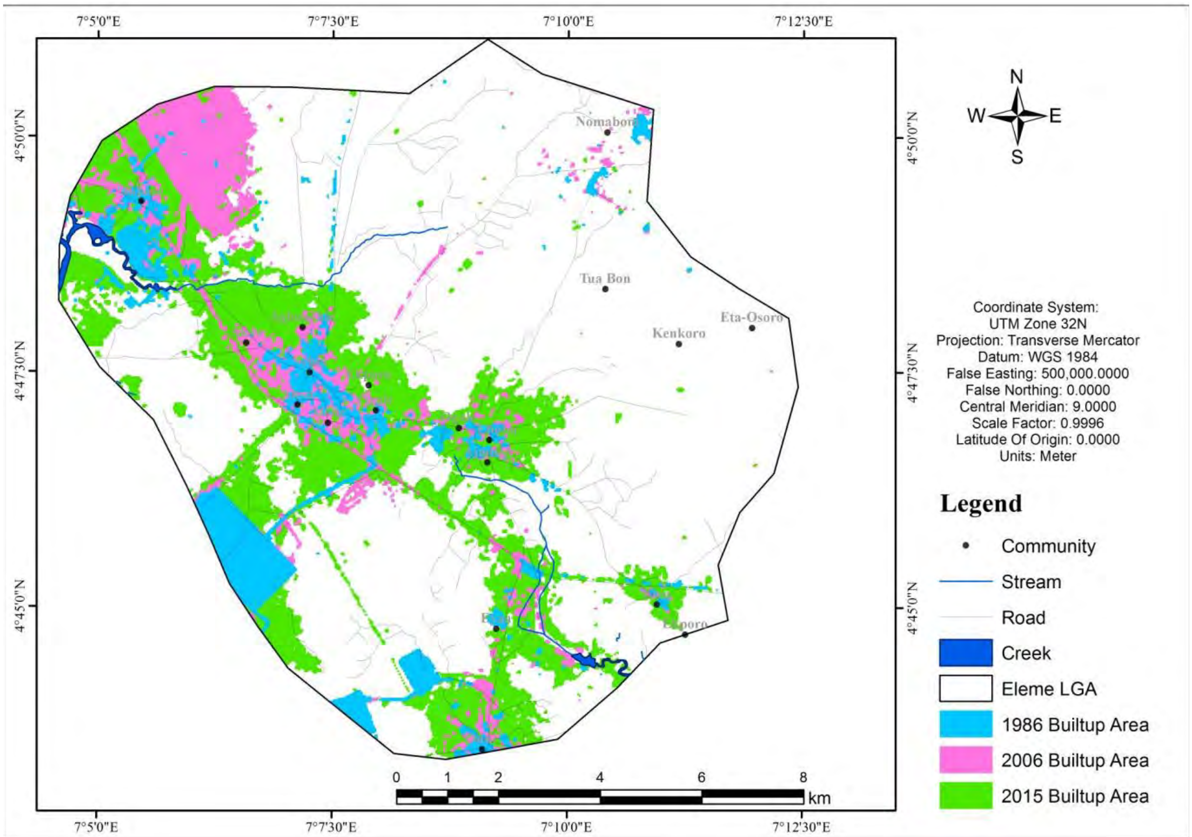


Figure 7-26 Distribution of the Built-up Area within the Eleme LGA (1986 – 2015)
Source: Obende et al. 2020

A breakdown of the primary land uses in the Eleme LGA is presented in Table 7-18. It is evident from the field observations made that in 2019, residential made up the largest percentage (50%) of the land use, followed by industry covering approximately 35% of the area.

Table 7-18 Observed Land Use Pattern within the Eleme LGA

Land use	Percentage
Residential	50%
Industry	35%
Agriculture	10%
Undistributed forest	5%
Habitat protected area	0%

7.4.7 Groundwater

7.4.7.1 Hydrostratigraphy

On a regional scale, the bulk of groundwater in the Niger Delta is contained in very thick and extensive sediments of the Benin Formation. In general, the hydrogeological data in the upland areas of the Niger Delta have very broad similarities not only on the sub-surface lithology but also in the overall aquifer characteristics. The exploited aquifers in the Niger Delta including the Greater Port Harcourt are derived from the Benin Formation (The Coastal Plain Sands). The Benin Formation comprises a very thick layer (>2 000 m) of unconsolidated sediments. The sand sediments of Benin Formation are intercalated with layers of clay, and this has given rise to a multi layered aquifer system, which is a common feature of the Niger Delta.

Based on geophysical and borehole data collected over the years the Niger Delta hydrogeological set up can be classified into the following broad hydrogeological units:

- Impermeable / semi-permeable horizons from ground level to 10 m below ground level (mbgl).
- A highly permeable gravel / sand layer up to 80 mbgl.
- A permeable sand / gravel layer with thin impermeable / semi-permeable clay/silt layers from 80 to 225 mbgl.

Based on the information obtained from the geological logs of the boreholes drilled in the Project Area, the primary aquifer locally is regarded as being a shallow, unconfined aquifer comprising stratified medium to coarse sand with grain size increasing with depth. These lithologies are indicative of reasonably high permeability which increases with depth (associated with the increasing grain size). The thickness of this shallow sandy aquifer layer ranges between 14 – 19 m across the Project Area and is underlain by a clayey sand, which has a thickness between 9.0 – 13 m.

Given the relatively high permeability of the shallow, unconfined aquifer, as well as the shallow depth to groundwater (<7.5 m), the aquifer is a sensitive receptor towards potential contamination from surface sources.

A second, slightly deeper aquifer, is found within the coarse-grained sands and coarse to gravelly sands which extend from 32 – 70 mbgl across the Project Area. The two aquifers are regarded as being separated by the clayey sand formation.

The main source of recharge to the aquifers of the Niger Delta is through direct precipitation where annual rainfall is as high as 3,000 mm (Amajor and Ofoegbu, 1988; Ojo *et al.,* 1992). The rainwater infiltrates through the highly permeable sands of the Benin Formation to recharge the unconsolidated aquifers. It is estimated that groundwater recharge across the Niger Delta ranges between 300 – 400 mm/a (Abam and Nwankwoala, 2020), which equates to approximately 8 – 12% of the Mean Annual Precipitation (MAP).

The thick sands, shallow water table, high rainfall, and the permeable nature of the aquifers in the area are good evidence for a sustainable groundwater supply that can be exploited. Any groundwater abstraction should, however, be closely monitored to ensure groundwater is abstracted sustainably.

7.4.7.2 Groundwater Monitoring

Groundwater monitoring within the Study Area is necessary, as it provides an overview of groundwater conditions, enables the establishment of baselines, identifies potential trends in groundwater quality, and as well facilitates long-term groundwater quality assessments.

The groundwater sample collection and laboratory analysis methodologies were undertaken in line with the following standard references:

- *Environmental Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN) issued by DPR. Third Edition (2018).* These guidelines provide field sampling guides and approaches for environmental sampling activity for environmental assessments in Nigeria.
- *APHA (American Public Health Association) 2005.* Standard method for the examination of water and wastewater 21st edition, Washington DC. This methodology provides test procedures specifically for the examination of a wide spectrum of parameters in water and wastewater.

The results of the groundwater chemical analyses were compared against the following guidelines:

- *Nigerian Standard for Drinking Water Quality (NSDWQ)*. The standard sets parameters and maximum allowable limits in drinking water in Nigeria. It also includes normative references / laws guiding drinking water quality, definition of terminologies, institutional roles and responsibilities, monitoring, data management and compliance criteria.

Three boreholes have been drilled within the Project Area for groundwater monitoring purposes (i.e. collection of groundwater samples for physico-chemical analysis, as well as for groundwater level measurements to determine groundwater flow directions).

In addition to the three newly drilled boreholes, 10 boreholes were identified within the Study Area, which include one borehole situated within the existing Indorama Complex, seven boreholes within the surrounding communities and two situated outside of the Study Area in order to obtain regional groundwater qualities. These monitoring boreholes are listed in Table 7-19 and their locations are illustrated on Figure 7-27.

It is noted that the groundwater monitoring network includes borehole situated upstream, within and downstream of the Project Area.

Table 7-19 Boreholes Included in the Monitoring Network

Station	Sample Location Description	GPS Coordinates	
		North (N)	East (E)
GW1	Within Indorama complex (In-front of Off-site control room)	4°50’04.50”	7°06’30.50”
GW2	Axis of Iriebe Community	4°51’51.00”	7°06’47.00”
GW3	Agbonchia Community	4°48’12.00”	7°07’04.00”
GW4	Aleto Community	4°48’40.00”	7°06’09.80”
GW5	Akpajo Community	4°49’44.50”	7°05’17.60”
GW6	Elelenwo Community	4°50’15.00”	7°04’43.00”
GW7	Nguru Community	4°48'14.65"	7° 07'13.96"
GW8	Okerewa Community	4°48'22.77"	7° 06'26.71"
B1/GW9	Within precincts of proposed project area (new project site)	4°50'36.7"	7° 06'32.7"
B2/GW10		4°50'18.9"	7° 06'51.7"
B3/GW11		4°50'10.93"	7° 06'36.18"
GWC1	Rumukrushi	4°50’31.00”	7°03’38.00”
GWC2	Ogale	4°47’54.00”	7°07’05.00”

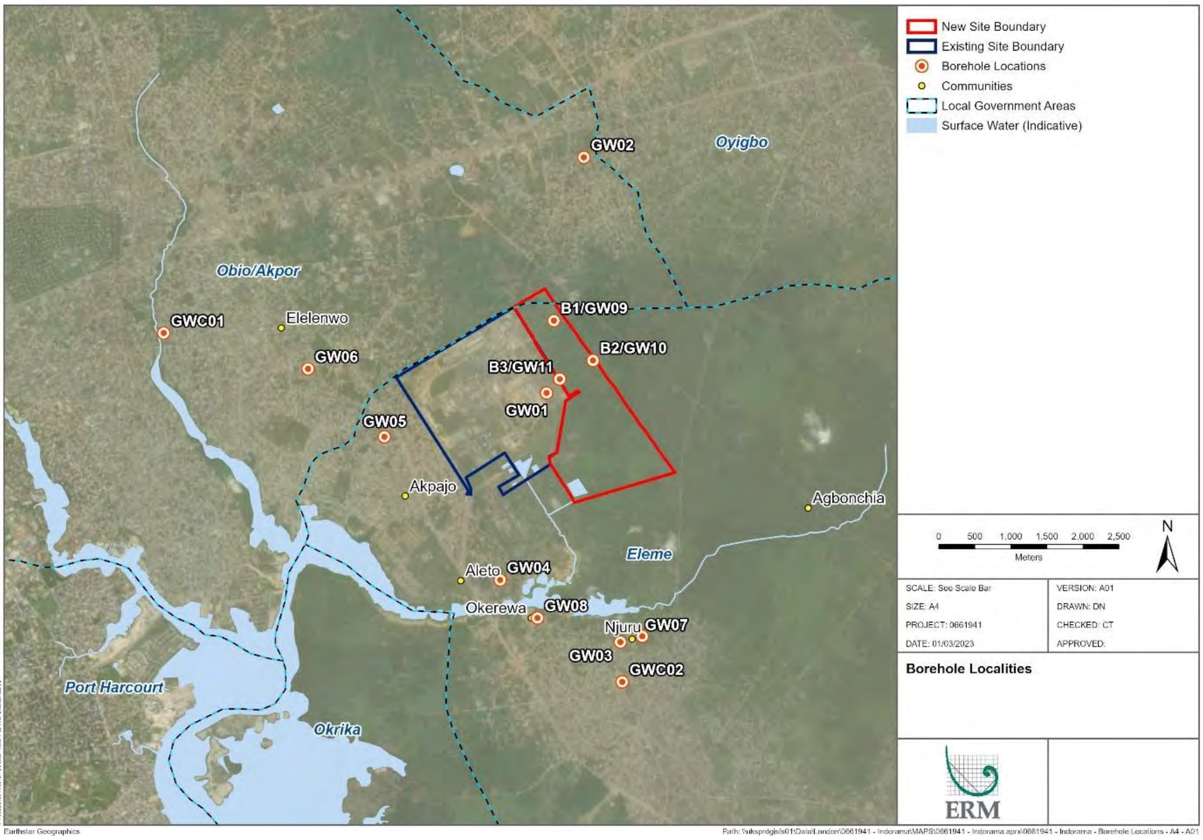


Figure 7-27 Borehole Localities

7.4.7.3 Groundwater Levels and Flow Directions

Groundwater level measurements were obtained from the three boreholes situated within the precincts of the Project Area (B1/GW9, B2/GW10 and B3/GW11) and are summarised in Table 7-20.

The local groundwater levels are relatively shallow, ranging between 6.4 – 7.4 mbgl (16.8 – 17.4 mamsl). The highest groundwater level / hydraulic head is found around B1/GW09 (17.4 mamsl) located North of the Project Area, whereas the lowest groundwater level / hydraulic head is found at borehole B3/GW11 (16.8 mamsl) to the southwest. The localised groundwater flow direction is therefore in a southerly to south-westerly direction across the Project Area, as presented on the triangular plot on Figure 7-28.

The groundwater flow direction therefore follows topography, which is generally from north to south across the Project Area. This is typical for shallow, unconfined aquifers, such as the one underlying the Project Area.

Table 7-20 Measured Groundwater Levels from the Boreholes in the Project Area

Borehole ID	Surface Elevation (mamsl)	Depth to Water Level (mbgl)	Groundwater Level (mamsl)
B1 / GW09	24.8	7.4	17.4
B2 / GW10	24.0	6.8	17.2
B3 / GW11	23.2	6.4	16.8

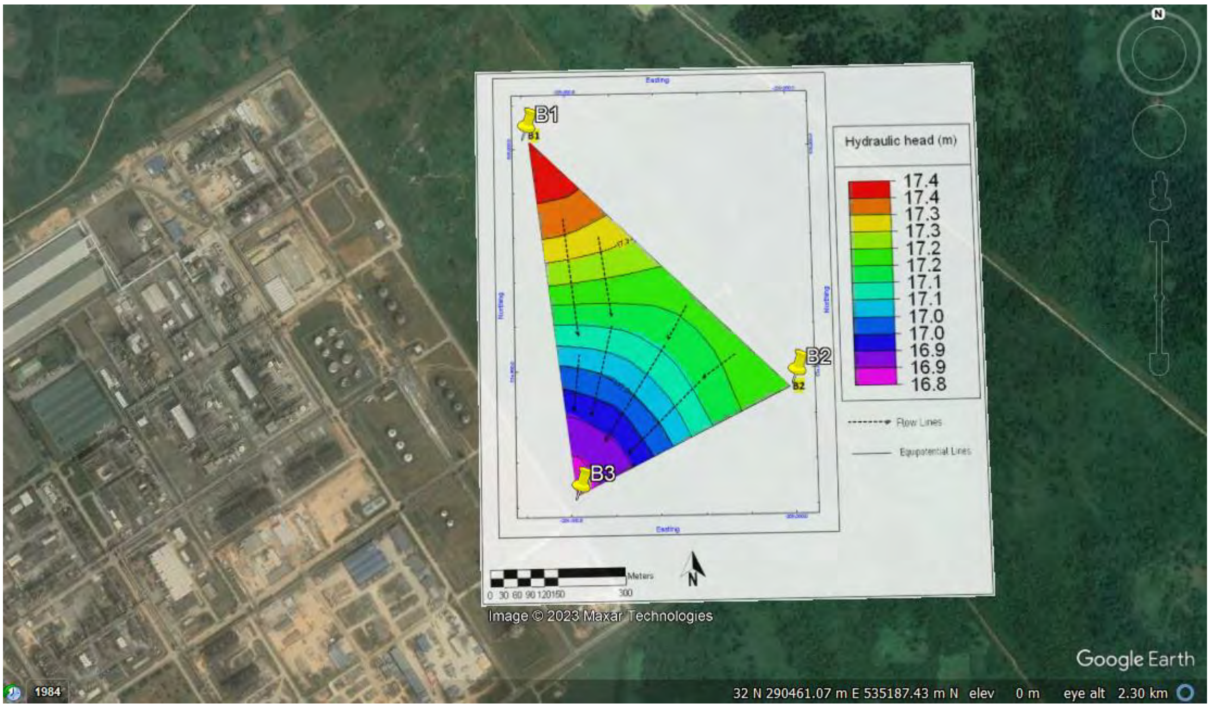


Figure 7-28 Groundwater Elevation Map showing the Direction of Groundwater Flow across the Project Area

7.4.7.4 Groundwater Chemistry

Baseline groundwater quality sampling was performed as part of a wet season infield baseline data study campaign undertaken by ECSL appointed by IEFCL in October 2021, during which groundwater samples were collected from each of the boreholes listed in Table 7-19. The samples were submitted to M/s Anal Concept Limited, an FMEnv accredited laboratory situated in Port Harcourt, Nigeria for physico-chemical analysis.

The sampling methodology applied in the field as well as the results of the analyses are discussed in the following sections.

Groundwater Chemistry Results

The results of the groundwater sample analysis are presented in Table 7-21. The groundwater chemistry results have been compared against the limits set out in the Nigerian Standard for Drinking Water Quality (NSDWQ).

In general, the quality of the groundwater within the Study Area is found to be good, with almost all of the analysed parameters being within the acceptable drinking water limits set out in the NSDWQ. The average electrical conductivity value across the Study Area is 105 µS/cm, with values ranging between 15 – 400 µS/cm. Low concentrations of the major anions (bicarbonate, chloride, sulphate, phosphate, nitrate) and cations (sodium, potassium, calcium, magnesium) are present, all at concentrations below the NSDWQ limits. Furthermore, heavy metal concentrations are found to be below the laboratory detection limits, the only exception being iron content which is characteristic of groundwater in the Niger Delta region.

pH values are, however, slightly low (acidic) with 11 of the 13 boreholes sampled having pH values that are below the drinking water limits set out by the NSDWQ. It is understood that the groundwater in the Niger Delta is slightly acidic due to presence of dissolved carbon dioxide.

Microbiological constituents such as coliforms and heterotrophic bacteria were also detected within the groundwater in the Project Area. Digestion of these constituents by humans could lead to adverse health effects and should thus be closely monitored going forward.

Overall, the quality of the groundwater within the Project Area is similar to that of the off-site / regional groundwater quality with no significant differences being observed. Both are characterised by slightly acidic waters with concentrations of inorganic constituent and metal concentrations. Total coliforms were, however, detected within each of the boreholes situated within the Project Area, whereas, only 1 of the 10 regional / off-site boreholes had Total Coliforms detected.

7.4.7.5 Groundwater Users

Groundwater in the Study Area is mainly used for domestic purposes such as drinking, cooking, bathing, and washing whereas a few industries operating in the area use the groundwater for industrial purposes. Groundwater use for irrigation in the study area is very limited because of fallow farming (a farming technique in which arable land is left without sowing for one or more vegetative cycles) and prolonged raining season.

It is understood that as the Project commences, groundwater will be sourced (as the sole source of water) for the Project. During normal operation, the total requirement of raw water sourced through production boreholes will be approximately 710 m^3/hr. The wastewater recovery plant is designed to treat 580 m^3/hr of wastewater with a recovery of 522m^3/hr (90%). With the installation of water recovery plant, the net raw water consumption to be sourced from production boreholes will be 190m^3/hr.

Table 7-21 Groundwater Chemistry Results

Parameter(s)	NSDWQ Limits	Regional / Off-site Boreholes within the greater Study Area										Boreholes within the Project Area		
		GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GWC1	GWC2	B1/GW9	B2/GW10	B3/GW11
pH	6.5-8.5	6.6	6.2	6.2	6.8	6.2	6.2	6.2	6.2	6.2	6.1	6.0	6.0	5.5
Appearance	NS	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Temperature (°C)	NS	27	29	29	28	27	28	27	28	28	27	26	27	27
Elect. Cond. (µS/cm)	1000	112	70	400	324	100	48	15	91	30	24	45	58	47
TDS (mg/l)	500	57	34	200	162	51	24	8.0	45	15	12	25	32	26
Bicarbonate (mg/l)	NS	27	29	30	27	21	19	28	25	19	24	27	23	25
Turbidity (NTU)	5.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
TSS (mg/l)	NS	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Total Hardness (mg/l)	150	9.0	11	28	31	16	8.0	2.0	12	22	14	14	15	14
Alkalinity (mg/l)	NS	16	12	12	20	12	12	14	16	14	12	12	14	10
Chloride, Cl^-(mg/l)	250	6.0	14	27	27	22	7.0	4.0	15	14	26	10	10	12
Sulphate, SO_4^{2-} (mg/l)	100	1.2	2.0	4.0	3.0	2.0	2.0	1.0	1.8	2.0	2.0	2.0	3.0	2.0
Phosphate, PO_4^{3-} (mg/l)	NS	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Nitrate, NO_3^-(mg/l)	50	0.13	0.80	1.2	1.0	0.64	0.62	0.10	0.30	0.70	0.60	0.24	0.27	0.22

Parameter(s)	NSDWQ Limits	Regional / Off-site Boreholes within the greater Study Area										Boreholes within the Project Area		
		GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GWC1	GWC2	B1/GW9	B2/GW10	B3/GW11
Cyanide (mg/l)	0.010	<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
Silica (mg/l)	NS	13.7	12.8	10.9	7.9	8.9	9.8	6.9	8.8	11.2	14.8	11.9	13.2	12.7
DO (mg/l)	NS	3.0	2.5	3.0	3.0	2.1	2.3	3.1	3.0	2.1	2.8	3.1	3.2	3.0
BOD (mg/l)	NS	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	0.71	0.92	<1.00	<1.00	<1.00
COD (mg/l)	NS	1.8	1.3	1.7	1.8	1.3	1.5	<1.00	1.6	1.1	1.4	2.0	1.9	2.0
Sodium, Na (mg/l)	200	6.2	9.8	12	15	13	8.4	8.3	11	8.2	14	6.3	5.3	6.4
Potassium, K (mg/l)	NS	1.7	2.31	0.54	0.28	1.53	0.29	0.49	1.14	0.33	2.45	1.2	1.38	1.33
Iron, Fe (mg/l)	0.30	0.060	<0.01	<0.01	<0.01	<0.01	0.10	<0.01	0.12	<0.001	<0.001	0.090	0.14	0.23
Calcium, Ca (mg/l)	NS	2.8	2.6	8.8	10	4.8	2.8	0.29	3.5	0.88	0.75	3.3	4.3	3.8
Magnesium, Mg (mg/l)	20	0.36	1.0	1.0	1.1	0.77	0.17	0.080	0.58	4.5	2.8	1.1	0.88	0.90
Zinc, Zn (mg/l)	3.0	<0.01	<0.01	0.050	<0.01	<0.01	0.060	<0.01	0.030	<0.001	<0.001	<0.01	<0.01	<0.01
Copper, Cu (mg/l)	1.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001	<0.01	<0.01	<0.01
Manganese, Mn (mg/l)	2.0	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001	<0.01	<0.01	<0.01
Chromium, Cr (mg/l)	0.05	<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
Lead, Pb (mg/l)	0.010	<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
Mercury, Hg (mg/l)	0.0010	<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

Parameter(s)	NSDWQ Limits	Regional / Off-site Boreholes within the greater Study Area										Boreholes within the Project Area		
		GW1	GW2	GW3	GW4	GW5	GW6	GW7	GW8	GWC1	GWC2	B1/GW9	B2/GW10	B3/GW11
Cadmium, Cd (mg/l)	0.0030	<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
Nickel, Ni (mg/l)	0.020	<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
Arsenic, As (mg/l)	0.010	<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
Total Coliform (MPN/100ml)	10	0	0	0	0	0	0	0	0	3.0	0	3.0	6.0	3.0
Faecal Coliform (MPN/100ml)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Plate Count (MPN/100ml)	NS	270	130	250	170	230	160	280	230	210	150	100	180	230
HUB (CFU/ml)	NS	30	NIL	10	NIL	30	400	10	20	Nil	Nil	0.40	0.20	0.20
HUF (CFU/ml) x 10^2	NS	0.10	NIL	NIL	NIL	NIL	0.1	NIL	NIL	Nil	Nil	0.20	0.10	NIL
THB (CFU/ml) x 10^2	NS	2.2	1.8	1.6	1.2	2.7	1.9	1.3	2.1	1.8	1.0	1.6	2.0	1.2
THF (CFU/ml) x 10^2	NS	0.80	0.20	0.90	0.20	0.60	0.70	0.40	1.0	0.40	0.20	0.70	1.1	0.40
*NS- Not Stated														

7.4.8 Surface Water

7.4.8.1 Introduction

This Section presents the baseline for surface water and has assessed the surface water resources and associated riverine sediments in the region of the Project. This Section also assesses the baseline condition of the existing treatment plant at the existing Indorama operations, in order to inform the baseline condition of the receiving environment.

The information presented in this Section draws on desk-based research including review of existing literature and wet season infield baseline surveys undertaken by ECSL appointed by IEFCL in October 2021. An additional location was sampled by ECSL appointed by IEFCL in last week of September during Biodiversity study and is also incorporated here.

The following information and sources were consulted during desk-based research of the surface water resources for the Study Area:

- Information supplied by IEFCL regarding existing water treatment processes;
- Published and available academic research and published reports of the region; and
- Publicly available spatial data including satellite imagery.

The October 2021 wet season survey identified relevant surface water resources around the Project site and their condition, identified sampling points and included sampling of surface water and riverine sediment for water quality aspects.

In addition, the field survey included an assessment of the existing water treatment processes at the existing Indorama Complex, and water quality samples were analysed from the relevant effluent pits, as the planned water treatment process is the same as the existing, and as such assessment of the existing provides an indication of the potential impact for water resources.

7.4.8.2 Surface Water Resources

Regional Setting

The Project is situated adjacent to the northeast boundary of the existing Indorama Complex in the Eleme LGA, approximately 20km from the capital city of Port Harcourt, Rivers State, within the coastal plains of the eastern Niger Delta basin. The site is on the eastern side of Port Harcourt, which was formed on the dry islands between the low-lying mangrove swamps that form part of the Bonny River delta, therein part of the broader Niger Delta basin (Lawal and Umeuduhi, 2017). The mainstem of the Niger River lies approximately 100 km west of the Project site.

The region between Port Harcourt and the Gulf of Guinea (open ocean lies approximately 45 km to the south of the city and the site) is further made up of swampy low-lying islands between a dense network of creeks, streams and wider rivers that form the Bonny River estuary. The Bonny River estuary is an important waterway for shipping and transportation of goods.

The Project Site itself is generally flat lying with topography typically around 15 mamsl. The topography reduces gradually towards the southeast of the Project site, where the Okulu River lies approximately 1.3km from the site. The Okulu River originates around 3 km east of the eastern site boundary, flowing in a south-westerly direction, and turning to flow from east to west to the south of the site. A channel originates within the existing Indorama Complex and flows in a southerly direction to join the Okulu River. The existing Indorama Complex discharges treated effluent mixed with storm water run-off through this channel, and the proposed IEFCL Train 3 Project intends to do the same, via canals shown in Figure 7-29.

The Okulu River flows west and joins the Akpajo and then Amadi creek, both of which are part and connected to the network of surface waters flowing south and forming the Bonny River system. The Bonny River system – and the connected Okulu River - is subject to tidal influences.

Drainage is poor in the wider region related to the low-lying land with significant rainfall, and many areas of Rivers State are tidally or seasonally flooded, limiting agricultural practices. River bank levees are prominent and valley side slopes are very gentle and prone to erosion and accretion.

Local (Site) Setting

Land use within Okulu River environs is largely residential and agricultural with vegetable farming and cattle grazing. Industrial activities include the existing Indorama complex and an abattoir processing facility (in the approximate region of SW3 (Onyeugbo *et al*, 2021). The river is not used for particular purpose, but community domestic waste is routinely dumped on the riverbanks. In addition to this, the Okulu River has been subjected to intense sand mining/dredging and other over several years this has significantly altered and widened the Okulu water course, causing it to become a tidal water body (compare satellite images for 2005 and 2022 in Figure 7-30). The channel flowing south from the current Indorama Complex to the Okulu River has also widened significantly over time. The commercial sand mining (through mechanical and manual means) had also resulted in high turbidity and regular bank collapses and ongoing erosion (Onyeugbo *et al*, 2021).

7.4.8.3 Surface Water Study Area

The Study Area from a surface water perspective has been approximately delineated and focusses on the immediate surroundings of the Project Area that have the potential to be most impacted by proposed activities. There is however a potential for contamination events to have impact beyond this area if transported downstream. The Study Area is delineated as follows:

- The area is based on a 5 km circular radius of influence, the centre of which is beyond the south of the Project Area to account for the surface water flow direction towards the south.
- The area is cropped around 200 m south of the Okulu Riverbank.

Due to the tidal nature of the Okulu River, any contamination of surface water due to proposed site activities that reaches the Okulu River from the channel, may be transported upstream (east).

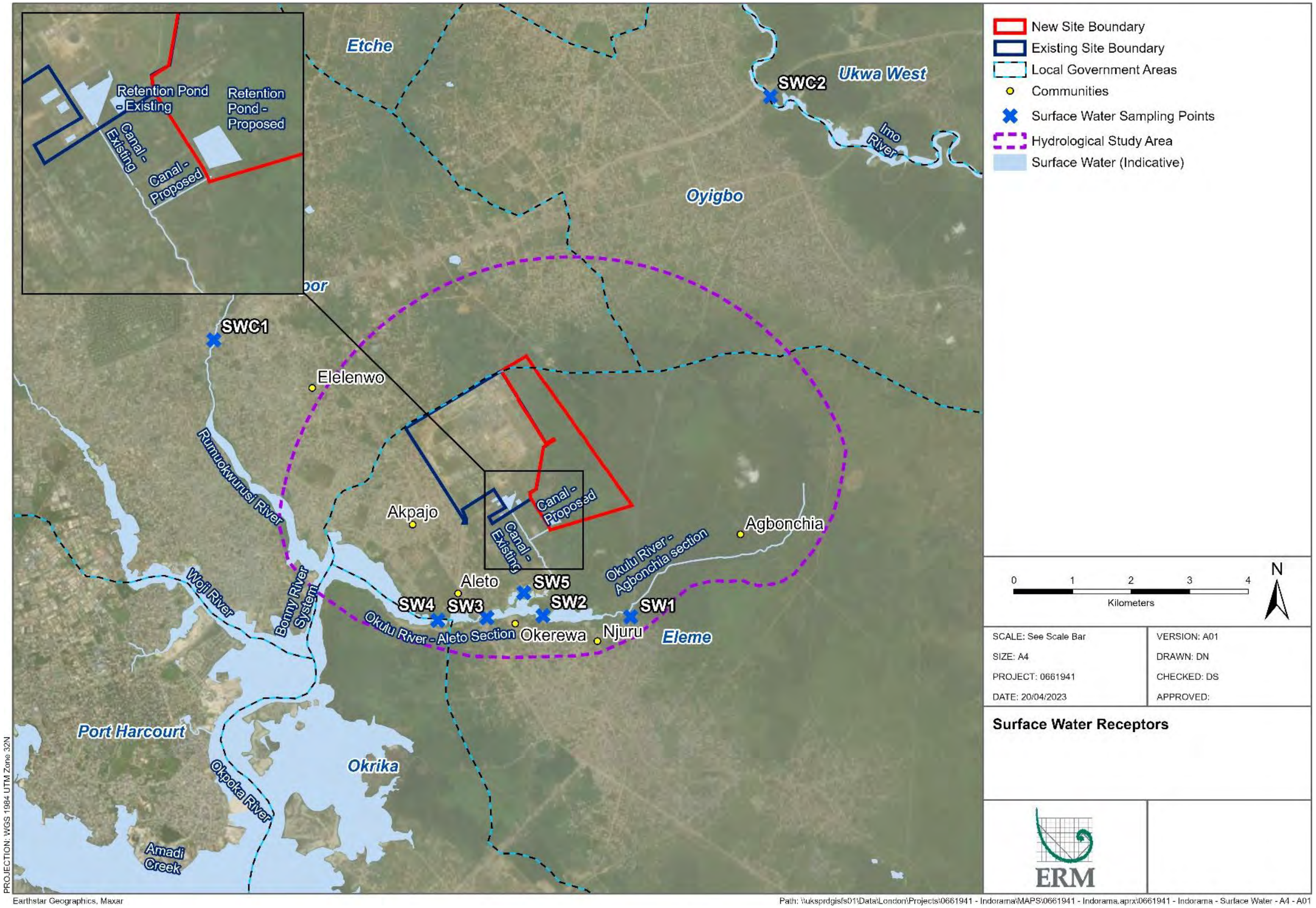


Figure 7-29 Project Area of Influence showing Surface Water Features of Interest and Surface Water Sampling Sites

Figure 7-30 Satellite Images for 2005 (top) and 2022 (bottom) for Identical Locations, showing the Area between the Southern Boundary of the Proposed Site and the Okulu River

7.4.8.4 Water Treatment Process

Introduction

Chapter 4 of this ESIA provides and overview of the water treatment process in the context of the proposed IEFCL Train 3 Project. As previously mentioned, IEFCL-Train 3 will have its own dedicated effluent treatment facilities and infrastructure. The treatment scheme and process, wastewater flows, and quantity will be identical to existing Train1 and 2.

Given that the existing water treatment process is operational and that the October 2021 wet season baseline survey included an assessment of the existing water treatment processes, it is important to provide an overview of the existing treatment process here.

Process

The process condensates generated in the ammonia and urea plants are routed to the condensate storage tank. The steam and turbine condensates are also routed to this condensate storage tank. The homogenized and mixed condensate is treated in polisher units to remove impurities. The purified water is recycled and used as boiler feed water. The effluent generated during regeneration of polisher resin is collected in a dedicated neutralisation pit, and after pH correction (if needed), transferred to the ammonia stripper. The stripped water is transferred to the ISBL treated effluent pit i.e. one each for each production line; named “IEFCL-Train1 ISBL Pit” and “IEFCL-Train2 ISBL Pit” for the existing two production lines.

The floor washing water from the urea synthesis section is collected in dedicate pits inside the urea plants and treated in the hydrolyser and stripper and then routed to ISBL treated effluent pit.

The ISBL treated effluent pit has a neutralisation facility for pH correction and a facility to improve the water quality by increasing dissolved oxygen concentration.

The treated effluent from the two ISBL treated effluent pits is routed to the equalisation pond by means of a closed overhead pipe line. The control valve installed at the up-stream end of the discharge pump is controlled and dependent on the pH of the discharged treated effluent. If the pH of discharged treated effluent is out of range (above 8.5 or less than 6.5), then the control valve automatically closes to stop the transfer of treated effluent to the equalisation pond. In such cases, the discharged treated effluent is recycled back to treated effluent pit by recycle line, illustrated in Figure 7-31.

Cooling tower blow down and neutralised regeneration effluent from the DM plant is also sent directly to the equalisation pond. The equalisation pond has neutralisation and recycling facilities. The homogenised treated effluent is transferred to holding ponds by gravity feed from the equalisation pond. After checking the quality of treated effluent at holding pond outlet, it is discharged to the retention pond. In the retention pond, it is further mixed with storm-water runoffs from the premises and discharged to Oluka Tributary after quality assurance (shown in Figure 7-29). The discharges from the Retention Pond are carried out intermittently, when the level is high.

It is estimated that under the current treatment process, with the three lines of fertiliser production implemented, approximately 740 m^3/hour (equivalent to 206 litres/second) of treated effluent is discharged to the retention pond (water balance shown in Figure 7-32).. With the addition of the third line, the treatment facility is planned to also incorporate a wastewater recovery plant, and the discharge of final treated effluent to the Retention Pond is expected to reduce to 275 m^3/hour (equivalent to 76 litres/second), as shown in Figure 7-33.

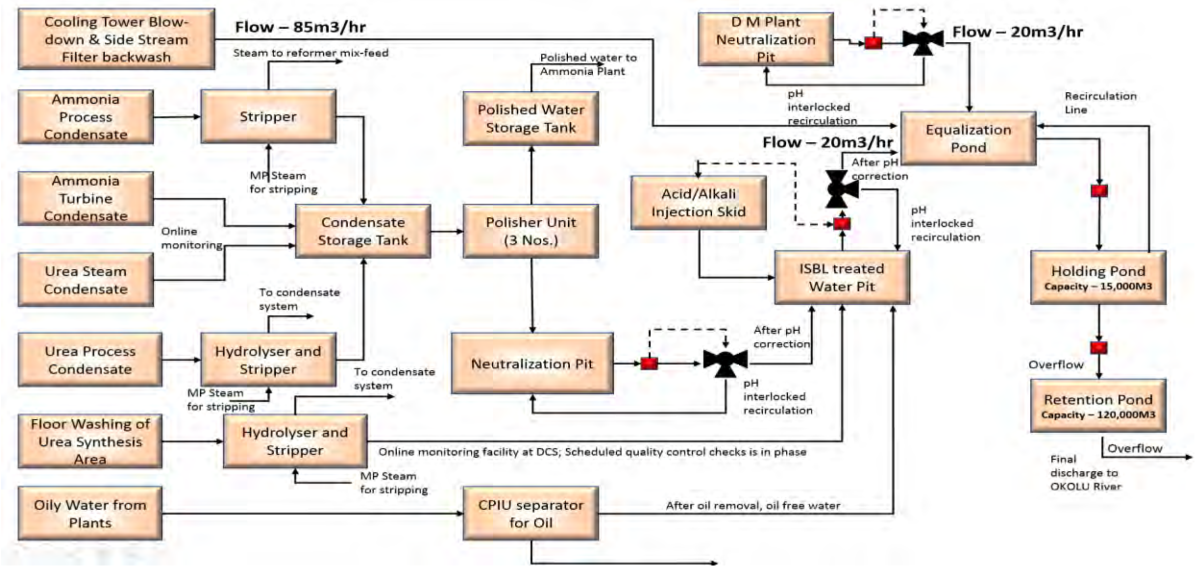


Figure 7-31 Process Flow Diagram illustrating Existing Water Treatment Process

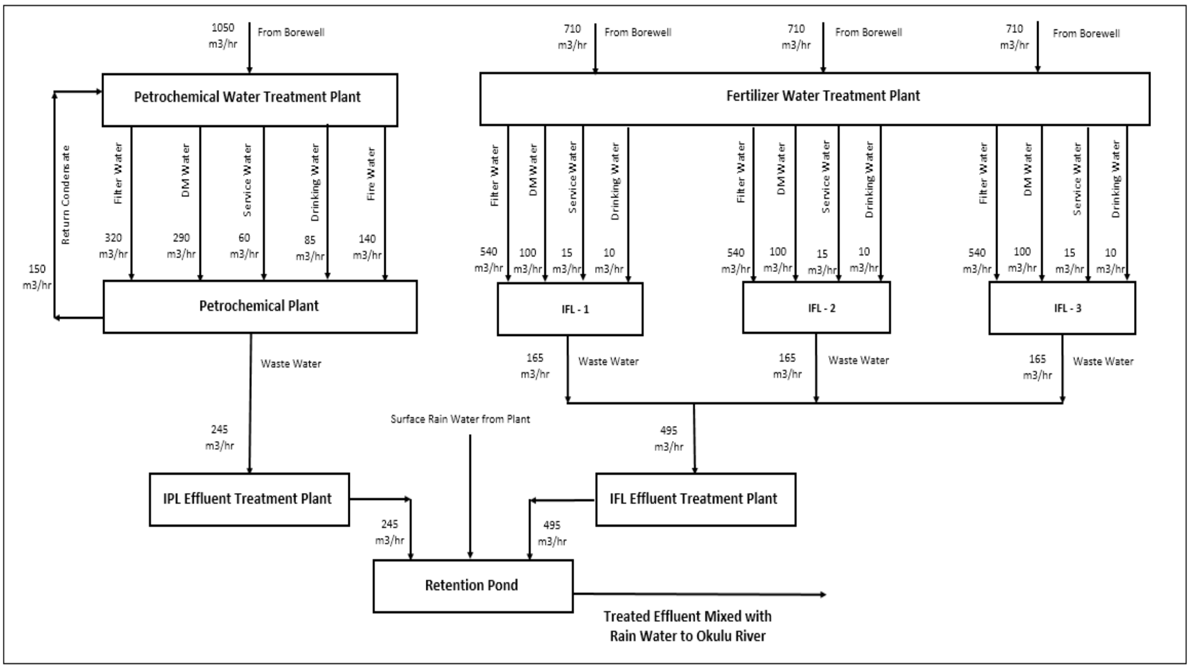


Figure 7-32 Process Flow Diagram illustrating Existing and Planned Water Treatment Process and associated Estimated Water Balance

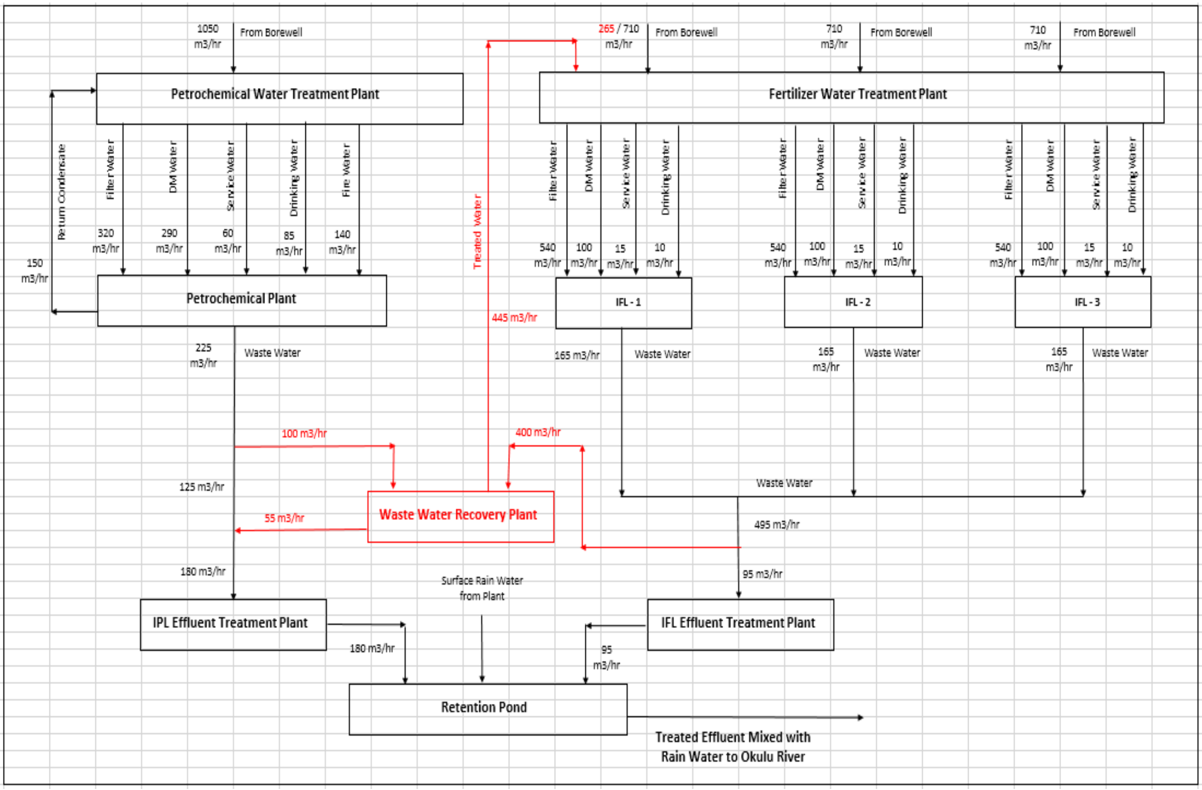


Figure 7-33 Process Flow Diagram illustrating Existing Water Treatment Process with Addition of Planned Wastewater Recovery Plant, and associated Estimated Water Balance

7.4.8.5 Field Survey Findings

Introduction

During the October baseline survey, four surface water sampling locations were identified in the Okulu River, and two additional sites were identified outside of the Study Area to reflect control sites (although on different rivers). A fifth surface water sampling location in the Okulu River was surveyed and incorporated in the baseline dataset. At each sampling location the physical characteristics of the site were described, and surface water quality and riverine sediment quality samples were taken for laboratory analysis.

The water treatment plant at the existing Indorama Complex was also included in the field surveys, as the existing and planned water treatment process is a key source of potential impact for water resources.

The surface water sampling locations were selected taking into account ecological features, geographical location of communities, and control points were selected outside of the Project environs. Sampling points were approximately in the middle of the section of the stream. The sites are shown in Table 7-22 and on Figure 7-29.

Table 7-22 Surface Water and Riverine Sediment Sampling Locations

Station	Location	GPS Coordinates	
		North (N)	East (E)
SW1	Okulu River - Agbonchia section (Near Road Bridge)	4°48'26.82"N	7° 7'27.75"E

Station	Location	GPS Coordinates	
		North (N)	East (E)
SW2	Okulu River - Aleto section (Near Pipeline ROW)	4°48'27.33"N	7° 6'39.19"E
SW3	Okulu River - Aleto section (Near E-W Expressway Bridge)	4°48'26.05"N	7° 6'8.12"E
SW4	Okulu River - Aleto section (Near NNPC housing)	4°48'24.55"N	7° 5'40.93"E
SW5	Okulu River – Aleto section (Outfall Area)	4°48'40.05"N	7° 06'28.55"
SWC1	Rumukrushi River	4°51'0.01"N	7° 3'36.45"E
SWC2	Imo River (Near Imo Gate)	4°53'16.17"N	7° 8'44.39"E

The sites that were sampled as part of the effluent sampling are shown in Table 7-23.

Table 7-23 Water Treatment Plant Sampling Locations

Station	Location	Description	GPS Coordinates	
			North (N)	East (E)
Eff1	IEFCL-Train1 ISBL Pit	Treated effluent pit of line fertiliser production line 1 located at north of existing site	4º50’22.33”	7º06’08.72”
Eff2	IEFCL-Train2 ISBL Pit	Treated effluent pit of line fertiliser production line 2 located at north of existing site	4º50’23.64”	7º06’08.71”
Eff3	IEFCL Holding Pond	Final (shared) holding pond located at south of existing site	4º49’30.79”	7º06’23.60”
Eff4	Retention Pond Sluice Gate	Final (shared) retention pond located at south of existing site	4º49’25.73”	7º06’20.52”

Physical Characteristics of Surface Water Features

The Okulu River is relatively shallow, typically around 4 m deep, with a large surface area compared to its depth. The Okulu River used to be a freshwater body with one directional flow towards the west, towards Amadi creek and the Bonny River System. Manual and mechanical sand mining has altered the depth and width to the extent that now the waterbody experiences two directional flows i.e., during high tide water flows from Amadi creek into Okulu stream (from west to east). The Okulu River therefore tends towards brackish conditions. There are no gauging stations on the river to quantify the flow rate or surface water availability in the river. Upstream of the Okulu River, around site SW1, the river is around 20m wide. This increases significantly to 230m at SW4 (Figure 7-29).

Surface Water Quality results

The water quality is influenced by geomorphology, geology, climatic and biological factors, as well as anthropogenic activities and the tidal influence. The results shown in Table 7-20 indicate the salty/brackish water condition in both low and high tide. The results illustrate:

- pH was slightly acidic for all stations sampled at low and high tide.
- The conductivity and TDS are high and increases at high tide, as would be expected. Related to the tidal influence, the concentration of sodium and chloride is also high.
- Turbidity and TSS is high, which may be related to sand mining activities.
- High BOD and COD values were observed across all sampled stations including the control stations, which may be related to the use of the shores as waste dumps and associated surface run-off in the Study Area. The results also indicate some microbiological contamination of surface waters as total and fecal coliforms are elevated, related to solid wastes and sewage that are released to the water bodies.
- Ammonium was detected in all Okulu River sites, and also the two control sites. The control sites pass urbanised areas and so may be impacted by effluent discharges. The Okulu River environs is used for farming and cattle grazing, which may impact ammonia; and the concentrations in the river are higher than in the treated effluent from the existing Indorama plant.
- Metal concentrations were low but above detection limits detected for:
  - Iron at all surface water sites including the control sites.
  - Magnesium, zinc, copper, only at the Okulu River sites (zinc was also detected at one control site).
  - Chromium was detected at one Okulu River sites sampling site.
  - Nickel was detected at SW5 (low and high tide) and also SW2 (high tide).

Notably; the maximum concentration of iron is lower in the treated effluent samples than in the Okulu River samples (0.19mg/l compared to 0.3 mg/l). The maximum magnesium concentration in the Okulu River is 56 mg/l, compared to a maximum of 1.47 mg/l in the treated effluent. The zinc concentrations are up to 0.22mg/l in the Okulu River, and at a similar level around 0.53mg/l and 0.37mg/l in the holding and retention pond respectively. Copper and nickel concentrations are below detection in treated effluent yet detected at (some of) the surface water sample sites. Whilst the degree to which the elevated metal concentrations in surface water are related to the natural underlying geology, verses anthropogenic impacts is uncertain, these results suggest, that the current effluent treatment is not significantly impacting the Okulu River. Additional future routine monitoring is required to investigate this. An additional sampling location is required on the Okulu River, much further upstream than where it is tidally influenced. i.e., at a location near its source due east of the proposed Project site, in order to provide a better control site for comparison of impact. This has been recommended as part of the post-ESIA monitoring plan.

Effluent Water Quality Results

*The Wastewater from the existing Indorama Complex is treated, homogenised and quality checked to ensure compliance with the regulatory limits, before discharge. The analytical results, and comparison with FMEnv water quality criteria for effluent discharges (*National Environmental Protection (Effluent Limitation) Regulation 1991, S.I. 8) *are shown in Sediment Quality Results*

The river sediments were also collected at the surface water sampling locations. The sediment quality is influenced by geomorphology, geology, climatic and biological factors, as well as anthropogenic activities and the tidal influence. The sediment quality results are shown in Table 7-21 indicate acidic nature of sediments that is peculiar to Niger Delta Region

Table 7-26 and shows:

- The pH of effluent samples ranges from 6.59 – 7.34, and all samples were within limits.

- In treated effluent samples collected Cadmium (Cd), Chromium (Cr), Lead (Pb), Copper (Cu), Nickel (Ni), Manganese (Mn) and Mercury (Hg), Silver (Ag) and Arsenic (As) were below detection limits whereas Iron, Calcium, Magnesium and Zinc were detected in low concentrations. All the heavy metal detected were below regulatory limits.

Table 7-24 Water Quality Sampling Results for Surface Water Sampling Locations for wet season October 2021

Parameters	SW1	SW2	SW 3	SW4	SW5	SW1	SW2	SW 3	SW4	SW5	SWC1	SWC2
Tide at time of sampling:	Low Tide					High Tide					n/a	n/a
pH	6.33	6.79	6.56	6.33	6.1	6.39	6.89	6.95	6.9	6.51	6.99	6.13
Temperature (°C)	25.5	27.3	27.7	25.5	26.9	25.5	27.4	27.1	27	27.2	27.8	26.2
Elect. Cond. (µs/cm)	230	4,927	7,501	9,350	2,290	260	5,050	8,870	9,860	2,520	1,080	480
TDS (mg/l)	131	2,428	3,813	4,753	1,330	140	2,550	4,445	5,130	1,287	540	242
Turbidity (NTU)	4.1	14	13.4	4.1	20.7	5.4	22.7	18	17.2	23.2	16.9	14
TSS (mg/l)	3.2	12.6	12.1	12.7	19.1	4.3	20.5	17.4	16.3	21.1	15.4	12.8
Total Hardness (mg/l)	12	452	536	690	-	16	528	624	816	-	36	12
Alkalinity (mg/l)	22	42	30	25	-	24	39	34	31	-	18	14
Chloride, Cl^-(mg/l)	8.7	637	815	1,088	-	9.2	780	986	1,228	-	60	18
Sulphate, SO_4^{2-}(mg/l)	3	42	42	34	-	3.2	35	52	64	-	1.5	0.2
Nitrate, NO_3^-(mg/l)	1.06	2.12	2.54	2.65	2.9	1.17	4.3	6.3	5.6	3.5	0.6	0.1
Phosphate, PO_4^{3-} (mg/l)	0.11	0.62	0.81	1.05	0.03	0.14	2.3	3.2	3.1	0.03	1.03	0.1
Cyanide (mg/l)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Ammonium, NH_4^+ (mg/l)	0.3	0.45	0.9	0.96	0.84	0.35	1.1	1.33	0.9	1.02	3.12	0.6
Total Nitrogen (mg/l)	2.14	6.88	7.24	7.98	-	2.25	7.74	8.15	8.78	-	8.76	2.26

Parameters	SW1	SW2	SW 3	SW4	SW5	SW1	SW2	SW 3	SW4	SW5	SWC1	SWC2
Tide at time of sampling:	Low Tide					High Tide					n/a	n/a
Urea (mg/l)	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10
Formaldehyde (mg/l)	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10	<0.10	<0.10	-	<0.10	<0.10
DO (mg/l)	5.66	6.8	6.49	5.66	5.5	3.35	5.57	5.67	5.12	5.58	6.46	5.06
BOD (mg/l)	11.2	13.8	14.2	16.6	10.3	12.4	12.8	10.8	11.6	13.8	16.8	8.2
COD (mg/l)	45.6	51.2	54	57.9	43	49.4	47	49.5	44	49.5	41.25	28.9
O & G (mg/l)	<1.00	<1.00	<1.00	<1.00	<1.00	<1.00	<0.01	<0.01	<0.01	<1.00	<1.00	<1.00
Sodium, Na (mg/l)	9.8	240	308	407	-	10.4	287	387	455	-	28.4	14
Potassium, K (mg/l)	1.9	16.2	26.3	38.4	-	1.9	18.3	25.4	42	-	4.81	0.38
Iron, Fe (mg/l)	0.19	0.22	0.2	0.24	0.43	0.27	0.21	0.25	0.3	0.294	1.62	1.06
Calcium, Ca (mg/l)	4.1	112.8	130.9	171.69	-	4.65	138.7	162.7	220	-	10.8	3.8
Magnesium, Mg (mg/l)	0.36	38.8	45.3	54.3	-	0.85	41.8	47	56	-	1.8	0.5
Zinc, Zn (mg/l)	0.03	0.09	0.13	0.22	0.02	0.06	0.09	0.01	<0.001	0.117	0.05	<0.001
Copper, Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	0.003	<0.01	0.06	0.11	0.08	0.075	<0.001	<0.001
Manganese, Mn (mg/l)	<0.01	<0.01	0.04	0.1	0.037	<0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Chromium, Cr (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Silver, Ag (mg/l)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001

Parameters	SW1	SW2	SW 3	SW4	SW5	SW1	SW2	SW 3	SW4	SW5	SWC1	SWC2
Tide at time of sampling:	Low Tide					High Tide					n/a	n/a
Lead, Pb (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Mercury, Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Cadmium, Cd (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel, Ni (mg/l)	<0.001	<0.001	<0.001	<0.001	0.041	<0.001	0.082	<0.001	<0.001	0.056	<0.001	<0.001
Cobalt, CO (mg/l)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Vanadium, V (mg/l)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Arsenic, As (mg/l)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Total Coliform (MPN/100ml)	200	600	400	120	-	200	640	420	260	-	≥2,400	≥2,400
Fecal Coliform (MPN/100ml)	34	64	40	75	-	34	50	35	70	-	≥2,400	460
Total Plate Count (MPN/100ml)	1.2 $\times10^2$	2.6 $\times10^2$	1.8 $\times10^2$	2.4 $\times10^2$	-	1.2 $\times10^2$	2.2 $\times10^2$	1.2 $\times10^2$	1.8 $\times10^2$	-	3.1 $\times10^2$	2.1 $\times10^2$
HUB (CFU/ml)	0.1 $\times10^2$	0.1 $\times10^2$	0.1 $\times10^2$	0.3 $\times10^2$	-	0.1 $\times10^2$	0.1 $\times10^2$	0.1 $\times10^2$	023 $\times10^2$	-	0.4 $\times10^2$	0.4 $\times10^2$
HUF (CFU/ml) x 10^2	NIL	NIL	NIL	0.1	-	NIL	NIL	NIL	0.1	-	0.1	0.3
THB (CFU/ml) x 10^2	1.1	2.6	1.2	2.7	-	1.1	2.1	1	1.5	-	2.8	1.9
THF (CFU/ml) x 10^2	0.1	0.1	0.3	0.6	-	0.1	0.1	0.2	0.3	-	1	1.1

Table 7-25 Results for River Sediment Quality Sampling

Parameter(s)	SED 01	SED 02	SED 03	SED 04	SED 05	SED Control-1	SED Control-2
pH	5.85	3.40	5.03	5.20	-	5.35	5.84
Sulphide, S^{2-} (mg/kg)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Sulphate, SO_4^{2-} (mg/kg)	2.00	25.0	10.0	17.0	-	<0.10	3.00
Nitrate, NO_3^- (mg/kg)	0.80	2.50	2.00	0.20	1.50	0.50	1.30
Phosphate, PO_4^{3-} (mg/kg)	0.15	1.67	0.68	0.10	0.25	0.10	0.27
THC (mg/kg)	<0.01	<0.01	<0.01	<0.01	3.70	<0.001	<0.001
Color	Brown	Black	Brown	Brown	-	Brown	Brown
Permeability (cm/sec)	0.14	0.13	0.12	0.13	-	0.15	0.16
Moisture Content (%)	18.7	15.3	19.7	21.5	-	17.68	21.6
Porosity	0.40	0.38	0.41	0.41	-	0.41	0.41
Bulk Density (g/cm^3)	1.54	1.27	1.43	1.35	-	1.17	1.18
Sand (%)	86.3	74.5	88.4	90.4	-	89.3	90.6
Silt (%)	3.48	4.91	1.92	1.89	-	1.8 0	2.71
Clay (%)	10.27	20.42	9.68	7.69	-	8.86	6.68
PSD	LS	SCL	SS	SS	-	NA	NA
Manganese, Mn (mg/kg)	0.53	5.59	<0.001	1.61	33.98	17.78	7.35
Vanadium, V (mg/kg)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001

Parameter(s)	SED 01	SED 02	SED 03	SED 04	SED 05	SED Control-1	SED Control-2
Nickel, Ni (mg/kg)	<0.001	<0.001	<0.001	<0.001	2.02	<0.001	<0.001
Chromium, Cr (mg/kg)	<0.001	1.89	<0.001	<0.001	2.38	<0.001	<0.001
Iron, Fe (mg/kg)	39.75	1,840.1	96.06	196.64	3938.4	745.4	451.7
Lead, Pb (mg/kg)	3.84	0.72	5.02	13.61	<0.001	12.97	<0.001
Copper, Cu (mg/kg)	<0.001	5.37	<0.001	<0.001	7.46	27.15	<0.001
Zinc, Zn (mg/kg)	0.44	3.33	3.08	1.82	61.69	28.3	3.99
Mercury, Hg (mg/kg)	<0.001	<0.001	<0.001	<0.001	-	<0.001	<0.001
Arsenic, As (mg/kg)	<0.01	0.02	<0.01	<0.01	-	<0.001	<0.001
THB (CFU/g)	3.2×10^5	1.1×10^6	2.8×10^5	2.4×10^6	-	1.5×10^6	2.0×10^5
THF (CFU/g)	1.0×10^5	0.7×10^6	1.2×10^5	1.9×10^6	-	0.8×10^6	0.4×10^5
HUB (CFU/g) x 10^3	0.6	0.2	0.6	1.0	-	0.3	0.5
HUF (CFU/g) x 10^3	0.3	0.1	0.2	0.6	-	0.1	0.2

Sediment Quality Results

The river sediments were also collected at the surface water sampling locations. The sediment quality is influenced by geomorphology, geology, climatic and biological factors, as well as anthropogenic activities and the tidal influence. The sediment quality results are shown in Table 7-21 indicate acidic nature of sediments that is peculiar to Niger Delta Region

Table 7-26 Water Quality Sampling Results for Effluent Water Sampling Locations Compared to the Project Applicable Limit

Parameter(s)	Train 1, ISBL Pit	Train 2, ISBL Pit	Holding pond	Retention Pond	*Project Applicable limit*
	Eff 1	Eff 2	Eff 3	Eff 4	
pH	6.81	6.59	6.99	7.34	*6.5 – 8.5*
Appearance	Clear	Clear	Clear	Clear	*NS*
Temperature, (°C)	28	28.6	27.1	27.8	*<3*
Elect. Cond. (µs/cm)	749	650	881	764	*NS*
TDS (mg/l)	382	332	449	390	*2000*
Turbidity (NTU)	3.8	5.4	8.6	11.6	*NS*
TSS (mg/l)	3.0	4.5	7.4	9.8	*30*
Total Hardness (mg/l)	11	9	26	20	*NS*
Alkalinity (mg/l)	25	20	35	45	*NS*
Chloride, Cl^-(mg/l)	4	8	45	36	*600*
Sulphate, SO_4^{2-}(mg/l)	54	47	66	53	*500*
Nitrate, NO_3^-(mg/l)	0.3	0.72	1.3	1.45	*20*
Phosphate, PO_4^{3-} (mg/l)	0.12	0.34	1.85	1.24	*5.0*
Cyanide (mg/l)	<0.001	<0.001	<0.001	<0.001	*0.1*
Silica (mg/l)	9.4	11.7	98.6	43.7	*NS*
Ammonium (mg/l)	0.8	0.9	0.4	0.2	*5.0*
Urea (mg/l)	<0.10	<0.10	<0.10	<0.10	*1.0*
Formaldehyde (mg/l)	<0.10	<0.10	<0.10	<0.10	*NS*
Total Nitrogen (mg/l)	4.86	5.12	5.86	5.32	*15*
DO (mg/l)	5.96	5.58	5.91	5.87	*>4.0*
BOD (mg/l)	9.8	11.2	13.4	11.5	*30*
COD (mg/l)	31.3	36.8	34.6	39.8	*150*

Parameter(s)	Train 1, ISBL Pit	Train 2, ISBL Pit	Holding pond	Retention Pond	*Project Applicable limit*
	Eff 1	Eff 2	Eff 3	Eff 4	
O & G (mg/l)	<1.00	<1.00	<1.00	<1.00	*10*
Sodium, Na (mg/l)	31.04	28.91	57.12	48.94	*NS*
Potassium, K (mg/l)	4.89	3.79	13.64	21.31	*NS*
Iron, Fe (mg/l)	0.1	0.14	0.18	0.19	*5.0*
Calcium, Ca (mg/l)	3.48	2.98	6.79	5.35	*200*
Magnesium, Mg (mg/l)	0.45	0.36	1.9	1.47	*200*
Zinc, Zn (mg/l)	0.04	0.09	0.53	0.37	*1.0*
Copper, Cu (mg/l)	<0.01	<0.01	<0.01	<0.01	*1.0*
Manganese, Mn (mg/l)	<0.01	<0.01	<0.01	<0.01	*5.0*
Chromium, Cr (mg/l)	<0.001	<0.001	<0.001	<0.001	*1.0*
Silver, Ag (mg/l)	<0.001	<0.001	<0.001	<0.001	*0.1*
Lead, Pb (mg/l)	<0.001	<0.001	<0.001	<0.001	*1.0*
Mercury, Hg (mg/l)	<0.001	<0.001	<0.001	<0.001	*0.05*
Cadmium, Cd (mg/l)	<0.001	<0.001	<0.001	<0.001	*0.1*
Nickel, Ni (mg/l)	<0.001	<0.001	<0.001	<0.001	*1.0*
Arsenic, As (mg/l)	<0.001	<0.001	<0.001	<0.001	*0.05*

7.4.9 Summary of Key Physical Environmental Sensitivities

- In terms of climatic hazards, the broader Project Area is susceptible to extreme heat, water stress and drought.
- Given the relatively high permeability of the shallow unconfined aquifer, as well as the shallow depth to groundwater (<7.5m), the aquifer is a sensitive resource towards potential contamination from surface sources. This is likely to be experienced by the communities surrounding the Site.
- Soils in the Project Area are sensitive to compaction and will increase surface runoff during rainfall events. Further, the local community also rely on the soils for subsistence farming. Therefore, contamination of the soils can impact not only on the quality of water, but also the field carrying capacity for livestock and crop production.
- The Okulu River is located directly downstream of the existing and planned plants. Pollutants from the effluent plant have the potential to be transported from Project Site to the River, resulting in a potential for impact (specifically the potential for a large release related to failure of plant due to flood, retention pond wall failure, or continual undetected release of untreated effluent).

7.5 Biophysical Environment

7.5.1 Introduction

This Section of the Report presents the ecological baseline for the Project and was prepared using the international guidance on Impact Assessments for biodiversity (mainly IFC PS6).

Biodiversity was identified using desktop-based research, as well as wet season infield baseline studies undertaken by ECSL specialists appointed by IEFCL in October 2021. Field studies were supplemented by additional herbarium research to help identify species collected during the fieldwork.

A variety of sampling techniques were used to sample the terrestrial biodiversity of the site. The Study Area was set using the Project Area as the core and adding a 4 km buffer to this to allow for a complete assessment of the biodiversity of the receiving environment (Figure 7-34).

Figure 7-34 Satellite Imagery showing the Study Area[38]

Data collection was undertaken during the wet season (one sampling season). Characterisations of the vegetation and wildlife species in the Project Area were carried out initially by general surveillance to determine the natural stratification of the plant community. The vegetation distribution, composition, abundance, and diversity were then determined. A summary of the methods used in vegetation and wildlife surveys are as presented in Table 7-27.

Table 7-27 Summary of Method used in Vegetation and Wildlife Survey

Field Activity	Method Used
Plants	Transects and quadrats
Reptiles	Field observations and interviews with the hunters

[38] Note that the dark blue boundary is the proposed Train-3 Project Site, while the yellow circle is the core study area directly adjacent to the Project Site. In addition, the light blue circle represents the 4 km buffer of the proposed Project Site.

Field Activity	Method Used
Birds	Field observations and interviews with the hunters
Mammals	Field observations and interviews with the hunters

Vegetation sampling was undertaken by placing nested quadrants along transects, these quadrants measuring approximately 10 m x 10 m along each transect. Six transects of 200 m each were surveyed, near Aleto (T1), Agbonchia (T2), Njuru/Okerewa (T3), Elelenwo (T4), Indorama (T5), and Oyigbo (T6). An additional four transects were made from the centre of the project site towards North (T7), South (T8), East (T9), and West (T10). In each transect, four quadrats were marked at 50 m intervals. Random quadrants of varying dimensions of 10 m x 10 m (for tree enumeration), 5 m x 5 m (for shrubs enumeration), and 1 m x 1 m (for herbs enumeration) were laid along the transact pathways for the plant community identification and counts. All plant species were identified as far as possible, with unknown species collected, labelled, pressed, and taken to the University of Port Harcourt Herbarium for identification. The identification and ethno-botanical uses of the plants were derived from the local interviews.

Faunal data were obtained through active searching for animal paths, burrows, nesting sites, calls, scales, food cuttings, footprints, droppings, fur, and sighting. However, 60% of the checklists on mammalian, avian, rodent, and reptilian species were obtained from hunters, farmers and gatherers of non-timber forest products in the community.

The avifaunal assemblage was sampled during the morning hours from 6:30 am to 9:30 am, and again from 4:00 pm to 6:30 pm. All birds encountered were recorded, and nest searches were also undertaken along the vegetation transects.

Amphibians were sampled using their calls, the presence of eggs, and tadpole stages. Again, this sampling was undertaken along the transects and quadrants used for the vegetation assessment.

Insects were sampled using active (tree beating, sweep netting, active searching) and passive (pitfall traps and bait traps) techniques. As with the other groups sampled above, the majority of the insect sampling was undertaken along the transects, and within the quadrats previously described for the vegetation assessment.

7.5.2 Terrestrial Environment

7.5.2.1 Vegetation Characteristics

The Study Area is comprised of predominantly secondary forest (Figure 7-35) in addition to mixed forest, which is characterized by patches of riparian (Figure 7-36). Further there are savanna-like landscaped open spaces with grasses (lawns), mainly found in the existing Indorama Complex (Figure 7-37), and a mosaic of cultivated crops (Figure 7-35). The eastern section of the Project Area has some seasonally flooded plains (Figure 7-38). The vegetation within the Study Area can be subdivided into three main habitat types, namely: the seasonal floodplains/riparian forests (mostly modified), dry-land forest (modified), and cultivated farmland (modified). The vegetation with the Study Area is characterised with three distinct canopies. The upper canopy is dominated by trees such as *Elaeis guineensis, Polyalthia longifolia, Mangifera indica, Spondias mombin, Cleistopholis patens, Alstonia* spp., etc. The second (middle) canopy is dominated by shrubs such as *Baphia nitida, Rauvolfia vomitoria,* etc while the third layer is made up of herbaceous plants.

Figure 7-35 Overview of the Forest Types within the Study Area (A) secondary forest, (B) secondary forest/farmland, (C) secondary forest, and (D) secondary forest

Figure 7-36 Riparian Forests within the Study Area (A) Okulu River and (B) Fresh water body in Agbonchia community

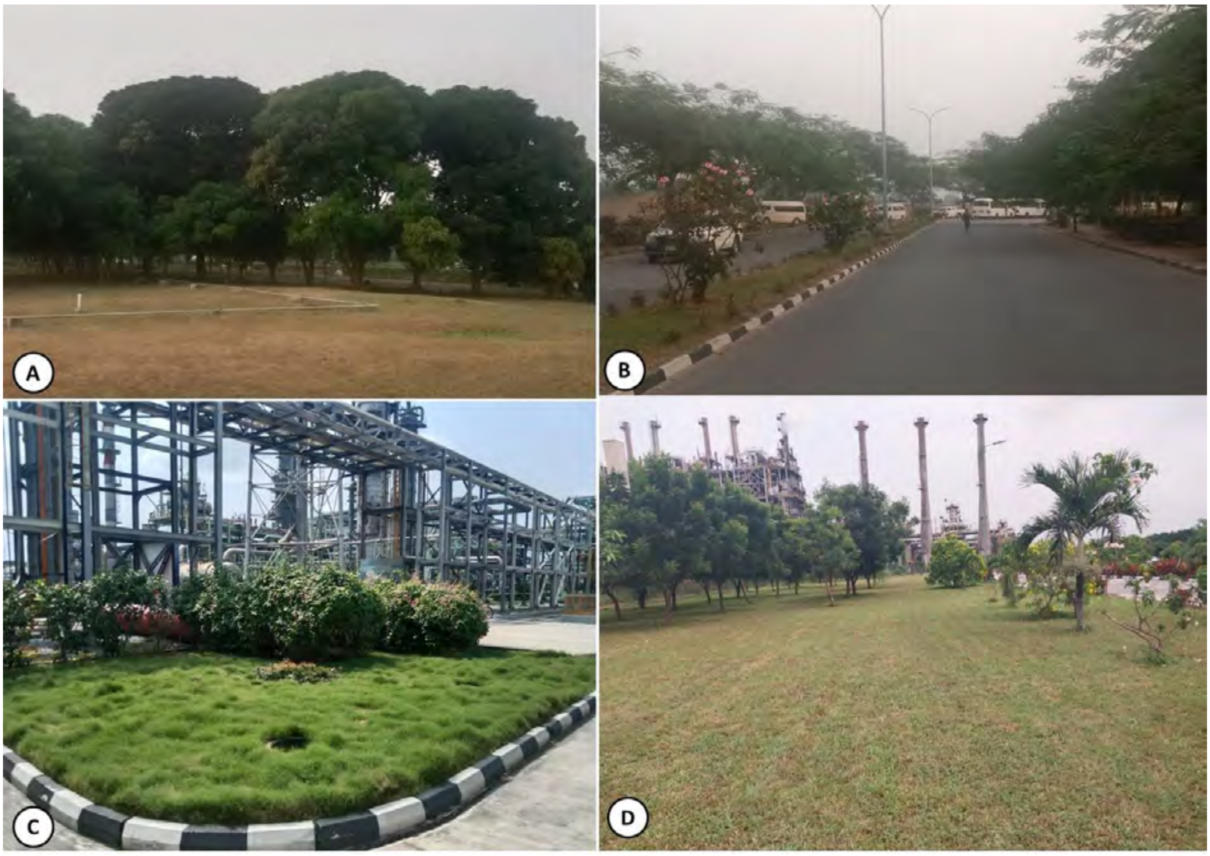


Figure 7-37 **Overview of Vegetation within the Indorama Complex (A) Mango trees (B) other tree species along the walkway/road (C) Ornamental plants within Indorama complex, and (D) Ornamental and grass species**

Figure 7-38 **Overview of the Seasonally Flooded Forests within the Study Area**

Species Composition

A total of 149 plant species belonging to 133 genera, and 53 families were identified in the Study Area (Table 7-28). The species could be classified into trees, shrubs, and herbs. The herbs were the predominant group with 59.21% of the species identified, shrubs comprised 22.37% of the species, and trees comprised 18.42%.

Species Richness

The Study Area is rich in plant species. Transcet-10 (west of the facility) had the highest number of plant species, 71 (912 individuals). This is followed by Transect-1 (Aleto) with 67 species (717 individuals), T3 with 68 species (952 individuals), T8 with 63 species (987 individuals), T7 with 62 species (687 individuals), T6 with 59 species (416 individuals), and T2 with 55 species (523 individuals) Figure 7-39.

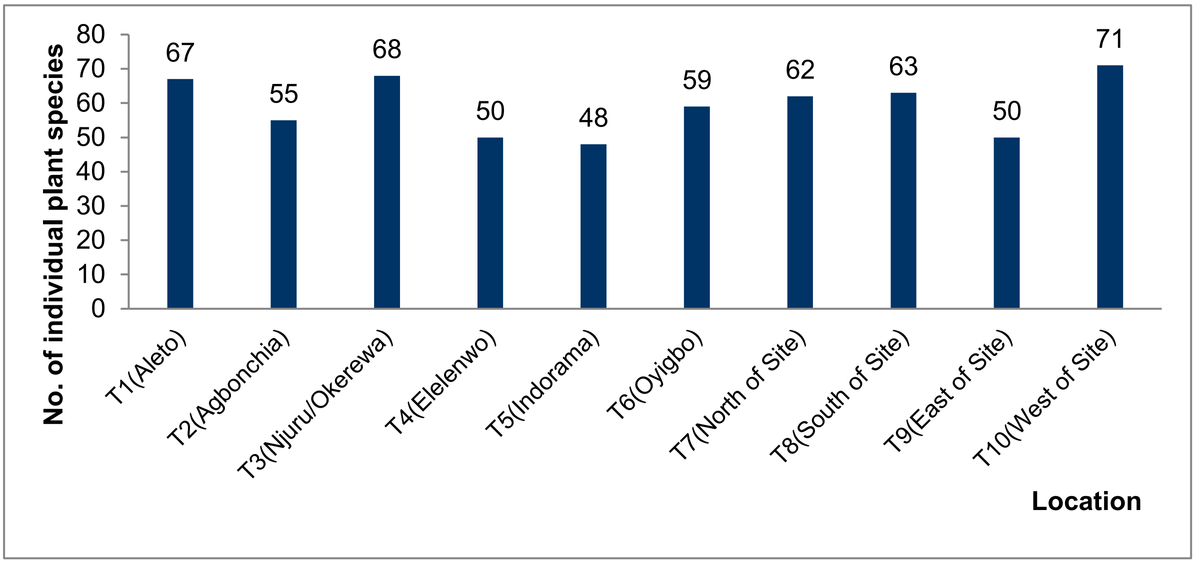


Figure 7-39 Distribution of the Plant Species in the Study Area

Plant Relative Abundance, Evenness, and Diversity

The relative abundance of the individual plant species varied from *Chromolaena odorata* (3.84%) to *Ficus glumosa* (0.02%). Other plants with high relative abundance are *Alchornea cordifolia, Aspilia Africana, Bambusa vulgaris, Elaeis guineensis, Tridax procumbens, Tithonia diversifolia, and Ageratum conyzoides* (Table 7-28). Some species are evenly distributed within the Study Area; however, a few of the species such as *Zea mays, Raphia hookeri, Thaumatococcus daniellii, Pycnanthus angolensis, Syzygium aromaticum, Dacryodes edulis, Palisota hirsuta, Terminalia superba, Allanblackia floribunda, Bombax buonopozense, Milicia excels* have zero evenness. The diversity index varied from 2.24 for *Ficus exasperata* to zero in *Ocimum* sp, *Delonix regia, Polyalthia longifolia, Phoenix* sp, *Moringa oleifera, Mansonia altissima, Triplochiton scleroxylon, Hevea brasiliensis, Theobroma cacao, Brachystegia eurycoma, Juglans regia, Trachycarpus martianus, Ceiba pentandra, Citrus sinensis,* and *Ficus glumosa* (Table 7-28).

Conservation and IUCN Status of the Plant Species

Among the plant species identified, 97 species are not evaluated (NE), 46 species are least concern (LC), 3 are vulnerable (VU), 2 are Near Threatened (NT), and one is Data Deficient (DD). The vulnerable species include *Garcinia kola, Terminalia ivorensis*, and *Entandrophragma cylindricum*, while *Milicia* *excelsa* and *Nauclea diderrichii* are near threatened. There are no conservation areas within the Study Area.

Several alien invasive plant (AIP) and exotic cultivated (EXO) species are present within the Study Area.

Table 7-28 Checklist of Plant Species, Diversity, Evenness, IUCN Status, and Relative Abundance in the Study Area and their uses and Vegetation Types

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
1	*Acanthus mollis*		Acanthaceae	EXO	1.53	0.95	0.53	DLF/POF
2	*Asystasia gangetica*	Chinese Violet	Acanthaceae	NE	1.24	0.89	0.55	DLF/POF
3	*Hypoestes* spp		Acanthaceae	NE	1.05	0.95	0.32	DLF/POF
4	*Cyathula prostrata*		Amaranthaceae	NE	0.50	0.72	0.24	DLF/POF
5	*Amaranthus spinosa*	Spiny amaranth	Amaranthaceae	AIP	1.30	0.81	1.19	DLF/POF
6	*Alternanthera sessilis*	Sessile Joyweed	Amaranthaceae	NE	1.33	0.83	1.06	DLF
7	*Mangifera indica*	Mango	Anacardiaceae	EXO	1.78	0.99	0.98	DLF/POF
8	*Spondias mombin*	yellow mombin or hog plum	Anacardiaceae	LC	1.99	0.95	0.93	DLF
9	*Annona muricata*	Soursop	Annonaceae	LC	1.08	0.98	0.11	DLF
10	*Monoon longifolia*	Masquerade tree	Annonaceae	NL	0.00	0.00	0.19	DLF
11	*Xylopia aethiopica*	Guinea pepper or Negro pepper	Annonaceae	LC	0.45	0.65	0.19	DLF
12	*Cleistopholis patens*		Annonaceae	LC	0.69	0.99	0.26	DLF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
13	*Alstonia macrophylla*	Hard milkwood	Apocynaceae	LC	1.33	0.96	0.10	DLF/RF
14	*Picralima nitida*	The Akuamma	Apocynaceae	NL	1.05	0.96	0.08	DLF
15	*Alstonia boonei*	God's tree	Apocynaceae	LC	1.63	0.91	0.77	DLF/RF
16	*Funtumia africana*		Apocynaceae	LC	1.01	0.73	0.37	DLF
17	*Funtumia elastica*	Silk rubber	Apocynaceae	LC	0.87	0.79	0.10	DLF
18	*Rauvolfia vomitoria*	Poison devil pepper	Apocynaceae	LC	1.89	0.91	0.82	DLF/POF
19	*Syngonium podophyllum*	Arrowhead vine	Araceae	NE	0.97	0.88	0.55	DLF/POF
20	*Caladium bicolor*	Devils cocoyam	Araceae	EXO	1.08	0.99	1.95	DLF/RF
21	*Phoenix* sp	Indian date palm	Arecaceae	NE	0.00	0.00	0.16	DLF
22	*Raphia hookeri*	Raphia palm	Arecaceae	LC	1.10	1.00	0.51	DLF/RF
23	*Cocos nucifera*	Coconut tree	Arecaceae	NE	1.33	0.96	0.68	DLF/POF
24	*Elaeis guineensis*	Palm tree	Arecaceae	LC	2.18	0.95	3.26	DLF/POF
25	*Trachycarpus martianus*	England palm	Arecaceae	NE	0.00	0.00	0.03	DLF
26	*Musanga cecropioides*	African corkwood tree	Moraceae	LC	1.98	0.95	1.30	DLF/RF
27	*Dracaena arborea*	African dragon tree	Asparagaceae(Dracaenaceae)	LC	1.02	0.63	0.72	DLF/RF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
28	*Chromolaena odorata*	Siam weed	Asteraceae	AIP	1.95	0.94	3.84	DLF/POF
29	*Tithonia diversifolia*	Mexican sunflower	Asteraceae	AIP	1.26	0.91	2.44	DLF/POF
30	*Ageratum conyzoides*	Billygoat weed	Asteraceae	AIP	1.96	0.94	2.32	DLF/POF
31	*Tridax procumbens*	Goat's button	Asteraceae	AIP	1.76	0.90	2.73	DLF/POF
32	*Stachytarpheta cayennensis*	Blue rat tail	Asteraceae	AIP	1.69	0.87	1.22	DLF/POF
33	*Aspilia africana*	Haemorrhage plant	Asteraceae	NE	1.54	0.79	3.63	DLF/RF
34	*Eclipta alba*	False daisy	Asteraceae	NE	1.36	0.85	0.43	DLF/RF
35	*Vernonia amygdalina*	Bitter leaf	Asteraceae	NE	0.93	0.84	0.21	DLF/POF
36	*Sclerocarpus africanus*		Asteraceae	NE	1.51	0.94	0.39	DLF/SFRF
37	*Synedrella nodiflora*		Asteraceae	AIP	1.16	0.83	0.51	DLF/POF
38	*Kigelia africana*	Sausage tree	Bignoniaceae	LC	1.36	0.98	0.74	DLF/POF
39	*Newbouldia laevis*	Boundary tree	Bignoniaceae	LC	2.21	0.96	1.91	DLF/POF
40	*Dacryodes edulis*	Bush pear	Burseraceae	NE	0.69	1.00	0.26	DLF/POF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
41	*Canna indica*	Canna lily	Cannaceae	AIP	0.93	0.85	0.35	DLF/RF
42	*Allanblackia floribunda*	Tallow tree	Clusiaceae	LC	1.39	1.00	0.06	DLF/POF
43	*Garcinia kola*	Bitter kola	Clusiaceae	VU	1.06	0.97	0.14	DLF/POF
44	*Terminalia ivorensis*	Black afara	Combretaceae	VU	0.64	0.92	0.05	DLF
45	*Terminalia catappa*	India almond	Combretaceae	LC	0.29	0.41	0.19	DLF/POF
46	*Combretum hispidum*		Combretaceae	NE	1.55	0.96	1.21	DLF/RF
47	*Combretum racemosum*	Christmas rose	Combretaceae	NE	1.18	0.85	0.39	DLF/RF
48	*Terminalia superba*	Africa limba wood or white afara	Combretaceae	NL	1.10	1.00	0.14	DLF
49	*Aneilema aequinoctiale*	ẹfĩajija	Commelinaceae	NE	1.01	0.92	0.31	DLF/RF
50	*Aneilema beniniense*		Commelinaceae	NE	0.64	0.92	0.14	DLF/RF
51	*Palisota hirsuta*		Commelinaceae	NE	0.69	1.00	0.21	DLF/RF
52	*Cleome rutidosperma*	Consumption weed	Capparidacea	NE	1.81	0.93	0.90	DLF/RF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
53	*Costus afer*	Ginger lily/bush sugar cane.	Costaceae	NE	1.46	0.90	1.33	DLF/RF
54	*Telfairia occidentalis*	Fluted pumpkin	Cucurbitaceae	NE	0.97	0.89	0.40	POF
55	*Lagenaria breviflora*	wild water melon	Cucurbitaceae	NE	1.08	0.99	0.50	POF
56	*Luffa aegyptiaca*		Cucurbitaceae	NE	1.25	0.90	0.37	DLF/POF
57	*Kyllinga bulbosa*	Sedge	Cyperaceae	NE	1.48	0.92	1.29	DLF/POF
58	*Cyperus* sp.		Cyperaceae	NE	1.09	0.79	1.78	DLF/RF
59	*Kyllinga* sp.		Cyperaceae	NE	1.35	0.97	0.85	DLF/POF
60	*Pteridium aquilinum*	fern	Dennstaedtiaceae	NE	0.65	0.94	0.58	DLF/RF
61	*Dioscorea* sp.	Yam	Dioscoreaceae	NE	1.30	0.81	0.34	POF
62	*Dioscorea alata*	Water yam	Dioscoreaceae	NE	0.45	0.65	0.19	POF/RF
63	*Dioscorea bulbifera*	Air Yam	Dioscoreaceae	NE	1.34	0.83	0.64	POF
64	*Alchornea cordifolia*	Christmas bush	Euphorbiaceae	LC	1.98	0.95	3.70	DLF/RF
65	*Hevea brasiliensis*	Rubber tree	Euphorbiaceae	EXO	0.00	0.00	0.06	DLF/RF
66	*Hura crepitans*	Sandbox tree	Euphorbiaceae	NL	0.69	0.50	0.26	DLF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
67	*Ricinodendron heudelotii*	Corkwood	Euphorbiaceae	LC	1.57	0.88	0.72	DLF
68	*Euphorbia thymifolia*	Gulf Sandmat	Euphorbiaceae	NE	1.51	0.84	1.43	DFL
69	*Macaranga barteri*		Euphorbiaceae	LC	1.01	0.92	0.32	POF
70	*Euphorbia heterophylla*	Spurge weed	Euphorbiaceae	NE	1.18	0.85	1.72	DLF/RF
71	*Croton lobatus*		Euphorbiaceae	NE	1.43	0.89	1.90	DLF/RF
72	*Anthonotha macrophylla*	African rosewood	Fabaceae	LC	1.74	0.97	1.17	DLF/POF
73	*Baphia nitida*	Camwood	Fabaceae	LC	1.72	0.88	1.01	DLF/POF
74	*Brachystegia eurycoma*	Naga (tebako)	Fabaceae	LC	0.00	0.00	0.05	DLF
75	Cassia sp	Candle bush	Fabaceae	LC	0.85	0.77	0.35	DLF/POF
76	*Delonix regia*	Royal Poinciana	Fabaceae	EXO	0.00	0.00	0.21	DLF
77	*Calopogonium mucunoides*	Calapo	Fabaceae	NE	1.32	0.95	0.92	DLF/POF
78	*Albizia zygia*	Nongo	Fabaceae	LC	1.84	0.95	0.87	DLF/POF
79	*Pentaclethra macrophylla*	Africa oil bean	Fabaceae	LC	1.53	0.95	0.64	DLF/POF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
80	*Pterocarpus erinaceus*	Abura	Fabaceae	NE	0.72	0.66	0.19	DLF/RF
81	*Tetrapleura tetraptera*	Aidan fruit	Fabaceae	LC	0.67	0.97	0.08	DLF/POF
82	*Centrosema pubescens*	Blue cento	Fabaceae	NE	1.07	0.77	2.25	DLF/POF
83	*Indigofera hirsuta*	Indigo	Fabaceae	NE	1.55	0.87	0.48	DLF/POF
84	*Anthocleista vogelii*	Cabbage tree	Gentianaceae	LC	2.17	0.94	1.85	DLF/RF
85	*Hydrolea palustris*		Hydroleaceae	NE	0.64	0.93	0.47	DLF/RF
86	*Harungana madagascariensis*	Dragon's blood tree	Hypericaceae	LC	1.49	0.92	1.05	DLF/POF
87	*Juglans regia*	Common walnut	Juglandaceae	LC	0.00	0.00	0.05	DLF
88	*Gmelina arborea*	Gmelina	Lamiaceae	EXO	1.77	0.99	1.45	DLF/POF
89	*Ocimum* sp	Scent leaf	Lamiaceae	NE	0.00	0.00	0.24	POF
90	*Persea americana*	Avocado pear	Lauraceae	EXO	0.90	0.82	0.16	DLF/POF
91	*Gloriosa superba*	Lily	Liliaceae	NE	1.01	0.92	0.10	DLF/RF
92	*Spigelia anthelmia*	Warm weed	Loganiaceae	AIP	0.94	0.86	0.61	DLF/POF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
93	*Mansonia altissima*	African black walnut	Malvaceae	LC	0.00	0.00	0.10	DLF/RF
94	*Clappertonia ficifolia*	Bolo-bolo	Malvaceae	NE	0.27	0.39	1.91	DLF
95	*Abelmoschus esculentus*	okra	Malvaceae	NE	0.31	0.45	0.34	POF
96	*Bombax ceiba*	Cotton tree	Malvaceae	LC	1.63	0.84	0.21	DLF/POF
97	*Bombax buonopozense*	Cotton tree	Malvaceae	LC	0.69	1.00	0.06	DLF/POF
98	*Ceiba pentandra*	Kapok	Malvaceae	LC	0.00	0.00	0.03	DLF/POF
99	*Theobroma cacao*	Cacao tree	Malvaceae	NE	0.00	0.00	0.06	POF
100	*Triplochiton scleroxylon*	Obeche	Malvaceae	LC	0.00	0.00	0.08	DLF
101	*Urena lobata*	Caditto	Malvaceae	NE	1.22	0.68	1.53	DLF/POF
102	*Sida acuta*	Broom weed	Malvaceae	NE	1.52	0.94	0.51	DLF/POF
103	*Thaumatococcus daniellii*	Sweet Prayer Plant	Marantaceae	NE	0.69	1.00	0.42	DLF/RF
104	*Zea mays*	Maize	Poaceae	EXO	1.61	1.00	0.84	POF
105	*Melastomastrum capitatum*		Melastomataceae	NE	1.12	0.81	0.51	POF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
106	*Entandrophragma cylindricum*	Sapele	Meliaceae	VU	1.22	0.88	0.42	DLF
107	*Tectona grandis*	Teak	Meliaceae	EXO	0.99	0.90	1.03	DLF/POF
108	*Artocarpus altilis*	Breadfruit	Moraceae	NL	1.08	0.98	0.23	POF
109	*Ficus exasperata*	Sand paper tree	Moraceae	LC	2.24	0.97	2.14	DLF/RF
110	*Ficus glumosa*	Cedar bush fig/Hairy rock fig	Moraceae	LC	0.00	0.00	0.02	DLF/RF
111	*Ficus sur*	Broom cluster fig	Moraceae	LC	1.35	0.84	0.39	DLF/RF
112	*Milicia excelsa*	Iroko	Moraceae	NT	0.69	1.00	0.06	DLF
113	*Moringa oleifera*	Moringa	Moringaceae	LC	0.00	0.00	0.16	DLF/POF
114	*Pycnanthus angolensis*	African nutmeg	Myristicaceae	LC	0.69	1.00	0.35	DLF/POF
115	*Myristica* sp		Myristicaceae	NE	0.41	0.59	0.11	DLF/POF
116	*Psidium guajava*	Guava	Myrtaceae	EXO	0.68	0.99	0.23	POF
117	*Syzygium aromaticum*	Brush cherries (clove)	Myrtaceae	NE	0.69	1.00	0.29	DLF/POF
118	*Boerhavia diffusa*	Red spidering	Nyctaginaceae	NE	0.95	0.59	0.51	DLF/POF
119	*Ludwigia* sp		Onagraceae	NE	1.48	0.92	1.51	DLF/RF
120	*Adenia lobata*		Passifloraceae	NE	0.43	0.62	0.21	DLF/RF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
121	*Passiflora foetida*	Running Pop/Wild Water Lemon	Passifloraceae	NE	1.07	0.98	0.26	DLF/RF
122	*Sesamum indicum*	Beni seed	Pedaliaceae	NE	1.37	0.85	0.40	DLF/RF
123	*Bambusa vulgaris*	Bamboo	Poaceae	EXO	1.51	0.85	3.54	DLF/RF
124	*Acroceras zizanioides*	Oat grass	Poaceae	NE	1.04	0.95	0.59	DLF
125	*Megathyrsus maximum*	Guinea grass	Poaceae	NE	1.45	0.90	1.70	DLF
126	*Brachiaria deflexa*	Guinea millet	Poaceae	NE	1.48	0.82	1.90	DLF/RF
127	*Eleusine indica*	Bull grass	Poaceae	NE	1.36	0.98	0.88	DLF
128	*Andropogon tectorum*	Giant blue stem grass	Poaceae	NE	1.55	0.96	1.14	DLF
129	*Chrysopogon aciculatus*	Love grass	Poaceae	NE	0.49	0.70	1.69	DLF
130	*Imperata cylindrica*	Cogon grass	Poaceae	NE	1.22	0.88	2.28	DLF/POF
131	*Echinochloa pyramidalis*		Poaceae	LC	1.39	0.86	1.03	DLF
132	*Paspalum scrobiculatum*	Ditch mullet	Poaceae	NE	1.39	0.86	0.92	DLF/POF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
133	*Pennisetum purpureum*	Poaceae	Poaceae	AIP	1.15	0.83	0.66	DLF/RF
134	*Mitragyna ciliate*	Heartwood	Rubiaceae	NE	1.55	0.86	0.80	DLF/RF
135	*Nauclea diderrichii*	Bilinga/Aloma/Opepe	Rubiaceae	NT	1.46	0.91	0.76	DLF
136	*Spermacoce verticillata*	Shrubby false buttonweed	Rubiaceae	NE	1.68	0.94	0.72	DLF/POF
137	*Citrus sinensis*	Sweet oranges	Rutaceae	EXO	0.00	0.00	0.03	DLF/POF
138	*Selaginella myosurus*		Selaginellaceae	NE	0.20	0.29	0.32	DLF/RF
139	*Solanum* sp.	Garden egg	Solanaceae	NE	1.33	0.96	0.55	POF
140	*Solanum torvum*	Turkey berry	Solanaceae	NE	1.03	0.94	0.16	DLF/POF
141	*Solanum nigrum*	Black nightshade	Solanaceae	NE	1.36	0.98	0.19	DLF/POF
142	*Sterculia tragacantha*	African tragacanth	Sterculiaceae	LC	1.01	0.92	0.10	DLF
143	*Laportea aestuans*	Stringing herb	Urticaceae	NE	0.77	0.56	0.95	DLF/POF
144	*Musanga sp*	African corkwood tree or umbrella tree,	Urticaceae	NE	1.25	0.90	0.39	DLF/RF
145	*Peperomia pellucida*	Silver plant	Urticaceae	NE	1.35	0.84	1.53	DLF

S/N	Species name	Common name	Family name	IUCN status	Shannon index	Evenness	Relative Abundance	Vegetation types
146	*Girardinia diversifolia*	Stinging nettle	Urticaceae	NE	1.22	0.88	0.66	DLF/POF
147	*Cissus gracilis*		Vitaceae	NE	0.86	0.78	0.32	DLF/POF
148	*Vitex* sp		Vitaceae	NE	1.01	0.92	0.29	DLF
149	*Aframomum* spp.	Alligator pepper	Zingiberaceae	NE	1.07	0.97	0.34	DLF/RF

IUCN Red List of Ecosystems risk categories are: Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE); Alien Invasive Plant (AIP), Exotic/cultivated plant (EXO); Riparian Forest (RF), Dry-Land Forest (DFL), Patches of Farmlands (POF).

7.5.2.2 Faunal Assemblage

Introduction

The faunal assemblage of the Study Area includes a number of mammals, reptiles, birds, amphibians and insects; however, the number of species is relatively low due to increased human induced pressure. This anthropogenic pressure is exerted through hunting, farming and loss of natural habitat for sand mining and timber cropping.

Mammals

The mammals recorded within the Study Area include *Hippotragus equines* (Roan antelope), *Lemniscomys striatus* (Striped grass mouse), *Xerus erythropus* (Geoffroy's ground squirrel), *Funisciurus pyrrhopus* (Tree squirrel), *Cricetomys gambianus* (Gambian pouched rat), *Saccolaimus peli, Galago sp,* (Porcupine) *Precolombus* sp., *Cercopithecus* sp. (Mona monkey *Phataginus sp.* (Pangolin, VU or EN), *Protoxerus* sp., (Squirrels), *Epixerus* sp., *Funisciurus* spp., *Xerus* sp.), *Rattus rattus* (House rat), *Lemniscomys striatus, Arvicanthis sp., Cricetomys gambianus, Thryonomys sp., Vivera civetta, Genetta sp, etc.* Among the mammals, the Cane Rat *(Thryonomys swinderianus)* and the giant rat *(Cricetomys emini)* were the most frequently trapped "bush meat" in the area. This however suggests that they are the most abundant mammals in the Study Area.

Reptiles

The reptiles of the Study Area include *Kinixys spp* (Tortoise), *Agama agama*, *Mabuya affinis*, *Trachylepis maculilabris* (skink), forest gecko, and chameleon (Figure 7-40). The Large lizards include *Osteolaemus tetraspis* (Dwarf Crocodile, VU globally and *Varanus niloticus,* which are endangered. The local hunters noted that a number of snakes occur in the forest, and include the spitting cobra *(Naja nigrocollis*), Emerald green snake, (*Gastropyxis smaragdina*), the Jameson's mamba, (*Dendoaspis jamesoni*), Gabon viper, (*Bitis gabonica, VU globally*), and the pythons (*Python regius,* NT and *P. sebae,* NT), which inhabit the humid forests areas. The borders of the secondary forest at the northern end were found to be the habitat of a population of monitor lizards. Villagers reported regular cases of snake bites.

Birds

The avian fauna of the Study Area consists mainly of pigeons (Columbidae), Kites, hawks, swifts (Micropopidae) and herons. *Streptopelia semitorquata* (Red eye dove), *Merops nubicus* (Northern carmine bee-eater), *Milvus migrans* (Black kite), *Psittacus erithacus* (African grey parrot, EN), *Necrosyrtes monachus* (Hooded vulture, CR), *Ardeola ibis* (Cattle egret), *Tyto alba* (Barn owl), *Bubo africanus* (Spotted eagle owl) and, Ploceidae (weaver birds) are common in the study area. The most abundant species during this study period were the white egrets, sunbirds, and the African swifts. Avifauna species are limited in abundance due to the transformed nature of the site (Figure 7-40).

Amphibians

The common amphibians in the Study Area include *Sclerophrys regularis* (Common African Toad), *Bufo lentiformis* (Toad), *Rana temporaria* (True green Frog), *Conraua goliath* (Goliath Frog, EN), *Xenopus tropicalis* (Clawed toe frog) and *Hyperclius sp* (Tree frog). Among the amphibians within the Study Area, the common toads *(Bufo sp.)* were most abundant, and its primary habitat was the humid forest in the Agbonchia freshwater bush and farmlands.

Molluscs

African giant snail *Archachatina marginata*, was the prominent mollusc found in the Study Area. Others include: *Achatina spp.* and *Limicolaria aurora* (Figure 7-41).

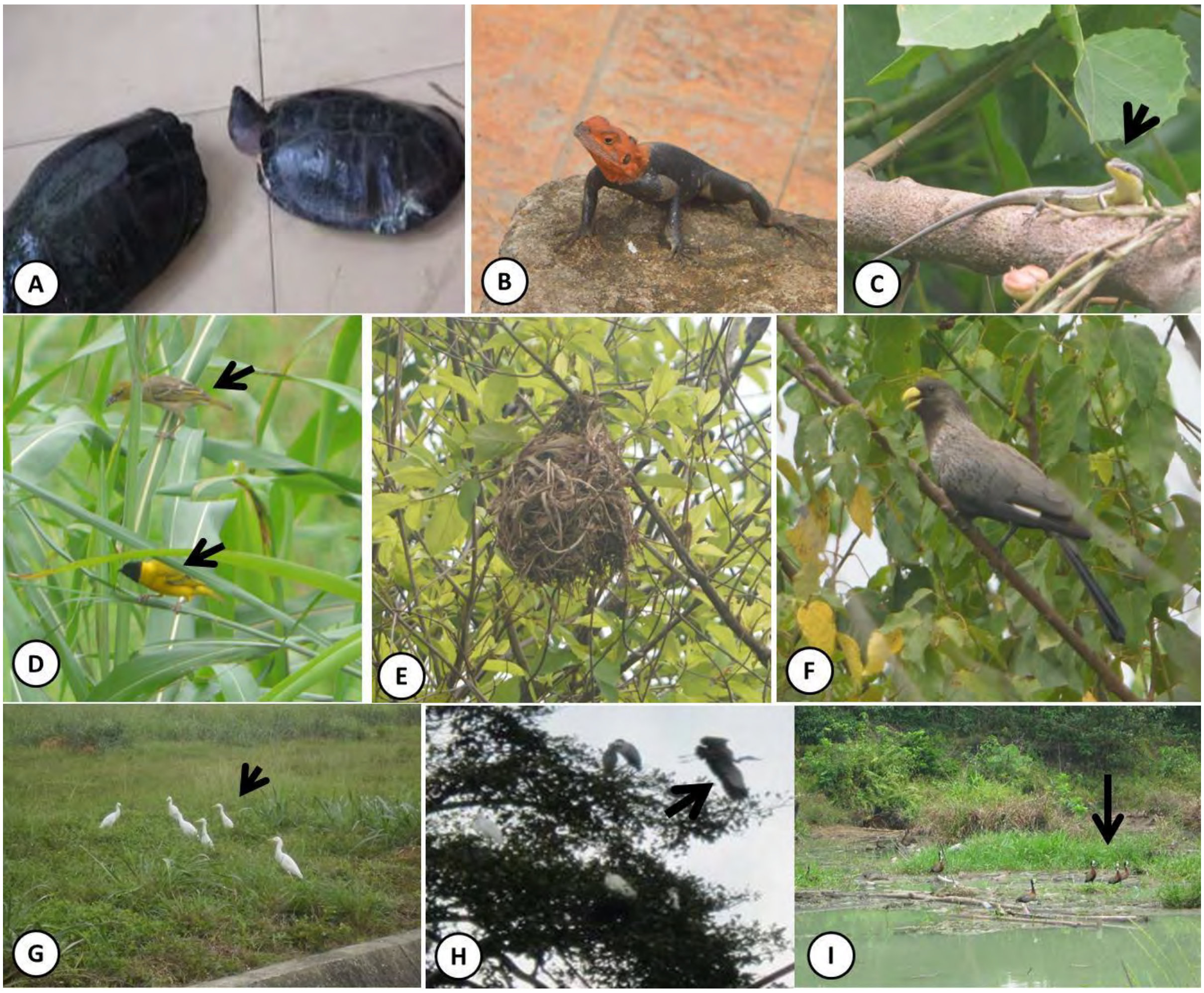


Figure 7-40 Reptiles and Birds observed in the Study Area (A) Kinixys spp (Tortoise), (B) Agama agama (small lizards), (C). Mabuya sp. (skink), and (D – I) bird species observed in the Study Area

Figure 7-41 (A) Achatina sp., (B and D) Limicolaria aurora, and (C) African giant snail (Archachatina marginata) (possibly Achatina fulica) found in the Study Area

Insects/Butterflies

Some of the insects identified in the Study Area include; *Papilio demodocus*, *Precis Octavia, Osmodes laronia* and *Euphaedra janetta* (Figure 7-42 and Figure 7-43).

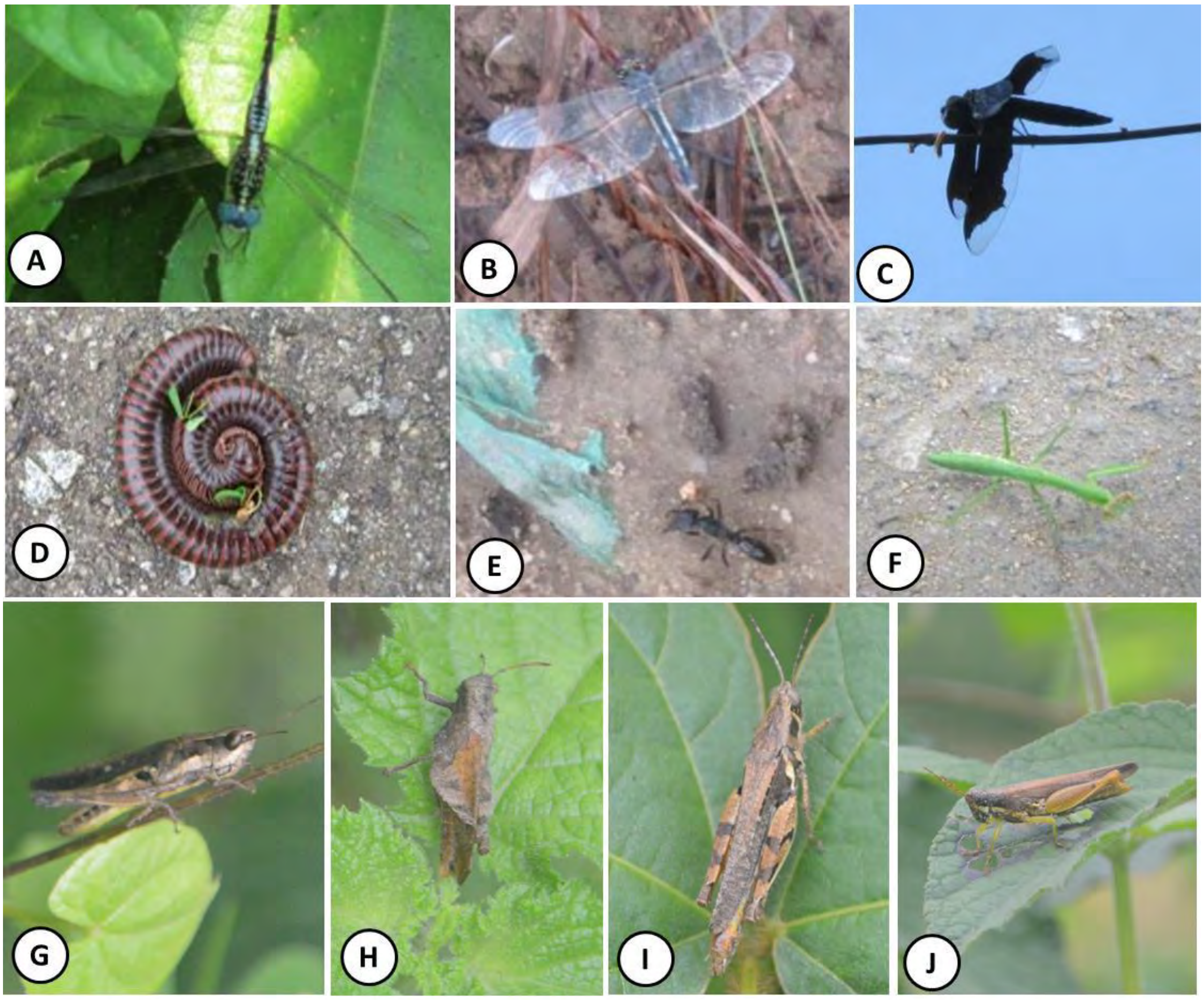


Figure 7-42 **(A – C) Dragon flies, (D) millipede, (E) black ant, (F) praying mantis, (G – J) grasshoppers found in the Study Area**

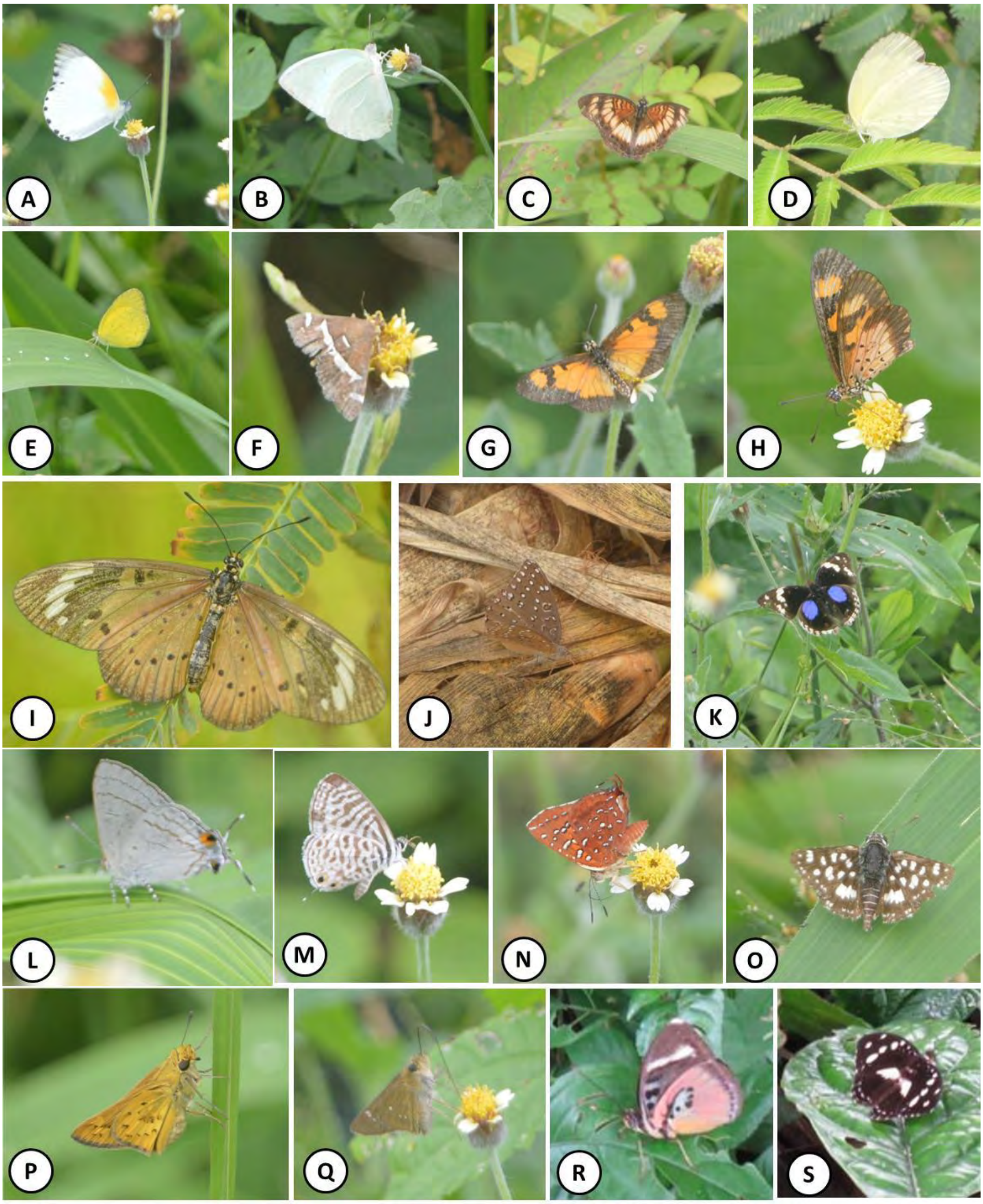


Figure 7-43 Various Butterflies observed in the Study Area

7.5.2.3 Conservation

Interviews with local hunters noted that several species that historically occurred in the Study Area; however, had not been seen in a number of years, and the probability of finding relic populations of various species in the wild is low. With regards to the IUCN Red list, no species was found in the critically endangered or endangered category.

7.5.2.4 Observed Impacts

The Study Area has been extensively altered through human induced disturbance. Most of the impacts relate to vegetation clearing by communities, cultivation, and the cropping of trees for timber products. In addition, sand mining operations within the broader Study Area have led to a decrease in riparian vegetation, and disturbance of wetland systems. These freshwater system impacts have also led to an increase in saline conditions within some of the water resources surrounding the Project Area.

7.5.3 Aquatic Environment

7.5.3.1 Introduction

A field survey was undertaken by ECSL specialists appointed by IEFCL in October 2021. A variety of sampling techniques were used to sample the aquatic biodiversity of the site. The sampling points considered for this ESIA are the same as for surface water and sediment studies and are shown in Table 7-29 and in Section 7.4.8 (Figure 7-29).

Table 7-29 Sampling Stations for Surface water / Sediment / Aquatic Biodiversity

Station	Location	GPS Coordinates	
		North (N)	East (E)
SW1	Agbonchia stream (Near Road Bridge)	4°48'26.82"N	7° 7'27.75"E
SW2	Aleto stream (Near Pipeline ROW)	4°48'27.33"N	7° 6'39.19"E
SW3	Aleto stream (Near E-W Expressway Bridge)	4°48'26.05"N	7° 6'08.12"E
SW4	Aleto stream (Near NNPC housing)	4°48'24.55"N	7° 5'40.93"E
SW5	Aleto stream (Outfall area)	4°48'40.05"N	7° 06'28.55"
SWC1	Rumukrushi stream	4°051'0.01"N	7° 3'36.45"E
SWC2	Imo River (Near Imo Gate)	4°53'16.17"N	7° 8'44.39"E

Plankton samples were collected by filtering 50L of water through a plankton net (65µ for mesh size 30 cm diameter). The content of the collection bottle was rinsed into sample containers and fixed immediately with a 5% formaldehyde-water mixture. Complimentary phytoplankton samples were obtained by the screen method. The Okulu stream is under tidal influence and the samples were collected during low tide condition. The control stations are not under tidal influence.

Benthos samples were collected with a grab sampler, sieved through a 0.5 mm mesh size net and the debris emptied into a plastic container. The samples were immediately preserved with 5% formaldehyde-water mixture and stained with eosin to aid sorting. The Okulu stream is under tidal influence and the samples were collected during low tide condition. The control stations are not under tidal influence.

Physical observation of fishing activities was undertaken to capture types of fishing gear and catch assessment. The use of Cast and Seine nets is common and suitable fishing gear used within the region. However, the depth of water and physical conditions at the sampling stations precluded the use of seine nets. Therefore, only cast nets were used for fish sampling during the study in Okulu Stream. Samples from each throw were counted to determine catch per unit effort (CPUE). All samples collected were placed in labelled polythene bags and placed in ice-cooled boxes for transportation to the laboratory where they were immediately frozen until analyzed. Fish were individually identified and counted.

Floating aquatic macrophytes were studied by visual assessment in the field. The Okulu stream banks are collapsing due to sand mining and hence samples cannot be collected for study of fauna associated with emergent vegetation.

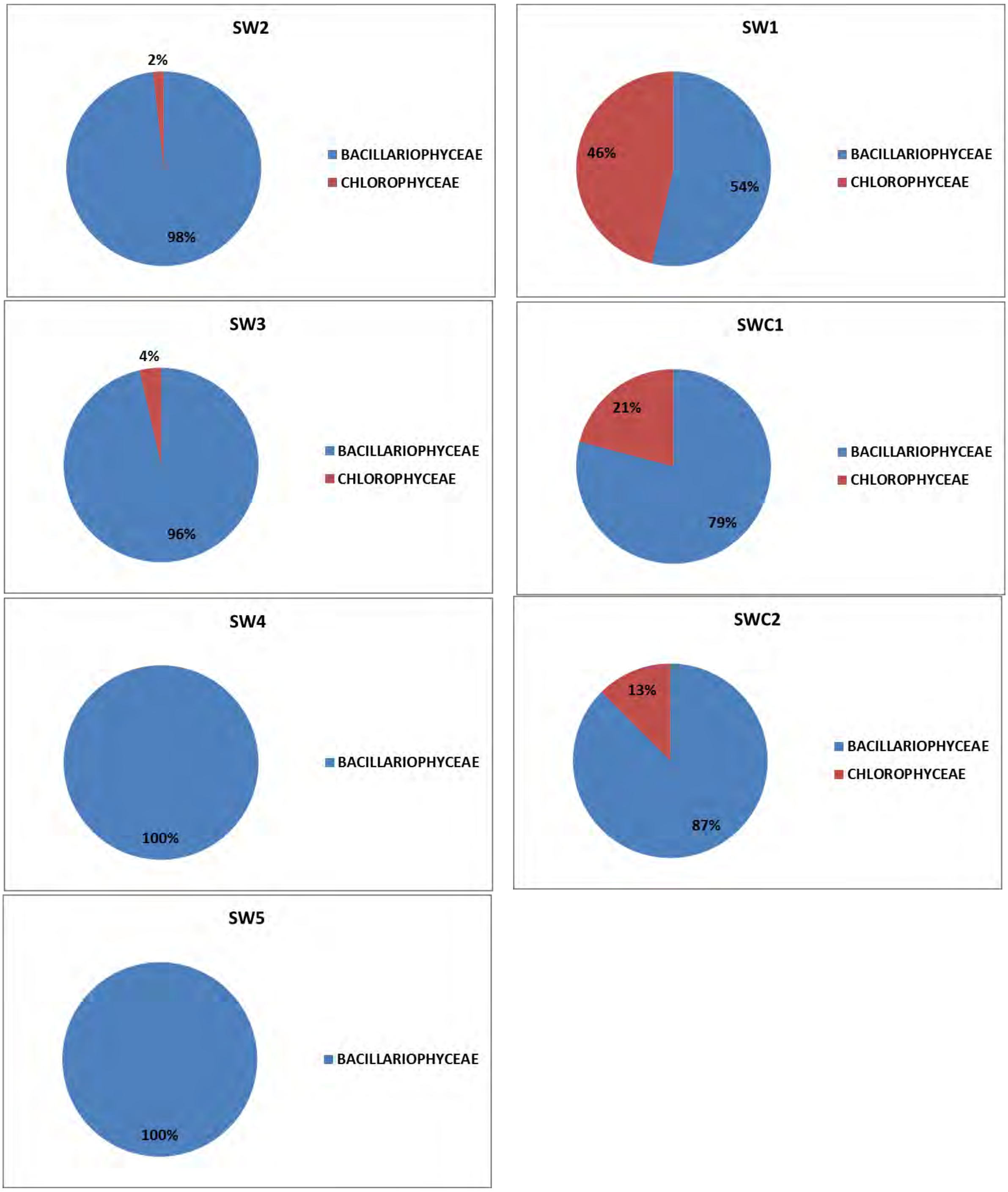
7.5.3.2 Survey Findings

Phytoplankton

The phytoplankton composition from the Study Area is shown in Table 7.25a and presented in Figure 7-44. Bacillariophyceae (diatoms) were the most dominant and abundant species. The phytoplankton consisted of seven genera of *bacillariophyeae* (diatoms) and three genera of chlorophyceae (green algae). The relative abundance showed that 95% to 100% in the brackish water stations. However, the green algae accounted for 13% to 36% in the freshwater stations. *Cyclotella* and *Synedra* were the most widely distributed diatoms, followed by *Nitzschia*. *Spyrogyra* was found only in the freshwater stations. The ranges of phytoplankton community indices were: Margalef- 0.207 to 0.696; Shannon-Weiner- 0.637 to 1.171; Pielou- 0.589 to 0.918 and Simpson- 0.351 to 0.556. The dominance of diatoms (which are an important component of the diet of several fish resources) is consistent with some other studies in the Niger Delta.

Table 7-25a Composition and Distribution of Phytoplankton

TAXA	SW1	SW2	SW3	SW4	SW5	SWC1	SWC2
BACILLARIOPHYCEAE							
Cyclotella sp	190	870	920	390	0	1200	0
Synedra sp	70	90	0	80	42	80	50
Melosira sp	0	0	0	20	0	0	70
Fragilaria sp	40	0	0	0	0	80	0
Navicula sp	0	10	0	10	0	0	0
Gyrosigma	0	200	300	0	0	0	0
Nitzschia sp	0	125	50	70	83	0	0
BACILLARIOPHYCEAE	**300**	**1295**	**1270**	**570**	**125**	**1360**	**120**
CHLOROPHYCEAE							
Closterium sp	0	20	40	0	0	60	0
Ourococcus sp	0	0	0	0	0	190	20
Spirogyra sp	260	0	0	0	0	110	0
CHLOROPHYCEAE	**260**	**20**	**40**	**0**	0	**360**	**20**
No of Genera	4	6	4	5	2	6	3
Abundance (N): Cells/L	560	1315	1310	570	125	1720	140
Margalef Richness (d)	0.474	0.696	0.418	0.63	0.207	0.671	0.405
Pielou Evenness (J')	0.845	0.596	0.589	0.61	0.918	0.599	0.903
Shannon-Weiner Diversity (H')	1.171	1.068	0.817	0.981	0.637	1.073	0.992
Simpson Dominance (λ)	0.351	0.475	0.548	0.504	0.556	0.509	0.398



A: Brackish Water Stations **B: Freshwater Stations**

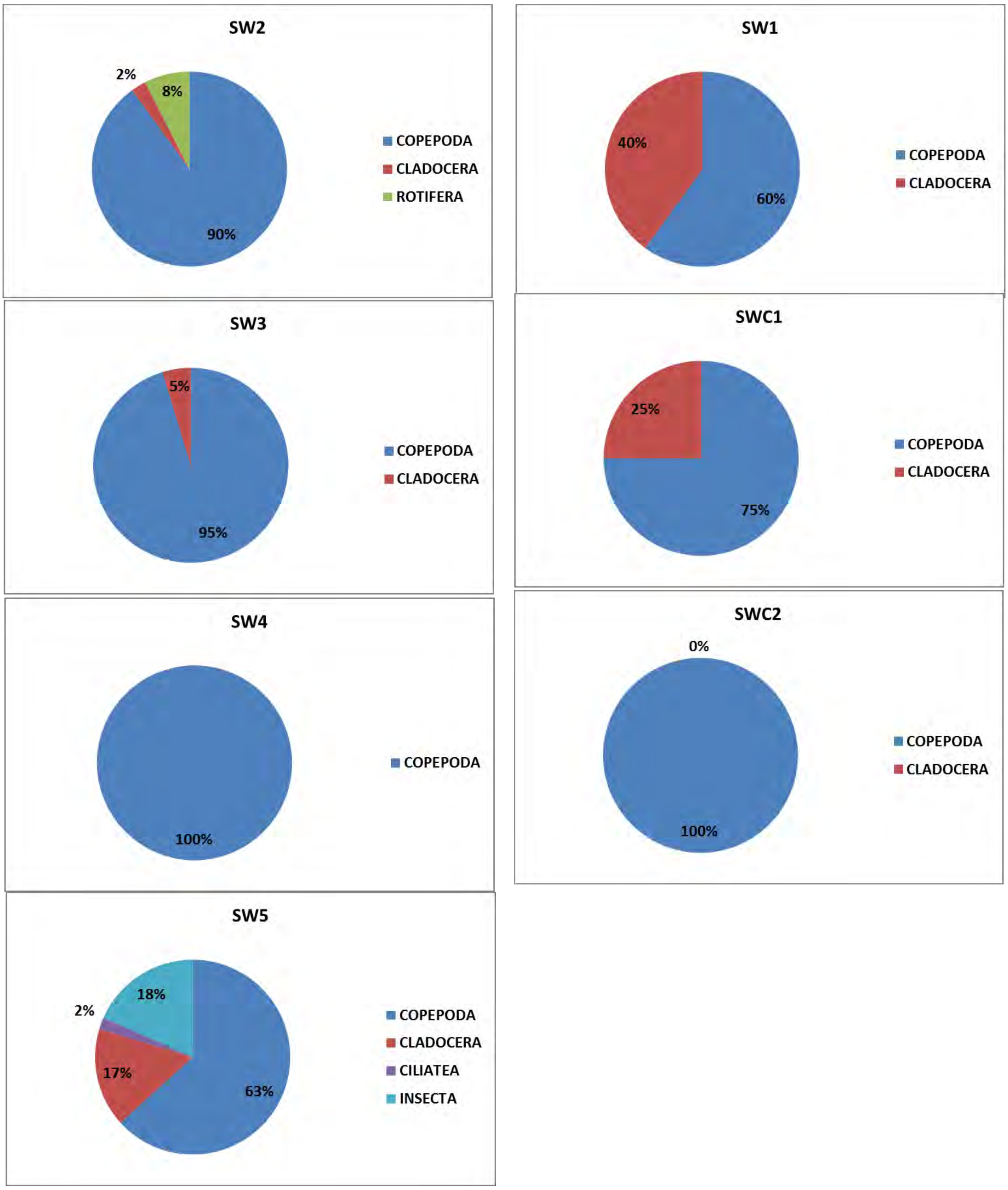
Figure 7-44 Relative Abundance of Phytoplankton

Zooplankton

The relative abundance of major taxa in the zooplankton is shown in Table 7.25b and presented in Figure 7-45. Copepods were the most dominant, accounting for between 63% to 100% of the relative abundance in the brackish water stations, and 60% to 100% in the freshwater stations. Cladocera were recorded from three brackish water stations (representing 2% and 17%) and two freshwater stations where they contributed between 25% and 40%. Rotifers were observed in one station where it accounted for less than 8%. Fourteen genera comprising seven copepods, four Cladocera, one insecta, one ciliate and one rotifer were recorded. The genus *Senecella* (with two species), *Diaptomus, Eucyclops* and copepod naupli were the most widely distributed amongst the copepods. For Cladocera, *Bosmina* was more widely distributed than *Holonedium*, while *Brachionus* was the only rotifer observed. The ranges of zooplankton community indices for the area were: Margalef- 0.256 to 1.166; Shannon-Weiner- 0.673 to 1.972; Pielou- 0. 658 to 0.971 and Simpson- 0.248 to 0.520.

Table 7-25b Composition and Distribution of Zooplankton

TAXA	SW1	SW2	SW3	SW4	SW5	SWC1	SWC2
COPEPODA							
Nauplius	50	70	50	100	250	70	0
Senecella parvus	0	100	220	0	0	20	0
Senecella calanoides	10	210	180	0	0	0	0
Diaptomus siciloides	0	270	190	40	0	0	30
Eucyclops serrulatus	0	80	20	20	0	10	20
Epischura sp	20	60	0	0	0	0	0
Temora	0	0	0	0	8	0	0
CILIATEA (Tintinnidae)							
Tintinnid	0	0	0	0	8	0	0
CLADOCERA							
Holonedium giberum	0	20	0	0	0	0	0
Bosmina spp	50	75	0	0	0	50	0
Daphinia rosea	0	0	0	0	33	0	0
Diaphanosoma spp	0	0	0	0	33	0	0
INSECTA							
insect larva	0	0	0	0	75	0	0
ROTIFERA							
Brachionus spp	0	70	40	0	0	0	0
No of Species (S)	4	9	6	3	6	4	2
Abundance (N): no /L	130	955	700	160	408	150	50
Margalef Richness (d)	0.616	1.166	0.763	0.394	0.832	0.599	0.256
Pielou Evenness (J')	0.88	0.897	0.849	0.819	0.658	0.845	0.971
Shannon-Weiner Diversity (H')	1.22	1.972	1.521	0.9	1.180	1.171	0.673
Simpson Dominance (λ)	0.325	0.168	0.248	0.469	0.423	0.351	0.52



A: Brackish Water Stations **B: Freshwater Stations**

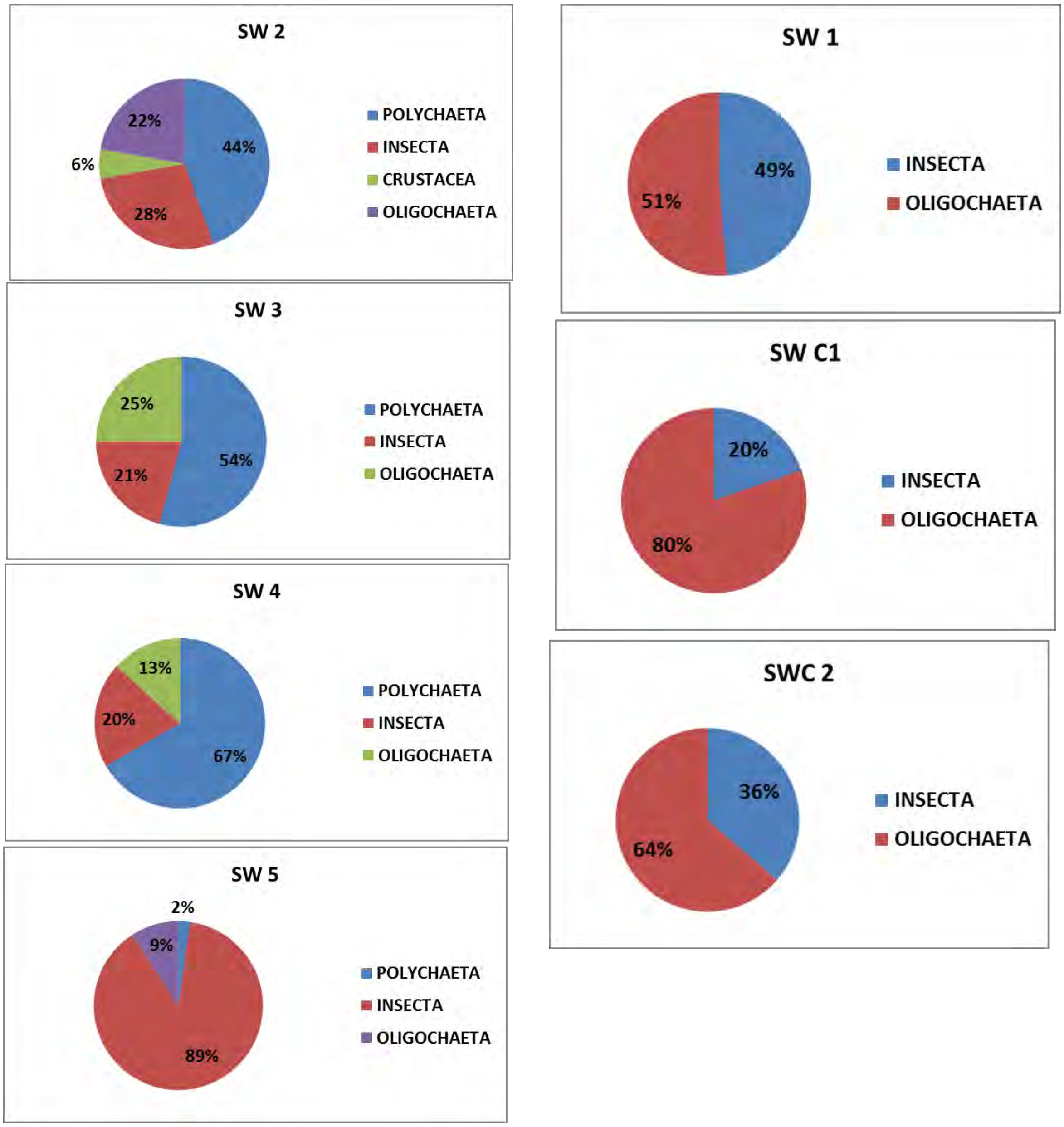
Figure 7-45 Relative Abundance of Zooplankton

Benthic Organisms

The composition and abundance of benthic organisms in the Study Area are shown in Table 7.25c and presented in Figure 7-46. Four taxa namely Polychaeta (2 species), oligochaeta (5 species), insecta (1 species) and Crustacea (1 species) were recorded. Polychaeta were observed only in the brackish water stations, accounting for 2% to 64%. Oligochaeta were more abundant in the freshwater stations with 51% to 80%; brackish water proportions ranged from 9% to 28%. The insecta (*Chironomus* larvae) was widely distributed being observed from all stations; they accounted for 20% to 89%. The polychaete genera were *Nereis* and *Capitella*. *Lumbriculus* was the most widely distributed oligochaete, followed by *Ophidonais* and *Eiseniella*. Abundance values ranged from 180/ m^2 to 2290/m^2. The ranges of community indices of benthic organisms were: Margalef- 0.340 to 0.770; Shannon-Weiner- 1.090 to 1.538; Pielou- 0.380 to 0.956 and Simpson- 0.226 to 0.790.

Table 7.25c Composition and Distribution of Benthos

TAXA	SW 1	SW 2	SW 3	SW 4	SW5	SW C1	SWC 2
POLYCHAETA							
Nereis spp	0	80	70	90	8	0	0
Capitella capitata	0	0	60	110	0	0	0
INSECTA							
Chironomus larvae	370	50	50	60	317	450	40
CRUSTACEA							
Uca tangeri	0	10	0	0	0	0	0
OLIGOCHAETA							
Ophidonais serpentina	170	0	40	0	0	100	30
Uncinais Uncinata	210	30	0	0	33	180	40
Eiseniella tetrahidra	10	0	0	0	0	1400	0
Lumbriculus variegatus	0	10	20	40	0	150	0
Dero obtusa	0	0	0	0	0	10	0
No of Genera	4	5	5	4	3	6	3
Abundance (N): individuals/m^2	760	180	240	300	358	2290	110
Margalef Richness (d)	0.452	0.77	0.73	0.526	0.340	0.646	0.425
Pielou Evenness (J')	0.792	0.83	0.956	0.952	0.380	0.647	0.992
Shannon-Weiner Diversity (H')	1.098	1.336	1.538	1.32	0.418	1.159	1.09
Simpson Dominance (λ)	0.364	0.309	0.226	0.282	0.790	0.425	0.339



A: Brackish Water Stations **B: Freshwater Stations**

Figure 7-46 Relative Abundance of Major Taxa in the Benthos

Fish

There is minimal fishing activity in the Aleto (Okulu) stream, and it is not a commercial venture. This is similar to the report by IEFCL (2017) that fishing activities in the surface water bodies around the Project Area are generally subsistent and nearly absent in the last few years. During the fieldwork in October 2021, a couple of fishermen were observed in dug-out canoes using cast nets. No fishing activity is carried out in the Agbonchia stream. Also, no fishing activity were observed in the Rumukrushi stream and Imo River. The fish biodiversity study in Okulu stream in October 2021 showed a composition of predominantly black-chin tilapia, *Sarotherodon melanotheron*. Other fish observed during the study were mullet- *Liza grandisquanmis*, Atlantic tarpon - *Megalops atlanticus* and snapper- *Lutjanus dentatus* (Table 7-30, Figure 7-47 to Figure 7-50). *Sarotherodon melanotheron* has distribution from freshwater to marine. However, the observation of the African brown snapper, *Lutjanus dentatus*, a predominantly marine/estuarine fish (which has not been previously reported from the area) is an indication of the brackish water intrusion into Okulu stream. Subsequent studies of fish assemblages in the area in January, July and October 2022 captured *Mugil caphalus, Coptodon guineensis* and *Sardinella maderensis* (Table 7-30, Figure 7-51 to Figure 7-53), indicating further presence of brackish water.

The spatial boundaries of the study where the Okulu stream at Aleto and Agbonchia are located do not fall within any national legally protected area or an internationally recognized area. It is not an aquatic critical or sensitive fish habitat. There are no endemic species, and the IUCN status of the fish were mostly Least Concern or Data Deficient. Although the Atlantic tarpon Megalops atlanticus is listed as vulnerable globally; however, it is not common.

Figure 7-47 ***Sarotherodon melanotheron***

Figure 7-48 ***Liza grandisquamis***

Figure 7-49 ***Metalops atlanticus***

Figure 7-50 ***Lutjanus dentatus***

Figure 7-51 ***Mugil cephalus***

Figure 7-52 ***Coptodon guineensis***

Figure 7-53 ***Sardinella maderensis***

Table 7-30 Composition and Abundance of Fish Species

Fish Species	Oct 2021	Jan 2022	Jul 2022	Oct 2022	IUCN Red List Status	CITES
Sarotherodon melanotheron	382	225	435	486	LC (2019)	NE
Liza grandisquamis	3				DD (2019)	NE
Megalops atlanticus	26				VU (2019)	NE
Lutjanus dentatus	1				DD (2011)	LC
Mugil cephalus		27	58	13	LC (2018)	
Coptodon guineensis		1			LC (2019)	NE
Sardinella maderensis				4	VU (2014)	NE

DD = Data Deficient; LC = Least Concern; VU = Vulnerable; NE = Not Evaluated

Macrophytes

No floating aquatic macrophytes were observed in much of the stretch of the Aleto section of the Okulu stream. However, floating vegetation was observed in a small segment (Figure 7-54); this consisted of floating mats of *Sacciolepis africana, Eichhornia crassipes* and *Nymphaea macrantha*. The water hyacinth *Eichhornia crassipes* is an alien invasive species in the Niger Delta. A floating mat of *Nymphaea macrantha* was also found in Agbonchia stream (Figure 7-55) and Rumukrushi streams (Figure 7-56).

Figure 7-54 Floating Mat in a Section of Okulu Stream

Figure 7-55 Floating Mat in a Section in Agbonchia Stream

Figure 7-56 Floating Mat in a Section in Rumukrushi Stream

7.5.4 Ecosystem Services

7.5.4.1 Introduction

The field work for both the terrestrial and aquatic biodiversity of the Study Area included interviewing local hunters, fisherman, gatherers, farmers, and communities with regards to their uses of the natural environment, and the resources that it contains. The ecosystem services that the communities gain from the local environment are varied, and includes direct services, such as food, medicine, timber for furniture and construction, leafy vegetables, fuelwood, fruits, seeds, nuts, spices, raw materials for pharmaceuticals, organic fertilizers, ornamentals, gums, resins, palm oil, and indirect services, such as sacred groves which serve spiritual and worship purposes.

Beyond the socio-economic and cultural gains of biodiversity, the ecosystem services extend to regulating the hydrological cycles regime, local and ambient air quality, carbon sequestration, recreation, and environmental aesthetics.

7.5.4.2 Survey Findings

The ecosystems surrounding the Project Area such as secondary forest, riparian forest, marshy terrain, and freshwater swamp forest ecosystems have several habitats for different species of animals and plants. However, some of the ecosystems like the riparian and freshwater swamp forests have started losing their natural attributes due to human alterations in its structure, size and extent. The secondary forests, Guinea savanna etc. provide shade, cover, nesting and breeding grounds, seeds and nuts, food and nectar for birds and other wildlife in the area.

Ongoing anthropogenic activities in the Study Area, in terms of logging, regular hunting/trapping of animals, indiscriminate extraction of sand and gathering of non-timber forest products (NTFPs), and infrastructural developments are drivers of degradation to ecological systems in the Study Area.

The variety of ecosystem services that were identified by the local communities as important natural resources are listed in Table 7-31 below.

Table 7-31 Ecosystem Services and Provisioning in the Study Area

S/N	Flora	Fauna	Avifauna	Molluscs	Insects
1	Herbs for medicine	Meat	Production of feathers	Source of food for man and animals	Pollination
2	Gums and resins	Fats and oil for medicine	Pest control	Sources of protein	Plants dispersion
3	Timber	Cultural affiliation and belief systems (dances, totem, masquerades, rhymes and rhythms)	Pollination	Income and revenue	Production of honey
4	Organic matter	Hide and skin	Seed dispersion	Substrates for animal feed production	Food and source of protein
5	Regulation of local climate	Pets	Meat and food	Used for decoration	Environmental indicators

S/N	Flora	Fauna	Avifauna	Molluscs	Insects
6	Regulation of hydrological cycle	Soil forming factors and processes	Planters of trees and fruits	Soil forming factors and processes	Decomposers and detritus's feeders
7	Soil aeration and moisturisation	Addition of nutrients to the soil	Cultural attachments	Soil aeration and moisturisation	Pest and weed control
8	Fruits, nuts, seeds	Guardian spirits	Production of eggs and source of protein	Detritus feeders and decomposers	Provides food for other organisms especially birds and insect eating animals
9	Edible leaves and vegetables	Pollination	Nutrient recycling	Medicine	
10	Spices	Seed dispersal	Provision of organic matter	Shells used for jewelleries	
11	Shelter for wildlife	Pest and weed control	Community time keepers		

Expanding on the use of medicinal plants, and the use of plants for various products, the ethnobotanical uses of some plant species in the Study Area are presented in Table 7-32. A total of 66 plants were recorded to have different uses by the community. These plant species are in abundance in the Project Area and are also found in the adjoining forests within the Study Area and can be sourced from those areas by the locals if needed.

Table 7-32 Ethnobotanical Value/Uses of Plant in the Project Area

S/N	Species Composition	Common Name	Family	Ethnobotanical Value/Uses
1	*Gmelina arborea*	Gmelina	*Lamiaceae*	It is used for making furniture, boats, and musical instruments.
2	*Tectona grandis*	Teak	*Lamiaceae*	It is used for for poles, beams, trusses, columns, roofs, doors, window frames, flooring, planking, panelling, and staircases etc.
3	*Pentacletra macrophylla*	Africa oil bean	*Fabaceae*	Extracts of the leaf, bark, seed and fruit pulp have anti-inflammatory and anthelmintic activity, and are used to treat gonorrhoea and convulsions etc.
4	*Newbouldia laevis*	Boundary tree	*Bignoniaceae*	The bark of *Newbouldia laevis* tree can be used for treating stomachic, piles and constipation.
5	*Ficus exasperate*	Sand paper tree	*Moraceae*	Sandpaper tree is widely used as a source of sandpaper and as a valuable medicinal plant.
6	*Mangifera indica*	Mango	*Anacardiaceae*	Various parts of plant are used as a dentrifrice, antiseptic, astringent, diaphoretic, stomachic, vermifuge, tonic, laxative and diuretic and to treat diarrhoea, dysentery, anaemia etc.
7	*Cassia Sp*	Candle bush	*Fabaceae*	The leaves of the tree is used for erysipelas, malaria, rheumatism, and ulcers, the buds are used for biliousness, etc.
8	*Moringa oleifera*	Drumstick tree	*Moringaceae*	Protecting and nourishing skin and hair.
9	*Anthocleista vogelii*	Cabbage tree	*Gentianaceae*	It is used in West Africa as a strong purgative and diuretic.
10	*Harungana madagascariensis*	Haronga	*Hypericaceae*	It is used for the treatment of chest pains and urogenital infections.
11	*Nauclea dendrichii*	Opepe	*Rubiaceae*	It is hard, dense and resistant to fungi and insects, and is used in joinery, flooring and marine construction.
12	*Spondias moubin*	Hog plum	*Anacardiaceae*	The fruit has been used as a diuretic and febrifuge.
13	*Rauvolfia vomitoria*	Poison devil pepper	*Apocynaceae*	The roots, leaves, and stem are used in medicine. People use Rauvolfia vomitoria for convulsions, fever, weakness, inability to sleep, mental disorders, etc.

S/N	Species Composition	Common Name	Family	Ethnobotanical Value/Uses
14	*Coco nucifera*	Coconut tree	*Arecaceae*	Industry is using the husk fibre from the pith as raw material for carpets, car seat stuffing, and in agricultural as fertilizers.
15	*Psidium guajava*	Guava	*Myrtaceae*	It is used for inflammation, diabetes, hypertension, caries, wounds, pain relief, fever, diarrhoea, rheumatism, lung diseases, and ulcers.
16	*Persea americana*	Avocado	*Lauraceae*	It is used in the treatment of diarrhoea, dysentery caused by helminths and amoebas, toothache.
17	*Alstonia macrophylla*	Hard milkwood	*Apocynaceae*	It is used for making roof beams, frames, poles and toys.
18	*Alstonia boonei*	Stool wood	*Apocynaceae*	It is used with other preparations in the treatment of fractures or dislocation.
19	*Raphia hookeri*	Raphia palm	*Arecaceae*	It is used as tying material for horticulture and handicrafts.
20	*Albizia zygia*	Nongo	*Fabaceae*	It is used for carving, flooring and furniture.
21	*Garcinia cola*	Bitter kola	*Clusiaceae*	The seeds are used for liver disorders, bronchitis, throat infections, colic, head or chest colds, and cough.
22	*Entandrophragma cylindricum*	sapele or sapelli or sapele mahogany	Meliaceae	It is used for for flooring, interior joinery, interior trim, panelling, stairs, furniture, cabinet work, musical instruments, carvings, ship building, veneer and plywood.
23	*Funtumia elastica*	Silk rubber	*Apocynaceae*	It is used for treatment of whooping cough, asthma, blennorrhoea, painful menstruation, fungal infections, and wounds.
24	*Ricinodendron heudelotii*	Corkwood	*Euphorbiaceae*	It is used in treating constipation, cough, dysentery, rheumatism, rickets in children, oedema etc.
25	*Ficus sur*	Sand paper tree	*Moraceae*	The tree is used as an ornamental and shade tree.
26	*Sterculia tragacantha*	African tragacanth	*Sterculiaceae*	It is used as food and medicine.
27	*Hevea brasiliensis*	Pará rubber tree	*Euphorbiaceae*	It is used for the manufacture of a range of products, especially tyres.

S/N	Species Composition	Common Name	Family	Ethnobotanical Value/Uses
28	*Mitragyna ciliate*	Heartwood	*Rubiaceae*	*Mitragyna ciliata* is widely used in traditional medicine for the treatment of inflammation, hypertension, headache, rheumatism, gonorrhoea and broncho-pulmonary diseases.
29	*Terminalia catappa*	India almond	*Combretaceae*	Juice of young leaves are employed in preparation of ointment for leprosy, scabies and also used internally for colic and headache.
30	*Theobroma cocoa*	Cacao tree	*Malvaceae*	Food and pharmaceutical additives.
31	*Ficus glumosa*	Cedar bush fig	*Moraceae*	It is used as an ornamental.
32	*Xylopia aethiopica*	Cherry tree (Uda)	*Annonaceae*	It is used extensively in construction, African cuisine and traditional medicine. The plant's bark is used to make doors and partitions.
33	*Ceiba pentandra*	Ukong	*Malvaceae*	*Ceiba pentandra* bark decoction has been used as a diuretic, as an aphrodisiac, and to treat headache, as well as type II diabetes.
34	*Pterocarpus erinaceous*	Abura	*Fabaceae*	It is used for fuel wood, for medicinal purposes, as a woodworking material, and is useful as a nitrogen-fixing plant.
35	*Terminalia ivorensis*	Black afara	*Combretaceae*	The wood is used for fine carpentry, joinery, building, flooring and plywood manufacture.
36	*Brachystegia eurycoma*	Achi	*Fabaceae*	It is used in cooking.
37	*Triplochiton scleroxylon*	Obeche	*Malvaceae*	The timber is used in the manufacture of veneer, furniture, picture frames and mouldings.
38	*Mansonia altissima*	African black walnut	*Malvaceae*	It is used in spear traps for large game.
39	*Bambusa vulgaris*	Bamboo	*Bambusae*	It is used as a building material.
40	*Phoenix Sp*	Indian date palm	*Arecaceae*	The fruit serves as a tonic and restorative, and is also used as an analgesic to mitigate pain from backache and in the buttocks.
41	*Baphia nitida*	Camwood	*Fabaceae*	It is used for house posts, rafters, naves of wheels and utensils such as walking sticks, mortars, pestles, etc.

S/N	Species Composition	Common Name	Family	Ethnobotanical Value/Uses
42	*Polyalthia longifolia*	Masquerade tree	*Annonaceae*	It is used in the treatment of fever, helminthiasis, diabetes and various cardiac problems.
43	*Delonix regia*	Royal Poinciana	*Fabaceae*	It provides forage for livestock and the seed meal can be fed to farm animals.
44	*Hura crepitans*	Sandbox tree	*Euphorbiaceae*	It treats skin diseases, rheumatism, intestinal worms.
45	*Citrus sinensis*	sweet oranges	*Rutaceae*	It's main uses are for food and beverages, and cosmetics.
46	*Dracaena arborea*	African dragon tree	*Asparagaceae*	It is used against gonorrhoea, small pox, malaria and leishmaniosis.
47	*Musanga cecropioides*	Umbrella tree	*Moraceae*	The sheath-like stipules are applied as emmenagogue and oxytocic, and to treat stomach complaints, hiccough and wounds.
48	*Alchornea cordifolia*	Christmas bush	*Euphorbiaceae*	It supplies dye and wood and in other occasions it is widely used for food.
49	*Elaeis guineensis*	Palm tree	*Arecaceae*	Palm oil is extracted from the mesocarp of the fruit and is used traditionally for the treatment of headaches, pains, rheumatism, etc.
50	*Pycnanthus angolensis*	African nutmeg	*Myristicaceae*	The seeds are sometimes used as a spice.
51	*Syzygium maloe*	Brush cherries or satin ash	*Myrtaceae*	It is used as fruit.
52	*Raphia hookeri*	Raphia palm	*Arecaceae*	It is used as tying material for horticulture and handicrafts.
53	*Dacryodes edulis*	Bush pear	*Burseraceae*	It is used in treating various ailments such as wound, skin diseases, dysentery and fever.
54	*Milicia excelsa*	African teak	*Moraceae*	The tree is nitrogen fixing and the leaves are used for mulching.
55	*Allanblackia floribunda*	Tallow tree	*Clusiaceae*	It has been long used in traditional African medicine to treat hypertension.
56	*Bombax ceiba*	Cotton tree	*Malvaceae*	
57	*Mansonia altissima*	African black walnut	*Sterculiaceae*	It is used for general and high-class joinery, cabinet work, furniture, turnery, decorative veneer and handicrafts.

S/N	Species Composition	Common Name	Family	Ethnobotanical Value/Uses
58	*Funtumia Africana*	Rubber tree	*Apocynaceae*	A latex exudes copiously from wounds in the bark.
59	*Picralima nitida*	The Akuamma	*Apocynaceae*	It is use in treating fever, hypertension, jaundice, dysmenorrhea, gastrointestinal disorders and malaria.
60	*Artocarpus altilis*	Breadfruit	*Moraceae*	The fruit is nutritious and a valuable staple food in most Pacific Islands.
61	*Annona muricata*	Soursop	*Annonaceae*	Muricata, the juicy flesh-fruit of the soursop is a remedy for rheumatism, arthritic pain, fever, neuralgia, heart, and liver diseases, etc.
62	*Kigelia Africana*	Sausage tree	*Bignoniaceae*	The powdered mature fruit is applied as a dressing in the treatment of wounds, abscesses, and ulcers.
61	*Ceiba buonopozense*	Cotton tree	*Malvaceae*	They are used in the treatment of cholera, tubercular fistula, coughs, urinary complaints etc.
63	*Terminalia superba*	Limba, or white afara	*Combretaceae*	It is used for making furniture, table tennis blades (as outer ply), and musical instruments etc.
64	*Quercus Sp*	Black oak	*Fagaceae*	It provides protective shading for houses and people, lowering energy needs for cooling homes.
65	*Tetrapleura tetraptera*	Aidan fruit	*Fabaceae*	It is used in the treatment of arthritis and other inflammatory conditions, asthma, diabetes mellitus, hypertension, epilepsy etc.
66	*Juglans regia*	Persia walnut	*Juglandaceae*	It is used in traditional medicine for a wide array of ailments that include helminthiasis, diarrhoea, sinusitis et.

In terms of aquatic ecosystem services, the provision of fish is one of the most important ecosystem services provided by rivers and streams. Fishing in Okulu stream is minimal and of low-level subsistence value. There are no species that support recreational fisheries, or culturally important fisheries. Aquatic ecosystems are also important in helping to ameliorate the impacts of flood events, and in the breakdown of waste material form the terrestrial environment.

7.5.5 Summary of Key Ecological Sensitivities

The following potential Critical Habitat triggering species were observed or recorded during interviews:

Plants:	*Garcinia kola* (VU), *Terminalia ivorensis* (VU), *Entandrophragma cylindricum* (VU)
Mammals:	*Phataginus* sp. (Pangolin, VU or EN)
Reptiles:	*Osteolaemus tetraspis* (Dwarf Crocodile, VU, potential CH trigger), *Gabon viper* (Bitis gabonica, VU globally)
Birds:	*Psittacus erithacus* (African grey parrot, EN), Necrosyrtes *monachus* (Hooded vulture, CR)
Amphibians:	*Conraua goliath* (Goliath Frog, EN)
Fish:	*Megalops atlanticus* (VU), *Sardinella maderensis* (VU)

Potential critical habitat triggering species appear to be associated with wetland/stream habitats (including seasonally flooded areas), and denser forest/thicket vegetation.

Terrestrial Biodiversity:
The terrestrial biodiversity of the site has been impacted upon by anthropogenic disturbances, but still retains both plants and animals that form an integral part of the community's ecosystem services. The loss of the area to be cleared for the proposed IEFCL Train 3 Project could directly affect the surrounding ecosystem through siltation and pollutants, alien invasive species introduction, and changes to the functionality of the systems.

Aquatic Biodiversity:
While little to no direct impact is predicted to occur to the aquatic biodiversity of the site, the possibility exists that effluent discharge could lead to contamination of these systems is thus a reduction in aquatic biodiversity, which is already under threat from a number of anthropogenic impacts. Most of the threatened species observed are associated with aquatic habitats.

Ecosystem Services:
The ecosystem services of the study area are most likely to be affected by the direct removal of natural systems from the footprint of the Project, as well as the loss of functionality that accompanies the loss of biodiversity noted above.

7.6 Socio-economic Environment and Health

7.6.1 Introduction

This Section describes the context of the socio-economic environment potentially affected by the Project.

The baseline was derived using desktop-based research, as well as wet season infield baseline studies undertaken by ECSL specialists appointed by IEFCL in October 2021.

Primary data was collected through sampling of the Project-affected communities in October 2021. Prior to the commencement of fieldwork, community gatekeepers were informed of the proposed study to obtain their consent and to facilitate access for fieldworkers. The Community Relations & Development Team from the existing Indorama site further assisted with access to community members and facilitation of data collection.

A non-proportional sample of 400 respondents were surveyed from the selected communities. Given the lack of reliable population data for the Study Area, it was not possible to select respondents proportional to community size. For further gathering of qualitative data, Focus Group Discussions (FGDs), Key Informant Interviews (KIIs), and Participatory Appraisal techniques were also used.

Collected data was analysed using relevant statistical software such as SPSS. In the case of data estimations, applicable formulae were used which are further detailed in the full Social Impact Assessment (SIA) Chapter.

To further understand socio-economic factors in the macro-environment, desktop research was conducted to corroborate and complement outcomes of primary data collection. Secondary data was collected through the following methods:

- Review of official publications such as the National Population Commission and the National Bureau of Statistics; and
- Additional desktop-based research, using reliable sources, where necessary.

7.6.2 Study Area

The area surrounding the Project Area is urbanised and populated. The socio-economic Area of Influence (otherwise known as the Study Area) includes the Site on which the Project is to be developed (which is a currently undeveloped piece of land adjacent to the operational Indorama Complex), as well as the host communities as notified by government.

The Project-affected communities appear to fall into two local government areas, as follows:

- The first are part of the Eleme Local Government Area, founded on a traditional kingdom covering a 140 square kilometre area. A hierarchical traditional leadership structure remains in place. The communities fall under Eleme LGA are Akpajo, Aleto, Agbonchia, Njuru and Okerewa.
- The second is the Elelenwo communities, which fall under the Obio-Akpor Local Government Area. The Wakoahu family of Elelenwo community is the originally affected by the construction of the Eleme Petrochemicals Company Limited (EPCL) plant, most notably the Wakoahu family. These communities consist of three traditional clans, led by a Paramount Leader.

As illustrated in Figure 7.57, the following areas are examined in this ESIA: Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area and Wakoahu family of Elelenwo in Obio-Akpor Local Government Area.

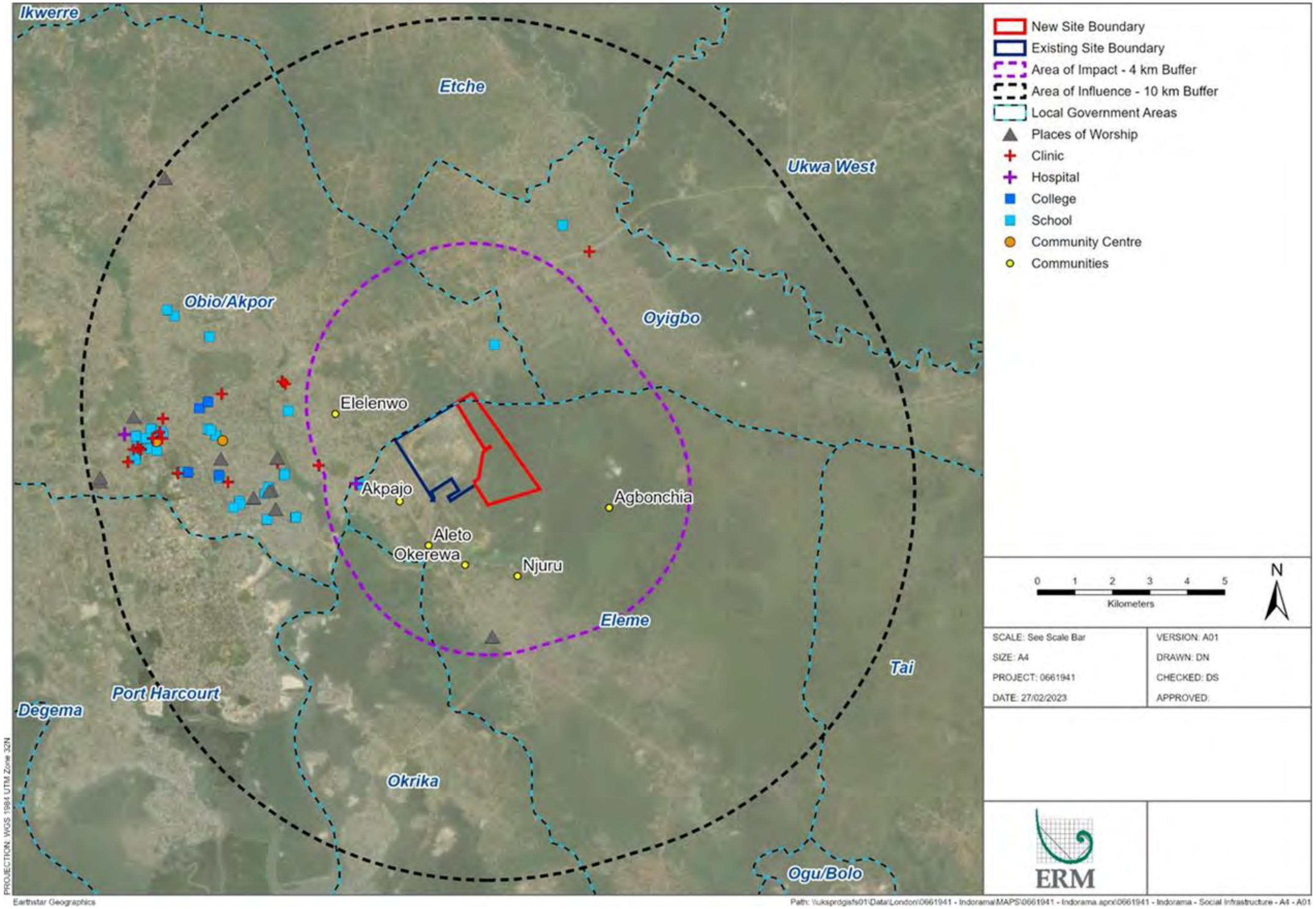


Figure 7.57 Study Area – Social Assessment

7.6.3 Governance and Administration

7.6.3.1 National Context

Nigeria achieved independence in 1960, followed by a prolonged period of primarily military rule (1966 – 1999). In 1999, a new Constitution was adopted and a peaceful transition to a civilian government took place. While the economy has continued to grow steadily, the Nigerian state faces several challenges, including the institutionalisation of democracy and the diversification of a largely oil-based economy[39].

There are challenges facing the institutionalisation of democracy at all levels of government[40]. Conflict in Nigeria is often triggered by political competition and communal, ethnic, and religious differences or allocation of benefits from natural resources like crude oil. Many Government institutions do not adequately engage with citizens or the private sector and lack the institutional capacity and requisite skills to carry out their mandates. Nigerian civil society tends to lack both the capacity and the resources to effectively engage with government and advocate for change.

Corruption is considered the most serious threat to long-term stability in Nigeria[41]. The Country is considered the second most corrupt in West Africa and ranked 154 out of 180 for transparency in the 2021 Corruption Perception Index, despite Government efforts to promote good governance.

The COVID-19 pandemic and resultant oil price crash highlighted the pressing need for Nigeria to diversify its economy beyond oil production, to avoid the vulnerabilities related to natural resource dependence[42]. In 2019, oil accounted for 84% of all export related revenue in the country. Economic diversification has been included in Government Policy since at least the 1960s but has proven difficult to achieve. This is attributed to factors like the “Dutch Disease”[43], pressure to increase short-term Government revenue over long-term economic objectives, a lack of technical capability, and entrenched interests within the economy. The result is a high dependence on the informal economy for everyday livelihoods, as well as adverse impacts on economic growth and government expenditure during natural resource slumps.

7.6.3.2 Administrative Structure

Nigeria is a Federal Presidential Republic, with capital in Abuja. It is divided into 36 states and one territory: the host state of the Project being the Rivers State. The president acts as both head of state and chief of government and is directly elected by a qualified majority popular vote and at least 25% of the votes cast in 24 of Nigeria's 36 states. The president is elected for a 4-year term (eligible for a second term); elections were last held on 23 February 2019 (next to be held on 25 February 2023).

The legislature comprises a bicameral National Assembly, with the Senate (109 seats - 3 each for the 36 states and 1 for Abuja-Federal Capital Territory; members directly elected in single-seat constituencies by simple majority vote to serve 4-year terms) and House of Representatives (360 seats; members directly elected in single-seat constituencies by simple majority vote to serve 4-year terms).

The cabinet is referred to as the Federal Executive Council and is appointed by the president but constrained constitutionally to include at least one member from each of the 36 states.

[39] Occupiers of the land when Nigerian National Petroleum Company (NNPC) acquired the land to build the Eleme Petrochemicals facility in 1984.

[40] USAID (2023)

[41] Obadare (2022)

[42] International Monetary Fund (2022)

[43] *Dutch Disease* refers to the tendency of the commodity sector to absorb factors of production from other sectors during a commodity boom. For example, in Nigeria in the 1970s, a commodity boom lured workers away from the agricultural sector despite rising rural wages, and resulted in Nigeria becoming a net agricultural importer.

Two distinct forms of local governance are present in the Study Area:

- Formal Governance
- Informal Governance

These governance structures are presented further below.

Formal Governance

The Project-affected communities fall under two Local Government Areas (LGAs) (Figure 7-58). The Eleme communities fall under the Eleme LGA, which is headquartered in Ogale. The Elelenwo communities fall under the Obio-Akpor LGA, headquartered in Rumuodomaya. Both LGAs form part of the Rivers State, which comprises of 23 LGAs and has Port Harcourt as its capital. The current governor of Rivers State is Barrister E. Nyesom Wike, and three senators from the state sit in the National Assembly.

As illustrated in Figure 7-58, Rivers State is divided into 23 Local Government Areas (LGAs). The capital of state, Port Harcourt City is administered by the Port Harcourt LGA. Communities within the Study Area fall into two immediately adjacent LGAs: Eleme and Obio-Akpor. The administrative seat of each LGA is further illustrated below; Nchia for Eleme LGA and Rumuodomaya for Obio-Akpor. Local authorities are responsible for delivery of services such as public health; pre-school, primary and adult education; town planning; waste disposal; local transport; and roads.[44]

[44] Commonwealth Governance (2023)

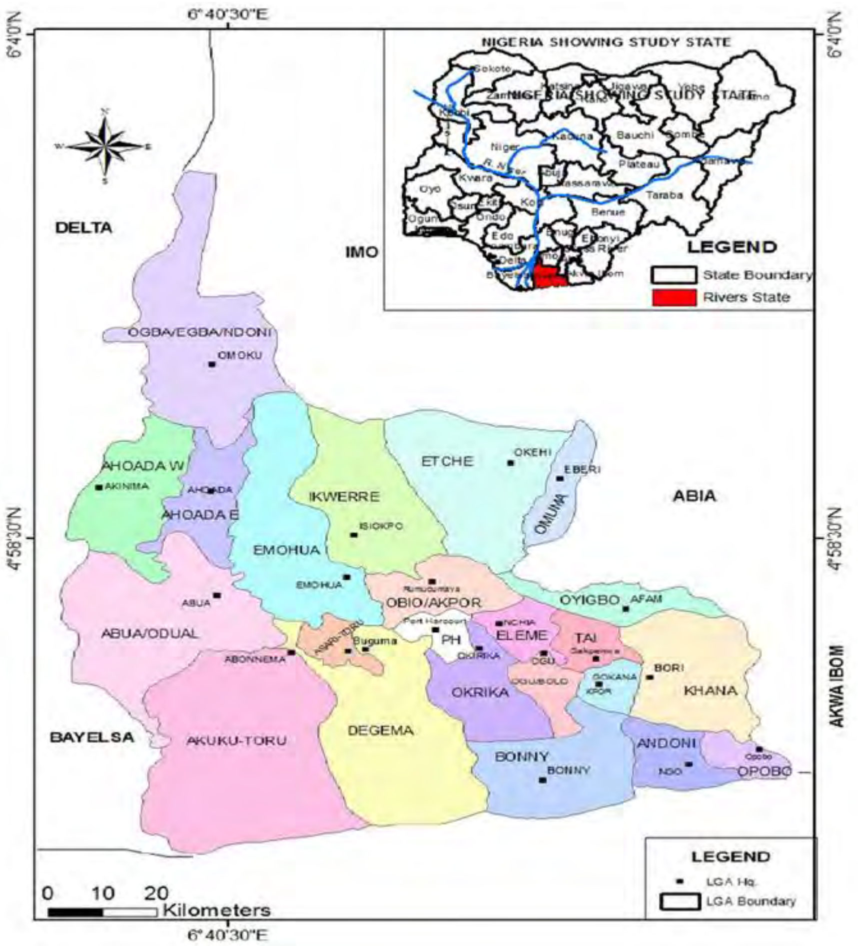


Figure 7-58 Local Government Areas in Rivers State[45]

Informal Governance

The traditional head or king of the Eleme Kingdom is the Onne-eh Eleme, a government recognised first class chief, and the present ruler originates from Aleto. There is a hierarchical order of leadership with the paramount ruler at the apex and the ordinary citizens at the bottom. Within the hierarchy are family heads or chiefs who usually sit with Emere Eleme in Council. Within the leadership structure are influential groups such as the Community Development Committee (CDC), the youth, and the female head-chiefs who represent women's issues.

The Elelenwo communities consists of three clans and a Paramount Chief. The headship is rotated so that every clan at some time has the chance of leading the community. For the Wakoahu family, there is a community development committee, youth council, and a women's group.

Present in both communities are community development committees, community-based organisations, as well as faith-based organisations. Together these various informal governance structures act as important role players in the day-to-day life of the community.

7.6.4 Planning and Development

Nigeria is Sub-Saharan Africa's largest economy, with oil comprising the main source of government revenue. Economic growth since 2008 has been largely driven by the agricultural, telecommunications, and service sectors, with oil production steadily declining since 2012. Despite economic growth and

45 Naluba, G. N & Arokoyu, S. B. (2015)

diversification, 62% of Nigeria's population live in extreme poverty. The unemployment rate was 9.79% in 2021, with 70% of the population employed in agricultural activities.

Port Harcourt and the Rivers State area have been shaped by the macroeconomic Nigerian context. Port Harcourt is the capital of Rivers State, and the fifth most populous city in Nigeria. The area has industrialised due to the presence of crude oil and natural gas, being referred to as the centre of Nigeria's petrochemicals economy. The Port Harcourt Refining Company operates a major crude oil refinery towards the south-east of the city. Alongside the proposed Project site, the existing IEFCL Trains 1 and 2 constitute the world's largest single-train urea plant, and the largest fertilizer producer in sub-Saharan Africa.

The existing petrochemicals plant was commissioned in 1996, under the EPCL, and was solely owned by the Nigerian State. In 2006 the complex privatised through purchase by the Indorama Group. In 2016, the IEFCL Train 1 commenced with production, followed by Train 2 commencing production in May of 2021.

Despite the large-scale industrialisation within the Port Harcourt area, upstream industrialisation remains limited. Within the AoI, local industrial activity centres around small-scale welding and fabrication, sand mining in the rivers in the area, traditional food processing like fish smoking, and cassava flour production. The presence of large industry, government offices, and resultant population influx, has brought commercial banks, retail outlets, and small hotels into the city. Notwithstanding this development, the majority of residents in the AoI depend on the informal economy for their livelihoods.

7.6.4.1 Development Plan

Desktop research reveals reference to a Rivers State 50 Year Strategic Development Plan, which was launched in 2017, as well as the Greater Port Harcourt City Development Plan.

The Greater Port Harcourt City (GPHC) Development Plan was commissioned in 2008 as a 50-year plan with a two-fold purpose; firstly, to promote urban renewal and regeneration of the old city, and secondly to provide direction for the development of the New City[46]. The New City will be an extension of the Old Port Harcourt City and will allow for urban growth through planning and de-densification of the Old City, while gradually integrating both cities into one single unit.

The key anchors of the GPHC Development Plan are the Port Harcourt International Airport, the Old Port Harcourt City and the Onne Sea port. The Master Plan is an aggregate of land use, transportation (roads, public transport, and freight transport), water, wastewater, storm water, energy, integrated waste management and social services infrastructure masterplans.

The necessity for a Development Plan was borne out of the constant population influx into the area and rapid physical expansion of Port Harcourt, resulting in uncontrolled development, poor living conditions for residents, and continuing deterioration of existing infrastructure.

It appears to be generally accepted that the Development Plan has had limited success in achieving its objectives. This is attributed to poor capacity of the local planning authorities, regular economic downturns (such as the 2008 financial crisis and COVID-19 pandemic) which hampered the availability of funding for capital developments, bureaucracy, and corruption, and policy inconsistencies due to political instability. It can be expected that future growth in the affected LGAs will continue to be spurred by population influx, and physical development.

7.6.5 Human Rights

The 2022 Freedom in the World Index ranks Nigeria as 'Partly Free'[47]. While Nigeria has made significant improvements to the quality of its elections since the 1999 transition to democratic rule, the

[46] Wenike & Dawaye (2021)

[47] Freedom House (2022)

2019 presidential and National Assembly elections, which saw President Muhammadu Buhari re-elected and the All-Progressives Congress (APC) regain its legislative majority. The petroleum industry remains vulnerable to global volatilities in the one hand and security challenges and corruption at the National level.

7.6.6 Demographics

There are two clans in the Eleme communities, namely Odido and Nchia. The Project-affected communities belong to the Nchia clan. The Elelenwo communities are descendants of Obio and are comprised of three clans (Table 7-33).

The most recently available population data is from 1991. Table 7-33 presents this data, as well as the projected potential population size of the Project-affected communities in 2021 and 2026, assuming a 3.5% annual growth rate.

Table 7-33 Population Data

LGAs	Communities	1991			Projected Population @ 3.5% Growth Rate		% Change
		Male	Female	Total	2021	2026	
Eleme	Agbonchia	4,869	4,458	9,327	30,923	35,970	19.5
	Akpajo	2,936	2,260	5,196	17,211	20,018	18.5
	Aleto	3,211	3,165	6,376	21,122	24,566	19.5
Obio/Akpor	Elelenwo	1,656	2,714	3,275	29,028	33,665	19.5
	Total	**7,803**	**12,597**	**24,174**	**98,284**	**114,219**	**19.3**

Source: Field Survey (2021): Social Impact Assessment Report for IEFCL-Train 3 project ESIA

The population is young, with 41% of residents below 25 years of age, and has a relatively equal ratio of men and women. The average household size is between 6 and 10 members. Migration and influx are key demographic drivers, with 57% of surveyed respondents having migrated into the Study Area. This is largely attributed to the industrialisation of the area, and the perceived presence of greater business and employment opportunities.

7.6.6.1 Ethnic Groups and Languages

The Eleme communities comprise of the Eleme ethnic group. Eleme shares a boundary with other ethnic groups in the Rivers State like Ikwerre, Okrika, Oyigbo and Ogonis. The language spoken is Eleme. There is a hierarchical traditional leadership system whereby the Paramount Ruler is at the apex of leadership. The other subordinate leaders are the Chiefs, Districts and family Heads who usually sit in the Eleme Traditional Council.

The Elelenwo communities appear to be less distinct, comprising of communities affected by the original acquisition of land by the Nigerian state to build the EPCL complex in 1984. Elelenwo comprises sections of the Rumuoduwere, Rumueheleze and Rumuodani communities, which are from the Ikwerre ethnic group. The primarily affected family is the Wakoahu family of Elelenwo. The Elelenwo have a committee of three clans whose chairman is the Paramount Ruler. The headship is rotated so that every clan at some time have the chance of leading the community.

Given the high levels of migration into the Study Area, the ethnic and language composition has likely become significantly more diverse over time. While English is the official language in Nigeria, there are over 500 additional indigenous languages. No specific primary data relating to the language composition of the Study Area appears to have been gathered.

7.6.6.2 Indigenous Peoples

According to the United Nations, Indigenous Peoples are defined as “inheritors and practitioners of unique cultures and ways of relating to people and the environment. They have retained social, cultural, economic, and political characteristics that are distinct from those of the dominant societies in which they live.”[48] In The Indigenous World 2022 Report, Nigeria is not currently listed as country with a significant population of indigenous people[49]. With that being said, the Eleme and Ikwerre ethnic groups are not directly linked to the dominant ethnic groups of Hausa (±30% of national population), Yoruba (±15%) or Igbo (±15%)[50], although they may share similarities with these. The high levels of influx into the area also suggest that a more diverse ethnic context is present, with the possibility of minority ethnic groups being present alongside the Eleme and Ikwerre.

7.6.6.3 Gender Context

The Study Area follows a patriarchal social system, in which men have dominant control in politics, resources, moral authority, social privileges, family, clan and traditional leadership. In the Eleme kingdom, for example, female representation is present in the higher echelons of traditional leadership but is reported to be tokenistic in nature.

Respondents in the community survey reported that 44% experienced frequent gender-based abuse, 31% experienced it occasionally, while 25% reported not experiencing any forms of abuse. Abuse of a female spouse, gender-based discrimination, and female genital mutilation were all reported in the Study Area. This points to a context in which females are highly oppressed.

Within the Eleme community, women head-chiefs in the various sub-clans are identified as the community leadership structure representing women’s needs. Within the Elelenwo communities, a women’s group is identified as sub-governance structure within the traditional leadership hierarchy. The primary data collection does not provide insight to the effectiveness or level of influence that these structures hold.

7.6.7 Education

At a national level, Nigeria reports a literacy level of 71.3% among the male population, and 52.7% among the female population. The significant difference in literacy levels is indicative of lower levels of female school attendance.

Primary data collected reveals that on average 45.40% and 30.10% of the respondents’ attained primary and secondary-school levels of education respectively. 12.10% had post-secondary education and 12.4% did not have any form of formal education but could communicate with Pidgin English. This points to a literacy rate of roughly 87% in the Study Area, which is significantly higher than the national average but unsurprising given the urban nature of the area.

7.6.8 Livelihood Activities

Results from primary data collection suggest that 61% of respondents are self-employed, 18% are unemployed while 20% are employed either in government or an organized private sector. Farming makes up the largest livelihood source, at roughly 30%. The next most common category is trading and business/construction, at 24.5%. Only 8.6% of respondents are employed in the industrial sector.

Primary data collection reveals that 53% of household monthly income is spent on food and accommodation. This is followed by healthcare, which makes up 13% of monthly spend. Savings in the

[48] United Nations (2023)
[49] IWGIA (2022)
[50] Statista (2023)

Study Area are traditionally made through investment into assets for primacy economic activity, such as fishing gear or boats. Informal rotating savings clubs are also a common feature.

7.6.9 Land Tenure and Land Use

60% of land in the Project-affected communities is owned and controlled by community structures and families. This is also applicable to the stretches of rivers and creeks adjoining such land. During FGD sessions across the communities it was observed that portions of land owned by families are shared to households within the families (compounds). The community leader occasionally leases land to non-locals. 75% of respondents live in homes that they own, with the remaining 25% in rental accommodation. The majority (95%) of housing is formal in nature, with very few respondents living in traditional mud huts.

Given that the Project is located on the outskirts of a densely populated urban area, immediate land uses are dedicated to human settlement, including housing, industrial and commercial (formal and informal). Open areas of land within and outside of settlements is likely to be used for subsistence and market farming. The main crops cultivated in order of importance to local communities are cassava, maize, yam, plantain, green vegetables, cocoyam, and fruits. The farming system is a limited form of shifting cultivation where land is cleared and cultivated for several years until productivity diminishes; it is then abandoned until natural processes regenerate the soil.

The Project will be developing on a currently open piece of land, adjacent to Trains 1 and 2. This 250 ha land parcel is part of 895.991 hectares of land which originally was acquired by government in 1984. Since then, there has been no socio-economic activities on the land parcel. This land was designated for industrial development by the Nigerian National Petroleum Company (NNPC) and secured. It is, therefore, assumed that there is currently no public use of the site. Some subsistence farming (agriculture) may take place immediately adjacent to the site boundary; however, the extent of this is unknown.

7.6.10 Health

There are well over thirty standard public and private health facilities within the two LGAs. These include seven Model Primary Health Centres, two secondary health facilities and a good number of chemists/pharmacies and traditional-medical centres. All the participants acknowledged the presence of health facilities and how to access them. Public health facilities do not operate at optimal capacity as they lack adequate personnel, equipment, prophylactic drugs, supply chains or consumables. Due to this deficiency, most of the supporting/complementary services such as laboratory, x-ray and ophthalmic services are referred to private facilities, which make access to treatment at government facilities cumbersome for patients who may need to travel to multiple healthcare facilities.

Common ailments in the Study Area include Malaria, Typhoid, dysentery, and skin conditions. The Rivers State has an HIV/AIDS prevalence of 3.8%, as compared to the national average of 1.4%. A significant challenge in the Study Area is waste management, with uncontrolled dumping observed in all Project-affected communities. The build-up of waste serves as a vector of pests and disease, especially malaria.

7.6.11 Education

Every community in the Study Area has a model primary school established and funded by both the community and the state government. All the settlements also have secondary schools. There are a handful of privately-owned schools from primary to secondary levels in all the settlements. These private schools offer a teaching standard that is highly competitive with those in government schools, but the fees limit this option to the wealthy only. There is no higher institution of learning in the Study Area except the recently established PAMO Medical University in Iriebe of Elelenwo. Education attainment in the Study Area is presented in Table 7-34.

Table 7-34 Educational Attainment in the Study Area

Educational Attainment by Household Members			
Categories	**Obio/Akpor**	**Eleme**	**Average %***
No formal Education	375	457	16.5%
Pre-primary Education	213	162	7.3%
Primary Comp.	341	231	11.2%
Secondary Uncompleted	238	216	8.9%
Secondary completed	312	478	15.8%
Tertiary Uncompleted	98	104	4.0%
Tertiary Completed	476	337	15.9%
Teachers Grade2	236	176	8.1%
Trade test cert.	128	118	4.8%
City and Guild Cert.	287	101	7.4%
TOTAL	**2,704**	**2,380**	***100%***

Source: Adapted from Field survey, 2021 and LGAs publications (various editions) in Social Impact Assessment Report for IEFCL-Train3 PROJECT ESIA

**A based-on data provided*

7.6.12 Infrastructure and Public Services

Table 7-35 summarises access to infrastructure within the Study Area.

Table 7-35 Infrastructure in the Study Area

Infrastructure	Condition / Availability
Electricity	Project-affected communities are linked to the national grid, but electricity supply is unreliable. Communities source and maintain their power through small-scale private generation, lanterns etc.
Water	No functional municipal water is available, but individuals have boreholes / wells.
Roads /Drainage	The East-West Road, a gateway to industrial hubs that traverses through the target communities is in a state of disrepair. A stretch from Elelenwo to Onne was recently repaired by Indorama.

Infrastructure	Condition / Availability
	Poor internal road networks and drainage systems are not maintained causing flooding during the wet season. Drains are clogged with debris.
Transportation	The area is traversed by two major highways: the East-West Road that begins in Warri and ends in Eket and the Port-Harcourt-Aba Expressway. The highways are used extensively by trucks transporting loads for industry. Cars, tricycles (keke napep) and motorcycles are the mode of transportation used by the public.
Telecommunications	Project-affected communities have access to public communication facilities like telephones and postal services. The networks of the major telecommunications companies (Glo, MTN, and Airtel) are available.

Source: Field Survey (2021): -Social Impact Assessment Report for IEFCL-Train3 Project ESIA

7.6.13 IEFCL Operations

7.6.13.1 Labour and Employment

The current operations are situated on approximately 51 hectares of land within the Indorama Complex and a pipeline of 83.5 km for gas supply. Also located within the Indorama Complex is the IEPL plant which produces a range of polyethylene and polypropylene resins. IEFCL-Train 1 commenced operations in 2016 and employs 225 people and IEFCL-Train 2 commenced in mid-2021. A total of 801 people are employed at IEFCL Port Harcourt operations, 4% are female (Table 7-36) and 72% are Nigerian nationals (28% expatriates) (Table 7-37).

Table 7-36 Current Employment Overview

	Female	Male	Total
Contract	15 (8%)	180 (92%)	195 (24%)
Permanent	15 (2%)	591 (98%)	606 (76%)
Total	**30 (4%)**	**771 (96%)**	**801**

Table 7-37 Classification of Current Employment

	Female	Male	Grand Total
Expatriate	2	226	228 (28%)
Junior Staff	11	240	251 (31%)
Non-Union Mgt. Staff	-	1	1 (0.1%)
Non-Union Snr. Staff	-	9	9 (9%)
Senior Staff	2	115	117 (15%)

	Female	Male	Grand Total
Skilled	-	85	85 (11%)
Unskilled	15	95	110 (14%)
Grand Total	**30**	**771**	**801**

7.6.13.2 *Internal Health and Safety*

The operation maintains "a good safety performance relative to other manufacturing industries operating on the African continent with established safety management systems"[51]. IEFCL has robust policies, procedures and plans in place which includes (but not limited to):

- A Quality, Health, Safety and Environmental (QHSE) policy, which includes:
  - EHS procedures such as permit to work, management of change, scaffolding, waste management;
  - An EHS risk assessment process including the development of EHS risk assessments for key areas and activities;
  - A medical surveillance programme;
  - An incident reporting system;
  - An incident investigation process;
  - A detailed EHS monitoring programme;
  - EHS inspections and audits, an EHS training programme;
  - Established health and safety committees including worker representatives;
  - EHS awareness mechanisms (e.g. signage, posters, daily "tool box talks", EHS awareness competitions etc.); and
  - Contractor management processes.
- Occupational Health, Safety & Wellbeing Policy
- On-Site Emergency Management Plan
- Employee Grievance Management Procedure
- Employee Handbook: HR Policies & Procedures Guide
- Indorama Corporation Group Handbook:
  - Code of Conduct
  - Community and Stakeholder Policy
  - Environment and Climate Change Policy
  - Health and Safety Policy
  - Human Rights and Labour Policy
  - Intellectual Property Policy

[51] As above – IBIS (2022)

- Product Stewardship and Treatment of Customers Policy
- Responsible Business Policy
- Social Media Policy
- Confidential Reporting

In addition, there is a Local Hiring Plan for Construction & Operation phase of IEFCL Train 3 Project (dated 2023).

7.6.14 Assumptions on the Socio-economic Baseline

The following assumptions are applicable to the socioeconomic baseline:

- The data provided from primary data collection is accurate and analysed correctly.
- The study communities are mostly aligned to the Project-affected communities, and where Project-affected communities were not involved in the study, their demographic characteristics are similar to those of the study communities.

The following limitations should be considered with regards to this socioeconomic baseline:

- Data collected and methodologies used by in-country consultants can only be partially verified for reliability.
- Where recent data is not available, professional judgement has been used to extrapolate data reflecting the current context.
- Data sets for Project-affected communities are often limited or non-existent; it is therefore necessary to rely on data and information which is applicable at a regional or national level.

7.6.15 Summary of Key Socio-economic Sensitivities

- Proximity of communities to site:
  - The construction phase could result in disruption to nearby communities to the north and north-west. The access to the site (roads and entrances) should be considered to minimise impacts to adjacent communities.
  - Construction noise, dust, traffic must be managed to prevent impacts on nearby communities.
  - Air quality was raised as a perceived issue from the current Indorama facility – and should be considered in the ESIA – i.e., to what extent does the current facility impact on local air quality and what is the potential for this to change with the proposed project.
- Labour
  - There is an ongoing influx of people from outside the immediate area moving into Port Harcourt seeking employment and business opportunities. The proposed Project is likely to create expectations around employment and opportunities. This must be managed through effective and ongoing stakeholder engagement (adjacent communities and the broader public).
  - Sourcing of labour for construction must be done in a manner that is open and transparent, and through reputable organisations or structures.
  - Indorama needs to outline the number and skill levels of employees and contractors required during construction and operation and how labour will be sourced, or provide a commitment statement to this effect, before stakeholder engagement commences.
- Community Investment
  - Currently Indorama have agreements (MoUs) with host communities (Akpajo, Njuru, Okerewa, Aleto, Agbonchia, Wakoahu Family defined by government), which is renewed every three (3) years. The expectation from the communities is likely to be that these will be reinstated with new terms and/or amounts to be paid. With the expansion of the Indorama site, it is likely that communities will expect an increased level of social investment.
  - The ESIA team (stakeholder engagement team) needs to be clear about the intentions around community investment prior to engagement with these communities.
- Town Planning and Development
  - The Port Harcourt area has historically suffered from rapid and uncontrolled physical expansion. This trend is likely to continue, with human settlement densifying in adjacent communities and further surrounding the Project site.
  - The cumulative impact of population influx can be expected to worsen high-density, unplanned human settlement in the Greater Port Harcourt area with little to no provision of basic services.

7.7 Cultural Heritage

7.7.1 Introduction

This Section of the Report provides the Cultural Heritage baseline and assess the nature, distribution, and value (significance) of cultural heritage resources for the establishment of the Project.

The baseline was derived using desktop-based research, as well as wet season infield baseline studies undertaken by ECSL specialists appointed by IEFCL in October 2021. The aim of the infield assessment was to gather information on the following intangible Cultural Heritage:

- Places that might be of spiritual importance, for example shrines, places of worship, ancestral places etc.;
- Traditions, crafts, festivals, or rituals in the area that may be impacted; and
- Land farmed or managed in a particular way or tradition that is unique to a specific location.

All identified Cultural Heritage resources within the Study Area with the potential to be directly or indirectly affected are considered. The extent and value (significance) of archaeological and paleoenvironmental remains, historic buildings, the built environment and historic landscape are also considered. Table 7-38 provides a definition of the Study Area for cultural heritage.

Table 7-38 Project Area of Influence – Study Area

Project Phase	Activity with Potential Impact	Project Area of Influence (Study Area)
Construction	Ground Disturbance activities (Earthworks) Restricted Public Access Introduction of intrusive noise, (including vibration noise), dust, and visual elements.	500 metres of the proposed development and associated infrastructure.
Operation	Restricted Public Access Introduction of intrusive noise and visual elements.	500 metres of the proposed development and associated infrastructure.

The Cultural Heritage assessment has been prepared using the guidance on Heritage Impact Assessments for Cultural World Heritage Sites (International Council on Monuments and Sites[52], ICOMOS[53]) and international guidance (ICOMOS and IFC PS8[54]). No national guidance currently exists on methodology for assessment of impacts on Cultural Heritage within Nigeria.

The surface geology of the Study Area consists of fluvial sediments transported by the Niger River tributaries with Quaternary Upper and Low Deltaic deposits[55]. The land is typically low-lying with poor drainage and a combination of thick vegetation and seasonally cultivated soil, limiting the identification of potential cultural heritage features through remote sensing.

7.7.2 Archaeological and Historic Background

7.7.2.1 Literature Review of Nigerian Archaeology Studies to Date

Archaeological research began relatively late in south-eastern Nigeria, with the first systematic excavation in the region taking place in 1960[56]. Prior to this more informal research began in 1910 with European scholar Frobenius who focussed on recovering objects rather than documenting archaeological context. The discovery of terracotta, copper and bronze objects spurred further

[52] ICOMOS, 49-51 rue de la Fédération 75015 Paris, France in collaboration with the World Heritage Centre. 2011. Guidance on Heritage Impact Assessments for Cultural Heritage Properties. A publication of the International Council on Monuments and Sites. Available at: iccrom.org. Accessed on: 31/03/2022.

[53] This guidance has recently been updated and can be found here: https://www.iccrom.org/sites/default/files/2018-07/icomos_guidance_on_heritage_impact_assessments_for_cultural_world_heritage_properties.pdf

[54] https://www.ifc.org/wps/wcm/connect/topics_ext_content/ifc_external_corporate_site/sustainability-at-ifc/policies-standards/performance-standards/ps8

[55] Report No: C-202111 Soil Investigation Report FISAS. January 2022.

[56] Ngonadi, C. Archaeology of Igboland, Southeastern Nigeria. Oxford Research Encyclopedia of Anthropology. Retrieved 18 Feb. 2023, from https://oxfordre.com/anthropology/view/10.1093/acrefore/9780190854584.001.0001/acrefore-9780190854584-e-556.

research, leading to a flurry of researchers interested in the collection of Nigerian artefacts through archaeological surveys. Up until the late 1930s, Nigerian archaeological studies were fuelled by locating fascinating objects as opposed to researching the broader topic of civilisations that existed in West Africa[57].

In 1943 the Nigerian Department of Antiquities (NDA) was established in Nigeria to oversee archaeological works and in the late 1960s the first systematic surveys were carried out by the NDA in partnership with University of Cape Town, University or Ibadan, University of Ile-Ife and University of Nigeria. This opened the doors for local scholars to study the archaeology of their own country. Excavations such as the Igboukwu excavations yielded large quantities of glass beads, intricately produced bronze artefacts (Figure 7-61) and potsherds and various iron tools which revealed intrinsic value and ingenuity of the surrounding Igbo kingdom. Figure 7-59 locates the Igbo region of Nigeria on a map in relation to the Study Area.

Archaeological studies in south-eastern Nigeria in more recent years have shed light on the technology used to extract raw materials in the past for the production of stone, metal tools and pottery. Traditional methods of raw material extraction continue into the 21st century within the Igbo region with evidence of iron smelting, pottery making and tin mining. Figure 7-60 locates these different technologies on a map in relation to the Study Area.

7.7.2.2 Prehistory

Most archaeological sources suggest that hunter gatherers occupied Igboland during the Middle to Late Stone Age (8000 – 3000 BC) before migrating south to populate most of sub-Saharan Africa between 5000 – 4000 BC. Oral traditions today speak of the foraging and hunter gathering time, for example the *Nri* give hints of foraging by claiming that their ancestors and mythical leader *Eri* descended from the sky when yams and other crops had not yet been domesticated. The town of Aba, approximately 40 km to the northeast of the Study Area has a folk tale that ancestors of the surrounding land arrived from Ngwaland using elephant paths to migrate and settle near the Aza River. Aba is known today as the '*enyi mba'* which translates to *'The elephant town'.*[58]

Early trade routes were established between southeastern Nigeria and India in the 9th century AD with beads recovered in an Igbo Ukwa burial site originating from Indian soil. This is the earliest evidence of global trade but in the 1400s Igboland was conquered by the British which fuelled the Atlantic slave trade.

[57] Olanrewaju Blessing Lasisi. 2015. History of Archaeological Research in the Yoruba-Edo region of Nigeria: New Directions for Urban earthworks. University of Ibadan.

[58] Oriji, J.N. (2011). Igboland Before and During the Iron Age: From Stateless Societies to Mini States. In: Political Organization in Nigeria since the Late Stone Age. Palgrave Macmillan, New York.

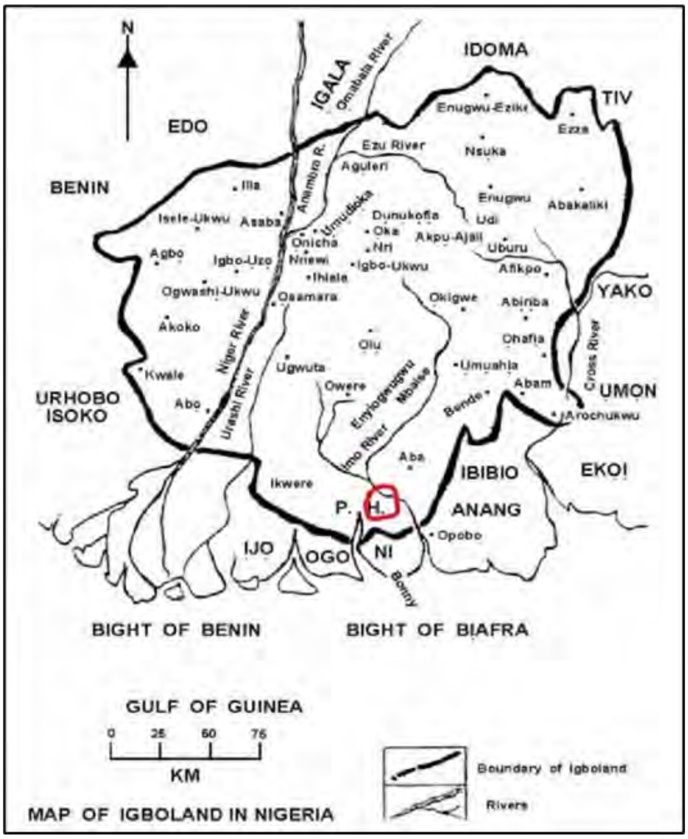


Figure 7-59 The Extent of Igboland, with approximate Study Area circled in red[59]

59 Validating perceptual objective listening quality assessment methods on the tonal language Igbo - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Map-of-Igboland-in-Nigeria_fig2_27353122 [accessed 18 Feb, 2023]

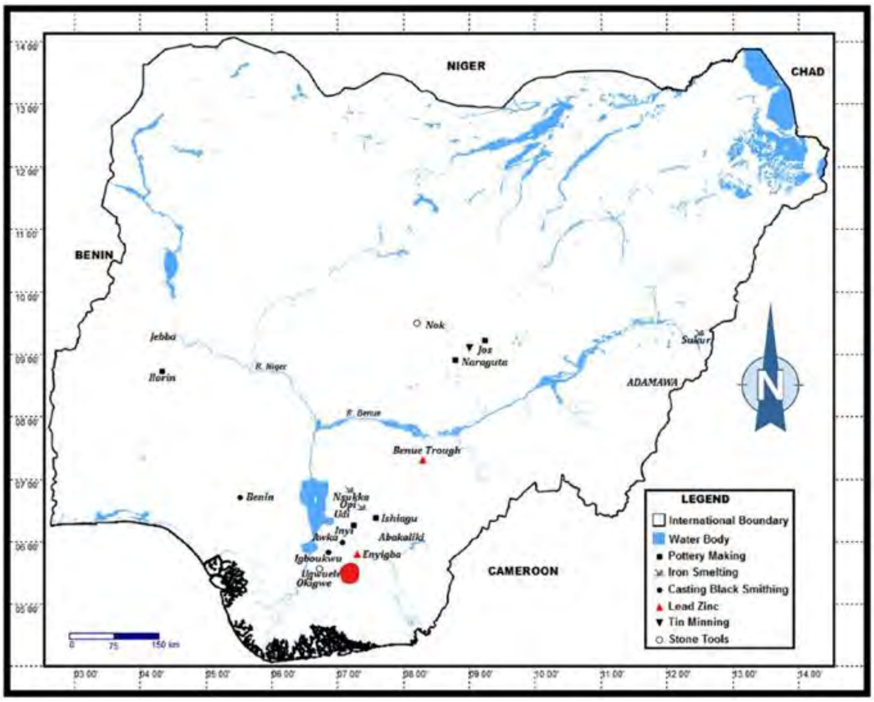


Figure 7-60 **Locations for Studied Archaeological Sites in Southeast Nigeria in relation to the Study Area**

Figure 7-61 **Cast Bronze Vessel with an Animal Motif Excavated at Igbo Ukwu[60]**

60 https://www.thoughtco.com/igbo-ukwu-nigeria-site-171378. Accessed 18 February 2023

7.7.2.3 Historic Era

Following the abolition of the slave trade in 1807, the British Royal Navy opened a trade route with the coastal towns driven by the palm oil industry. The arrival of the British lead to increased encounters between Igbo and other communities around the Niger River and Delta, as well as an influx of Christianity. Christianity played a large part in the introduction of European ideology into Igbo society, leading to the construction of Christian churches, some of which may still be present in the villages surrounding the Study Area.

Nigeria claimed independence from the United Kingdom in 1960, leaving Igboland confined mostly to the southeast region of Nigeria. In 1966 there was a coup in which time many Igbo soldiers were called to assassinate politicians from western and northern regions and the Capital was seized. The eastern region formed a core and requested to become the Republic of Biafra, independent from Nigeria. A flag was created, known as the flag of the Igbo and evidence of civil conflict may be seen on the landscape surrounding the town of Aba[61]. Biafra became part of Nigeria once again in 1970 with military support from the United Kingdom however the tactics used to reunite Biafra and Nigeria remain controversial[62].

7.7.2.4 Intangible Cultural Heritage

Ancestral worship has been identified in previous baseline surveys as a form of traditional religion, with sacrificial rituals performed at designated places known as sacred areas or shrines in order to service, maintain and protect families or communities. Recognised deities are associated with these families or communities, however most of the land associated with sacred rituals has been sold or converted for commercial use, which threatens the extinction of traditional religions. For example, the *Okala nsin* of *Okerewa* associated with an inland body of water which is no longer in existence due to development. Another example is *Otalloboni* in Akpajo which has been relocated for its safe keeping from development of the area. Photographs or exact locations are aften not permitted for this reason.

The traditional New Yam festival takes place during and after harvest from September to October, during which time it is customary to not eat the harvests of yams until it is offered to the ancestors, whom the community believes made the harvest possible. Recently though the decline in yam production has led to a decrease in participation in the yam festival. This is due largely to recent urbanization and industrialisation of the land previously used for agriculture.[63] Issues such as this need to be considered within the context of this Project and by applying appropriate mitigation measures following an impact assessment.

7.7.3 Key Baseline Findings

The baseline study identified one potential cultural heritage resource within the Project Area. Each identified resource is assigned a unique identifier (for example IND_CH_001). Details of the potential cultural heritage resource is provided in Figure 7-62 and Figure 7-63.

[61] Mathews, Martin P. (2002). Nigeria: Current Issues and Historical Background. Nova Publishers. p. 38. ISBN 1-59033-316-0.

[62] Minogue, Martin; Judith Molloy (1974). African Aims & Attitudes: Selected Documents. General C. O. Ojukwu: CUP Archive. p. 393. ISBN 0-521-20426-7.

[63] SIA, HIA Cultural Heritage report for the IEFCL-Train3 Project ESIA. November 2021.

Figure 7-62 Potential Cultural Heritage Resource (IND_CH_001) in Project Area

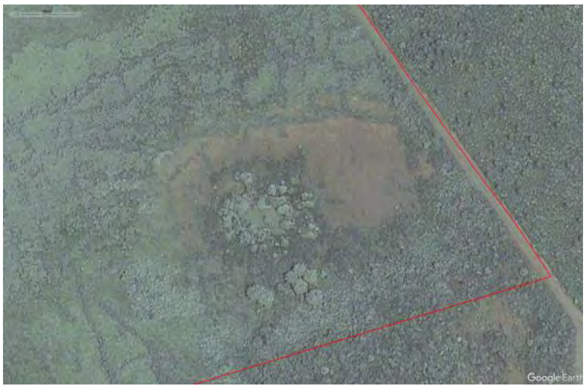
7.7.3.1 Designated Cultural Heritage

No designated cultural heritage resources were identified within the Study Area.

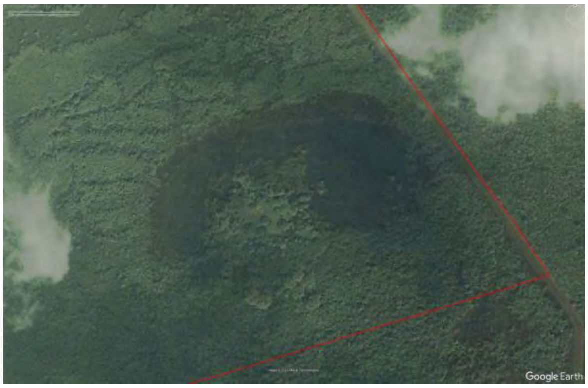
7.7.3.2 Non-designated Cultural Heritage

One non-designated potential cultural heritage resource was identified within the Study Area (IND_CH_001) and is presented below:

- **IND_CH_001**: An area of land approximately 250 metres in diameter slightly elevated from the land surrounding (+- 19 masl based on the topographic survey). From satellite imagery and the topographic report, it appears to contain a small body of water. Figure 7-63 illustrates the potential cultural heritage resources observed through satellite imagery from 2000 to 2015, which remains undisturbed in the surrounding seasonal agricultural development. With reference to the intangible cultural heritage section of this baseline it was initially perceived that the site had the potential to contain intangible cultural heritage in the form of a sacred grove with spiritual or religious value; however, a subsequent ground truthing exercise indicated that IND_CH_001 contains no heritage value.

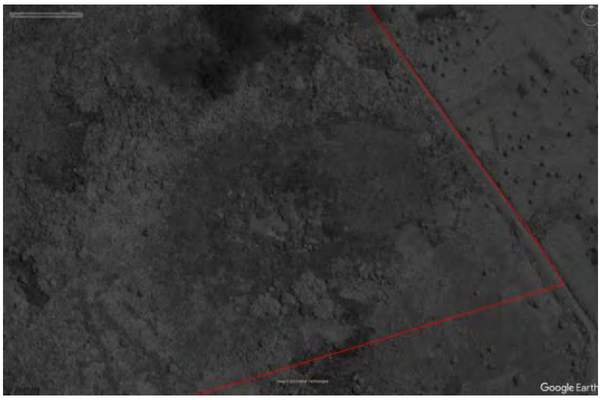


2000



2002

2005



2007

2013

2015

Figure 7-63 Mapping the Consistency of IND_CH_001 within the Surrounding Landscape within the Project Area[64]

7.7.3.3 Value of Identified Receptors

Each identified Cultural Heritage resource is assigned a sensitivity/ value expressed as” Low”, “Medium” and “High”. The assignment is based on desk-based research, the social survey incorporating elements

[64] Source: Google Earth. 4°49'32.22"N, 7° 7'11.33"E. Eastern Niger Delts, Nigeria. 18 February 2023

of intangible cultural heritage and professional judgement, along with the ERM methodology aligned with the IFC PS8 guidance as set out in Table 7-39 below.

Table 7-39 Criteria for Cultural Heritage Impact Significance

	Cultural Heritage Site Sensitivity		
	Low	Medium	High
Definitions	**Defining Characteristic(s):** Site is not specifically protected under local, national, or international laws or treaties; Site can be moved to another location or replaced by a similar site, or is of a type that is common in surrounding region; site has limited or no cultural value to local, national, or international stakeholders; and/or site has limited scientific value or similar information can be obtained at numerous sites. (Replicable Cultural Heritage)	**Defining Characteristic(s):** Site is specifically or generically protected by local or national laws but laws allow for mitigated impacts; Site can be moved or replaced, or data and artefacts recovered in consultation with stakeholders; Site has considerable cultural value for local and/or national stakeholders; and/or Site has substantial scientific value but similar information can be obtained at a limited number of other sites. (Non-replicable Cultural Heritage)	**Defining Characteristic(s):** Site is protected by local, national, and international laws or treaties; Site cannot be moved or replaced without major loss of cultural value; Legal status specifically prohibits direct impacts or encroachment on site and/or protection zone; Site has substantial value to local, national, and international stakeholders; and/or Site has exceptional scientific value and similar site types are rare or non-existent. (Critical Cultural Heritage)

Tangible Cultural Heritage

Tangible Cultural Heritage refers to physical artefacts, objects or places produced, maintained, and transmitted inter-generationally in a society. No tangible cultural heritage resources were assigned a sensitivity.

Intangible Cultural Heritage

Intangible Cultural Heritage refers to 'the practices, representations, expressions, knowledge, skills as well as the instruments, objects, artefacts and cultural spaces associated therewith that communities, groups and, in some cases, individuals recognize as part of their Cultural Heritage' (UNESCO, 2003).

Due to the instrumental and artefactual nature of Intangible Cultural Heritage, it is common for Cultural Heritage to have both tangible and intangible value. Intangible Cultural Heritage features may be impacted by restricted access during construction phase and operation phase.

The one identified intangible Cultural Heritage resource (IND_CH_001) was assigned a "**low"** sensitivity.

7.8 Traffic

7.8.1 Road Network

Major roads that will be used by the Project include:

- **Uzaku-Alese Road**: This regional north-south road connects communities on the east side of Port Harcourt. Near the Project site the road connects Eleme with Oyigbo, passes by the western border of the Project site, and intersects the East West Road south of the Indorama access road. The Uzaku-Alese Road has asphalt paving from south of the East West Road to central Oyigbo, with a typical pavement width of 8 m. In urbanised areas, unpaved shoulders and drainage ditches are present along both sides of the road, and residential and commercial structures immediately about the drainage ditches. At Eleme Market, the Uzaku-Alese Road is unmarked, has a curb and has a sidewalk adjacent to the Comprehensive High School field. Market stalls often extend into the roadway. In more rural locations between Eleme and Oyigbo, the Uzaku-Alese Road has no drainage, an unpaved shoulder, and no sidewalks. The pavement in rural areas is often degraded. This road is used for pedestrian as well as vehicular travel.
- **East West Road**: This arterial (also referred to as the Eastwest Expressway) connects southeastern Nigeria to Port Harcourt, and has an interchange with the A3 road, a national north-south highway, in Port Harcourt. In the vicinity of the Indorama Complex entrance/exit road, the East-West Road is a paved (asphalt) four-lane road with two travel lanes in each direction, approximate paved width of 24 m, an intermittent low jersey barrier median, no drainage or sidewalks, and unpaved shoulders. The pavement condition is degraded.
- **The entrance/exit road to the Indorama Complex** is a concrete road with two dedicated lanes (one in each direction) for trucks. The designated road surface is 15 m wide, with 2 m wide walkways on either side. The entrance also includes a separate two-lane asphalt road (approximately 6 m wide) for personnel entry with paved shoulders, drainage, and a walkway along one side. The entrances to the Indorama Complex Road have security gates and guard posts at the East West Road. The intersection with the East West Road has no traffic signal. The Indorama Complex Road has a length of approximately 1.3 km from the East West Road to the Indorama Complex and becomes the perimeter road for the Indorama complex.
- **Federal Ocean Terminal Roadway**: Project construction and operation will use terminal facilities at the port of Onne for the movement of materials and goods. Trucks hauling materials and goods would use the Federal Ocean Terminal roadway to connect to the East West Road. The Federal Ocean Terminal Roadway is an asphalt-paved, divided road with a paved width of about 8 m in each direction, a 5 m wide landscaped median with curbs, and intermittent unpaved shoulders. Although wide enough for multiple lanes, each direction of the road typically accommodates one lane of traffic, along with vehicles parked along the edge of the roadway.
- **Onne Road**: Onne Road connects the Federal Ocean Terminal roadway to East-West Road. Onne Road is an asphalt-paved, divided road with an unmarked paved width of about 8 m in each direction, a 2 m concrete median, and intermittent unpaved shoulders. The road could accommodate two travel lanes but typically accommodates one lane of traffic, primarily truck traffic, with vehicles parked along the roadway edges. Onne Road also has parallel service roads on either side of the main roadway. The service roads are 4 to 5 meters wide with asphalt paving, separated from the main roadway by a curbed, grass median about 0.5 m wide. Residences, businesses, market stalls and local roads have direct access to the service roads, while the median prohibits access to the centre roadway lanes. Access to the centre lanes are provided at three major intersections by traffic circles.
- **Local road networks** that intersect the larger roadways are generally paved but narrower in width. Some include walkways and drainage, but shoulders are not typically present.

7.8.2 Existing Traffic Data

A traffic survey of the Study Area was conducted during the period 4 to 10 February 2022. The traffic study was conducted manually over a 14-hour time period (06:00 h to 20:00 h). Figure 7-64 identifies the locations where traffic data (including information on traffic origin and destination) were recorded. Traffic was grouped into four vehicle categories:

1. Motorcycles/Tricycles
2. Cars and Light Vans
3. Medium and Heavy Goods Vehicles (Lorries and Trucks)
4. Buses and Coaches

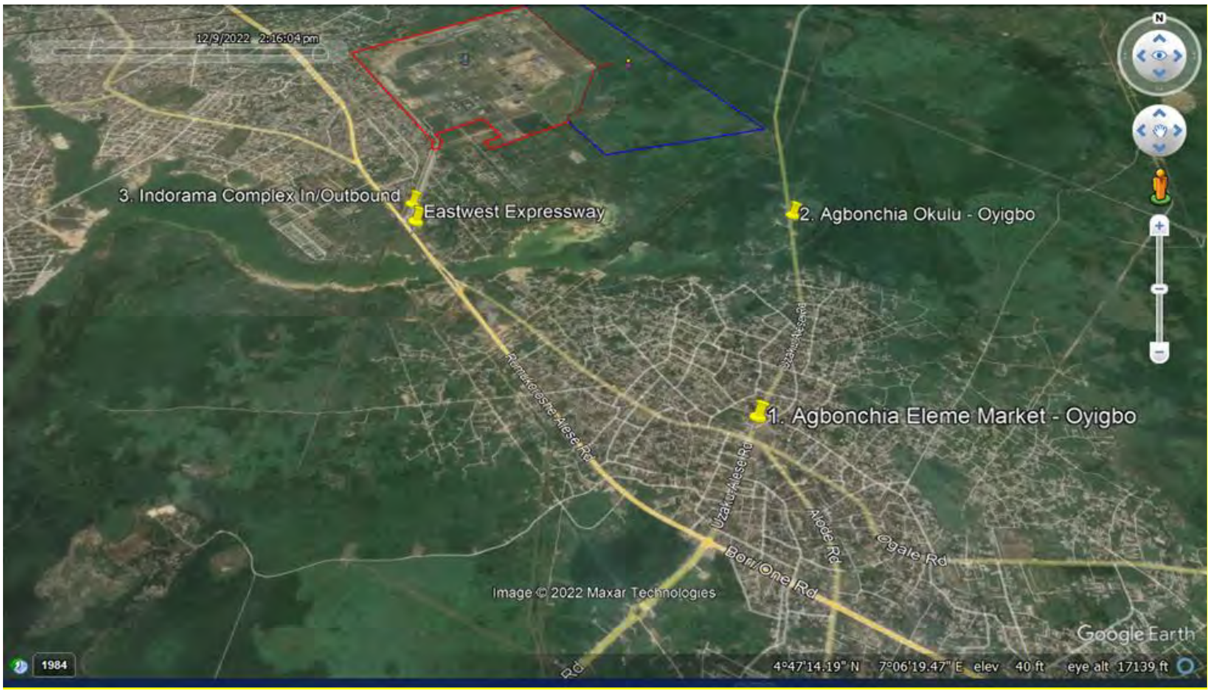


Figure 7-64 Location of Traffic Data Surveys

Table 7-40 summarises daytime traffic volumes at the count locations. The highest levels of traffic occurred along the East West Road. Specific days of highest traffic volumes varied, but Sunday had the lowest traffic per day for all roads surveyed. Hours of peak traffic and lowest traffic varied. The sections below summarize traffic data trends and observations for each traffic data survey location.

Table 7-40 Summary of Average Daytime Traffic Volumes (February 4-10, 2022, 06:00 to 20:00h)

	Uzaku-Alese Road at Eleme Market		Uzaku Alese Road North of Eleme		Indorama Complex Entrance		East West Road	
Category	**Northbound**	**Southbound**	**Northbound**	**Southbound**	**Inbound**	**Outbound**	**Eastbound**	**Westbound**
1 (Motorcycle/Keke)	2,271	2,516	401	295	2,251	2,615	5232	6,141
2 (Car and Light Vans)	1,260	1,152	474	465	1,355	1,852	6838	6,281
3 (Lorries and Trucks)	63	77	34	26	292	501	1335	1,192
4 (Buses and Coaches)	32	38	19	24	61	86	2405	1,413
Total	**3,626**	**3,783**	**927**	**810**	**3,959**	**5,054**	**15,810**	**14,926**

7.8.2.2 Uzaku-Alese Road at Eleme Market

Traffic fluctuated at this location from day to day with a maximum of about 8,600 vehicles on Monday (4,500 northbound and 4,100 southbound) and a minimum of about 5,800 vehicles on Sunday. The average hourly traffic volume ranged from 202 to 290 vehicles in the northbound lanes and 215 to 324 vehicles in the southbound lane. Traffic was constant throughout the day, with only slightly higher volumes during the peak hours from 07:00 to 08:00 and 18:00 to 19:00. Light vehicles, and especially motorcycles/tricycles, dominated the traffic, with Category 1 vehicles accounting for 64.6% and Category 2 vehicles accounting for 32.6% of all traffic.

7.8.2.3 Uzaku-Alese Road North of Eleme

Traffic at this location had its highest traffic volumes on Thursday and Friday, with about 2,200 vehicles on both days, evenly split between northbound and southbound traffic. The lowest traffic volume occurred on Sunday, when 1,204 vehicles were counted. The average hourly traffic volumes ranged from 50 to 102 vehicles northbound and 38 to 75 vehicles southbound. Peak traffic hours occurred from 08:00 to 09:00 and 17:00 to 18:00. Category 1 vehicles accounted for 40.0% and Category 2 vehicles for 54.0% of all traffic.

7.8.2.4 Indorama Complex Access Road

Weekday traffic entering the Indorama Complex ranged from 3,732 vehicles on Monday to 5,234 vehicles on Wednesday. Weekend traffic was lower, with 3,034 vehicles entering the complex on Saturday and 2,433 vehicles on Sunday. Weekday traffic volumes for outbound vehicles were similar to the inbound traffic, ranging from 4,889 vehicles on Friday to 5,533 vehicles on Monday. Weekend outbound traffic was higher than the inbound traffic, with 4,710 vehicles on Saturday and 3,916 vehicles on Sunday.

The Indorama Complex access road experienced average morning peak traffic from 08:00 to 09:00 that included an average of 501 inbound and 563 outbound vehicles. A lower afternoon peak traffic hour occurred from 18:00 to 19:00 pm, with an average of 317 inbound and 434 outbound vehicles. The lowest traffic volumes occurred from 12:00 to 15:00. Vehicles using the access road consisted of 54.0% Category 1 vehicles and 35.6% category 2 vehicles. Trucks made up 8.8% and buses 1.6% of total traffic.

7.8.2.5 East West Road

Traffic volumes on the East West Road were by far the largest of the traffic count locations, varying from a high of 36,457 vehicles on Tuesday to a low of 20,845 vehicles on Sunday. The average hourly traffic ranged from 849 vehicles to 1,448 vehicles for westbound traffic (towards Port Harcourt) and from 958 to 1,372 vehicles for eastbound traffic (towards Eleme). Peak hourly traffic occurred between 17:00 and 18:00 for westbound traffic and between 07:00 and 08:00 am for eastbound traffic. Vehicles on the East West Road consisted of 36.7% motorcycles, 42.7% cars/light vans, 8.2% trucks and 12.4% buses.

7.8.2.6 Night-time Traffic Volumes

Traffic volumes between the hours of 20:00 and 06:00 were counted over the course of three days during the seven-day survey period. Table 7-41 presents the total traffic volumes for each count location, reflecting combined traffic in all directions and for all vehicle categories. Night-time traffic volumes were low, confirming the observations of nearby residents.

Table 7-41 Traffic Volume Survey from 8pm to 6am

Station	Sunday 06/2/22	Monday 7/02/22	Tuesday 8/02/22	Average
Uzaku-Alese Road at Eleme Market	41	97	94	77
Uzaku-Alese Road North of Eleme	9	17	15	14
Indorama Complex Access Road	259	346	330	312
East West Road	681	1,042	1,197	2,920

7.8.3 Road Safety

Nigeria reported 5,053 traffic fatalities in 2016, although the World Health Organization (WHO) estimated a significantly larger number. The WHO estimated that Nigeria experiences 21.4 fatalities per 100,000 population in 2016, equivalent to nearly 40,000 traffic fatalities per year (WHO 2018). This rate was lower than the Africa-wide estimate of 27.6 fatalities per 100,000 population (World Bank 2019). Nigeria has established numerous regulations to increase road safety, including road design standards, seat belts and motorcycle helmets requirements, a ban on hand-held mobile phone use, blood alcohol limits and speed limits. WHO ranks Nigeria's traffic regulation enforcement at 3 to 9 on a scale of 1 to 10 (with 10 representing the most rigorous enforcement).

7.8.4 Summary of Key Traffic Sensitivities

- There is congestion on the East West Road, which connects south-eastern Nigeria to Port Harcourt, resulting from increases in peak hour traffic, increases in large vehicle traffic, as well as turning movements at the Indorama Complex access road.
- There are also congestion and safety concerns at the intersection of the Indorama Complex access road and the East West Road due to lack of traffic controls (traffic signals or signage) and the volume of vehicle turning movements at this intersection.
- Congestion on the route from the port at Onne to the East West Road is due to increased truck traffic.
- The impact of higher traffic volumes and more truck traffic is felt on residents, businesses, and other road users of the Uzaku Alese Road within and near Eleme and nearby towns.

8. ASSOCIATED AND POTENTIAL ENVIRONMENTAL AND SOCIAL IMPACTS

8.1 Introduction

The predicted impacts to the physical, biological, and socio-economic environment as a result of the proposed IEFCL Train 3 Project are described in this Chapter. This Chapter also provides a prediction of the residual impact that will remain, assuming that the appropriate mitigation measures are implemented.

Chapter 9 details the potential mitigation measures in order to avoid, minimise, reduce, remedy or compensate for potentially negative impacts, and enhance potential benefits of the Project. The development of mitigation/management measures and the management of residual impacts are further described in the Environmental and Social Management and Monitoring Plan (ESMMP) (refer to Chapter 10).

The impact assessment process and methodology to identify and assess impacts is explained in Chapter 5. The impact assessment laid out in this Chapter is as follows:

- Each section begins with the type of impact being assessed.
- Background information relating to the impact is then provided. This includes a description of the baseline environment that will be affected, the Project aspect or activities that will cause the impact and a description of the affected receptors.
- The significance of the impact (pre-mitigation) is then assessed and rated through use of a significance rating table.
- Residual impacts (post-mitigation) are rated through use of a less detailed rating table, taking into account the mitigation and management measures provided in Chapter 9.

8.2 Impacts to the Physical Environment

The predicted impacts on the physical environment are presented as follows:

- Risk of Climate Change on the Project (refer to Section 8.2.1);
- Greenhouse Gas (GHG) Assessment (refer to 8.2.2);
- Impacts on Air Quality (refer to 8.2.3);
- Noise Impacts (refer to 8.2.4);
- Impacts on Soil and Geology (refer to 8.2.5);
- Impacts on Groundwater Resources (refer to 8.2.6); and
- Impacts on Surface Water Resources (refer to 8.2.7).

8.2.1 Risk of Climate Change on the Project

8.2.1.1 Identified Climatic Hazards

As part of the climate change risk assessment, relevant hazards deemed relevant to the Project Area were identified. Various data sources were consulted for use within this assessment (refer to Chapter 7), including baseline information and projections data. Existing baseline data has been used to provide an indication of the presence and potential severity of climate hazards under present day conditions.

The climate hazards deemed applicable and reviewed in this assessment include:

- Extreme Heat;
- Extreme Cold;

- Extreme Rainfall and Flooding;
- Water Stress & Drought, and
- Wildfires.

Tropical storms, cyclones, coastal flooding and extreme storms and winds were not included in this assessment, as no relevant data for the Project Area's location were found.

Data results were obtained for a number of climate hazards to understand the present-day conditions and projected changes of each hazard at the Project Area location (as presented in Chapter 7). The rationale for the inclusion of each event / hazard is included in Table 8-1.

Overall, Extreme Heat is the most predominant and most significant hazard for the Site. There is a direct link between Extreme Heat and Water Stress & Drought and Wildfires, which were also identified as being significant. Moreover, precipitation is also projected to increase in intensity, quantity, and severity, which in turn increases the risk of flooding.

8.2.1.2 Sensitive Receptors

Table 8-2 and Table 8-3 provide an overview of the Project elements during the construction and operational phases that can be deemed as being susceptible to climate change risks.

8.2.1.3 Potential Impacts to Sensitive Receptors

Table 8-4 and Table 8-5 provides an analysis of those Project elements (otherwise known as sensitive receptors) that are potentially exposed to climate risks during the construction and operational phases respectively.

Those risks included in **bold** and highlighted are identified as risk items likely to be of greater materiality to the Project and therefore should be considered in future climate change risk assessment studies.

8.2.1.4 Mitigation and Management Measures

Refer to Section 9.2.1 (Chapter 9) for the recommended mitigation and management measures associated with Climate Change.

Table 8-1 Table Showing the Rationale for Hazard Inclusion

Climate Hazard	Will the Hazard be Included?	Rationale for Inclusion
Extreme Heat	Yes	Historical (for construction): Historically the heat index is rated as being likely material. Projections (for operation): Trends of average monthly temperatures and number of extreme heat days are Projected to have significant increases into 2030 and 2050. This hazard has the potential to impact the Site during the construction and operation phases and is therefore included in this assessment
Extreme Cold	No	Historical (for construction): Historically lowest monthly temperature is rated as being likely present and likely material. Projections (for operation): Trends in extreme cold conditions and number of cold days are Projected to decrease significantly into 2030 and 2050 and possibly at worst case scenario to have no risk at all. This hazard is unlikely to impact the Site during the construction and operation phases and is therefore not included in this assessment.
Extreme Rainfall Flooding *Including hail, lightning & tornadoes*	Yes	Historical (for construction): Historically precipitation and Extreme Rainfall Flooding is rated as being likely present and likely material. Projections (for operation): Trends in extreme precipitation, increases in quantity, intensity and extreme events that may lead to Extreme Rainfall Flooding are Projected to increase in 2030 and 2050 with the worst case scenario in 2050 having Extreme Rainfall Flooding being one of the three main hazards for the Site. This hazard has the potential to impact the Site during the construction and operation phases and is therefore included in this assessment.
Water Stress & Drought	Yes	Historical (for construction): Historically water risk is rated as being high. Projections (for operation): Water stress and drought events and the duration of heat waves are Projected to increase in 2030 and 2050. This hazard has the potential to impact the Site during the construction and operation phases and is therefore included in this assessment.

Climate Hazard	Will the Hazard be Included?	Rationale for Inclusion
Wildfires	No	Historical (for construction): Historically wildfire risk is rated as being likely material. Projections (for operation): although wildfires have been flagged as a potentially material hazard for the broader Project area it must be noted that the risk of wildfires is not material in that the actual Project site is situated in an area where year round relative humidity is in excess of 70% and in an area that has a high annual rainfall (above 2,300 mm).

Table 8-2 Project Site Receptors: Construction Phase

Receptor Type	Site Elements	
Machinery	■ Construction equipment ■ Construction trucks	■ Construction vehicles
Storage & Materials	■ Construction materials (cement, bricks, steel, plastic pipe, wood, etc.	
Structures & Operations	■ Reservoir	■ Powerhouse
Infrastructure (On Site & off-Site surface)	■ Substation Connections ■ Temporary Office facilities	■ Laydown, Pre-fabrication, Construction warehouse area
Transport	■ Site Access Roads and haul roads ■ Vehicles	■ Internal roads, parking areas and walkways ■ Culverts
Human (staff and community)	■ Staff working on ground ■ Worker Camps and Contractor Lay-Down Areas	■ Local community & farmers

Table 8-3 Project Site Receptors: Operational Phase

Receptor Type	Site Elements	
Machinery	■ Operations equipment	■ Operations trucks / vehicles

Receptor Type	Site Elements	
Structures & Operations	■ Reservoir ■ Ammonia Plant ■ Urea Plant ■ Flare Stack	■ Powerhouse ■ Cooling Towers ■ Polisher, Wastewater treatment and Air Dryer Units
Infrastructure (On Site & off-Site surface)	■ Substation Connections ■ Offices ■ Concrete surfaces associated with infrastructure ■ Electrical power distribution network and associated infrastructure ■ Gas Turbine Generators (GTG) ■ Package Boilers ■ Steam Generation and Boiler Feed Water System ■ Effluents treatment system ■ Demineralized Water System ■ Urea Warehouse for Bulk Storage ■ Natural Gas (NG) Receipt Facilities ■ Wastewater Recovery Plant	■ Offices / administrative space ■ Maintenance/Workshop Facilities ■ Storage areas ■ Ammonia Storage Tank ■ Urea Storage ■ Power lines ■ Telephone lines ■ Electrical Sub Stations ■ Boreholes ■ Condensate Polishing System ■ Inside plant battery limit effluent treatment ■ Urea Truck Loading facilities ■ Raw Water and DM Water
Transport	■ Site Access Roads ■ Vehicles	■ Internal roads, parking areas and walkways
Human (staff and community)	■ Staff working on ground	■ Local community & farmers

Table 8-4 Potential Impacts to Sensitive Receptors during the Construction Phase

Climate Hazard	Risk Item	Potential Impact to Site Receptor Type					
		Machinery	Storage & Materials	Structures & Operations	Infrastructure (On Site & off Site surface)	Transport	Human
Extreme Heat	Could disrupt and / or delay construction works.	Reduced efficiency of equipment / engines due to higher ambient temperatures.			Heat stress to steel in infrastructure by thermal expansion. **Overheating of electrical power disruption network.**		Increased use of air conditioning at staff Sites over an extended period to assist with staff health, safety, and wellbeing.
	May disrupt and / or delay debris and other material being removed from Site, and vehicles coming on to Site.	Days of extreme and prolonged heat periods could cause cracks and potholes in the road surface.				Overheating of vehicles. Days of extreme and prolonged heat periods could cause cracks and potholes in the road surface.	
	Could result in health issues for workers.	Delays in removing materials from Site due to health issues of workers.					**Prolonged heat causing fatigue, sunstroke, and other related health issues, which could result in restricted working hours or work delays due to shortages of staff.**
Extreme Precipitation & Extreme Rainfall Flooding	Heavy precipitation with extreme flooding can restrict Site access.	Heavy precipitation may result in surface runoff on access and internal roads.	**Potential delays in raw material delivery due to wet and flooded roads.**			**Flooding of roads during heavy precipitation causing road closure and delays of vehicles onto Site.**	
	Heavy precipitation with extreme floods can delay construction activities.	Disable construction equipment (e.g. cranes) resulting in delays due to flooding. Damage to equipment and possible washing away of equipment during flooding.		Building interruptions and complications due to flooding.		Flooding of roads causing road closure and delays of vehicles onto Site.	
	Heavy precipitation with extreme floods can damage Site infrastructure, storage & material.		Loss of construction materials, which are washed away due to flooding.	**Damage to buildings by floodwaters.**	**Extreme flooding could damage key infrastructure.** Flooding causes damage to fencing (potential security risk on Site).		Inaccessible or unsafe working conditions in Site offices for staff.
	Heavy precipitation with extreme flooding can lead to increasing damage to local communities and farms.						Severe precipitation events reducing surface water quality, affecting clean water availability for workers and surrounding community.
	Heavy precipitation with extreme flooding has the potential to result in injuries / illness to workers or delay in work.						Risk of injuries due to both surface and flowing water. Potential spread of waterborne disease as a result of standing water (e.g.: cholera etc.).

Climate Hazard	Risk Item	Potential Impact to Site Receptor Type					
		Machinery	Storage & Materials	Structures & Operations	Infrastructure (On Site & off Site surface)	Transport	Human
Water Stress & Drought	Prolonged and more frequent dry periods result in less water potentially being available for construction.		Decrease in water used for construction. Reservoir will decrease in depth and area if dry spells are longer leading to water shortages.	**Decrease in water used for construction. Groundwater reservoirs may decrease in depth if dry spells are longer leading to water shortages.**			
	Prolonged and more frequent dry periods result in higher evaporation.		Higher evaporation can lead to less water being available in reservoir for construction.				
	Prolonged and more frequent dry periods result in dust generation (dust storms) for Site and local communities.	Impacts on visibility along transportation corridors.				Impacts on visibility along transportation corridors.	Impacts on health and safety of Site personnel and surrounding communities, e.g. respiratory issues.
Wildfires	Restrict access to roads.	**Delays in getting construction equipment & vehicles to Site due to access problems.**	**Delays in getting materials to Site due to wildfires causing access problems.**			Restricting access to roads, potential delays to construction.	Prevent Site staff from accessing their workplace.
	Damage temporary buildings & infrastructure.				Potential damage from wildfires to on Site facilities, pipeline system, electrical power distribution network and associated infrastructure, substation. Damage to fencing/buildings due to fires. Possible fire damage to supporting infrastructure.		
	Delay or interrupt construction (e.g. building).		Impact of fire damages to construction Site.				
	Damage equipment.	**Possible damage to equipment from wildfires.**					
	Health issues for workers and surrounding communities.						Impacts on health and safety e.g. respiratory issues, burns, air quality for staff and surrounding communities.

Table 8-5 Potential Impacts to Site Receptors for Operations Phase on the Indorama Train 3 Project

Climate Hazard	Risk Item	Potential Impact to Site Receptor Type				
		Machinery	Structures & Operations	Infrastructure (On Site & off Site surface)	Transport	Human
Extreme Heat	Could disrupt and / or delay operations.	Reduced efficiency of equipment / engines due to higher ambient temperatures.		**Heat stress to various steel infrastructure by thermal expansion.**	Extreme heat causing overheating of operation vehicles.	
				Increased use of air conditioning at staff Sites over an increased period.		
	May disrupt and / or delay transport vehicles onto and off Site.	Days of extreme and prolonged heat periods could cause cracks and potholes in the road surface.			Days of extreme and prolonged heat periods cause cracks and potholes in the road surface.	
	May result in damage to operation infrastructure.			**Extreme heat could damage water supply infrastructure.**		
				Extreme heat may cause overheating to electrical power disruption network, substations.		
				Extreme heat may cause pressure valve to open and therefore lead to Natural gas leakage.		
	Could result in health issues for workers.					**Heat impacting workers, resulting in health issues and restricted working hours and work delays due to shortages of staff.**
Extreme Precipitation & Extreme Rainfall Flooding	Heavy precipitation with extreme flooding can restrict Site access.	Heavy precipitation with flooding may result in surface runoff on access and internal roads.			Waterlogging of road surface during flooding, creating surface cracking.	
	Heavy precipitation with extreme floods can delay operations.	Disable operation equipment resulting in delays due to flooding.		**Extreme flooding could damage water supply infrastructure.**	Flooding of roads during heavy precipitation causing road closure.	
		Damage to equipment and possible washing away of equipment during flooding.		Flooding causes damage to fencing.	Flooding of roads during heavy precipitation causing road closure and delays of vehicles onto Site.	
				Maintenance of plant difficulties.		
				Flooding causes damage to fencing, plant equipment / structures (including offices) etc.		
				Damage to buildings by floodwaters.		
	Heavy precipitation with extreme flooding can lead to increasing damage to local communities and farms.					Severe precipitation events reducing surface water quality, affecting clean water availability for workers and community uses.
	Heavy precipitation with extreme flooding has the potential to					**Risk of injuries due to both surface and flowing water.**

Climate Hazard	Risk Item	Potential Impact to Site Receptor Type				
		Machinery	Structures & Operations	Infrastructure (On Site & off Site surface)	Transport	Human
	result in injuries / illness to workers or delay in work.					**Potential spread of waterborne disease because of standing water (e.g. cholera etc.).**
Water Stress & Drought	Prolonged and more frequent dry periods result in higher water consumption for operation.		**Reservoir will decrease in depth if dry spells are longer leading to water shortages.**	Decrease in water available for operation. Reservoir will decrease in depth if dry spells are longer leading to water shortages.		
	Prolonged and more frequent dry periods result in higher evaporation.			Higher evaporation and water shortages can result in less water being available for the Project.		Higher evaporation and water shortages due to extreme heat can lead to reservoir and water pipelines decreasing in depth if dry spells are longer leading to water shortages for surrounding communities and farmers.
Wildfires	Wildfires damage operations.			**Potential damage to fencing, plant equipment/structures (including offices) etc. from wildfires.**		
	Wildfires restrict access to roads.	Delays in getting operation vehicles to Site due to access problems.			Restricting access to roads, potential delays to operation.	
	Wildfires damage infrastructure.	Possible damage to equipment from wildfires.	**Possible damage as a result of wildfires to urea and ammonia storage and may result in accidental unplanned events.**	Possible fire damage to water supply infrastructure.		
				Potential damage from wildfires to pipeline system, electrical power distribution network and associated infrastructure, substation.		
				Damage to fencing / buildings due to fires.		
	Wildfires have the potential for health issues for surrounding communities.					**Impacts on health and safety, e.g. respiratory issues, burns, air quality for staff and surrounding communities.**

8.2.2 GHG Assessment

8.2.2.1 Introduction

As greenhouse gases (GHG) have accumulated in the atmosphere, scientists have recorded a gradual warming of the Earth's average surface temperatures. According to leading scientific organizations, "observations throughout the world make it clear that climate change is occurring, and rigorous scientific research demonstrates that the greenhouse gases emitted by human activities are the primary driver."[65] These heat-trapping gases (or GHG), include carbon dioxide, methane, nitrous oxide (N_2O), and others.

The Paris Agreement Article 4.19 invites countries to formulate and communicate "long-term, low greenhouse gas emission development strategies", or Long-Term Strategy (LTS) which supports achievement of low-carbon and climate-resilient societies. Nigeria has submitted its Long-term Vision 2050 (LTV 2050), to the UNFCCC Secretariat in December 2021 as a first contribution towards the elaboration of the full-blown LTS. "By 2050, Nigeria would be a country of low-carbon, climate-resilient, high growth circular economy that reduces its current level of emissions by 50%, moving towards having net-zero emissions across all sectors of its development in a gender-responsive manner".

This study estimates the GHG emissions resulting from the Project and compares the magnitude of those emissions with the thresholds developed by the IFC.[66] The study does not attempt to quantify the physical impacts of the Project on the global climate, as climate change is a global phenomenon. Scientists predict that further global temperature increases will result in further loss of sea ice, melting glaciers and ice sheets, sea level rise, and more intense heat waves. Severe weather damage will also increase and intensify.

This Section also highlights IEFCL's commitment towards GHG emission reduction in line with LTV 2050 of Nigeria.

8.2.2.2 Scope

The global standard for GHG reporting—known as the WRI/WBCSD GHG Protocol methodology—divides emissions into three 'Scopes' defined as follows:

- **Scope 1** – direct emissions from sources owned or under the operational control of the company.
- **Scope 2** – indirect emissions from the consumption of purchased electricity (and other energy).
- **Scope 3** – indirect or supply chain emissions, both upstream and downstream, from the reporting entity (e.g., indirect emissions from purchased goods).

For the purposes of this ESIA, emission estimates for the future activities of the Project cover those activities that are under its <u>direct operational control</u> of the project developer. IFC PS3 states that *'the client will quantify direct emissions from the facilities owned or controlled within the physical project boundary, as well as indirect emissions associated with the off-site production of energy used by the project'* and therefore this study will focus upon Scope 1 and Scope 2 emissions only, during the operational phase of the Project.[67]

This study does not include an assessment of GHG emissions arising from the construction phase, or an assessment of Scope 3 GHG emissions associated with the manufacture and transport of materials to/from the plant, and other indirect source categories. Scope 3 GHG emissions can be significant but represent a source of indirect emissions that are not under the Project's direct operational control.

[65] AAAS Reaffirms Statements on Climate Change and Integrity. December 2009.

[66] The IFC, a member of the World Bank Group, is the largest global development institution focused on private sector development in developing countries. The IFC Performance Standards on Environmental and Social Sustainability detail a clients' responsibilities for managing their environmental and social risks, including the management of greenhouse gas emissions.

[67] IFC. Performance Standards on Environmental and Social Sustainability: Performance Standard 3 Resource Efficiency and Pollution Prevention. Page 2. January 1, 2012.

8.2.2.3 Methodology

A *Carbon Footprint* is a measure of the estimated GHG emissions produced directly and indirectly by an individual, organisation, facility, or product. The calculation of a carbon footprint generally involves the following equation.

$$\textbf{\textit{Carbon footprint emissions}} \\ = \textbf{\textit{Activity data x Emissions factor x Global warming potential}}$$

- *Activity data* relates to the emission-causing activity, e.g., the consumption of electricity or the on-site combustion of fossil fuels;
- *Emission factors* (EFs) convert the activity data into estimates of GHG emissions (e.g., CO_2 per litre of diesel fuel consumption); and
- *Global warming potentials* (GWPs)[68] are applied to convert the different GHG emissions to a common metric: carbon dioxide equivalent (CO_2e).

Good practice for calculating a carbon footprint dictates that actual monitored data are used in estimating emissions (e.g., kWh electricity consumed, or liters diesel used). Given that this Project involves an estimation of a future carbon footprint for activities yet to begin, a series of assumptions have been made in order to forecast the activity data required to undertake this calculation. Scope 1 emissions for the Project (Train 3) have been estimated for a single year of operation (330 days), based on the proposed nominal production rates for ammonia (2,300 Mtpa) and urea (4,000 Mtpa). Indirect Scope 2 emissions from the consumption of purchased electricity are not applicable as power for the Project would be generated onsite. The following methodologies have been used to estimate the GHG emissions from the plant.

- GHG Protocol: Corporate Accounting & Reporting Standard (World Resources Institute/World Business Council for Sustainable Development), and
- Intergovernmental Panel on Climate Change (IPCC) 2006 GHG Inventory guidelines.

8.2.2.4 GHG Emissions Assessment

GHG emissions from the Project result primarily from ammonia synthesis and the energy generated onsite (both steam and electricity). The primary input to the plant is natural gas for the production of ammonia. The plant will also rely on natural gas to power the gas turbine generators and the steam boilers. The CO_2 generated as a by-product of gas reforming is used as a reagent in the urea synthesis process, and hence accounts for a net reduction in emissions from the Project.

The facility relies on heavy vehicles for material handling, but these are considered to be a relatively minor source of emissions, and therefore have not been considered in the assessment. Based on the methodology described above, the following GHG sources have been considered in the calculation of operational emissions for the proposed IEFCL Train 3 Project:

Source
Process related emissions (CO_2) from gas reforming
Urea synthesis (net reduction in CO_2)

(68) A number of different gases contribute to the greenhouse effect. The effect that they have varies according to their relative ability to trap and retain radiant energy arriving at the Earth. These differences are reflected in the gases' global warming potentials (GWP), which are a measure of their greenhouse effect 'strength' relative to CO2. The GWP of CO2 is 1, methane (CH4) is 25, and nitrous oxide (N2O) is 298 for a 100-year time horizon. Figures are taken from the IPCC's Fourth Assessment Report, in line with the GHG Protocol.

Combustion of natural gas for steam generation (boilers)
Combustion of natural gas for onsite power generation (gas turbine generators)
Combustion of natural gas for flaring (pilot)

Emissions Estimation Methods:

The following estimation methodologies were used to compute the CO_2 emissions for the Project:

- Theoretical calculations based on the Process Design Package of Line 2 (as Line 3 is a duplication of Line 2)
- Calculations based on actual plant operating data (Line 1) for Natural gas consumption, production, power consumption etc. over a period of one year (Y2021) (as Line 1 is also a duplicate of Line 2)

The Gas firing for the reforming process, steam production, and power generation, as well as flaring, were extracted for each of the above. The CO_2 emissions were calculated for the Project using both methodologies above, and the estimates were found to be in close agreement. For the purposes of this analysis, the actual operating data from Line 1 were used to estimate the emissions for the proposed IEFCL Train 3 Project, including the gas reformer, package boiler, gas turbines, and flare. CO_2 is also produced as a by-product of gas reforming in the Ammonia Plant. However, this CO_2 is recovered, purified, and routed to the Urea Plant for Urea synthesis and, hence, there is no venting of the process generated CO_2.

Table 8-6 below details the key parameters used in estimating the GHG emissions for the Project, including the quantity of gas consumption, the emission factors applied, and the estimated annual emissions from each source category. Total net GHG emissions for the Project are estimated at 688,156 metric tons CO_2 per year.

Table 8-6 Key Parameters used in Estimating GHG Emissions for the Project

Source	Energy Consumption (TJ/Year)	Emission Factor (tCO_2/TJ)	GHG emissions (tCO_2/year)	Contribution (%)
Reformer Fuel (NG)	3,337	56.1	187,233	27
Process off gas to fuel	1,288		72,241	10
Process steam from Boiler	2,662		149,346	22
Power generation (on-site)	4,666		261,790	38
Flaring	313		17,545	3
Total	12,267		688,156	100%

Note: Assumes 330 operating days per year

Source of activity data: actual operating data for 2021 (Line 1)

Source of emissions factors: IPCC-2006, Volume II, Chapter 2, Chapter 3

These estimates are based on the amount of natural gas that would be consumed by the Project for gas reforming and energy production, based on the PDP of Line 2, considering that the Project would be a duplication of the same. Actual operations could vary, but this estimate is a very good representation of the facility's operational emissions.

IFC PS 3 defines a reporting threshold for annual GHG emissions of 25,000 tonnes of tCO_2e and requires clients to "consider alternatives and implement technically and financially feasible and cost-effective options to reduce project related GHG emissions during the design and operation of the project". The estimated operational emissions associated with the Project exceed the IFC reporting threshold.

IEFCL has evaluated various options for reducing the carbon footprint associated with the Project, Train 1 and Train 2, and IEFCL plans to implement these initiatives over a 3-year period. IEFCL's operational staff identified a total of 30 initiatives for implementation, reducing energy use and emissions by 32% from the base line (Year 2022) (new hardware, process modifications, and operational improvements). Similar initiatives would be implemented from the outset of operations of the proposed IEFCL Train 3 Project. These emissions are projected to deliver an overall reduction of about 725 KTA CO_2 from baseline emissions levels (this includes about 200 KTA from Line 3 alone). This would offset the total estimated emissions from Line 3.

8.2.2.5 Summary of GHG Assessment Findings

The Total net GHG emissions for the Project are estimated at 688 KTA CO_2. IEFCL plans to implement a wide variety of process modifications, equipment upgrades, and operational improvements across the plants to reduce energy use and emissions over the next four years. These investments will offset the baseline emissions from the proposed Project.

In addition to above, the Project will help reduce approx. 2,100 KTA of CO_2 Emissions by reducing the flaring of Natural Gas in Nigeria by 90 MMSCFD.

8.2.3 Air Quality Impact Assessment

8.2.3.1 Description of the Baseline Environment

In terms of ammonia, ERM understands that the proposed Project and the existing two operational IEFCL trains are the only major source of ammonia. Indeed, it is reasonable to assume that the ammonia baseline is un-degraded in the absence of other major sources.

In terms of NO_x and NO_2, the proposed and operational IEFCL Projects will not be the only source. There will be numerous other sources nearby that will also contribute and given the urban areas close by these are likely to be substantial. Sources include traffic, domestic sources, industry and agricultural sources. Given this context, it is not unreasonable to expect that the baseline NO_2 may be degraded in busy urban locations.

Similarly, for PM_{10} and $PM_{2.5}$ there will be numerous sources of emissions. In addition to the domestic and light industry, there will also be substantial contribution from natural sources. This will be particularly evident during the dry season, when fugitive emissions form fields, unpaved roads; open land and agriculture will be significant. In addition, local and regional agricultural burning will also periodically increase PM_{10} and $PM_{2.5}$. This may mean that during the dry season baseline PM_{10} and $PM_{2.5}$ may be degraded.

8.2.3.2 Significance of Impacts (Pre-mitigation)

Construction Phase

The main sources of atmospheric emissions are associated with:

- Site preparation activities;
- General construction activities for Project infrastructure;
- Vehicle movement over unpaved surfaces; and
- Vehicle exhaust emissions.

Activities during the pre-construction and construction phases can result in emissions of dust and particulate matter (PM_{10} and $PM_{2.5}$). Moreover, use of vehicular/equipment will result in emissions of NO_x, SO_2 and particulate matter. The movement of vehicles around the Project Area will furthermore be associated with exhaust emissions and dust emissions from the road surface and open surfaces.

Dust raising activities may have an effect on human and ecological receptors sensitive to dust and PM_{10}. The Project workforce have the potential to also be exposed to occupational health and safety (OHS) air quality emission risks; however, it is considered appropriate that workers would have a lower sensitivity to air emissions than residential receptors.

As such, dust and PM_{10} and $PM_{2.5}$ generation during the construction phase is determined to be of large magnitude (having the potential to exceed dust and PM_{10} and $PM_{2.5}$ air quality standards (AQS)). Therefore, this impact is of **major significance**.

Operational Phase

Dispersion modelling was performed to assess the potential effects of the Projects emissions on ambient air quality and resulting potential effects on the receptors around the Project Area. The existing two trains (Trains 1 and 2) were not modelled for their pollution contribution to the Project on the basis that ambient air quality monitoring undertaken between 2019 and 2022 will capture impacts of these sources.

During the operational phase, the Project alone is not predicted to result in any AQS being exceeded. Based on the results obtained from the air dispersion modelling (Table 8-7), AQS were not exceeded for any of the pollutants. Contour plots are set out in Figure 8-1 to Figure 8-8 for the pollutants of interest.

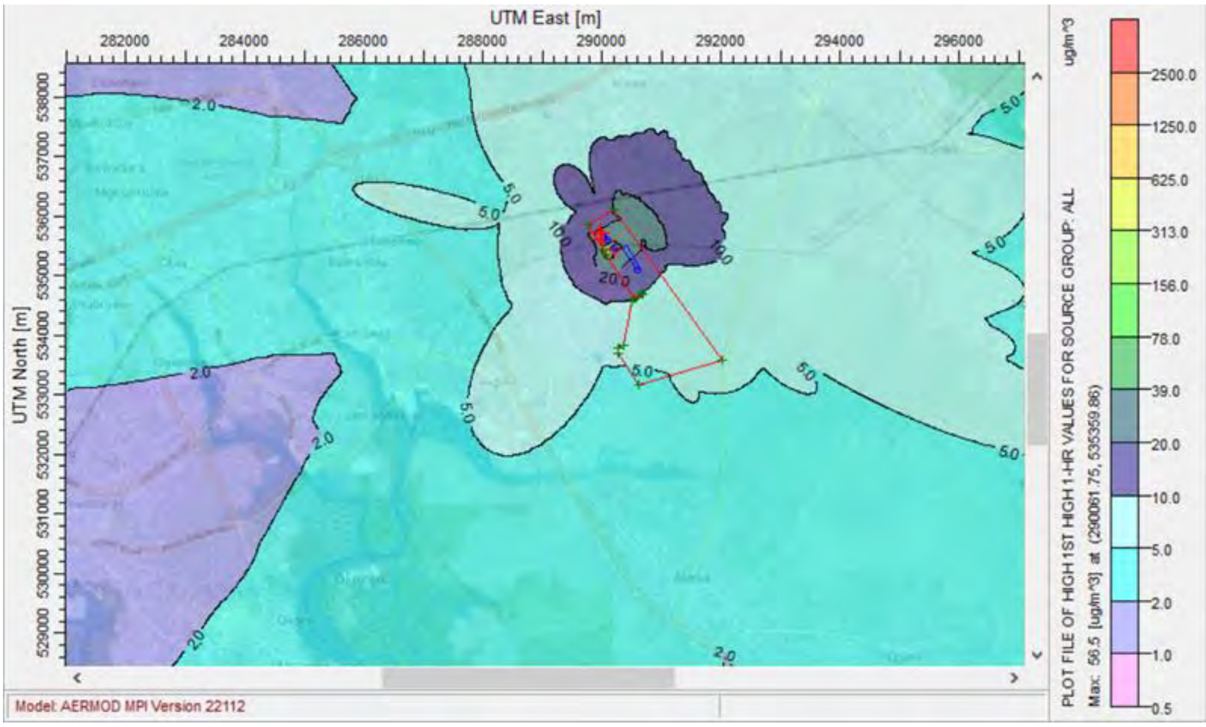


Figure 8-1 NH_3 1 Hour Maximum (AQS not exceeded)

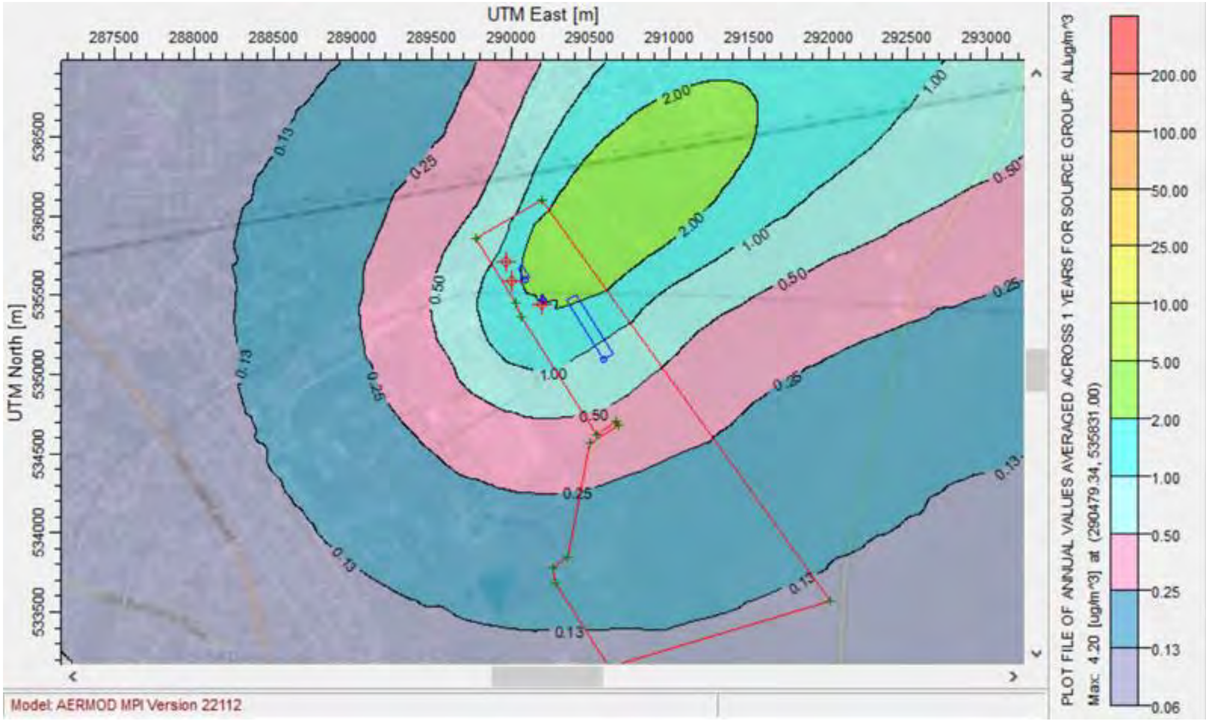


Figure 8-2 NH_3 Annual (AQS not exceeded)

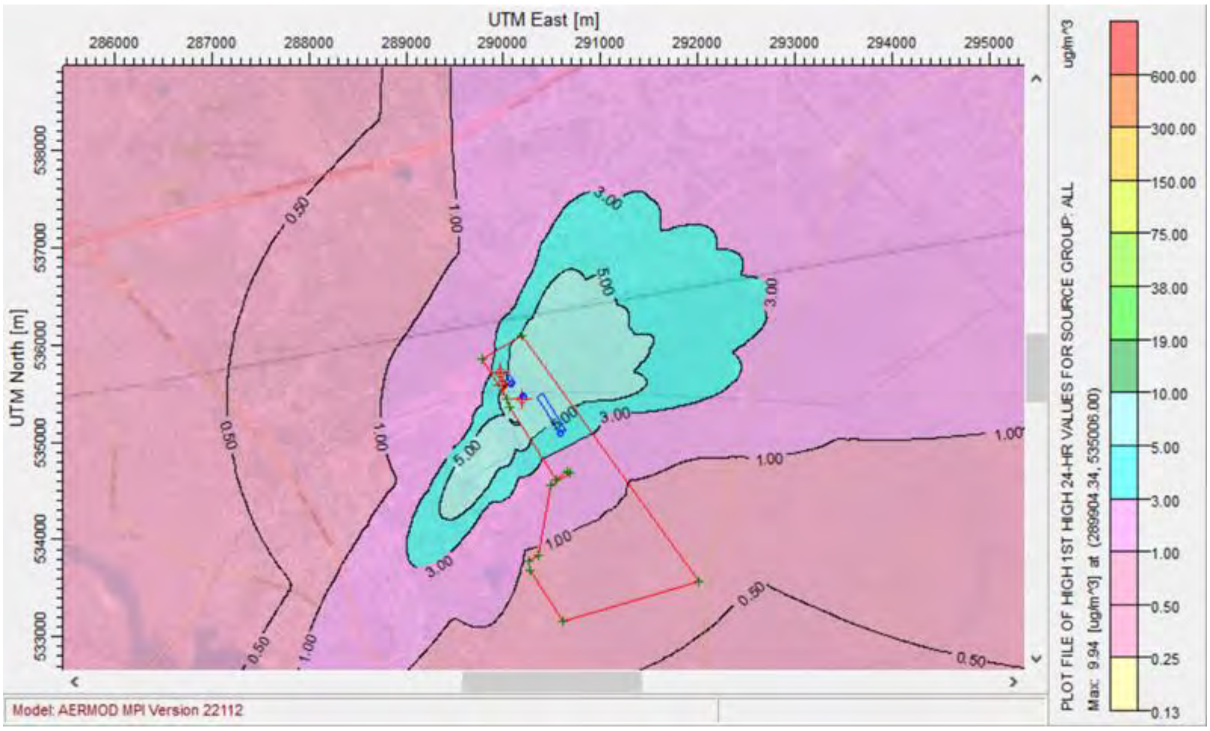


Figure 8-3 NH_3 24-hour (AQS not exceeded)

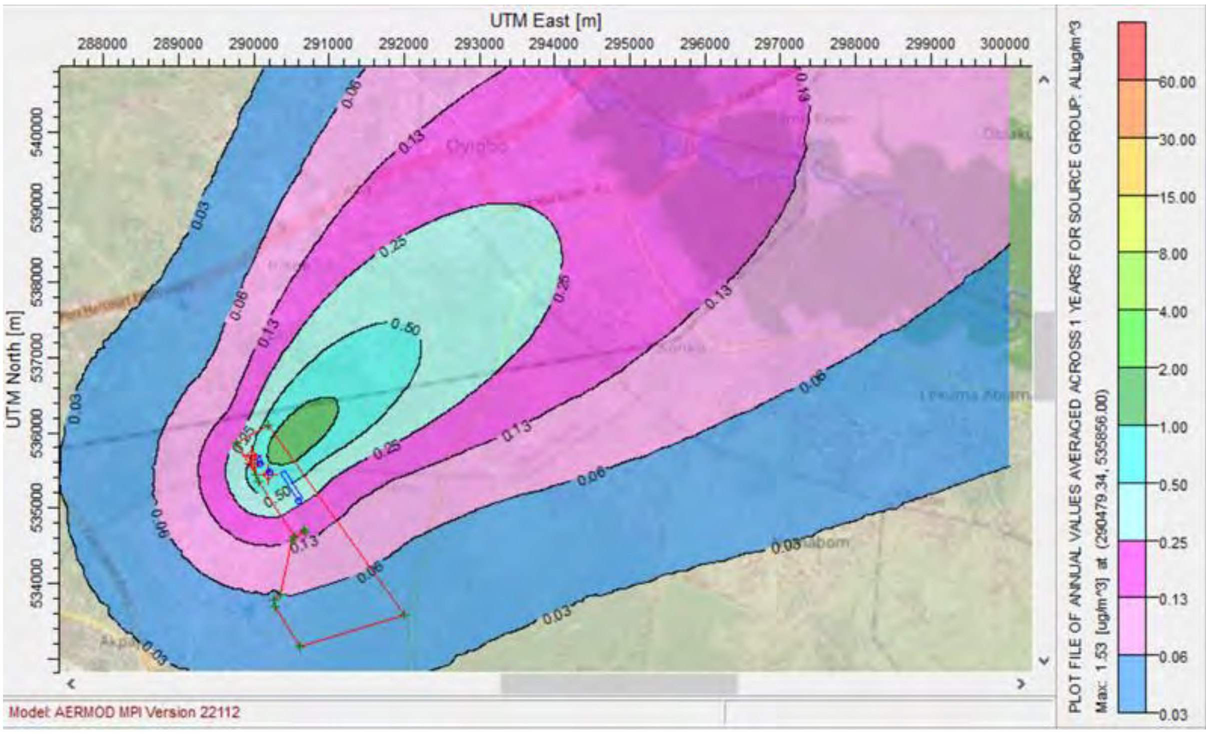


Figure 8-4 PM$_{10}$ Annual (AQS not exceeded)

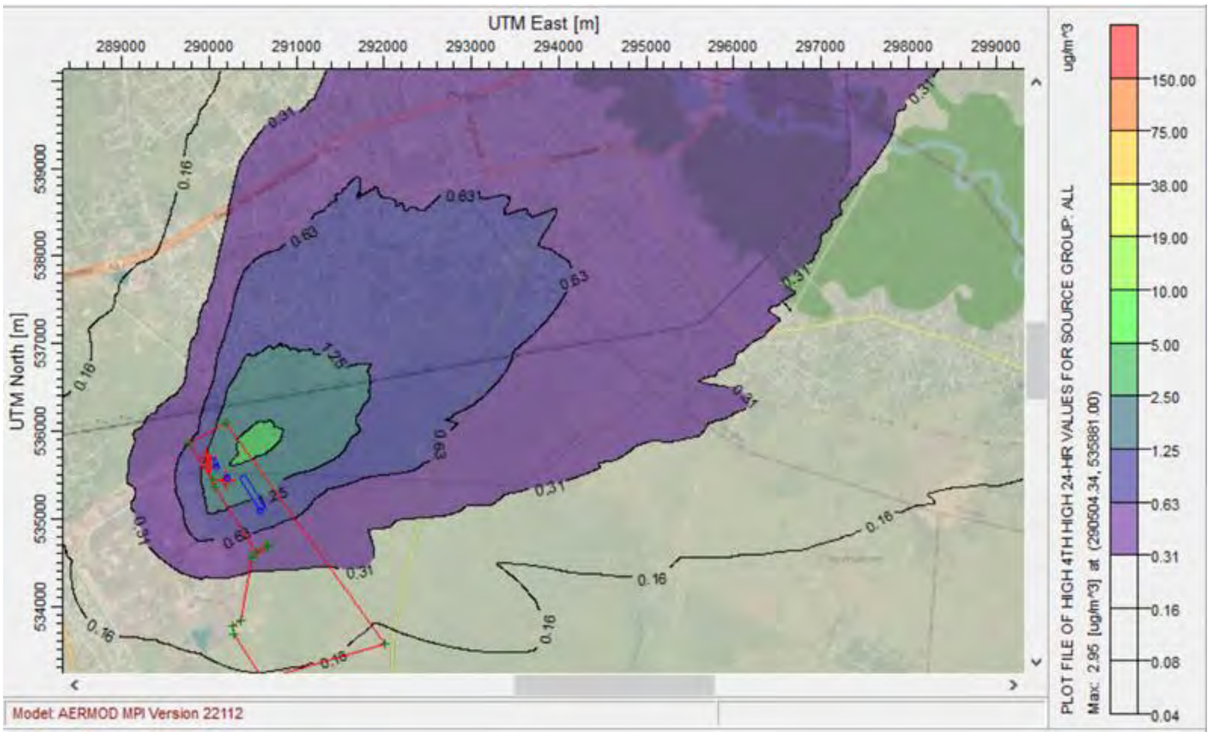


Figure 8-5 24-hour 4 exceedances (AQS not exceeded)

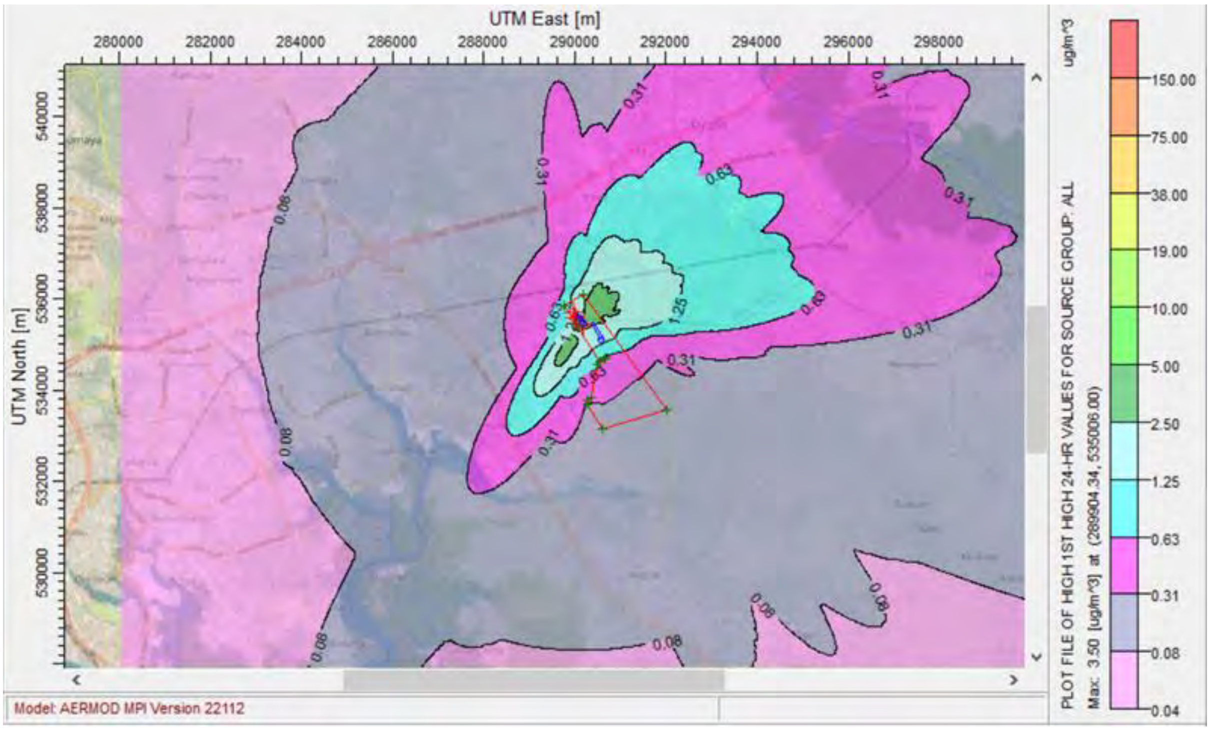


Figure 8-6 PM_{10} 24 hours (AQS not exceeded)

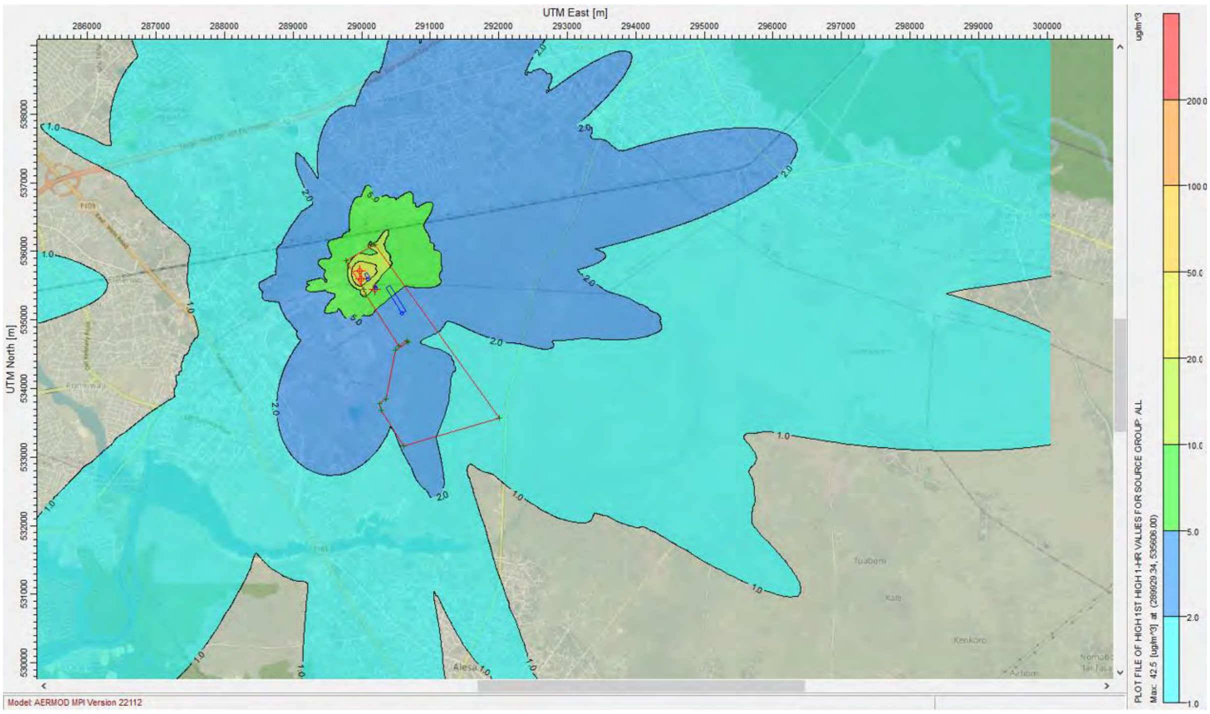


Figure 8-7 NO_2 1 Hour (AQS not exceeded)

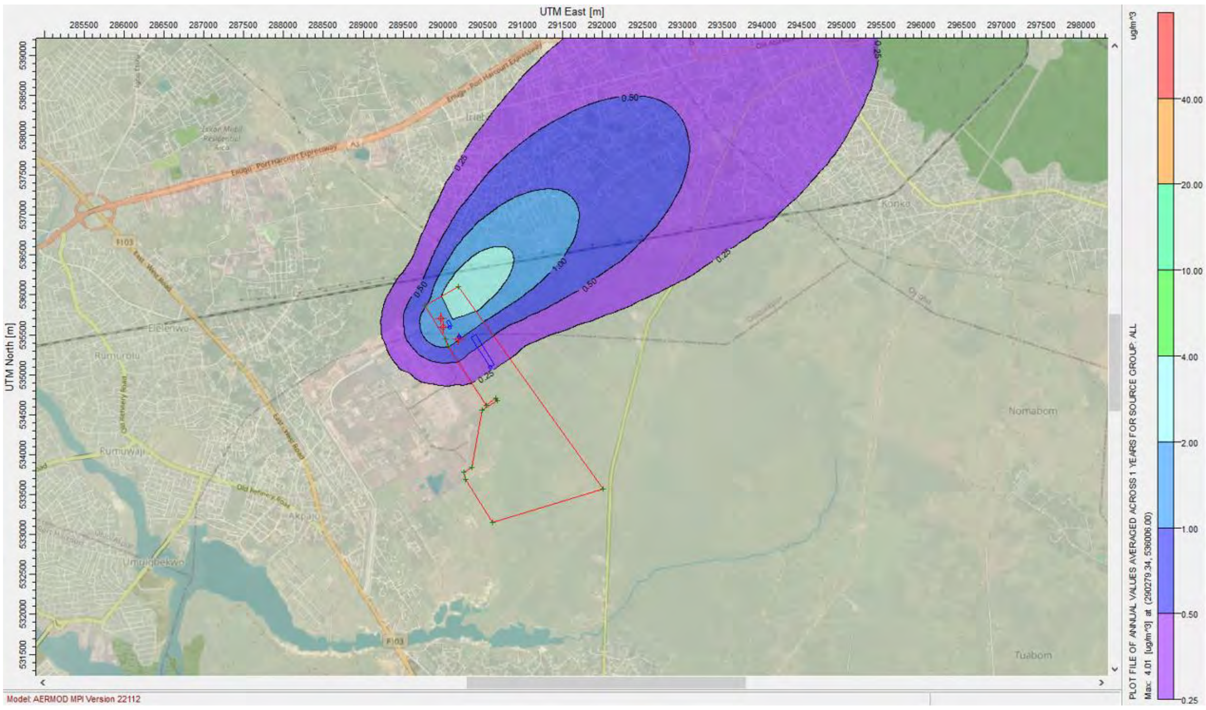


Figure 8-8 NO_2 Annual (AQS not exceeded)

8.2.3.3 Residual Impact (Post-mitigation)

Construction Phase

The construction of the Project is not predicted to result in significant impacts due to road traffic, based upon the expected level of traffic. In terms of construction dust, with the correct implementation of the appropriate mitigation and management measures (refer to Section 9.2.2.2 in Chapter 9), **residual impacts are considered to be Negligible or at worst Minor**.

Operational Phase

The operation of the proposed IEFCL Train 3 Project is not predicted to result in air quality standards being exceeded, and only minor impacts are predicted associated with NO_2.

However, at this stage, based on Train 3 results, the in-combination impacts with Train 1 and Train 2 are not anticipated to lead to air quality standards being exceeded. As such, no further mitigation or design changes are proposed.

8.2.3.4 Mitigation and Management Measures

Refer to Section 9.2.2 (Chapter 9) for the recommended mitigation and management measures associated with air quality.

Table 8-7 Air Quality Impacts during the Operational Phase

Pollutant	Averaging Time	Origin of Standards	Environmental Assessment Levels (EALs) µg/m^3	Baseline µg/m^3	PC (max)		PEC (max)			
					µg/m3	% AQS	µg/m^3	% AQS	Magnitude	Significance
NO_2	Annual mean	IFC	40	27.15	4.01	10.0%	31.16	78%	small	Minor
	Annual, mean	Nigeria	80	27.15	4.01	5.00%	31.16	39%	negligible	Not Significant
	24 hour, max	Nigeria	120	54.3	5.24	4.40%	59.54	50%	negligible	Not Significant
	1h, max	Nigeria/IFC	200	54.3	42.5	21.0%	96.8	48%	small	Minor
PM_{10}	Annual, mean	IFC (Interim target 1)	70	26.12	1.53	2.20%	27.65	40%	negligible	Not Significant
	Annual, mean	Nigeria	60	26.12	1.53	2.50%	27.65	46%	negligible	Not Significant
	24 hour, <4 exceedances yearly	IFC (Interim target 1)	150	52.24	2.95	2.00%	55.19	37%	negligible	Not Significant
	24 hour, max	Nigeria	150	52.24	3.5	2.30%	55.74	37%	negligible	Not Significant
$PM_{2.5}$	Annual mean	Nigeria	20	13.32	1.53	7.60%	14.85	74%	negligible	Not Significant
	24 hour mean	Nigeria	40	26.64	3.5	8.70%	30.14	75%	negligible	Not Significant
NH_3	Annual, mean	Nigeria	200	3.15	4.2	2.10%	7.35	4%	negligible	Not Significant
	Annual, mean	UK	180	3.15	4.2	2.30%	7.35	4%	negligible	Not Significant
	24 hours	Nigeria	600	6.3	9.94	1.70%	16.24	3%	negligible	Not Significant
	1 Hour, Max	UK	1500	6.3	56.5	2.30%	62.8	4%	negligible	Not Significant

PEC > AQS/Guidelines			**PEC < AQS/Guidelines**		
PC as % of AQS	**Magnitude**	**Significance**	**PC as % of AQS**	**Magnitude**	**Significance**
<5%	Negligible	Not Significant	**<10%**	Negligible	Not Significant
5-10%	Small	Minor	**10-25%**	Small	Minor
10-25%	Medium	Moderate	**25-75%**	Medium	Moderate
>25%	Large	Major	**>75%**	Large	Major

Negligible: a resource/receptor will essentially not be affected in any way by the PC, or the predicted effect is deemed to be 'imperceptible' or is indistinguishable from natural background variations.
Minor: a resource/receptor will experience a noticeable effect, but the impact magnitude is sufficiently small and well within applicable standards.
Moderate: the impact magnitude is within applicable standards but falls somewhere in the range from a threshold below which the impact is minor, up to a level that might be just short of breaching a legal limit.
Major: an accepted limit or standard may be exceeded.

* Assumed equal to baseline NOx
** long term (annual) baseline multiplied by a factor 2 as per UK Defra (2009) Local Air Quality Management Technical Guidance Note TG(09)

8.2.4 Noise Impact Assessment

This section assesses the likely noise impacts at the nearby noise sensitive receptors (NSRs) in the Study Area due to the construction and operation of the Project.

8.2.4.1 Description of the Baseline Environment

The baseline acoustic environment as presented in Chapter 7, were synthesized from the baseline noise survey undertaken between the 19th and 24th February 2023. Daytime noise levels (LA_{eq}) comply with IFC guidelines of 55 dB for mixed residential receptors at all measured locations. Night-time noise levels (LAeq) comply with IFC guidelines of 45 dB at locations L1 and L4. For locations L2 and L3 exceedance is up to 13 and 11 dB respectively. Refer to Figure 8-9 for NSR locations.

8.2.4.2 Proposed Project Activities

Construction Phase

Predicted noise levels at nearby NSRs due to construction activities are presented in Table 8-1. The predicted noise contours due to construction of the Project are presented in Figure 8-9.

Noise levels are predicted to comply with the relevant criteria at all assessment locations for the day and night- time operating periods. The predicted impact magnitude during the construction phase is anticipated to be **Negligible.**

Table 8-8 Predicted Noise Levels during the Construction Phase

Receptor	Noise Level LAeq, dB	Criteria	Impact Magnitude
		Day LAeq, dB(A)	Day
L1	48	75	Negligible
L2	50	75	Negligible
L3	57	75	Negligible
L4	43	75	Negligible

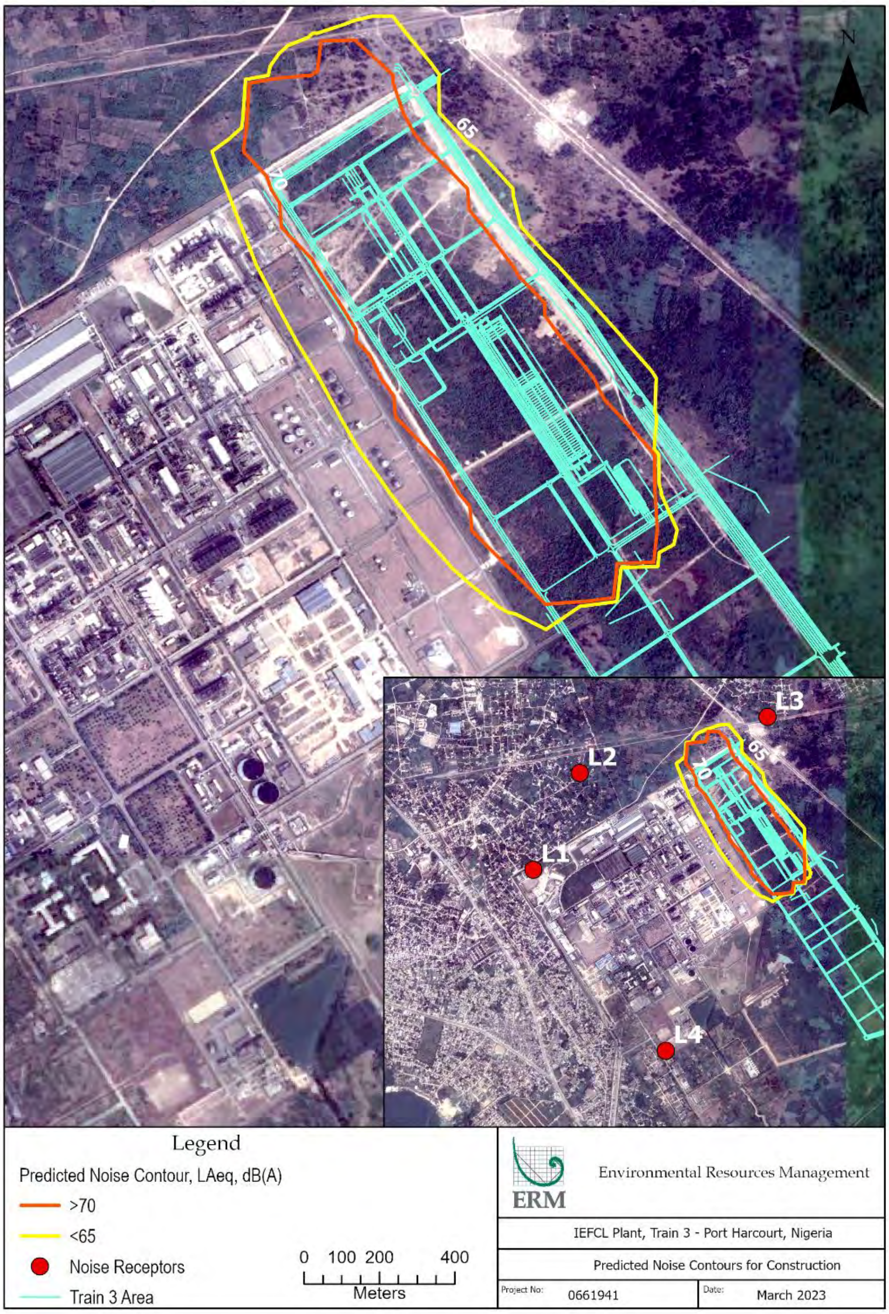


Figure 8-9 Predicted Noise Contours during the Construction Phase

Operational Phase

Predicted noise levels at NSR locations due to the operation of the Project are presented in Table 8-9. The predicted noise contours due to operation of the Project are presented in Figure 8-10.

Predicted noise levels comply with the relevant criteria for day and night-time period at all locations assessed. The predicted impact magnitude during the operational phase is anticipated to be **Negligible.**

Table 8-9 Predicted Noise Levels during the Operational Phase

Receptor	Noise Level LAeq, dB(A)	Criteria		Impact Magnitude	
		Day LAeq, dB(A)	Night LAeq, dB(A)	Day	Night
L1	30	55	45	Negligible	Negligible
L2	33	55	45	Negligible	Negligible
L3	39	55	45	Negligible	Negligible
L4	24	55	45	Negligible	Negligible

Figure 8-10 Predicted Noise Contours during the Operational Phase

8.2.4.3 Significance of Impact (Pre-mitigation)

The expected impacts are assessed in Table 8-10 and Table 8-11. Based on the analysis provided earlier in this Section:

- The impact of noise associated with construction activities is considered a "**Negligible Negative impact**" pre-mitigation; and

- The impact of noise associated with operation activities is considered a "**Negligible Negative impact**" pre-mitigation.

Construction

Table 8-10 Rating of Impacts Related to Noise during the Construction Phase

Characteristic	Designation	Summary of Reasoning
Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	At receptors in the near proximity of the Project Area.
Duration	Medium-term	Construction expected to last 32 months.
Scale	n/a	In the near proximity of the Project Area.
Frequency	Irregular and rare	Impact is likely to occur irregularly and rarely.
Likelihood	Unlikely	Impact is unlikely.
Magnitude		
Negligible magnitude related to the construction noise		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The receptors in the proximity of the Project are classified as "buildings other than hospitals, schools, institutions of higher learning and homes for the disabled" receptors group according to the Nigerian construction standards.		
Significant Rating Pre- Mitigation		
Negligible Impact		

Operation

Table 8-11 Rating of Impacts Related to Noise during the Operation Phase

Characteristic	Designation	Summary of Reasoning
Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	At receptors in the near proximity of the Project Area.
Duration	Long term	During operational phase.
Scale	n/a	In the near proximity of the Project Area.
Frequency	Irregular and rare	Impact is likely to occur irregularly and rarely.
Likelihood	Unlikely	Impact is unlikely.
Magnitude		
Negligible magnitude related to the operational noise		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The receptors in the proximity of the Project are classified as "mixed residential" receptors group as per Nigerian noise criteria.		
Significant Rating Pre-Mitigation		
Negligible Impact		

8.2.4.4 Mitigation and Management Measures

Refer to Section 9.2.3 (Chapter 9) for the recommended mitigation and management measures associated with noise.

8.2.5 Impacts on Soils and Geology

8.2.5.1 Baseline Environment

The soils of the proposed Project Area are moderately well drained and loose with soil aggregates largely dominated by high sand percentages (>75 %).

Whilst potential contamination of the soil might not have any direct consequences on the soil itself (as agricultural practices are unlikely to take place within the proposed Project Area), secondary impacts on the underlying groundwater could occur due to the permeable nature of the soils.

8.2.5.2 Proposed Project Activities

Construction Phase

During the construction phase, the Project could result in the following types of potential impacts:

- **Soil Erosion and Loss of Topsoil** – can occur due to site preparation, de-vegetation, and the associated increased surface runoff during rainfall events;
- **Soil Compaction** – can occur due to increased vehicular movement on site during construction;
- **Soil Contamination** – can occur due to hydrocarbon leakages from equipment, and/or chemical spills, and the subsequent intrusion of oil and chemical substance into the soil; and
- **Changes in the Soil-water Balance** – can occur due to surface soil compaction and can lead to flooding due to reduced recharge into the soil.

Operational Phase

During the operational phase, the Project could result in the following types of potential impacts:

- **Soil Erosion** – can occur due to the area being de-vegetated from prior construction activities and the associated increased surface runoff during rainfall events;
- **Soil Contamination** – can occur due to hydrocarbon leakages from equipment, and/or chemical spills, and the subsequent intrusion of oil and chemical substance into the soil; and
- **Changes in the Soil-water Balance** – can occur due to surface soil compaction from prior construction activities, which can lead to flooding due to reduced recharge into the soil.

8.2.5.3 Sensitive Receptors

Sensitive receptors in the surrounding Study Area have been identified as:

- Seven communities surrounding the Project Area. Communities include Iriebe, Agbonchia, Aleto, Akpajo, Elelenwo, Nguru, and Okerewa. These communities rely on wells for water supply. They also rely on subsistence farming. Contamination of the soils can migrate towards the communities, impacting the field carry capacity for livestock, planting crops, and their groundwater supply qualities; and
- The groundwater resource in the Study Area is considered a sensitive receptor. Once the aquifers are contaminated, they are considered pathways of contaminant migration.

8.2.5.4 Significance of Impact (Pre-mitigation)

The expected impacts (pre-mitigation) are assessed in the following tables. Based on the analysis provided:

- The impact from soil erosion is considered a "**Moderate Negative Impact**" pre-mitigation (Table 8-12);
- The impact of loss of topsoil and soil compaction is classified as a "**Minor Negative Impact**" pre-mitigation (Table 8-13);
- The impact of soil contamination from chemical and hydrocarbon spills is classified as a "**Minor Negative Impact**" pre-mitigation (Table 8-14); and
- The impact from changes in the soil-water balance is considered a "**Minor Negative impact**" pre-mitigation (Table 8-13).

Table 8-12 Rating of Impacts Related to Soil & Geology (Pre-Mitigation): Soil Erosion and Loss of Topsoil during Construction and Operation

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact will occur in areas where de-vegetation and Site clearance occurs.
Duration	Long-term	Impact will continue in the long term.
Scale	250 ha	Impact may occur over the extent of the property.
Frequency	Permanent	Impact, once it occurred, will be permanent.
Likelihood	Likely	Impact is Likely.
Magnitude		
Medium Magnitude related to the area that can be impacted		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The soils are sensitive to erosion, as it will lose the soil structure, fertile topsoil can be washed away.		
Significant Rating Before Mitigation		
Moderate Impact		

Table 8-13 Rating of Impacts Related to Soil & Geology (Pre-Mitigation): Soil Compaction during Construction and Operation

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact will occur in areas where vehicles operate and where surface infrastructure footprints are established.
Duration	Long-term	Impact will continue in the long term.
Scale	250 ha	Impact may occur over the extent of the property.
Frequency	Long term	Impact, once it occurred, will be long term.
Likelihood	Likely	Impact is Likely.
Magnitude		
Medium Magnitude related to the area that can be impacted		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		

Medium Sensitivity
The soils are sensitive to compaction and will increase surface runoff during rainfall events.
Significant Rating Before Mitigation
Moderate Impact

Table 8-14 Rating of Impacts Related to Soil & Geology (Pre-Mitigation): Soil Contamination during Construction and Operation

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact has the potential to migrate a few hundred metres from the point of pollution.
Duration	Long-term	Impact is expected to continue in the long term.
Scale	250 ha	Impact may occur over the extent of the property.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Likely	Impact is Likely.
Magnitude		
Small Magnitude related to the likely small volumes released in spills and limited extent of migration		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The surrounding communities are dependent on the groundwater resource, which can be contaminated as a receptor of contamination of the soils. Subsequent contamination of the groundwater resource may impact water supply of communities Southward of the Project site. However, the communities are located more than 1 km from the Site boundaries, and it is unlikely that any contamination will reach their water supply wells.		
Significant Rating Before Mitigation		
Minor Impact		

Table 8-15 Rating of Impacts Related to Soil & Geology (Pre-Mitigation): Changes to the Soil Water Balance

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact will be within the Project Site.
Duration	Long-term	Impact is expected to continue in the long term.
Scale	250 ha	Impact may occur over the extent of the property.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Likely	Impact is Likely.
Magnitude		
Medium Magnitude related to the area that can be impacted		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The soils are sensitive to changes in the soil water balance and can lead to increased flooding.		
Significant Rating Before Mitigation		
Moderate Impact		

8.2.5.5 Mitigation and Management Measures

Refer to Section 9.2.4 (Chapter 9) for the recommended mitigation and management measures associated with soils and geology.

8.2.5.6 Residual Impact (Post-mitigation)

Implementation of the proposed mitigation measures provided in Section 9.2.4 would not change the significance of the Project's impacts on soils and geology. As such, the impacts associated with soil erosion would remain a "**Moderate Negative Impact**", and the impacts associated with – loss of topsoil and soil compaction, soil contamination from chemical and hydrocarbon spills and changes in soil-water balance would remain "**Minor Negative Impacts**".

8.2.6 Impacts on Groundwater Resources

8.2.6.1 Description of the Baseline Environment

The primary groundwater receptor underlying the Project Area is the shallow, unconfined aquifer. Due to the shallow depth to groundwater (<7.5m), as well as the relatively high permeability of the lithologies underlying the Site (comprising sand and fine gravels), the local aquifer is sensitive towards potential contamination from surface sources. Furthermore, as groundwater in the Study Area is used for domestic purposes such as drinking, cooking, bathing, and washing, care should be taken to protect the aquifer from anthropogenic related impacts.

For a more detailed discussion on the baseline groundwater environment, please refer to Chapter 7.

8.2.6.2 Proposed Project Activities

Construction Phase

The following types of potential impacts are considered during the construction phase:

- **Chemicals and Hydrocarbon Spills** - during the construction phase, heavy machinery will be operational on site. There is a risk of impacts to the groundwater quality through accidental spills of fuels and oils, as well as other contaminants related to the transportation of equipment and materials during the construction phase. The spill can enter the soil and migrate vertically into the underlying aquifers from where it will migrate away from site.

Operational Phase

The following types of direct impacts are considered during the operational phase:

- **Effluent Treatment Plant** – there is a potential to introduce pollutants to the groundwater courses via:
  - Release of effluent that does not meet required standards due to i) malfunction or failures of treatment plant, ii) due to flood or overflow from retention pond; and
  - Accidental release or intentional dumping of solid waste from the effluent treatment plant.
- **Chemicals and Hydrocarbon Spills** – during the operational phase there is a risk of impacts to water quality through accidental spills of fuels and oils, as well as other contaminants related to the transportation of equipment and materials; and
- **Groundwater Abstraction** – groundwater will be abstracted for use in the petrochemical water treatment plant and fertiliser water treatment plant. Over abstraction can impact the sustainable groundwater supply in the surrounding sensitive receptors (communities).

8.2.6.3 Sensitive Receptors

During the hydro-census a total of seven communities surrounding the Project Area were identified. The identified communities include Iriebe, Agbonchia, Aleto, Akpajo, Elelenwo, Nguru, and Okerewa. These communities rely on wells for water supply. The details of the wells are summarised in Chapter 7. These communities will be sensitive to impacts on the groundwater resource quantity and quality.

8.2.6.4 Significance of Impact (Pre-mitigation)

The expected impacts are assessed in the following tables. Based on the analysis provided:

- The impact from chemical and hydrocarbon spills is considered to be a "**Minor Negative Impact**" pre-mitigation (Table 8-16);
- The impact from effluent from the effluent treatment plant into the Okulu River, and subsequently, the underlying aquifer is considered to be a "**Minor Negative Impact**" pre-mitigation (Table 8-17);
- The impact from overflow of the effluent treatment plant retention pond and release of solid waste is considered to be "**Minor Negative Impact**" pre-mitigation (Table 8-18); and
- The impact from groundwater abstraction for use in the water treatment plants is considered to be a "**Minor Negative Impact**" pre-mitigation (Table 8-19).

Table 8-16 Rating of Impacts Related to Groundwater Resources (Pre-Mitigation): Hydrocarbon Spills during Construction and Operation

Type of Impact		
Direct (spills to groundwater), Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact has the potential to migrate a few hundred metres from the point of pollution.
Duration	Long-term	Impact has the potential to continue in the long term.
Scale	250 ha	Impact may occur over the extent of the property.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Likely	Impact is Likely.

Magnitude
Small Magnitude related to the likely small volumes released in spills and limited extent of migration
Sensitivity/Vulnerability/Importance of the Resource/Receptor
Medium Sensitivity
The surrounding communities are dependent on the groundwater resource, and contamination will impact their water supply. However, the communities are located more than 1 km from the Site boundaries, and it is unlikely that any contamination will reach their water supply wells.
Significant Rating Before Mitigation
Minor Impact

Table 8-17 Rating of Impacts Related to Groundwater Resources (Pre-Mitigation): Release of Poor-quality Water in the Okulu River during Operation

Type of Impact		
In-direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	The pollutants will migrate off-site in the river. The impact on the groundwater resource can thus occur anywhere along the extent of the river where constituent concentrations are elevated, and the polluted water from the stream infiltrate into the groundwater resource.
Duration	Long-term	Impact has the potential to continue in the long term.
Scale	Undefined	Impact may occur along the footprint of the river where constituent concentrations are elevated, and the polluted water from the stream infiltrate into the groundwater resource.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Possible	Impact is possible in the case that the plants are not maintained and operated properly.
Magnitude		
Small Magnitude related to the likely low volumes released and dilution with stream water.		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The surrounding communities are dependent on the groundwater resource, and contamination will impact their water supply. However, the communities are located more than 1 km from the Project Area boundaries, and it is unlikely that any contamination will reach their water supply wells.		
Significant Rating Before Mitigation		
Minor Impact		

Table 8-18 Rating of Impacts Related to Groundwater Resources (Pre-Mitigation): Overflow of the Effluent Treatment Plant Retention Pond and Release of Solid Waste during Operation

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact has the potential to migrate a few hundred metres from the point of pollution.
Duration	Long-term	Impact has the potential to continue in the long term.

Scale	<50 ha	Impact may occur in the vicinity of the water treatment plants and/or retention pond.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Possible	Flood events are possible. Intentional dumping of solid waste is assumed to be unlikely.
Magnitude		
Small Magnitude related to the likely low volumes released, localised footprint, and limited extent of migration		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The surrounding communities are dependent on the groundwater resource, and contamination may impact their water supply. However, the communities are located more than 1 km from the Project Area boundaries, and it is unlikely that any contamination will reach their water supply wells.		
Significant Rating Before Mitigation		
Minor Impact		

Table 8-19 Rating of Impacts Related to Groundwater Resources (Pre-Mitigation): Groundwater Abstraction during Operation

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	The groundwater level drawdown cone is expected to extend <250 m from the water supply well, depending on the abstraction rate, depth of groundwater level drawdown, and aquifer transmissivity.
Duration	Long-term	Impact has the potential to continue in the long term.
Scale	20 ha	The groundwater level drawdown cone can extend several hundred metres from the water supply well. For the purpose of this assessment, it is assumed to extend up to 250 m from the water supply well.
Frequency	Long term	Impact, once it occurred, will be long-term (life of operations), but will recover once groundwater abstraction stops at the end of life of operations.
Likelihood	Possible	The drawdown in groundwater level is definite; however, the impact on the surrounding water supply wells is rated as possible given the distance from the known communities to the Project Area.
Magnitude		
Small Magnitude due to the distance from the communities to the Project Area		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The surrounding communities are dependent on the groundwater resource, and a reduction in groundwater levels will impact their water supply.		
Significant Rating Before Mitigation		
Minor		

8.2.6.5 Mitigation and Management Measures

Refer to Section 9.2.5 (Chapter 9) **Post Mitigation**
Minor Impact

8.2.6.6 Residual Impact (Post-mitigation)

Based on the implementation of the proposed mitigation measures provided in Section 99.2.5, the significance of the impacts on groundwater resources are as follows:

- The residual impact from chemical and hydrocarbon spills is considered to remain a "**Minor Negative Impact**" post-mitigation (**Table 8-20**);
- The residual impact from effluent from the effluent treatment plant into the Okulu River, and subsequently, the underlying aquifer is considered to remain a "**Minor Negative Impact**" post-mitigation (**Table 8-21**);
- The residual impact from overflow of the effluent treatment plant retention pond and release of solid waste is considered to remain a "**Minor Negative Impact**" post-mitigation (**Table 8-22**); and
- The residual impact from groundwater abstraction for use in the water treatment plants is considered to remain a "**Minor Negative Impact**" post-mitigation (Table 8-23).

Table 8-20 Rating of Impacts Related to Groundwater Resources (Post-Mitigation): Hydrocarbon Spills during Construction and Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact has the potential to migrate a few hundred metres from the point of pollution.
Duration	Long-term	Impact has the potential to continue in the long-term.
Scale	10 ha	Impact may occur in some individual areas of the property.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Unlikely	Impact is unlikely.
Magnitude		
Small Magnitude related to the likely small volumes released in spills and limited extent of migration.		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-21 Rating of Impacts Related to Groundwater Resources (Post-Mitigation): Release of Poor-quality Water in the Okulu River during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	The pollution will migrate off-site in the river. The impact on the groundwater resource can thus occur anywhere along the extent of the river where constituent concentrations are elevated, and the polluted water from the stream infiltrate into the groundwater resource.
Duration	Long-term	Impact has the potential to continue in the long-term.
Scale	Undefined	Impact may occur along the footprint of the river where constituent concentrations are elevated, and the polluted water from the stream infiltrate into the groundwater resource.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Unlikely	Impact is unlikely based on assumed regular maintenance of the treatment plants.
Magnitude		
Small Magnitude related to the likely low volumes released and dilution with stream water		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-22 Rating of Impacts Related to Groundwater Resources (Post-Mitigation): Overflow of the Effluent Treatment Plant Retention Pond and Release of Solid Waste during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Impact has the potential to migrate a few hundred metres from the point of pollution.
Duration	Long-term	Impact has the potential to continue in the long-term.
Scale	<50 ha	Impact may occur over around the water treatment plants and/or retention dam.
Frequency	Long term	Impact, once it occurred, will be long-term.
Likelihood	Unlikely	Flood events are possible; however, it is assumed the retention pond will be engineered and sized appropriately, and therefore, it is considered unlikely that accidental spills will occur. Intentional dumping of solid waste is assumed to be unlikely.
Magnitude		
Small Magnitude related to the likely low volumes released, localised footprint, and limited extent of migration		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-23 Rating of Impacts Related to Groundwater Resources (Post-Mitigation): Groundwater Abstraction during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	The groundwater level drawdown cone is expected to extend <250 m from the water supply well, depending in the abstraction rate, depth of groundwater level drawdown, and aquifer transmissivity.

Duration	Long-term	Impact has the potential to continue in the long term
Scale	20 ha	The groundwater level drawdown cone can extend several hundred metres from the water supply well. For the purpose of this assessment, it is assumed to extend up to 250 m from the water supply well.
Frequency	Long term	Impact, once it occurred, will be long-term (life of operations), but will recover once groundwater abstraction stops at the end of life of operations
Likelihood	Unlikely	The drawdown in groundwater level is definite, however, the impact on the surrounding water supply wells is rated as unlikely given that the plant water supply well(s) will be spaced such that the groundwater level drawdown cones of the individual water supply wells will not overlap.
Magnitude		
Small Magnitude due to the distance from the communities to the Project Site		
Significant Rating Post Mitigation		
Minor		

8.2.7 Impacts on Surface Water Resources

8.2.7.1 Description of Baseline Environment

The baseline study identified the Okulu River as a surface water resource that is within the area of influence for the Project and downstream of the Project Area. As per the ERM impact assessment methodology, it was assigned a high sensitivity. The sensitivity assignment is informed by: i) the sandy nature of the Okulu tributary and therefore sensitivity of river geomorphology and flow rate to increases in flow from treated effluent; ii) the relatively low inflow to the Okulu River upstream if the discharge point and therefore higher vulnerability (lower flush) to changes in flow rate or water chemistry.

The Project AoI considered for the surface water resources Impact Assessment is described in Chapter 7.

8.2.7.2 Proposed Project Activities

Construction Phase

The following types of potential impacts are considered during the construction phase:

- **Chemicals and Hydrocarbon Spills** – during the construction process there is a risk of impacts to water quality through accidental spills of fuels and oils, as well as other contaminants related to the transportation of equipment and materials during the construction phase.

Operational Phase

The following types of direct impacts are considered during the operation phase:

- **Effluent Treatment Plant** – the potential to introduce pollutants to surface water courses via:
  - Release of effluent that does not meet required standards due to i) malfunction or failures of treatment plant or poor operation and maintenance, ii) due to flood or overflow from retention pond;
  - Accidental release or intentional dumping of solid waste from effluent treatment plant to surface waters; and
  - Spills or leaks from the effluent treatment plant ponds or transport lines occurring direct to surface water where in contact or occurring to soil/ groundwater and then reaching surface water receptors.

- **Chemicals and Hydrocarbon Spills** – there is a risk of impacts to water quality through accidental spills of fuels and oils, as well as other contaminants related to the transportation of equipment and materials during the operational phase.
- **Hard Surfacing** – increased storm/ surface water runoff to Okulu River subsequent to hardening of surfaces (and reduced infiltration to soils and groundwater). The stormwater from the Project Area will be directed to the Retention Pond of the effluent treatment plant, and discharged to the Okulu River. The hard surfacing and the volumes of water used in operations and disposed of in the effluent treatment plant both have the potential together to increase the flow regime in the Okulu tributary and river.

8.2.7.3 Sensitive Receptors

The Okulu River lies 1.3 km south of the southern boundary of the Project Area. A channel originating within the existing Indorama complex flows in a southerly direction to join the Okulu River. The existing Indorama complex discharges treated effluent mixed with storm run-offs from this channel and the proposed Project intends to do the same.

8.2.7.4 Significance of Impact (Pre-mitigation)

The impacts listed above are assessed in the following tables. Based on the analysis provided:

- The impact from hydrocarbon spills is considered to be a “**Minor Negative Impact**” pre-mitigation (refer to Table 8-24).
- The impact of spill of untreated effluent from the effluent treatment plant due to plant malfunction is considered to be a “**Major Negative impact**” pre-mitigation (refer to Table 8-25).
- The impact from hard surfacing and effluent discharge both of which combine and increase flow in the Okulu River is considered to be a “**Minor Negative Impact**“ pre-mitigation (Table 8-26).

Table 8-24 Rating of Impacts Related to Surface Water Resources (Pre-Mitigation): Hydrocarbon Spills during Construction and Operation

Type of Impact		
Direct (spills to surface water) and indirect (spills migrating to surface water through soils or groundwater), Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations. Contaminants such as fuels would result in a medium scale impact.
Frequency	Irregular and rare	Impact is likely to occur irregularly and rarely.
Likelihood	Likely	Impact is possible.
Magnitude		
Small Magnitude related to the likely small volumes released in spills		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The Okulu River is located directly downstream of the existing and planned plant. Spills have the potential to be transported from Project Area to the River, resulting in a minor impact.		
Significant Rating Before Mitigation		
Minor Impact		

Table 8-25 Rating of Impacts Related to Surface Water Resources (Pre-Mitigation): Effluent Treatment Plant Malfunction during Operation

Type of Impact		
Direct (spills to surface water) and indirect (leaks from ponds migrating to surface water through soils or groundwater), Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations.
Frequency	Constant	Impact has the potential to be continual
Likelihood	Possible	Impact is possible
Magnitude		
Large Magnitude related to the potential for large volumes of untreated effluent to be released in cases of malfunction of plant, poor operations and maintenance		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The Okulu River is located directly downstream of the existing and planned plant. Pollutants from the effluent treatment plant have the potential to be transported from the Project Area to the River, resulting in a major impact (specifically the potential for a large release related to failure of plant due to flood, retention pond wall failure, or continual undetected release of untreated effluent)		

Significant Rating Before Mitigation
Major Impact

Table 8-26 Rating of Impacts Related to Surface Water Resources (Pre-Mitigation): Hard Surfacing and Effluent Discharge Increasing Flow in Okulu River during Operation

Type of Impact		
Direct, Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact extends beyond the Project Area.
Duration	Long-term	Impact will continue during the Project life.
Scale	Small	Discharge of effluent likely to be around 275 m^3/hour (equivalent to 76 litres/second) – this likely presents a small portion of natural flow of the Okulu River.
Frequency	Constant	Impact will be continual during operation.
Likelihood	Likely	Impact is likely.
Magnitude		
Small magnitude to the Okulu River related to the small change in flow rate		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The Okulu River is located directly downstream of the existing and planned plant. Runoff and stormwater from Project Area will be directed to the retention pond and ultimately to the Okulu River, increasing the flow in the river.		
Significant Rating Before Mitigation		
Minor Impact		

8.2.7.5 Mitigation and Management Measures

Refer to Section 9.2.6 (Chapter 9) for the recommended mitigation and management measures associated with surface water resources.

8.2.7.6 Residual Impact (Post-mitigation)

Based on the implementation of the proposed mitigation measures provided in Section 9.2.6, the residual significance of the impacts to surface waters is as follows:

- The residual impact from hydrocarbon spills is considered to be a "**Negligible Negative impact**" post-mitigation (Table 8-27).
- The residual impact from the effluent treatment plant due to malfunction is considered to be a "**Minor Negative Impact**" post-mitigation (Table 8-28).
- The residual impact from the effluent treatment plant due to flood is considered to be a "**Minor Negative Impact**" post-mitigation (Table 8-29).
- No specific mitigation measures are proposed for the impact from hard surfacing and effluent discharge both of which combine and increase flow in the Okulu River. As such, the residual impact is considered to remain a "**Minor Negative Impact**" post-mitigation (Table 8-30).

Table 8-27 Rating of Impacts Related to Surface Water Resources (Post-Mitigation): Hydrocarbon Spills during Construction and Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations. Contaminants such as fuels would result in a medium scale impact.
Frequency	Irregular and rare	Impact is likely to occur irregularly and rarely.
Likelihood	Unlikely	Impact is unlikely.
Magnitude		
Negligible Magnitude related to the likely negligible volumes that could reach surface water as a result of spills		
Significant Rating Post Mitigation		
Negligible Impact		

Table 8-28 Rating of Impacts Related to Surface Water Resources (Post-Mitigation): Effluent Treatment Plant Malfunction during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations.
Frequency	Constant	Impact has the potential to be continual.
Likelihood	Unlikely	Impact is unlikely based on assumed regular maintenance of the treatment plants.
Magnitude		
Small Magnitude related to related to the likely low volumes released if the plant is maintained well, and dilution with stream water		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-29 Rating of Impacts Related to Surface Water Resources (Post-Mitigation): Effluent Treatment Plant Overflow during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations.
Frequency	Constant	Impact has the potential to be continual.
Likelihood	Unlikely	Impact is unlikely based on assumed adequate design of Project storm water drainage and treatment plant retention pond.
Magnitude		
Small Magnitude related to related to the likelihood of only small volumes being released if proper flood assessment is incorporated in design.		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-30 Rating of Impacts Related to Surface Water Resources (Post-Mitigation): Hard Surfacing and Effluent Discharge Increasing Flow in Okulu River during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact extends beyond the Project Area.
Duration	Long-term	Impact will continue during the Project life.
Scale	Small	Discharge of effluent likely to be around 275 m^3/hour (equivalent to 76 litres/second) – this likely output presents a small portion of natural flow of the Okulu River.
Frequency	Constant	Impact will be continual during operation.
Likelihood	Likely	Impact is likely.
Magnitude		
Small Magnitude related to related to the likelihood of only small volumes being released under normal operation.		
Significant Rating Post Mitigation		
Minor Impact		

8.3 Impacts on Biodiversity and Ecosystem Services

8.3.1 Description of the Baseline Environment

The baseline study identified that while the terrestrial and aquatic biodiversity of the Project Area have been altered through anthropogenic impacts; the area does contain some biodiversity of value and provides ecosystem services to the greater community in the Study Area.

8.3.2 Proposed Project Activities

8.3.2.1 Construction Phase

The following types of potential impacts are considered during the construction phase:

- **Loss of biodiversity** – during the construction process there will be loss of biodiversity in the Project Area, as well as potential impacts to the surrounding fauna and flora through accidental spills of fuels and oils, erosion onto adjoining land parcels, and direct disturbance of fauna and flora by construction personnel and activities.

8.3.2.2 Operational Phase

The following types of direct impacts are considered during the operation phase:

- **Loss of Biodiversity** – during the operational phase, there are potential impacts to the surrounding fauna and flora through accidental spills of fuels and oils and direct disturbance of fauna and flora by personnel and operations.
- **Effluent Treatment Plant** – the potential to introduce pollutants to surface water courses via:
  - Release of effluent that does not meet required standards due to i) malfunction or failures of effluent treatment plant or poor operation and maintenance, ii) due to flood or overflow from retention pond;
  - Accidental release or intentional dumping of solid waste from effluent treatment plant to surface waters; and
  - Spills or leaks from the effluent treatment plant ponds or transport lines occurring direct to surface water where in contact or occurring to soil/ groundwater and then reaching surface water receptors.

8.3.3 Sensitive Receptors

- The **Terrestrial Biodiversity** of the Project Area has been impacted upon by anthropogenic forces, but still retains both plants and animals that form an integral part of the community's ecosystem services. The loss of the area to be cleared for the Project could directly affect the surrounding ecosystem through siltation and pollution, alien invasive species introduction, and changes to the functionality of the systems.
- While little to no direct impact is predicted to occur to the **Aquatic Biodiversity** of the Project Area, the possibility exists that effluent discharge could lead to contamination of these systems, which is already under threat from a number of anthropogenic impacts. Most of the threatened species observed (and potential critical habitat triggers), are associated with aquatic habitats.

8.3.4 Significance of Impact (Pre-mitigation)

The impacts listed above are assessed in the following tables. Based on the analysis provided:

- The impact from loss of biodiversity during construction is considered a "**Major Negative Impact**" pre-mitigation (refer to Table 8-31).
- The impact from loss of biodiversity during operation is considered a "**Major Negative Impact**" pre-mitigation (refer to Table 8-32).
- The impact from loss of aquatic biodiversity through effluent treatment plant malfunction during operation is considered a "**Major Negative Impact**" pre-mitigation (refer to Table 8-33).

Table 8-31 Rating of Impacts Related to Biodiversity Resources (Pre-Mitigation): Biodiversity Loss during Construction

Type of Impact		
Direct (Loss of Biodiversity) Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to cause changes up to a few kilometres of the Project Area.
Duration	Short-term	Impact has the potential to continue for the short-term.
Scale	Medium	The affected habitat is modified and relatively widespread within the greater landscape. No loss of unique habitats or species are expected to occur.
Frequency	Constant	Impact has the potential to be continual.
Likelihood	Likely	Impact is possible unless mitigation is implemented.
Magnitude		
Large Magnitude related to the potential loss of biodiversity and ecosystem services		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The biodiversity of the Project Area is partially degraded, but still supplies valuable ecosystem services to the immediate community.		
Significant Rating Before Mitigation		
Major Impact		

Table 8-32 Rating of Impacts Related to Biodiversity Resources (Pre-Mitigation): Biodiversity Loss during Operation

Type of Impact		
Direct (Loss of Biodiversity) Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to cause changes up to a few kilometres of the Project Area.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The affected habitat is modified and relatively widespread within the greater landscape. No loss of unique habitats or species are expected to occur.
Frequency	Constant	Impact has the potential to be continual.
Likelihood	Likely	Impact is possible unless mitigation is implemented.
Magnitude		
Large Magnitude related to the potential loss of biodiversity and ecosystem services		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The biodiversity of the Project Area is partially degraded, but still supplies valuable ecosystem services to the immediate community.		
Significant Rating Before Mitigation		
Major Impact		

Table 8-33 Rating of Impacts Related to Biodiversity Resources (Pre-Mitigation): Aquatic Biodiversity Loss through Effluent Treatment Plant Malfunction during Operation

Description of Impact		
Loss of aquatic biodiversity through direct spills to surface water and indirect (leaks from ponds migrating to surface water through soils or groundwater).		
Type of Impact		
Direct, Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations.
Frequency	Frequent	Impact will be frequent during operation.
Likelihood	Possible	Impact is possible
Magnitude		
Large Magnitude related to the potential for large volumes of untreated effluent to be released in cases of malfunction of plant, poor operations and maintenance		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
High Sensitivity		
The aquatic biodiversity of the area is partially degraded, but still supplies valuable ecosystem services to the immediate community.		
Significant Rating Before Mitigation		
Major Impact		

8.3.5 Mitigation and Management Measures

Refer to Section 9.2.7 (Chapter 9) for the recommended mitigation and management measures associated with biodiversity and ecosystem services.

8.3.6 Residual Impact (Post-mitigation)

Based on the implementation of the proposed mitigation measures provided in Section 9.2.7, the residual significance of the impacts to biodiversity is as follows:

- The residual impact from loss of biodiversity during construction is considered a "Minor Negative Impact" post-mitigation (refer to Table 8-34).
- The residual impact from loss of biodiversity during operation is considered a "**Minor Negative Impact**" post-mitigation (refer to Table 8-35).
- The residual impact from loss of aquatic biodiversity through effluent treatment plant malfunction during operation is considered a "**Minor Negative Impact**" post-mitigation (refer to Table 8-36).

Table 8-34 Rating of Impacts Related to Biodiversity Resources (Post-Mitigation): Biodiversity Loss during Construction

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to cause changes up to a few kilometres of the Project Area.
Duration	Short-term	Impact has the potential to continue for the short term
Scale	Medium	The affected habitat is modified and relatively widespread within the greater landscape. No loss of unique habitats or species are expected to occur.
Frequency	Constant	Impact has the potential to be continual
Likelihood	Unlikely	Impact is unlikely
Magnitude		
Small Magnitude related to the control of the Project Sites' impact on the surrounding environment		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-35 Rating of Impacts Related to Biodiversity Resources (Post-Mitigation): Biodiversity Loss during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to cause changes up to a few kilometres of the Project Area.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The affected habitat is modified and relatively widespread within the greater landscape. No loss of unique habitats or species are expected to occur.
Frequency	Constant	Impact has the potential to be continual.
Likelihood	Unlikely	Impact is unlikely.
Magnitude		
Small Magnitude related to the control of the Project Sites' impact on the surrounding environment		
Significant Rating Post Mitigation		
Minor Impact		

Table 8-36 Rating of Impacts Related to Biodiversity Resources (Post-Mitigation): Aquatic Biodiversity Loss through Effluent Treatment Plant Malfunction during Operation

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	Impact has the potential to migrate beyond the Project Area several kilometres transported by surface water.
Duration	Long-term	Impact has the potential to continue for the long-term lifetime of Project.
Scale	Medium	The scale of the impact is dependent on the type of contaminants that enter the surface water resource and their concentrations.
Frequency	Rarely	Impact will be rare during operation.
Likelihood	Unlikely	Impact is unlikely based on assumed adequate design of Site storm water drainage and treatment plant retention pond
Magnitude		
Small Magnitude related to related to the likelihood of only small volumes being released if proper flood assessment is incorporated in design.		
Significant Rating Post Mitigation		
Minor Impact		

8.4 Impacts to the Socio-economic Environment

This Section assesses the predicted socio-economic, cultural heritage, traffic, and transportation impacts (both positive and negative) associated with the Project. Box 8.1 below provides the predicted risks and impacts to the socio-economic environment.

Box 8.1 Predicted Risks and Impacts to the Socio-economic Environment

- Resettlement
- Increased employment within the Project area (construction and operation)
- Increased income and spending within the Project area (construction and operation)
- Socioeconomic development benefits (construction and operation)
- Influx of migrant workers and job seekers (construction)
- Community frustration over unmet expectations (construction and operation)
- Public and Worker Health and Safety Impacts (construction and operation), including:
  - Increased Incidence of Communicable Diseases (construction)
  - Increased Risk of Traffic Accidents during (construction and operation)
  - Disturbance due to dust, noise and vibration (construction)
- Impacts on Cultural Heritage Resources

8.4.1 Resettlement

The IEFCL Train 3 Project is located within Land designated for Industrial Development, and ERM understands that a Certificate of Occupancy for the 250ha site was legally granted by the Government of Rivers State of Nigeria in October 2019.

In order to ensure a thorough review, ERM sought prior land rights documents from IEFCL to confirm previous land uses and ensure that no activities have occurred to trigger IFC Performance Standard 5 – Involuntary Resettlement and Land Acquisition.

The following Land and other documents were provided by IEFCL for further review to ascertain the procedure followed for acquiring said land:

- NNPC COA for 895.991 Ha - original Certificate of Occupancy (including gazette notification (1984/85)
- NNPC-EPCL - Deed of Assignment (2006/07)
- IEFCL 250Ha_Certificate of Occupancy (2019)

In November 1984, Rivers State Government of Nigeria published a Gazette Notification, inviting persons who have any right or interest in the said land to claim their rights so that Government can compensate affected persons as per Land use degree/act. After the expiration of notified time for claims, Rivers State Government followed all the legal and traditional procedures and finally issued a Certificate of Occupancy of 895.991ha Land in favour of Nigerian National Petroleum Corporation (NNPC) in September 1985.

In February 2007, documentation has been provided constituting a ‘Deed of Assignment’ between the Nigerian National Petroleum Corporation and Eleme Petrochemicals Company, comprising 361ha land out of 895.991Ha, which was originally acquired from Rivers State Government of Nigeria

In October 2019, Rivers State Government of Nigeria, issued a Certificate of Occupancy on 250ha of land which is also part of originally acquired 895.991 Ha Land, to Indorama Eleme Fertilizer & Chemicals Limited.

NNPC had built boundary wall to fence the entire perimeter of 895.991Ha land in 1985/86 and further industrial development. Since then, no socio-economic activities were carried out by communities in the said land.

In order to confirm the status of the land and any outstanding issues, IEFCL's Grievance Database (dating from 2018 to 2022) was consulted, and no grievances pertaining to land were identified.

It was also confirmed from interviews with IEFCL that during the preparation works for the ESIA, stakeholders were consulted with detailed information pertaining to land, project location, and proposed developmental activities and no objections were received.

It is understood that upon the transfer of occupancy to IEFCL in 2019, it was found that some local community members were accessing the site; however, this was due to broken sections of fencing leading to opportunistic access from local people. No livelihood activities were identified within the site, and community members were later employed to rebuild a more secure wall around the site boundary.

Further engagements held with local leadership in June 2023 have confirmed that site access was limited to grazers from the northern parts of Nigeria opportunistically accessing land during the dry season, when pastures are more abundant in southern Nigeria. Local leadership confirmed that there had been no conflict between local communities and northern grazers, and that no grievances had been lodged with the local leadership with respect to any loss of access to the land.

On the basis of review of available documentation and records, ERM is of the opinion that there is no risk associated with legacy land acquisition.

8.4.2 Increased Employment within the Study Area

8.4.2.1 Description of the Baseline Environment

Since 2008, economic growth in Nigeria has been largely driven by the agricultural, telecommunications, and service sectors, with oil production steadily declining since 2012. Despite economic growth and diversification, 62% of Nigeria's population live in extreme poverty. The unemployment rate was 9.79% in 2021, with 70% of the population employed in agricultural activities[69].

8.4.2.2 Proposed Project Activities

Construction Phase

It is anticipated that the construction phase will create a peak demand of 4,424 for direct employment opportunities for a period of 32 months. It is anticipated that up to 88% of the staff will be sourced from within Niger Delta region of Nigeria, and 29% of the total will be from within Eleme Local Government Area. Members from the local community in the Study Area are likely to be in a position to qualify for the majority of the low skilled and a proportion of the semi-skilled employment opportunities.

Operational Phase

During the operational phase, it is anticipated that up to 172 jobs will be generated, 67% of which are anticipated to be Nigerian nationals.

The IEFCL Recruitment Strategy will include a written aptitude test, followed by a technical test and oral interview to be eligible for training. IEFCL will implement a local Graduate Engineer & Diploma Engineer Internship Programme to provide opportunities for suitably qualified individuals to be employed at the operations, and Refresher Courses for Indigenous candidates. The Refresher Course will aim to training

[69] The World Factbook (2023)

and coach indigenous candidates to take the Technical Test (in collaboration with Rivers State University located about 19 km from the Project Area).

8.4.2.3 Sensitive Receptors

The communities within the Study Area, namely Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area, and Elelenwo in Obio-Akpor Local Government Area are likely to benefit from unskilled labour requirements for the Project due to their proximity to the Site. The broader Port Harcourt area is also likely to be positively impacted by employment opportunities.

8.4.2.4 Significance of Impact (Pre-enhancement)

Based on the analysis provided above, the impact associated with increased employment opportunities will be a "**Positive Impact**" (refer to Table 8-37).

There is the potential for the host communities to benefit from the construction phase; however, limited skills are available in these communities, and many of the opportunities may be sourced from outside the immediate area. The broader Port Harcourt and Rivers State are likely to be the key areas of employment, somewhat diluting the positive impact. Skilled and professional positions are likely to be sourced at a national or international level.

Table 8-37 Rating of Impacts Related to Increased Employment in the Study Area (Pre-enhancement)

Type of Impact
Positive
There is low formal employment within the host communities; therefore, it is anticipated that temporary opportunities will have some positive impact on these communities (depending on numbers and locally sourced appointments). However, due to the temporary nature of the construction phase, the overall impact is likely to be minor.

8.4.2.5 Enhancement Measures

Refer to Section 9.2.8.1 (Chapter 9) for the recommended enhancement measures associated with increased employment within the Study Area.

8.4.3 Increased Income and Spending within the Study Area

8.4.3.1 Description of the Baseline Environment

Livelihoods within the Project-affected communities are a combination of formal and informal employment, supported through agriculture and fishing. Income is generally low with more than half-earning ₦ 10 000 (~USD $20) per month. Informal market trading plays a crucial role in the livelihoods and trade of the local economy.

8.4.3.2 Proposed Project Activities

The wage bill associated with the construction phase is estimated at $ 74.2 million for the 32-month construction phase. A percentage of the wage bill will therefore be spent in the local economy over the construction phase. This will create opportunities for local businesses in the Study Area. The sector of the local economy that is most likely to benefit from the proposed Project is the local service industry. The potential opportunities for the local service sector are linked to accommodation, catering, cleaning, transport, and security, etc. associated with the construction workers on the Site. Local procurement will create opportunities for local business in the area, specifically engineering and construction companies.

8.4.3.3 Sensitive Receptors

The communities within the Study Area, namely Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area, and Elelenwo in Obio-Akpor Local Government Area. The broader Port Harcourt area is also likely to be positively impacted by employment opportunities.

8.4.3.4 Significance of Impact (Pre-enhancement)

Based on the analysis provided above, the impact from **Increased income and spending within the Study Area** will be a "**Positive Impact**" (refer to Table 8-38).

There is the potential for the host communities to benefit from the construction phase; however, limited skills are available in these communities, and many of the opportunities may be sourced from outside the immediate area. The broader Port Harcourt and Waters State are likely to be the key areas of employment, somewhat diluting the positive impact. Skilled and professional positions are likely to be sourced at a national or international level.

Local spend (catering, accommodation, security, transport, etc.) within the area of impact is likely to provide temporary income for some sectors and individuals. However, due to the temporary nature of the construction phase, the impact is likely to be limited.

Table 8-38 Rating of Impacts Related to Increased Income and Spending in the Study Area (Pre-enhancement)

Type of Impact
Positive
There is a reliance on informal economic activities and agriculture within the host communities; therefore, it is anticipated that any spend locally (even temporary) may have some positive impact on these communities (depending on level of local spend, sourcing of materials and services). However, due to the temporary nature of the construction phase, the overall impact is likely to be minor.

8.4.3.5 Enhancement Measures

Refer to Section 9.2.8.2 (Chapter 9) for the recommended enhancement measures associated with increased income and spending within the Study Area.

8.4.4 Socio-economic Development Benefits

8.4.4.1 Description of the Baseline Environment

IEFCL has previously implemented community socio-economic development (SED) interventions in the areas of women empowerment, sustainable community development projects, scholarships, vocational training, preferential recruitment, and procurement, as well as a youth empowerment scheme. These interventions have previously been governed by Memorandums of Understanding (MOU) signed between host communities and IEFCL. Host communities expressed positive sentiments towards these interventions.

8.4.4.2 Proposed Project Activities

IEFCL and Host communities have completed the MOU for the period 2023 – 2025. In the said MOU provision for USD 1.8 million has been allocated for community SED intervention. Potential SED interventions will remain in line with those previously implemented by IEFCL. Indorama has a comprehensive CSR Program amounting USD 0.60 million per Annum. This program is overseen by the project advisory committee with three members drawn from each of the host communities.

8.4.4.3 Sensitive Receptors

Sensitive receptors are the communities within the Study Area, namely Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area, and Elelenwo in Obio-Akpor Local Government Area.

8.4.4.4 Significance of Impact (Pre-enhancement)

Based on the analysis provided above, the impact from socio-economic development interventions will be a "**Positive Impact**" (refer to Table 8-39).

Communities have the potential to benefit from SED interventions to a greater extent due to expanded operations. Previous interventions undertaken by IEFCL have been received positively; however, there will likely be a much-increased expectation from communities for SED benefits given the Project's construction. Community expectations should be managed to ensure they are reasonable, as SED interventions cannot address all existing socio-economic challenges in the Study Area.

Table 8-39 Rating of Impacts Related to Socio-economic Development Interventions (Pre-Mitigation)

Type of Impact
Positive
Given the relative lack of socio-economic opportunities and formal economic activity in host communities, SED interventions will likely be important to community members and represent pathways to economic activity, which are otherwise absent.

8.4.5 Influx of Migrant Workers and Job Seekers into Adjacent Communities

8.4.5.1 Description of Baseline Environment

An analysis using satellite information from 2002 to 2022 reveals that human settlement has increasingly spread towards the existing Trains 1 and 2 and its environs. Settlement in the immediately adjacent communities has also increased in density during the same period. This suggests the presence of influx into these communities, likely consisting of jobseekers, migrant workers, or those seeking to benefit socioeconomically from the Project due to close living proximity.

8.4.5.2 Proposed project Activities

The Project will have a construction workforce of 5,052 and an operational workforce of 172. The Project will rely on sourcing ~1,200 people from local communities within Eleme, and ~3,100 workforce from outside the local area but within Nigeria. Though difficult to quantify precisely, the construction of a large infrastructure Project will create further economic opportunities in the form of workforce spend in the surrounding formal and informal service sectors, potential procurement opportunities, and the establishment or growth of local businesses to service the Project. Such induced consequences further contribute to influx in the adjacent communities.

8.4.5.3 Sensitive Receptors

The communities within the Study Area, namely Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area, and Elelenwo in Obio-Akpor Local Government Area. The broader Port Harcourt area is also likely to be impacted by an increase in influx.

8.4.5.4 Significance of Impact (Pre-mitigation)

Based on the analysis provided above, the impact from the influx of migrant workers and job seekers into adjacent communities will be a "**Moderate Negative Impact**" pre-mitigation (refer to Table 8-40).

The settlement of migrant workers or jobseekers directly related to the Project is most likely to be observed in the immediately adjacent communities. However, the induced economic activity and potential for "camp followers" suggests that influx may also occur more broadly, throughout the Port Harcourt area.

Table 8-40 Rating of Impacts Related to Influx of Migrant Workers and Job Seekers into Adjacent Communities (Pre-Mitigation)

Type of Impact		
Direct, indirect, and induced negative impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	While jobseekers may settle near to the Project Site, influx is likely to occur more broadly throughout Port Harcourt, especially when considering formal and informal economic activity created during construction and operational phases.
Duration	Long-term	Migrants are likely to settle fairly permanently and throughout the construction and operation phases of the Project.
Scale	5,052 during construction; 172 during operation	IFC guidelines suggest that for every formal Project job created, between three and ten additional jobs are created in the Project area. Furthermore, an estimated three to four "camp followers" per formal job may be attracted during construction and operational phases[70].
Frequency	Annual	Frequency of influx is likely to occur sporadically throughout the year, with notable differences measured on an annual basis.
Magnitude		
Medium Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
Baseline indications suggest that influx has already had a negative impact on the AoI. The Project is likely to accelerate influx, especially during the construction period, and further due to induced migration. However, influx is likely to be cumulative in nature across various large industries in the AoI.		
Significant Rating Before Mitigation		
Moderate Impact		

8.4.5.5 Mitigation and Management Measures

Refer to Section 9.2.8.4 (Chapter 9) for the recommended mitigation and management measures associated with influx of migrant works and job seekers into adjacent communities.

8.4.5.6 Residual Impact (Post-mitigation)

Based on the implementation of the proposed mitigation measures provided in Section 9.2.8.4, the significance of the residual impact from the influx of migrant workers and job seekers into adjacent communities will be a "**Minor Negative Impact**" post mitigation (refer to Table 8-41).

Table 8-41 Rating of Residual Impacts Related to Influx of Migrant Workers and Job

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Regional	While jobseekers may settle near to the Project Site, influx is likely to occur more broadly throughout Port Harcourt, especially when considering formal and informal economic activity created during construction and operational phases.

70 Projects and People: A Handbook for Addressing Project-Induced In-Migration (ifc.org)

Duration	Short-term	Where skills and services can be effectively developed within local communities, the reliance on externally sourced labour and procurement may mostly be limited to the construction phase.
Scale	5,052 during construction; 172 during operation	Appropriate mitigation measures will reduce the ratio of migrants to formal jobs created.
Frequency	Annual	Frequency of influx is likely to occur sporadically throughout the year, with notable differences measured on an annual basis.
Magnitude		
Small Magnitude		
Significant Rating After Mitigation		
Minor Impact		

8.4.6 Community Dissatisfaction over Unmet Expectations

8.4.6.1 Description of Baseline Environment

The baseline study revealed that communities in the Study Area have a positive perception of IEFCL. This is mostly linked to the previous socio-economic development interventions undertaken by IEFCL and implemented in accordance with signed MOUs. IEFCL is furthermore implementing preferential local recruitment and procurement policies. There also appears to be effective relationship management between IEFCL and the study communities.

With the commencement of the Project, there is a high likelihood of increased expectations from communities. The baseline study identified 18 separate community expectations, and 22 areas of community concern related to the Project. The community expectations included: water facility installation and maintenance; subsidisation of fertilizer, support the construction of more health centres, support transportation and communication facilities among others. The concerns raised included but not limited to issues related to environmental hazards, limited stakeholder engagement and lack of job and employment. These expectations and concerns, whether perceived or real, have the potential to cause community anger if not met or responded to in a manner expected by and acceptable to community members.

8.4.6.2 Proposed Project Activities

The *Local Hiring Plan for Construction & Operation phase of IEFCL Train 3 Project* will be implemented during both the construction and operation phase of the Project. SED interventions to the amount of USD 1.8 million has been planned in the MOU 2023 - 2025. The Project's community liaison will occur primarily through the existing Project Advisory Committee (PAC) constituted by the Rivers State Government. The PAC includes representatives from communities, traditional leaders, and local authorities and deals with issues including employment, subcontracting and suppliers, corporate social responsibility, skill acquisition programmes, micro grants for women and awarding of scholarships.

8.4.6.3 Sensitive Receptors

The communities within the Study Area, namely Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area, and Elelenwo in Obio-Akpor Local Government Area.

8.4.6.4 Significance of Impact (Pre-mitigation)

Based on the analysis provided above, the impact from community anger over unmet expectations will be a "**Moderate Negative Impact**" pre-mitigation (refer to Table 8-42).

Table 8-42 Rating of Impacts Related to Community Dissatisfaction over Unmet Expectations (Pre-Mitigation)

Type of Impact		
Direct negative impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Beneficiaries of Indorama's SED interventions and policies have typically been concentrated within the immediately adjacent communities.
Duration	Medium-term	Expectations are likely to peak during construction phase, with a reduction in expectation levels during operations. Expectation levels are directly linked to the risk of community anger.
Scale	18 expectations and 22 areas of concern	The baseline study identified 40 expectations and areas of concern. The incident and grievance register may also be consulted to further understand the expectation levels of communities.
Frequency	Daily	Community expectations, perceptions, and anger may fluctuate or emerge daily.
Magnitude		
Medium Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
The socio-economic conditions of the Study Area suggest desperation for socioeconomic opportunity. Given the proximity of the host communities to the Project location, community dissatisfaction may potentially result in work stoppages or production losses due to community disruptions arising from unmet expectations.		
Significant Rating Before Mitigation		
Moderate Impact		

8.4.6.5 Mitigation and Management Measures

Refer to Section 9.2.8.5 (Chapter 9) for the recommended mitigation and management measures associated with community dissatisfaction over unmet expectations.

8.4.6.6 Residual Impact (Post-mitigation)

Based on the implementation of the proposed mitigation measures provided in Section 9.2.8.5, the significance of the impact from Community dissatisfaction over Unmet Expectations will be a "**Negligible Impact**" post mitigation (refer to Table 8-43).

Table 8-43 Rating of Impacts Related to Community Dissatisfaction over Unmet Expectations (Post-Mitigation)

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Beneficiaries of IEFCLs SED interventions and policies have typically been concentrated within the immediately adjacent communities.
Duration	Short-term	While it is unavoidable for the Project to create some community expectations, proactive expectation management can ensure realistic community expectations from the beginning of construction phase, and minimise risks related to community anger.
Scale	18 expectations and 22 areas of concern	Upon commencement of construction and implementation of mitigation measures, the Incident and Grievance Register and Commitment Register will measure the scale of community expectations.

Frequency	Quarterly	If channelled correctly, all community expectations and grievances can be addressed during standing PAC meetings.
Magnitude		
Negligible Magnitude		
Significant Rating After Mitigation		
Negligible Impact		

8.4.7 Public and Workers Health, Safety and Human Rights Impacts

8.4.7.1 Description of Baseline Environment

The Study Area has a few public and private healthcare facilities, although the public healthcare system appears under-equipped to service the general population. The area also faces ongoing public health challenges related to communicable diseases, malaria, as well as lack of adequate waste management. A population increase as a result of influx may further contribute to these issues during the construction phase.

The baseline study reveals that the quality of roads in the Study Area are poor, partly due to inadequate maintenance and partly to high volumes of industrial traffic such as trucks. Though not providing a detailed analysis, the baseline study also suggests that traffic accidents are a challenge in the Study Area.

Respondents in the community survey reported that 44% of the sampled population experienced frequent gender-based violence (GBV), 31% experienced GBV occasionally, while 25% reported not experiencing any forms of abuse. Abuse of a female spouse, gender-based discrimination, and female battering were all reported in the Study Area. This points to a context in which females are highly oppressed.

8.4.7.2 Proposed Project Activities

The Project will make use of several expatriate and national contractors during the construction phase. This is likely to increase the burden on public health facilities, as well as instances of communicable diseases. There is also the potential for sexually transmitted diseases to be spread between contractors and community members. A large presence of contractor workers may also result in sexual exploitation of local women, especially those engaged in sex work or in socio-economically vulnerable circumstances.

During the construction phase, estimated traffic movement is 122 vehicles per day. During operation, this increases to 570 vehicles per day (for both Trains 2 and 3). The State Government is presently constructing a new access road. This road will bypass almost all of the currently congested and highly deteriorated East-West Expressway, except for a stretch of 800 m where the new road converges with the existing Onne road.

Due to the large-scale nature of the construction, the Project will have an inevitable impact in terms of dust, noise, and vibrations. This impact will be limited to communities immediately adjacent to the Project Area.

The Project will use both private and state security services to protect IEFCL's assets. The enforcement of security measures may infringe on the human rights of community members, for example through involuntary bodily searches. There is also the potential for excessive use of force, especially by state security services, in the event of any security incidents.

8.4.7.3 Sensitive Receptors

The communities within the Study Area, namely Akpajo, Aleto, Agbonchia, Njuru (including Akpakpan area), Okerewa in Eleme Local Government Area, and Elelenwo in Obio-Akpor Local Government Area, as well as all permanent and temporary workers during construction and operation phases. Socio-economically vulnerable women within the Study Area will be particularly sensitive receptors to this impact.

8.4.7.4 Significance of Impact (Pre-mitigation)

Based on the analysis provided above, the impact from public and worker health and safety impacts will be a "**Moderate Negative Impact**" pre-mitigation (refer to Table 8-44).

Public and worker health and safety risks are embedded into any construction and operation of a large industrial facility. Significant impacts may be experienced by the host areas through exposure to a large contractor workforce, which will place strain on local healthcare facilities and increase instances of communicable disease, and potentially gender-based harm. Impacts related to increased traffic volumes will be minimal due to the Project's design. Dust, noise, and vibrations will be present, but should have a limited impact as no human settlement is directly adjacent to the proposed Project Site. Human rights impacts related to security services will be present throughout the asset's operational life.

Table 8-44 Rating of Impacts Related to Residual Impacts to Public and Worker Health, Safety, and Human Rights (Pre-Mitigation)

Type of Impact		
Direct negative impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Communities adjacent to the Project Area and along transportation routes will be most impacted.
Duration	Short/Long-term	Short-term impacts related to traffic, a contractor workforce, and dust, noise, and vibrations, will be associated with the construction phase. However, traffic impacts and labour and security-related human rights impacts will continue throughout the operational life of the asset.
Scale	More than 10 cases per month	Without sufficient management policies and procedures and monitoring of the implementation of these, there is the potential for the number of reported and unreported issues and incidents to be high.
Frequency	Daily	During construction and operational phases, health and safety impacts will occur daily (noise, dust and vibrations will occur daily; vehicular traffic to and from the Project Area will be daily). Enforcement of security will also take place daily.
Magnitude		
Medium Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
Given the urban and industrialised nature of the Study Area, the Project will increase health and safety impacts somewhat above the baseline situation. The Project design will minimise impacts from construction and traffic, suggesting that communities will adjust to these impacts quite easily. Women in the Study Area are particularly vulnerable to sexual exploitation and gender-based harm and other human rights impacts.		
Significant Rating Before Mitigation		
Moderate Impact		

8.4.7.5 Mitigation and Management Measures

Refer to Section 9.2.8.6 (Chapter 9) for the recommended mitigation and management measures associated with public and worker health, safety, and human rights impacts.

8.4.7.6 Residual Impact (Post-mitigation)

Based on the implementation of the mitigation measures provided in Section 9.2.8.6, the significance of the impact public and worker health and safety impacts will be a "**Negligible Impact**" post mitigation (refer to Table 8-45).

Table 8-45 Rating of Residual Impacts Related to Public and Worker Health and Safety Impacts (Post-Mitigation)

Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Communities adjacent to the Project Area and along transportation routes will be most impacted.
Duration	Short-term	Some short-term impacts related to the construction workforce and increased traffic are unavoidable. However, longer-term impacts can be successfully mitigated.
Scale	Less than one case per month	With suitable management policies and procedures and monitoring of the implementation of these in place, the number of reported and unreported issues and incidents is likely to be significantly reduced.
Frequency	Monthly	During construction and operational phases, health and safety impacts will occur daily (noise, dust and vibrations will occur daily; vehicular traffic to and from the Project Area will be daily).
Magnitude		
Small Magnitude		
Significant Rating After Mitigation		
Minor Impact		

8.4.8 Impacts on Cultural Heritage Resources

One non-designated potential cultural heritage resource was identified within the Study Area (IND_CH_001). An area of land approximately 250 metres in diameter slightly elevated from the land surrounding (+- 19 masl based on the topographic survey). From satellite imagery and the topographic report, it appears to contain a small body of water. With reference to Chapter 7 of this ESIA, it was initially perceived that the site had the potential to contain intangible cultural heritage in the form of a sacred grove with spiritual or religious value; however, a subsequent ground truthing exercise indicated that IND_CH_001 contains no heritage value.

8.4.9 Impacts on Traffic and Transportation

8.4.9.1 Description of the Baseline Environment

Local travel occurs by foot, motorcycles/tricycles, and passenger vehicles. Trucks and buses are generally a small proportion of traffic but comprise a larger proportion of traffic on major highways, port access roads, and the Indorama Complex access road.

Entry to the existing Indorama Complex is provided by an access road with separate, dedicated lanes for truck traffic and smaller vehicles driven by personnel. The access road connects to the East West Road, a heavily travelled, regional arterial road with two travel lanes in each direction and a median barrier. The East West Road carries about 31,000 vehicle trips daily. The Indorama access road generates about 9,000 vehicle trips daily, which all require a turning movement to or from the East West Road.

The Uzaku-Alese Road is a two-lane road with unmarked pavement and varying pavement condition that traverses rural areas and towns and has residences, businesses and market stalls abutting the roadway, especially within Eleme and other towns. The road is important for both vehicular and pedestrian travel. The Onne port is located approximately 19 km south of the Indorama Complex access road and is accessible via the East West Road, Onne Road and the Federal Ocean Terminal Roadway. All of these roads are built to accommodate truck traffic, although pavement conditions vary.

8.4.9.2 Proposed Project Activities

The Project would include the construction and operation of the IEFCL-Train 3 as described in Chapter 4. A second access road (the Indorama-Agbonchia-Ogale-Ebubu-East West Link Road) is currently being constructed by the State Government, as shown in red on Figure 8.11. The new access road would intersect the East West Road approximately 800 m east of the Onne Road/East West Road intersection. From the East West Road, the new access road would cross rural land to the east and north of Ogoni, Eleme and other settlements, cross the Uzaku-Alese Road in a rural area north of Eleme, and connect the Project Area at its south-eastern corner. The new access road would be 10.5 km long, constructed of asphalt, and with two lanes in each direction and street lighting. Except for the 800 m segment east of the Onne Road, the new access road would bypass the heavily travelled East West Road.

Figure 8.11 Existing Road Network and Proposed New Access Road to Indorama Complex

Source: Indorama Traffic Survey Report Annex 1

Construction is estimated to take approximately 32 months. Once constructed, all Project equipment movement, oversized loads, and employee buses would use the new access road. The route for other types of shipments (sand, aggregate, other deliveries) is not specified and would likely depend upon where the trip originates. Project activities generating traffic would include the following:

- Employee transportation at the start and end of work shifts, provided primarily by buses (40 seats each). IEFCL estimates that approximately 100 buses daily would be needed during the peak period, with a lesser number at other times during the construction period.
- Delivery of equipment, supplies and components needed for construction would require an estimated 22 trucks daily during construction to deliver sand, aggregate, cement, containerised cargo, break bulk cargo, and oversized loads.
- The waste removal and routine supplies such as fuel estimates an additional two trucks daily for these and similar purposes.

The estimated 22 daily truck deliveries include 460 over-dimensional cargo (ODC) loads. Oversized and overweight truck transports from the Onne port facility to the Project Area will travel on the Federal Ocean Terminal Roadway, Onne Road, East West Road, and the new Project access road (Traffic Survey Report Annex 5, MOS for ODC Transportation 2023). Truck congestion in the port area will make these movements challenging, and oversized trucks may not be able to clear corners and traffic circles without encroaching on adjacent land. Personnel from the Federal Road Safety Corporation and Government Security will clear roads before an ODC convoy departs the port area and provide traffic control at narrow areas, cross-junctions and bridge crossings. IEFCL will coordinate with Port Harcourt Electricity Distribution Company to cut electrical power and disconnect cables that would obstruct high loads when needed. The advantage of night-time travel is recognised. Estimated construction traffic volumes are summarized in Table 8-46.

Table 8-46 Projected Traffic during Construction

Vehicle Type and Function	Description of traffic	Daily one-way trips
Buses	Maximum 100 buses daily at beginning and end of shifts. (Each bus arriving will be parked at designated parking space bringing the total number of trips to 200 per day.)	200
Delivery Trucks	Average of 22 trucks daily, including a total of 460 oversized loads	44
Waste removal and routine supply delivery	Estimated 2 trucks daily	4
Total large vehicle trips		**248**

Source: Indorama. IFL-3 Material and Manpower Movement Philosophy. 2023.

The addition of the proposed IEFCL Train 3 Project operations would increase traffic from the Indorama Complex by about 1,000 vehicle trips daily. In addition, during operations, bulk urea truck transports from the existing Train 2 would be shifted to the new access road, thus reducing the traffic on the Indorama Complex access road and the East West Road by 100 trucks per day. The estimated daily additional traffic due to the Train 3 operations is summarised in Table 8-47.

Table 8-47 Projected Added Traffic during Operations

Vehicle Type and Function	Description of traffic	Daily one-way trips
Buses	25 buses; assume that each would arrive and depart twice daily	100
Employee and contractor vehicles (motorcycles, cars and light vans)	330 vehicles; assume that each would arrive and depart once daily	660
Urea transports from Train 3	100 shipments daily	200
Other truck deliveries or shipments	20 deliveries or shipments daily	40
Total large vehicle trips		**1,000**

Source: Indorama. IFL-3 Material and Manpower Movement Philosophy. 2023.

The second access road currently being constructed does not form part of the scope of this ESIA, as the road is being constructed independently by the State Government. The second access road will be open for public use; will not be owned, operated or managed by IEFCL (or their contractors); and is therefore not regarded a component of the IEFCL Train 3 Project. ERM understands that State Government initiated their own separate and independent E&S studies and associated permitting required for construction and operation of the access road. In a public announcement on 07 December 2022,[71] the Rivers State Governor formally stated that local government is deliberately creating new roads in the immediate area to encourage the development of substantial industrial activities to advance

[71] The Sun, 2022. Rivers Creating New Roads because of FG's Failure on East-West Road – Wike. (https://sunnewsonline.com/rivers-creating-new-roads-because-of-fgs-failure-on-east-west-road-wike-2/)

the Rivers State economy. The second access road is one of many roads currently planned by State Government. Other roads proposed include the 6.5 km dual carriage Woji-Aleto-Alesa-Refinery Road, the reconstruction of the 7.2 km Alode-Onne Road and the 3 km Alode internal roads.

8.4.9.3 Sensitive Receptors

Receptors for the Project's transportation-related impacts include users of and residents or business owners with property adjacent to the Uzaku-Alese Road, East West Road, Onne Road, Federal Ocean Terminal Road, and local roads. Receptor sensitivity is characterised as either Low, Medium, or High, based on the ability of these receptors to adapt to Project-related changes in road traffic volumes, transportation safety risk, and degradation of road infrastructure. Table 8-48 describes potential receptor sensitivity levels.

Table 8-48 Receptor Sensitivity to Transportation Impacts

Sensitivity	Description
Low	Receptors can easily adapt to Project traffic, because they are accustomed to anticipated traffic volumes and heavy vehicle traffic, are comfortable sharing the road with Project-related vehicles or are able to reach their destination using alternative routes not affected by Project traffic.
Medium	Somewhat frequent or regular users of the affected roads, and residents/business owners for properties impacted by Project traffic, but whose property is not adjacent to Project roads. These receptors can adapt to Project traffic with some difficulty, either because of lack of comfort with frequent heavy vehicle traffic or lack of alternative routes. These receptors may choose to delay or reschedule trips due to Project traffic.
High	Frequent, regular users of the affected roads and residents/business owners of properties adjacent to Project roads. These receptors would have great difficulty adapting to Project traffic, either because of lack of comfort with frequent heavy vehicle traffic, lack of alternative routes, or concerns about direct access to their property. These receptors may avoid travel altogether or may find even limited travel on Project roads to be highly stressful.

8.4.9.4 Significance of Impact (Pre-mitigation)

This ESIA evaluates three types of transportation impacts related to Project construction, operation, and closure, as described below:

- Increased traffic congestion and delay, due to Project-related vehicle trips. These impacts would primarily occur along the East West Road, which connects the Project to the regional and national road network. These impacts could also occur on the Onne Road and Federal Ocean Terminal Road, which carry heavy truck traffic to the port at Onne.
- Increased deterioration of public roads due to Project-related vehicle trips, especially heavy vehicle trips. This deterioration is most likely to occur on the new Project access road, the East West Road, Onne Road and Federal Ocean Terminal Road, the roads that will carry the largest share of heavy Project vehicles.
- Increased risk of deaths, injuries, and property damage due to crashes involving Project vehicles on public roads. Due to their size, weight, and limited manoeuvrability, trucks, buses, and other heavy vehicles are typically associated with more severe outcomes resulting from crashes.

Traffic Operations

Employee commuting for Project construction and operations would increase bus and small vehicle traffic on local roads and on the East West Road. The employee transport vehicles for the Project would travel to the East West Road intersection with the new access road and could come from areas either to the east or west of that intersection. An additional 400 bus trips during construction, and 760 combined bus, employee vehicle, and contractor vehicle trips during operation would increase the current volume of about 30,800 daily vehicle trips on the East West Road by 1 to 2 percent. The increased traffic would add to peak hour road congestion.

During construction, the new access road (assumed to be completed prior to the start of the proposed IEFCL Train 3 Project construction phase) would carry heavy component traffic from the Onne port, as well as employee bus traffic to the Project Area. Although not specified, truckloads of aggregate and sand would likely use either the new or existing Indorama access road depending upon the starting point for the trip. The truck volume during construction—anticipated to average 48 trucks daily— would not add significantly to the traffic volume on the East West Road, but temporary delays and congestion would result from the movement of oversized truck loads and convoys on the roads between the Onne port and the new Project access road.

Anticipated truck traffic would be higher during operations than during construction, with an estimated additional 240 truck trips daily, of which 200 trips would be urea shipments to the Onne port (along with return trips of empty trucks) via the new access road. Assuming these trips are distributed through a 10-hour day, an additional 20 trucks hourly would use the Onne Road, Federal Ocean Terminal Road, and an 800 m segment of the East West Road. The Onne Road and Federal Ocean Terminal Road carry high volumes of truck traffic, but information on the level of congestion and delay on these roads is not known. An additional 240 truck trips would increase the current average of 2,527 truck trips on the East West Road by about 9 percent; however, almost all of these trips would only be on an 800 m segment of the East West Road between the new access road and Onne Road.

The proposed new access road would carry all urea truck shipments from the existing Train 2 operation to the Onne port, removing about 200 one-way trips (100 shipments and return trips) from the existing Indorama access road and from the East West Road segment between the Indorama complex and the Onne Road.

The new access road would cross the Uzaku-Alese Road within a rural area of low traffic volumes (approximately 1,700 vehicles during daytime hours). The intersection may experience temporary delays and conflicting traffic patterns during employee peak hour travel. Based on the analysis provided above, it is anticipated that Project construction and operations would have a "**Moderate Negative Impact**" pre-mitigation (refer to Table 8-49), primarily due to the creation of a potential pinch point on the 800 m segment of the East West Road between the Onne Road and the new access road.

Table 8-49 Rating of Impacts Related to Traffic Operations (Pre-Mitigation)

Type of Impact		
Direct Negative Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	Project traffic would use the Project's existing and new access roads, the East West Road, Onne Road and Federal Ocean Terminal Road. Beyond that point, Project traffic would disperse along other local and regional roads, at which point Project-related traffic volumes are unlikely to be discernible from the background traffic levels. As a result, the Project's primary effects on traffic operations would be localised.
Duration	Short-term and long-term	Construction would result in short-term impacts on traffic volume and road congestion. Operations would result in long-term impacts.
Scale	Locally significant	Impacts on traffic operation would be most significant on the 800 m segment of the East West Road from the new access road to Onne Road. Periodic, short-term delays and congestion would result from construction-related oversized loads. The segment could experience delays due to employee vehicles queuing to turn onto the access road during the morning commute, or during the evening commute as employee vehicles turn onto the East West Road. Truck traffic would be distributed throughout the day and would add to already heavy truck volumes on the Onne Road and Federal Ocean Terminal Road, with potential for a minor increase in levels of congestion. The locally significant scale of impacts would be due to the need for significant portions of Project traffic to make left turns across the East West Road (either onto the access road from eastbound lanes of the East West Road, or to access the Onne Road from the westbound lanes of the East West Road).
Frequency	Continual	Traffic would occur daily during Project construction and operation.

Likelihood	Possible	Crashes, breakdowns, or other unplanned events involving Project vehicles on the roads could lead to road closures or partial blockages that result in temporary traffic congestion and delays
Magnitude		
Medium Magnitude on East West Road; small magnitude on the Onne Road, Federal Ocean Terminal Road; negligible magnitude on Uzaku-Alese Road resulting from new intersection with the new access road.		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
Residents and users of the East West Road, Onne Road and Federal Ocean Terminal would have medium sensitivity. These road users are accustomed to high traffic volumes and heavy vehicles, but these routes are essential for regional truck and freight transport. Alternative routes for passenger vehicles, but not for trucks, are available within towns and settlements. Road users of the Uzaku-Alese Road would also have medium sensitivity to increased traffic volumes; these users are accustomed to the traffic volumes within the towns and alternative routes are available.		
Significant Rating Before Mitigation		
Moderate Impact		

Transportation Infrastructure

Project-related heavy truck traffic would result in incrementally faster wear and deterioration of road surfaces. Table 8-50 summarises these impacts. The wear would be most prominent on the short segment of the East West Road to be used for Train 3 construction and operations, and on the roads to the Onne port. While these roads are designed and intended for heavy vehicles and high volumes, the road surfaces currently show indications of delayed maintenance and resultant deterioration. Deteriorated road surfaces lead to delays, vehicle damage, increased risk of traffic incidents and stressful travel conditions. Construction of the new access road would provide a significant improvement in the road infrastructure. Based on the analysis provided above, it is anticipated that Project construction and operations would have a "**Minor Negative Impact**" to road infrastructure pre-mitigation.

Table 8-50 Rating of Impacts Related to Road Infrastructure (Pre-Mitigation)

Type of Impact		
Direct Negative Impact and Direct Positive Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	The greatest impacts would be on the segment of the East West Road between the new access road and Onne Road, and on the roads to the Onne port.
Duration	Long-term	Road condition impacts would be observed over the long term, during Project operations.
Scale	Locally significant	Project traffic will contribute incrementally to the already heavy truck traffic volumes on the affected roads. Use of the new access road would limit the scale of impact.
Frequency	Continual	Heavy vehicle traffic would occur throughout Project construction and operation, resulting in continual wear and deterioration of road surfaces
Likelihood	Unlikely	Unplanned events are unlikely to change the Project's impact on road condition.
Magnitude		
Small Magnitude		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Medium Sensitivity		
Road users are accustomed to the current, variable condition of the East West Road and port access roads. Alternative routes for truck traffic are not available.		
Significant Rating Before Mitigation		
Minor Impact		

Transportation Safety

Table 8-51 summarises the Project's impacts on the transportation safety risks. The East West Road and port access roads have sufficient width to safely carry heavy vehicles; however, the risks of transportation-related deaths, injuries, and property damage generally rise along with the increase in traffic volumes, and especially the increase in truck traffic volumes. The Project would result in limited additional risk to pedestrians, because the Project would result only in a single new road crossing of the Uzaku- Alese Road, which is used for pedestrian travel. The East West Road and port access roads are not intended for use by pedestrians. Based on the analysis provided above, the Project would have a "**Minor Negative Impact** "on transportation safety pre-mitigation.

Table 8-51 Rating of Impacts Related to Road Safety (Pre-Mitigation)

Type of Impact		
Direct Negative Impact and Direct Positive Impact		
Rating of Impacts		
Characteristic	**Designation**	**Summary of Reasoning**
Extent	Local	The greatest impacts would be on the East West Road and port access roads. Once out of the immediate Study Area, heavy vehicle traffic would be dispersed to numerous regional and national highways and Project traffic impacts would not be discernible. Indorama shall be suing new road for construction / ODC material movement thus by passing the entire East West Express way and will not add to traffic load

Duration	Long-term	Road safety impacts would be continual during construction and operations. The most substantial safety impacts would occur during construction, when local road users would be unfamiliar with Project traffic schedules and volumes. (The movement will not be regular every day as specified in Traffic Document. Employee buses will move twice in a Day at specified times)
Scale	Locally significant	A modest increase in road safety risk attributable to increased volume resulting from the Project could occur on segments of the East West Road and the port access roads. The increased safety risk would be greatest at the planned intersections of the new access road with the heavily travelled East West Road and with the Uzaku-Alese Road. Regular road users on the rural segment of the Uzaku-Alese Road would need to adjust their driving habits based on the new intersection, which will have heavy use during employee peak hour travel. Indorama shall be suing new road for construction / ODC material movement thus by passing the entire East West Express way and will not add to traffic load.
Frequency	Continual	The increased vehicle traffic would occur throughout Project construction and operation.
Likelihood	Possible	Unplanned events such as crashes would substantially increase the Project's impacts on transportation safety.
Magnitude		
Small Magnitude on East West Road, Onne Road, Federal Ocean Terminal Road; medium magnitude at the intersections of the new access road with the East West Road and Uzaku-Alese Road		
Sensitivity/Vulnerability/Importance of the Resource/Receptor		
Low Sensitivity		
Residents and road users of the East West Road, Onne Road, Federal Ocean Terminal Road and Uzaku Alese Road can adjust their driving and expectations to accommodate the new intersections with the new access road. Road users on the major roads are accustomed to high traffic volumes and heavy vehicles.		
Significant Rating Before Mitigation		
Minor Impact		

8.4.9.5 Mitigation and Management Measures

Refer to Section 9.2.8.8 (Chapter 9) for the recommended mitigation and management measures associated with impacts associated with traffic and transportation.

8.4.9.6 Residual Impact (Post-mitigation)

Implementation of the proposed mitigation measures provided in Section 9.2.8.8 would not change the significance of the Project's impacts on traffic operations. The impact on this resource would remain a **"Moderate Negative Impact"** post mitigation. Based on the implementation of the proposed mitigation measures, the significance of the impact on transportation infrastructure and transportation safety would be a **"Minor negative Impact"** post mitigation.

8.5 Summary of Impact Assessment

A summary of pre- and post- (residual) impacts is provided in Table 8-52.

Table 8-52 Summary of Physical, Biophysical and Socio-economic Environmental Impacts

Impact	Significance (pre-mitigation)	Residual Impact Significance
Physical Environmental Impacts		
Impacts on Air Quality during construction	**Major Negative Impact**	Negligible to Minor Impact

Impact	Significance (pre-mitigation)	Residual Impact Significance
Impacts on Air Quality during operation	Minor to Negligible Negative Impact	Minor to Negligible Negative Impact
Noise Impact from Construction Activities	Negligible Impact	Negligible Impact
Noise Impact from Operation Activities	Negligible Impact	Negligible Impact
Impacts on soils and geology (Soil Erosion)	Moderate Negative Impact	Moderate Negative Impact
Impacts on soils and geology (Soil Compaction)	Minor Negative Impact	Minor Negative Impact
Impacts on soils and geology (Soil Contamination)	Minor Negative Impact	Minor Negative Impact
Impacts on soils and geology (Soil Water Balance)	Moderate Negative Impact	Moderate Negative Impact
Impacts on Groundwater Resources (Hydrocarbon Spills)	Minor Negative Impact	Minor Negative Impact
Impacts on Groundwater Resources (Release of Poor-quality Water)	Minor Negative Impact	Minor Negative Impact
Impacts on Groundwater Resources (Overflow of the Effluent Treatment Plant Retention Pond)	Minor Negative Impact	Minor Negative Impact
Impacts on Groundwater Resources (Groundwater Abstraction)	Minor Negative Impact	Minor Negative Impact
Impacts on Surface Water Resources (Hydrocarbon Spills)	Minor Negative Impact	Negligible Negative Impact
Impacts on Surface Water Resources (Effluent Treatment Plant Malfunction)	**Major Negative Impact**	Minor Negative Impact
Impacts on Surface Water Resources (Hard Surfacing and Effluent Discharge)	Minor Negative Impact	Minor Negative Impact
Biophysical Environmental Impacts		
Impacts related to Biodiversity Loss during construction	**Major Negative Impact**	Minor Negative Impact
Impacts related to Biodiversity Loss during operation	**Major Negative Impact**	Minor Negative Impact
Aquatic Biodiversity Loss through treatment plant malfunction	**Major Negative Impact**	Minor Negative Impact
Socio-economic Impacts		
Increased Employment within the Study Area	Positive Impact	Positive Impact
Increased Income and Spending within the Study Area	Positive Impact	Positive Impact
Socio-economic Development Benefits	Positive Impact	Positive Impact
Influx of Migrant Workers and Job Seekers into Adjacent Communities	Moderate Negative Impact	Minor Negative Impact

Impact	Significance (pre-mitigation)	Residual Impact Significance
Community Dissatisfaction over Unmet Expectations	Moderate Negative Impact	Negligible Negative Impact
Public and Workers Health, Safety, and Human Rights Impacts	Moderate Negative Impact	Negligible Negative Impact
Impacts Related to Traffic Operations	Moderate Negative Impact	Moderate Negative Impact
Impacts Related to Transportation Infrastructure	Minor Negative Impact	Minor Negative Impact
Impacts Related to Transportation Safety	Minor Negative Impact	Minor Negative Impact

8.6 Potential Cumulative Impacts Assessment

8.6.1 Introduction

The IFC Performance Standard 1 (Paragraph 5) defines the broader Project area to include *"… areas potentially impacted by cumulative impacts from further planned development of the Project, any existing project or condition, and other project-related developments that are realistically defined at the time the Social and Environmental Assessment is undertaken."*

In addition, the IFC Performance Standard 1 (Paragraph 6) states that the *"… assessment will also consider potential trans-boundary effects, such as pollution of air, or use or pollution of international waterways, as well as global impacts, such as the emission of greenhouse gases."*

Cumulative impacts are those impacts that act together with other impacts (including those from concurrent or planned future third-party activities) to affect the same resources and/or receptors as the Project. Cumulative impacts are therefore generally impacts that act with others in such a way that the sum is greater than the parts. This is, however, not always the case – sometimes they will simply be the sum of the parts, but that sum becomes significant.

In practice, effective design and implementation of a complete Cumulative Impact Assessment processes is beyond the technical and financial capacity of a single developer. This is particularly true since a single developer will not have authority on other developers within the region. Cumulative Impact Assessments have to be conducted and implemented with the authorities associated with developments, and are multi-stakeholder, iterative processes that:

- Require the involvement of multiple multi-disciplinary teams and an effective, efficient governance structure; and
- Tend to be time and data intensive.

This Section provides a qualitative description of the cumulative impacts that would result from the combination of the proposed IEFCL Train 3 Project, and *other* actual or proposed future developments in the broader Project Area.

8.6.2 Development Context

In addition to what has already being assessed, the Project may experience cumulative impacts as a result of –

- Existing IEFCL Train 1 and 2 operations.
- Greater Port Harcourt City Development Plan – this includes the development of a residential, commercial, and industrial urban area to the north of the city as an extension of the Old Port Harcourt City, which will allow for urban growth and de-densification Port Harcourt. The necessity

for a master development plan was borne out of the constant population influx into the area and rapid physical expansion of Port Harcourt, resulting in uncontrolled development, poor living conditions for residents, and continuing deterioration of existing infrastructure.

- Proposed industrial park located east of the Project site (still in planning, with no details);
- Reopening of revamped Port Harcourt refinery by Nigerian National Petroleum Corporation (NNPC), although delays are expected.
- The Okulu River has been subjected to intense sand mining/dredging and other over several years this has significantly altered and widened the Okulu water course
- A subsidiary of Indorama (Meliora Methanol FZE) is proposing to develop a Methanol Project on a greenfield site south of the Project Area.

8.6.3 Identified Cumulative Impacts

The cumulative impacts that would result from a combination of the Project and other actual or proposed future developments in the broader Study Area include:

- Air Quality Impacts
- Soil and Geology Impacts
- Groundwater Impacts
- Surface Water Impacts
- Biodiversity Impacts
- Socio-economic Impacts

8.6.3.1 Cumulative Air Quality Impacts

The proposed IEFCL Train 3 Project will interact with emission from Indorama Train 1 and Train 2, and also pollutants in the baseline environment. Baseline monitoring has been undertaken to gather information on the existing air quality, including the existing Train 1 and Train 2. Based on the information gathered to date and the modelling undertaken for Train 3 the cumulative impacts are within the relevant air quality standards. Of note is that Train 1 and Train 2, and the proposed Project emit well below emission limits, suggesting that emissions abatement is effective, and therefore impacts on air quality are adequately managed.

In addition to the above, activities associated with (in particular) construction activities carried out for the Project and other Projects in the region have the potential to create negative cumulative impacts associated with the generation of total dust, PM_{10} and $PM_{2.5}$ (for example through site preparation activities, dust dispersion lifted from unpaved road surfaces, etc.). The magnitude of these potential impacts may be minor, moderate or major, depending upon how the impacts from other developments combine with impacts arising from the Project and the respective location and timing of each of the projects. These impacts may be worsened by elevated wind speeds, increasing the potential for cumulative impacts during periods of adverse weather. This said, the distance between project sites is such that it is unlikely that there will be a cumulative increase in airborne dust emissions.

8.6.3.2 Cumulative Soil and Geology Impacts

Due to the shallow nature of excavations that will take place, no impacts on the geology are expected.

Impacts from the proposed IEFCL Train 3 Project operations include soil erosion and loss of topsoil due to site preparation and de-vegetation, soil compaction due to increased vehicular movement on site, soil contamination due to hydrocarbon and chemical spills, and changes in the soil-water balance due to compaction. There are already similar impacts at the existing Train 1 and Train 2 operations. The additional impacts from the Train 3 development and operation will result in cumulative impacts on the sub-catchment within which the operations are located.

8.6.3.3 Cumulative Groundwater Impacts

Groundwater Volumes

The impact on groundwater volume due to groundwater abstraction for water supply will have a cumulative impact on the groundwater resource in the sub-catchment in which the water supply well is located. IEFCL currently extracts groundwater via a water supply well for the existing Train 1 and Train 2 operations. Future planning is that required additional groundwater will be abstracted by IEFCL for use in the petrochemical water treatment plant and fertiliser water treatment plant, while private groundwater users in the area abstract groundwater from the aquifers for domestic purposes such as drinking, cooking, bathing, and washing.

The additional groundwater abstraction by IEFCL will impact the water balance of the sub-catchment within which the wells are located and reduce the sustainable groundwater supply for the surrounding groundwater users.

A groundwater level drawdown cone will develop around the IEFCL water supply well. Should any private groundwater supply wells fall within this drawdown cone, then the sustainable yield of that privately owned water supply well will be reduced. The groundwater abstraction by IEFCL for water supply to the petrochemical plant can also impact the surface water resources in the area; however, the magnitude of this potential impact is expected to the relatively small, as the operations include water recovery systems which make up a large proportion of water demand.

Groundwater abstraction can reduce the baseflow contribution to the surface stream, thereby reducing the surface flow volume. The scale of this indirect impact will change depending on the season, with a larger impact during the dry season when stream flow is mostly dependent on baseflow contribution to the stream, and a smaller impact during the rainy season when the majority of the stream flow volumes originate from surface runoff during rainfall events. Overall, the magnitude of this indirect impact is expected to the relatively small (less than 1% of the total stream flow volume).

There can also be a direct impact on the stream flow volumes in the case where the water supply well is located close to the Okulu tributary, and the groundwater level drawdown cone intercept the stream. In this case, it is possible that water is drawn directly from the stream towards the abstraction well, thereby reducing the stream flow volume directly. The scale of this impact will depend on a number of factors, including the distance between the water supply well and the stream, the groundwater abstraction rate, and the riverbed hydraulic conductivity.

Groundwater Quality

Hydrocarbon and chemical spills, as well as effluent from the water treatment plant can impact the groundwater qualities. It is expected that there can be a cumulative impact on the sub-catchment wide groundwater resource due to combination of accidental spills and effluent from the existing Train 1 and Train 2 operations and contamination of the groundwater resource from other developments in the broader Study Area.

The contaminated groundwater will migrate in a down gradient direction towards the Okulu tributary. It is possible that the poor-quality groundwater can enter the stream in the form of baseflow contribution, thereby impacting the stream water quality. The magnitude of this impact will depend on the stream flow volume as the poor contaminants will be diluted. In general, it can be said that the contamination entering the stream will have a greater impact on stream water qualities during the dry season when stream flow volumes are lower. The contamination will migrate faster downstream once the contamination entered the surface stream.

8.6.3.4 Cumulative Surface Water Impacts

The impacts to the surface water resource from the proposed IEFCL Train 3 Project include changes in water quality due to hydrocarbon and chemical spills, as well as effluent from the effluent treatment plant.

Other existing impacts in the area, which can combine with the Projects operations to form cumulative impacts, include the existing adjacent IEFCL Train 1 and Train 2 operations, as well as the reported illegal sand mining and dredging that takes place in the Study Area. Due to the cumulative effect of the combined impacts from the Train 1, Train 2, and Train 3 operations, as well as the illegal mining and dredging in the area, the impact on the water qualities in the Okulu stream will be larger than the impacts from the proposed IEFCL Train 3 operations alone.

In areas where the surface water is contaminated, and the stream is a losing stream (meaning water from the stream recharges into the underlying aquifer), contamination can enter the groundwater resource. This will be localised along the stream channel, and the contamination will not migrate a significant distance away from the recharge area due to the regional groundwater flow directions being from the high lying areas towards the low-lying area, where the Okulu stream lies.

8.6.3.5 Cumulative Biodiversity Impacts

Although the proposed IEFCL Train 3 Project is located in an area that has been altered through anthropogenic impacts; the area does contain some biodiversity of value and provides ecosystem services to the greater community in the Study Area. There is a continuous growth of human populations resulting in expansion of settlements and cultivated areas and shrinking availability of natural habitats. Moreover, the development of greenfield sites for industrial purposes in the broader Study Area has and will continue to result in further loss of greenfield areas. In addition, development will result in continued degradation of the biodiversity within the broader Study Area through the potential introduction of alien invasive species and the provision of additional illegal access for resource users.

Increased development in the broader Study Area will likely lead to an increase in hardened surfaces and a commensurate increase in stormwater runoff. These increased stormwater outputs will likely lead to potential erosion hazards, and thus a further reduction in aquatic biodiversity related to potential water quality reductions, and increased risk of pollution from these developments.

8.6.3.6 Cumulative Socio-economic Impacts

Migration and influx are key demographic drivers in the broader Study Area, with 57% of surveyed respondents having migrated into the Study Area. This is largely attributed to the industrialisation of the area, and the perceived presence of greater business and employment opportunities. Constant population influx, and rapid physical expansion, has resulted in uncontrolled urban development in Port Harcourt, poor living conditions for residents, and continuing deterioration of existing infrastructure. Though the Project does represent a significant industrial expansion in Port Harcourt, it should be emphasised that the area in general is subject to heavy industrialisation. Population influx is therefore likely to be cumulative in nature, and difficult to specifically disaggregate from other existing industrial activities. Influx into the Port Harcourt area is almost certain to continue regardless of the Project.

8.6.4 Holistic Management of Cumulative Impacts

The following measures will help to holistically mitigate and manage cumulative impacts:

- **Undertaking a Strategic Regional Environmental and Social Impact Assessment** – a strategic regional impact assessment would allow a comprehensive assessment of potential impacts that may result from IEFCL operations in the region together with other developments within the broader Study Area. This type of assessment would consider the cumulative impacts associated with the presence of developments and would prevent isolated and iterative decision-making. The assessment would require greater integration and planning by private developers and should be led by the Government of Nigeria. Such an assessment would ideally feed into combined and issue-specific mitigation and enhancement measures.

- **Revenue Management** – the Project and developments in the region will generate revenue for the local, regional and national government through taxes and royalties. The extent that this revenue is invested and used productively (by national or regional government) back into the Study Area and surrounds would determine the extent to which local infrastructure and resources will be provided to manage a range of social and environmental impacts effectively. Developers / Operators in the area should combine to lobby the Nigerian Government for a systematic system of revenue recording and management that would enable directing benefits back to the region.
- **Regional Forum** – the establishment of a Regional Forum, where companies in the area can share lessons learnt, align strategies, and agree coordinated approaches to responding to social and environmental issues, will help to improve cooperation in managing stakeholder (including community) expectations, avoid setting bad precedents and improve ways in the pursuit of joint goals for sustainable development.
- **Data Sharing** – a data sharing agreement should be setup with other developers/operators in the region to share operational monitoring data. Data should be shared with regulators and interested stakeholders to allow cumulative impacts to be documented and to inform adaptive operational management.

8.6.5 Implications of Uncertainty

The cumulative environmental and social impacts described in this Section were assessed on the basis of the information available at the time and using information made available to ERM. The cumulative impact assessment has a certain level of uncertainty, which is inevitable with a study of this type.

9. MITIGATION AND MANAGEMENT MEASURES

9.1 Introduction

This Chapter details potential mitigation measures to avoid, minimise, reduce, remedy, or compensate for potentially negative impacts, and enhance potential benefits of the Project. The development of mitigation/management measures and the management of residual impacts are further described in the Environmental and Social Management and Monitoring Plan (ESMMP) (refer to Chapter 10 and Appendix C).

9.2 Physical Environment – Mitigation and Management Measures

9.2.1 Climate Change

This Section (and more specifically Table 9-1) provides high-level mitigation/management measures for the Project to consider in their planning for both construction and operation.

Table 9-1 Summary of High-Level Risk Mitigation / Management Measures

Risk	Phase	Mitigation/Management Measures
Flooding and wildfires may lead to delays in construction and operations, and damage to fencing, equipment, infrastructure, structures, buildings, on-site fuel storage facilities, pipeline system, electrical aspects, etc.	Construction Operation	**Flooding** – assess potential flood risk and determine if additional flood defence measures are required. Further assessment may be required to determine the best flood measures to put in place and where (slopes or ground). Current controls IEFCL have in place include: ■ The Project site runoff drains are designed considering the highest hourly rainfall in this region. ■ IEFCL has initiated Flood Risk Assessment study. ■ Siting of the proposed Train 3 Project area is such that the Project area is located at a higher elevation (approximately 15m) from the Okulu River. **Wildfires** – ensure a fire policy is in place, and staff are trained and practice drills. Training staff on fire risk is important and can significantly improve safety and awareness reducing the overall risk.
Prolonged and more frequent dry periods result in higher water consumption for construction and operations.	Construction Operation	Consider design aspects that can reduce water use for the Project during the construction and operational phases. Such design considerations will need to be balanced with the costs associated with implementation. Indorama is setting up Water Recovery Project (WRP) to treat the 580 m^3/hr effluent water and generate 520 m^3/hr treated water for process use. This will reduce ground water consumption in the proposed IEFCL Line 3 Project from 715 to about 190 m^3/hr
Impacts on health and safety for workers, resulting in health issues and restricted working hours.	Construction Operation	Ensure an occupational health and safety policy is in place, and staff are trained and practise requirements, especially for extreme temperature conditions, wildfires and for heavy rainfall conditions. The occupational health and safety management system is in place and implemented effectively in operational plants and same shall be extended to Line 3.

Risk	Phase	Mitigation/Management Measures
Extreme heat may cause overheating to electrical power disruption network, substations etc.	Construction	Temperature sensitive electrical infrastructure / equipment should be identified in the current Project design. Once identified, the Project should consider options for cooling of equipment to deliver the same performance output (for example through air or water-cooling). Moreover, procedures should be established to regularly check the condition of the electrical infrastructure / equipment for signs of overheating, this increases the chance of any early-stage damage or stress being identified and therefore repaired. This in turn minimises the risk and OPEX. Current controls IEFCL have in place include: ■ Electrical substations are fully air-conditioned. ■ The Control Rooms are fully air-conditioned. ■ The Transmission / power cables are Fire Retardant Cables designed for 70 to 90 C^0 ambient/ surrounding temperature ■ All rotary equipment such as compressors are designed with interstage coolers to keep the process gas temperature in controlled range. ■ All process equipment / pipelines are insulated or refractory lined.

9.2.2 *Air Quality*

9.2.2.1 Construction Phase

In terms of traffic related impacts, on the basis that construction traffic is unlikely to be in excess of the thresholds provided in this ESIA, no further mitigation is required.

In terms of dust, the following mitigation and management measures are recommended.

Management Measures

- The Project should develop and implement an Air Quality Management Procedure including for dust deposition, dust flux, PM_{10} monitoring and visual inspections. The procedure should also include ‘action levels’ for triggering further dust mitigation when exceeded (feed-back loop).
- Develop and implement a stakeholder communications procedure that includes community engagement before the commencement of the construction phase.
- Record all dust and air quality complaints, identify cause(s), take appropriate measures to reduce emissions in a timely manner, and record the measures taken.

Site Planning

- Plan Project layout so that machinery and dust causing activities are located as far away from receptors as possible.
- Consider fences and enclosures around specific operations where there is a high potential for dust production and the site is actives for an extensive period.

- Limit site runoff (of water or mud) to prevent egress of material to other areas, which can create dust emissions when dried.
- Keep site fencing, barriers and scaffolding clean using wet methods.
- Remove materials that have a potential to produce dust from site as soon as possible, unless being re-used on site. If they are being re-used on-site cover as described below.
- Reduce vehicle speed limits to as low as reasonably possibly, especially on unsurfaced haul roads and work areas (if long haul routes are required these speeds may be increased with suitable additional control measures provided). Implement awareness training for drivers. IEFCL currently implements a speed limit of no more than 20 kph for construction sites, which is deemed sufficient.

Mitigation Specific to Earthworks

- Re-vegetate or hard stand earthworks and exposed areas and open soils to stabilise surfaces as soon as practicable.
- Beside the wetting procedure for exposed surfaces which is currently in place, consider using Hessian, mulches or tackifiers where it is not possible to re-vegetate or cover with topsoil, as soon as practicable.
- Only remove the cover in small areas during work and not all at once.

Construction Material Management

- Ensure sand and other aggregates are stored in bunded areas and are not allowed to dry out, unless this is required for a particular process, in which case ensure that appropriate additional control measures are in place.
- Ensure bulk cement and other fine powder materials are delivered in enclosed containers or in covered trailers and appropriately stored.in a warehouse to prevent dust emissions.
- For smaller supplies of fine powder materials, ensure bags are sealed after use and stored appropriately to prevent dust.

Mitigation Specific to Track out on Hardstanding Public Roads

- Use water-assisted dust sweeper(s) on hardstanding access and local roads, to remove, as necessary, any material tracked out of the Project site.
- Avoid dry sweeping of large areas.
- Ensure vehicles entering and leaving the Project site are covered to prevent escape of materials during transport.
- Inspect on-site haul routes for integrity and instigate necessary repairs to the surface as soon as reasonably practicable.
- Implement a wheel washing system (with rumble grids to dislodge accumulated dust and mud prior to leaving the Site where reasonably practicable).

General Construction Measures

- Where construction compounds cannot be hardstanding, watering as required to supress dust generation.
- Where possible, use cutting, grinding, or sawing equipment fitted or in conjunction with suitable dust suppression techniques, such as water sprays or local extraction, e.g., suitable local exhaust ventilation systems.

- Ensure an adequate water supply on the Project site for effective dust/particulate matter suppression/mitigation, using non-potable water where possible and appropriate.
- Minimise drop heights from conveyors, loading shovels, hoppers and other loading or handling equipment and use fine water sprays on such equipment wherever appropriate.
- Ensure equipment is readily available on the Project site to clean any dry spillages and clean up spillages as soon as reasonably practicable after the event using wet cleaning methods.
- Avoid fires on the Project site and burning of waste materials.

Monitoring Measures

- Undertake on-site and off-site inspections, where receptors (including roads) are nearby, to monitor dust and record inspection results.
- Carry out regular Project site inspections to monitor compliance with the Air Quality Management Procedure, record inspection results and identify any events that require further investigation or actions.
- Increase the frequency of Project site inspections when activities with a high potential to produce dust are being carried out and during prolonged dry or windy conditions.

9.2.2.2 Operational Phase

As mentioned in Section 8.2.3, the operation of the proposed IEFCL Train 3 Project is not predicted to result in air quality standards being exceeded in its own right, and only minor impacts are predicted associated with NO_2.

However, at this stage, based on Train 3 results, the in-combination impacts with Train 1 and Train 2 are not anticipated to lead to air quality standards being exceeded. As such, no further mitigation or design changes are proposed.

9.2.3 Noise

As detailed in Section 8.2.4, the predicted magnitude of noise impacts during both construction and operations are anticipated to be negligible at NSRs in the immediate vicinity of the Project Area.

As such, other than general noise mitigation and management measures included in the ESMMP (refer to Chapter 10), no further mitigation or design changes are proposed for the Project.

This being said, ERM does recommend that during both the construction and operational phases that noise levels should be monitored. Noise monitoring should include operator noise measurements at the closest and most affected receptors identified. Monitoring should be undertaken by suitably trained environmental personnel at regular intervals. In the event that there is an exceedance of the criteria being identified, then IEFCL would need to implement corrective actions to minimise the impact.

9.2.4 Soils and Geology

As detailed in Section 8.2.5, the predicted impacts associated with soil erosion, loss of topsoil and soil compaction, soil contamination from chemical and hydrocarbon spills and changes in soil-water balance are anticipated to be moderate to minor.

As such, other than general soil mitigation and management measures included in the ESMMP (refer to Chapter 10), no further mitigation or design changes are proposed for the Project.

This being said, the following measures should be undertaken to limit any impacts to the soils in the Project Area:

- Restrict removal of vegetation and soil cover to necessary areas only.

- Land clearance should only be undertaken immediately prior to construction activities taking place there.
- The footprints for all construction areas and areas for associated infrastructure (viz. equipment laydown areas, etc.) should be restricted to the minimum feasible extent with measures implemented to avoid footprint creep.
- Areas where spillage of soil contaminants occurs should be excavated (to the depth of contamination) removed and suitably rehabilitated. If any other minor spillage occurs the spillage should be cleaned immediately, and the contaminated area should be rehabilitated. All contaminated material should be suitably disposed of.
- The Project should prevent any *ad hoc* maintenance of vehicles / equipment in and around the Project Area. All vehicles/ equipment should be maintained at a designated workshop. The workshop should include an oil/grease trap.
- Contractors and applicable Project staff should be trained regarding proper methods for transporting, transferring and handling hazardous substances that have the potential to impact soil resources.
- Hazardous waste storage areas should be provided with secondary containment. Moreover, hazardous waste should be stored in sealed / covered containers to prevent rainwater intrusion.
- All dangerous and hazardous material stores and handling areas should be provided with secondary containment capable of holding 110% of the total capacity of all tanks / vessels.
- The loading and unloading of dangerous and hazardous material should be confined to areas that are provided with secondary containment and in line with hazardous material handling procedures.

9.2.5 Groundwater Resources

9.2.5.1 Construction and Operational Phase

Chemicals and Hydrocarbon Spills

- The mitigation and management measures included for Soils and Geology (refer to Section 9.2.4) are applicable for the management of groundwater resources during the construction phase.
- All construction areas and associated facilities will be maintained in a good and tidy condition. This will include bunding of vehicle parking areas, oil and silt traps in the workshop area and proper disposal of waste material.

9.2.5.2 Operational Phase Only

Effluent from Effluent Treatment Plants – release of effluent that does not meet required standards due to malfunction or failures of treatment plant

- The effluent treatment plants should be maintained according to the recommended schedule to prevent or minimise malfunction or failure.
- The effluent treatment plants will be operated within the relevant specifications to prevent failure or malfunction.

Effluent from Effluent Treatment Plants – overflow of the effluent treatment plant retention pond and release of solid waste

- The retention pond will be sized and engineered to be able to accommodate surface run-offs.
- The retention pond will be operated according to specification, maintaining the specified freeboard that allow management of flood events.

- Solid waste will be disposed of by licensed contractors at an appropriate facility.

Groundwater Abstraction

- The two new additional water supply wells should be located away from any local community water supply wells to prevent or minimise overlap of the groundwater level drawdown cones around the individual water supply wells. This will prevent or minimise the reduction in the sustainable yields of the water supply wells.
- An aquifer test should be performed on the Project water supply wells and the sustainable yield of the water supply calculated. Groundwater will be abstracted via the water supply well at a rate less than the sustainable yield of the well in order to prevent over abstraction and collapse of the aquifer.
- The Project will implement their grievance procedure in the event of any water reduction and subsequent water availability complaints being received.

9.2.6 Surface Water Resources

9.2.6.1 Construction Phase

- The mitigation and management measures included or Soils and Geology (refer to Section 9.2.4) and for Chemicals and Hydrocarbon Spills for Groundwater resources (refer to Section 9.2.5.1) are applicable for the management of surface water resources during the construction phase.
- Erosion control must be implemented across the construction site and should be inspected regularly for any damage caused by erosion.
- Debris and wastes should be contained in such a way that they cannot become entrained in surface run off during periods of heavy rain.
- Where practical, exposed surfaces and friable materials should be covered / sheeted.
- Sufficient toilets at active work areas should be provided for site staff and workers and these should be serviced regularly by a competent and suitably qualified person.
- The sewage treatment system associated with any temporary toilets in the Project Area should be managed in a manner that results in zero discharge of raw sewage to the environment.
- Sediment traps and culverts should be installed around the Project Area prior to site clearance and earthworks, so as to prevent any sediment run-off into the surrounding area.
- Culverts along new access roads in the Project Area should be provided to facilitate drainage along with ditches.
- Adequate infrastructure should be put in place around the Project Area so as to ensure that clean water is diverted around the site and that dirty water is diverted into the existing treatment plant for treatment prior to discharge to the environment.
- The Project will implement their grievance procedure in the event of any water quality complaints being received.

9.2.6.2 Operational Phase

- The mitigation and management measures included for Effluent from Effluent Treatment Plant for Groundwater Resources (refer to Section 9.2.5.2) are applicable for the management of surface water resources during the operational phase.
- The Project should ensure that wastewater at the point of discharge does not cause erosion to natural stream and water courses.
- Any effluent or stormwater discharge to the environment will need to meet the requirements of the Project effluent discharge limits.

- Wastewater at the point of discharge must be monitored for quality and quantity.
- A flood risk assessment is required to quantify the Project Area flood risks (including risk of stormwater drainage breaching the retention pond, and risk of inundation of Site from the Okulu stream) and identify necessary mitigation measures. Site stormwater is diverted to the retention pond and as such it must be deigned to cater for all flood waters generated across the operations in addition to the load from treated water. The design should cater for a 1:100-year flood. IEFCL has already commissioned the flood risk assessment study and the recommendations shall be complied with.
- Effluent generated should be minimised through minimising freshwater intake, regular monitoring and reporting on water utilisation and wastewater recycled as appropriate using available technology to the greatest extent possible.

9.2.7 Biodiversity and Ecosystem Services

9.2.7.1 Construction Phase

- The mitigation and management measures included or Soils and Geology (refer to Section 9.2.4), for Chemicals and Hydrocarbon Spills for Groundwater resources (refer to Section 9.2.5.1) and for Surface water Resources during the construction phase (refer to Section 9.2.6.1) are applicable for the management of biodiversity and ecosystem services during the construction phase.
- During the design phase, ensure lighting designs are of such nature that they create minimal interference with nocturnal wildlife (i.e. down-lights, low lighting, as dimmed as possible, using hues that do not attract or interfere with fauna)
- All construction areas and associated facilities should be demarcated, and no activities are to take place outside of these.
- A Biodiversity management and monitoring plan shall be drafted, which will include, but not limited to:
  - Alien Invasive Plant Control guidelines with implementation and monitoring rosters, also including a list of permissible herbicides to be used
  - Monitoring parameters for terrestrial and aquatic fauna and flora. This will also focus on all observed threatened species. Where such are plants (trees), attempts will be made to retain such within the plant where possible or replant such species as part of the Site internal landscaping.
  - Daily pre-site works inspection of construction areas to ensure no fauna are on or have become entrapped within the construction site. This would need to be cross-referenced in the applicable earthworks procedure and supplemented with an appropriate faunal handling and release/relocation procedure.
  - A faunal incidence register needs to be kept; indicating species, where and when observed or interacted with, any mitigation undertaken and outcomes of such.
  - Landscaping and rehabilitation guidelines post-construction, aiming to create habitat of value for biodiversity within landscaped gardens, and ensuring only non-invasive plant species are used, preferably only indigenous species.
  - This plan shall be carried over and adapted for the operational phase and reviewed and updated at least every 5 years.
- Adequate site drainage system to be designed to avoid flooding during raining seasonal.
- As far as possible, construction should be limited to daytime only.
- Threatened tree species should be demarcated and spared from clearing where possible.

- The waste-control plan should be fully aligned to biodiversity sensitivities, also ensuring that organic wastes are adequately secured to prevent access to scavenging fauna.
- The emergency response plan should be fully aligned to biodiversity sensitivities, also ensuring that post-emergency monitoring is implemented and aligned to the biodiversity management plan.
- Staff shall be given toolbox talks regarding fauna and flora and should be made aware that no illegal plant or animal collection (including snaring or trade from local communities) is allowed.

Operational Phase

- As indicated above, the biodiversity management and monitoring plan shall be updated post construction and carried over to the operational phase. This will include continued monitoring, auditing of the effectiveness of management actions and reviews at least every 5 years, with adaptive updates to management actions where required. The primary objectives will be to ensure landscaped areas are of value to indigenous biodiversity, surrounding landscapes and ecosystem processes (and services) are not adversely impacted due to the operations, and alien invasive species are strictly kept under control within and around site boundaries.
- The mitigation and management measures included for Effluent from Effluent Treatment Plant for Groundwater Resources (refer to Section 9.2.5.2) and for Surface Water Resources during the operational phase (refer to Section 9.2.6.2) are applicable for the management of biodiversity and ecosystem services during the operational phase.
- All Project staff are to be made aware that no illegal plant or animal collection is allowed, including snaring or trade from local communities.
- The waste-control plan will be fully aligned to biodiversity sensitivities, also ensuring that organic wastes are adequately secured to prevent access to scavenging fauna.
- The emergency response plan will be fully aligned to biodiversity sensitivities, also ensuring that post-emergency monitoring is implemented and aligned to the Biodiversity management and monitoring plan.

9.2.8 Socio-economic

9.2.8.1 Local employment

- Where reasonable and practical IEFCL should appoint local contractors and implement a 'locals first' policy (refer to Indorama's *Local Hiring Plan for Construction & Operation phase of IEFCL Train 3 Project*), especially for semi and low-skilled job categories. Due to the low skills levels in the Study Area, the majority of skilled posts are likely to be filled by people from outside the area.
- All appointments (direct or through contractors) must abide by national / international labour laws.
- Before the construction phase commences IEFCL should meet with representatives from the host communities (through the PAC or Employment Sub Committee) to establish the process for recruitment. A skills database has been developed based on the IEFCL Line 1 and Line 2 projects, which will be used a reference during the Line 3 Project construction phase for IEFCL, contractors and community leadership.
- The local authorities, relevant community representatives should be informed of the final decision regarding the Project and the potential job opportunities for locals and the employment procedures that IEFCL intends following for the construction phase of the Project.
- Where feasible, training and skills development programmes for local workers should be initiated prior to the initiation of the construction phase.
- The recruitment selection process should seek to promote gender equality and the employment of women wherever possible.

9.2.8.2 Increased Income and Spending

- IEFCL should liaise with the host communities (through the PAC or other legitimate representation) with regards the establishment of a database of local companies, which qualify as potential service providers (e.g., construction companies, catering companies, waste collection companies, security companies etc.) prior to the commencement of the tender process for construction contractors. These companies should be notified of the tender process and invited to bid for Project-related work.
- Where possible, IEFCL should assist local companies to complete and submit the required tender forms and associated information.
- The PAC, in conjunction with the local business sector and representatives from the local hospitality industry, should identify strategies aimed at maximising the potential benefits associated with the Project.

9.2.8.3 Socio-economic Development

- IEFCL should ensure that future SED interventions are governed by updated MOUs to reduce exposure to reputational and social risks.
- A proactive community engagement campaign should be initiated with a view to manage community expectations of future SED plans and benefits.
- Where possible and appropriate, IEFCL should seek to integrate any SED interventions into broader sectoral economic activities, as well as IEFCL’s career progression plans, to ensure maximum benefit is delivered to recipients.

9.2.8.4 Influx of Migrant Workers and Job Seekers

- During the construction of the IEFCL Line 1 and Line 2 projects, 89% to 90% of manpower came from the Niger Delta region, and these workers resided within the environs of Port Harcourt, Rivers State. IEFCL propose a similar recruitment scenario for the proposed Train 3 Project. This will significantly minimise reliance on migrant labourers. Given the long-term operational life of the Project, IEFCL should investigate the possibility of using vocational training in local communities to close skills-gaps and further reduce reliance on migrant labour for future skills requirements.
- IEFCL should actively engage with local authorities to understand the infrastructure and service delivery challenges associated with influx and identify means by which IEFCL can partner with authorities to address these. Where possible and appropriate, this should include engagement local authorities on regional growth and development plans.
- IEFCL may consider enterprise and supplier development initiatives, which enhance the capacity of local businesses to supply both the Project and other industries within the Study Area. Leveraging local suppliers and reducing reliance on external procurement will enhance the ability of the local economy to absorb job seekers.
- IEFCL should consider the inclusion of buffer zones into Project design, to reduce the likelihood of ‘fence line’ settlements, as well as mitigate the human rights risks associated with informal human settlement developing directly adjacent to the Project.

9.2.8.5 Unmet Community Expectations

- IEFCL should ensure that an updated MOU is signed with host communities and extends its scope to include the Project.
- IEFCL should ensure that the increased socio-economic benefits derived to communities are commiserate with the expansion of IEFCL’s existing operations. This should translate to an increase in the budgetary allocation for CSR Projects within forthcoming MOUs.

- IEFCL should ensure transparent and continued communication with all stakeholders to ensure that community expectations are aligned to what the Project can realistically deliver. This must include the update of the Stakeholder Engagement Plan to include activities related to the Project, as well as continuous oversight to ensure the timely and effective implementation of this plan.
- IEFCL should capacitate, on an ongoing basis, the PAC to serve as an effective vehicle of communication between the Project and community members. The PAC should serve as the primary means of expectation setting of community members.
- IEFCL should ensure that an updated Incident and Grievance procedure is in place and that it covers the new activities undertaken in relation to the Project. Additionally, a Commitment Register should be regularly updated to track all commitments made to stakeholders and progress in delivering on these.

9.2.8.6 Public and Worker Health, Safety, and Human Rights

- IEFCL should maximise the use of a local workforce, to minimise the health and safety risks related to interactions between local populations and a large contractor workforce.
- Where contractors are unavoidable, IEFCL should consider providing temporary facilities for primary healthcare services to avoid overwhelming of local healthcare facilities.
- The incident and grievance management process should be updated to appropriately accommodate grievances related to sexual assault or abuse by contractors, or gender-based harm as a result of Project activities.
- IEFCL should design and implement workplace policies in line with IFC guidelines[72], and ensure that EP & C contractors do likewise, to prevent gender-based violence and sexual abuse of local communities.
- The traffic management plan should be implemented as set out in the Project design documents.
- All reasonable measures should be taken, during construction, to minimise community exposure to noise, dust, and vibrations.
- IEFCL should design security policies in line with the Voluntary Principles on Security and Human Rights (VPSHR). Local contractors used to carry out security-related services should be compliant with the VPSHR.

9.2.8.7 Cultural Heritage

- The incident and grievance management process should make provision for cultural heritage input.
- A Chance Finds Procedure should be designed and implemented to manage any unexpected discovery of archaeological material in-line with international requirements and guidelines IFC PS8.

9.2.8.8 Traffic and Transportation

This ESIA has considered the embedded controls documented as part of IEFCL's established procedures, which include a vehicle maintenance checklist and the Traffic Survey Report Annex 04B and 04C.

In addition to the above, ERM recommends that IEFCL develop a comprehensive Transportation Management Plan (TMP) for the Project. Consistent with international best practice, the TMP would include the components described in Table 9-2.

[72] Addressing Gender-Based Violence and Harassment: Emerging Good Practice for the Private Sector (ifc.org) and Supporting Companies to Develop and Manage Community-Based Grievance and Feedback Mechanisms Regarding Sexual Exploitation, Abuse and Harassment (ifc.org)

Table 9-2 Recommended Transportation Management Plan Components

Component Category	Purpose	Controls and Mitigations
Road infrastructure maintenance	Maintain road surfaces and bridges to allow safe travel near regulatory speed limits, to reduce noise and vibration, and to avoid continued pavement deterioration	■ Maintain the existing and new Indorama Access Roads in good condition. ■ Require Project drivers to report observed instances of road degradation. ■ Work with appropriate authorities to encourage maintenance of public roads near the Indorama Complex.
Active traffic management	Actively manage Project and public traffic during peak travel times	■ Consistent with the procedures described in Traffic Survey Report Annex 5, MOS for ODC Transportation (2023), provide active traffic management along the route from Onne Port to the Project site, especially at the intersection of the East West Road with the Project access road and with the Onne Road.
Stakeholder engagement and education	Provide for greater awareness of problems and risks; promote positive community relationships; promote safety	■ Maintain and enhance relationships with local stakeholders to understand risks specific to Project activities, ■ Provide a grievance mechanism that is easy to access, transparent, and responsive.
Driver qualifications for Urea Bulk Truck owned by Indorama	Ensure all drivers have suitable driver training, both general and Project-specific	■ Employ only drivers with the required driving licenses. ■ Establish driver training program specific to the vehicles, roads and risks encountered for the tasks for IEFCL drivers. ■ Require regular truck driver safety training, defensive driving training, and testing for IEFCL drivers. ■ Enforce driver qualifications and training for all drivers, whether employees or sub-contractors. Include requirements in applicable contracts.

Component Category	Purpose	Controls and Mitigations
Driver behaviour	Require drivers to consistently display safe driving practices	■ Establish and enforce rest and break standards that comply with industry and national standards. ■ Structure contracts with truck contractors to avoid incentives for speeding or insufficient fatigue breaks. ■ To the degree permissible by law, require daily or periodic drug and alcohol testing for all drivers. ■ Equip trucks with speed governors and on-board GPS to monitor vehicle speed and location. ■ Enforce driver quality through loss of jobs or contracts for individual drivers for drug or alcohol offenses and chronic or egregious speeding.
Vehicle Condition of Own trucks and Construction equipment	Ensure that haul vehicles are in good condition and safe to operate on public roads; provide for driver communication in case of emergencies.	■ Require scheduled, preventative vehicle maintenance according to manufacturers' recommendations for all Project vehicles, whether owned by Project or a contractor. ■ Complete a basic vehicle safety checklist daily prior to vehicle operation on public roads. ■ Provide uniform in-vehicle communications systems that enable contact with truck traffic controllers and other drivers. ■ Require that noise-controlling devices (silencers) be in good operating condition
Vehicle Cleaning and Loading	Ensure that haul trucks do not create a nuisance and visibility hazard by generating airborne dust or contributing to dirt on roads; prevent hazards and delays from spills	■ Securely cover loads on trucks to minimize spillage and dust. ■ Do not overload trucks ■ Use water trucks to reduce dust that would be carried onto the public roads by haul trucks and other vehicles, especially during construction. Provide a spray/cleaning station during construction for trucks entering the public road system. IEFCL to continue the current practice of using wetting trucks.

10. ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

As part of the environmental approval process for the proposed IEFCL Train 3 Project, a simple and easy to implement Environmental and Social Management and Monitoring Plan (ESMMP) is needed to address the issues identified in the ESIA. The ESMMP sets out a formal system by which the Project can manage mitigation commitments during the construction and operational phases of the proposed IEFCL Train 3 Project.

Note – a standalone ESMMP has been developed for the Project and has been included in this ESIA as Appendix C.

11. CONCLUSIONS AND RECOMMENDATIONS

The ESIA process undertaken Extensive Risk Assessment, identified and assessed a range of potential impacts to the physical, biological, and social environment. Where impacts have been identified, appropriate mitigation measures have been provided in the ESIA. It should be noted that for many of the impacts identified, the proposed mitigation measures will reduce the significance of the impacts to a minor or negligible level. However, for some impacts, even with mitigation, residual impacts will remain. Those impacts that have a moderate to major post-mitigation (residual) significance, and which will require careful and consistent ongoing management, include:

- Impacts on soils and geology during the construction phase of the Project, as a result of soil erosion and loss of topsoil from site preparation, de-vegetation, and associated increased surface run-off during rainfall events.
- Impacts associated with changes to the soil-water balance, which can occur due to surface soil compaction, which can lead to reduced water infiltration into the soil.

More so, Indorama has aligned GHG initiatives with The Paris Agreement and Nigeria Long-term Vision 2050 (LTV 2050) submitted to the UNFCCC Secretariat by Nigerian Government in December 2021. As per LTV 2050 "By 2050, Nigeria would be a country of low-carbon, climate-resilient, high growth circular economy that reduces its current level of emissions by 50%, moving towards having net-zero emissions across all sectors of its development in a gender-responsive manner". The Line3 project will help reduce flaring of the associated gas to the tune of 90 MMSCFD thereby significantly reducing the GHG emissions amounting to approx. 2100 KTA of CO2 equivalent, in line with the country's NDC, over the lifetime of the plant operations. In addition, Indorama has developed a Roadmap of reducing the GHG (CO2 Eq.) by 32% from the 2022 baseline in the complex by year 2026 through various GHG reduction initiatives.

Moreover, some gaps remain in the understanding of the baseline aquatic biodiversity. In this respect, the following additional post-ESIA baseline studies will need to be undertaken, ideally prior to the commencement of the construction phase of the Project[73]:

- **Aquatic Biodiversity** – in order to address the aquatic biodiversity impacts related to potential spillage, water quality issues and increased stormwater discharge, a dry-season aquatic biomonitoring campaign will need to be conducted prior to the commencement of construction. This study will be in line with international best practices. Data will be consolidated to develop comprehensive assessments of the Present Ecological State of aquatic ecosystems. Preconstruction Aquatic Ecology baselines will be established and will be included as an addendum to this ESIA. Post construction Aquatic Ecology baselines will be established and compared against data from the preconstruction baselines.

The ESIA process should not stop with the submission of this ESIA report and associated ESMMP to the FMEnv. Upon submission, there will be need for continued work and monitoring of environmental components. Where any changes are observed, these will be assessed in terms of their potential to alter the ESIA findings. Some changes may not result in a material change to the ESIA findings; however, any further changes to Project scope should be re-evaluated in terms of the influence on impact significance, and if necessary, mitigation / management measures included in the ESMMP will be amended to ensure negative impacts are mitigated and positive impacts enhanced. Typically, such substantive changes will be submitted as an addendum to this ESIA.

To provide the vehicle for the integrated management of the potential impacts identified in the ESIA (both positive and negative) an ESMS will need to be implemented. The ESMS provides a mechanism for ensuring that mitigation measures identified in the ESIA and associated ESMMP are adequately

[73] Ideally, the undertaking these post-ESIA studies would commence prior to the start of the construction phase, so as to obtain a true and representative baseline that is not influenced by construction / operational activities associated with the proposed IEFCL Train 3 Project.

implemented. Moreover, the ESMS provides a framework for monitoring, compliance auditing and inspection programmes, which assist the Project in meeting its commitments, as stipulated in Nigerian regulations and lender standards (primarily the IFC PSs).

Provided that all the social and environmental mitigation / management measures provided in this ESIA and associated ESMMP are implemented, and additional dry season study of biodiversity is performed post ESIA to resolve the gaps, it can be concluded that there are no environmental or social fatal flaws which inhibit authorisation of the proposed IEFCL Train 3 Project.

Moreover, the positive benefits of the proposed Project also need to be considered in the authorisation decision. These positive benefits, provided in more detail under the Project Justification (Chapter 3), include: improving domestic urea and ammonia production, promoting the setting up of downstream blending plants, enhancement of supply/distribution networks and the provision of new employment opportunities for the growing demand from the young Nigerian population. With all three units (Train1, 2 & 3) in operation, IEFCL will be able to produce 4.2 million tonnes of urea annually. Overall, the Project will help improve the share of agriculture in the Country's GDP and derive valuable foreign exchange from the export of urea, as well as improve the local economy in the immediate Project Area.

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APPENDIX A ESIA TERMS OF REFERENCE (TOR)

APPENDIX B STAKEHOLDER ENGAGEMENT PLAN (SEP)

APPENDIX C ENVIRONMENTAL AND SOCIAL MANAGEMENT AND MONITORING PLAN

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