Draft

Environmental & Social Impact Assessment (ESIA)

Report for CNG Autogas Mother Station Project at Rigasa, Igabi Local Government Area, Kaduna State.

By

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ABBREVIATIONS/ACRONYMS

AfDB	African Development Bank
AKK	Abuja-Kaduna-Kano Pipeline
ALARP	As Low As Reasonably Practical
BID	Background Information Document
BOD	Biochemical Oxygen Demand
BRV	Big Road Vehicles
BTEX	Benzene, Toluene, Ethylbenzene, Xylene
CBOs	Community-Based Organizations
CEO	Chief Executive Officer
CNG	Compressed Natural Gas
COD	Chemical Oxygen Demand
CPR	Cardiopulmonary Resuscitation
CRO	Community Relations Officer
CSW	Commercial Sex Workers
D&A	Decommissioning and Abandonment
dB	Decibel
DO	Dissolved Oxygen
EC	Electrical Conductivity
EHS	Environmental, Health and Safety
EIA	Environmental Impact Assessment
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EPR	Extended Producer Responsibility
ERP	Emergency Response Plan
ESIA	Environmental and Social Impact Assessment
ESMP	Environmental and Social Management Plan
ESMS	Environmental and Social Management System
FEPA	Federal Environmental Protection Agency
FGD	Focus Group Discussion
FMEnv	Federal Ministry of Environment
FRN	Federal Republic of Nigeria

GBV	Gender-Based Violence
GHG	Greenhouse Gases
GIIP	Good International Industry Practice
GPS	Global Positioning System
GRU	Gas Receiving Unit
GVLNG	Greenville Liquefied Natural Gas Company Limited
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HCHO	Formaldehyde
HOCNS	Harmonized Offshore Chemical Notification System
HR	Human Resources
HSE	Health, Safety and Environment
HSE-MS	Health, Safety and Environment Management System
HSSE	Health, Safety, Security and Environment
IFC	International Finance Corporation
IFCS	Intergovernmental Forum on Chemical Safety
ILO	International Labour Organization
INC	Intergovernmental Negotiating Committee
IPCS	International Programme on Chemical Safety
ISO	International Organization for Standardization
IUCN	International Union for Conservation of Nature
KASUPDA	Kaduna State Urban Planning and Development Authority
KEPA	Kaduna Environmental Protection Authority
KII	Key Informant Interview
LDAR	Leak Detection and Repair
LFN	Laws of the Federation of Nigeria
LGA	Local Government Area
LTIFR	Lost Time Injury Frequency Rate
LULC	Land Use and Land Cover
MDGIF	Midstream and Downstream Gas Infrastructure Fund
MISTDO	Minimum Industry Safety Training for Downstream Operations
MoU	Memorandum of Understanding
MSDS	Material Safety Data Sheet
NDC	Nationally Determined Contribution
NESREA	National Environmental Standards and Regulations Enforcement

	Agency
NGEP	National Gas Expansion Programme
NGOs	Non-Governmental Organizations
NiMet	Nigerian Meteorological Agency
NMDPRA	Nigerian Midstream and Downstream Petroleum Regulatory Authority
NOSDRA	National Oil Spill Detection and Response Agency
NPE	National Policy on Environment
NUPRC	Nigerian Upstream Petroleum Regulatory Commission
OHS	Occupational Health and Safety
OP	Operational Policy
ORP	Oxidation-Reduction Potential
OSCP	Oil Spill Contingency Plan
OSPAR	Oslo-Paris Convention for the Protection of the Marine Environment
PAERs	People, Assets, Environment, and Reputation
PAH	Polycyclic Aromatic Hydrocarbons
PDR	Post Decommissioning Report
PHC	Primary Health Centre
PIA	Petroleum Industry Act
PM	Particulate Matter
PMP	Pest Management Plan
PMS	Premium Motor Spirit
POPs	Persistent Organic Pollutants
PPE	Personal Protective Equipment
PS	Performance Standard
PTD	Permanent Total Disability
PTW	Permit to Work
QA/QC	Quality Assurance/Quality Control
QHSE	Quality, Health, Safety and Environment
RAM	Risk Assessment Matrix
SCADA	Supervisory Control and Data Acquisition
SEA	Sexual Exploitation and Abuse
SEMP	Social and Environmental Management Plan
SH	Sexual Harassment
SOP	Standard Operating Procedure

SPM	Suspended Particulate Matter
STD	Sexually Transmitted Disease
TDS	Total Dissolved Solids
THC	Total Hydrocarbon Content
ToR	Terms of Reference
TPH	Total Petroleum Hydrocarbons
TSS	Total Suspended Solids
TVOC	Total Volatile Organic Compounds
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
VOC	Volatile Organic Compound
WCN	Waste Consignment Note

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EXECUTIVE SUMMARY

ES1.1 INTRODUCTION (BACKGROUND).

Natural gas is one of the most sought energy sources globally. This is because it is a cleaner source of energy compared to diesel, coal and wood, and also cheaper than most other fossil fuels. Nigeria has abundant gas reserves in a number of gas fields, mostly in remote locations within and around the Niger Delta area. The country has not fully harnessed the economic potential of its gas resources due to various factors, which include a lack of infrastructure. Thus, useful gas resources have been either flared or remain stranded in remote areas. Gas gathering, processing and transportation infrastructure in Nigeria is grossly inadequate, which has greatly hampered the industrial growth of the country. Therefore, the implementation of the Greenville LNG Project offers an opportunity to harness Nigeria's natural resources for use across the country, particularly in locations not served by pipeline infrastructure. The project, therefore, aligns with the Federal Government's policies:

- To reduce gas flaring
- To monetize gas resources
- To improve energy availability across the country through its gas-to-power initiative.

ES 1.2 The Project Proponent

Greenville Liquefied Natural Gas Company Limited (GVLNG) was founded in 2015 and is a Nigerian private company based in Abuja, FCT, Nigeria**.** Greenville Liquefied Natural Gas Company Limited (GVLNG), formerly Greenville Oil and Gas Company Limited (GOGCL).

ES 1.3 Project Location and Accessibility

The proposed project would be sited on a 10ha of land at Rigasa, Igabi Local Government Area, Kaduna State. The proposed project site falls within the following geographical coordinates: 10°35.364'N, 7°21.633'E**.**

ES 1.4 Legal and Administrative Framework

The environment has emerged as one of the most critical issues of contemporary times, driven by the increasing negative impacts of rapid industrial development. As natural resources are exploited at unprecedented rates, environmental quality deteriorates, rendering many development projects unsustainable. This situation has necessitated the enforcement of environmental protection laws to safeguard and restore the Nigerian environment.

The requirement for an Environmental and Social Impact Assessment (ESIA) aligns with

the Federal Republic of Nigeria's (FRN) laws and policies aimed at achieving sustainable development goals through environmental stewardship, public health protection, and social well-being. It also fulfills international requirements for projects of this scale, ensuring adherence to best practices in environmental and social safeguards. This section reviews relevant Nigerian legislation, guidelines, and international conventions applicable to infrastructure development. The legislative framework outlined here is drawn from federal and state laws, as well as international conventions and instruments to which Nigeria is a signatory.

National Legislation

National Policy on Environment

Environmental management in Nigeria is based on the National Policy on the Environment (1988), revised in 1999 and 2016. The Policy states that Nigeria is committed to safeguarding the country's natural and built environment for the use of present and future generations. This commitment demands that efficient resource use and the reduction of environmental impacts be a core requirement of all developmental activities. The National Policy on the Environment aims to achieve sustainable development in Nigeria, and in particular to:

- Secure a quality of environment adequate for good health and well-being;
- Conserve and use the environment and natural resources for the benefit of present and future generations;
- Restore, maintain and enhance the ecosystem and ecological processes essential for the functioning of the biosphere to preserve biological diversity, and the principle of optimum sustainable yield in the use of living natural resources and ecosystems;

Raise public awareness and public understanding between the environment and development and encourage individual and community participation in environmental improvement efforts.

Environmental Impact Assessment (EIA) Act CAP E12 LFN 2004

The Act makes EIA mandatory for all new major public and private projects in Nigeria. It sets out to:

- ✓ Consider the likely impacts and the extent of these impacts on the environment before embarking on any project or activity.
- ✓ Promote the implementation of appropriate policies in all federal lands consistent with all laws and decision-making processes through which the goal of this Act may be realized; and

- ✓ Encourage the development of procedures for information exchange, notification and consultation between organizations and persons when the proposed activities are likely to have significant environmental effects.

National Environmental Standards and Regulation Enforcement Agency (NESREA)

The National Environmental Standards and Regulations Enforcement Agency (NESREA) were established in 2007 by the FGN as a parastatal of the 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 developmental projects.

The Petroleum Industry Act (2021)

The Petroleum Industry Act (PIA) was passed into law in August 2021. It provides a comprehensive framework for the legal, governance, regulatory and fiscal matters of the Nigerian Petroleum Industry (upstream, midstream, and downstream) as well as the development of Host Communities. The Act repeals the following six (6) laws:

- the Associated Gas Reinjection Act 1979
- the Hydrocarbon Oil Refineries Act,
- Motors Spirit Returns Act,
- Nigerian National Petroleum Corporation (Projects) Act,
- Nigerian National Petroleum Corporation Act,
- the Petroleum Products Pricing Regulatory Agency (Establishment) Act

Nigerian Oil and Gas Industry Content Development Act, 2010

The Nigerian Local Content law was created to enhance utilization of the country's human and material resources for the provision of goods and services to the petroleum industry by ensuring that:

- Nigerians are given first consideration in the award of oil blocks, oil field licenses, oil lifting license and shipping service as well as projects for which contracts are to be awarded in the industry;
- there is exclusive consideration for Nigerian indigenous services to the oil and gas industry subject to the fulfilment of specified conditions;

National Gas Policy, 2017

The Nigerian gas policy was developed to encourage sustainable development and use of the Nigerian gas. The policies developed are listed below:

- the nation's gas resources shall be harnessed and optimally integrated into the national economy, energy mix and industrial processes;

- the nation shall engage intensively in gas exploration and development with a view to increasing the reserve base to the highest level possible;
- the nation shall put in place necessary infrastructure and incentives to encourage indigenous and foreign companies to invest in the industry; and
- the nation shall put in place necessary infrastructure and incentives to ensure adequate geographical coverage of the gas transmission and distribution network.

Land Use Act Cap L5 LFN 2004

The Land Use Act Cap L5 LFN 2004 states that "it is public interest that the rights of all Nigerians to use and enjoy land in Nigeria and the natural fruits thereof in sufficient quality to enable them to provide for the sustenance of themselves and their families be assured, protected and preserved".

Harmful Waste Act

The Harmful Waste (Special Criminal Provisions) Act Cap H1, LFN 2004 prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria. The following sections are notable:

Section 6: provides for a punishment of life imprisonment for offenders as well as the forfeiture of land or anything used to commit the offence.

Section 7: makes provision for the punishment accordingly, of any conniving, consenting or negligent officer where the offence is committed by a company.

Section 12: defines the civil liability of any offender. He would be liable to persons who have suffered injury as a result of his offending act.

Penal Code Act of Nigeria 2004

The Act makes it an offence punishable with up to 6 month's imprisonment for any person who:

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

Climate Change Act, 2021

The Climate Change Act, 2021 is a landmark legislation in Nigeria aimed at addressing climate change and promoting sustainable development. It establishes

the National Council on Climate Change (NCCC) to coordinate national climate actions and introduces a Climate Change Fund to finance climate resilience projects. The Act mandates carbon budgeting, sectoral emission targets, and the development of a National Climate Change Action Plan.

State Regulations

The Project site falls within the jurisdiction of Kaduna State Government. The key State administrative authorities and legal instruments that apply to the Project are briefly described below.

Kaduna State Environmental Protection Law No. 7 of 2010

Initially cited as the Edict No. 1 of 1998, the Kaduna State Environmental Protection Authority Law (No. 7) was enacted in 2010. The enabling legislation confers on the Authority (KEPA) the general responsibility for all matters relating to the environment1. KEPA is expected to:

- Enact and enforce State regulations, procedures, guidelines and environmental standards for effective -prevention, remediation, control and monitoring of point and non-point source of pollution and degradation;
- Implement, and review environmental policy in the State and in particular to demand and review environment impact assessment and statement and for new development projects and to also demand review environmental audit reports for existing developments and such other operations which are deemed to have significant impact on the environment; amongst others.

Kaduna State Urban Planning & Development Authority (KASUPDA), 2018

The Kaduna State Urban Planning and Development Authority (KASUPDA) Act of 2018 tasked KASUPDA with regulating orderly growth in designated urban areas of the state like Kaduna, Zaria, Kafanchan, etc. KASUPDA formulates state urban planning policies aligned with national frameworks, preparing master plans, local plans, and subject-specific strategies (e.g., zoning, renewal, etc.), and also exercises development control by issuing planning permits, approving building layouts, and enforcing compliance to prevent unauthorized constructions and slum proliferation. Furthermore, the Authority oversees physical developments, outdoor advertisements (in collaboration with LGAs), and subdivision approvals, sealing violations and imposing sanctions like fines or demolition. It conducts research on urban trends including transport infrastructure standards/development, and engages stakeholders through public inquiries for plan adoption.

Kaduna State Environmental Protection Authority (KEPA) Regulations, 2011

In exercise of the powers conferred upon KEPA by Section 13 of Kaduna State Environmental Protection Law No. 7 of 2010, a number of regulations were made to further guide persons and corporate entities whether public or private, on environmental matters. These regulations, which took effect on 1st January 2011, are all relevant and applicable (fully or in part) to the proposed TPEZs projects development within Kaduna.

Igabi Local Government Area Council

Igabi Local Government Area Council is one of the Local Government Areas of Kaduna State established to administer local government functions within its jurisdiction. Igabi is responsible for the provision and coordination of certain municipal services including environmental sanitation, waste management, public health administration, local roads, markets, community liaison, and other statutory local government functions.

International Regulatory Framework

In addition to national and state laws/regulations, Nigeria is signatory or party to several International Conventions and treaties that support the use of EIA as key tool for achieving sustainable development in executing projects.

International conventions to which Nigeria is signatory-to include, *but not limited to***:**

- The Vienna Convention on the Protection of the Ozone Layer;
- Montreal Protocol on Substances that deplete the Ozone Layer;
- The United Nations Guiding Principles on the Human Environment

- The Basel Convention on the Control of Tran boundary Movements of Hazardous Wastes and their disposal;
- Protocol on the 1972 Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter.
- Convention on the Conservation of Nature and Natural Resources, 1986
- Convention on Occupational Safety and Health and the Working Environment
- Stockholm Convention Against Persistent Organic Pollutants of 2004
- United Nations Framework Convention on Climate Change (1992)
- International Best Practices

ES2 PROJECT JUSTIFICATION

Proposed Project Justification

The establishment of a Compressed Natural Gas (CNG) Mother/Daughter station network is a highly viable strategic project. The business and economic justification relies on four primary pillars:

- Proximity to Feedstock and Existing Infrastructure
- Virtual Pipeline Efficiency via Daughter Stations
- Immediate Commercial Demand
- Direct Policy Alignment

Need for the Project

The oil and gas industry plays an important role in the Nigerian economy, and this CNG Compression is one such.

- The project will reduce dependence on PMS and diesel, lower greenhouse-gas and particulate emissions. This shift supports improved air quality and public health outcomes.
- Stimulate local economic activity and boost living conditions
- Enhance energy security in line with Nigeria's Decade of Gas policy.
- Improve the health of society and the environment
- Conservation of energy
- Provide resources for industrial production at lower cost and increase productivity
- Create employment opportunities for Nigerians

Benefits of the Project

The proposed CNG mother/daughter station will deliver significant environmental, economic, and energy-security benefits.

- It will reduce greenhouse-gas and air-pollutant emissions by providing a cleaner alternative to petrol and diesel, thereby improving local air quality and supporting Nigeria's energy-transition goals.
- The project enhances regional energy security by supplying a stable, locally sourced fuel and extending gas access to areas without pipeline infrastructure.
- It will stimulate economic growth through job creation, lower fuel costs for transport and industrial users, and increased business activity.

Value of the Project

The value of the proposed project is highlighted by the desire to enhance local environment cleanliness and health in the oil and gas operational areas. The project estimated cost is N1 billion, to be independently funded. The project lifespan shall be 25 - 30years.

PROJECT SUSTAINABILITY

The project's sustainability is addressed under its economic, technical, social and environmental sustainability potentials. The project proponent will ensure that the project is in compliance with the universally accepted Sustainability Model. The universally accepted model of sustainability is one which focuses on preserving the environment, ensuring economic profitability and protecting the society.

Economic Sustainability

The project is economically sustainable as it leverages Nigeria's abundant natural gas resources to provide a cheaper and more stable alternative to petrol and diesel. The station will reduce fuel costs for transport operators, SMEs, and industrial users, thereby improving business competitiveness. It will generate direct and indirect employment during construction and operation, stimulate local supply chains, and support long-term economic diversification in Kaduna State.

Technical Sustainability

The project is technically sustainable due to the use of proven CNG compression, storage, and transportation technologies widely adopted globally. The modular mother/daughter configuration allows phased expansion based on demand, reducing technical risk. The proximity to existing gas infrastructure ensures reliable feedstock supply, while modern safety systems—pressure relief devices, gas detection, automated shutdowns—enhance operational reliability. The design complies with relevant engineering standards, ensuring long-term functionality and maintainability.

Environmental Sustainability

CNG is a cleaner-burning fuel that significantly reduces CO_2, NOx, SOx, and particulate emissions compared to conventional liquid fuels. The project will contribute

to improved air quality and reduced greenhouse-gas emissions in line with Nigeria's climate commitments. CNG poses minimal risk of soil or water contamination because it dissipates rapidly when released. Identified environmental impacts—noise, construction disturbance, waste generation—are limited in scale and can be effectively mitigated through standard environmental management practices, making the project environmentally viable.

Social Sustainability

The project supports social sustainability by creating employment opportunities, enhancing local skills, and improving access to affordable energy. Lower fuel costs will benefit transport operators and commuters, contributing to improved mobility and reduced cost of living. The project promotes safer fuel handling and reduces community exposure to pollutants associated with diesel and petrol. Engagement with host communities ensures inclusion, transparency, and alignment with local development priorities.

Project Options and Alternatives

As required by law in Nigeria, some reasonable options and alternatives to the various elements of the proposed project shall be considered and examined. Accordingly, a number of alternatives have been weighed up for the construction and operation of the proposed CNG Mother/Daughter Station using economic, technical and environmental considerations.

No- Project Option

The no-project option means the development of the planned CNG Station shall not take place. As a direct consequence, this would result in no effect on the environment in the area as this option would result in no change of environmental features. A key implication of this option is that the project area which is suitable for the CNG operations, will be under-utilized.

Delayed Project

Delaying the project involves moving the project to a later date. This situation is unlikely, and can only be considered if existing circumstances are highly un-favourable or risky for the execution of the project. Conflicts, war, hostilities, communities deeply resentful of the project or unacceptable/unattractive economics are some of the reasons this option can be adopted. In contrast, the economics and the political environment favour the execution of the project.

"Go Ahead Project Option"

The justification of this project outweighs other negative variables; therefore the "go ahead" option is proposed for the project at the present location. It is therefore recommended that the project be carried out as planned, since adequate mitigation measures shall be incorporated into the project plan to minimise or eliminate potential negative environmental and social impacts of the proposed project.

Alternate Site/ Locations

Alternative site locations were considered early on by the board of GVLNG Limited. Other location alternatives were considered before deciding on the present location but the current site is best suited for the project.

ES 3 PROJECT AND PROCESS DESCRIPTION

Project Background

The proposed project entails the establishment of a Compressed Natural Gas (CNG) mother/daughter station in Rigasa Community, Igabi Local Government Area of Kaduna State. The gas source for the CNG Compression Station comes from the AKK Pipeline. The designed flow rate is 5000 Nm3/h, with an inlet gas pressure ranging from 5 to 6 MPa. The hydrogen sulfide content is no more than 15 mg/m3, and the total sulfur content is no more than 100 mg/m3. A control ball valve is installed on the pressure regulating and metering skid, which serves as the emergency shut-off valve for the inlet gas.

Facilities Description

The proposed CNG Compression Station is an industrial energy facility comprising two integrated zones: a compression section and a retail section.

- **Gas Receiving Unit (GRU):** Receives natural gas from an upstream pipeline or gas supplier.
- **Compression System:** High-pressure compressors that raise gas pressure to CNG standards (typically 200–250 bar).
- **Cascade Storage System:** High-pressure storage cylinders arranged in banks for efficient loading and unloading.
- **Dispenser Units:** For direct vehicle fueling (if applicable) and for loading CNG into daughter-station transport modules.
- **Control Room & SCADA System:** For monitoring pressure, flow, safety systems, and operational parameters.
- **Fire & Safety Infrastructure:** Fire-suppression systems, gas detectors, emergency shutdown systems, and safety signage.

- **Ancillary Facilities:** Administrative building, workshop, security post, internal roads, drainage, and utilities.

Project Development Activities

Pre-Construction Activities: The activities in the pre-construction stage shall primarily be made up of:

- Concept development,
- Feasibility studies
- Site acquisition
- Site survey and geotechnical investigations

Construction Phase: The construction of the facility would involve:

- Topographic Surveys
- Soil Investigation Surveys
- Mobilization of equipment and labour
- Site clearing and grading
- Installation of facilities that shall be fitted within the storage terminal e.g., piping, valves, loading hoses/nozzles, and safety alarms.
- Construction and installation of an administrative block, etc.
- Installation of Installation of foundations, equipment, and storage systems
- Construction of buildings and utilities
- Provision of Parking spaces.
- Painting of facilities
- Erection of safety signs around the facility
- Designation of Muster Stations
- Testing and commissioning of mechanical and electrical systems

Operations Phase: The operational activities shall include the following:

- Continuous gas compression, storage, and distribution
- Routine maintenance of compressors, storage banks, and safety systems
- Monitoring of environmental and safety parameters
- Good housekeeping
- Engagement with host communities and regulatory agencies

Decommissioning Activities

- Removal of equipment and structures
- Site remediation and restoration
- Waste disposal in accordance with regulatory standards

Maintenance Activities

Periodic checks of the pipeline, valves, compressors and dispensers shall be carried

out. All leaks and spills shall be reported to the safety personnel who shall recommend and take appropriate actions. In addition, security personnel shall man the facility round the clock. Informal inspections shall be done on a daily basis noting the overall facility condition however formal inspections shall be conducted on a monthly basis. Piping must be maintained in sound condition and hydrostatically tested yearly. Sagging and cracking pipes as well as rusting or rotten pipe supports shall be checked for routinely. Maintenance activities shall also include repainting pipes; and repairing and replacement of defective pipes and valves. The hydrant tanks shall be checked for peeling, blistering or chipping periodically. The storage tanks shall be emptied, cleaned and the inside examined for holes and corrosion. The nozzles shall be checked for any signs of leaks from the valves and they shall be checked to see if they can be completely turned on and turned off to stop product flow.

Record keeping is a key aspect of maintenance and this would be kept for inspections, maintenance activities, training and product inventory.

Waste Management

According to the Basel Convention, wastes are substances or objects that are disposed or are intended to be disposed of, or are required to be disposed of by the provisions of national laws. Wastes include any items that people no longer have any use for, which they either intend to get rid of, or have already discarded. In addition, wastes also include such items which are required by law to be discarded, because of their hazardous properties.

In the light of this, Greenville LNG Limited recognize the implications of the ineffective handling and final disposal of generated wastes. GVLNG intends to be practical, systematic and efficient in the handling of waste materials during the construction and operation phases at the petroleum products terminal.

As a result, a stand-alone Waste Management Plan will be developed to conform to the universal principles of minimize/reduce at source (waste generation); reuse (components); recycle (before disposal) and responsible disposal – the 4 Rs Principle.

GVLNG has developed and is implementing a Waste Management Plan (WMP) for all wastes generated from its operational areas. The plan documents waste streams, sources of generation, segregation and disposal methods. Approved waste handling facilities and technologies have also been indicated for the various waste streams as appropriate. The WMP is also used to manage all types of wastes that are generated

during various phases of the proposed development. The WMP is operated on the principles of reducing (waste generation), reusing (components), or recycling (before disposal).

It is anticipated that the following wastes will be generated during the site preparation and construction phase:

- Construction wastes (minimal cleared and cut vegetation, unwanted soil, dunnage, packaging material, waste oils, etc.);
- Domestic waste (including sanitary wastes generated from on-site accommodation facilities); and
- Hydrotest water from the linkage pipeline and the CNG Tank.

Some of the above listed waste types have been categorised into:

- Sanitary Wastes;
- Project-Worker Camp Refuse (e.g., packaging, kitchen waste);
- Project Refuse (e.g., packing materials, spent PPE);
- Project Dunnage (e.g., wooden crating, metal scraps); and
- Hazardous Waste

Project Workforce

Each phase of the planned expansion will be staffed in line with activity requirements. Project activities commence with site preparation as described in earlier sections. This phase is estimated to require about 30 workers. Construction activities follow site preparation and will require about 39 workers comprising skilled, unskilled Nigerians and expatriates at peak periods. It is envisaged that a number of the workers will have permanent residence outside the plant site. Pre-commissioning and operations workforce are estimated at 20 and 38, respectively.

ES4 DESCRIPTION OF THE PROJECT ENVIRONMENT

Environmental baseline study of the CNG Compression Station is undertaken in order to establish the situation of the physical, biological, social and health environment of the study area prior to the commencement of the project development. This serves as baseline or benchmark to assess and monitor the impacts of the proposed CNG Mother Station at Rigasa, Igabi Local Government Area, Kaduna State.

Consequently, upon completion of the environmental baseline study, the results generated would serve as a benchmark against which any potential beneficial or

non- beneficial impact of the proposed project on the environment and socio-economics of the project area would be identified and assessed.

The main environmental components considered in the environmental baseline study include:

- **Physical components**: soil, surface/ground water resources, water/air quality and climatology;
- **Biological environment**, which includes: flora, (i.e trees, grasses, forest, fauna i.e, fish, Mega fauna, birds, mammal), threatened, and/or endangered species (plant/animals), species diversity, overall ecosystem stability etc.
- **Cultural** and **socio-economic components**: pollution trends, distribution of socio-economic resources indicative of human welfare, i.e. educational system, transportation/land use networks, and other infrastructures like water supply, waste water/domestic disposal, solid waste management, public services, fire protection, medical facilities and health impacts.

The baseline field data gathering was carried out in one season (dry season) from 18th to 19th June, 2026 as approved by the Federal Ministry of Environment (FMEnv)).

Climate and Meteorology

Kaduna metropolis lies within the Northern Guinea Savannah climatic zone and is characterised by a strongly seasonal hydro-climatic regime, with a distinct wet season typically extending from April to October and a dry season from November to March. The early dry season is often influenced by Harmattan conditions, marked by low relative humidity and dust-laden winds. Rainfall follows a unimodal pattern, increasing from the onset rains in April/May, reaching peak intensities in the mid- to late-wet-season months, and gradually tapering towards cessation in October.

Relative Humidity: The annual relative humidity time series for Kaduna metropolis between 2000 and 2025 reveals considerable inter-annual variability in atmospheric moisture conditions over the study period. The average annual relative humidity values ranged from approximately 53.62% to 72.87%, indicating fluctuations in moisture availability and climatic conditions within the metropolis. The lowest relative humidity values were recorded in 2005 (54.16%) and 2006 (53.62%), while the highest values occurred in 2022 (72.87%), 2020 (70.80%), and 2021 (69.94%). The variability observed in the dataset reflects changing atmospheric conditions influenced by seasonal rainfall distribution, temperature variability, urbanization processes, and land surface changes occurring within Kaduna metropolis and its surrounding environments.

Wind Speed: The annual wind speed time series for Kaduna metropolis between 2000 and 2025 indicates moderate variability in wind conditions over the 25-year study period. The average annual wind speed values ranged from approximately 7.18 m/s to 8.82 m/s, reflecting relatively stable but fluctuating atmospheric circulation patterns within the region. The highest annual average wind speed was recorded in 2008 with a value of 8.82 m/s, while the lowest value occurred in 2016 with 7.18 m/s. Other years such as 2000 (8.56 m/s), 2005 (8.45 m/s), and 2015 (8.40 m/s) also recorded relatively high wind speeds, whereas lower wind conditions were observed in 2003 (7.68 m/s), 2009 (7.65 m/s), and 2025 (7.45 m/s). Overall, the dataset demonstrates moderate inter-annual variability without a clearly defined long-term increasing or decreasing trend in wind speed conditions across Kaduna metropolis.

Rainfall: The analysis of the annual maximum 24-hour rainfall series for Kaduna metropolis from 1960 to 2025 indicates considerable inter-annual variability in extreme rainfall events, reflecting the dynamic climatic conditions within the region. The recorded annual maximum daily rainfall values generally ranged from moderate to very intense storm events, demonstrating the episodic nature of heavy rainfall occurrences within the Northern Guinea Savannah zone. The observed variability suggests that extreme rainfall events within Kaduna metropolis are largely influenced by short-duration, high-intensity convective storms rather than a consistent long-term increase or decline in mean annual rainfall patterns.

Temperature: The annual minimum temperature time series for Kaduna metropolis between 2000 and 2025 reveals noticeable inter-annual variability in minimum temperature conditions, with average values ranging from approximately 14.93°C to 17.61°C. The data indicates fluctuations in minimum temperature over the 25-year period rather than a perfectly stable climatic pattern, reflecting the influence of regional climatic variability, changing land surface conditions, and increasing urbanization within Kaduna metropolis. The lowest annual minimum temperature was recorded in 2001 with an average value of 14.93°C, while the highest minimum temperatures were observed in 2005 (17.61°C) and 2025 (17.42°C). Overall, the temperature series suggests a gradual tendency toward warmer minimum temperature conditions over time, particularly in recent years, which may be associated with increasing urban growth and land use transformation within the metropolis.

Air Quality and Noise Levels

The pollutants commonly monitored in relation to air quality are; nitrogen dioxide (NO_2), sulphur dioxide (SO_2), suspended particulate matter (SPM), ammonia (NH_3), hydrogen sulphide (H_2S), carbon dioxide (CO_2), carbon monoxide (CO), and volatile

organic compounds (VOCs). Sulphur Dioxide (SO_2), Nitrogen dioxide (NO_2) and Ammonia (NH_3) levels in the study area and control station were below equipment detection limit.

Carbon Monoxide (CO): Carbon monoxide concentrations ranged from 0.9–1.3 ppm across the project area, while control locations recorded concentrations of 0.7–0.8 ppm.

These concentrations are significantly lower than the FMEnv limit of 10 ppm and the WHO guideline of approximately 9 ppm (8-hour average).

Carbon Dioxide (CO_2): Carbon dioxide concentrations ranged from 424–448 ppm across the project area, while background concentrations varied between 410 and 415 ppm.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide concentrations ranged from 0.02–0.04 ppm across the project area, while control stations recorded approximately 0.01 ppm.

Sulphur Dioxide (SO_2): Sulphur dioxide concentrations ranged from 0.004–0.007 ppm within the project area and approximately 0.003 ppm at the control locations.

Hydrogen Sulphide (H_2S): Hydrogen sulphide was not detected at any monitoring location, including the background control stations.

The FMEnv guideline value for hydrogen sulphide is 0.008 ppm, while WHO recommends concentrations below approximately 0.005 ppm to prevent nuisance odour and potential health concerns.

Ammonia (NH_3): Ammonia concentrations ranged from 0.02–0.04 ppm across the project area, while background concentrations remained at approximately 0.01 ppm.

The FMEnv guideline value for ammonia is 0.20 ppm, while WHO has not established a specific ambient air quality standard for ammonia.

These concentrations are typical of rural environments where agricultural activities may contribute minor atmospheric ammonia emissions. The observed levels pose no significant environmental or public health risk.

Volatile Organic Compounds (VOC): TVOC concentrations ranged from 0.022–0.028 mg/m³ across the project area and from 0.018–0.020 mg/m³ at the control stations.

Temperature, Relative Humidity and Wind Speed

Ambient temperatures ranged from 28.5 to 33.4°C, relative humidity ranged between 45.6% and 65.2%, while wind speeds varied from 0.9 to 2.6 m/s.

These meteorological conditions are typical of Kaduna State during the sampling period and favour effective atmospheric dispersion of pollutants. Moderate wind speeds reduce pollutant accumulation but may facilitate the transport of construction-generated dust if appropriate dust control measures are not implemented.

Ambient Noise Level: Ambient noise levels ranged between 45.7 and 57.5 dB(A), while control locations recorded 45.9–47.3 dB(A). These values are below the FMEnv daytime ambient noise guideline of 90 dB(A) for industrial environments and also below the WHO recommended daytime outdoor community noise guideline of 55 dB(A) for most locations. The few values slightly above 55 dB(A) remain environmentally acceptable and are characteristic of normal rural community activities.

Generally, the baseline ambient air quality of the proposed Greenville CNG Mother Station at Afaka, Rigasa is generally good, with virtually all monitored pollutants complying with applicable FMEnv standards and, for most parameters, WHO Air Quality Guidelines. $PM_{2.5}$ concentrations marginally exceed the stringent WHO 24-hour guideline at several locations but remain well below FMEnv limits, suggesting that existing particulate pollution is primarily attributable to natural dust and local activities rather than industrial sources. The absence of detectable H_2S, HCl and PH_3, coupled with very low concentrations of CO, SO_2, NO_2, TVOCs and formaldehyde, demonstrates that the project site currently experiences minimal atmospheric pollution.

Geology: The project area lies within the Basement Complex terrain of Northern Nigeria, composed predominantly of Precambrian rocks including migmatites, granites, gneisses, and quartzites.

Local Geology: Outcrops are sparse, with underlying geology dominated by weathered granite-gneiss formations, forming moderately deep to deep profiles of lateritic soils suitable for agriculture. Figure 4.8 presents the basic geology of the project area (Pre-Cambrian Basement Complex) and of the other Nigerian regions.

Hydrology: The proposed project site is close to River Kaduna and one of its tributaries, which serve as the major hydrological features in the area. Seasonal streams may traverse or border parts of the site during the wet season. The flow regime shows peak flow in July to September, while low flow rates are recorded in December to April. Localised flooding may occur in low-lying areas adjacent to streams during peak rains if drainage is not well managed. Thus, the hydrology of the project area supports the water needs of the proposed project.

Groundwater and Surface Water Quality

Water quality assessment was undertaken using three (3) surface water samples (SW01 to SW03), five (5) groundwater samples (GW01 to GW05), and one (1) groundwater control sample (GW06) collected within and around the proposed Greenville CNG Mother Station at Afaka Community, Rigasa District, Igabi LGA, Kaduna State. The samples were analysed for physical, chemical, heavy metal, organic and microbiological parameters and compared with the Federal Ministry of Environment (FMEnv) permissible limits. Where applicable, the results are also compared with the World Health Organization (WHO, 2022) Guidelines for Drinking-water Quality.

Overall, the groundwater quality was found to be considerably better than the surface water quality. Surface water exhibited elevated suspended solids, microbial contamination and elevated concentrations of some heavy metals, whereas groundwater generally complied with FMEnv and WHO standards except for isolated parameters such as iron. The results from the laboratory were analyzed and the interpretations are summarized as follows;

pH and Temperature: The pH values ranged from 6.5 to 6.9 in both surface and groundwater samples. These values fall entirely within the FMEnv and WHO acceptable range of 6.5 to 8.5, indicating neutral to slightly acidic water conditions. Neutral pH is desirable because it minimizes corrosion, reduces metal dissolution and provides favourable conditions for aquatic organisms.

Water temperatures ranged from 26.2 to 28.5°C, reflecting normal ambient climatic conditions during sampling. Although FMEnv does not prescribe a fixed numerical standard, these temperatures are typical of tropical freshwater systems and are unlikely to adversely affect aquatic ecosystems or groundwater quality.

Electrical Conductivity (EC): All measured values remained well below the FMEnv and WHO guideline value of 1,000 µS/cm. The low conductivity indicates relatively low dissolved ionic content and confirms that neither salinity intrusion nor significant anthropogenic contamination presently affects the water resources.

Turbidity: Surface water turbidity ranged between 1 and 2 NTU, whereas all groundwater samples recorded 0 NTU. These values are significantly below the FMEnv and WHO guideline of 5 NTU, indicating excellent water clarity. The absence of turbidity in groundwater reflects effective natural filtration through subsurface soils and geological formations.

Total Dissolved Solids (TDS) and Total Suspended Solids: The values of TDS are substantially below the FMEnv and WHO permissible limit of 500 mg/L. Low TDS indicates excellent palatability, minimal mineral enrichment and limited anthropogenic influence.

A marked difference exists between TSS values of surface and groundwater. Surface water contained 355 to 428 mg/L, while groundwater contained only 3 to 11 mg/L.

Dissolved Oxygen (DO), Chemical Oxygen Demand and Biological Oxygen Demand: Dissolved oxygen concentrations ranged from:

- 6.2 to 7.4 mg/L in surface water.
- 5.0 to 6.0 mg/L in groundwater.

These values fall within the FMEnv guideline range of 2 to 8 mg/L. The relatively high dissolved oxygen concentrations indicate healthy aquatic conditions capable of supporting aerobic biological processes and aquatic organisms.

Surface water BOD ranged between 2.9 and 3.6 mg/L, whereas groundwater ranged from 1.1 to 1.7 mg/L.

Calcium and Magnesium: Calcium concentrations ranged from 0.11 to 3.57 mg/L, while Magnesium ranged between 0.02 and 1.66 mg/L. These values are considerably lower than the FMEnv limits of 200 mg/L for calcium and 20 mg/L for magnesium, indicating soft water with minimal hardness.

Sodium: Surface water sodium ranged between 15 and 27 mg/L, while groundwater ranged from 21 to 41 mg/L. Most groundwater samples exceeded the FMEnv limit of 20 mg/L, while surface water values were generally close to or slightly above the limit.

Potassium: Potassium concentrations ranged between 0.4 and 1.2 mg/L, remaining well below the FMEnv limit of 20 mg/L. The results indicate no enrichment from agricultural fertilizers or industrial activities.

Sulphate: Sulphate concentrations varied from 18 to 63 mg/L, remaining comfortably below the FMEnv limit of 100 mg/L. The concentrations indicate negligible sulphate pollution and suggest that sulphide oxidation or industrial sulphur contamination is absent.

Nitrate: Nitrate concentrations ranged from 0.41 to 7.57 mg/L, considerably below the FMEnv and WHO limit of 50 mg/L. These concentrations pose no risk of nitrate toxicity or infant methemoglobinemia ("blue baby syndrome").

Chloride: Chloride concentrations ranged from 0.0 to 2.3 mg/L, substantially below the FMEnv limit of 150 mg/L. The results confirm the absence of saline intrusion or wastewater contamination.

Heavy Metals and Trace Elements:

Zinc: Surface water zinc ranged from 2.003 to 3.421 mg/L, while groundwater ranged between 1.026 and 1.999 mg/L. Groundwater complies with the FMEnv limit of 3.0 mg/L, whereas two surface water samples slightly exceed this limit. The elevated zinc may originate from natural mineral weathering or metallic materials within the catchment.

Copper: Copper concentrations ranged from 0.00 to 0.43 mg/L, remaining well below the FMEnv limit of 1.25 mg/L. No evidence of copper contamination exists.

Chromium: Chromium concentrations in surface water ranged between 1.01 and 1.33 mg/L, whereas groundwater ranged from 0.00 to 0.02 mg/L. Groundwater complies fully with the FMEnv and WHO limit of 0.05 mg/L, but all surface water samples exceed this limit by more than twentyfold.

Nickel: Nickel concentrations ranged between 0.00 and 1.03 mg/L. Surface water samples exceeded the FMEnv and WHO limit of 0.07 mg/L, whereas groundwater complied. The elevated surface water concentrations suggest localized geogenic enrichment or surface runoff transporting trace metals into nearby water bodies.

Mercury and Lead: Mercury and lead concentrations were either absent or detected only at trace levels well below the FMEnv and WHO guideline values. These findings indicate that the project area is not presently affected by mercury or lead contamination.

Microbiology

Escherichia coli (E. coli): Surface water contained 6 to 12 cfu/100 mL, while groundwater recorded 0 cfu/100 mL. Both FMEnv and WHO require zero E. coli in drinking water.

Accordingly, all surface water samples fail the drinking water standard, whereas groundwater fully complies. The presence of E. coli indicates faecal contamination and renders untreated surface water unsuitable for direct consumption.

Total Coliform

Surface water contained 97 to 147 cfu/100 mL, whereas groundwater contained 1 to 2 cfu/100 mL. Surface water greatly exceeds the FMEnv limit of 10 cfu/100 mL, while groundwater remains within acceptable limits. The elevated coliform counts further confirm that surface water is vulnerable to contamination from runoff, livestock and human activities.

The baseline assessment indicates a clear distinction between surface water and groundwater quality within the proposed project area. Groundwater generally complies with FMEnv and WHO drinking water guidelines, exhibiting acceptable pH, low turbidity, low dissolved solids, absence of BTEX and petroleum hydrocarbons, and no detectable E. coli. However, isolated exceedances of iron and sodium warrant periodic monitoring.

Soil Quality Assessment

Soil quality assessment was carried out using thirty (30) soil samples collected across the proposed Greenville CNG Mother Station site and three (3) control samples. The analyses covered soil physicochemical characteristics, exchangeable cations and anions, heavy metals, organic contaminants, particle size distribution and microbiological properties. The results were compared with applicable Federal Ministry of Environment (FMEnv) intervention/target values and internationally accepted guideline values (WHO/FAO and Dutch Target Values where FMEnv standards are unavailable).

Soil Reaction (pH): The soil pH ranged from 6.81 to 9.41, while the control samples ranged from 6.43 to 6.97. Most project samples recorded pH values between 8.0 and 8.9, indicating moderately to strongly alkaline soils. Although FMEnv has no regulatory limit for soil pH, agricultural guidelines generally consider 6.0–8.5 suitable for most crops. Consequently, a number of sampling locations slightly exceed the upper desirable range. The alkaline condition is likely associated with the natural parent material and local geology rather than anthropogenic contamination.

Electrical Conductivity (EC): Electrical conductivity ranged between 883 and 2,863 µS/cm, while control locations recorded 943–1,432 µS/cm. These values indicate non-saline to slightly saline soils, remaining below conductivity values generally associated with severe salinity problems (>4,000 µS/cm). The results suggest that soluble salt

accumulation is presently insignificant and is unlikely to restrict plant growth or soil productivity.

Exchangeable Cations: Calcium (Ca^{2+}): Calcium concentrations ranged from 0.69 to 4.30 mg/kg. These concentrations indicate adequate calcium availability for plant growth. Calcium contributes to soil structure, root development and nutrient uptake. No evidence of calcium deficiency or excessive accumulation was observed.

Magnesium (Mg^{2+}): Magnesium concentrations ranged from 0.03 to 1.53 mg/kg. The concentrations are characteristic of naturally occurring tropical soils and indicate balanced magnesium availability without evidence of contamination.

Sodium (Na^{+}): Exchangeable sodium ranged from 3 to 43 mg/kg. These values are relatively low and do not indicate sodic soil conditions. Consequently, the soils are not expected to experience structural degradation, poor infiltration or dispersion arising from sodium accumulation.

Potassium (K^{+}): Potassium concentrations varied from 0.4 to 4.2 mg/kg. Potassium levels are typical of undisturbed agricultural soils and are adequate for maintaining normal plant physiological functions.

Exchangeable Anions

Sulphate (SO_4^{2-}): Sulphate concentrations ranged from 10 to 63 mg/kg. These concentrations indicate adequate sulphur availability without evidence of sulphate contamination from industrial sources.

Nitrate (NO_3^{-}): Nitrate concentrations varied between 0.1 and 8.1 mg/kg. These relatively low concentrations suggest limited fertilizer enrichment and indicate that the soils have not experienced excessive agricultural nitrogen loading.

Nitrite (NO_2^{-}): Nitrite concentrations ranged from 0.000 to 0.186 mg/kg. Nitrite is generally unstable in soils and the measured concentrations are very low, indicating normal nitrogen cycling without significant contamination.

Phosphate (PO_4^{3-}): Phosphate concentrations ranged from 0.2 to 3.6 mg/kg. These values indicate moderate phosphorus availability typical of tropical soils. No evidence of excessive phosphate accumulation from agricultural runoff or waste disposal was observed.

Chloride (Cl^{-}): Chloride concentrations ranged from 0.3 to 2.7 mg/kg. The very low chloride concentrations confirm the absence of salinity intrusion or contamination from industrial effluents.

BTEX: BTEX compounds were not detected in any soil sample. This establishes an excellent baseline environmental condition against which future operational monitoring can be undertaken.

Soil Texture: Particle size analysis indicates that the soils are predominantly loamy, comprising approximately: Sand: 11 to 88%, Loam: 21 to 83%, Clay: 0 to 19%, Silt: 0 to 19%. The predominance of loam indicates favourable physical characteristics, including moderate permeability, good aeration, satisfactory water-holding capacity and suitability for supporting vegetation.

Soil Microbiology

***Escherichia coli* (E. coli):** *E. coli* populations ranged from 2 to 26 mg/100 kg. The presence of *E. coli* is expected in natural tropical soils because of wildlife activity, livestock grazing and decomposition of organic materials. The observed levels do not indicate significant anthropogenic contamination.

Fungal Population: Fungal counts ranged between 12 and 430 mg/100 kg. The presence of fungi reflects healthy microbial activity responsible for organic matter decomposition, nutrient recycling and maintenance of soil fertility. Variations among sampling locations are attributable to differences in vegetation cover, moisture content and organic matter availability.

Vegetation and Wildlife Characteristics

The proposed project site itself is predominantly open with sparse herbaceous vegetation and patches of exposed lateritic soil resulting from previous land preparation and anthropogenic disturbances. The surrounding landscape consists largely of cultivated farmlands interspersed with secondary vegetation and remnant woody species. No primary forest, riparian forest, protected woodland or ecologically sensitive vegetation communities were observed within the proposed development footprint. Vegetation density increases away from the immediate project footprint, particularly along seasonal drainage depressions and low-lying areas where shrubs and small trees occur in relatively denser clusters. The field survey also revealed mature scattered trees within cultivated fields, with several trees supporting large active termite mounds around their bases. These mature trees provide shade and contribute to the ecological integrity of the surrounding landscape.

Floral Composition

The vegetation observed during the survey comprised predominantly Guinea Savannah species commonly associated with northern Nigeria. The vegetation observed during the field survey is representative of the Northern Guinea Savannah ecosystem commonly found across Kaduna State and northern Nigeria. Field

observations identified a mixture of indigenous and introduced plant species comprising mature trees, shrubs, herbaceous vegetation and cultivated crops. The dominant vegetation recorded during the survey includes the following:

Trees

- Shea Tree (*Vitellaria paradoxa*)
- African Locust Bean (*Parkia biglobosa*)
- Neem (*Azadirachta indica*)
- Mango (*Mangifera indica*)
- Fan Palm (*Borassus aethiopum*)
- Jujube (*Ziziphus* spp.)
- Various indigenous savannah tree species

Shrubs

- Mixed secondary woody shrubs
- Regenerating savannah shrub species
- Seasonal bush vegetation

Herbaceous Vegetation

- Guinea Savannah grasses
- Annual herbs
- Broadleaf weeds
- Agricultural weeds commonly associated with cultivated fields

Cultivated Crops

- Maize (*Zea mays*)
- Other seasonal food crops observed within neighbouring farmlands

Faunal Composition

Faunal observations recorded during the field survey were characteristic of a disturbed Guinea Savannah agroecosystem. The most conspicuous vertebrate fauna observed within and around the proposed project area were grazing cattle, confirming that portions of the surrounding landscape are utilised for livestock grazing alongside crop cultivation. The survey also recorded numerous active termite mounds distributed across the project area and its surroundings, particularly around mature trees and

within open grassland. These mounds are indicative of active termite colonies (Macrotermes spp.), which contribute significantly to soil aeration, organic matter decomposition, nutrient recycling and improvement of soil structure. The abundance of termite mounds further reflects the ecological importance of soil macrofauna within the Guinea Savannah ecosystem. Apart from grazing livestock and termite colonies, no other wildlife species were directly observed during the field survey. Likewise, no evidence of breeding sites, wildlife corridors, nesting colonies or habitats of conservation significance was encountered within the proposed project footprint.

Ecological Significance

Overall, the proposed project site comprises a modified Guinea Savannah ecosystem dominated by agricultural land use and secondary vegetation. The floral communities are representative of common savannah vegetation widely distributed across Kaduna State and northern Nigeria, while the faunal component recorded during the survey was dominated by grazing cattle and abundant termite colonies. The vegetation provides local ecosystem services including erosion control, carbon sequestration, microclimate regulation and maintenance of soil stability, whereas termite activity contributes to nutrient recycling, soil aeration and organic matter decomposition. Given the absence of unique vegetation communities, protected habitats, threatened flora or fauna, or other species of conservation concern, the ecological value of the project area is considered **low to** moderate. Consequently, the anticipated impacts associated with vegetation clearance are expected to be site-specific, localized and readily mitigated through implementation of appropriate vegetation management and ecological restoration measures during project implementation. This baseline description provides the reference condition against which potential project-related impacts on terrestrial flora and fauna will be assessed in subsequent sections of the ESIA.

Socio-economic and Health Studies

The socio-economic survey collated baseline socio-cultural, economic and infrastructural indices of the study areas, while the consultation process elicited responses on stakeholders' concerns and expectations from the proposed project. This study is an integral part of the environmental and social impacts management and overall sustainable development arrangement. The objectives of the socio-economic survey include:

- Study and documentation of the socio-economic and cultural situation of the project area.

- Determining the impacts of the project on settlements, cultural treasures, population, social and physical infrastructures, predominant economic structures and the baseline health status of the people.
- Documenting the views of the affected population, industries and other relevant institutions/agencies in terms of environmental problems, perceived community problems and needs; and
- The engagement of stakeholders, with a view:
    - to enabling the stakeholders, understand the project processes and cycle;
    - to consider the views and opinions of stakeholders concerning the construction, operation and decommissioning of the project.
    - to developing and maintaining a robust relationship among the GVLNG Limited and the project affected communities
    - to prevent any form of social unrest among various levels of stakeholders that might arise from the development of the proposed project.

Consultations

It involves information dissemination and interaction/dialogues with identified stakeholders (including communities within the project vicinity) on the EIA of the proposed project. Interaction with people and eliciting feedback allows the affected populations to influence the decision-making process by raising issues that should be considered in project design; mitigation; monitoring and management plans; and the analysis of alternatives.

Methodology

This section describes the research design, study area, sampling strategy, data collection methods, and analytical techniques employed in the socioeconomic assessment of Afaka Village. The methodology was designed to ensure comprehensive coverage of the community and to generate reliable and representative data for the ESIA.

Study Area

The study area for this socioeconomic assessment is Afaka Village, located in Rigasa District, Igabi Local Government Area of Kaduna State. The village is the immediate host community for the proposed CNG Mother Station Project. The proposed

Installation of a Compressed Natural Gas (CNG) Mother Station along the AKK Pipeline at Afaka Community, Rigasa District, Igabi Local Government Area of Kaduna State.. The study focused specifically on the residential areas within the village, covering all households identified during the field survey.

Data Collection

Data for this socioeconomic assessment was collected through multiple methods to ensure triangulation and validation of findings. The primary methods employed were household surveys, key informant interviews, direct field observations, and secondary data review.

Household Surveys: A structured questionnaire was administered to 60 households in Afaka Village.

Key Informant Interviews: In addition to household surveys, key informant interviews were conducted with community leaders and stakeholders.

Direct Field Observations: The study team conducted direct observations of the community's physical environment, housing conditions, infrastructure, and daily activities.

Secondary Data: Secondary data was obtained from published and unpublished sources, including the 2006 National Population Census, reports from the Kaduna State Ministry of Environment, literature on Igabi Local Government Area, and previous ESIA reports for similar projects in the region.

Demographic Characteristics

Afaka Community is strategically located along the Kaduna-Abuja transportation corridor and is accessible through a network of major roads linking it to Rigasa, Kaduna metropolis, and neighbouring communities. The community is situated approximately 3 kilometres from Rigasa town and about 1 kilometre from the Nigerian Defence Academy (NDA).

Administratively, Afaka falls under Rigasa District in Igabi Local Government Area. The community operates under a traditional governance system that complements the formal local government administrative structure. Traditional institutions play an important role in maintaining peace, resolving disputes, mobilising community members for development activities, and facilitating communication between government agencies and residents.

The area has experienced significant population growth over the years due to urban expansion, migration, commercial activities, and its proximity to Kaduna city. The

growing population has increased demand for housing, infrastructure, employment opportunities, healthcare services, and educational facilities.

Traditional Governance Structure: The District Head serves as the highest traditional authority within the district and provides leadership on matters affecting the communities under his jurisdiction. The Village Head oversees local community affairs and works closely with elders, youth leaders, and women leaders to ensure effective administration and community development.

Community elders provide advisory functions and contribute to decision-making on issues relating to land, culture, security, and social welfare. Youth and women leaders represent their respective groups and facilitate communication between community members and traditional authorities.

The traditional institution was actively engaged during the stakeholder consultation process and played a significant role in mobilising community members for the socioeconomic survey and public consultation meetings.

Ethnicity and Cultural Heritage: The study area is culturally diverse and consists of both indigenous and settler populations. The dominant ethnic groups found within Rigasa District and Afaka Community include Hausa, Fulani, Gbagyi, and other ethnic groups that have migrated to the area for economic, educational, and commercial reasons.

Hausa is the most widely spoken language and serves as the principal medium of communication among residents. English language is commonly used in schools, government institutions, and formal engagements.

Islam is the predominant religion within the study area, accounting for approximately 95 percent of the respondents surveyed. Christianity is also practised by a smaller proportion of residents, contributing to the cultural diversity of the community. The relationship between adherents of the two faiths is generally peaceful, with both groups participating in community development activities.

Population Size and Households

Rigasa District is recognised as one of the most densely populated areas in Kaduna State and among the largest urban settlements in Nigeria. Available demographic estimates indicate that the district has a population exceeding three million residents.

For the sake of this study, a total of 300 valid questionnaires were administered and analysed during the socioeconomic survey. The respondents were drawn from households located within Afaka Community and surrounding areas within the project's area of influence.

Gender Distribution

Gender composition is an important indicator for understanding community structure and participation in socioeconomic activities.

The survey results indicate that males constituted the majority of respondents, accounting for 55 percent of the total sample, while females accounted for 45 percent.

Age Distribution

The age structure of a population provides an indication of the available labour force and the level of economic activity within a community. The survey findings show that the majority of respondents fall within the economically active age group of 18 to 40 years. This age category accounted for 65 percent of respondents. Individuals aged between 41 and 60 years constituted 30 percent, while respondents above 60 years accounted for 5 percent.

Religion

Religion plays an important role in shaping cultural practices, social interactions, and community values within the study area.

The survey revealed that Islam is the dominant religion, representing 95 percent of respondents. Christianity accounted for 5 percent, while no respondents identified with traditional religious practices

Marital Status

Marital status influences household responsibilities, economic commitments, and social relationships within communities.

The survey results show that married respondents constituted the largest proportion of the sample, accounting for 60 percent. Single respondents represented 35 percent, while divorced and widowed respondents accounted for 5 percent.

Household Size

Household size is an important socioeconomic indicator because it influences housing demand, income allocation, healthcare needs, educational expenditure, and access to social services.

The survey findings indicate that households containing between six and ten persons were the most common, accounting for 45 percent of respondents. Households with one to five members represented 40 percent, while households with more than ten members accounted for 15 percent.

Main Occupations

The economic activities of the study area are diverse, with agriculture remaining the dominant source of livelihood. Other activities include trading, artisan work, civil service, and informal labour.

The survey results show that farming is the most common occupation, accounting for 50 percent of respondents. This is followed by trading at 25 percent, while civil servants and artisans each account for 10 percent. A small proportion of respondents (5 percent) are engaged in other forms of livelihood activities.

Monthly Income Levels

Household income levels within the study area are generally low, reflecting the subsistence nature of many economic activities.

The survey shows that 45 percent of respondents earn less than ₦30,000 per month. About 30 percent earn between ₦31,000 and ₦60,000, while 15 percent earn between ₦61,000 and ₦90,000. Only a small proportion of respondents earn above ₦90,000 per month.

Education and Health

Education and healthcare are important indicators of the social well-being and development status of any community. This section presents the educational profile of respondents, the availability of healthcare services, common health challenges, and healthcare utilization patterns within the study area.

Information obtained from the household survey, stakeholder consultations, and field observations was used to assess the existing conditions relating to education and health in Afaka Community and surrounding settlements.

Healthcare Facilities and Common Diseases

Access to quality healthcare services is essential for maintaining the health and productivity of community members. The study area is served by a combination of Primary Healthcare Centres (PHCs), private clinics, hospitals, pharmacies, and patent medicine stores.

The survey results indicate that 50 percent of respondents rely primarily on clinics and primary healthcare centres for medical services, while 40 percent access hospitals. However, 10 percent of respondents reported that the nearest healthcare facility is located more than five kilometres from their residence.

Waste Disposal Practices

Waste disposal practices in the community are also inadequate. The survey data shows that 100 per cent of households dispose of their rubbish through open dumping or burning, with no collection services available.

Community Support Level

The household survey conducted as part of this socioeconomic assessment provides quantitative data on community support for the proposed project. The survey found that 30 per cent of respondents fully support the project, 65 per cent support the project with conditions, and 5 per cent do not support the project.

Perceived Benefits

Respondents were asked to identify the benefit they consider most important from the proposed project.

The survey results indicate that employment creation is the most anticipated benefit, accounting for 60 percent of responses. Business opportunities account for 20 percent, while improved roads and other community development initiatives account for 15 percent. Cleaner and more affordable energy was identified by 5 percent of respondents.

Concerns and Fears

Although support for the project is high, stakeholders also expressed concerns regarding potential environmental and social impacts.

The survey results show that concerns about pollution and health impacts constitute the highest fear among respondents, accounting for 45 percent. Concerns regarding accidents account for 30 percent, while 15 percent expressed fears about possible

increases in the cost of living. Ten percent of respondents reported having no significant concerns.

Community Demands and Expectations

Stakeholders were asked to identify the most important action they expect from the project proponent.

The survey findings reveal that local employment is the most significant expectation, accounting for 55 percent of responses. Construction of schools, healthcare facilities, and other community development projects account for 25 percent. Formal community agreements account for 15 percent, while monthly stipends account for 5 percent.

ES 5 ASSOCIATED AND POTENTIAL IMPACTS

Preliminary Identification and Screening

In line with recommended impact assessment approaches (FMEnv, 1995; UNEP, 1996; Canter, 1996; DPR 2002, Lohani, *et al*., 1997), the first level of impact assessment involves the preliminary identification and screening of potential environmental impacts by anticipating activity-environment interactions. This requires a thorough understanding of the project activities (project description), the project setting (the environmental and social characteristics), and the interaction with environmental components. A modified Leopold matrix (Leopold, 1971) was used for the identification and screening. The matrix arrays project activities against environmental (biophysical, social and health) components, and supports a methodical, comprehensive, and objective identification of the impacts that each distinct project activity may have on the biophysical, social, and health components.

Modified Leopold Matrix Screening

The modified Leopold impact matrix consists of a horizontal list of biophysical and social environment components that could be affected by the proposed project activities versus a vertical list of project activities, which represent environmental aspects, or "sources of impact," associated with each sub-project phase. Environmental aspects are elements of an activity that can or will interact with the biophysical, social and health conditions within the area of influence.

Impact Severity Evaluation

During detailed assessment, five criteria were used to assess the severity of the environmental (biophysical, social, and health) impacts that were not screened out in the earlier steps.

The severity criteria set forth in this section are applicable to all types of impacts identified, including impacts that can be expected from the project and impacts resulting from emergencies. Several types of potential consequences (or impacts) were considered for all project stages where applicable:

- Biological and physical environment
- Social environment
- Health and Safety of the public or workers

The detailed assessment of impacts involved evaluating the potential effects of project activities on the impact indicators but in greater detail. Impacts were assessed as to whether they are positive (beneficial) or negative (detrimental). Only negative impacts were given a detailed assessment.

Impact Identification

Impact prediction considers any mitigation, control and operational management measures that are part of the project design and project plan. Social, economic and biophysical impacts are inherently and inextricably interconnected. Change in any of these domains will lead to changes in the other domains.
Direct impacts of the project result from construction, maintenance and operation of the facility. The most significant project-related impacts are those related to site preparation activities, construction and operation/maintenance. The environmental aspects of the proposed project were teased out from the planned Project Activities description. These aspects were then matched with the existing baseline description of the Project Environment and used to develop a checklist of potential and associated impacts of the proposed project. From the planned project implementation, four major phases could be identified:

- Site Preparation (Pre-Construction Phase)
- Construction Phase
- Post Construction phase
- Decommissioning Phase

Summary of Impact

Increase in Income from Transportation

During the Project implementation, there will be transportation of workers, equipment, and supplies to and from the project area by road. Nigerian companies involved in road transportation will benefit directly from the increase in demand for transportation services related to the project. Although specific estimates of income generation associated with this business opportunity are presently hard to determine, it is

anticipated that 98% or more of the transport business will be handled by Nigerian Companies drawing workers from both within and outside the project area.

Increase in Income from Employment

A number of Nigerians (local area indigenes and others) will be employed during the implementation of the project activities. A number of people will be employed over the project implementation period. The project labour requirements include a mix of local, national, and expatriate workers, based on need and skills, and prioritised for the recruitment of nationals. The Project will be executed largely by local contractors, so a number of jobs will be filled by local and national workers with additional support from expatriates and other developing country Nationals. Detailed identified impacts of the project are presented in chapter five of this report.

ES6 MITIGATION MEASURES

Mitigation measures are options that can be used to either completely eliminate or minimize identified negative impacts of a development project. The traditional approach to design and operations is to ensure compliance with the applicable safety codes and standards during design. However, compliance with regulations, codes and standards may not be sufficient to achieve an appropriate level of Health Safety and Environmental (HSE) performance in design. Design codes are generic and applicable to facilities in a number of geographical areas that face a wide range of technical challenges unique to the project. The design of the proposed project is based on the best practices of international codes.

General Mitigation Measures

General mitigation measures encompass those measures built into the engineering design or operational design of the project. These measures are environmental, social, and health best practices, most already in use by the project sponsors in their operations or proposed as operational controls during the project execution. Some mitigations are however specific to impacts associated with particular activities of the various project activities. Many general mitigation measures have been developed and adopted by the project before the ESIA process commenced; therefore, the impact assessment has already applied them in assessing the project impacts. Furthermore these measures were incorporated into the GVLNG Limited Project-design considerations and project implementation planning as part of the overall operational controls and ESMP for the project.

These mitigations will be incorporated into plans and procedures that contractors will follow to ensure the protection of the environment. The measures will be implemented by GVLNG directly, and passed on through contractual commitments to its

contractors, subcontractors, and suppliers. Further details about the content of each plan and operational control are provided in Chapter 7.

ES 7 ENVIRONMENTAL MANAGEMENT PLAN (EMP)

Environmental and Social Management Plan (ESMP) is the essential component of an Environmental and Social Impact Assessment (ESIA) that provides the assurance that the mitigation measures developed for reducing the effects of adverse associated and potential impacts to as low as reasonably practicable (ALARP) as well as those proposed for enhancing beneficial impacts are implemented and maintained throughout the project lifecycle.

EMP Objectives

The objectives of this EMP are:

- To demonstrate that a systematic procedure, which ensures all project activities are executed in compliance with applicable legislations and GVLNG policies on Health, Safety, Environment, Security and Community Relations have been established for the project;
- To show that mitigation measures for all impacts have been established and shall be maintained throughout the project life cycle, so that impact risk levels will remain ALARP;
- To demonstrate that emergency response measures will be in place. This will ensure that adequate responses in case of emergency have been established for the project; and
- To set out the structure that will ensure compliance to the EMP by GVLNG and its contractors.

Management Organization

In accordance with regulatory requirements, GVLNG has established a HSE organization structure that defines roles, responsibilities and authority to put into practice an effective HSE Management System, including undertaking any training necessary to do so.

During pre-operations activities, all instructions and official communications regarding environmental matters shall follow the generic organogram. The organizational structure identifies and defines the authority structure, and the communication structure for the various parties involved in the construction of the proposed development. The structure may require revision as the project unfolds.

Training

GVLNG shall identify, plan, monitor, and record HSE training needs for personnel whose work may have a significant adverse impact upon the environment or social conditions. GVLNG recognizes that it is important that employees and Contractors at each relevant function and level are aware of GVLNG's environmental, social, and health policy; potential impacts of their activities; roles and responsibilities in achieving conformance with the policy and procedures.

This will be achieved through a formal HSE training process. It is expected that employee training will include awareness of and competency with respect to:

- Environmental and social impacts that could potentially arise from their activities;
- Necessity of conforming to the requirements of the EIA and EMP, in order to avoid or reduce those impacts; and
- Roles and responsibilities to achieve that conformity, including with regard to change management and emergency response.

The HSE Manager is responsible for coordinating the training, maintaining employee-training records, and ensuring that these are monitored and reviewed on a regular basis. The HSE Manager will also periodically verify that staffs are performing competently through discussion and observation.

Employees responsible for performing site inspections shall receive training drawing on external resources as necessary. Training will be coordinated by the HSE Manager and/or Human Resources Manager prior to the beginning of construction activities. Upon completion of training and once deemed competent in the requirements, staff will be allowed to train other people. Similarly, GVLNG shall require that each of the Contractors institute training for its personnel. Each Contractor is responsible for site HSE awareness training for personnel working on the job sites. The Contractor is also responsible for identification of any additional training requirements to maintain required competency levels.

The GVLNG training program will be subject to audit to ensure that:

- Training programs are adequate;
- All contractor requiring training have been trained; and
- The Contractor has periodically verified that its personnel perform competently after training.

Environmental Monitoring Plan

An Environmental Monitoring Plan is a systematic schedule for the collection of

environmental data through a series of repetitive measurements. UNEP (1996) describes three known types of environmental monitoring within the conceptual EIA (or ESIA) framework as follows:

- ***Baseline Monitoring***: This refers to the measurements of environmental parameters during the pre-project period;
- ***Effects Monitoring***: This involves the measurements of environmental parameters during project construction and implementation so as to detect changes in these parameters which can be attributed to the project; and
- ***Compliance Monitoring***: It is the periodic or continuous measurement of environmental parameters or discharges to ensure that regulatory requirements and standards are met. Compliance monitoring can further be broken down into:
    - Mitigative measures monitoring, which relates to the prescribed mitigation measures put in place by the pre-project EIA to the existing operational structure of the project, and
    - Regulatory compliance monitoring, which compares the regulatory monitoring requirements to the existing operational, occupational and environmental parameters.

GVLNG shall adopt a systematic monitoring schedule that will comprise both effects and compliance monitoring plans for the implementation of the proposed LNG Project. Baseline requirements are already embodied in Chapter 4 of this report and are, therefore, not considered in this chapter. The monitoring schedule prescribed by this ESIA shall be implemented as the Post-ESIA Monitoring Programme by GVLNG.

Scope of the Environmental Monitoring Plan

The Environmental Monitoring Plan shall cover two types of monitoring activities as follows,

- Monitoring of compliance with mitigation measures during site preparation, construction and operation activities;
- Effects-environmental monitoring, which includes sampling and analyses of discharges and the recipient environmental components during site preparation, construction and operational activities.

The monitoring programme under the plan shall establish the specifics of the environmental and socioeconomic monitoring parameters for each component of the environment that will be affected by the proposed project. The components shall include:

- Air quality
- Noise
- Water quality (surface and sub-surface water qualities)
- Hydrology
- Hydrobiology and fisheries
- Waste management
- Traffic and transport
- Personnel health and safety
- Public health and safety
- Socio-economic and community health impacts

Based on the project activities, predicted impacts and recommended mitigation measures, the monitoring programme is considered adequate for the project.

ES 8 DECOMMISSIONING AND ABANDONEMENT

This section presents the plans that have been put in place by GVLNG to recover and/or restore the project site to its original state after the project's life cycle. Remediation plans after decommissioning require a sound understanding of all the environmental components of the project on the ecosystem during its lifespan. It is therefore a best-practice requirement to take this component into cognisance even at the conceptualisation of the project. After decommissioning, there are various restoration options as it relates to the environment where the project once existed. These options include:

- Remediation to pre-project state or condition.
- Partial remediation.
- Remediation to an acceptable alternative condition.
- No remediation.

For the proposed project, GVLNG proposes to adopt a combination of partial remediation and complete remediation to acceptable state.

Decommissioning Activities

The major activities that will be carried out during the decommissioning phase include:

- Dismantling and removal of LNG plant and other ancillary equipment.
- Excavation, dismantling and removal of all underground cables, water pipes and other facilities.

- Removal of all structures including administrative office buildings etc.

The recommended remediation measures are expected to mitigate the possible resultant negative impacts of this decommissioning phase on the environment.

Site Remediation

The remediation measures depend on the environmental/social characterization of the project area as well as the predicted potential and associated impacts. However, the following measures shall be planned for implementation after decommissioning/closure. All equipment and debris shall be removed from the environment and disposed of in an environmentally friendly manner. The mode of disposal of these shall include the following:

- Gas pipes shall be sold to steel making industries or for other commercial uses.
- Excess laterite from excavated portions shall be used to fill other failed portions around the project area or sold off as inputs in the building industry.
- Plant debris shall be cut into pieces and carted away by accredited waste management consultant or used as organic manure.
- Administrative buildings shall be leased out or used for other purposes.
- Reinstatement of all excavated routes to their original status to minimize negative impacts.
- Grading of site to its original topography to prevent erosion.
- Good waste management plan shall be put in place.

ES 9 CONCLUSIONS AND RECOMMENDATIONS

Based on the detailed description of baseline environmental characteristics, impact assessments, mitigation measures, and the Environmental Management Plan (EMP) presented in this Environmental and Social Impact Assessment (ESIA) report for the Proposed CNG Compression Station Project at Rigasa Community, Igabi LGA, Kaduna State. It is concluded that:

- The technology, equipment, and facilities proposed for the CNG facility are among the most cost-effective and environmentally friendly available. These technologies have been successfully utilized by other developers in across the world and have proven to be both efficient and sustainable.
- Safety distancing shall be maintained between the gas storage tanks and other buildings, while the generator house will be adequately soundproofed to minimize noise pollution in the surrounding office environment.

- The project is expected to yield several positive impacts, including the creation of employment opportunities, improved gas availability, and increased local income.
- Negative impacts have also been identified, such as potential air, water, and soil pollution, soil erosion, increased noise levels, pressure on limited infrastructure, and the possible proliferation of sexually transmitted diseases (STDs). However, with the recommended mitigation measures, these impacts can be effectively reduced to minor and negligible levels.

Recommendations

GVLNG Limited has demonstrated a strong commitment to implementing this project in an environmentally responsible manner. The use of best available technology and the existing good relationship with host communities provide a solid foundation for the successful implementation of the proposed CNG facility. In light of this, the following recommendations are made:

- All project activities from the planning and construction phases through to operations should be closely monitored by relevant environmental regulatory agencies to ensure compliance with environmental standards.
- GVLNG should strictly adhere to all design and construction specifications, including the mitigation measures and the Environmental Management Plan (EMP) as outlined in this report.
- Continuous consultation with relevant stakeholders, including host communities, should be maintained to foster transparency, cooperation, and the successful implementation of the project.
- The mitigation measures prescribed in this report must be fully implemented by GVLNG and its contractors, with strict adherence to regulatory guidelines and standards throughout the project lifecycle.
- GVLNG should enforce all safety programs outlined in this report, particularly those related to worker safety during all project phases.
- Emergency response procedures should be continuously improved and adhered to throughout the lifecycle of the LNG facility to ensure swift action in the event of any unforeseen incidents.

ACKNOWLEDGEMENT

Greenville LNG Limited (GVLNG) wishes to express her appreciation to the Federal Ministry of Environment, Kaduna State Environmental Protection Authority, the Project host Community as well as Zipod Environmental and Engineering Services Limited (The Environmental Consultant) and other stakeholders for their support during the Environmental and Social Impact Assessment of this CNG Compression Mother Station Project. You all made the work possible, Thank you.

CHAPTER ONE: INTRODUCTION

1.0 Background

Natural gas is one of the most sought energy sources globally. This is because it is a cleaner source of energy compared to diesel, coal and wood, and also cheaper than most other fossil fuels. Nigeria has abundant gas reserves in a number of gas fields, mostly in remote locations within and around the Niger Delta area. The country has not fully harnessed the economic potential of its gas resources due to various factors, which include a lack of infrastructure. Thus, useful gas resources have been either flared or remain stranded in remote areas. Gas gathering, processing and transportation infrastructure in Nigeria is grossly inadequate, which has greatly hampered the industrial growth of the country. Therefore, the implementation of the Greenville LNG Project offers an opportunity to harness Nigeria's natural resources for use across the country, particularly in locations not served by pipeline infrastructure. The project, therefore, aligns with the Federal Government's policies:

- To reduce gas flaring.
- To monetize gas resources.
- To improve energy availability across the country through its gas-to-power initiative.

1.1 The Project Proponent

Greenville Liquefied Natural Gas Company Limited (GVLNG) was founded in 2015 and is a Nigerian private company based in Abuja, FCT, Nigeria**.** Greenville Liquefied Natural Gas Company Limited (GVLNG), formerly Greenville Oil and Gas Company Limited (GOGCL).

In compliance with the provisions of the Nigeria Environmental Impact Assessment (EIA) Act No 86 of 1992 (now codified as the EIA Act CAP E12 Law of the Federation of Nigeria, 2004), as well as international environmental best practices GVLNG Limited wishes to subject the proposed plant upgrade project to an EIA process. Despite the laudable benefits associated with the proposed project, it could be associated with some significant environmental, social and health hazards/impacts that need to be carefully identified and appropriately avoided or mitigated, hence the EIA study. This Environmental Impact Assessment (EIA) identified the likely impacts that could arise from the proposed project activities and then proffer mitigation measures to ameliorate adverse impacts and enhance the beneficial ones. For the conduct of this study GVLNG Limited Commissioned Messr *Zipod Environmental Consultancy and*

Energy Services Limited to carry out the Environmental Impact Assessment (EIA) of the proposed LNG plant upgrade.

1.2 Project Location and Accessibility

The proposed project would be sited on a 10ha of land at Rigasa, Igabi Local Government Area, Kaduna State. The proposed project site falls within the following geographical coordinates: 10°35.364'N, 7°21.633'E**.**

Figure 1.1: Nigeria Showing Kaduna State.

Figure 1.2: Kaduna State showing Igabi LGA in Blue Colour

1.3 Terms of Reference for the ESIA

In line with the ESIA Procedural Guidelines of the Federal Ministry of Environment (FMEnv, 1995), World Bank/International Finance Corporation (IFC) Performance Standards, the terms of reference (ToR) for ESIA of the GVLNG CNG Mother Station Project was submitted to the FMEnv by GVLNG. The ToR defined the scope of work, objectives, baseline data requirements and assessment tools and methods for the ESIA. The document also outlined the regulatory and administrative framework within which the ESIA would be conducted and highlighted the key issues / activities of environmental concern in the proposed project planning and implementation.

1.4 ESIA Objectives

The objectives of the ESIA of the GVLNG CNG Mother Station Project are:

- To provide information and evidence needed for developing an Environmental Impact Statement (EIS) for the proposed project in its entirety;
- To generate all the necessary data for establishing the environmental baseline conditions of the proposed project area;
- To demonstrate that a systematic approach has been adopted in identifying, evaluating and characterizing as well as proffering cost-effective mitigation.

- To develop a Social and Environmental Management Plan (SEMP) for all phases of the proposed project.

1.5 ESIA Methodology

The collection of environmental baseline data/information, environmental impact analysis and the preparation of the report were performed by a multi-disciplinary team. The team selection was based on characteristics of the project environment and experience/discipline of each specialist. A team leader coordinated the tasks and team members towards achieving set targets as well as liaison with client. The methods adopted in performing specific tasks of the ESIA for the proposed Plant Upgrade Project are as follows:

1.5.1 Desktop Research

The geography and the relevant environmental, socio-economic and health information on the proposed project location were gathered from maps, charts, articles, previous study reports on the area and similar environment, photographs, fisheries research publications, textbooks, etc. The information generated enabled definition of limits of the area to be assessed. Data gap analysis was carried out to identify areas where additional information was required and the result was used in planning the execution of field sampling/measurement aspects of the ESIA project.

1.5.2 Field Data Collection

The information gathered from desktop consultation and site identification was used in categorising the major habitats in the area, and their respective sampling requirements defined to effectively collect qualitative and quantitative data on the flora and fauna of the project area. The fieldwork covered all relevant elements of the ecological, socio-economic and health conditions to complement information obtained from desktop studies.

1.5.3 Consultation with Stakeholders and Experts

In order to more efficiently deliver improved project sustainability and protect the interest of the affected communities, especially the poor and vulnerable, an elaborate public consultation process was undertaken as part of this ESIA. It involved engaging them in a dialogue characterized by two-way information flow.

Consultation allowed obtaining from the affected population information that might influence the decision-making process in scoping, project design, mitigation, monitoring and management plans, as well as the analysis of alternatives to be implemented.

The decision-making and the representatives of the host communities were consulted (as appropriate) for their opinions on issues relating to the potential ecological, socio-economic and health impacts of the proposed project.

1.5.3.1 Stakeholder Engagement Activities

Stakeholder engagement is a two-way process of communication between the project proponent and its stakeholders. It is a key aspect of the ESIA process, allowing stakeholders to express their views about Project. It involves sharing information and knowledge, seeking to understand the concerns of others and building relationships based on collaboration, thereby allowing stakeholders to understand the risks, impacts and opportunities of a project in order to achieve positive outcomes.

This section focuses on stakeholder engagement activities that have been carried out to date in support of the ESIA process for the Project

1.5.3.2 Objectives of Stakeholders Engagement

The objective of the engagement process is to present the proposed project and ESIA process to stakeholders and to identify associated potential issues, concerns and opportunities. This phase involved: identification of preliminary list of stakeholders; meetings with a number of government departments and stakeholder groups; and focus group discussions with local community members.

Specifically, GVLNG Limited and her consultants consulted the following organizations:

- Federal Ministry of Environment;
- Kaduna Environmental Protection Authority (KEPA)
- Igabi Local Government Area Council
- Rigasa Community

1.5.3.3 Stakeholder Engagement Planning

The stakeholder engagement process followed the requirements of the Nigerian Environmental Impact Assessment Act No 86 (1992) as amended by EIA Act Cap E12 LFN 2004, and was also guided by environmental and social policies, guidelines and performance standards of the World Bank Group. To fulfill these requirements, the Project developed a plan for engagement with stakeholders that was aligned to key stages of the ESIA process. The plan included the following key steps.

- Identification of stakeholders and mechanisms for their engagement (meetings, letters, press releases, etc);
- Development of project information for and a Background Information document (BID) to convey high level project information and provide an overview of the project and potential impacts; and

- Identification of where in the ESIA process certain stakeholders should be contacted and how'

1.5.3.4 Screening/Scoping Workshop

In line with international best practices on environmental management, a Screening/Scoping Workshop for the proposed project was held at Rigasa Community. In attendance were representatives of the Regulatory Agencies, the proposed project team, independent environmental consultants, Non-Governmental Organizations (NGOs) and representatives of the host communities,

Specifically, representatives from the following groups participated in the meeting:

- Federal Ministry of Environment (FMEnv)
- Nigerian Midstream and Downstream Petroleum Regulatory Authority (NMDPRA)
- Kaduna Environmental Protection Authority (KEPA)
- Igabi Local Government Area Council
- Rigasa Community

The objectives of the Screening/Scoping Workshop were the following:

- To enhance the process of identifying potential project impacts by assembling all stakeholders to the project;
- To provide opportunity for regulators and stakeholders to have a better outstanding of the project thereby allowing the relevant stakeholders' view and concerns to be integrated into the scope of the ESIA Study; and
- To identify potential environmental and social concerns early in the project cycle.

1.5.3.5 Disclosure

During disclosure, this ESIA report will be submitted to the FMEnv. The relevant authorities will determine the level of engagement required during disclosure of the ESIA report and meetings with the local communities. The objective of this engagement would be to explain the results of the ESIA and to obtain feedback. The ESIA report will also be disclosed in the Africa Development Bank and World Bank's InforShop, an online, resource center offering access to information on ADB and World Bank projects and programs to the public.

1.5.3.6 Grievance Mechanism

International standards require that a grievance mechanism be put in place. A grievance mechanism is a company process that enables any stakeholder to make a

complaint or a suggestion about the way a project is being implemented and that provides a mechanism for follow-up and resolution, if appropriate.

1.5.3.7 Impact Identification and Evaluation

The environmental aspects of the proposed project that may interact positively or negatively with the environment at the construction, operation and decommissioning phases were identified at this stage of the assessment. The FMEnv's EIA Sectoral Guidelines for Infrastructure projects, the World Bank Environmental Source Book and Risk Assessment report, among other information, were used in the process.

The ISO 14001 – Environmental Management System approach was adopted in evaluating the potential and associated impacts of the project on the environment.

1.5.3.8 Impact Mitigation

Mitigation measures designed to prevent, reduce or control the adverse impacts of the proposed project activities were proffered using professional judgment based on scientific deductions and project experience. Other resource materials also consulted include the FMEnv's EIA Sectoral Guidelines for Infrastructures projects, the World Bank Environmental Sourcebook, Risk Assessment Study report, etc. Similarly, enhancement measures were proffered to ensure that beneficial impacts of the project are optimized. Furthermore, post-auditing or monitoring has been designed into the social and environmental management plan of the proposed project to allow for continual operations improvement.

The flowchart presented as **Figure 1.3** summarizes the general approach adopted in this ESIA.

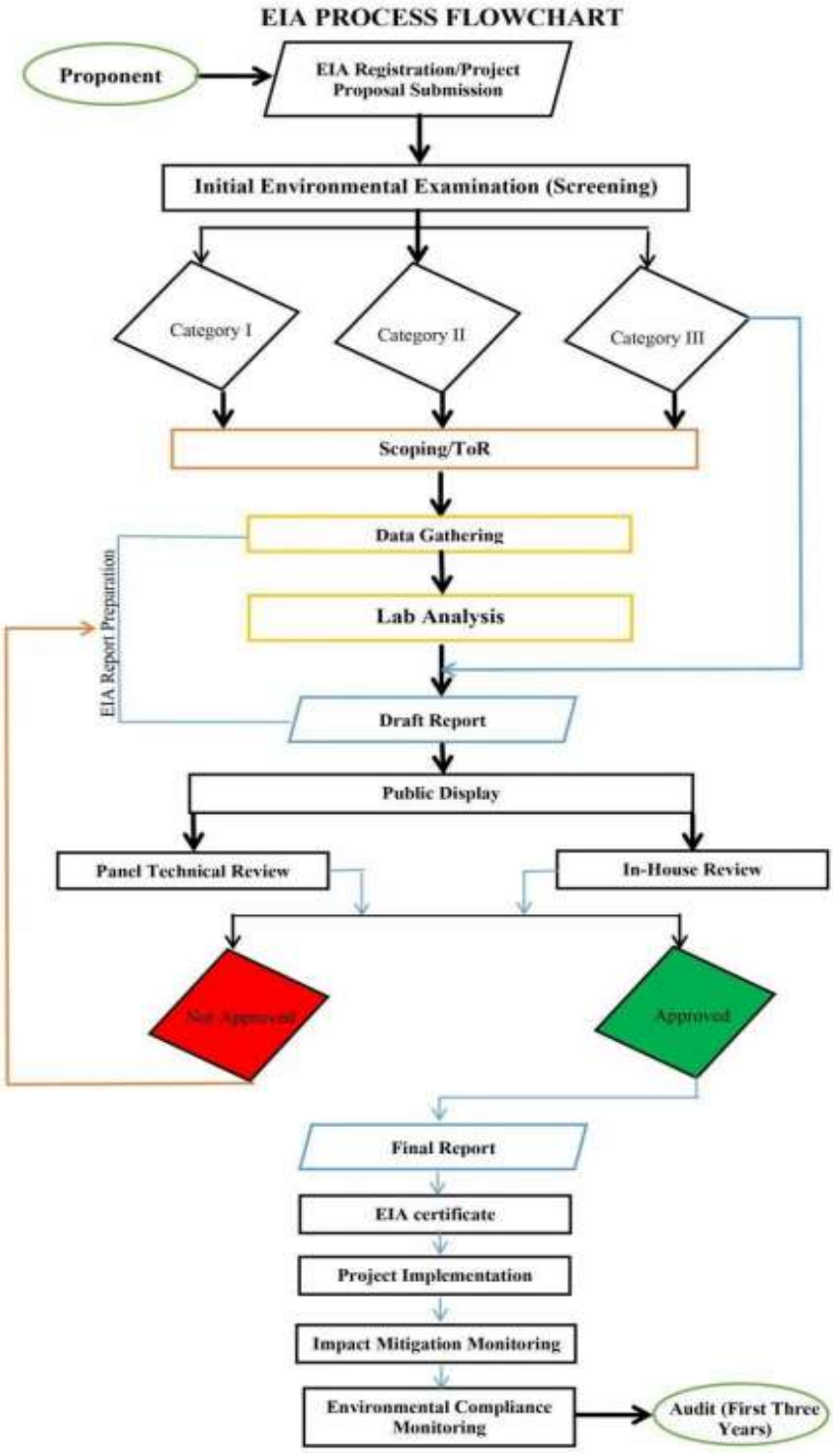

Figure 1.3: ESIA Flow Diagram

1.7 Legal and Administrative Framework for ESIA in Nigeria

The environment has emerged as one of the most critical issues of contemporary times, driven by the increasing negative impacts of rapid industrial development. As natural resources are exploited at unprecedented rates, environmental quality deteriorates, rendering many development projects unsustainable. This situation has necessitated the enforcement of environmental protection laws to safeguard and restore the Nigerian environment.

The requirement for an Environmental and Social Impact Assessment (ESIA) aligns with the Federal Republic of Nigeria's (FRN) laws and policies aimed at achieving sustainable development goals through environmental stewardship, public health protection, and social well-being. It also fulfills international requirements for projects of this scale, ensuring adherence to best practices in environmental and social safeguards. This section reviews relevant Nigerian legislation, guidelines, and international conventions applicable to infrastructure development. The legislative framework outlined here is drawn from federal and state laws, as well as international conventions and instruments to which Nigeria is a signatory. In accordance with the **Nigerian Environmental Impact Assessment (EIA) Act CAP E12 LFN 2004**, the potential environmental impacts of this project must be evaluated through an EIA process and documented in an Environmental Impact Statement (EIS). Screening of the project under Nigerian law confirmed the need for an EIA. Additionally, compliance with the **World Bank/International Finance Corporation (IFC)** requirements and the **African Development Bank's (AfDB) Environmental and Social Safeguard Policies** is essential for financing a project of this magnitude.

In line with Nigerian law and AfDB policies, public participation is integral to the ESIA process. The **World Bank/IFC Environmental and Social Standards** also require transparent stakeholder engagement and disclosure of information. As part of these requirements, the final ESIA has been published for public review and comment, ensuring compliance with regulatory standards and facilitating final approval and financing of the project.

This revalidated ESIA underscores adherence to all relevant environmental and social safeguards to guarantee the project's alignment with local and international best practices, thereby supporting its sustainability throughout its lifecycle.

The legal and regulatory framework for carrying out ESIA of the proposed plant upgrade Project are contained in GVLNG Limited's policies, relevant national statutes and international environmental conventions to which Nigeria is signatory. These include:

- Various National regulations, standards, codes and recommended practices;
- The Environmental Impact Assessment Act;
- The regulations, standards, codes and recommended practices of Kaduna Environmental Protection Authority (KEPA);
- GVLNG Company Limited's policies on health, safety and environment (HSE); and
- Applicable international guidelines and conventions to which Nigeria is signatory.

1.7.1 National Regulations

1.7.1.1 The Federal Ministry of Environment

The defunct Federal Environmental Protection Agency (FEPA) was created by Decree No. 58 of 1988 as a parastatal of the Federal Ministry of Works and Housing. In 1992, the Agency's authority was strengthened through Decree 59 of 1992 by which the defunct FEPA was transferred to the Presidency. FEPA's goals were to improve and maintain the quality of the Nation's environment, manage its resources and physical characteristics, prepare ecological Master Plan to guide the use of coastal areas rift with diverse and often conflicting economic and social activities.

In same year, Nigeria took a giant step towards the sustainable management of its environment by formulating a decree of Environmental Impact Assessment (EIA). This has become globally accepted as an environmental management tool. June (1999), Nigeria formed a bigger body, "The Federal Ministry of Environment" which include the defunct FEPA and other departments from different Federal Ministries and Parastatal. The Federal Ministry of Environment is charged with the responsibility of all matters concerning the nation's environment and its biodiversity.

It has developed instruments of intervention to halt environmental degradation in form of policies, standards, guidelines and regulations and programmes. With the initiation of these instruments, enforcement by FMEnv has become the most effective tool to bring industries and regulated community into compliance through compliance promotions. The relevant policies, guidelines and regulations of the ministry are outlined below:

National Policy on the Environment

In 1989, the Federal Government of Nigeria through the Federal Environmental Protection Agency established a National Policy on Environment (NPE) revised 1999 and 2016 with the goal of achieving sustainable development. Environmental

management in Nigeria is based on the NPE, as revised in 1999 and 2016. The goal of this policy is to achieve sustainable development, to:

- securing a quality of environment adequate for good health and well-being;
- promoting sustainable use of natural resources and the restoration and maintenance of the biological diversity of ecosystems;
- promoting an understanding of the essential linkages between the environment and economic development and encouraging individual and community
- participation in environmental improvement initiatives;
- raising public awareness and engendering a national culture of environmental preservation; and
- partnership among all stakeholders including government at all levels, international institutions and governments, non-governmental agencies and communities on environmental matters.

The action plans to achieve the policy objective include the following:

- that environmental aspects are considered in major economic decision-making processes;
- that an integrated environmental management approach is built into major development projects;
- that economic instruments and environmental reporting are employed in the management of natural resources;
- that the best practicable environmental technology is applied in major economic activities;
- that environmental impact assessment (EIA) is mandatory before any major development project is embarked upon; and
- that environmental monitoring and auditing is routinely carried out in major economic activities.

All environmental regulation in Nigeria is intended to align with the NPE. Based on this policy, the National Guidelines and Standards for Environmental Pollution Control in Nigeria were published.

National Guidelines and Standards for Environmental Pollution Control

These guidelines and standards were initiated in March 1991 sequel to the promulgation of the National Environmental Policy in 1989 revised in 1999 and 2016. This document is a basic instrument for monitoring and controlling industrial and urban pollution. The guidelines and standards relate to six (6) areas of concern, thus:

- Effluent limitations;
- Water quality or industrial water uses at point of intake;
- Industrial emission limitations;

- Noise exposure limitations;
- Management of solid and hazardous wastes, and
- Pollution abatement in industries.

National Environmental Protection Regulations

S. I. 8 -National Environmental Protection (Effluent Limitation) Regulations 1991

The National Effluent Limitation Regulation, S.I.8 of 1991, makes it mandatory for industries as waste generating facilities to install anti-pollution and pollution abatement equipment on site. The regulation is specific for each category of waste generating facility with respect to limitations of solid and liquid discharges or gaseous emissions into the ecosystem. Appropriate penalties for contravention are also prescribed.

S. I. 9 -National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations 1991.

National Environmental Protection (Pollution Abatement in Industries and Facilities Generating Wastes) Regulations, S.I.9 of 1991, imposes restrictions on the release of toxic substances and stipulates requirements for pollution monitoring units, machinery for combating pollution and contingency plan by industries; submission of lists and details of chemicals used by industries to Federal Ministry of Environment (FMEnv); requirement of permit by industries for the storage and transportation of harmful or toxic waste; the generator's liability; strategies for waste reduction; permissible limits of discharge into public drains; protection of workers and safety requirements; environmental audit (or environmental impact assessment for new industries) and penalty for contravention.

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

The Management of Hazardous and Solid Waste Regulation, S.I.15 of 1991, defines the requirements for groundwater protection, surface impoundment, land treatment, waste piles, landfills, incinerators etc. It also describes the hazardous substances tracking programme with a comprehensive list of acutely hazardous chemical products and dangerous waste constituent. It also states the requirements and procedure for inspection, enforcement and penalty.

The Environmental Impact Assessment Act

The EIA Act Cap E12 LFN 2004 requires that for all new major public and private projects in Nigeria, where the extent, nature or location of a proposed project or activity is such

that it is likely to significantly affect the environment, its EIA is undertaken in accordance with the provision of the Act. The EIA Act sets out to:

- consider the likely impacts, and the extent of these impacts on the environment before embarking on any project or activity;
- promote the implementation of appropriate policy in all Federal Lands consistent with all laws and decision-making processes through which the goal of this Act may be realized; and
- encourage the development of procedures for information exchange, notification and consultation between organizations and persons when the proposed activities are likely to have significant environmental effects on boundary or trans-state or on the environment of bordering towns and villages.

The Act gives specific powers to the FMEnv to facilitate environmental assessment of projects. In 1995, the then Federal Environmental Protection Agency (FEPA, now FMEnv) published *EIA Procedural Guidelines.* The guideline is intended to assist in the proper and detailed execution of EIA studies in Nigeria.

NESREA Requirements

The National Environmental Standards and Regulations Enforcement Agency (NESREA) was established in November 2006 by the federal government. It is charged with the responsibility of enforcing all environmental laws, guidelines, policies, standards, and regulations in Nigeria. It also has the responsibility for enforcing compliance with the provisions of international agreements, protocols, conventions and treaties on environment to which Nigeria is signatory.

NESREA Act

Administered by the Ministry of Environment, the National Environment Standards and Regulation Enforcement Agency (NESREA) Act of 2007 replaced the Federal Environmental Protection Agency (FEPA) Act. It is the embodiment of laws and regulations focused on the protection and sustainable development of the environment and its natural resources. The following sections of the act are worth noting:

Section 7: provides authority to ensure compliance with environmental laws, local and international, on environmental sanitation and pollution prevention and control through monitory and regulatory measures.

Section 8: empowers the agency to make and review regulations on air and water quality, effluent limitations, control of harmful substances and other forms of environmental pollution and sanitation.

Section 27: prohibits, without lawful authority, the discharge of hazardous substances into the environment. This offence is punishable under this section, with a fine not exceeding, N1,000,000 (One Million Naira) and an imprisonment term of 5 years. In the case of a there is an additional fine of N50,000, for every day the offence persists. Other sections include:

Section 1: requires industry facilities to have anti-pollution equipment for the treatment of effluent.

Section 3: requires a submission to the agency of a composition of the industry's treated effluents.

Section 4 and 5: requires industries to report a discharge if it occurs and to submit a comprehensive list of chemicals used for production to the Agency.

1.7.1.2 The Petroleum Industry Act (2021)

The Petroleum Industry Act (PIA) was passed into law in August 2021. It provides a comprehensive framework for the legal, governance, regulatory and fiscal matters of the Nigerian Petroleum Industry (upstream, midstream, and downstream) as well as the development of Host Communities. The Act repeals the following six (6) laws:

- the Associated Gas Reinjection Act 1979
- the Hydrocarbon Oil Refineries Act,
- Motors Spirit Returns Act,
- Nigerian National Petroleum Corporation (Projects) Act,
- Nigerian National Petroleum Corporation Act,
- the Petroleum Products Pricing Regulatory Agency (Establishment) Act

Two extant (2) laws are to be subsequently repealed upon the happening of some events – the Petroleum Profit Tax Act, 2004 and the Deep Offshore and Inland Basin Production Sharing Contract Act, 2019.

It is noted that the PIA (2021) does not repeal the Petroleum Act (1969). Holders of the previously issued licenses/leases such as the Oil Prospecting License, Oil Mining Lease, etc. are still governed by the provision of the Petroleum Act (1969) until the license/lease expires or are converted to leases or licenses issued under the Petroleum Industry Act. More importantly, provisions under the repealed laws shall remain in force provided that they are not inconsistent with the provisions of the PIA.

The PIA (2021) also establishes dual regulators for the petroleum industry,

- The Nigerian Upstream Petroleum Regulatory Commission (The Commission) - which is a body whose functions are limited to only the upstream petroleum activities as provided for in Section 4 of the Act.
- Nigerian Midstream and Downstream Petroleum Authority (The Authority) – which is responsible for the technical and commercial regulation of the midstream and downstream petroleum operations in the petroleum industry as provided under Section 29(3) of the Act.

Relevant Highlights on HSE issues:

- The Act empowers the Authority to:
  - Ensure strict compliance with environmental policies, laws, guidelines and regulations applicable to midstream and downstream petroleum operations.
  - Ensure compliance with all conditions of permits granted for midstream and downstream petroleum operations
  - Promote healthy, safe, and effective conduct of midstream and downstream operations in an environmentally acceptable and sustainable manner
- The operator of a midstream or downstream facility is required by the Authority to submit for approval an environmental management plan in respect of projects which require environmental impact assessment within one year of the effective date of the PIA or six months after the grant of the applicable license.

1.7.1.3 Nigerian Oil and Gas Industry Content Development Act, 2010

The Nigerian Local Content law was created to enhance utilization of the country's human and material resources for the provision of goods and services to the petroleum industry by ensuring that:

- Nigerians are given first consideration in the award of oil blocks, oil field licenses, oil lifting license and shipping service as well as projects for which contracts are to be awarded in the industry;
- there is exclusive consideration for Nigerian indigenous services to the oil and gas industry subject to the fulfilment of specified conditions;
- every multinational oil company operating in Nigeria is to domicile a minimum of 10% of its annual profit in Nigerian banks;
- Nigerian insurance companies are to do all aspect of insurance in the oil and gas sector except where local capacity has been exhausted;

- one percent of every contract awarded in Nigeria's oil and gas sector to be set aside for capacity building;
- at least 50% of the asset of any company seeking to execute oil and gas contract in Nigeria must be domicile in Nigeria, among others.

1.7.1.4 National Gas Policy, 2017

The Nigerian gas policy was developed to encourage sustainable development and use of the Nigerian gas. The policies developed are listed below:

- the nation's gas resources shall be harnessed and optimally integrated into the national economy, energy mix and industrial processes;
- the nation shall engage intensively in gas exploration and development with a view to increasing the reserve base to the highest level possible;
- the nation shall put in place necessary infrastructure and incentives to encourage indigenous and foreign companies to invest in the industry; and
- the nation shall put in place necessary infrastructure and incentives to ensure adequate geographical coverage of the gas transmission and distribution network.

The aims of the policies shall be achieved by:

- eliminating the flaring of associated gas in Nigeria;
- expanding the utilization of natural gas as industrial and domestic fuel, as well as for power generation;
- increasing the use of natural gas as industrial feedstock for petrochemical, pharmaceutical and fertilizer plants, etc.;
- using gas to diversify the foreign exchange earnings base of the nation;
- accelerating the process of technology acquisition and diffusion in the gas industry;
- encouraging indigenous entrepreneurial capability in the gas industry including the development of end-use devices; and
- determining the level of gas reserves available to the nation.

Strategies put in place by the Nigerian Government to ensure these aims are achieved are:

- encouraging the oil-producing companies to gather and utilize associated gas in order to eliminate flaring;
- imposing appropriate and effective penalties to discourage gas flaring;
- encouraging the establishment of the necessary infrastructure for the effective gathering, transmission and distribution of gas nationwide;

- formulating suitable urban and regional planning regulations needed for the effective distribution of natural gas to, and its utilization by, domestic and industrial consumers;
- providing necessary incentives to indigenous and foreign entrepreneurs to facilitate their participation in the gas industry;
- providing incentives to encourage industrial and domestic consumers to use gas or to convert to gas;
- establishing suitable infrastructure for the export of natural gas;
- expanding and promoting gas related R & D outfits in the country; and
- ensuring that the price of natural gas is cost-effective, while giving due attention to the effect on local consumption.

In line with the National Gas Policy, the Gas Master Plan was developed and approved by the Federal Executive Council to provide a framework for Nigeria to maximize value from its gas resources through leveraging the multiplier effect of gas in the domestic economy and optimizing Nigeria's share in the high value export market.

- The Nigerian Gas Master Plan is hinged on 3 critical elements, which are:
- Gas pricing policy;
- Domestic gas supply obligation; and
- Gas infrastructure blueprint

1.7.1.5 The Nigerian Urban and Regional Planning

The Nigerian Urban and Regional Planning Act **CAP N138, LFN 2004** was established to:

- promote co-operation and co-ordination among states and local governments in the preparation and implementation of urban and regional plans;
- formulate urban and regional planning standards in Nigeria;
- ensure effective supervision and monitoring of the execution of projects in urban and regional areas; and
- ensure development control over Nigeria.

The specific requirements of the Act pertinent to the proposed development as contained in Part II of the Act are as follows:

Planning Authority Approval

- it is mandatory for a developer to submit a development plan which would be approved by the Development Control Department (department under the commission);
- it is mandatory for a developer (whether private or government) to apply for development permit by using specified forms and providing information such as

plans; design drawings and other information as may be prescribed by regulation made pursuant to this section.

- no development shall commence by any Government or its agencies without obtaining an approval from the relevant Development Control Department.
- plan required to be made under this Act shall be prepared by registered Architect of Town Planner or Engineer and shall be in accordance with the provisions of this Act.

Submission of Detailed Environmental Impact Statement

A developer shall at the time of submitting his development application submit to an appropriate Control Department a detailed environmental impact statement for an application for:

- residential land in excess of 2 hectares; or
- permission to build or expand a factory or for the construction of an office.
- permission for a major recreational development.

Validity of Development Permit:

A development permit granted to a developer shall:

- remain valid for two years from date of communication of the plan to the approval of a developments permit to a developer; and
- where a developer fails to commence development within two years the development permit shall be subject to re-validation by the Control Department which issued the original permit.

Acquisition of Land and Compensation

Part IV of the Act requires that where it is necessary to obtain any land in connection with planned urban or development in accordance with the policies and proposals of any approved plan, any right of occupancy subsisting on that land shall be revoked on the recommendation of the appropriate authority. All matters connected with the payment of compensation for the revocation of the right of occupancy under the Act shall be governed in accordance with the relevant provision of the Land Use Act. Any compensation payable because of the revocation of the right of occupancy shall be paid within a reasonable period.

1.7.1.6 Water Resources

The Water Resources Act Cap W2 LFN 2004 is targeted at developing and improving the quantity and quality of water resources. The following sections are pertinent:

Section 5 and 6 provides authority to make pollution prevention plans and regulations for the protection of fisheries, flora and fauna; and

Section 18 makes offenders liable, under this Act, to be punished with a fine not exceeding N2000 or an imprisonment term of six months. He would also pay an additional fine of N100 for every day the offence continues.

1.7.1.8 The Labour Act Cap L1 LFN, 2004

The Labour Act Cap L1 LFN, 2004 is the primary law protecting the employment rights of individual workers. The Labour Act covers protection of: wages; contracts; employment terms and conditions; and recruitment. It also classifies workers and special worker types. Union membership is governed by the Trade Union Amendment Act (1995). A 1999 constitution includes stipulation of "equal pay for equal work without discrimination on account of sex, or any other ground whatsoever".

Labour will be sourced from a national, regional and local scale depending on project requirements during the construction and full operation of the plant upgrade. The Labour Act will guide all labour engagement in line with this.

1.7.1.9 Land Use Act Cap L5 LFN 2004

The Land Use Act Cap L5 LFN 2004 states that "it is public interest that the rights of all Nigerians to use and enjoy land in Nigeria and the natural fruits thereof in sufficient quality to enable them to provide for the sustenance of themselves and their families be assured, protected and preserved".

1.7.1.10 Endangered Species Act

Section 1 (*prohibition of hunting of or trading in wild animals*) of the Endangered Species Act 11 of 1985 (amended in 1990 as Act, Cap 108 and Act Cap E9, Laws of the Federation of Nigeria, 2004) prohibits the hunting, capture and trade on endangered species such as otter shrew, giant / tree / long-tailed pangolin, colobus monkeys, chimpanzee, gorilla, African palm squirrel, lion, leopard, cheetah, hyenas, immature elephant, giraffe, tortoises, crocodiles, etc. being animal species threatened with extinction or otherwise deal with animals species which though not necessarily now threatened with extinction may become so threatened except one is in possession of a license issued under the Act.

The Act also stipulates pertinent permits, certificates and the processes for trading of the identified endangered species as well as prescribes penalties for contraventions.

1.7.1.11 Harmful Waste Act

The Harmful Waste (Special Criminal Provisions) Act Cap H1, LFN 2004 prohibits, without lawful authority, the carrying, dumping or depositing of harmful waste in the air, land or waters of Nigeria. The following sections are notable:

Section 6: provides for a punishment of life imprisonment for offenders as well as the forfeiture of land or anything used to commit the offence.

Section 7: makes provision for the punishment accordingly, of any conniving, consenting or negligent officer where the offence is committed by a company.

Section 12: defines the civil liability of any offender. He would be liable to persons who have suffered injury as a result of his offending act.

1.7.1.12 Penal Code Act of Nigeria 2004

The Act makes it an offence punishable with up to 6 month's imprisonment for any person who:

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

1.7.1.13 Employees Compensation Act 2011

An Act to repeal the Workmen Compensation Act CAP. W6 LFN, 2004, and to make Provisions for Compensations for any death, injury, disease or disability arising out of or in the course of employment; and for related matters. The objectives of the Act are to:

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

1.7.1.14 Climate Change Act 2021

Nigeria's 2021 Climate Change Act provides for an ambitious framework for mainstreaming climate actions in line with national development priorities and sets a net-zero target for 2050-2070. The Act codifies national climate actions by mandating

the Ministry of Environment to set, among others, a carbon budget, keeping average increase in global temperature within 2oC and pursuing efforts to limit the temperature increase to 1.5oC above pre-industrial levels. It further approves of formulation of a National Climate Change Action Plan in every five-year cycle to ensure that the national emission profile is consistent with the carbon budget goals and prescribes measures for identifying actions for climate adaptation and mitigation.

The Act applies to both public and private entities within Nigeria's territorial jurisdiction and directs both to implement mechanisms geared towards fostering a low-carbon emission, environmentally sustainable, and climate resilient society. The Act obligates any private entity with employees numbering 50 and above to put in place measures to achieve the annual carbon emission reduction targets in line with the Action Plan; and designate a climate change officer responsible for submitting annual reports to the National Climate Change Secretariats, at meeting its carbon emission reduction and climate adaptation plan.

The Act also establishes the National Council on Climate Change, chaired by the President of Nigeria, with members from both the public and private sectors, including members of the civil society, women, youth, and persons with disabilities. It empowers the Council with significant powers to coordinate national climate actions, administer the newly established Climate Change Fund, mobilize resources to support climate actions, and collaborate with the Nigerian Sovereign Green Bond in meeting Nigeria's NDC.

1.7.1.15 Natural Resources Conservation Act CAP 286 LFN 2004

This Act established the Natural Resources Conservation council to be responsible for the conservation of natural resources in Nigeria and formulate national policy for natural conservation. Section 3 of the Act provides that the functions of the council shall be to:

- Coordinating matters concerning the conservation of natural resources in Nigeria
- Formulate a national policy for national resources conservation.
- It also carries out such other activities calculated to facilitate the effectiveness of the performance of the functions of the council under this Act in Section 3(e).

Moreover, the Act measures in collaboration with other agencies, control coastal zone development to minimize erosion on the national coastline.

1.7.1.16 National Health Act, 2014

This Act provides a framework for the regulation, development and management of a national health system and set standards for rendering health services in the

federation, and other matters connected therewith, 2014. It also provides justification for the execution of developmental projects under guidelines that promote health by protecting the environment and safeguarding the humans' health. The Public Health Laws empower Medical Officers of Health (operating at the local government council, under the supervision of the State and Federal Ministries) to ensure the promotion of good health.

1.7.1.17 National Policy on Occupational Safety and Health, 2016

This policy is designed to make for safety and health of workers at workplaces. "It derives from the main ground norm law of the 1999 constitution as amended, which in section 17 (3c) prescribes that the Nigerian State shall make laws and bye-laws for preservation of the health and well-being of workers in the workplaces; men and women at work. "It also derives from the ILO convention 155, which Nigeria has also domesticated. Again, that talks about making the workplace conducive and ensuring the health and well-being of workers,

The policy is aimed at facilitating the enhancement of occupational safety and health performance in all sectors of the economy and ensuring that employees rights protection is consistent with regional and international standards.

1.7.1.18 Public Health Law Cap 103 LFN 1990

Public Health Law examines the authority of the government at various jurisdictional levels to improve the health of the general population within societal limits and norms. The State is empowered to protect and improve the environment and safeguard the water, air and land, forest and wildlife of Nigeria. The law prohibits the public or private sector of the economy not to undertake or embark on or authorize projects or activities without prior consideration of the effect on the environment.

1.7.1.19 National Guidelines on Environmental Audit 2010

FEPA National Guidelines for Environmental Audit in Nigeria defines environmental audit as a management tool consisting of a systematic, documented, periodic and objective evaluation of environmental performance, management systems and equipment with the aim of firstly, facilitating management control of environmental.

1.7.1.20 National Guidelines on Environmental Management Systems of 1999

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work.

ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Environmental Management Systems (EMS), the part of the overall management system that includes organizational structure, planning activities, responsibilities, practices, procedures, processes and resources for developing, implementing, achieving, reviewing and maintaining the environmental policy.

1.7.2 State Policy, Guidelines and Regulations

1.7.2.1 *Kaduna State Legislation and Local Government Byelaws*

The project site sits within Igabi Local Government Area making it subject to the administrative authority of the Kaduna State Government alongside federal oversight.

1.7.2.2 Kaduna State Environmental Protection Law No. 7 of 2010

Initially cited as the Edict No. 1 of 1998, the Kaduna State Environmental Protection Authority Law (No. 7) was enacted in 2010. The enabling legislation confers on the Authority (KEPA) the general responsibility for all matters relating to the environment1. KEPA is expected to:

- Enact and enforce State regulations, procedures, guidelines and environmental standards for effective -prevention, remediation, control and monitoring of point and non-point source of pollution and degradation;
- Implement, and review environmental policy in the State and in particular to demand and review environment impact assessment and statement and for new development projects and to also demand review environmental audit reports for existing developments and such other operations which are deemed to have significant impact on the environment;
- Prepare in accordance with the State policy and Law on the environment periodic master plans for the development and financial requirements for implementation of such plans;
- Prevent or stop any act or omission which consequences are likely to diversely affect the environment and to generally deal with any discharge either solid, liquid or gaseous materials deposited willfully or otherwise in the environment and to deal generally with any violation which the Authority may deem hazardous to the environment and the ecosystem, and shall in particular:
    - monitor the whole parts of the State for any such discharge;

- cause the Responsible parties to stop or remove such discharge;
- remove or cause or be removed such discharge at the expense of the defaulting party;
- penalty to be paid in accordance with appropriate regulations;
- reinstate, rehabilitate or cause the effect environment to be removed
- to its original state at the expense of the responsible parties;
- approve landscaping for all and drainage plans on new developments; and,
- grant final approval.

- Monitor environmental quality, conduct programmes for continuing surveillance and of regular periodic inspection of actual or potential contaminants of point and non-point sources of environmental pollution in accordance with the laid down regulations as the Authority may deem fit;
- To liaise with Federal, State, Local Government and other public and private authorities, agencies and institutions engaged in environmental planning and functions;
- Research, collect information and research findings in various environment disciplines.
- Develop libraries and archives, and to establish and maintain a database on environment; Stimulate public interest on environment by public awareness, campaign and generally encourage environmental education programmes in schools, mass media and other formal and informal sectors;
- Where feasible, conduct training programmes for industrial, commercial and public institutions and or recruit or train environmental extension workers and staff of the Authority for the purpose of effective mobilization of the public towards environmental education and awareness;
- Issue permits, licenses, approvals and to issue certification and operation levies for the issuance of such permits, license, approval and certifications as the authority may from time to time prescribe.

- Establish and maintain close liaison and linkages with major research and scientific institutions, professional associations, experts and consultants as well as government and non-governmental organizations in the field of environment; investigate and ascertain all violation of this law and, or relevant rules and regulations under the law and prosecute or to be prosecuted such violators;

- Demand to access to any public or private property or premises at all reasonable time enter upon for the purpose of inspecting and investigating for ascertaining any violations or potential violations;

- Establish Zonal Offices in the State and constitute joint consultative committee with the Federal and Local Governments, for the purpose of operating, administering and enforcing the provision of any existing law and regulations and or any enactment relating to environment generally.

1.7.2.3 Kaduna State Urban Planning & Development Authority (KASUPDA), 2018

The Kaduna State Urban Planning and Development Authority (KASUPDA) Act of 2018 tasked KASUPDA with regulating orderly growth in designated urban areas of the state like Kaduna, Zaria, Kafanchan, etc. KASUPDA formulates state urban planning policies aligned with national frameworks, preparing master plans, local plans, and subject-specific strategies (e.g., zoning, renewal, etc.), and also exercises development control by issuing planning permits, approving building layouts, and enforcing compliance to prevent unauthorized constructions and slum proliferation. Furthermore, the Authority oversees physical developments, outdoor advertisements (in collaboration with LGAs), and subdivision approvals, sealing violations and imposing sanctions like fines or demolition. It conducts research on urban trends including transport infrastructure standards/development, and engages stakeholders through public inquiries for plan adoption.

The Authority is led by a Board Chairman and members (appointed by the Governor of the State), and also maintains a Planning Permit Tribunal for disputes and generates revenue via fees, grants, and levies. It advises on land use, urban renewal, and integrates climate resilience, ensuring sustainable aesthetics and liveability amid Kaduna's urban population growth. This mandate, rooted in the 2018 Act, positions KASUPDA as Kaduna's primary enforcer of spatial order, bridging policy with on-ground execution for economic vitality and safety.

1.7.2.4 Kaduna State Environmental Protection Authority (KEPA) Regulations, 2011

In exercise of the powers conferred upon KEPA by Section 13 of Kaduna State

Environmental Protection Law No. 7 of 2010, a number of regulations were made to further guide persons and corporate entities whether public or private, on environmental matters. These regulations, which took effect on 1st January 2011, are all relevant and applicable (fully or in part) to the proposed TPEZs projects development within Kaduna. They include:

- Kaduna State Environmental Protection Authority: Solid Waste Management Regulation No. 1;
- Kaduna State Environmental Protection Authority: Control of Water Pollution Sources Regulation No. 2;
- Kaduna State Environmental Protection Authority: Effluent Limitation and Management Regulation No. 3;
- Kaduna State Environmental Protection Authority: Environmental Impact Assessment and Audit Regulation No. 4;
- Kaduna State Environmental Protection Authority: Bush Burning Control Regulation No. 5;
- Kaduna State Environmental Protection Authority: Control and Management of Hazardous Substances Regulation No. 6; and,
- Kaduna State Environmental Protection Authority: Special Work Places Regulation No.

Specifically, Regulation No. 4 stipulates that ―any person, corporate body or unincorporated or Authority including Government Agencies that intend to embark on a new development or the extension/expansion of existing development shall prepare and submit an Environmental Impact Assessment (EIA) Report and obtain a permit/certificate from KEPA before embarking on the projectǁ. This provision, along with the other regulations, mandates KEPA to enforce and place punitive measures on defaulters, including fines and/or jail terms.

1.7.2.4 Igabi Local Government Area Council

The Igabi Local Government Area Council is one of the Local Government Areas of Kaduna State established to administer local government functions within its jurisdiction. Igabi is responsible for the provision and coordination of certain municipal services including environmental sanitation, waste management, public health administration, local roads, markets, community liaison, and other statutory local government functions.

1.7.4.5 Rigasa Community

Rigasa Community is situated within the jurisdiction of the Igabi Local Government Area. Accordingly, implementation of the proposed project will require appropriate

coordination with the Council regarding environmental sanitation, construction waste management, public health, traffic management and other municipal services that may be affected during project implementation.

1.7.3 International Legal Framework

In addition to national and state laws/ regulations, Nigeria is signatory or party to several International Conventions and treaties that support the use of ESIA as key tool for achieving sustainable development in executing projects. International institutions such as the World Bank, African Development Bank, etc. provide guidance on requirements for the ESIA process and place emphasis on achieving sustainable environmental, social and health outcomes. They provide environmental standards and limits for emissions and discharges. This ESIA has been subjected to relevant guidelines and therefore is expected to meet the environmental requirements of other applicable institutions.

1.7.3.1 International Finance Corporation Performance Standards

The IFC Performance Standards, which define clients' responsibilities for managing their environmental and social risks have been adopted by the World Bank as the Performance Standards (WB Performance Standards) for Private Sector Activities. These Performance Standards are applicable to projects designed, owned, constructed and/or operated by a Private Entity1 for which the Bank's support is needed.

The Performance Standards are directed towards a private entity, 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 private entity in relation to project-level activities.

There are eight Performance Standards (PS) which the private entity is expected to meet throughout the life of an investment by IFC:

- Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts
- Performance Standard 2: Labor and Working Conditions
- Performance Standard 3: Resource Efficiency and Pollution Prevention
- Performance Standard 4: Community Health, Safety, and Security
- Performance Standard 5: Land Acquisition and Involuntary Resettlement
- Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

- Performance Standard 7: Indigenous People
- Performance Standard 8: Cultural Heritage

For the CNG Mother Station Project, it's important to identify which standards are applicable and which are not. Below is a detailed explanation of the relevant Performance Standards that may likely be triggered by the project:

Performance Standard (PS) 1: Assessment and Management of Environmental and Social Risks and Impacts

PS 1 describes the importance of an integrated assessment to identifying the environmental and social impacts, risks, and opportunities of the project, an effective community engagement through appropriate and timely disclosure of information and consultation; and the private entity's management of environmental and social performance throughout the project lifecycle. This Performance Standard applies to business activities with environmental and/or social risks and/or impacts, which fits the classification of plant upgrade project. As part of the requirements of this performance standard, GVLNG Limited has in conjunction with all project stakeholders conducted an environmental and social assessment presented in this report, and shall establish and maintain an Environmental and Social Management System (ESMS) appropriate to the nature and level of environmental and social risks and impacts assessed.

This ESMS shall incorporate the following elements: (i) policy; (ii) identification of risks and impacts; (iii) management programs; (iv) organizational capacity and competency; (v) emergency preparedness and response; (vi) stakeholder engagement; and (iv) monitoring and review.

Performance Standard 2: Labor and Working Conditions

PS 2 recognizes that pursuit of economic growth through employment creation and income generation should be accompanied by protection of the fundamental rights of workers. This standard maintains that failure to establish and foster a sound worker management relationship can undermine worker commitment and retention, can jeopardize a project and hamper its overall sustainability. Guided by conventions and instruments of the International Labour Organization (ILO) and the United Nations (UN),

The objectives of this performance standard are to: (i) promote the fair treatment, nondiscrimination and equal opportunity of workers, (ii) establish, maintain and improve the worker-management relationship, (iii) promote compliance with national employment and labour laws, (iv) protect workers, including vulnerable categories of workers such as children, migrant workers, workers engaged by third parties, and

workers in the client's supply chain, (v) promote safe and healthy working conditions, and the health of workers, and (vi) avoid the use of forced labor.

The environmental and social risks of this factor are established during the impact's identification process, and managed through the private entity's ESMS. GVLNG Limited shall ensure that all identified risks and impacts are managed following international and national standard policies and procedures. These are either documented in this report or included in supporting documents, plans and/or policies to this report.

Performance Standard 3: Resource Efficiency and Pollution Prevention This standard recognizes that increased economic activity and urbanization often generate increased levels of pollution to air, water and land, and consume finite resources in a manner that may threaten people and environment at the local, regional and global levels. In the light of more efficient and effective resource use and pollution prevention technologies, this performance standard takes a project-level approach to resource efficiency and pollution prevention and control in line with international best practices.

The levels of emissions for Greenhouse Gases (GHGs) and other recorded pollutants have been measured in this study and the expected levels during plant operation documented in this report as part of an environmental and social risks and impacts identification process. GVLNG Limited will consider all ambient conditions and apply technically and financially feasible resources efficiency and pollution prevention techniques best suited to avoid, or minimize adverse impacts on human health and the environment. The abatement measures to be implemented as highlighted in the Environmental and Social Management Plan (ESMP) and other supporting plans are consistent with national environmental laws and internationally recognized sources, including the World Bank Group Environmental, Health and Safety Guidelines (EHS Guidelines).

Performance Standard 4: Community Health, Safety, and Security

The objective of this performance standard is to scope and avoid adverse impacts on the health and safety of the project area during the lifecycle of the project from both direct and indirect project activities. It is also to ensure that property and personnel are safeguarded in a manner that avoids or minimizes risks to the local community especially to vulnerable groups.

Following an expansive scoping process and stakeholder engagement, GVLNG Limited has documented environmental and social risks and impacts affecting the community. Mitigation measures where these impacts cannot be avoided have been

proffered in the report. Further to this, actions required to meet the requirements of this Performance Standard are managed by GVLNG Limited's ESMP and ESMS.

Performance Standard 5: Land Acquisition and Involuntary Resettlement

This performance standard recognizes that project-related land acquisition and land use change can have adverse impacts on persons and communities that use this land. Among the objectives of this standard are: (i) to avoid, and when avoidance is not possible, minimize displacement by exploring alternative project designs, (ii) to avoid forced eviction, (iii) to improve, or restore, the livelihoods and standards of living of displaced persons, where applicable (iv) To anticipate and avoid, or where avoidance is not possible, minimize adverse social and economic impacts from land acquisition or restrictions on land use.

Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources

This Performance Standard addresses how the private entity can sustainably manage and mitigate impacts on biodiversity and ecosystem services throughout the project's lifecycle. The objectives of this performance standard are: (i) to protect and conserve biodiversity, (ii) maintain the benefits from ecosystem services, (iii) promote the sustainable management of living natural resources through the adoption of practices that integrate conservation needs and development priorities.

Scoping during assessment of environmental and social conditions for the project identified modified habitats which will experience direct and indirect impacts because of the development. Threats to biodiversity and ecosystem services have been mapped in this report and mitigation measures proffered. Implementing measures that ensure resource efficiency and proper utilization of land area to ensure minimal distortion to biodiversity are methods proffered to minimize impacts.

1.7.3.2 Equator Principles

The Equator Principles is a risk management framework, adopted by financial institutions, for determining, assessing and managing environmental and social risk in projects and is primarily intended to provide a minimum standard for due diligence to support responsible risk decision-making. The Equator Principles are presented in Table 2.1.

Table 1.1: Equator Principles

Principle	Requirements
Principle 1	Review and Categorization of project
Principle 2	Conduct environmental and social impact assessment
Principle 3	Applicable social and environmental standards
Principle 4	Action plan and management systems
Principle 5	Stakeholder engagement
Principle 6	Grievance mechanism
Principle 7	Independent review
Principle 8	Covenants
Principle 9	Independent monitoring and reporting
Principle 10	Reporting and transparency

The Equator Principles set out the process for assessing a project in four key phases: Impacts are assessed on their degree of potential impact and are categorized as either A (High), B (Medium) or C (Low).

Category A- Projects with potentially significant adverse social or environmental impacts that are diverse, irreversible or unprecedented;

Category B- Projects with potentially limited adverse social and environmental impacts that are few, generally site-specific, largely reversible and readily addressed through mitigation measures; and

Category C- Projects with minimal or no social or environmental impacts.

1.7.3.3 World Bank Guidelines on Environmental Assessment

The World Bank requires an Environmental Impact Assessment (EIA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable to improve decision making. Additionally, the policy specifies that the Bank undertakes environmental screening of each proposed project to determine the appropriate extent and type of EIA. The Bank classifies projects into one of four categories, depending on the type, location, sensitivity, and scale of the project and the nature and magnitude of its potential environmental impacts. Details of World Bank

EIA procedures and guidelines are published in the bank's EA Source Books Vols. i – iii of 1991.

World Bank Operational and Safeguard Policies

The World Bank is committed to several operational and safeguards policies that aim to prevent and mitigate undue harm to people and their environment in any development initiative involving the bank. These policies provide guidelines for bank and borrower staff in the identification, preparation, and implementation of programs and projects. There are ten World Bank Environmental/Safeguard Policies. Not all these policies are triggered by the CNG Mother Station Project. The World Bank policies that have been triggered by the proposed CNG Mother Station Project are:

Operational Policy (OP)/Bank Procedure (BP) 4.01: Environmental Assessment (last updated February 2011). This is the umbrella policy for the Bank's environmental 'safeguard policies' which among others include:

Operational Policy/Bank Procedure 4.04 (Natural Habitat) - seeks to ensure that World Bank-supported infrastructure and other development projects take into account the conservation of biodiversity, as well as the numerous environmental services and products which natural habitats provide to human society.

Operational Policy/Bank Procedure 4.36 –(Forests.) This policy aims to reduce deforestation, enhance the environmental contribution of forested areas, promote afforestation, reduce poverty, and encourage economic development.

Operational Policy 4.09 (Pest Management) policy recognizes that pesticides can be persistent and harmful to the environment for a long time. If pesticides must be used, the policy requires that Pest Management Plan (PMP) be prepared by the borrower, either as a stand-alone document or as part of an Environmental Assessment.

Operational Policy /Bank Procedure 4.11 - Physical Cultural Resources seeks to avoid, or mitigate, adverse impacts on cultural resources from development projects that the World Bank finances.

The Bank requires environmental assessment (EA) of projects proposed for Bank financing to help ensure that they are environmentally sound and sustainable, and thus improve decision making. Such EA is carried out by the borrower to evaluate a project's potential environmental risks and impacts in its area of influence. The EA process analyzes project alternatives; identifies ways of improving project selection, siting, planning, design, and implementation by preventing, minimizing, mitigating, or compensating for adverse environmental impacts and enhancing positive impacts;

and includes the process of mitigating and managing adverse environmental impacts throughout project implementation. The Bank favours preventive measures over mitigatory or compensatory measures, whenever feasible. EA looks at the interaction of the project with the natural environment (air, water, and land); human health and safety; social aspects (involuntary resettlement, indigenous peoples, and physical cultural resources); and where applicable, transboundary and global environmental aspects.

World Bank Group EHS Guidelines

The Environmental, Health, and Safety (EHS) Guidelines are technical reference documents with general and industry-specific examples of Good International Industry Practice (GIIP). When one or more members of the World Bank Group are involved in a project, these EHS Guidelines are applied as required by their respective policies and standards.

The EHS Guidelines contain the performance levels and measures that are generally considered to be achievable in new facilities by existing technology at reasonable costs. Application of the EHS Guidelines to existing facilities may involve the establishment of site-specific targets, based on environmental assessments and/or environmental audits as appropriate, with an appropriate timetable for achieving them.

When host country regulations differ from the levels and measures presented in the EHS Guidelines, projects are expected to achieve whichever is more stringent. If less stringent levels or measures than those provided in these EHS Guidelines are appropriate, in view of specific project circumstances, a full and detailed justification for any proposed alternatives is needed as part of the site-specific environmental assessment. This justification should demonstrate that the choice for any alternate performance levels is protective of human health and the environment.

The General EHS Guideline (*May, 2017*) is organized to provide environmental, occupational health and safety, community health and safety, construction and decommissioning guidelines for new and existing facilities. The General EHS Guidelines are designed to be used together with relevant Industry Sector EHS Guidelines to provide guidance on EHS issues in specific industry sectors.

1.7.3.4 United Nations Guiding Principles on the Human Environment

The United Nations (UN), concerned about negative environmental trends since its formation, published two major concept documents: Guiding Principles on the Human Environment, 1972 and the Rio Declaration on Environment and Development.

Ten of these Guiding Principles were defined as formal declarations that express the basis on which an environmental policy can be built and which provide a foundation for action. The principles relevant to the proposed project are summarised as follows.

Principle Two

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

Principle Four

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

Principle Six

The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted to ensure that serious or irreversible damage is not inflicted upon the ecosystems.

1.7.3.5 The Rio Declaration on Environment and Development

The UN Conference on Environment and Development met at Rio de Janeiro in June 1992, at which time it reaffirmed the 1972 declaration on the Human Environment, and sought to build upon it. This is with the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people. It is also to aid work towards international agreements, which respect the interests of all, protect the integrity of the global environmental developmental system, and recognized the integral and interdependent nature of the earth. The UN thus added additional principles to the originals, the more relevant being:

Principle Ten

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, everyone shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes.

States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

Principle Thirteen

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

Principle Seventeen

Environmental impact assessment, 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.

1.7.3.6 United Nations Conference on Environment and Development (1992) (Popularly referred to as Agenda 21)

The United Nations Conference on the Environment and Development (UNCED) in 1992 led to the adoption of agenda 21, which recommended a set of 21measures for waste management. Some of the recommendations include the following:

- Prevent and minimize waste production
- Reuse or recycle the waste to the extent possible.
- Treat waste by safe and environmentally sound methods.
- Dispose of the final residues by landfills in confined and carefully designated sites.
- Integrate environment into development planning at all levels of Government and the private sector;
- Commence a transition to sustainable development.
- Address sectorial priorities, plan policies and strategies for the major sectors of the economy; and
- Simultaneously foster regional and global partnership.

1.7.3.7 Convention on Biological Diversity (1992)

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

1.7.3.8 Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and Their Disposal (1987)

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

1.7.3.9 Convention on the Conservation of Nature and Natural Resources, 1986

This convention came into force in Nigeria on May 7th,1974. The objectives of the convention to encourage individual and joint action for the conservation, utilization and development of soil, water flora and fauna for the present and future welfare of mankind, from an economic, nutritional, scientific, educational, cultural and aesthetic point of view.

1.7.3.10 Montreal Protocol on Substances that Deplete the Ozone Layer, 1987 (as Amended)

The objective of the convention is to protect the ozone layer by-taking precautionary measure to control global emissions of substances that deplete it. This convention is aimed at protecting workers against occupational Hazards in the working environment.

1.7.3.11 Convention on Occupational Safety and Health and the Working Environment

The convention EIAs the objective of enhancement of the existing legal framework for occupational safety regulating the management of chemicals in the work place with the broad purpose of protecting the environment and the public, and with the specific objective of protecting workers from harmful effects of chemicals.

1.7.3.12 United Nations Convention on Climate Change

The Convention on the Climate Change was signed in 1992 during the Rio Earth Summit but was put into force in 1994. The Convention called on developed countries and economies in transition to limit their emissions of the greenhouse gases which cause global warming, although it does not impose mandatory emissions on developing countries.

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

The world is in a race to limit climate change and find workable, practical, and cost-efficient solutions (Renewable Energy, Circular Economy, and Natural Capital) to this emergency that is redefining global partnerships in a way not seen before. This is a race we, as humanity, can win. But for this to happen, unprecedented leadership, sacrifices,

concessions from all nations big and small are needed. Nigeria has ratified the 2915 Paris Agreement. This is commendable considering it is one of the top six greenhouse gas emitters in Africa. The Paris Agreement builds upon the Convention and for the first time brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries to do so. As such, it charts a new course in the global climate effort The Paris Agreement's central aim is to strengthen the global response to the threat of climate change by keeping a global temperature rise this century well below 2 degrees Celsius above pre-industrial levels and to pursue efforts to limit the temperature increase even further to 1.5 degrees Celsius. Additionally, the agreement aims to strengthen the ability of countries to deal with the impacts of climate change. To reach these ambitious goals, appropriate financial flows, a new technology framework, and an enhanced capacity-building framework will be put in place, thus supporting action by developing countries and the most vulnerable countries, in line with their national objectives. The Agreement also provides for enhanced transparency of action and support through a more robust transparency framework.

1.7.3.13 Polluter Pays Principle (Adopted by Nigeria in 1999)

In environmental law, the polluter pays principle is enacted to make the party responsible for producing pollution responsible for paying for the damage done to the natural environment. It is regarded as a regional custom because of the strong support it has received in most Organization for Economic Co-operation and Development (OECD) and European Community (EC) countries. The polluter pays principle underpins environmental policy such as an ecotax, which, if enacted by the government, deters and essentially reduces greenhouse gas emissions. Some eco-taxes underpinned by the polluter pays principle include: the Gas Guzzler Tax, in the US, Corporate Average Fuel Economy (CAFE) - a "polluter pays" fine. The U.S. Superfund law requires polluters to pay for clean-up of hazardous waste sites when the polluters can be identified. Polluter pays is also known as extended producer responsibility (EPR). This is a concept that was probably first described by Thomas Lindhqvist for the Swedish government in 1990. EPR seeks to shift the responsibility for dealing with waste from governments (and thus, taxpayers and society at large) to the entities producing it. In effect, it internalised the cost of waste disposal into the cost of the product, theoretically meaning that the producers will improve the waste profile of their products, thus decreasing waste and increasing possibilities for reuse and recycling

1.7.3.14 Stockholm Convention Against Persistent Organic Pollutants of 2004

Stockholm Convention on Persistent Organic Pollutants is an international environmental treaty, signed in 2001 and effective from May 2004, that aims to

eliminate or restrict the production and use of persistent organic pollutants (POPs). In 1995, the Governing Council of the United Nations Environment Programme (UNEP) called for global action to be taken on POPs, which is defined as "chemical substances that persist in the environment, bio-accumulate through the food web, and pose a risk of causing adverse effects to human health and the environmentⅡ. Following this, the Intergovernmental Forum on Chemical Safety (IFCS) and the International Programme on Chemical Safety (IPCS) prepared an assessment of the 12 worst offenders, known as the dirty dozen. The INC met five times between June 1998 and December 2000 to elaborate the convention, and delegates adopted the Stockholm Convention on POPs at the Conference of the Plenipotentiaries convened from 22–23 May 2001 in Stockholm, Sweden. The negotiations for the Convention were completed on 23 May 2001 in Stockholm. The convention entered into force on 17 May 2004 with ratification by an initial 128 parties and 151 signatories. Co-signatories agree to outlaw nine of the dirty dozen chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans. Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention if they meet certain criteria for persistence and transboundary threat. The first set of new chemicals to be added to the Convention was agreed upon at a conference in Geneva on 8 May 2009. As of June 2018, there are 182 parties to the Convention, (181 states and the European Union). Notable non-ratifying states include the United States, Israel, Malaysia, and Italy. The Stockholm Convention was adopted to EU legislation in REGULATION (EC) No 850/2004.

1.7.3.15 Cartagena Protocol on Bio-safety of 2003

The Cartagena Protocol on Biosafety to the Convention on Biological Diversity is an international agreement on biosafety as a supplement to the Convention on Biological Diversity effective since 2003. The Biosafety Protocol seeks to protect biological diversity from the potential risks posed by genetically modified organisms resulting from modern biotechnology The Biosafety Protocol makes clear that products from new technologies must be based on the precautionary principle and allow developing nations to balance public health against economic benefits. It will for example let countries ban imports of genetically modified organisms if they feel there is not enough scientific evidence that the product is safe and requires exporters to label shipments containing genetically altered commodities such as corn or cotton

1.7.3.16 Vienna Convention for the Protection of the Ozone Layer

This Convention was instituted in 1985 and places general obligation on the countries to make appropriate measures to protect human health and the environment against adverse effects resulting from human activities which tend to deplete the ozone layer.

1.7.3.17 International Best Practices

Other considerations of the ESIA include other international best practices. International institutions provide guidance on best practices for the ESIA process and place emphasis on achieving sustainable environmental, social, and health outcomes. They also provide environmental standards and limits for emissions and discharges. Some key project impact mitigation measures such as resettlement are also specified. The overall project design and this ESIA will align with international best practices such as guidelines published by the International Finance Corporation (IFC) and the World Bank. The following is a summary of the specific international requirements and standards that will be applied to this ESIA. It should be noted that, given the private-sector nature of the development, the IFC Performance Standards described below will be most directly applicable to the project in this case.

Other Relevant International Conventions

Other conventions, (classified according to their applicability to waste management, marine and biodiversity protections), relevant to the proposed project and to which Nigeria is signatory, but for which enabling legislation may not be in place in all cases, include:

- Environment of the West and Central African Regions, 1981;
- Convention on the Protection of the World Cultural and Natural Heritage, 1972;
- Convention on International Trade in Endangered Species (CITES), 1973;
- Bonn Convention on the Conservation of Migratory Species of Wild Animals, 1979;
- United Nations Convention on Biological Diversity (CBD) adopted at the Earth Summit in Rio de Janeiro, 1992;
- The Copenhagen Accord reached by Heads of State, Heads of Government, Ministers and other heads of delegation at the United Nations Climate Change Conference 2009 in Copenhagen, Denmark.

1.7.4 Greenville LNG Health, Safety and Environment (HSE) Policy

Greenville LNG Company Limited is committed to the protection of People, Assets, Environment, and its Reputation (PAERs), in all her operations including Construction, Production, Transportation, Service Stations, Customer Centers, etc. It aims to be in full compliance with all applicable legislation and industry best practices.

The philosophy of its operations is based on verifiable and reportable systems that engender the right and demonstrate positive HSE culture amongst employees, our host communities and other stakeholders. Our focus is for HSE continual performance improvement by implementing value-adding recommendations.

At Greenville LNG, we see safety as everyone's responsibility, and we work towards ensuring that every person at all our locations becomes safety-conscious and prioritises it. Thus, we task every person in our team with their safety and the safety of others.

1.8 Structure of the Report

This ESIA report has been prepared to highlight the biophysical, socio-economic and health issues related to the implementation of the Greenville LNG CNG Compression Station Project. It highlights the positive and negative impacts that may affect the installation and operation of the planned additional facilities on the project site and prescribes cost-effective mitigation measures to minimize or eliminate the negative impacts. In addition, it suggests a practical environmental and social management program (ESMP) for the expansion project. This report is presented in eight chapters.

- ***Chapter One*** is an introduction containing relevant background information about the proposed project and the Legal and Administrative Framework for ESIA in Nigeria among other relevant laws and guidelines relevant to the project.
- ***Chapter Two*** discusses the project justification, the need/value and the envisaged sustainability of the project as well as the project development and site/route options considered.
- ***Chapter Three*** contains the detailed descriptions of the proposed project including its location, overall layout, basis for design, type and specifications of equipment/facilities to be installed, source of power supply to the plant, operation/maintenance of facility, and specific project activities as contained in the conceptual design report. The emergency safety and security measures and overall project schedule are also contained in this chapter.
- ***Chapter Four*** describes the baseline ecological and socio-economic status of the study area. Information on consultation with stakeholders is also presented in this chapter.
- ***Chapter Five*** discusses the identified potential and associated environmental impacts of the proposed project.
- ***Chapter Six*** discusses the mitigation of identified potential and associated environmental impacts of the proposed project and highlights the various mitigation measures proffered against the identified significant impacts.
- ***Chapter Seven*** outlines a cost-effective environmental management plan that would be adopted throughout the project cycle. It also enumerates the environmental monitoring plan, the waste management plan and the project's decommissioning/abandonment plan.
- ***Chapter Eight*** discusses the decommissioning and restoration plans

- ***Chapter Nine*** gives the conclusion and requests approval for project implementation.

Other sections of this report include (not in any chronological order) are the table of contents, the list of references as highlighted in the report, the list of ESIA preparers, list of abbreviations and acronyms, the acknowledgement page, the Executive Summary and various appendices (attachments).

CHAPTER TWO: PROJECT JUSTIFICATION

2.0 Preamble

The establishment of a Compressed Natural Gas (CNG) mother/daughter station in Rigasa, Igabi Local Government Area of Kaduna State is justified by the growing national transition toward cleaner fuels, and the need to expand affordable energy access. The site's proximity to existing Abuja-Kaduna-Kano (AKK) gas infrastructure enables efficient gas sourcing and distribution, while the mother/daughter configuration supports flexible supply to areas without pipeline connectivity.

2.1 Proposed Project Justification

The establishment of a Compressed Natural Gas (CNG) Mother/Daughter station network is a highly viable strategic project. The business and economic justification relies on four primary pillars:

- **Proximity to Feedstock and Existing Infrastructure**: The site is just a few meters away from the existing Abuja-Kaduna-Kano (AKK) Gas Pipeline, the Mother Station shall directly taps into the existing domestic gas pipeline network. This allows for highly cost-efficient, high-volume gas compression at the source.
- **Virtual Pipeline Efficiency via Daughter Stations**: Due to the lack of vast secondary pipeline grids across the area, a Daughter Station model acts as a "virtual pipeline". The Mother Station compresses gas into mobile storage trucks, which then supply skid-mounted Daughter Stations in surrounding commercial areas and commuter corridors. This approach eliminates the exorbitant cost of building new physical pipelines and shorter construction timelines to meet pressing energy demands.
- **Immediate Commercial Demand**: The Abuja-Kaduna-Kano axis has a dense concentration of commercial transport fleets, tricycles, industrial logistics trucks, and marine vessels. High premium motor spirit (PMS) and diesel prices make local fleet operators eager to transition to cheaper fuel.
- **Direct Policy Alignment**: The project perfectly aligns with the Federal Government's Presidential CNG Initiative (Pi-CNG). This ensures strong regulatory backing, smoother environmental approvals through the Federal Ministry of Environment and potential fiscal incentives from the Midstream and Downstream Gas Infrastructure Fund (MDGIF).

2.2 Need for Project

The oil and gas industry plays an important role in the Nigerian economy, and this CNG

Compression is one such.

- The project will reduce dependence on PMS and diesel, lower greenhouse-gas and particulate emissions. This shift supports improved air quality and public health outcomes.
- Stimulate local economic activity and boost living conditions
- Enhance energy security in line with Nigeria's Decade of Gas policy.
- Improve the health of society and the environment
- Conservation of energy
- Provide resources for industrial production at lower cost and increase productivity
- Create employment opportunities for Nigerians

Environmental impacts identified are manageable and can be mitigated through established engineering and operational controls, making the project both environmentally viable and socio-economically beneficial

2.3 Benefits of the Proposed Project

The proposed CNG mother/daughter station will deliver significant environmental, economic, and energy-security benefits.

- It will reduce greenhouse-gas and air-pollutant emissions by providing a cleaner alternative to petrol and diesel, thereby improving local air quality and supporting Nigeria's energy-transition goals.
- The project enhances regional energy security by supplying a stable, locally sourced fuel and extending gas access to areas without pipeline infrastructure.
- It will stimulate economic growth through job creation, lower fuel costs for transport and industrial users, and increased business activity.
- The station also aligns with national policies such as the Decade of Gas and the National Gas Expansion Programme, while promoting safer fuel handling and reduced spill risks compared to liquid fuels.:

2.4 Value for the Proposed Project

The value of the proposed project is highlighted by the desire to enhance local environment cleanliness and health in the oil and gas operational areas. The project estimated cost is N1 billion, to be independently funded. The project lifespan shall be 25 - 30years.

2.5 Envisaged Sustainability

The sustainability of the proposed project is categorised as follows:

2.5.1 Economic Sustainability

The project is economically sustainable as it leverages Nigeria's abundant natural gas resources to provide a cheaper and more stable alternative to petrol and diesel. The station will reduce fuel costs for transport operators, SMEs, and industrial users, thereby improving business competitiveness. It will generate direct and indirect employment during construction and operation, stimulate local supply chains, and support long-term economic diversification in Kaduna State. The mother/daughter model also ensures cost-effective distribution to areas without pipeline infrastructure, enhancing market reach and financial viability.

2.5.2 Technical Sustainability

The project is technically sustainable due to the use of proven CNG compression, storage, and transportation technologies widely adopted globally. The modular mother/daughter configuration allows phased expansion based on demand, reducing technical risk. The proximity to existing gas infrastructure ensures reliable feedstock supply, while modern safety systems—pressure relief devices, gas detection, automated shutdowns—enhance operational reliability. The design complies with relevant engineering standards, ensuring long-term functionality and maintainability.

2.5.3 Environmental Sustainability

CNG is a cleaner-burning fuel that significantly reduces CO_2, NOx, SOx, and particulate emissions compared to conventional liquid fuels. The project will contribute to improved air quality and reduced greenhouse-gas emissions in line with Nigeria's climate commitments. CNG poses minimal risk of soil or water contamination because it dissipates rapidly when released. Identified environmental impacts—noise, construction disturbance, waste generation—are limited in scale and can be effectively mitigated through standard environmental management practices, making the project environmentally viable.

2.5.4 Social Sustainability

The project supports social sustainability by creating employment opportunities, enhancing local skills, and improving access to affordable energy. Lower fuel costs will benefit transport operators and commuters, contributing to improved mobility and reduced cost of living. The project promotes safer fuel handling and reduces community exposure to pollutants associated with diesel and petrol. Engagement with host communities ensures inclusion, transparency, and alignment with local development priorities.

2.5.5 Legal/Legislative Sustainability

The project aligns with Nigeria's regulatory framework governing natural gas utilization, environmental protection, and industrial development. It complies with FMEnv EIA requirements, NESREA environmental standards, and NUPRC guidelines for gas handling and distribution. The project will operate under valid permits and licenses, adhere to national safety codes, and implement an Environmental Management Plan (EMP) consistent with statutory obligations. This ensures long-term legal compliance and regulatory sustainability.

2.5.6 Political Sustainability

The project is politically sustainable as it directly supports national policy priorities, including the Decade of Gas Initiative, the National Gas Expansion Programme (NGEP), and Nigeria's broader energy transition agenda. It aligns with government efforts to reduce dependence on imported refined fuels, promote cleaner energy, and stimulate gas-based industrialization. The project strengthens government credibility in delivering energy reforms and is likely to receive continued political support at federal and state levels.

2.6 Project Options

As required by law in Nigeria, some reasonable options and alternatives to the various elements of the proposed project shall be considered and examined. Accordingly, a number of alternatives have been weighed up for the construction and operation of the proposed CNG Mother/Daughter Station using economic, technical and environmental considerations.

2.6.1 No- Project Option

The no-project option means the development of the planned CNG Station shall not take place. As a direct consequence, this would result in no effect on the environment in the area as this option would result in no change of environmental features. A key implication of this option is that the project area which is suitable for the CNG operations, will be under-utilized. Additionally, the waste generated at the oil operation terminals may likely be spilled into the host environment, thus creating pollution and health challenges in that local environment. The adoption of this option will mean, negative impact on the environment, society and nation's economy as well as loss of employment opportunities with the opportunity to improve the host local community.

This option also goes against the gas policy of Federal Government of Nigeria that has declared the decade on gas and has deepened investment in the sector and has

continued to woo private investment in the sector. Importantly, this mandate is geared toward addressing inadequate product (CNG – Autogas) availability across the country. In addition, the site is currently under-utilised, and the economic stimulus the proposed development will have on the host community would not occur. Since no viable economic or technical reason supports this option despite not negatively impacting the environment, the option was deemed not feasible and is rejected.

2.6.2 Delayed Project

Delaying the project involves moving the project to a later date. This situation is unlikely, and can only be considered if existing circumstances are highly un-favourable or risky for the execution of the project. Conflicts, war, hostilities, communities deeply resentful of the project or unacceptable/unattractive economics are some of the reasons this option can be adopted. In contrast, the economics and the political environment favour the execution of the project. Moreover, delaying the project will have no net effect on significant environmental impacts that would arise from the project. Additionally, the project will create job opportunities for the host communities. thus, delaying the project will have dire consequences as all processes that have been set up for the project design and implementation will be stopped. Furthermore, contractors will have to be demobilized, and when inflationary trends are taken into account, project costs could increase if the project is delayed and this leads to a decrease in the final profit and benefits accruable from the project. For these stated reasons, the delayed option is not considered.

2.6.3 "Go Ahead Project Option"

The justification of this project outweighs other negative variables; therefore the "go ahead" option is proposed for the project at the present location. It is therefore recommended that the project be carried out as planned, since adequate mitigation measures shall be incorporated into the project plan to minimise or eliminate potential negative environmental and social impacts of the proposed project. Importantly, it will add to achieving the FGN drive towards gas sector investment in the northern parts of Nigeria, which has been starved for years.

2.6.4 Alternate Site/ Locations

Alternative site locations were considered early on by the board of GVLNG Limited. Other location alternatives were considered before deciding on the present location but the current site is best suited for the project. This location is only about 100m from the gas node along the Abuja-Kaduna–Kano (AKK) pipeline. Thus, access to gas is assured with limited need for a lengthy gas pipeline into the compression station. In addition, this location was considered as it's not within a dense community and

promises lower environmental impacts during the project lifecycle. The key advantage of this alternative from an environmental perspective is minimal impact on the host community. As a result, this is the preferred and selected site.

CHAPTER THREE: PROJECT AND OPERATIONS DESCRIPTION

3.0 Project Introduction

This chapter provides a comprehensive description of the Greenville Compressed Natural Gas (CNG) plant and associated facilities, which are strategically located at Rigasa Community, Igabi Local Government Area, Kaduna State. Project details contained in this Chapter have all been provided by the project proponent. The project proponent is Greenville Liquefied Natural Gas Company Limited (GVLNG), formerly Greenville Oil and Gas Company Limited (GOGCL).

3.1 Geographical Location

The proposed project would be sited on a 10ha of land at Rigasa, Igabi Local Government Area, Kaduna State. The proposed project site falls within the following geographical coordinates: 10°35.364'N, 7°21.633'E.

Figure 3.1: Nigeria Showing Kaduna State.

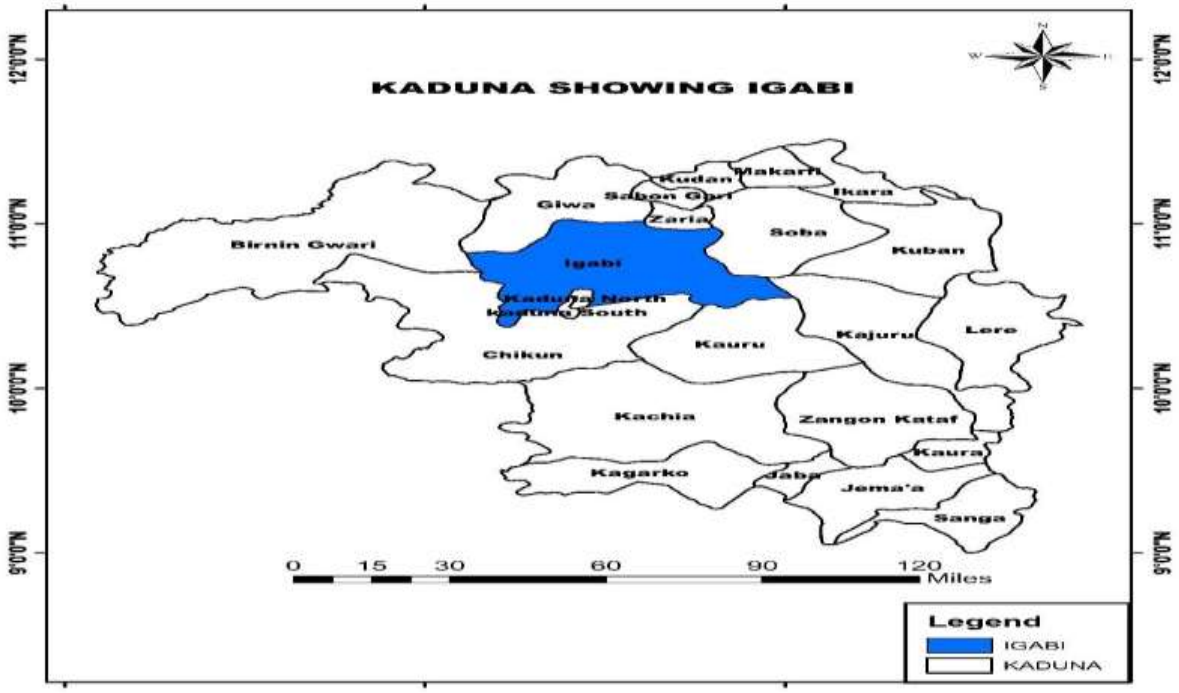

Figure 3.2: Kaduna State showing Igabi LGA in Blue Colour

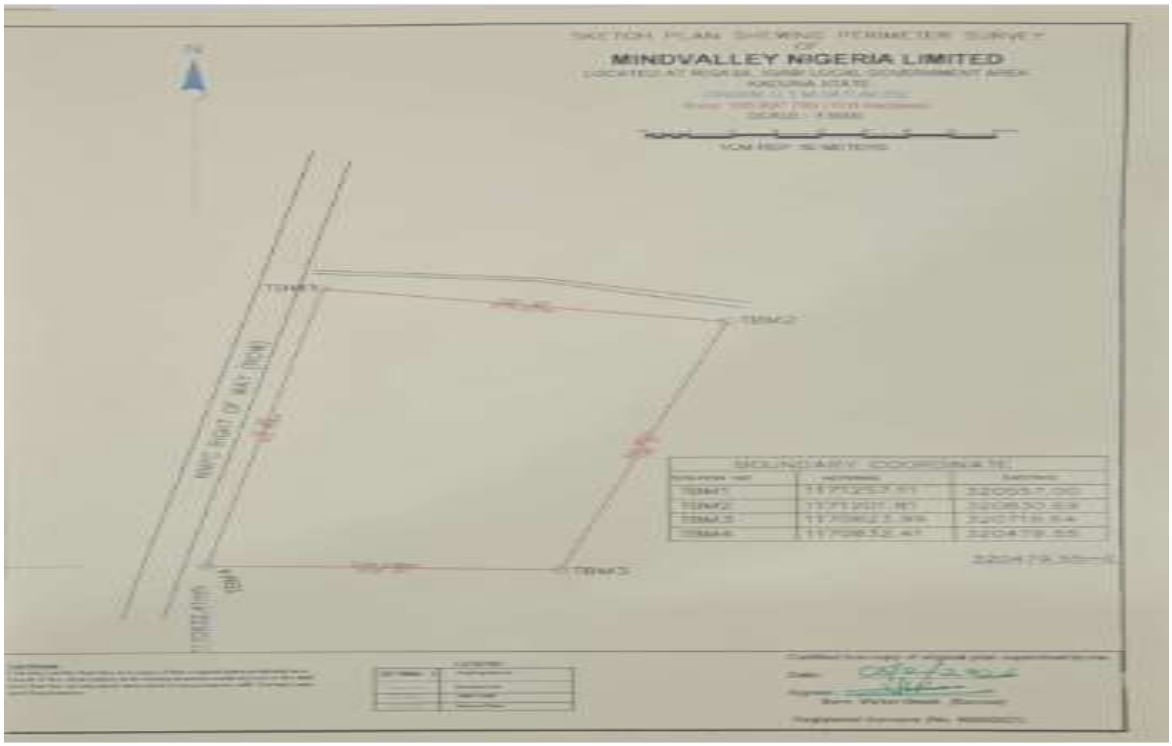

Figure 3.3: Layout of the Proposed Project Location

3.2 Project/Process Description

The gas source for the CNG Compression Station comes from the AKK Pipeline. The designed flow rate is 5000 Nm3/h, with an inlet gas pressure ranging from 5 to 6 MPa. The hydrogen sulfide content is no more than 15 mg/m3, and the total sulfur content is no more than 100 mg/m3. A control ball valve is installed on the pressure regulating and metering skid, which serves as the emergency shut-off valve for the inlet gas.

Inside the station, the gas pressure is regulated to about 4 to 4.5 MPa through the pressure regulating and metering skid, and then dried by a dehydration device. It is then reserved in a natural gas buffer tank with a volume of 5 m3 and subsequently compressed to 25 MPa by a compressor. (Three compressors are configured, each with a processing capacity of 2000 Nm3/h). The compressed natural gas is filled into CNG long tubes (CNG cascade storage group - sets), which are connected to a set of truck dispensers. A buffer recovery system is set up in this station.

The compressed gas is fed into a recovery tank with a volume of 2 m3, and the recovered natural gas is returned to the inlet of the buffer tank and then enters the compression and pressurization process through the buffer tank. The exhaust gas and wastewater from the compressor recovery tank (V102) and the dryer buffer tank (V101) are collected in a sewage tank (V103) with a capacity of 1 m3. After gas-liquid separation, the liquid phase is regularly discharged through a water seal pool. The vent pipes at all levels of this station's system are centrally released in a graded manner.

The vent pipe outlets are at least 5 meters above the ground. The vent pipe outlets are set vertically upward along the columns of the process area canopy.

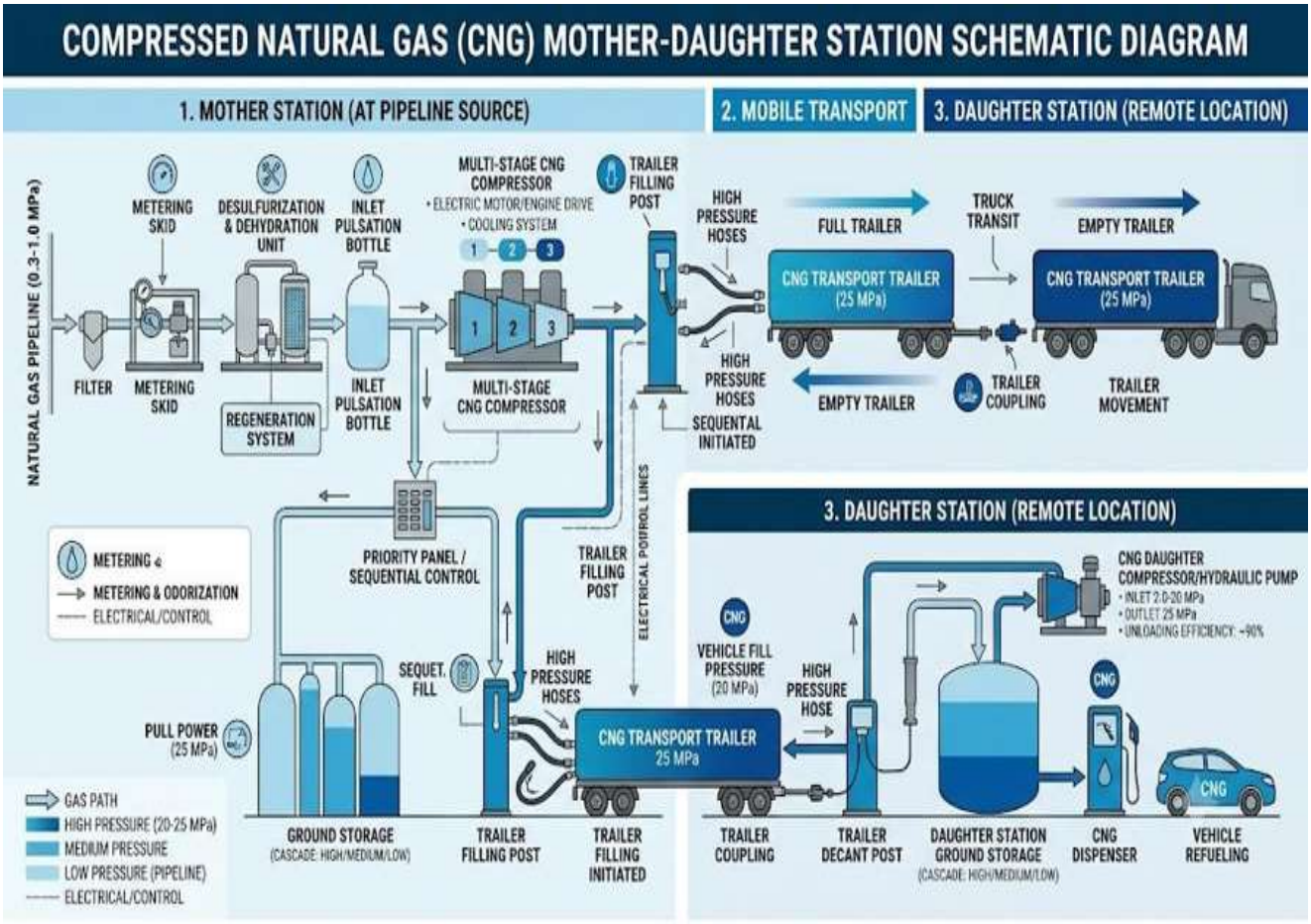

Fig 3.4: Process Flow Diagram for the CNG Mother Station Station Operations

Table 3.1: Key Equipment

Mother Station	Daughter Station
Gas filter/separator	Trailer unloading manifold
Fiscal metering skid	Priority panel
Gas dryer	Storage cascade
High-pressure compressor	Pressure regulating system
Cascade storage banks	CNG dispensers
Tube trailer filling skid	Emergency shutdown system
CNG dispensers	CNG dispensers

3.3 Facilities Description

The proposed CNG Compression Station is an industrial energy facility comprising two integrated zones: a compression section and a retail section.

- **Gas Receiving Unit (GRU):** Receives natural gas from an upstream pipeline or gas

supplier.

- **Compression System:** High-pressure compressors that raise gas pressure to CNG standards (typically 200–250 bar).
- **Cascade Storage System:** High-pressure storage cylinders arranged in banks for efficient loading and unloading.
- **Dispenser Units:** For direct vehicle fueling (if applicable) and for loading CNG into daughter-station transport modules.
- **Control Room & SCADA System:** For monitoring pressure, flow, safety systems, and operational parameters.
- **Fire & Safety Infrastructure:** Fire-suppression systems, gas detectors, emergency shutdown systems, and safety signage.
- **Ancillary Facilities:** Administrative building, workshop, security post, internal roads, drainage, and utilities.

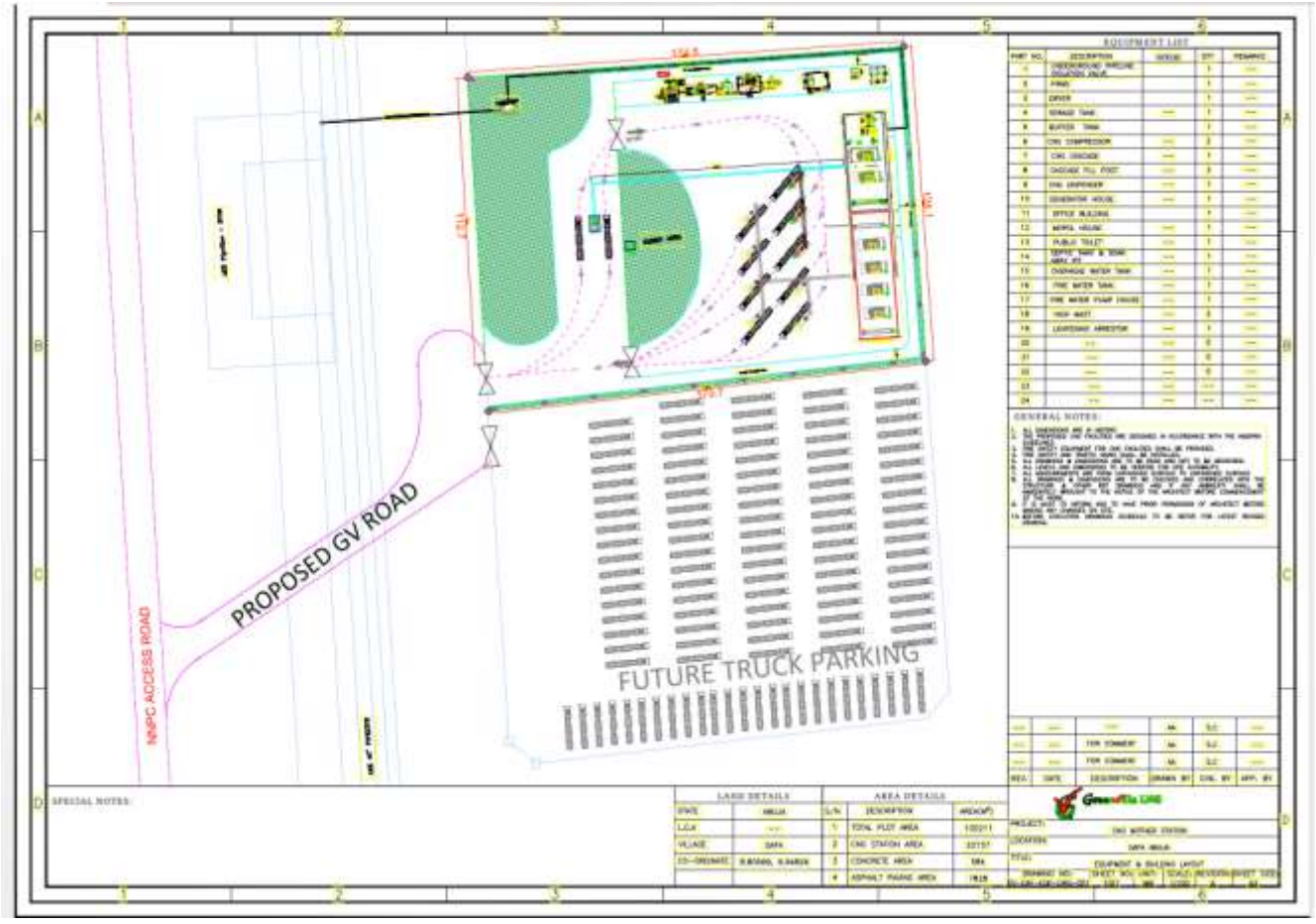

Figure 3.4: CNG Compression Station Facility Layout

3.4 Project Phases

3.4.1 Pre-Construction Activities

The activities in the pre-construction stage shall primarily be made up of:

- Concept development,
- Feasibility studies
- Site acquisition
- Site survey and geotechnical investigations
- Front-End Engineering Design,
- Environmental baseline studies
- Community engagement and stakeholder consultations
- Procurement of permits and approvals

All activities in this phase of project shall take into account environmental, technical and economic considerations.

3.4.2 Construction Phase

The construction of the facility would involve:

- Topographic Surveys
- Soil Investigation Surveys
- Mobilization of equipment and labour
- Site clearing and grading
- Installation of facilities that shall be fitted within the storage terminal e.g., piping, valves, loading hoses/nozzles, and safety alarms.
- Construction and installation of an administrative block, etc.
- Installation of Installation of foundations, equipment, and storage systems
- Construction of buildings and utilities
- Provision of Parking spaces.
- Painting of facilities
- Erection of safety signs around the facility
- Designation of Muster Stations
- Testing and commissioning of mechanical and electrical systems

3.4.3 Operations Phase

The operational activities shall include the following:

- Continuous gas compression, storage, and distribution
- Routine maintenance of compressors, storage banks, and safety systems
- Monitoring of environmental and safety parameters
- Good housekeeping
- Engagement with host communities and regulatory agencies

3.4.4 Decommissioning Activities

- Removal of equipment and structures
- Site remediation and restoration
- Waste disposal in accordance with regulatory standards

Applying a contemporary view, it is expected that all operation streams shall be stopped and all facilities shall be put out of use and/ or dismantled. Furthermore, the facility shall most likely have to be utilized for a different purpose and the environment shall be restored to as close to its original state as possible, with the specific decommissioning plan to be drawn up following the prescribed decommissioning guidelines of by FMEnv.

3.4.5 Maintenance Activities

Periodic checks of the pipeline, valves, compressors and dispensers shall be carried out. All leaks and spills shall be reported to the safety personnel who shall recommend and take appropriate actions. In addition, security personnel shall man the facility round the clock. Informal inspections shall be done on a daily basis noting the overall facility condition however formal inspections shall be conducted on a monthly basis. Piping must be maintained in sound condition and hydrostatically tested yearly. Sagging and cracking pipes as well as rusting or rotten pipe supports shall be checked for routinely. Maintenance activities shall also include repainting pipes; and repairing and replacement of defective pipes and valves. The hydrant tanks shall be checked for peeling, blistering or chipping periodically. The storage tanks shall be emptied, cleaned and the inside examined for holes and corrosion. The nozzles shall be checked for any signs of leaks from the valves and they shall be checked to see if they can be completely turned on and turned off to stop product flow.

Record keeping is a key aspect of maintenance and this would be kept for inspections, maintenance activities, training and product inventory.

3.4.6 Health, Safety, Security and Environmental Issues - Construction Stage

- All personnel involved in the construction activities shall wear appropriate PPE's during work;
- Hearing protection devices shall be provided in areas of excessive noise pressures;
- Only authorized personnel shall be allowed into the construction site;
- Wastes shall be appropriately handled during the construction phase to protect the water resource and environment;
- The entire construction area shall be cordoned off using a tape that serves a dual purpose for security and safety;
- Strict access control shall be implemented at the facility;
- There shall be sufficient security to protect all workers as well as the site, with security agencies being deployed if necessary.
- A secondary security team made up of members of the community shall be used, if necessary, to foster a good relationship with the community and negate any form of local security threats.
- A competent security officer shall manage security affairs during construction and shall report directly to the Managing Director.

3.4.7 Health, Safety, Security and Environmental Issues - Operations Phase

- An HSE Officer shall be in charge of all HSE related matters.
- PPE's and safety signs shall be in place all over the facility.
- The facility shall be run with an integrated safety management system that shall cover health, safety, environment and quality. All the safety items and features required by the management system after Hazard identification and risk assessment shall be made available.
- Relevant industrial training for staff shall be carried out, including operational health, environmental awareness and basic safety training;
- Adequate attention shall be given to environmental pollution;
- The plan for security during facility operations shall include the use of a reputable security firm to provide a team of trained private security personnel;
- Security matters shall be implemented following an approved security plan. The plan shall include round the clock security, access control, surveillance, training, communication, community relationship, emergency response, drills, exercises etc. This plan shall be reviewed periodically for update.
- The Chief Security Officer shall be at the senior management level with direct

line of reporting to the CEO.

- The facility shall be inspected regularly for general cleanliness
- The safety superintendent shall visually inspect generators feed tank, water reservoir valves, pipelines, flanges and loading arms for leaks, cracks, dents, corrosion, open/close position of valves and will record all observations appropriately.
- The fire hydrant system shall be inspected daily to ensure that it is ready for use. In addition, firefighting equipment shall be manned at all times by at least one well-trained fire staff.
- The Health and Safety department shall have a firefighting unit. The unit shall be made up of highly trained personnel. However, all work units within the facility shall have at least one staff trained in firefighting and designated "Unit Fire man" in addition to their primary duties. These men shall be effective in fire prevention efforts within their units, assisting the safety officers and act as first responders in the case of a fire within their work areas;
- Fire drills shall be carried out half yearly for the entire staff of the factory. Situations may, however arise such as employment of new staff or introduction of new processes or equipment which may necessitate a fire drill before the set time;
- There shall be muster points for fire drills and safety signs also displayed at various locations of the facility to put all workers, contractors and visitors on alert.
- There shall be "no smoking" signs at smoking prohibited areas, in addition to danger and warning signs all around the facility

3.4.8 Health, Safety, Security and Environmental Issues - Decommissioning Stage

- All personnel involved in decommissioning activities shall wear appropriate PPE's during work
- Hearing protection devices shall be provided in areas of excessive noise pressures
- Only authorized personnel shall be allowed into the project area
- Wastes shall be appropriately handled by DSEPA during the decommissioning phase to protect the groundwater and the environment.

3.5 Emergency Response Procedures

Emergency Response Procedures during the project shall be in the areas of:

- Medical emergencies
- Fire Outbreaks
- Security

- Extended power losses
- Chemical/ Oil spills
- Water contamination

The response for medical emergencies shall be:

- Immediately contact emergency phone numbers of paramedics and health care facilities and notify them of the nature and location of the emergency;
- Not to move the victim unless absolutely necessary;
- Any trained personnel available will give CPR/ first aid to the victim/ injured personnel involved prior to the arrival of professional help. However, if no trained personnel are available, minor actions like stopping bleedings through the application of pressure on wounds as well as clearing victims' air passages can be initiated;
- In case of rendering assistance to personnel exposed to hazardous materials, the Material Safety Data Sheet (MSDS) will be consulted and appropriate personal protective equipment will be worn. In such cases, first aid will be attempted by ONLY trained and qualified personnel.

The response for fire outbreaks shall be:

- Activation of the nearest fire alarms;
- Notifying the Nigerian Fire Service/ Kaduna Fire Service;
- Getting all personnel within the facility to the muster points through the designated escape routes, but in the case of very large fires evacuating all personnel from the facility;
- Ensuring all personnel have evacuated the affected area;
- Getting trained firefighting personnel to combat the fire while awaiting the Nigerian Fire Service;
- Using the appropriate fire extinguishers for the various fire classes (viz Multipurpose Dry Chemical for Classes A, B, C and Dry powder for Class D;
- Regularly servicing the extinguishers for optimal performance
- Shutting down any processes and isolation of any materials that will escalate the fire, if it is safe to do so; and
- Ensuring all personnel remain at their designated muster stations until the competent authority decides it is safe to re-enter the affected area when the fire is out.

The response for security incidents shall be:

- Notifying the relevant security agencies particularly the Nigerian Police on the nature of the threat;
- Getting all personnel to take shelter to any threat that may pose danger to personnel, with all exterior doors locked;
- Encourage personnel to flee the facility if the threat is within and they are close to an exit;
- Encourage personnel to hide, turn off phones and lights, if personnel are facing a clear and present danger within the facility;
- Keep all doors locked in the building until law enforcement or security officers issue an official "all clear";
- Only the security personnel at the site will be allowed to combat the security threats.

The response for extended power losses shall be:

- Cease activities or operations that involve potentially hazardous conditions;
- Plug equipment needed during a prolonged power outage into emergency power outlets;
- Turn off equipment sensitive to power failure while unnecessary electrical equipment and appliances should be turned off in the event that power restoration would surge, causing damage to electronics and affecting sensitive equipment in the process;
- Use of alternative sources of lights like emergency lights or flashlights; but use of open flames will be avoided;
- Increasing natural lighting by opening windows to aid visibility;
- After power is restored, all equipment will be checked to make sure they have restarted properly; and
- Personal belongings must be secured.
- The response to chemical/ oil spills shall be:
- Immediate notification of the designated personnel and safety coordinator;
- Containing the spill with available equipment (e.g. pads, booms, absorbent powder etc.);
- Securing the area and alerting other site personnel;
- Preventing personnel from attempting to clean-up the spill unless trained to do so;
- Attending to injured personnel and calling in the medical team;

- Calling the registered spill clean-up company; and
- Notifying the necessary Government regulatory body/ agency.
- The response for water contamination shall be:
- Immediate notification of the designated personnel and safety coordinator;
- Notification of Local Authorities and the appropriate regulatory agencies;
- Notification of neighbouring communities and other water resource users;
- Providing alternative sources of water for use by personnel;
- Immediate removal of the source of contamination; and
- Conducting immediate water quality monitoring.

3.6 Waste Generation

According to the Basel Convention, wastes are substances or objects that are disposed or are intended to be disposed of, or are required to be disposed of by the provisions of national laws. Wastes include any items that people no longer have any use for, which they either intend to get rid of, or have already discarded. In addition, wastes also include such items which are required by law to be discarded, because of their hazardous properties.

In the light of this, Greenville LNG Limited recognize the implications of the ineffective handling and final disposal of generated wastes. GVLNG intends to be practical, systematic and efficient in the handling of waste materials during the construction and operation phases at the petroleum products terminal.

As a result, a stand-alone Waste Management Plan will be developed to conform to the universal principles of minimize/reduce at source (waste generation); reuse (components); recycle (before disposal) and responsible disposal – the 4 Rs Principle.

The Waste Management Plan shall entail detailed strategies for conducting waste identification, waste collection/characterization, waste segregation, storage, tracking, treatment and disposal and the various strategies are highlighted in this section.

3.6.1 Waste Identification and Characterisation

Various forms of waste expected to be generated during the construction and operations phases have been identified. These wastes have been classified as solid, liquid and gaseous; they have also been categorized as hazardous and non-hazardous as well as biodegradable and non-biodegradable. The characterization of

expected wastes from the project is shown in **Table 3.2**.

Table 3.2: Expected Wastes, Sources and Characterization of Wastes in the Various Project Phases

S/N	Wastes	Source(s)	Solid/ Liquid/ Gaseous	Hazardous/ Non-Hazardous	Biodegradable / Non-Biodegradable	Project Phases Associated with Wastes	
						Construction Stage	Operations Stage
1	Earth Fill	Excavation	Solid	Non-Hazardous	Non-Biodegradable	X	
2	Vegetation (Trees, tree stumps and thick branches)	Excavation and Site Clearing	Solid	Non-Hazardous	Biodegradable	X	
3	Construction Wastes/ Rubble	Unused and Broken aggregates, cement powder, concrete, grout, bricks and tiles	Solid	Non-Hazardous	Non-Biodegradable	X	
4	Steel Rods	Off-cuts of steel rods, steel plates	Solid	Non- Hazardous	Non-Biodegradable	X	
5	Scrap metal	Metal off-cuts, metal drums, rusted scaffolds and fabrication	Solid	Non-Hazardous	Non-Biodegradable	X	
6	Untreated Wood	Support boards, wood chippings and cuts, boxes and crates	Gaseous	Non-Hazardous	Biodegradable	X	
7	Gaseous Emissions	Generator diesel engines, heavy duty engines, storage tank vents, flash emissions, vehicular emissions	Solid	Hazardous	Non-Biodegradable	X	X
8	Dust	Excavation, site clearing, Dust present in the ambient air	Liquid	Non-Hazardous	Non-Biodegradable	X	
9	Spent/ Spilled hydraulic and lubricating Oil	Generators, BRV's, pumps	Liquid	Hazardous	Non-Biodegradable	X	X
10	Used/ Spent Oil	Generators, machinery and Big Road Vehicles (BRV's)	Liquid	Hazardous	Non-Biodegradable	X	X
11	Oil Spills	Pipeline leakages;	Solid	Hazardous	Biodegradable		X
12	Oil Filters	Maintenance of Engines and pumps	Solid	Hazardous	Non-Biodegradable		X
13	Oily Rags/ Absorbents	Clean up of oily surfaces and equipment	Solid	Hazardous / Non-Hazardous	Non-Biodegradable	X	X
14	Lead –Acid Batteries	Used Lead-acid batteries	Liquid	Hazardous	Non-Biodegradable		X
15	Run-off Water	Precipitation into drainage channels and indiscriminate surface run-off during construction	Liquid	Hazardous / Non-Hazardous	Non-Biodegradable	X	X
16	Paints	Spilled or residual paints in	Solid	Hazardous/	Non-Biodegradable	X	X

		containers		Non-Hazardous			
17	Nails	Unwanted or damaged nails	Solid	Non-Hazardous	Non-Biodegradable	X	
18	Bulbs/ tubes	Damaged or destroyed bulbs from illuminated areas	Solid	Hazardous	Non-Biodegradable	X	X
19	Treated Wood	Unused, Damaged or destroyed finished wood products such as office furniture etc.	Solid	Hazardous / Non-Hazardous	Biodegradable		X
20	Plastic	Packaging materials, damaged plastic materials and containers, PVC pipes and plumbing fittings	Solid	Non-Hazardous	Non-Biodegradable	X	X
21	Glass	Bottles and jars, ceramics, broken windows	Solid	Non-Hazardous	Non-Biodegradable	X	X
22	Paper and cardboard	Packaging, newspapers, computer prints, domestic sources, office documents,	Solid	Non-Hazardous	Non-Biodegradable	X	X
23	Metal drums and tins	Packaging for chemicals, paints, varnishes etc	Solid/ Liquid	Hazardous / Non-Hazardous	Non-Biodegradable	X	X
24	Food and Beverage	Personnel food consumption	Solid/ Liquid	Non-Hazardous	Biodegradable	X	X
25	Sanitary Wastes/ Sewage	Urinals, Water Closet, sinks, showers and laundry	Solid	Non-Hazardous	Biodegradable		X
26	Agricultural/ Plant Waste	Pruning of plants, Excavated plant / agricultural material or dead or decayed plant material	Solid	Non-Hazardous	Biodegradable	X	
27	Electrical Waste and E-Waste	Unused or damaged electric wires; off cuts of electric wires, Old computer systems, flash drives, CD's, Digital scanning equipment		Hazardous	Non-Biodegradable	X	X

3.6.2 Construction Wastes

During construction, the main type of wastes are rubble, concrete-based masonry, blocks and tiles. Others envisaged wastes include earth fill, tree and tree stumps, wooden planks, packaging material, waste oils, spent diesel, oily rags, steel rods, plastic, glass, plumbing off-cuts and electric wiring. Dust and gaseous emissions shall be released into the ambient air. Exposure to dust in construction sites shall come from material stockpiles and unpaved surfaces or excavation operations, while sources of gaseous emissions shall be from earth moving equipment and diesel generators.

Reusable wastes shall be recycled on-site, so as to reduce the collection, transportation and disposal and any associated charges from handling.

3.6.3 Operations Waste

Operational wastes shall include: packaging materials, paper and plastic materials accumulated from consumables and deliveries. The primary sources of such materials shall be mainly from maintenance works during operations.

Wastes shall be accumulated in suitable receptacles which shall be placed in appropriate areas throughout the facilities where these wastes are generated.

Metals and plastic containers shall be used for a wide range of lubricants and chemicals, while drums and containers shall inevitably contain variable quantities of residues. These wastes and other solid wastes shall be cleared, properly packaged and disposed of at designated disposal locations. GVLNG shall also seek opportunity for waste minimization through the use of the "reduce, reuse and recycle / recover" philosophy.

Treated wood waste shall be generated from office furniture that are no longer used or needed and they shall be sold for reuse at other locations or sent to an offsite facility for treatment (if hazardous) prior to final disposal.

Oily rags are envisaged to be generated from cleaning oily surfaces (lubricating oils), fuels, paints or other solvents. Oily rags used in cleaning hazardous substances (if any) shall be stored in air-tight, non-combustible containers and sent to KEPA or any FMEnv/NMDPRA approved disposal facility.

Lead-acid batteries from generators and automobiles shall be replaced regularly during the operational phase of the project. Lead-acid batteries contain large quantities of lead and sulphuric acid. Once the lead plates begin to wear and the acid weakens, they will need to be changed and disposed-of, and these wastes shall then be sent for recycling for its valuable components or to a lead-acid battery vendor.

3.6.4 Decommissioning Waste

A broad range of wastes shall be generated during decommissioning. These could range from demolition waste/ rubble from any structures that shall be brought down, earth fill and plant wastes that would be generated from any excavations being carried out, in addition to scrap metals, wood, plastic, glass, metal drums, paper and bulbs. Steel plates from the storage tanks and other structures shall be removed and re-used/ recycled if practical. Spent oil/fuel could be generated from the earth moving equipment used during decommissioning operations. Dust and gaseous emissions is envisaged to be generated from the earth moving equipment used.

3.6.5 Waste Segregation

An integral part of the Waste Management Programme is waste segregation which prevents the disposal of hazardous waste with non-hazardous wastes, and also ensures re-use of recyclable wastes. During construction, wastes shall be segregated as inert construction waste, non-inert construction waste, chemical waste and general refuse; while during operations, the wastes shall be further segregated into general wastes, food waste, effluents, oil/ chemical spills, glass, paper, plastic waste, tins and drums, e-waste and electrical wastes etc. and stored in separate colour-coded bins.

3.6.6 Waste Storage

All wastes shall be handled and stored in a manner which ensures they are held securely without loss or leakage to minimize the potential pollution. Portable containers shall be used to accumulate and hold solid wastes prior to disposal by appropriate vendors. While, sanitary wastes shall be routed to a septic tank, and be removed by accredited waste managers.

3.6.7 Waste Tracking

To ensure that all wastes collected from the proposed CNG Mother/Daughter Station are disposed of appropriately, a Waste Consignment Note (WCN) shall accompany all waste transfers.

The WCN shall contain the description and the quantity of waste, as well as the disposal facility. The materials handler shall prepare a WCN for each transport, and shall include the Materials Safety Data Sheet (MSDS) for any hazardous wastes.

3.6.8 Waste Disposal

The individual waste streams collected from the proposed project across all project phases shall be managed or disposed of in varying manners, with the frequency of disposal individually tailored to the characteristics of each individual waste stream. For example, general refuse generated on-site during construction shall be

disposed-off by a waste vendor on a daily or every other day, to minimize potential odour impacts; minimize the presence of pests and other scavengers, and prevent unsightly accumulation of waste.

Due to the nature and scale of activities associated with the proposed project, GVLNG shall engage a waste vendor for handling the facilities waste streams to ensure a more effective and sustainable management of generated wastes. **Tables 3.3** and **3.4** shows the waste disposal, treatment and management options for the project.

Table 3.3: Construction Waste Streams

Wastes	Disposal/ Treatment
Earth Fill	• Reuse a portion on-site as backfill material for foundations as well as for landscaping • Any good quality fill can be transported for reuse at other locations • Surplus material to be collected and transported to an off-site disposal facility
Vegetation (Trees, tree stumps and thick branches)	• Trees and tree stumps to be cut into logs and sold for timber for various uses including fuel/ charcoal • Leaves and small branches to be transported for composting at an off-site facility
Construction Wastes/ Rubble	• Wastes to be reduced by purchase control of construction materials and prevention of excessive concrete mixing • Proper storage will minimize the damage or contamination of construction materials • Construction rubble will be reused as much as possible within the project • Waste that cannot be reused will be collected and transported to landfill
Steel Rods/ Steep Plates	• Waste volumes will be reduced by purchase control of steel materials • As much steel as possible will be reused on-site • Unused steel materials will be collected and reused offsite • Damaged/ broken steel rods/ plates will be gathered and sent to a metal scrap yard for recycling
Scrap metal	• Waste volumes to be reduced by purchase control of metals/ metal containing materials • Scrap metal will be collected and sent for recycling
Wood	• Wood will be reused if practical • Unused wood waste will be collected and transported to recycling or disposal facility
Gaseous Emissions	• Emissions will be minimized through strict equipment maintenance programs • Total hours of operation of equipment will be optimized • Low sulphur, clean burning diesel will be used

Spent/ Spilled hydraulic and lubricating Oil	• Planning and good housekeeping practices to be employed to minimize surplus and contamination Surplus chemicals may be usable in other locations or returned to vendors, if possible
Used/ Spilt Diesel or Fuel	• Fuel wastes generated will be reduced through purchase control of fuels • Spills and leakage to be avoided by improved housekeeping, maintenance and transport procedures (like use of secondary containment and proper decanting system for petrol/diesel from damaged drums or vessels.)
Oily Rags	• The potency for fires will be reduced by storing in air-tight containers • Used oil rags employed to clean hazardous substances will be collected and transported to waste disposal facility
Run-off Water	• Contamination of the runoff water to be avoided as much as possible as the groundwater is prone to contamination in the construction phase. • Thought will be given to the segregation of drainage from oil, fuel and chemical storage areas from the rest of the site.
Paints	• Residual Paints will be reused where it is feasible • Old and poor-quality paints will be hardened and disposed to landfill (with the exception of oil paints) • Residual oil paints will be collected and transport to disposal facility • Unused paints to be returned to vendors
Nails, screws, bolts and nuts	• Waste quantities to be reduced through purchase control • Nails, screws bolts and nuts to be reused if practical • Damaged nails will be collected for recycling at a metal scrap yard
Bulbs/ tubes	• Damaged bulbs to be collected and transported to disposal facility
Plastic	• Plastic containers or bottles to be reused for various purposes if safe to do so • Plastic containers/ plastic materials no longer needed, will be collected and sent for recycling
Glass	• Waste glass will be collected and transported to a disposal facility
Paper and Cardboard	• Will be collected and sent for recycling
Metal drums and tins	• Bulk transport and storage for high volume consumption items to reduce the number of waste drums and tins generated. • These containers will be refilled and reused where possible • Non-refillable containers will be returned to vendors for reuse or to a company specializing in container refurbishment.
Food and Beverage	• Food wastes to be used as animal feed • Food and beverage wastes to be collected by a waste disposal vendor
Sanitary Wastes/ Sewage	• Sanitary waste to be collected and treated in a septic tank

Agricultural/ Plant Waste	• To be collected for composting
Electrical Waste	• Electrical wastes will be collected and transported for recycling to recover valuable materials including copper/ other conducting metal as well as rubber.

Table 3.4: Operations Waste Streams

Wastes	Disposal/ Treatment
Scrap metal	• Scrap metal to be gathered and sent for recycling at a metal scrap yard
Wood	• Wood waste will be collected and transported to recycling or disposal facility
Gaseous Emissions	• Emissions will be minimized through strict equipment maintenance programs • Total hours of operation of equipment will be optimized Low sulphur clean burning diesel will be used
Spent/ Spilled hydraulic and lubricating Oil	Planning and good housekeeping practices to be employed to minimize surplus and contamination
Used/ Spent Oil	• Fuel wastes generated will be reduced through purchase control of fuels • Spills and leakage to be avoided by improved housekeeping, maintenance and transport procedures (like use of secondary containment and proper decanting system for petrol/diesel from damaged drums or vessels.) Spent oil to be discharged into sump pit and recycled
Oil Spills	• Planning and good housekeeping practices to be employed to minimize oil spills • Absorbed where possible, booms will also be used (if on water), absorbent, and then collected before injecting into a waiting vessel for reprocessing
Oil Filters	• Old oil filters to be collected and transported to disposal facility to recover used oil and steel components for recycling
Oily Rags	• The potency for fires will be reduced by storing in air-tight containers • Rags containing oil and grease will be laundered, dried and reused • Used oil rags employed to clean hazardous substances will be collected and transported to disposal facility
Lead-Acid Batteries	• Batteries to be collected and transported and sent to a recycling facility or lead acid battery vendors
Run-off Water	• Contamination of the surface drainage water to be avoided as this is considerably easier than any subsequent treatment. • Thought will be given to the segregation of drainage from oil, fuel and chemical storage areas; loading/unloading areas; • and production operations areas from the rest of the facility.
Paints	• Any leftover paints will be reused when required • Old and poor-quality paints will be hardened and disposed to

	landfill (with the exception of oil paints) • Residual oil paints will be collected and transported to disposal facility
Nails, screws, bolts and nuts	• Waste quantities to be reduced through purchase control • Nails, screws bolts and nuts to be stored for reuse during maintenance • Damaged nails will be collected for recycling at a metal scrap yard
Bulbs/ tubes	• Wastes can be reduced by purchasing LED/ energy saving bulbs as substitutes • Old bulbs to be collected and transported to disposal facility
Treated Wood	• Will be collected to be reused at another facility or recycled • Wasted treated wood will be collected and transported for treatment and disposal
Plastic	• Plastic containers or bottles for various purposes will be reused if safe to do so • Plastic containers/ plastic materials no longer needed will be collected and sent for recycling
Glass	• Waste glass will be collected and transported to a disposal facility
Paper and Cardboard	• Will be collected and sent for recycling
Metal drums and tins	• Bulk transport and storage will be used for high volume consumption items. • Containers will be refilled and reused where possible, • Non-refillable containers will be returned to the vendor for reuse or to a company specializing in container refurbishment.
Food and Beverage	• Food wastes to be used as animal feed • Food and beverage wastes to be collected by a waste disposal vendor
Sanitary Wastes/ Sewage	Sanitary waste to be collected and treated in a septic tank
Agricultural/ Plant Waste	To be collected for composting
Electrical Waste and E-waste	• Electrical and E-wastes will be collected and transported for recycling to recover valuable materials including copper/ other conducting metal as well as rubber/ plastics
Process Wastewater/ Effluent	• Treated in skimmer pit before disposal

3.7 Traffic Management

GVLNG's Traffic Management Plan is essential for maintaining optimal traffic flow and taking into account worst-case scenarios, especially during operations. The plan contains the mandatory minimum requirements for traffic management during the various project phases and separate Traffic Management Plans shall be designed for the construction and operations phases. Accidents carry a risk of loss of life, property, money; products, or damage to equipment. The traffic

management plan shall aim to:

- Identify, assess and control the risks associated with traffic hazards
- Eliminate traffic hazards where reasonably practical;
- Adopt adequate traffic management planning where operations/ work force causes changes to the flow of either pedestrian, vehicular or mobile plant traffic

The key features of the Traffic Management Plan include:

- Vehicle Routes
- Signage
- Facility Protection
- Safe Crossings and Pedestrian Zones
- Training and Review

3.7.1 Vehicle Routes

Vehicle routes shall be designated within the premises during the different project phases and there shall be specified vehicle lanes for road tankers and smaller vehicles during project operations. Parking areas will be provided separately for trailers and cars, and these will be clearly marked. Stopping and non-stopping areas shall also be specified in addition to haul and loading/ unloading routes for supplies and materials. In a bid to keep optimal traffic flow, there shall be separate entry and exit points especially in the operational phase where the route surface will be made of well-drained material such as bitumen or concrete in order increase grip and prevent slippage.

The route surfaces shall always be kept free of hazards such as oil, slippery substances, potholes or other surface damage as these hazards affect stopping distances, maximum speeds and cause vehicle wear. Excessively steep gradients shall be avoided as much as possible, as they will create instability in vehicular movements within the facility.

The lane widths are crucial and shall have buffer zones slightly larger than the widest load of the largest vehicles thus reducing the risk of accidents and collisions. The roads widths shall be designed to permit easy maneuvering of vehicles, with corner radii to suit the turning circle of the largest vehicle expected (i.e., fire trucks, road tankers or any specialist vehicles carrying special loads).

3.7.2 Signage

Signage is an integral part of the Traffic Management Plan as it guides drivers and pedestrians on appropriate movement around the facility. Reflective markers and lines and easy to read signs will alert all vehicles and pedestrian users to things of

importance. It will be ensured that all signs will need to be legible at maximum speeds and they will be placed far above eye level. Clear signage will be used to alert drivers to:

- Exclusion zones
- Parking/no parking zones
- Speed limits
- Pedestrian crossings
- Vehicle crossings
- Blind corners
- Steep gradients
- Overhead hazards (e.g., powerlines) specifying maximum vehicle clearance heights
- Poor or changed traffic conditions
- Sharp or blind corners
- Other known hazards

3.7.3 Facility Protection

Areas within the proposed facility having vulnerability and susceptible to wear will be subject to protection. Protective items like bollards will be useful in protecting important parts of the facility and to also alert pedestrians to dangerous zones and prevent them from walking into oncoming traffic. In addition to bollards, guardrails will be used in certain areas to protect pedestrians from traffic.

To reduce wear on the structural features of the facility, bump rails or rub rails, may be used to extend the life of key facility structures. These protective measures will extend the life of the facility and they will be put in place to minimize the possibility of accidents.

3.7.4 Safe Crossings and Pedestrian Zones

Pedestrian zones shall be clearly demarcated and physically separated so that vehicles cannot encroach. Where it is not possible to physically separate pedestrian and vehicle zones, alternative options such as vision panels in doors, mirrors for pedestrian and vehicle use will be applied. Natural pedestrian routes and clearly marked footpaths will be made obvious to both the people walking them and the vehicles.

Barriers will be used not just to stop traffic but also to remind pedestrians of entrances and exits when moving around the facility. Should pedestrians need to cross vehicle routes, protection through the use of physical barriers with inward opening gates,

gates with warning devices and the use of traffic light systems will all be contemplated. These control measures will also be combined with clearly visible ground markings, lights and signs.

3.7.5 Training and Review

Every person who enters the facility shall be made to understand the Traffic Management Plan during induction training. They will be made aware of designated safe routes, no-go zones and speed limits which will be done through an induction process. A supervisor will be provided for visitors to ensure their safety and protection when navigating around the facility. Training is a critical element and many types of vehicles require operators to have high risk work licences.

A review of the Traffic management Plan will be done periodically to assess whether all strategies have been effective and how they could be improved. This will ensure that the Traffic Management Plan keeps up with the advancements offered by new technology, new procedures and staff experience.

3.7.6 Responsibilities and Duties

The CEO of GVLNG is ultimately responsible for all safety, health and environmental issues in the company, including the provision of adequate human and material resources for effective implementation of the company's Spill Prevention and Countermeasures plan. The general manager (operations) has the overall authority and responsibility in the management of all activities related to control, and effective combating of any oil spill in the company's operations. The commercial manager's primary responsibility is to ensure that the Facility/ Plant Manager and the Marine Manager are fully equipped to handle emergency situations in their respective business units; while the HSE Manager ensures that oil spill response operations are carried out in accordance with company HSE Policy and Procedures, relevant laws and regulations.

The Facility Manager shall be the on-scene commander in the event of an oil spill occurring at the proposed CNG Compression Station.

The transportation or logistics manager shall be responsible for providing facilities, services and materials in sufficient quantities to support oil spill incident response; with the clean-up coordinator being responsible for co-ordinating oil spill clean-up on land by determining resource needs; mobilizing clean-up personnel for oil spill response in addition to delegating various assignments as deemed fit to the response team/personnel assigned to deal with any oil spill incident.

3.7.7 Spill Risk Analysis

The proposed project will be evaluated to determine where there is reasonable potential for equipment failure, which would result in a potential release of oil to the environment. This will involve the predetermination of potential sources of oil

spillages, analysis of oil spill scenarios, resources at risk and potential damage to the resources. Spill risk analysis based on knowledge of the facility operations shows that the major risks are associated with:

i. Pipeline corrosion/rupture
ii. Malfunctioning of valves/nozzles
iii. Loading Failure
iv. Road Tankers accident/overfill
v. Fire/Explosion.

3.7.8 Spill Prevention Mechanisms

The proposed CNG Mother/Daughter Station shall contain the following at vulnerable areas:

- Curbing; culverts, gutters or other drainage systems;
- Storage sheds with built-in containment
- Weirs, booms or other barriers;

3.7.9 Equipment and Materials for Spill Response and Clean-up

The equipment and materials that will be stockpiled at the facility for Tier-1 Spill response include:

Response Equipment

- Response vehicle fitted with spark arresters.
- Waste oil storage tanks and drums of various capacities
- Caution signals and Reflecting Tapes
- Pick-up trucks with spark arresters.

Clean-up Equipment

- Hot water cleaner
- Sorbent Pillows
- Sorbent sheets
- Non-spark Shovels/Rakes
- Sorbent booms
- Vacuum truck and hoses
- Containment boom
- Storage containers of various sizes.
- Buckets

- Fire mains water portable air pumps
- Sand

Personnel Protective Equipment

- Rubber boots
- Rubber Gloves
- Face Visors/goggles
- Waterproof suits/coveralls
- Respirators
- Hazardous Vapour defector
- Stock of soap detergent for degreasing/deoiling of concreted areas, vessel/decks and general cleaning purposes.
- Hard hats

Contact Persons and Agencies

Spills at the proposed facility shall be under the jurisdiction of the Kaduna Environment Protection Authority (KEPA) and the National Oil Spill Detection and Response Agency (NOSDRA). In addition, some key personnel of GVLNG Limited will be designated as being responsible for oil spill prevention at the facility. Their names, roles and responsibility and contacts will be contained in the Spill Prevention, Control and Countermeasures plan at the start of operations.

CHAPTER FOUR: DESCRIPTION OF THE EXISTING ENVIRONMENT

4.1 The Study Approach

Environmental baseline study of the Compressed Natural Gas (CNG) Mother/Daughter Station in Rigasa Community, Igabi Local Government Area of Kaduna State is undertaken in order to establish the situation of the physical, biological, social and health environment of the study area prior to the commencement of the project development. This serves as baseline or benchmark to assess and monitor the impacts of the proposed CNG Station at Kaduna State.

Consequently, upon completion of the environmental baseline study, the results generated would serve as a benchmark against which any potential beneficial or non- beneficial impact of the proposed project on the environment and socio-economics of the project area would be identified and assessed.

The main environmental components considered in the environmental baseline study include:

- **Physical components**: soil, surface/ground water resources, water/air quality and climatology;
- **Biological environment**, which includes: flora, (i.e trees, grasses, forest, fauna i.e, fish, Mega fauna, birds, mammal), threatened, and/or endangered species (plant/animals), species diversity, overall ecosystem stability etc.
- **Cultural** and **socio-economic components**: pollution trends, distribution of socio-economic resources indicative of human welfare, i.e. educational system, transportation/land use networks, and other infrastructures like water supply, waste water/domestic disposal, solid waste management, public services, fire protection, medical facilities and health impacts.

An integrated approach was adopted in presenting the multidisciplinary results of the baseline studies. The environmental baseline studies conducted were grouped under five main categories viz:

Physico-Chemical Environment Studies

- Climate and Meteorology
- Land Use
- Air Quality and Noise Level
- Water quality – surface and underground water
- Soil Studies
- Aquatic Studies

Biological Environment studies

- Flora and Fauna
- Soil and Water Microbiology
- Hydrobiology and Fishery including benthos

Socio-Economic studies

- Corporate Social Responsibility of Greenville LNG to the host community
- Educational, Socio and cultural setting in the study area

Health Status

- Health infrastructure and human health disease patterns.

Waste Management Analysis

4.2 Environmental Baseline Data Acquisition Methods

The acquisition of data basically involved field data gathering, measurements and the collection of representative samples used to establish the environmental conditions of the study area. This exercise involved a multi-disciplinary approach and was executed within the framework of a QHSE Management System approach. This approach assured that the required data and samples were collected in accordance with agreed requirements (scientific and regulatory) using the best available equipment, materials and personnel. Elements of this approach include:

- Review of existing reports that contain environmental information on the study area;
- Designing and development of field sampling strategies to meet work scope and regulatory requirements;
- Pre-mobilization activities (assembling of field team, sampling equipment/materials calibrations/checks, review of work plan and schedule with team, and job hazard analysis);
- Mobilization to field;
- Fieldwork implementation - sample collection (including positioning and field observations), handling, documentation and storage protocols and procedures;
- Demobilization from field; and
- Transfer of sample custody to the laboratory for analyses.

The following sections present the field data gathering methodology/procedures and the descriptions of the environmental baseline conditions of the study area. The detailed documentation of the fieldwork execution including descriptions of the laboratory analytical methods and procedures, the detection limits for the various

parameters analyzed as well as an overview of the general QHSE plan adopted for field data gathering and laboratory analysis is presented.

4.2.1 Desktop Studies

Desktop studies involved the acquisition of relevant background information on the environment of the study area. Materials that were consulted included approved reports on previous environmental surveys in the area, publications, textbooks, articles, maps, etc. on the area and similar environments. The list of materials consulted is specified in relevant sections. Specific documents consulted are given in their respective sections.

4.2.2 Field Sampling

The data gathering exercise was undertaken between 17th to 18th June, 2026 for the proposed, Projects at Rigasa Community, Igabi Local Government Areal, Kaduna State. The specific objectives of the field sampling were to:

- Determine the ambient air quality and noise level of the study area;
- Determine the physico-chemical and biological characterization of groundwater and surface water of the study area;
- Establish the socio-economic and health status of the host and impacted communities.

The exercise involved in-situ measurement of salinity, temperature and pH. Samples were taken at defined sample points using bottle sampler for water quality determinants. These were stored and preserved as appropriate for each analysis. Water samples were collected for laboratory analyses using

- 2-litre plastic bottle for groundwater samples for physicochemical analysis;
- 1-litre plastic bottle for groundwater samples for microbiological analysis;
- 1-litre glass bottle with Teflon seal cap for groundwater samples to be analysed for hydrocarbon content (oil and grease, etc.).

4.2.3 Field Studies and Sampling Design

Sampling was designed to comprehensively capture all the ecological and socio-economic components peculiar to the study area. Design of field activities was made prior to mobilization. This was aided by information obtained during reconnaissance survey of the project area.

Sampling locations were decided as waypoints in Geographic Position System (GPS) and later plotted in a sampling map used during the field studies. Locations for biophysical sampling considered ecological types around the project areas, vulnerable environmental attributes with regards to the potential and associated impacts of the environment and control or buffer zones. Socio economic and health impact studies on the other hand, considered human habitations, infrastructure,

cultural heritage sites and prevailing health conditions of people within the sphere of influence to the project area. The spatial location maps of the sampled points are presented in the respective component sections.

The Quality Assurance/Quality Control (QA/QC) procedures were implemented during sample collection, labeling, analyses and data verification. Chain of custody procedures including sample handling, transportation, logging and crosschecking in the laboratory were also implemented.

4.2.4 Desktop Studies

Desktop studies were undertaken to acquire information on climate and atmospheric conditions, geology, soil, vegetation, socio-economics, and other environmental components of the proposed project expansion catchment area. In addition, materials reviewed include Internet sources, textbooks, reports, survey maps, aerial photographs, and articles in local and other international journals. These serve as secondary data for the environmental database for the EIA studies. Observations and results of laboratory analysis of samples collected on the field serve as primary sources of data.

4.2.5 Fieldwork Activities/Laboratory Analysis

Fieldwork activities/Laboratory analyses were carried out to complement secondary data gathered from literature and to collect new and additional primary data to fill information gaps. The activities were carried out in accordance with FMEnv and recommended international methods. The laboratory analyses of the samples collected were carried out at **Kano State Ministry of Environment Laboratory at Tarauni, Kano State.**

Plate 4.1: FMEnv Representative with the Lab Staff.

4.2.6 Field Data

Environmental Field data is gathered or collected during field exercises, gives a real time description of the state of that specific environment, at a particular time. Field data helps in **quantitatively** & **qualitatively** describing the state of the project site which has been selected for the study. The analysis of environmental field data is a particularly complicated task, owing to the fact that the potential sources of impacts recorded at a site, might be diverse, and of which they might not all be traceable to a single project. Therefore, due diligence must be done to ensure the integrity of environmental data analysis.

In subsequent sections, the field data gathered/collected/generated during the EIA baseline study are in line with the FMEnv EIA guidelines.

Table 4.1: Sample Matrix

S/N	Environmental component	Sampling points or Stations
1	Ground Water	2 + 1 Control
3	Surface Water	2 + 2 Control (where applicable)
4	Sediment	2 + 2 Control (where applicable)
5	Vegetation	

6	Soil	28 + 2 Controls
7	Ambient Air Quality	28 + 2 Controls
8	Socio-economic and Health	

4.2.6.1 Field Surveys

The field sampling was carried out for this study in line with the FMEnv/NUPRC - approved ToR. Sampling and observations for air quality and noise, soil, surface water/sediments, groundwater, vegetation, and wildlife were carried out during fieldwork. The socio-economic survey was obtained through consultation with the project community, which is within 2.5km radius of the proposed project site, and administration of questionnaire through stratified random sampling was done. Sample collection and handling procedures to maintain the integrity of samples and enhance quality of the results, were in accordance with international standards and with particular reference to FMEnv/NUPRC guidelines and standards. This was followed by detailed ecological sampling and laboratory analysis of samples.

All biophysical sampling and observation points were geo-referenced using Garmin eTrex 22x, Rugged Handled GPS Navigator, Garmin eTrex 10, and Worldwide Handheld GPS Navigator. The sample positions are also shown on the map of the project site. Quality assurance was applied to all aspects of the study including sample collection, handling, laboratory analysis, data coding, statistical analysis, presentation and communication of results.

4.2.6.2 Quality Assurance

All equipment and materials and their calibration certificates were inspected and certified by the regulator before the commencement of the field sampling. The methodology and procedures for sample collection, storage/handling and analysis were such that integrity was assured. To ensure the accuracy and reliability of in-situ field measurements, field instruments were calibrated prior to use and cross-checked from time to time. Sampling points were properly geo-referenced. Field portable pH meter was calibrated using pH4, pH7 and pH9 buffer solutions. The conductivity and dissolved solids meter were checked against solutions of known conductivity and dissolved solids provided by the manufacturers.

All sample containers for water sample collection were rinsed with the water being sampled before putting the sample into the containers. Amber bottles were used for BOD_5 samples while sterile vials were used for all microbiology samples. Plain glass bottles were used to collect water samples for THC. Soil samples for physio-chemical analysis were collected in appropriately labelled and sealed polythene bags in accordance with the quality assurance criteria as contained in the Environmental

Guidelines and Standards for the Petroleum Industry in Nigeria (EGASPIN, 2018 Revised) (Part (VIII) D (2) (Sampling & Handling of Samples)). Aluminium foils were used for soil samples for THC. Ice-chests were used to preserve samples in the field before transportation to the laboratory for analysis.

All parameters were analysed within their shelf life. Chain of custody procedures including sample handling, transportation, logging and cross-checking in the laboratory were also implemented. The samples were preserved in an ice chest during transportation to the laboratory.

4.2.6.3 Data Analysis

Standard data spreadsheets were used for recording and transmitting analytical results. Processing/calculation of results was done following written standard operating procedures. Final results were issued only after a general QA/QC check and validation had been done.

Table 4.2: Summary of Laboratory Methods

Sample Matrix	Parameter	Test Method	Test Equipment
Water	pH	APHA 4500H+B	HANNA HI 93414 in situ meter
Water	Temperature (°C)	APHA 2550B	HANNA HI 93414 in situ meter
Water	Chloride	APHA 4500 Cl^-	Titration
Water	Nitrate	EPA 352.1	UV/Visible light spectrophotometer
Water	Sulphate	APHA 4500-SO_4^{2-}-E	UV/Visible light spectrophotometer
Water	Magnesium	APHA 3111B/ASTM D 3561	FAAS
Water	Potassium	APHA 3111B/ASTM D 3561	FAAS
Water	Sodium	APHA 3111B/ASTM D 3561	FAAS
Water	Calcium	APHA 3111D	FAAS
Water	Cadmium	APHA 3111B	FAAS
Water	Total Chromium	APHA 3111C	FAAS
Water	Copper	APHA 3111B	FAAS
Water	Phosphate	APHA 4500 PD	UV/Visible light spectrophotometer
Water	Total Iron	APHA 3111B	FAAS
Water	Lead	APHA 3111B	FAAS
Water	Nickel	APHA 3111B	FAAS
Water	Zinc	APHA 3111B	FAAS
Water	Manganese	APHA 3111B	FAAS

Sample Matrix	Parameter	Test Method	Test Equipment
Water	Salinity	APHA 2520	HANNA HI 93414 in situ meter
Water	DO	APHA 4500-OG	HANNA HI 93414 in situ meter
Water	Turbidity	APHA 2130B	HANNA HI 93414 in situ meter
Water	TOC	BS 1377	Titration
Water	TDS	APHA 2510A	HANNA HI 93414 in situ meter
Water	TSS	APHA 2540D	Gravimetry
Water	BOD_5	APHA 5220D	WTW Oxitop
Water	COD	APHA 5220D	Titration
Water	Total Hardness	APHA 2340C	Titration
Water	Oil & Grease	ASTM D 3921	FTIR
Water	Microbiology	ASTM D5465-93	Microscope
Soil	pH	ASTM D 4972	WTW Multi 340i Meter
Soil	All heavy metals	USEPA 6200	X-ray fluorescence spectrometer
Soil	Extractable Sulphate	CAEM/APHA 4500 SO_4^{2-}E	UV/Visible Spectrophotometer
Soil	Extractable Phosphate	CAEM/APHA 4500 PD	UV/Visible Spectrophotometer
Soil	Microbiology	ASTM D5465-93	Microscope
Soil	TOC	BS 1377	Titration
Soil	Microbiology	ASTM D5465-93	Microscope

4.3 Environmental Conditions of the Proposed Project Area

4.3.1 Climate and Meteorological Features

The overview of climatic/meteorological features (rainfall, temperature, humidity, and wind) of the area presented here was based primarily on information from literature review and field measurements.

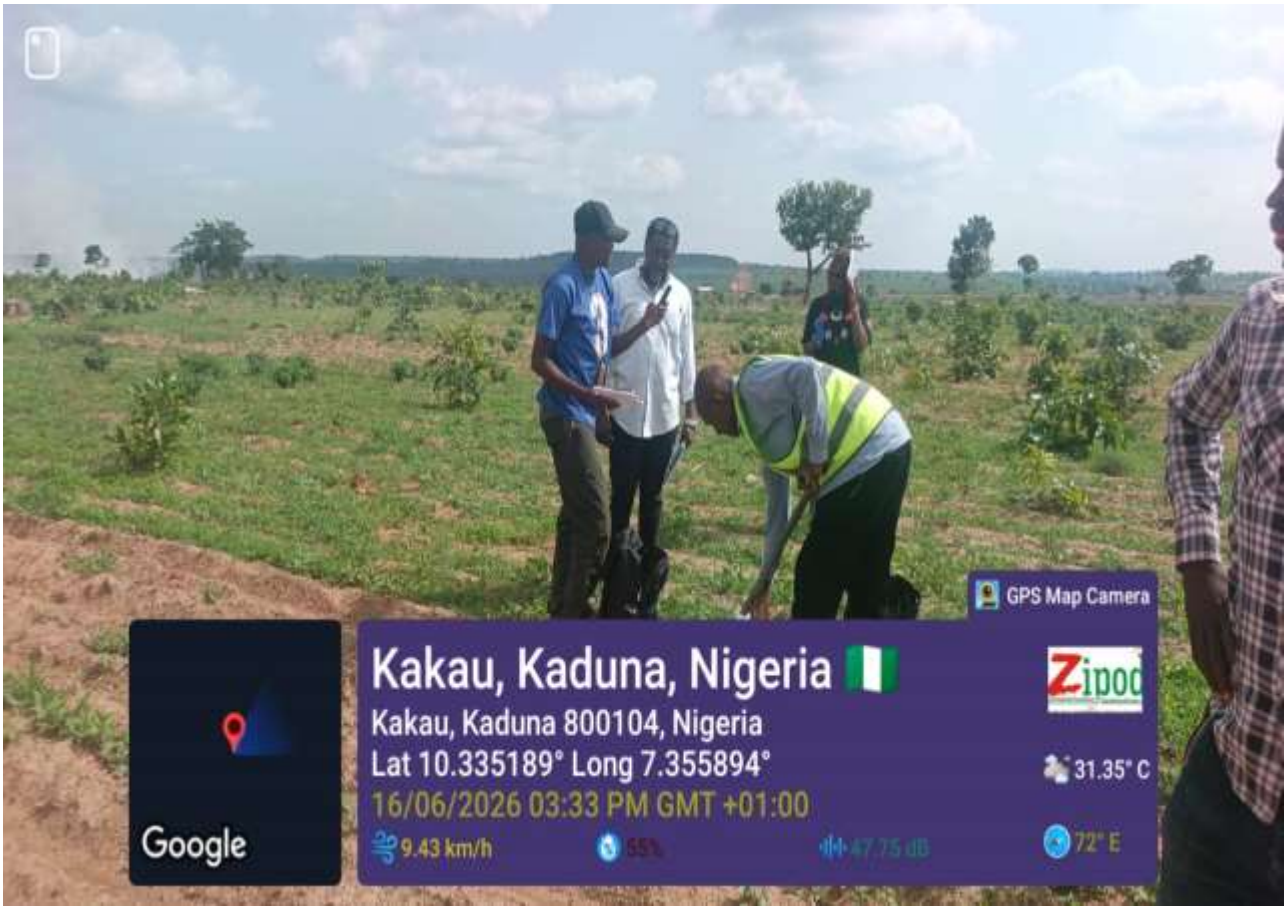

Plate 4.1: Measurements of air quality and meteorological parameters

Kaduna metropolis lies within the Northern Guinea Savannah climatic zone and is characterised by a strongly seasonal hydro-climatic regime, with a distinct wet season typically extending from April to October and a dry season from November to March. The early dry season is often influenced by Harmattan conditions, marked by low relative humidity and dust-laden winds. Rainfall follows a unimodal pattern, increasing from the onset rains in April/May, reaching peak intensities in the mid- to late-wet-season months, and gradually tapering towards cessation in October.

Rainfall data used for this assessment were obtained from the Nigerian Meteorological Agency (NiMet), providing a long-term climatic record suitable for evaluating climatic variability, environmental conditions, and urban development implications within Kaduna metropolis. The dataset consisted primarily of daily rainfall observations compiled into a continuous station-based time series format, enabling detailed analysis of annual rainfall distribution, monthly seasonality, rainfall intensity, and long-term climatic trends relevant to urban growth and infrastructure development. The extended temporal coverage of the dataset supports the assessment of historical climate behavior and its interaction with Land Use and Land Cover (LULC) changes.

4.3.1.1 Rainfall Trends & Variability

The analysis of the annual maximum 24-hour rainfall series for Kaduna metropolis from 1960 to 2025 indicates considerable inter-annual variability in extreme rainfall events, reflecting the dynamic climatic conditions within the region. The recorded annual maximum daily rainfall values generally ranged from moderate to very intense storm events, demonstrating the episodic nature of heavy rainfall occurrences within the Northern Guinea Savannah zone. The observed variability suggests that extreme rainfall events within Kaduna metropolis are largely influenced by short-duration, high-intensity convective storms rather than a consistent long-term increase or decline in mean annual rainfall patterns.

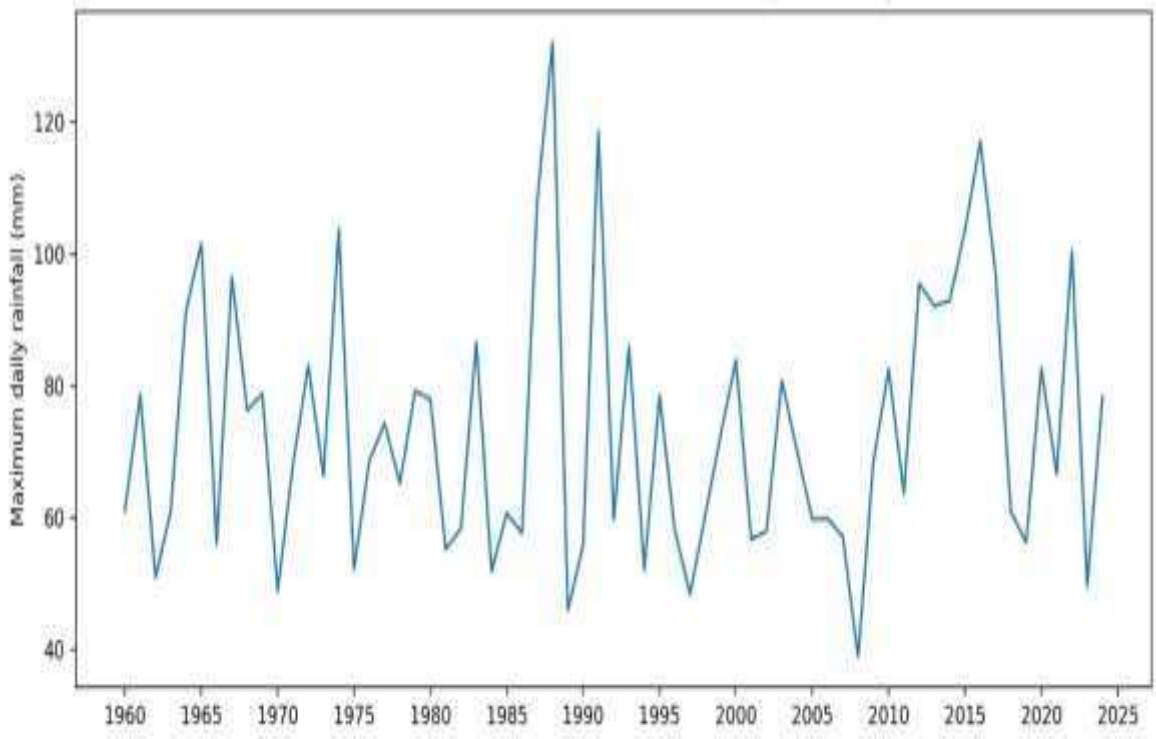

Figure 4.1: Average Daily Rainfall Distribution of Kaduna

From a probabilistic perspective, the likelihood of experiencing a high-intensity 24-hour rainfall event increases significantly during the peak wet-season months. Historical records indicate that the most probable period for annual maximum daily rainfall events is between July and September, with August representing the single highest-risk month. This aligns with the period of maximum atmospheric moisture availability, strong convective activity, and cumulative soil saturation across the Kaduna area. While extreme daily rainfall can occur on any day during the wet season, the highest likelihood is associated with storm days in late July through early September, often following successive days of moderate to heavy rainfall.

Kaduna 's rainfall regime is strongly seasonal and concentrated within a relatively short wet-season window, with the bulk of annual rainfall occurring between May

and September. Analysis of long- term mean monthly rainfall indicates that August is the wettest month, recording the highest mean monthly rainfall of approximately 310–315mm, closely followed by September, which also exhibits very high mean totals. In contrast, the lowest rainfall occurs during the dry-season months of January and December, when mean monthly rainfall is negligible (generally below 5 mm). When averaged across all twelve months, Kaduna records a long-term mean monthly rainfall of approximately 100–110 mm, reflecting the strong concentration of rainfall within a few wet-season months.

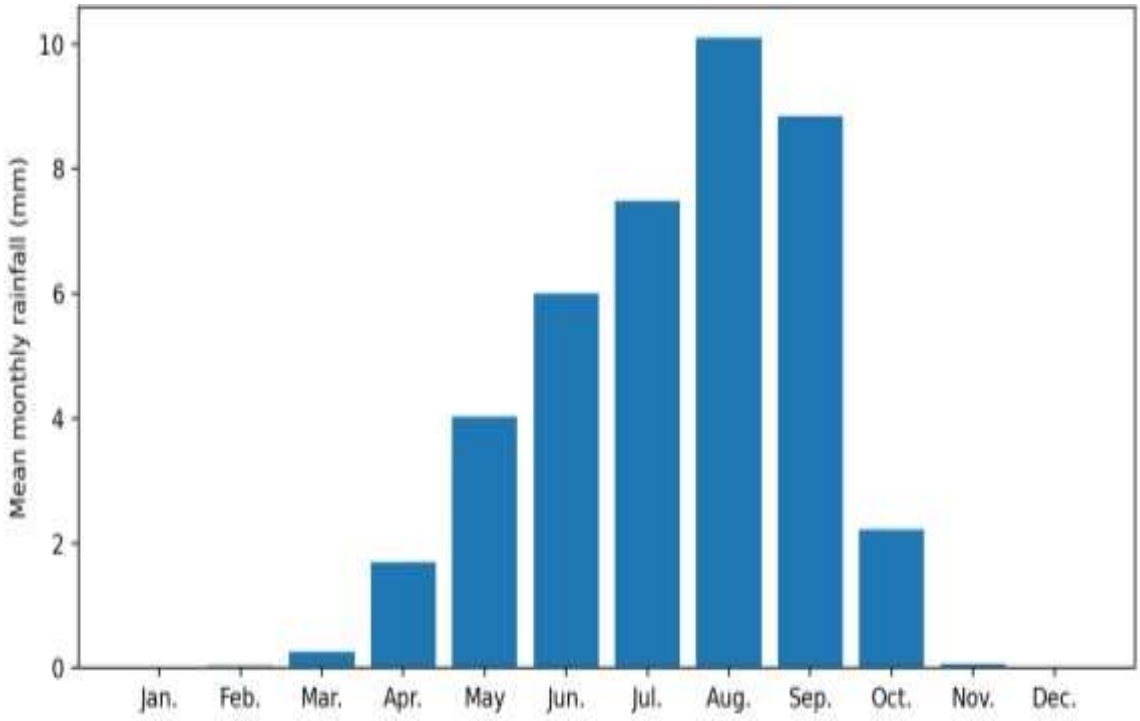

Figure 4.2: Average Monthly Rainfall Distribution of Kaduna

4.3.1.2 Temperature Trends and Variability

The annual minimum temperature time series for Kaduna metropolis between 2000 and 2025 reveals noticeable inter-annual variability in minimum temperature conditions, with average values ranging from approximately 14.93°C to 17.61°C. The data indicates fluctuations in minimum temperature over the 25-year period rather than a perfectly stable climatic pattern, reflecting the influence of regional climatic variability, changing land surface conditions, and increasing urbanization within Kaduna metropolis. The lowest annual minimum temperature was recorded in 2001 with an average value of 14.93°C, while the highest minimum temperatures were observed in 2005 (17.61°C) and 2025 (17.42°C). Overall, the temperature series suggests a gradual tendency toward warmer minimum temperature conditions over time, particularly in recent years, which may be associated with increasing urban growth and land use transformation within the metropolis.

The observed increase in minimum temperature values can be linked to the rapid expansion of built- up areas and the reduction of vegetation cover identified in the Land Use and Land Cover (LULC) assessment of Kaduna metropolis. Between 1980 and 2020, built-up areas increased significantly, while vegetation cover declined substantially due to urban expansion, infrastructural development, and population growth. The replacement of natural vegetation with impervious urban surfaces such as roads, buildings, pavements, and transportation infrastructure reduces evapotranspiration and increases heat absorption and retention within the urban environment. Consequently, urban areas tend to experience higher night-time and minimum temperatures, contributing to the development of urban heat island effects within Kaduna metropolis. The gradual warming trend observed in the minimum temperature series therefore reflects the interaction between climate conditions and urban spatial growth patterns within the study area.

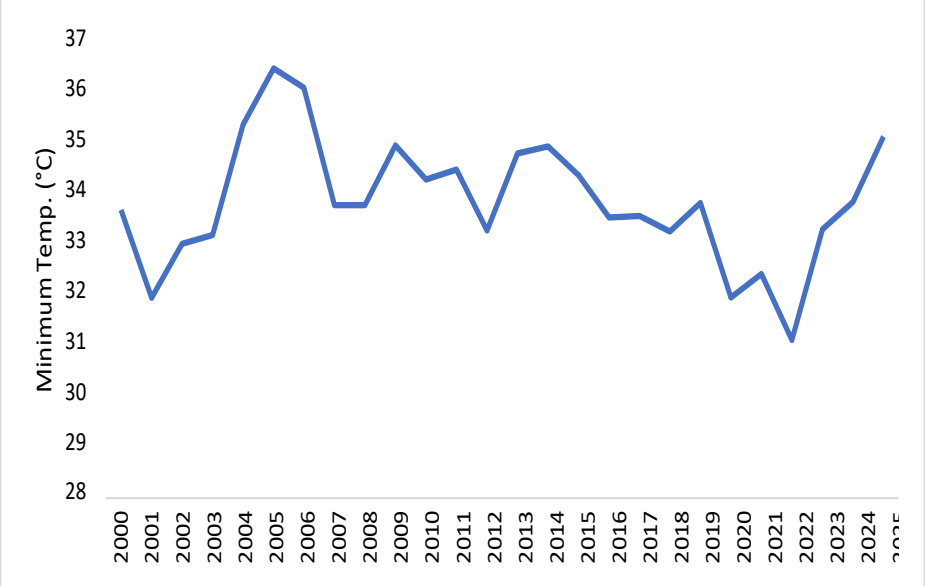

Figure 4.3: Annual Maximum Temperature Time Series of Kaduna (2000–2025)

4.3.1.3 Relative Humidity Trends and Variability

The annual relative humidity time series for Kaduna metropolis between 2000 and 2025 reveals considerable inter-annual variability in atmospheric moisture conditions over the study period. The average annual relative humidity values ranged from approximately 53.62% to 72.87%, indicating fluctuations in moisture availability and climatic conditions within the metropolis. The lowest relative humidity values were recorded in 2005 (54.16%) and 2006 (53.62%), while the highest values occurred in 2022 (72.87%), 2020 (70.80%), and 2021 (69.94%). The variability observed in the dataset reflects changing atmospheric conditions influenced by seasonal rainfall distribution, temperature variability, urbanization processes, and land surface changes occurring within Kaduna metropolis and its surrounding environments.

The observed increase in relative humidity values between 2020 and 2022 may be associated with wetter climatic conditions and increased atmospheric moisture content during those years. High humidity conditions combined with elevated temperatures can intensify thermal discomfort and influence urban environmental conditions within Kaduna metropolis. From a climate assessment perspective, the interaction between high humidity levels and rising temperatures is important because it affects human comfort, public health, and infrastructure performance within rapidly urbanizing environments. Increasing urban density and the projected expansion of built-up areas toward 2050 may further modify humidity patterns through changes in land cover composition and urban atmospheric processes.

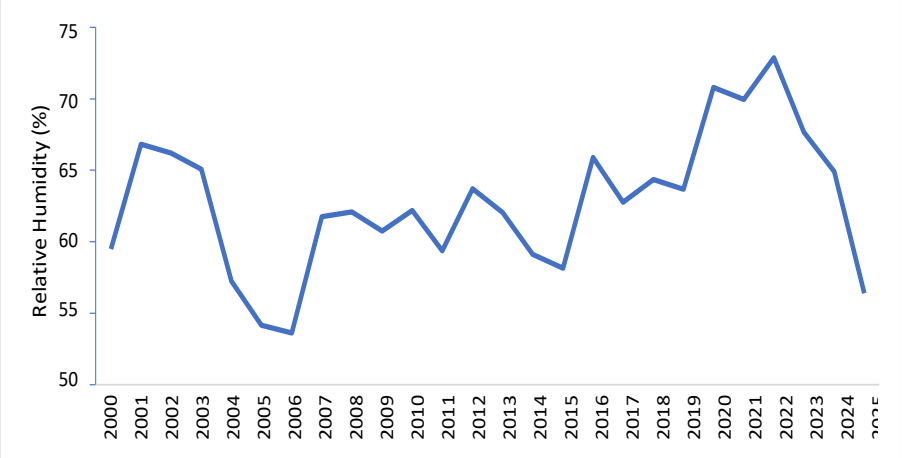

Figure 4.4: Annual Relative Humidity Time Series of Kaduna (2000–2025)

4.3.1.4 Wind Speed Trends and Variability

The annual wind speed time series for Kaduna metropolis between 2000 and 2025 indicates moderate variability in wind conditions over the 25-year study period. The average annual wind speed values ranged from approximately 7.18 m/s to 8.82 m/s, reflecting relatively stable but fluctuating atmospheric circulation patterns within the region. The highest annual average wind speed was recorded in 2008 with a value of 8.82 m/s, while the lowest value occurred in 2016 with 7.18 m/s. Other years such as 2000 (8.56 m/s), 2005 (8.45 m/s), and 2015 (8.40 m/s) also recorded relatively high wind speeds, whereas lower wind conditions were observed in 2003 (7.68 m/s), 2009 (7.65 m/s), and 2025 (7.45 m/s). Overall, the dataset demonstrates moderate inter-annual variability without a clearly defined long-term increasing or decreasing trend in wind speed conditions across Kaduna metropolis.

Furthermore, wind speed variability has implications for dust transport, erosion processes, and environmental conditions within peri-urban and hinterland areas surrounding Kaduna metropolis. Areas experiencing extensive land clearing,

vegetation removal, and increasing bare surfaces due to urban expansion may become more vulnerable to wind erosion and dust generation during dry periods.

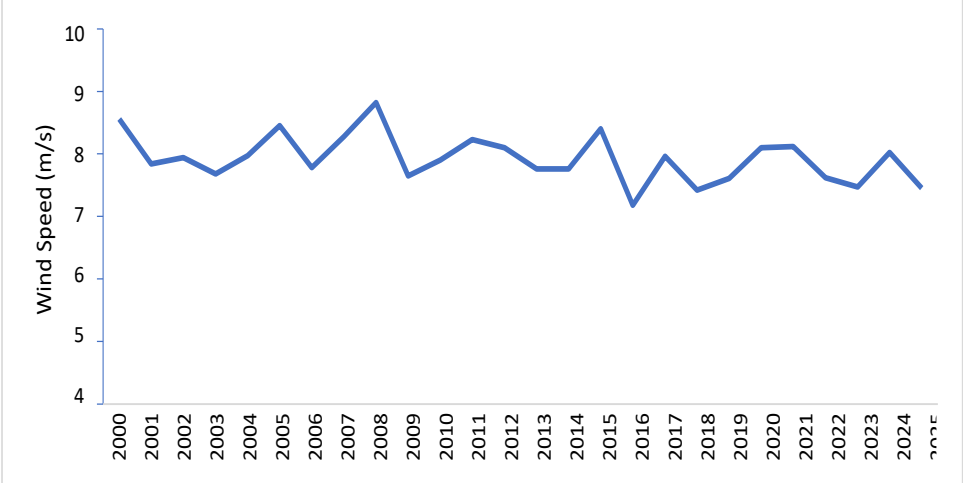

Figure 4.5: Annual Wind Speed Time Series of Kaduna (2000–2025)

4.3.2 Air Quality and Noise Characteristics

One of the main components of Earth's interdependent physical systems is the atmosphere. An atmosphere is made of the layers of gases surrounding a planet or other celestial body. Earth's atmosphere is composed of about 78% nitrogen, 21% oxygen, and one percent other gases. These gases are found in atmospheric layers (troposphere, stratosphere, mesosphere, thermosphere, and exosphere) defined by unique features such as temperature and pressure. The atmosphere protects life on Earth by shielding it from incoming ultraviolet (UV) radiation, keeping the planet warm through insulation, and preventing extremes between day and night temperatures.

The introduction into the air any chemical, physical or biological agent in quantities large enough to produce harmful effects on man and its surrounding is a call for concern. Effects of air pollutants on human health, vegetation, property or the global environment as well as create aesthetic insults in the form of brown or hazy air or unpleasant smells have been reported in the literature (Smith, 1991, Rim-Rukeh and Okokoyo, 2003., Pope, 1992., McComick *et al*., 1995).

The pollutants commonly monitored in relation to air quality are; nitrogen dioxide (NO_2), sulphur dioxide (SO_2), suspended particulate matter (SPM), ammonia (NH_3), hydrogen sulphide (H_2S), carbon dioxide (CO_2), carbon monoxide (CO), and volatile organic compounds (VOCs). The air quality in the study as expressed in their values is presented in Table 4.3. Samples were collected from Thirty (30) sampling stations and two (2) control points for air quality.

Table 4.3: Air Quality Assessment Result.

S/N	Location ID	NO (ppm)	CH_4 (ppm)	HCL (ppm)	TVOC (mg/m^3)	O_2 (%)	C_2H_4 (ppm)	PH_3 (ppm)	$PM_{1.0}$ ($\mu g/m^3$)	$PM_{2.5}$ ($\mu g/m^3$)	PM_{10} ($\mu g/m^3$)	HCHO (mg/m^3)	NH_3 (ppm)	Temp (°C)	Relative Humidity % / Wind Speed	Sound Level (dB)	CO_2 (ppm)	NO_X (ppm)	NO_2 (ppm)	CO (ppm)	H_2S (ppm)	SO_2 (ppm)	Cl_2 (ppm)
1	$GKPSSAQ_1$	0.25	2.1	0.00	0.021	20.9	5.032	0.000	15	22	35	0.003	0.02	30.8	60 / 2.0	48.6	420	0.114	0.02	0.9	0.000	0.004	0.01
2	$GKPSSAQ_2$	0.34	2.2	0.00	0.022	20.9	3.962	0.000	16	23	36	0.003	0.02	31.0	58 / 1.9	49.3	422	0.362	0.02	0.9	0.000	0.004	0.09
3	$GKPSSAQ_3$	0.22	2.0	0.00	0.020	20.9	4.971	0.000	14	21	33	0.003	0.02	30.6	61 / 2.2	47.4	418	0.148	0.02	0.8	0.000	0.004	1.05
4	$GKPSSAQ_4$	1.28	2.3	0.00	0.023	20.9	4.452	0.000	17	24	38	0.003	0.02	31.2	57 / 2.1	50.1	425	0.086	0.02	0.9	0.000	0.004	1.27
5	$GKPSSAQ_5$	0.23	2.0	0.00	0.020	20.9	5.002	0.000	15	22	34	0.003	0.02	30.5	62 / 2.3	46.0	417	0.091	0.02	0.8	0.000	0.004	0.36
6	$GKPSSAQ_6$	0.05	2.0	0.00	0.021	20.9	5.731	0.000	15	21	33	0.003	0.02	30.1	61.1 / 2.1	47.5	416	0.177	0.02	0.8	0.000	0.006	0.25
7	$GKPSSAQ_7$	1.29	2.1	0.00	0.023	20.9	3.941	0.000	16	22	35	0.003	0.02	31.2	59.6 / 2.2	48.3	420	0.216	0.02	0.9	0.000	0.003	1.18
8	$GKPSSAQ_8$	1.33	1.9	0.00	0.022	20.9	3.868	0.000	14	20	32	0.003	0.01	29.6	58.3 / 1.8	45.8	412	0.048	0.01	0.7	0.000	0.004	0.05
9	$GKPSSAQ_9$	0.45	2.3	0.00	0.019	20.9	3.301	0.000	17	24	38	0.002	0.03	28.5	47.4 / 1.7	52.6	428	0.133	0.03	1.0	0.000	0.005	0.47
10	$GKPSSAQ_{10}$	0.29	2.2	0.00	0.020	20.9	3.421	0.000	15	23	36	0.002	0.02	29.3	60.5 / 1.2	50.1	423	0.051	0.02	0.9	0.000	0.006	0.14
11	$GKPSSAQ_{11}$	0.43	2.4	0.00	0.019	20.9	4.561	0.000	18	25	40	0.002	0.03	29.7	63.0 / 1.3	55.3	430	0.036	0.03	1.0	0.000	0.003	0.94
12	$GKPSSAQ_{12}$	0.25	1.8	0.00	0.013	20.9	3.821	0.000	14	21	34	0.002	0.01	29.7	64.3 / 1.3	46.9	415	0.046	0.01	0.8	0.000	0.004	0.03
13	$GKPSSAQ_{13}$	0.22	2.0	0.00	0.020	20.9	2.225	0.000	16	22	35	0.003	0.02	30.1	58.2 / 1.2	48.0	419	0.119	0.02	0.9	0.000	0.004	2.01
14	$GKPSSAQ_{14}$	0.09	2.2	0.00	0.021	20.9	4.514	0.000	15	23	37	0.003	0.02	32.1	57.5 / 1.4	51.4	424	0.053	0.02	0.9	0.000	0.005	0.05
15	$GKPSSAQ_{15}$	0.03	2.3	0.00	0.022	20.9	2.362	0.000	17	24	39	0.003	0.03	33.4	57.3 / 1.3	53.8	429	0.043	0.03	1.0	0.000	0.006	0.06
16	$GKPSSAQ_{16}$	0.15	1.9	0.00	0.004	20.9	3.053	0.000	14	20	33	0.003	0.01	32.8	54.8/ 1.2	45.7	411	0.086	0.01	0.7	0.000	0.003	1.09
17	$GKPSSAQ_{17}$	0.29	2.0	0.00	0.024	20.9	2.414	0.000	15	21	34	0.003	0.02	31.4	59.1 / 1.2	47.2	417	0.011	0.02	0.8	0.000	0.004	1.11
18	$GKPSSAQ_{18}$	0.34	2.1	0.00	0.023	20.9	3.251	0.000	16	22	36	0.002	0.02	32.0	48.9 / 1.7	49.5	421	0.080	0.02	0.9	0.000	0.005	1.23
19	$GKPSSAQ_{19}$	0.19	2.3	0.00	0.021	20.9	3.668	0.000	17	23	38	0.003	0.03	31.7	50.8 / 0.9	52.9	427	0.021	0.03	1.0	0.000	0.006	1.86
20	$GKPSSAQ_{20}$	0.27	2.1	0.00	0.024	20.9	2.205	0.000	15	22	35	0.003	0.02	28.9	64.0 / 1.1	48.7	418	0.091	0.02	0.8	0.000	0.004	0.21
21	$GKPSSAQ_{21}$	0.22	1.8	0.00	0.021	20.9	4.004	0.000	14	21	33	0.003	0.01	32.0	48.9 / 1.4	46.5	413	0.089	0.01	0.7	0.000	0.003	0.35
22	$GKPSSAQ_{22}$	0.12	2.2	0.00	0.024	20.9	5.561	0.000	16	23	37	0.003	0.02	31.5	62.1 / 1.7	50.6	422	0.113	0.02	0.9	0.000	0.025	0.022
23	$GKPSSAQ_{23}$	0.28	2.3	0.00	0.021	20.9	5.328	0.000	17	24	39	0.002	0.03	29.6	53.2 / 0.9	54.5	428	0.186	0.03	1.0	0.000	0.023	0.25
24	$GKPSSAQ_{24}$	0.25	2.0	0.00	0.019	20.9	5.291	0.000	15	22	34	0.003	0.02	29.4	47.8 / 1.7	49.2	416	0.252	0.02	0.8	0.000	0.002	0.54
25	$GKPSSAQ_{25}$	0.14	2.4	0.00	0.019	20.9	5.443	0.000	18	25	40	0.002	0.03	30.1	55.9 / 1.6	57.5	430	0.497	0.03	1.0	0.000	0.011	0.14
26	$GKPSSAQ_{26}$	0.16	1.8	0.00	0.023	20.9	2.229	0.000	14	20	32	0.003	0.01	31.4	45.6 / 1.4	48.7	410	0.311	0.01	0.7	0.000	0.003	0.06
27	$GKPSSAQ_{27}$	0.17	2.1	0.00	0.027	20.9	3.432	0.000	16	22	35	0.004	0.02	32.6	48.3 / 1.2	50.2	419	0.016	0.02	0.9	0.000	0.005	0.23
28	$GKPSSAQ_{28}$	0.29	2.0	0.00	0.020	20.9	5.051	0.000	15	21	34	0.003	0.02	30.4	47.4 / 1.3	51.3	417	0.057	0.02	0.8	0.000	0.020	0.16
29	$GKPSSAQ_{29}$	0.23	2.3	0.00	0.017	20.9	5.263	0.000	17	23	38	0.003	0.03	30.6	52.2 / 1.5	55.8	426	0.141	0.03	1.0	0.000	0.002	0.05
30	$GKPSS\ AQ_{30}$	0.19	2.1	0.00	0.014	20.9	4.591	0.000	15	22	36	0.003	0.02	31.3	49.1 / 2.3	56.3	421	0.132	0.02	0.9	0.000	0.003	0.03
31	$GKPSS\ AQ_{21}$ (Control)	0.21	1.9	0.00	0.018	20.9	3.229	0.000	12	18	28	0.002	0.01	30.1	63.4 / 2.4	46.6	412	0.196	0.01	0.7	0.000	0.003	1.04
32	$GKPSS\ AQ_{22}$ (Control)	0.38	2.0	0.00	0.020	20.9	5.501	0.000	13	19	30	0.002	0.01	30.4	61.0 / 2.1	47.3	415	1.113	0.01	0.8	0.000	0.003	2.03
33	$GKPSS\ AQ_{23}$ (Control)	0.26	1.8	0.00	0.017	20.9	4.271	0.000	11	17	27	0.002	0.01	29.8	65.2 / 2.6	45.9	410	1.041	0.01	0.7	0.000	0.003	2.01

Source: Field Data ESIA of Greenville CNG Mother (Compression) Station Project, 2026

4.3.2.1 Air Quality and Noise Result Discussion

Ambient air quality monitoring was conducted at thirty (30) grid-based sampling locations distributed across the proposed Greenville LNG Nigeria Limited CNG Mother Station project site at Rigasa, Igabi Local Government Area, Kaduna State. Three (3) control locations situated approximately 800 m to 1 km outside the project influence area were also monitored to establish background atmospheric conditions. The assessment provides baseline information on the existing air environment prior to project development and serves as a benchmark for evaluating future environmental changes associated with project construction and operation.

The Particulate Matter ($PM_{1.0}$, $PM_{2.5}$ and PM_{10})

Particulate matter concentrations across the project area were moderately elevated compared to the control locations but remained generally within acceptable regulatory limits. PM_1 concentrations ranged from 16–21 µg/m³, $PM_{2.5}$ ranged from 23–30 µg/m³, while PM_{10} concentrations varied from 39–48 µg/m³. Background control locations recorded lower concentrations, with $PM_{2.5}$ ranging from 18–19 µg/m³ and PM_{10} ranging from 29–31 µg/m³.

The FMEnv permissible limits for ambient particulate matter are 35 µg/m³ for $PM_{2.5}$ and 250 µg/m³ for PM_{10}, while the WHO Air Quality Guidelines prescribe more stringent 24-hour limits of 15 µg/m³ for $PM_{2.5}$ and 45 µg/m³ for PM_{10}.

All recorded $PM_{2.5}$ and PM_{10} concentrations complied with FMEnv standards. However, $PM_{2.5}$ concentrations at all monitoring locations exceeded the WHO guideline value, while PM_{10} concentrations at a few locations, particularly GRPAQ05, GRPAQ09, GRPAQ15, GRPAQ19, GRPAQ24 and GRPAQ28, marginally exceeded the WHO guideline of 45 µg/m³. The elevated particulate levels are likely attributable to the urban and peri-urban setting of Rigasa, characterized by unpaved road networks, intense vehicular movement, commercial activities, construction activities, and wind-blown dust. For the proposed CNG Mother Station, particulate matter represents one of the most important environmental indicators during site preparation and construction activities. Dust generation from excavation, grading, equipment movement and transportation activities may further increase particulate concentrations if appropriate mitigation measures are not implemented.

Carbon Monoxide (CO)

Carbon monoxide concentrations ranged from 0.9–1.3 ppm across the project area, while control locations recorded concentrations of 0.7–0.8 ppm.

The FMEnv ambient air quality standard for carbon monoxide is 10 ppm, while the WHO guideline value for an 8-hour exposure period is approximately 9 ppm (10 mg/m³).

All measured concentrations were substantially below both FMEnv and WHO limits, indicating that combustion-related air pollution within the project area remains relatively low. Nevertheless, concentrations recorded within the project site were consistently higher than background values, suggesting the influence of vehicular traffic, commercial transportation activities, domestic power generation, and other combustion sources commonly associated with the Rigasa urban environment. Carbon monoxide remains a key parameter for future operational monitoring because project activities involving compressors, generators, maintenance equipment and gas transportation vehicles may contribute additional combustion emissions.

Carbon Dioxide (CO_2)

Carbon dioxide concentrations ranged from 424–448 ppm across the project area, while background concentrations varied between 410 and 415 ppm.

Neither FMEnv nor WHO prescribes an ambient air quality standard for carbon dioxide; however, normal atmospheric concentrations generally range between 400 and 450 ppm.

The recorded concentrations fall within expected atmospheric background levels, although slightly elevated values within the project area relative to control stations indicate localized influences from vehicular traffic, human activities and fuel combustion. The measured values do not indicate any significant atmospheric pollution concern and establish a useful baseline for future greenhouse gas assessments associated with operation of the proposed facility.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide concentrations ranged from 0.02–0.04 ppm across the project area, while control stations recorded approximately 0.01 ppm.

The FMEnv permissible limit for ambient NO_2 is 0.04–0.06 ppm, whereas the WHO 24-hour guideline value is 25 µg/m³ (approximately 0.013 ppm).

All recorded concentrations complied with FMEnv standards. However, most monitoring locations exceeded the more stringent WHO guideline value, particularly locations recording concentrations of 0.03–0.04 ppm. The elevated NO_2 concentrations are likely attributable to emissions from road traffic, diesel-powered generators, commercial transportation activities and urban combustion sources within the Rigasa area. Nitrogen dioxide is particularly relevant to the proposed CNG Mother Station because future compressor operations, utility generators and increased traffic movement may contribute to additional nitrogen oxide emissions. Consequently, NO_2 should be considered a priority parameter during operational environmental monitoring.

Sulphur Dioxide (SO_2)

Sulphur dioxide concentrations ranged from 0.004–0.007 ppm within the project area and approximately 0.003 ppm at the control locations.

The FMEnv ambient air quality limit for sulphur dioxide is 0.01 ppm, while the WHO guideline value is approximately 0.015 ppm (40 µg/m³).

All measured concentrations were well below both FMEnv and WHO standards, indicating minimal influence from sulphur-containing fuel combustion sources. The low concentrations suggest that industrial sulphur emissions within the project environment are limited. Given that natural gas contains significantly lower sulphur content than conventional liquid fuels, future operational impacts on ambient SO_2 levels are expected to remain relatively low.

Hydrogen Sulphide (H_2S)

Hydrogen sulphide was not detected at any monitoring location, including the background control stations.

The FMEnv guideline value for hydrogen sulphide is 0.008 ppm, while WHO recommends concentrations below approximately 0.005 ppm to prevent nuisance odour and potential health concerns.

The absence of detectable hydrogen sulphide indicates that no significant sulphide-generating industrial activities, waste treatment facilities, landfill operations, or hydrocarbon processing activities currently influence the project environment. These results establish an excellent baseline condition for future monitoring associated with natural gas handling operations.

Ammonia (NH_3)

Ammonia concentrations ranged from 0.02–0.04 ppm across the project area, while background concentrations remained at approximately 0.01 ppm. The FMEnv guideline value for ammonia is 0.20 ppm, while WHO has not established a specific ambient air quality standard for ammonia.

All measured concentrations were substantially below the FMEnv limit, indicating that ammonia pollution is currently insignificant within the project area. The observed concentrations may be associated with domestic waste decomposition, agricultural activities, livestock rearing and urban settlement activities. The proposed CNG Mother Station is not expected to constitute a major source of ammonia emissions; therefore, current concentrations can be regarded as representative of background environmental conditions.

Formaldehyde (HCHO)

Formaldehyde concentrations ranged from 0.003–0.004 mg/m³ within the project area, while control stations recorded approximately 0.002 mg/m³.

The FMEnv guideline value for formaldehyde is 0.08 mg/m³, while the WHO guideline value is 0.10 mg/m³ (100 µg/m³) for short-term exposure.

All measured concentrations were significantly below both guideline values, indicating negligible formaldehyde pollution within the project environment. The results suggest minimal influence from industrial solvents, fuel combustion emissions, chemical processing activities or other sources commonly associated with elevated formaldehyde concentrations.

Methane (CH_4)

Methane concentrations ranged from 2.1–2.7 ppm within the project area, compared to 1.8–1.9 ppm at the control locations.

Neither FMEnv nor WHO prescribes ambient air quality limits for methane because it is not considered toxic at environmental concentrations. Global atmospheric methane concentrations generally range between 1.8 and 2.2 ppm.

The slightly elevated methane concentrations observed within the project area may reflect localized emissions from waste decomposition, drainage channels, domestic activities and urban anthropogenic sources. Nevertheless, the measured concentrations remain within typical environmental ranges and do not suggest significant methane contamination. Since methane constitutes the principal component of compressed natural gas, this parameter is particularly important for future operational monitoring. The baseline results provide an essential benchmark for detecting any future fugitive emissions from gas compression, storage and transportation systems.

Total Volatile Organic Compounds (TVOCs)

TVOC concentrations ranged from 0.022–0.028 mg/m³ across the project area and from 0.018–0.020 mg/m³ at the control stations.

Although FMEnv and WHO do not prescribe specific ambient air quality limits for total VOCs, concentrations below 0.30 mg/m³ are generally considered indicative of good air quality.

The measured concentrations were very low and demonstrate the absence of significant industrial hydrocarbon emissions or solvent-related contamination within the project area. Nevertheless, the slightly elevated concentrations relative to control locations may reflect urban transportation activities and domestic fuel usage. Because volatile organic compounds are among the primary pollutants associated with natural gas handling systems, these baseline results will be valuable for future environmental performance assessments of the proposed facility.

Oxygen (O_2)

Atmospheric oxygen concentrations remained constant at 20.9% across all project and control locations.

Normal atmospheric oxygen concentration is approximately 20.9%, and neither FMEnv nor WHO establishes a specific ambient air quality guideline for oxygen under normal environmental conditions.

The consistent oxygen concentrations indicate adequate atmospheric circulation, effective dispersion conditions and the absence of oxygen-depleting industrial activities within the project area. These results further confirm that the ambient environment remains generally healthy and well ventilated.

Ambient Noise Level

Ambient noise levels ranged between 45.7 and 57.5 dB(A), while control locations recorded 45.9–47.3 dB(A). These values are below the FMEnv daytime ambient noise guideline of 90 dB(A) for industrial environments and also below the WHO recommended daytime outdoor community noise guideline of 55 dB(A) for most locations. The few values slightly above 55 dB(A) remain environmentally acceptable and are characteristic of normal rural community activities.

The baseline therefore indicates a relatively quiet acoustic environment, although temporary increases should be anticipated during construction due to heavy equipment operation.

Temperature, Relative Humidity and Wind Speed

Ambient temperatures ranged from 28.5 to 33.4°C, relative humidity ranged between 45.6% and 65.2%, while wind speeds varied from 0.9 to 2.6 m/s.

These meteorological conditions are typical of Kaduna State during the sampling period and favour effective atmospheric dispersion of pollutants. Moderate wind speeds reduce pollutant accumulation but may facilitate the transport of construction-generated dust if appropriate dust control measures are not implemented.

Generally, the baseline ambient air quality of the proposed Greenville CNG Mother Station at Afaka, Rigasa is generally good, with virtually all monitored pollutants complying with applicable FMEnv standards and, for most parameters, WHO Air Quality Guidelines. $PM_{2.5}$ concentrations marginally exceed the stringent WHO 24-hour guideline at several locations but remain well below FMEnv limits, suggesting that existing particulate pollution is primarily attributable to natural dust and local activities rather than industrial sources. The absence of detectable H_2S, HCl and PH_3, coupled with very low concentrations of CO, SO_2, NO_2, TVOCs and formaldehyde, demonstrates that the project site currently experiences minimal atmospheric pollution.

These results establish a favourable environmental baseline for the proposed development. Nevertheless, construction and operational activities have the potential to increase dust, combustion gases, traffic emissions and noise. Accordingly, routine air quality monitoring, effective dust suppression, preventive equipment maintenance, vehicle emission control and continuous leak detection for methane and VOCs should form integral components of the Environmental and Social Management Plan (ESMP).

4.3.3 Groundwater and Surface Water Quality Assessment

Water quality assessment was undertaken using three (3) surface water samples (SW01 to SW03), five (5) groundwater samples (GW01 to GW05), and one (1) groundwater control sample (GW06) collected within and around the proposed Greenville CNG Mother Station at Afaka Community, Rigasa District, Igabi LGA, Kaduna State. The samples were analysed for physical, chemical, heavy metal, organic and microbiological parameters and compared with the Federal Ministry of Environment (FMEnv) permissible limits. Where applicable, the results are also compared with the World Health Organization (WHO, 2022) Guidelines for Drinking-water Quality.

Overall, the groundwater quality was found to be considerably better than the surface water quality. Surface water exhibited elevated suspended solids, microbial contamination and elevated concentrations of some heavy metals, whereas groundwater generally complied with FMEnv and WHO standards except for isolated parameters such as iron. The results therefore indicate that groundwater represents the more suitable water resource within the project area, while surface water would require treatment before domestic use.

The result of the laboratory analysis of the water samples collected is presented on tables 4.4 below:

Table 4.4: Ground and Surface Water Quality Assessment Result

S/N	Parameter	Unit	GKP SW01	GKP SW02	GKP SW03	GKP GW01	GKP GW02	GKP GW03	GKP GW04	GKP GW05	GKP GW06 (Control)	FMENT LIMIT
A)	**Coordinate**											
1	Latitude	N	10.3380770	10.3356620	10.3332080	10.344220	10.345110	10.34102980	10.341760	10.346050	10.343500	-
2	Longitude	E	7.3510560	7.3494640	7.3463680	7.376940	7.378200	7.374850	7.377500	7.375600	7.379100	-
B)	**Physical Test**											
3	Colour	TCU	Pale Brown	Dark cloudy	Pale Brown	Clear	Clear	Clear	Clear	Clear	Clear	Clear
4	Odour	-	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless	Unobjectionable
5	Taste	-	ND	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Tasteless	Unobjectionable
6	pH	-	6.9	6.7	6.5	6.8	6.6	6.9	6.5	6.7	6.6	6.5 - 8.5
7	Temperature	°C	27.8	28.1	28.5	26.4	26.7	26.2	26.9	26.5	26.8	Ambient
8	Electrical Cond.	µS/cm	210	240	275	380	420	350	450	390	430	1000
9	Turbidity	NTU	2	1	1	0	0	0	0	0	0	5.0
10	Dissolved Oxygen	mg/L	7.4	6.8	6.2	5.8	5.2	6.0	5.0	5.6	5.1	2 - 8
11	TDS	mg/L	120	145	165	210	240	190	260	220	250	500
12	T.S.S	mg/L	428	392	355	8	3	11	9	10	6	20
13	Salinity	%	0.04	0.03	0.04	0.01	0.01	0.01	0.01	0.01	0.01	<1000
14	ORP	mV	116	103	112	252	197	158	96	137	150	200 - 600
15	B.O.D	mg/L	2.9	3.6	3.1	1.4	1.2	1.2	1.7	1.1	1.3	NS
C	**Chemical Test**											
16	Calcium (Ca^{2+})	mg/L	1.87	0.52	0.11	3.57	2.89	2.74	2.55	0.87	1.43	200
17	Magnesium (Mg^{2+})	mg/L	0.52	0.40	0.71	1.66	1.07	1.52	1.18	0.02	0.93	20
18	Sodium (Na^{+})	mg/L	23	15	27	41	37	37	37	36	21	20
19	Potassium (K^{+})	mg/L	0.4	0.9	1.2	0.5	0.5	0.5	0.5	0.5	0.4	20
20	Ammonium (NH_4^{+})	mg/L	0.062	0.697	0.143	0.032	0.047	0.026	0.142	0.021	0.031	NS
21	Sulphate (SO_4^{2-})	mg/L	18	61	29	37	59	60	54	63	29	100
22	Nitrate (NO_3^{-})	mg/L	6.49	7.52	7.57	2.51	2.93	1.082	1.22	0.58	0.41	50
23	Nitrite (NO_2^{-})	mg/L	0.3	0.3	0.3	0.00	0.00	0.00	0.00	0.00	0.00	0.2
24	Chloride (Cl^{-})	mg/L	0.1	0.0	0.3	1.4	0.9	1.7	2.3	1.2	1.5	150
D)	**Heavy Metals**											
25	Zinc (Zn^{2+})	mg/L	3.421	2.595	2.003	1.431	1.999	1.363	1.421	1.026	1.437	3.0
26	Copper (Cu^{2+})	mg/L	0.43	0.37	0.37	0.00	0.00	0.00	0.00	0.00	0.00	1.2
27	Chromium (Cr^{3+})	mg/L	1.33	1.08	1.01	0.02	0.01	0.00	0.01	0.00	0.00	0.0
28	Cobalt (Co^{2+})	mg/L	0.6	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.2
29	Iron (Fe^{2+})	mg/L	0.4	0.0	0.6	1.3	0.9	0.3	0.4	0.8	1.7	0.3

S/N	Parameter	Unit	GKP SW01	GKP SW02	GKP SW03	GKP GW01	GKP GW02	GKP GW03	GKP GW04	GKP GW05	GKP GW06 (Control)	FMENT LIMIT
30	Nickel (Ni^{2+})	mg/L	1.03	0.69	0.04	0.02	0.01	0.01	0.01	0.01	0.01	0.0
31	Mercury (Hg^{2+})	µg/L	0.034	0.017	0.112	0.000	0.000	0.000	0.000	0.000	0.000	0.0
32	Lead (Pb^{2+})	µg/L	0.013	0.204	0.010	0.000	0.000	0.000	0.000	0.000	0.000	0.0
33	Manganese (Mn^{2+})	mg/L	0.2	0.4	0.4	0.1	0.1	0.0	0.0	0.1	0.0	NS
E)	**Organics**											
34	Phenols	mg/L	0.74	0.77	0.82	0.06	0.01	0.00	0.00	0.00	0.00	0.0
35	Oil & Grease	mg/L	1	1	2	0	0	0	0	0	0	10
36	BTEX	mg/L	0	0	0	0	0	0	0	0	0	Nil
F	**Microbiological Test**											
37	E-coli	**cfu/100kg**	12	10	6	0	0	0	0	0	0	Nil
38	Total Coliform	**cfu/100kg**	147	126	97	2	1	1	2	1	2	10

Source: Field Data ESIA of Greenville CNG Mother Station Project, 2026

4.3.3.1 Result Discussions on Water Analysis

Physical Characteristics

pH: The pH values ranged from 6.5 to 6.9 in both surface and groundwater samples. These values fall entirely within the FMEnv and WHO acceptable range of 6.5 to 8.5, indicating neutral to slightly acidic water conditions. Neutral pH is desirable because it minimizes corrosion, reduces metal dissolution and provides favourable conditions for aquatic organisms.

The results demonstrate that neither acidification nor excessive alkalinity currently affects the project area, suggesting minimal influence from industrial discharges or acid-forming contaminants.

Temperature: Water temperatures ranged from 26.2 to 28.5°C, reflecting normal ambient climatic conditions during sampling. Although FMEnv does not prescribe a fixed numerical standard, these temperatures are typical of tropical freshwater systems and are unlikely to adversely affect aquatic ecosystems or groundwater quality.

Electrical Conductivity (EC): Electrical conductivity varied from:

- 210 to 275 µS/cm in surface water.
- 350 to 450 µS/cm in groundwater.

All measured values remained well below the FMEnv and WHO guideline value of 1,000 µS/cm. The low conductivity indicates relatively low dissolved ionic content and confirms that neither salinity intrusion nor significant anthropogenic contamination presently affects the water resources.

T**urbidity**: Surface water turbidity ranged between 1 and 2 NTU, whereas all groundwater samples recorded 0 NTU. These values are significantly below the FMEnv and WHO guideline of 5 NTU, indicating excellent water clarity. The absence of turbidity in groundwater reflects effective natural filtration through subsurface soils and geological formations.

Total Dissolved Solids (TDS): TDS concentrations ranged from:

- 120 to 165 mg/L in surface water.
- 190 to 260 mg/L in groundwater.

These values are substantially below the FMEnv and WHO permissible limit of 500 mg/L. Low TDS indicates excellent palatability, minimal mineral enrichment and limited anthropogenic influence.

Total Suspended Solids (TSS): A marked difference exists between surface and groundwater. Surface water contained 355 to 428 mg/L, while groundwater contained only 3 to 11 mg/L.

Groundwater complies comfortably with the FMEnv limit of 20 mg/L. However, all surface water samples greatly exceed this limit. The elevated suspended solids are likely attributable to soil erosion, runoff from surrounding land surfaces and sediment transport during rainfall events rather than industrial pollution. High suspended solids reduce light penetration, increase sedimentation and may transport attached contaminants into receiving waters.

Dissolved Oxygen (DO): Dissolved oxygen concentrations ranged from:

- 6.2 to 7.4 mg/L in surface water.
- 5.0 to 6.0 mg/L in groundwater.

These values fall within the FMEnv guideline range of 2 to 8 mg/L. The relatively high dissolved oxygen concentrations indicate healthy aquatic conditions capable of supporting aerobic biological processes and aquatic organisms.

Biological Oxygen Demand (BOD): Surface water BOD ranged between 2.9 and 3.6 mg/L, whereas groundwater ranged from 1.1 to 1.7 mg/L.

Although FMEnv provides no specific drinking water standard for BOD, these concentrations indicate relatively low organic pollution. Groundwater exhibits better quality because natural soil filtration removes biodegradable organic matter before recharge.

Major Ions

Calcium and Magnesium: Calcium concentrations ranged from 0.11 to 3.57 mg/L, while Magnesium ranged between 0.02 and 1.66 mg/L. These values are considerably lower than the FMEnv limits of 200 mg/L for calcium and 20 mg/L for magnesium, indicating soft water with minimal hardness.

Sodium: Surface water sodium ranged between 15 and 27 mg/L, while groundwater ranged from 21 to 41 mg/L. Most groundwater samples exceeded the FMEnv limit of 20 mg/L, while surface water values were generally close to or slightly above the limit.

Although these concentrations are not high enough to present significant health risks, elevated sodium may gradually influence irrigation suitability and drinking water taste if concentrations increase during project operation.

Potassium: Potassium concentrations ranged between 0.4 and 1.2 mg/L, remaining well below the FMEnv limit of 20 mg/L. The results indicate no enrichment from agricultural fertilizers or industrial activities.

Nutrients

Sulphate: Sulphate concentrations varied from 18 to 63 mg/L, remaining comfortably below the FMEnv limit of 100 mg/L. The concentrations indicate negligible sulphate pollution and suggest that sulphide oxidation or industrial sulphur contamination is absent.

Nitrate: Nitrate concentrations ranged from 0.41 to 7.57 mg/L, considerably below the FMEnv and WHO limit of 50 mg/L. These concentrations pose no risk of nitrate toxicity or infant methemoglobinemia ("blue baby syndrome").

Nitrite: Surface water contained 0.3 mg/L, while groundwater recorded 0.00 mg/L. The surface water concentration exceeds the FMEnv limit of 0.2 mg/L, whereas groundwater fully complies. Elevated nitrite in surface water may indicate recent organic matter decomposition, fertilizer runoff or microbial transformation of nitrogen compounds.

Chloride: Chloride concentrations ranged from 0.0 to 2.3 mg/L, substantially below the FMEnv limit of 150 mg/L. The results confirm the absence of saline intrusion or wastewater contamination.

Heavy Metals

Zinc: Surface water zinc ranged from 2.003 to 3.421 mg/L, while groundwater ranged between 1.026 and 1.999 mg/L. Groundwater complies with the FMEnv limit of 3.0 mg/L, whereas two surface water samples slightly exceed this limit. The elevated zinc may originate from natural mineral weathering or metallic materials within the catchment.

Copper: Copper concentrations ranged from 0.00 to 0.43 mg/L, remaining well below the FMEnv limit of 1.25 mg/L. No evidence of copper contamination exists.

Chromium: Chromium concentrations in surface water ranged between 1.01 and 1.33 mg/L, whereas groundwater ranged from 0.00 to 0.02 mg/L. Groundwater complies fully with the FMEnv and WHO limit of 0.05 mg/L, but all surface water samples exceed this limit by more than twentyfold.

This represents the most significant heavy metal concern identified during the assessment. Such elevated chromium concentrations require further investigation because prolonged exposure may present ecological and human health risks if untreated surface water is consumed.

Iron: Iron concentrations ranged from:

- to 0.6 mg/L in surface water.
- 0.3 to 1.7 mg/L in groundwater.

The FMEnv and WHO guideline value is 0.3 mg/L. Several groundwater samples exceed this guideline, with the highest value reaching 1.7 mg/L.

Although iron is primarily an aesthetic rather than toxicological concern, elevated concentrations may produce reddish staining, unpleasant taste and scaling within water distribution systems.

Nickel: Nickel concentrations ranged between 0.00 and 1.03 mg/L. Surface water samples exceeded the FMEnv and WHO limit of 0.07 mg/L, whereas groundwater complied. The elevated surface water concentrations suggest localized geogenic enrichment or surface runoff transporting trace metals into nearby water bodies.

Mercury and Lead: Mercury and lead concentrations were either absent or detected only at trace levels well below the FMEnv and WHO guideline values. These findings indicate that the project area is not presently affected by mercury or lead contamination.

Organic Pollutants

Phenols: Surface water phenol concentrations ranged from 0.74 to 0.82 mg/L, whereas groundwater ranged from 0.00 to 0.06 mg/L. The FMEnv limit is 0.05 mg/L. Consequently, all surface water samples exceed the regulatory limit, while most groundwater samples comply except one marginal exceedance (0.06 mg/L). Elevated phenols may originate from decomposition of organic matter or localized anthropogenic inputs and would require treatment before potable use.

Oil and Grease

Surface water contained 1 to 2 mg/L, while groundwater recorded 0 mg/L. These values are well below the FMEnv limit of 10 mg/L, indicating no petroleum contamination prior to project development.

BTEX: BTEX compounds were not detected in any sample. This is particularly important because the proposed project involves compressed natural gas infrastructure. The absence of BTEX establishes an excellent hydrocarbon baseline for future operational monitoring.

Microbiological Quality

Escherichia coli (E. coli): Surface water contained 6 to 12 cfu/100 mL, while groundwater recorded 0 cfu/100 mL. Both FMEnv and WHO require zero E. coli in

drinking water.

Accordingly, all surface water samples fail the drinking water standard, whereas groundwater fully complies. The presence of E. coli indicates faecal contamination and renders untreated surface water unsuitable for direct consumption.

Total Coliform

Surface water contained 97 to 147 cfu/100 mL, whereas groundwater contained 1 to 2 cfu/100 mL. Surface water greatly exceeds the FMEnv limit of 10 cfu/100 mL, while groundwater remains within acceptable limits. The elevated coliform counts further confirm that surface water is vulnerable to contamination from runoff, livestock and human activities.

Overall ESIA Interpretation

The baseline assessment indicates a clear distinction between surface water and groundwater quality within the proposed project area. Groundwater generally complies with FMEnv and WHO drinking water guidelines, exhibiting acceptable pH, low turbidity, low dissolved solids, absence of BTEX and petroleum hydrocarbons, and no detectable E. coli. However, isolated exceedances of iron and sodium warrant periodic monitoring.

In contrast, surface water exhibits several parameters exceeding FMEnv and WHO guideline values, including TSS, nitrite, chromium, nickel, zinc (at some locations), phenols, E. coli and total coliform, indicating that it is unsuitable for potable use without adequate treatment. These exceedances are more indicative of natural runoff, sediment transport and local anthropogenic activities than project-related impacts because the facility has not yet been developed.

For the ESIA, these findings establish an important environmental baseline. During construction and operation, strict erosion control, stormwater management, spill prevention, wastewater management and routine groundwater and surface water monitoring should be implemented to ensure that project activities do not degrade the existing water quality.

4.3.4 Soil Quality Assessment

Soil quality assessment was carried out using thirty (30) soil samples collected across the proposed Greenville CNG Mother Station site and three (3) control samples. The analyses covered soil physicochemical characteristics, exchangeable cations and anions, heavy metals, organic contaminants, particle size distribution and microbiological properties. The results were compared with applicable Federal Ministry of Environment (FMEnv) intervention/target values and internationally accepted guideline values (WHO/FAO and Dutch Target Values where FMEnv standards are unavailable).

Overall, the soil quality within the project area is generally good and typical of agricultural tropical soils. Heavy metal concentrations are generally very low, petroleum-related contaminants were not detected, and the soils exhibit moderate fertility characteristics. The only notable feature is the moderately alkaline soil reaction across much of the site.

Plate 4.2: Soil Sampling at the Proposed Project Site

The result of the soil analysis is presented on table 4.5a&b below

Table 4.5a: Physio-chemical Analysis of Soil Sample of the proposed project site

S/N	Parameters	Unit	GKPSS 01	GKPSS 02	GKPSS 03	GKPSS 04	GKPSS 05	GKPSS 06	GKPSS 07	GKPSS 08	GKPSS 09	GKPSS 10	GKPSS 11	GKPSS 12	GKPSS 13	GKPSS 14	GKPSS 15	GKPSS 16	GKPSS 17
A)	**Coordinate**																		
1	Latitude	N	10.337958	10.337958	10.337958	10.337958	10.337958	10.337328	10.337328	10.337328	10.337328	10.337328	10.336697	10.336697	10.336697	10.336097	10.336697	10.336067	10.336067
2	Longitude	E	7.354946	7.355589	7.356550	7.357511	7.358154	7.354946	7.355589	7.356550	7.356815 4	7.354946	7.355589	7.356550	7.357511	7.358154	7.354946	7.355589	7.356550
B)	**Physical Test**																		
3	pH		8.41	8.63	8.57	8.32	7.96	9.41	9.00	8.67	8.77	8.41	8.31	8.31	8.21	8.01	7.66	6.81	8.55
4	Colour	-	Brown	Dark Brown	Dark Brown	Very Dark Brown	Very Dark Brown	Dark Brown	Olive Brown	Pale Brown	Grayish Brown	Pale Brown	Pale Brown	Reddish Brown	Brown	Brown	Brown	Brown	Reddish Brown
5	Electrical Conductivity	µs/cm	2850	2335	2100	1963	1475	1077	2105	983	2524	2300	2621	2863	2051	1147	1052	1346	883
C)	**Exchangeable Cation**																		
6	Calcium (Ca^{2+})	mg/kg	2.99	3.02	3.22	2.07	1.93	2.63	1.54	2.55	1.69	2.74	3.66	3.54	2.51	2.88	3.55	4.30	2.86
7	Magnesium (Mg^{2+})	mg/kg	1.24	1.26	1.22	0.96	1.18	0.25	1.08	1.53	0.22	0.28	1.45	0.36	0.11	1.14	1.02	0.63	0.25
8	Ammonium (NH^{4+})	mg/kg	0.346	0.044	0.063	0.011	0.006	0.013	0.011	0.086	0.127	0.005	0.143	0.036	0.004	0.05	0.362	0.334	0.261
9	Sodium (Na^{+})	mg/kg	16	20	14	18	5	13	14	9	15	23	19	10	20	31	12	19	6
10	Potassium (K^{+})	mg/kg	4.2	3.8	2.1	3.8	1.5	2.4	2.1	1.3	1.4	2.2	2.9	1.2	1.7	1.0	2.5	1.3	2.0
D)	**Exchangeable Anion**																		
11	Sulphate (SO_4^{2-})	mg/kg	26	28	19	14	25	16	23	41	36	28	10	18	12	22	20	40	11
12	Nitrate (NO_3^{2-})	mg/kg	1.8	3.7	4.0	3.07	8.1	2.7	1.9	0.4	4.6	2.9	1.5	2.2	1.7	1.8	0.8	2.9	3.9
13	Nitrite (NO_2^{-})	mg/kg	0.006	0.017	0.007	0.002	0.001	0.002	0.041	0.000	0.004	0.006	0.107	0.014	0.000	0.013	0.036	0.003	0.024
14	Phosphate (PO_4^{2-})	mg/kg	2.3	2.8	3.6	2.7	1.8	1.4	1.4	2.6	2.3	1.4	2.2	1.7	2.1	2.2	3.5	0.6	2.6
15	Chloride (Cl^{-})	mg/kg	1.3	2.1	1.8	2.2	1.3	0.9	1.2	1.7	0.8	1.2	1.3	1.5	0.3	0.8	1.5	1.3	2.1
E)	**Heavy Metal**																		
16	Iron (Fe^{2+})	mg/kg	0.88	1.32	1.07	0.89	1.43	2.89	1.47	0.89	1.16	2.02	0.86	1.47	1.51	0.87	0.96	1.11	1.08
17	Zinc (Zn^{2+})	mg/kg	0.441	0.860	1.226	0.554	0.326	0.251	0.321	0.526	0.113	0.351	0.362	1.432	0.350	1.421	1.361	2.894	1.051
18	Copper (Cu^{2+})	mg/kg	0.83	0.44	0.93	0.05	0.16	0.18	0.11	0.27	0.57	0.86	0.25	0.07	1.32	0.81	0.43	1.11	0.86
19	Cobalt (Co^{2+})	mg/kg	0.96	0.71	0.06	0.74	0.57	0.86	0.71	0.26	0.05	0.00	0.00	0.00	0.10	0.14	0.0	0.4	0.13
20	Manganese (Mn^{2+})	mg/kg	2.8	1.7	1.4	1.4	0.5	0.3	1.2	1.0	0.3	0.4	0.2	0.5	0.9	0.3	0.9	0.6	1.7

S/N	Parameters	Unit	GKPSS 01	GKPSS 02	GKPSS 03	GKPSS 04	GKPSS 05	GKPSS 06	GKPSS 07	GKPSS 08	GKPSS 09	GKPSS 10	GKPSS 11	GKPSS 12	GKPSS 13	GKPSS 14	GKPSS 15	GKPSS 16	GKPSS 17
21	Chromium (Cr^{3+})	mg/kg	0.00	0.00	0.00	0.00	6.00	0.00	0.00	0.00	0.01	0.02	0.02	0.01	0.09	0.05	0.01	0.02	0.01
22	Nickel (Ni^{2+})	mg/kg	0.12	0.07	0.16	0.11	1.86	0.25	0.43	0.08	0.13	0.34	0.86	0.43	0.04	0.04	0.34	0.01	0.00
23	Mercury (Hg^{+})	µg/kg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	Lead (Pb^{2+})	µg/kg	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
F)	**Organics**																		
25	Phenols	mg/kg	0.24	0.87	0.23	0.05	0.11	0.03	0.74	0.14	0.32	0.66	0.34	0.24	0.18	0.32	1.41	0.02	0.05
26	Oil & Grease	mg/kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	BTEX	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
G)	**Soil Characteristics**																		
28	Sandy	%	25	14	20	30	21	22	43	35	31	20	31	22	31	22	25	11	16
29	Loam	%	64	71	74	65	58	56	49	59	64	77	55	46	59	56	61	83	81
30	Clay	%	5	8	6	5	19	12	5	4	1	3	9	13	7	15	8	0	0
31	Silt	%	6	7	0	0	2	10	3	2	4	0	5	19	3	7	6	6	3
H)	**Microbiological Test**																		
32	E. Coli	mg/100kg	14	6	11	21	22	18	23	15	4	8	13	3	5	2	9	3	8
33	Fungal	mg/100kg	129	281	51	251	73	430	56	266	68	199	145	94	108	281	74	192	54

Table 4.5b: Physio-chemical Analysis of Soil Sample of the proposed project site

S/N	Parameters	Unit	GKPSS 18	GKPSS 19	GKPSS 20	GKPSS 21	GKPSS 22	GKPSS 23	GKPSS 24	GKPSS 25	GKPSS 26	GKPSS 27	GKPSS 28	GKPSS 29	GKPSS 30	GKP Control 31	GKP Control 32	GKP SS Control 33
A)	**Coordinate**																	
1	Latitude	N	10.236067	10.336067	10.336067	10.335437	10.335437	10.335437	10.335437	10.335437	10.335100	10.335900	10.336500	10.337200	10.336900	10.336410	10.334500	10.331500
2	Longitude	E	7.357511	7.358154	7.354946	7.355589	7.356550	7.357511	7.358154	7.355200	7.357900	7.358600	7.358154	7.355200	7.357900	7.358600	7.357000	7.355000
B)	**Physical Test**																	
3	pH		8.01	8.34	8.60	8.34	8.53	8.33	8.36	8.54	8.21	8.33	8.87	8.21	8.43	6.97	6.56	6.43
4	Colour	-	Dark Brown	Dark Brown	Dark Brown	Pale Brown	Brown	Dark Brown	Brown	Brown	Dark Brown	Dark Brown	Dark Brown	Pale Brown	Pale Brown	Reddish Brown	Reddish Brown	Pale Reddish
5	Electrical Conductivity	µs/cm	1340	1256	1142	2551	2731	2801	1147	1752	1725	1196	2531	2110	1664	1432	1003	943

S/N	Parameters	Unit	GKPSS 18	GKPSS 19	GKPSS 20	GKPSS 21	GKPSS 22	GKPSS 23	GKPSS 24	GKPSS 25	GKPSS 26	GKPSS 27	GKPSS 28	GKPSS 29	GKPSS 30	GKP Control 31	GKP Control 32	GKP SS Control 33
C)	**Exchangeable Cation**																	
6	Calcium (Ca^{2+})	mg/kg	3.55	2.71	2.81	2.22	3.08	3.56	3.53	0.69	1.44	2.05	2.41	2.05	2.25	1.86	1.09	2.00
7	Magnesium (Mg^{2+})	mg/kg	1.19	0.11	0.53	0.42	0.11	1.30	1.37	0.36	1.21	0.16	0.96	1.33	1.47	0.03	0.16	0.07
8	Ammonium (NH^{4+})	mg/kg	0.582	0.216	0.035	0.117	0.005	0.061	0.009	0.056	0.334	0.052	0.034	0.062	0.005	0.108	0.004	0.026
9	Sodium (Na^{+})	mg/kg	18	3	4	43	9	35	11	14	13	16	13	17	19	11	10	10
10	Potassium (K^{+})	mg/kg	1.6	1.6	2.3	2.5	0.8	2.8	2.2	1.5	2.6	1.2	1.8	1.3	1.3	0.5	0.6	0.4
D)	**Exchangeable Anion**																	
11	Sulphate (SO_4^{2-})	mg/kg	23	13	17	31	26	21	15	30	45	63	54	38	29	16	16	15
12	$^{2-}$)	mg/kg	2.6	1.7	0.1	2.3	2.6	2.5	2.5	2.3	2.0	2.1	3.6	3.1	2.2	1.4	0.8	0.7
13	$^{-}$)	mg/kg	0.011	0.006	0.011	0.018	0.008	0.027	0.044	0.046	0.036	0.011	0.023	0.004	0.013	0.112	0.174	0.186
14	Phosphate (PO_4^{2-})	mg/kg	1.4	2.3	2.6	0.7	1.4	2.3	2.1	0.9	2.3	1.6	0.8	0.3	0.8	0.2	0.2	0.5
15	Chloride (Cl^{-})	mg/kg	2.0	1.8	2.7	0.9	2.3	2.1	2.1	0.5	0.7	1.8	1.4	0.6	1.4	0.7	0.7	0.7
E)	**Heavy Metal**																	
16	Iron (Fe^{2+})	mg/kg	0.94	1.04	1.52	0.86	0.41	0.34	0.56	1.17	1.56	2.74	1.96	2.96	1.94	2.00	2.34	1.86
17	Zinc (Zn^{2+})	mg/kg	1.326	0.898	0.114	0.367	0.866	1.425	0.571	0.324	0.113	0.852	1.007	1.863	1.045	1.006	1.399	1.482
18	Copper (Cu^{2+})	mg/kg	1.04	0.88	0.74	1.31	1.88	0.47	0.39	1.81	0.86	0.74	0.63	0.51	1.08	0.05	0.03	0.03
19	Cobalt (Co^{2+})	mg/kg	0.03	0.33	0.31	0.04	0.01	0.00	1.06	0.04	0.03	0.01	0.05	0.81	0.62	0.00	0.00	0.00
20	Manganese (Mn^{2+})	mg/kg	0.8	1.3	0.6	0.3	0.2	0.0	0.1	0.1	0.2	0.1	0.2	0.1	0.6	0.9	1.3	1.6
21	Chromium (Cr^{3+})	mg/kg	0.01	0.00	0.00	0.00	0.06	0.00	0.00	0.01	0.00	0.04	0.03	0.01	0.00	0.00	0.00	0.00
22	Nickel (Ni^{2+})	mg/kg	0.00	0.00	0.10	0.01	0.03	0.04	0.00	0.02	0.00	0.03	0.00	0.06	0.03	0.00	0.00	0.00
23	Mercury (Hg^{+})	µg/kg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
24	Lead (Pb^{2+})	µg/kg	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
F)	**Organics**																	
25	Phenols	mg/kg	0.16	0.32	0.14	0.00	0.06	0.24	0.13	0.05	0.01	0.06	0.03	0.04	0.00	0.00	0.00	0.00
26	Oil & Grease	mg/kg	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27	BTEX	mg/kg	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

S/N	Parameters	Unit	GKPSS 18	GKPSS 19	GKPSS 20	GKPSS 21	GKPSS 22	GKPSS 23	GKPSS 24	GKPSS 25	GKPSS 26	GKPSS 27	GKPSS 28	GKPSS 29	GKPSS 30	GKP Control 31	GKP Control 32	GKP SS Control 33
G)	**Soil Characteristics**																	
28	Sandy	%	22	11	88	19	21	19	31	28	30	28	27	30	21	70	71	65
29	Loam	%	74	80	64	70	65	71	45	39	50	59	57	66	70	23	21	28
30	Clay	%	1	7	6	8	10	8	6	19	18	7	9	4	6	7	7	6
31	Silt	%	3	0	2	3	4	2	18	14	2	6	7	0	3	0	1	1
H)	**Microbiological Test**																	
32	E. Coli	mg/100kg	26	12	14	15	8	9	21	8	13	15	12	9	16	8	2	2
33	Fungal	mg/100kg	48	235	78	194	96	87	107	58	96	36	35	43	98	45	12	14

Source: Field Data ESIA of Greenville CNG Mother Station Project, 2026.

4.3.4.1 Result Discussion on Soil Analysis of the Project Site

The soils were predominantly brown, pale brown and dark brown, with one sampling location exhibiting a pale greyish colour. These colour variations reflect differences in organic matter content, drainage characteristics and parent geological materials. Brown and dark brown soils generally indicate moderate organic matter accumulation and good aeration, whereas the pale greyish soil may be associated with localized poor drainage or prolonged moisture retention. The observed colour distribution is characteristic of tropical ferruginous soils commonly found within the Guinea Savannah ecological zone of central Nigeria and suggests that the soils have not undergone severe degradation or contamination.

Soil Reaction (pH)

The soil pH ranged from 6.81 to 9.41, while the control samples ranged from 6.43 to 6.97. Most project samples recorded pH values between 8.0 and 8.9, indicating moderately to strongly alkaline soils. Although FMEnv has no regulatory limit for soil pH, agricultural guidelines generally consider 6.0–8.5 suitable for most crops. Consequently, a number of sampling locations slightly exceed the upper desirable range. The alkaline condition is likely associated with the natural parent material and local geology rather than anthropogenic contamination. Alkaline soils generally reduce the mobility of many toxic heavy metals, thereby lowering their bioavailability. However, excessively alkaline conditions may reduce the availability of essential nutrients such as phosphorus, iron, manganese and zinc to plants.

From an ESIA perspective, the observed pH does not represent environmental contamination but should be considered when planning post-construction landscaping and vegetation restoration.

Electrical Conductivity (EC)

Electrical conductivity ranged between 883 and 2,863 µS/cm, while control locations recorded 943–1,432 µS/cm. These values indicate non-saline to slightly saline soils, remaining below conductivity values generally associated with severe salinity problems (>4,000 µS/cm). The results suggest that soluble salt accumulation is presently insignificant and is unlikely to restrict plant growth or soil productivity.

Exchangeable Cations

Calcium (Ca^{2+}): Calcium concentrations ranged from 0.69 to 4.30 mg/kg. These concentrations indicate adequate calcium availability for plant growth. Calcium contributes to soil structure, root development and nutrient uptake. No evidence of calcium deficiency or excessive accumulation was observed.

Magnesium (Mg^{2+}): Magnesium concentrations ranged from 0.03 to 1.53 mg/kg. The concentrations are characteristic of naturally occurring tropical soils and indicate balanced magnesium availability without evidence of contamination.

Sodium (Na^{+}): Exchangeable sodium ranged from 3 to 43 mg/kg. These values are relatively low and do not indicate sodic soil conditions. Consequently, the soils are not expected to experience structural degradation, poor infiltration or dispersion arising from sodium accumulation.

Potassium (K^{+}): Potassium concentrations varied from 0.4 to 4.2 mg/kg. Potassium levels are typical of undisturbed agricultural soils and are adequate for maintaining normal plant physiological functions.

Exchangeable Anions

Sulphate (SO_4^{2-}): Sulphate concentrations ranged from 10 to 63 mg/kg. These concentrations indicate adequate sulphur availability without evidence of sulphate contamination from industrial sources.

Nitrate (NO_3^{-}): Nitrate concentrations varied between 0.1 and 8.1 mg/kg. These relatively low concentrations suggest limited fertilizer enrichment and indicate that the soils have not experienced excessive agricultural nitrogen loading.

Nitrite (NO_2^{-}): Nitrite concentrations ranged from 0.000 to 0.186 mg/kg. Nitrite is generally unstable in soils and the measured concentrations are very low, indicating normal nitrogen cycling without significant contamination.

Phosphate (PO_4^{3-}): Phosphate concentrations ranged from 0.2 to 3.6 mg/kg. These values indicate moderate phosphorus availability typical of tropical soils. No evidence of excessive phosphate accumulation from agricultural runoff or waste disposal was observed.

Chloride (Cl^{-}): Chloride concentrations ranged from 0.3 to 2.7 mg/kg. The very low chloride concentrations confirm the absence of salinity intrusion or contamination from industrial effluents.

Heavy Metals

Iron (Fe): Iron concentrations ranged between 0.34 and 2.96 mg/kg. These concentrations are extremely low compared with FMEnv and Dutch intervention values for contaminated soils. The observed iron reflects natural geological occurrence and presents no environmental concern.

Zinc (Zn): Zinc concentrations ranged from 0.11 to 2.89 mg/kg. These concentrations are far below the FMEnv and Dutch Target Value of approximately 140 mg/kg, indicating that zinc contamination is absent.

Copper (Cu): Copper concentrations ranged from 0.03 to 1.88 mg/kg. These values are substantially lower than the FMEnv and Dutch Target Value of 36 mg/kg, confirming that copper contamination has not occurred within the project area.

Cobalt (Co): Cobalt concentrations ranged between 0.00 and 1.06 mg/kg. The concentrations are consistent with natural background levels and do not indicate anthropogenic enrichment.

Manganese (Mn): Manganese concentrations varied from 0.0 to 2.8 mg/kg. These concentrations are well below internationally accepted soil quality guideline values and indicate natural soil composition.

Chromium (Cr): Chromium concentrations ranged between 0.00 and 6.00 mg/kg, with only one sampling location recording 6.00 mg/kg. These concentrations remain far below the FMEnv and Dutch Target Value of 100 mg/kg, indicating that chromium contamination is absent. The isolated value of 6 mg/kg is still representative of natural geological variability rather than pollution.

Nickel (Ni): Nickel concentrations ranged from 0.00 to 1.86 mg/kg. These values are significantly below the FMEnv and Dutch Target Value of 35 mg/kg, confirming excellent soil quality with respect to nickel.

Mercury (Hg): Mercury was not detected in any soil sample. The absence of mercury demonstrates that no contamination from industrial chemicals or hazardous waste has occurred.

Lead (Pb): Lead was either not detected or detected only at trace concentrations (0.001 µg/kg). These concentrations are negligible and are substantially below the FMEnv and Dutch Target Value of 85 mg/kg. The results indicate that the proposed project area has not experienced contamination from petroleum products, batteries, paints or vehicular emissions.

Organic Contaminants

Phenols: Phenol concentrations ranged from 0.00 to 1.41 mg/kg. Although FMEnv does not prescribe a specific soil standard for phenols, the measured concentrations are relatively low and do not suggest significant contamination. The highest concentration is localized and may reflect decomposition of naturally occurring organic matter.

Oil and Grease: Oil and grease were not detected in any soil sample. This is particularly significant because the proposed development involves a CNG facility. The absence of petroleum hydrocarbons confirms that the site has not previously been impacted by fuel spills or hydrocarbon leakage.

BTEX: BTEX compounds were not detected in any soil sample. This establishes an excellent baseline environmental condition against which future operational monitoring can be undertaken.

Soil Texture: Particle size analysis indicates that the soils are predominantly loamy, comprising approximately: Sand: 11 to 88%, Loam: 21 to 83%, Clay: 0 to 19%, Silt: 0 to 19%. The predominance of loam indicates favourable physical characteristics, including moderate permeability, good aeration, satisfactory water-holding capacity and suitability for supporting vegetation. Such soils are generally considered ideal for site restoration following construction activities.

Microbiological Characteristics

***Escherichia coli* (E. coli):** *E. coli* populations ranged from 2 to 26 mg/100 kg. The presence of *E. coli* is expected in natural tropical soils because of wildlife activity, livestock grazing and decomposition of organic materials. The observed levels do not indicate significant anthropogenic contamination.

Fungal Population: Fungal counts ranged between 12 and 430 mg/100 kg. The presence of fungi reflects healthy microbial activity responsible for organic matter decomposition, nutrient recycling and maintenance of soil fertility. Variations among sampling locations are attributable to differences in vegetation cover, moisture content and organic matter availability.

Overall ESIA Interpretation

The baseline soil assessment demonstrates that the proposed Greenville CNG Mother Station site possesses good environmental quality, with no evidence of significant contamination by petroleum hydrocarbons, BTEX, mercury, lead or other priority heavy metals. Concentrations of chromium, nickel, copper, zinc and iron remain far below FMEnv and internationally accepted intervention values, indicating that the soils have not been adversely affected by industrial activities.

The dominant environmental characteristic is the moderately alkaline soil pH, which reflects the natural geochemical conditions of the area rather than pollution. The soils are predominantly loamy, providing favourable engineering properties, good drainage and suitable conditions for post-construction revegetation. Overall, the results establish an excellent baseline for the ESIA. To preserve this condition, the project should implement strict spill prevention measures, proper storage and handling of fuels and chemicals, effective waste management, erosion control and periodic soil quality monitoring throughout the construction and operational phases.

4.3.5 Geology and Hydrogeology of the Project Area

Regional Geology: The project area lies within the Basement Complex terrain of Northern Nigeria, composed predominantly of Precambrian rocks including migmatites, granites, gneisses, and quartzites.

Local Geology: Outcrops are sparse, with underlying geology dominated by weathered granite-gneiss formations, forming moderately deep to deep profiles of lateritic soils suitable for agriculture. Figure 4.8 presents the basic geology of the project area (Pre-Cambrian Basement Complex) and of the other Nigerian regions.

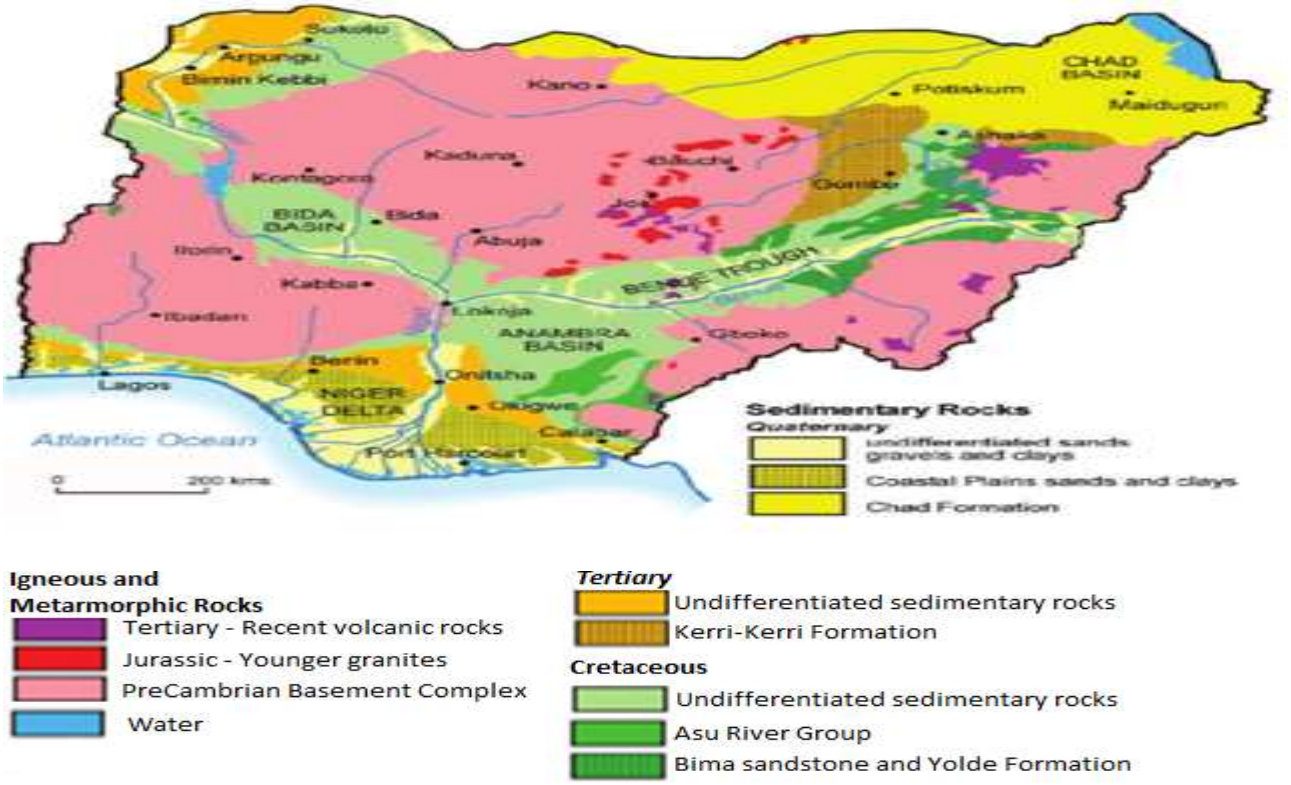

Figure 4.6: Geology of Nigerian regions (Source: Obaje, N.G, 2007)

Hydrology: The proposed project site is close to River Kaduna and one of its tributaries, which serve as the major hydrological features in the area. Seasonal streams may traverse or border parts of the site during the wet season. The flow regime shows peak flow in July to September, while low flow rates are recorded in December to April. Localised flooding may occur in low-lying areas adjacent to streams during peak rains if drainage is not well managed. Thus, the hydrology of the project area supports the water needs of the proposed project.

Hydrogeology: Aquifer type in the project area is Mainly weathered Basement Complex aquifers, consisting of regolith and fractured bedrock zones. With groundwater depth typically 15 – 30 m below ground level in dug wells; deeper

boreholes (~40 – 60 m) tap into fractured basement aquifers. The yield potential is moderate (0.5 – 2.0 litres per second) suitable for community water supply and agro-industrial use. The water quality is generally good for domestic and agricultural use but may require filtration and disinfection for drinking purposes. Therefore, hydrogeology also supports the proposed project, with potential for borehole water supply.

4.3.6 Ecological Baseline of the Study Area (Biodiversity/Flora and Fauna)

According to the convention on Biological Diversity, Biodiversity is defined as "the variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic systems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems". Biodiversity considerations are very important in environmental management. Many developmental activities are likely to play a major role in the overall reduction of biodiversity; hence there is need for proper understanding of the existing environmental setting in terms of habitat types, selected flora and fauna species, endangered or threatened species. This will help in developing mitigation measures for protecting and conserving biodiversity, maintaining ecosystem services and sustainably managing the living natural resources. This section presents a description of the terrestrial flora and fauna and other natural resources and habitats constituting the biological environmental setting.

Vegetation (Terrestrial Flora) Characteristics

A reconnaissance survey of the proposed Project site and its surrounding environment was undertaken to establish the existing terrestrial flora and fauna as well as habitat conditions. The survey, supported by direct field observations and photographic documentation, indicates that the project area lies within the Northern Guinea Savannah ecological zone of Kaduna State. The vegetation is typical of a disturbed savannah landscape characterized by cultivated farmland, open grassland, scattered shrubs, isolated mature trees, seasonal drainage channels and fallow agricultural fields.

The proposed project site itself is predominantly open with sparse herbaceous vegetation and patches of exposed lateritic soil resulting from previous land preparation and anthropogenic disturbances. The surrounding landscape consists largely of cultivated farmlands interspersed with secondary vegetation and remnant woody species. No primary forest, riparian forest, protected woodland or ecologically sensitive vegetation communities were observed within the proposed development footprint. Vegetation density increases away from the immediate project footprint, particularly along seasonal drainage depressions and low-lying areas where shrubs and small trees occur in relatively denser clusters. The field survey also revealed mature scattered trees within cultivated fields, with several trees supporting large active termite mounds around their bases. These mature trees

provide shade and contribute to the ecological integrity of the surrounding landscape.

Table 4.6: Major Habitat Types within the Project Area

Habitat Type	Description	Ecological Significance
Cultivated Farmland	Dominant land cover comprising actively cultivated maize fields, harvested plots and areas under land preparation.	Provides agricultural production but supports limited natural vegetation.
Open Savannah Grassland	Open grassland dominated by grasses, annual herbs and scattered shrubs.	Supports livestock grazing and maintains ground cover against erosion.
Shrubland and Secondary Vegetation	Regenerating woody shrubs, grasses and climbers occurring mainly along seasonal drainage channels and uncultivated areas.	Provides habitat, ecological connectivity and natural regeneration.
Scattered Mature Trees	Isolated indigenous and exotic trees dispersed within cultivated fields and open savannah.	Provide shade, microclimate regulation, carbon sequestration and habitat for associated fauna.

Habitat Description

Based on field observations, the vegetation within and around the project area can be classified into the following habitat types:

Cultivated Farmland

This constitutes the dominant land cover surrounding the proposed project site. The fields were actively cultivated with cereal crops, particularly maize, while some portions were recently harvested or under land preparation. Farming activities have significantly modified the original vegetation structure.

Plate 4.3: Farmland around the project area.

Open Savannah Grassland

Open grassland occurs extensively around the project area and is characterized by short grasses mixed with annual herbs and scattered shrubs. The photographs obtained during the survey also showed active grazing by cattle within these grasslands, indicating that the habitat serves both agricultural and livestock production purposes.

Shrubland and Secondary Vegetation

Areas adjoining the seasonal drainage channels contain dense shrub vegetation composed of regenerating woody species, grasses and climbers. These secondary growth communities represent previously disturbed vegetation undergoing natural regeneration.

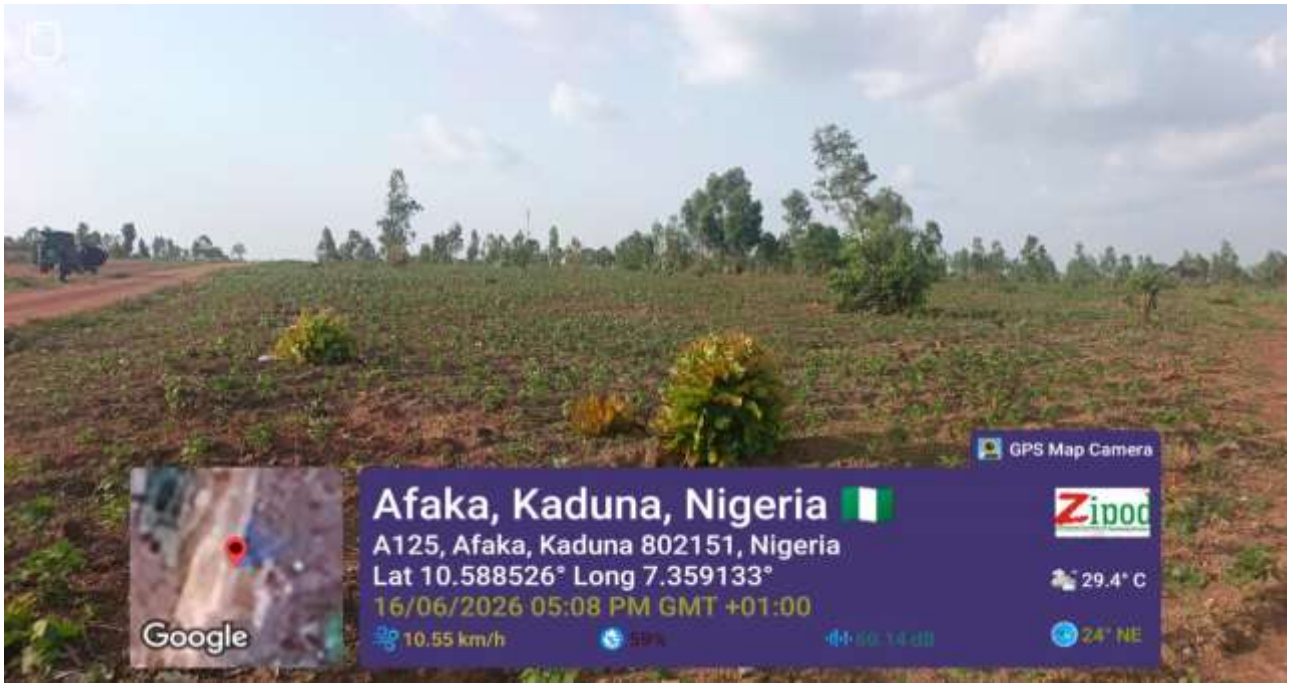

Plate 4.4: Shrub Land within the project area

Scattered Mature Trees

Several mature indigenous trees occur as isolated individuals within cultivated fields and open savannah. These trees provide shade and contribute to landscape diversity. Large active termite mounds were observed around some of these trees, indicating active biological processes and long-term ecological stability within portions of the landscape.

Floral Composition

The vegetation observed during the survey comprised predominantly Guinea Savannah species commonly associated with northern Nigeria. The vegetation

observed during the field survey is representative of the Northern Guinea Savannah ecosystem commonly found across Kaduna State and northern Nigeria. Field observations identified a mixture of indigenous and introduced plant species comprising mature trees, shrubs, herbaceous vegetation and cultivated crops. The dominant vegetation recorded during the survey includes the following:

Trees

- Shea Tree (*Vitellaria paradoxa*)
- African Locust Bean (*Parkia biglobosa*)
- Neem (*Azadirachta indica*)
- Mango (*Mangifera indica*)
- Fan Palm (*Borassus aethiopum*)
- Jujube (*Ziziphus* spp.)
- Various indigenous savannah tree species

Shrubs

- Mixed secondary woody shrubs
- Regenerating savannah shrub species
- Seasonal bush vegetation

Herbaceous Vegetation

- Guinea Savannah grasses
- Annual herbs
- Broadleaf weeds
- Agricultural weeds commonly associated with cultivated fields

Cultivated Crops

- Maize (*Zea mays*)
- Other seasonal food crops observed within neighbouring farmlands

Table 4.7: Dominant Flora Recorded During the Field Survey

Vegetation Category	Species/Type Observed	Scientific Name
Tree	Shea Tree	*Vitellaria paradoxa*
Tree	African Locust Bean	*Parkia biglobosa*
Tree	Neem	*Azadirachta indica*
Tree	Mango	*Mangifera indica*

Tree	Fan Palm	*Borassus aethiopum*
Tree	Jujube	*Ziziphus* spp.
Tree	Indigenous Savannah Trees	Various species
Shrubs	Secondary Woody Shrubs	Various species
Shrubs	Regenerating Savannah Shrubs	Various species
Shrubs	Seasonal Bush Vegetation	Various species
Herbaceous Vegetation	Guinea Savannah Grasses	Various species
Herbaceous Vegetation	Annual Herbs	Various species
Herbaceous Vegetation	Broadleaf Weeds	Various species
Herbaceous Vegetation	Agricultural Weeds	Various species
Cultivated Crop	Maize	*Zea mays*
Cultivated Crop	Seasonal Food Crops	Various species

Table 4.8: Some Floral Species Recorded around the project area with their IUCN Status

S/N	Scientific Name	Common Name	Family	IUCN	Endemic Status	Growth Form	Uses
1	*Azadirachta indica*	Neem	Meliaceae	LC	Non-endemic	Tree	Medicin shade
2	*Adansonia*	Baobab	Malvaceae	LC	Non-endemic	Tree	Food, .
3	*Isoberlinia doka*	-	Fabaceae	LC	Non-endemic	Tree	Timber, medicin
4	*Amaranthus*	Spiny amaranth	Amaranthace	LC	Non-endemic	Herb	Food, .
5	*Mangifera indica*	Mango	Anacardiace	LC	Non-endemic	Tree	Food
6	*Calotropis procera*	Sodom	Apocynaceae	LC	Non-endemic	Shrub	Medicin
7	*Balanites*	Desert date	Zygophyllacea	LC	Non-endemic	Tree	Food, .
8	*Guiera*	-	Combretacea	LC	Non-endemic	Shrub	Medicin
9	*Chamaecrista mimosoides*	Cassia	Fabaceae	LC	Non-endemic	Herb	Medicin
10	*Crotalaria pallida*	Rattlebox	Fabaceae	LC	Non-endemic	Shrub	Soil improve
11	*Mimosa pigra*	Giant	Fabaceae	LC	Non-endemic	Shrub	Invasive, medicin
12	*Mesosphaerum suaveolens*	Bush mint	Lamiaceae	LC	Non-endemic	Herb	Medicin
13	*Bombax costatum*	Red kapok	Malvaceae	LC	Non-endemic	Tree	Medicin
14	*Sida cordifolia*	Flannel	Malvaceae	LC	Non-endemic	Shrub	Medicin
15	*Sida acuta*	Wire weed	Malvaceae	LC	Non-endemic	Herb	Medicin
16	*Vachellia nilotica*	Gum tree	Fabaceae	LC	Non-endemic	Tree	Fodder, medicin
17	*Moringa oleifera*	Moringa	Moringaceae	LC	Non-	Tree	Food, .

S/N	Scientific Name	Common Name	Family	IUCN	Endemic Status	Growth Form	Uses
					endemic		
18	*Eucalyptus camaldulensis*	River red	Myrtaceae	LC	Non-endemic	Tree	Timber
19	*Cenchrus biflorus*	Kram-kram grass	Poaceae	LC	Non-endemic	Grass	Fodder
20	*Anacardium occidentale*	Cashew	Anacardiace	LC	Non-endemic	Tree	Food
21	*Annona*	Wild apple	Annonaceae	LC	Non-endemic	Shrub	Food
22	*Anogeissus*	African	Combretacea	LC	Non-endemic	Tree	Timber
23	*Daniellia oliveri*	African copaiba	Fabaceae	LC	Non-endemic	Tree	Medicin
24	*Gmelina arborea*	Gmelina	Lamiaceae	LC	Non-endemic	Tree	Timber
25	*Ageratum conyzoides*	Goat weed	Asteraceae	LC	Non-endemic	Herb	Medicin
26	*Saccharum officinarum*	Sugarcane	Poaceae	LC	Non-endemic	Grass	Food
27	*Chromolaena odorata*	Siam weed	Asteraceae	LC	Non-endemic	Shrub	Invasive
28	*Khaya*	African mahogany	Meliaceae	VU	Non-endemic	Tree	Timber
29	*Lophira lanceolata*	Ironwood	Ochnaceae	LC	Non-	Tree	Timber

Faunal Composition

Faunal observations recorded during the field survey were characteristic of a disturbed Guinea Savannah agroecosystem. The most conspicuous vertebrate fauna observed within and around the proposed project area were grazing cattle, confirming that portions of the surrounding landscape are utilised for livestock grazing alongside crop cultivation. The survey also recorded numerous active termite mounds distributed across the project area and its surroundings, particularly around mature trees and within open grassland. These mounds are indicative of active termite colonies (*Macrotermes* spp.), which contribute significantly to soil aeration, organic matter decomposition, nutrient recycling and improvement of soil structure. The abundance of termite mounds further reflects the ecological importance of soil macrofauna within the Guinea Savannah ecosystem. Apart from grazing livestock and termite colonies, no other wildlife species were directly observed during the field survey. Likewise, no evidence of breeding sites, wildlife corridors, nesting colonies or habitats of conservation significance was encountered within the proposed project footprint.

Table 4.9: Fauna Observed During the Field Survey

Faunal Group	Observation	Ecological Importance
Livestock	Grazing cattle	Demonstrates active livestock utilization of the surrounding grassland and farmland.
Invertebrates	Active termite mounds (*Macrotermes* spp.)	Contribute to soil aeration, nutrient recycling, organic matter decomposition and soil structure improvement.

Table 4.10: Some Faunal Species around the project area

Scientific Name	Common Name	IUCN Status	Endemic Status
Avifauna			
Milvus migrans	Yellow-billed Kite	LC	Not endemic
Corvus albus	Pied Crow	LC	Not endemic
Pycnonotus barbatus	Common Bulbul	LC	Not endemic
Passer griseus	Northern Grey-headed	LC	Not endemic
Ploceus cucullatus	Village Weaver	LC	Not endemic
Spermestes cucullata	Bronze Mannikin	LC	Not endemic
Streptopelia semitorquata	Red-eyed Dove	LC	Not endemic
Streptopelia vinacea	Vinaceous Dove	LC	Not endemic
Columba guinea	Speckled Pigeon	LC	Not endemic
Turtur afer	Blue-spotted Wood Dove	LC	Not endemic
Halcyon senegalensis	Woodland Kingfisher	LC	Not endemic
Halcyon malimbica	Blue-breasted Kingfisher	LC	Not endemic
Bubulcus ibis	Cattle Egret	LC	Not endemic
Ardea cinerea	Grey Heron	LC	Not endemic
Butorides striata	Striated Heron	LC	Not endemic
Phalacrocorax africanus	Reed Cormorant	LC	Not endemic
Scopus umbretta	Hamerkop	LC	Not endemic
Coracias abyssinicus	Abyssinian Roller	LC	Not endemic
Falco tinnunculus	Common Kestrel	LC	Not endemic
Kaupifalco	Lizard Buzzard	LC	Not endemic
Tockus nasutus	African Grey Hornbill	LC	Not endemic
Lamprotornis caudatus	Long-tailed Glossy Starling	LC	Not endemic
Prinia subflava	Tawny-flanked Prinia	LC	Not endemic
Camaroptera	Grey-backed	LC	Not endemic
Cyanomitra olivacea	Olive Sunbird	LC	Not endemic
Cinnyris venustus	Variable Sunbird	LC	Not endemic
Tchagra senegalus	Black-crowned Tchagra	LC	Not endemic
Pternistis bicalcaratus	Double-spurred Francolin	LC	Not endemic
Mammals			
Thryonomys swinderianus	Grasscutter	LC	Not endemic
Cricetomys gambianus	Gambian Giant Rat	LC	Not endemic
Xerus erythropus	Striped Ground Squirrel	LC	Not endemic
Eidolon helvum	Straw-coloured Fruit Bat	LC	Not endemic
Reptiles			
Agama agama	Common Agama	LC	Not endemic
Trachylepis perrotetii	Savanna Skink	LC	Not endemic

Ecological Condition

The vegetation and faunal communities within the project area have been substantially influenced by long-term agricultural activities, livestock grazing and other human disturbances. Consequently, the habitat is considered to be of low to moderate ecological sensitivity. Most of the original savannah vegetation has been replaced by cultivated farmland and secondary regrowth, with only scattered mature trees remaining across the landscape. No rare, threatened or endangered plant species were observed during the field survey. Similarly, no protected or endangered wildlife species were recorded. Likewise, no protected forests, wetlands, critical habitats or areas of high conservation importance were identified within the proposed project footprint. The scattered mature trees, shrub patches, seasonal drainage vegetation and active termite colonies nevertheless contribute to local ecological functions by supporting soil formation processes, nutrient cycling and maintaining the ecological stability of the surrounding environment.

Evidence of Human Activities

The survey revealed widespread anthropogenic activities within the project area and its surroundings, including:

- Rain-fed subsistence farming.
- Land clearing and cultivation.
- Livestock grazing by cattle.
- Footpaths and informal access routes.
- Scattered residential structures and farm settlements.
- Ongoing infrastructure development and earthworks within parts of the surrounding landscape.

These activities have contributed to habitat fragmentation and reduced the natural vegetation cover across much of the area while promoting secondary vegetation and agricultural land use.

Ecological Significance

Overall, the proposed project site comprises a modified Guinea Savannah ecosystem dominated by agricultural land use and secondary vegetation. The floral communities are representative of common savannah vegetation widely distributed across Kaduna State and northern Nigeria, while the faunal component recorded during the survey was dominated by grazing cattle and abundant termite colonies. The vegetation provides local ecosystem services including erosion control, carbon sequestration, microclimate regulation and maintenance of soil stability, whereas termite activity contributes to nutrient recycling, soil aeration and

organic matter decomposition. Given the absence of unique vegetation communities, protected habitats, threatened flora or fauna, or other species of conservation concern, the ecological value of the project area is considered **low to** moderate. Consequently, the anticipated impacts associated with vegetation clearance are expected to be site-specific, localized and readily mitigated through implementation of appropriate vegetation management and ecological restoration measures during project implementation. This baseline description provides the reference condition against which potential project-related impacts on terrestrial flora and fauna will be assessed in subsequent sections of the ESIA.

Table 4.11: Summary of Ecological Characteristics

Ecological Attribute	**Observation**
Ecological Zone	Northern Guinea Savannah
Dominant Vegetation	Secondary savannah vegetation, cultivated farmland, grasses, shrubs and scattered mature trees
Dominant Land Use	Agriculture and livestock grazing
Flora Diversity	Common Guinea Savannah species
Fauna Observed	Grazing cattle and active termite colonies
Protected Vegetation	None observed
Protected Wildlife	None observed
Wetlands/Riparian Forest	None observed within the project footprint
Conservation Status	Low to moderate ecological sensitivity
Overall Ecological Value	Modified agricultural savannah ecosystem with localized ecological functions

4.4 Socio-Economics

This section presents the findings of the socioeconomic assessment conducted for the proposed Installation of a Compressed Natural Gas (CNG) Mother Station along the AKK Pipeline at Afaka Community, Rigasa District, Igabi Local Government Area of Kaduna State.

The socioeconomic assessment was undertaken to establish the existing social, economic, cultural, and demographic conditions of the host community and surrounding settlements that may be influenced by the proposed project. The assessment provides baseline information that will assist in evaluating potential project impacts, identifying community expectations, and developing appropriate mitigation and enhancement measures.

The study focused on understanding the characteristics of the population, sources of livelihood, income levels, educational attainment, health conditions, housing characteristics, access to infrastructure and social services, land ownership patterns, and community perceptions regarding the proposed project.

Data for the assessment were obtained through household questionnaire surveys, stakeholder consultations, key informant interviews, field observations, and review of relevant secondary information. The information generated forms an important component of the Environmental and Social Impact Assessment (ESIA) process and serves as a basis for planning sustainable community engagement and social investment programmes.

The socioeconomic survey covered Afaka Community and neighbouring settlements within the project area of influence. Particular attention was given to residents living closest to the proposed project site because they are more likely to experience both the positive and negative effects of the project during construction and operation phases.

4.4.1 Methodology

The socioeconomic assessment was carried out using a combination of quantitative and qualitative research approaches. The methodology was designed to ensure that information collected was representative, reliable, and suitable for assessing the social and economic conditions of the affected communities.

4.4.1.1 Study Area

The study was conducted within Afaka Community and adjoining settlements located in Rigasa District of Igabi Local Government Area, Kaduna State. Afaka is situated along the Abuja-Kaduna transport corridor and falls within the area influenced by the proposed CNG Mother Station Project.
The community is predominantly inhabited by indigenous and settler populations

engaged in farming, petty trading, artisan activities, transportation services, and public sector employment. The area is characterized by rapid population growth due to its proximity to Kaduna metropolis and major transportation routes.

The study area was selected because of its direct relationship with the proposed project and the likelihood of experiencing socioeconomic impacts during project implementation. The selection of these communities ensured adequate representation of households, vulnerable groups, community leaders, women, youths, traders, farmers, and other stakeholders likely to be affected by the project.

4.4.1.2 Sampling

A household-based sampling approach was adopted for the socioeconomic survey. The sample size was determined using Cochran's formula for large populations.

The Cochran formula is expressed as:

$$n = Z^2 \times p \times (1-p) / e^2$$

Where:

n = Required sample size

Z = Standard normal deviation corresponding to a 95% confidence level (1.96)

p = Estimated proportion of the population possessing the attribute of interest (0.5)

e = Margin of error

Based on available demographic information, Rigasa is one of the largest and most populated wards in Nigeria, with an estimated population exceeding three million residents (NPC 2006). The combined population of Rigasa and Afaka is estimated to exceed five million persons.

Applying the Cochran sample size determination approach produced a recommended sample range of approximately 267 to 384 respondents depending on the acceptable margin of error. Consequently, a sample size of 300 respondents was adopted for the study, which provides adequate statistical representation of the host community and project area of influence.

To account for non-response and incomplete questionnaires, a total of 330 questionnaires were distributed, while 300 valid questionnaires were successfully completed and retrieved for analysis.

Table 4.12: ample Size Determination

Parameter	Value
Confidence Level	95%
Margin of Error	Approximately ±5.7%

Parameter	Value
Recommended Sample Size	300
Questionnaires Distributed	330
Questionnaires Retrieved	300
Response Rate	90.9%

The sampling process incorporated representation across gender groups, occupations, housing categories, and distance from the proposed project site.

Table 4.13: Survey Stratification

Category	Percentage (%)	Number of Respondents
Farmers	50	150
Traders/Business Owners	25	75
Artisans	10	30
Civil Servants	10	30
Others	5	15
Male	55	165
Female	45	135
Homeowners	70	210
Renters	30	90

4.4.1.3 Data Collection

Both primary and secondary sources of data were utilized during the study.

Primary Data Collection

Primary data were collected through:

1. Household questionnaire survey.
2. Key Informant Interviews (KIIs).
3. Stakeholder consultation meetings.
4. Community leader engagements.
5. Direct field observations.
6. Discussions with women and youth groups.

The structured questionnaire covered demographic characteristics, livelihood activities, income levels, housing conditions, health status, access to infrastructure, community concerns, and perceptions regarding the proposed project.

Key informant interviews were conducted with traditional rulers, community leaders, youth representatives, women leaders, and other knowledgeable persons within the study area.

Field observations were also undertaken to verify existing conditions relating to housing, roads, drainage systems, sanitation facilities, healthcare infrastructure, educational facilities, and economic activities.

Secondary Data Collection: Secondary information was obtained from:

- Published literature.
- Government reports.
- National Population Commission records.
- Kaduna State Government publications.
- Previous environmental studies.
- Academic journals.
- Relevant online demographic and socioeconomic databases.

The secondary information assisted in understanding the broader socioeconomic context of the study area and supported validation of field findings.

4.4.1.4 Data Analysis

Data obtained from the questionnaire survey were coded, entered, cleaned, and analysed using the Statistical Package for Social Sciences (SPSS) and Microsoft Excel.

Descriptive statistical techniques were employed to analyse the data. These included:

- Frequencies.
- Percentages.
- Tables.

The analysed data were used to describe the socioeconomic characteristics of the population and to identify prevailing community concerns, expectations, and development priorities.

Qualitative information obtained from stakeholder consultations, key informant interviews, and field observations was analysed through content analysis and integrated with the quantitative findings to provide a comprehensive understanding of the socioeconomic conditions within the project area.

The results of the analysis are presented in the subsequent sections of this chapter.

4.4.2 Profile of the Study Area

This section provides a comprehensive description of Afaka Village, the host community for the proposed Compressed Natural Gas (CNG) Mother Station

Project. The profile covers the location and administrative framework, traditional governance structure, and the ethnic and cultural characteristics of the community. Understanding these aspects is essential for assessing the social context within which the project will operate and for identifying potential social impacts and appropriate mitigation measures.

4.4.2.1 Location and Administration

The proposed CNG Mother Station Project is located within Afaka Community in Rigasa District, Igabi Local Government Area (LGA) of Kaduna State, Nigeria. The project site lies within the influence zone of the Ajaokuta-Kaduna-Kano (AKK) Natural Gas Pipeline corridor and forms part of the growing industrial and commercial development axis of Kaduna State.

Plate 4.5: Site Verification Exercise

Afaka Community is strategically located along the Kaduna-Abuja transportation corridor and is accessible through a network of major roads linking it to Rigasa, Kaduna metropolis, and neighbouring communities. The community is situated approximately 3 kilometres from Rigasa town and about 1 kilometre from the Nigerian Defence Academy (NDA).

Administratively, Afaka falls under Rigasa District in Igabi Local Government Area. The community operates under a traditional governance system that complements the formal local government administrative structure. Traditional institutions play an

important role in maintaining peace, resolving disputes, mobilising community members for development activities, and facilitating communication between government agencies and residents.

The area has experienced significant population growth over the years due to urban expansion, migration, commercial activities, and its proximity to Kaduna city. The growing population has increased demand for housing, infrastructure, employment opportunities, healthcare services, and educational facilities.

Agriculture, petty trading, transportation services, artisan work, and public sector employment constitute the major economic activities within the community. The strategic location of the area has also encouraged increasing private sector investment and commercial development.

4.4.2.2 Traditional Governance Structure

Traditional leadership remains an important institution within Rigasa District and Afaka Community. The traditional administration serves as the primary channel for community mobilisation, conflict resolution, cultural preservation, and stakeholder engagement.

The traditional governance structure observed within the study area is presented below in figure 4.7.

Figure 4.7: Traditional Governance Hierarchy

The District Head serves as the highest traditional authority within the district and provides leadership on matters affecting the communities under his jurisdiction. The Village Head oversees local community affairs and works closely with elders, youth leaders, and women leaders to ensure effective administration and community development.

Community elders provide advisory functions and contribute to decision-making on issues relating to land, culture, security, and social welfare. Youth and women leaders represent their respective groups and facilitate communication between community members and traditional authorities.

The traditional institution was actively engaged during the stakeholder consultation process and played a significant role in mobilising community members for the socioeconomic survey and public consultation meetings.

4.4.2.3 Ethnicity and Cultural Heritage

The study area is culturally diverse and consists of both indigenous and settler populations. The dominant ethnic groups found within Rigasa District and Afaka Community include Hausa, Fulani, Gbagyi, and other ethnic groups that have migrated to the area for economic, educational, and commercial reasons.

Hausa is the most widely spoken language and serves as the principal medium of communication among residents. English language is commonly used in schools, government institutions, and formal engagements.

Islam is the predominant religion within the study area, accounting for approximately 95 percent of the respondents surveyed. Christianity is also practised by a smaller proportion of residents, contributing to the cultural diversity of the community. The relationship between adherents of the two faiths is generally peaceful, with both groups participating in community development activities.

The cultural heritage of the area is reflected in traditional ceremonies, marriage rites, naming ceremonies, religious celebrations, and communal activities. Major Islamic festivals such as Eid-el-Fitr and Eid-el-Kabir are widely celebrated and attract participation from community members. Christian residents also celebrate important religious festivals such as Christmas and Easter.

Traditional values emphasise respect for elders, community solidarity, peaceful coexistence, and collective responsibility for development. Community members

commonly participate in communal activities aimed at maintaining public facilities, supporting vulnerable persons, and promoting social harmony.

There are no known nationally significant archaeological sites, sacred forests, or heritage monuments within the immediate project area. However, community members indicated that culturally sensitive locations, family burial grounds, and places of traditional significance should be respected during project implementation.

The proposed project is not expected to adversely affect the cultural identity, traditions, or heritage resources of the host community provided that project activities remain within the designated project footprint and all applicable environmental and social safeguards are implemented.

4.4.3 Demographic Characteristics

This unit presents the demographic characteristics of respondents within the study area. Understanding the demographic profile of the host community is important for assessing existing social conditions and evaluating how different population groups may be affected by the proposed project.

The demographic variables assessed include population and household characteristics, gender distribution, age structure, religion, marital status, and household size.

4.4.3.1 Population Size and Households

Rigasa District is recognised as one of the most densely populated areas in Kaduna State and among the largest urban settlements in Nigeria. Available demographic estimates indicate that the district has a population exceeding three million residents.

For the sake of this study, a total of 300 valid questionnaires were administered and analysed during the socioeconomic survey. The respondents were drawn from households located within Afaka Community and surrounding areas within the project's area of influence.

The survey revealed that households are generally large, reflecting the extended family system commonly practiced within the study area.

4.4.3.2 Gender Distribution

Gender composition is an important indicator for understanding community structure and participation in socioeconomic activities.

The survey results indicate that males constituted the majority of respondents, accounting for 55 percent of the total sample, while females accounted for 45 percent.

Table 4.14: Gender Distribution of Respondents

Gender	Frequency	Percentage (%)
Male	165	55
Female	135	45
Total	**300**	**100**

The relatively balanced gender representation suggests that both men and women actively participate in household decision-making and community affairs. The inclusion of female respondents also provided valuable insight into issues relating to family welfare, healthcare, education, and community development.

4.4.3.3 Age Distribution

The age structure of a population provides an indication of the available labour force and the level of economic activity within a community. The survey findings show that the majority of respondents fall within the economically active age group of 18 to 40 years. This age category accounted for 65 percent of respondents. Individuals aged between 41 and 60 years constituted 30 percent, while respondents above 60 years accounted for 5 percent.

Table 4.15: Age Distribution of Respondents

Age Category	Frequency	Percentage (%)
18-40 Years	195	65
41-60 Years	90	30
Above 60 Years	15	5
Total	**300**	**100**

The dominance of young and economically active individuals indicates the availability of labour that could potentially benefit from employment and business opportunities associated with the proposed project.

4.4.3.4 Religion

Religion plays an important role in shaping cultural practices, social interactions, and community values within the study area.

The survey revealed that Islam is the dominant religion, representing 95 percent of respondents. Christianity accounted for 5 percent, while no respondents identified with traditional religious practices

Table 4.16: Religious Affiliation of Respondents

Religion	Frequency	Percentage (%)
Islam	285	95
Christianity	15	5
Traditional Religion	0	0
Total	**300**	**100**

The findings indicate that the study area is predominantly Muslim, although the presence of Christians reflects the cultural diversity that exists within the community. Interfaith relations were observed to be peaceful during field consultations.

4.4.3.5 Marital Status

Marital status influences household responsibilities, economic commitments, and social relationships within communities.

The survey results show that married respondents constituted the largest proportion of the sample, accounting for 60 percent. Single respondents represented 35 percent, while divorced and widowed respondents accounted for 5 percent.

Table 4.17: Marital Status of Respondents

Marital Status	Frequency	Percentage (%)
Single	105	35
Married	180	60
Divorced/Widowed	15	5
Total	**300**	**100**

The high proportion of married respondents reflects the family-oriented nature of the community and suggests that household welfare issues remain an important consideration in project planning and implementation.

4.4.3.6 Household Size

Household size is an important socioeconomic indicator because it influences housing demand, income allocation, healthcare needs, educational expenditure, and access to social services.

The survey findings indicate that households containing between six and ten persons were the most common, accounting for 45 percent of respondents. Households with one to five members represented 40 percent, while households with more than ten members accounted for 15 percent.

Table 4.18: Household Size of Respondents

Household Size	Frequency	Percentage (%)
1-5 Persons	120	40
6-10 Persons	135	45
Above 10 Persons	45	15
Total	**300**	**100**

The findings indicate that medium to large household sizes are common within the study area. Such household structures often place considerable demands on household income and social services, particularly education, healthcare, water supply, and housing.

Overall, the demographic profile of the study area reveals a predominantly young, economically active, family-oriented, and culturally cohesive population. These characteristics present opportunities for local employment and participation in project-related activities while also highlighting the need for inclusive stakeholder engagement throughout the project lifecycle.

4.4.5 Economic Livelihoods

This section presents the economic characteristics of respondents within the study area. It provides an overview of the main sources of livelihood, household income levels, and expenditure priorities. The analysis is based on responses from 300 households within Afaka Community and surrounding settlements in Rigasa District, Igabi Local Government Area of Kaduna State.

Understanding the economic structure of the community is important for assessing the potential socioeconomic impacts of the proposed CNG Mother Station project, particularly in relation to employment opportunities, income generation, and local

business development.

4.4.5.1 Main Occupations

The economic activities of the study area are diverse, with agriculture remaining the dominant source of livelihood. Other activities include trading, artisan work, civil service, and informal labour.

The survey results show that farming is the most common occupation, accounting for 50 percent of respondents. This is followed by trading at 25 percent, while civil servants and artisans each account for 10 percent. A small proportion of respondents (5 percent) are engaged in other forms of livelihood activities.

Table 4.19: Main Occupations of Respondents

Occupation	Frequency	Percentage (%)
Farming	150	50
Trading	75	25
Civil Service	30	10
Artisan	30	10
Others	15	5
Total	**300**	**100**

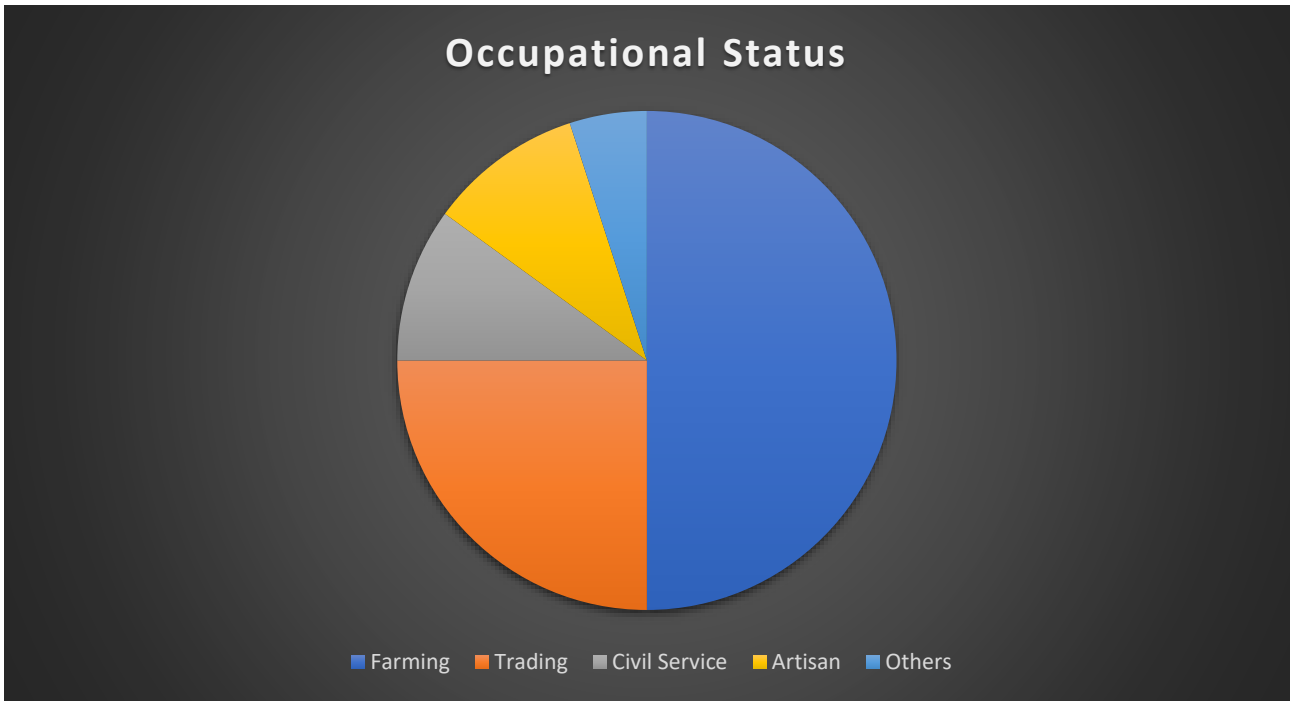

Figure 4.8: Main Occupations of Respondents

The findings indicate that the economy of the study area is largely informal and agriculture-based, with limited industrial and large-scale commercial activities. This highlights the importance of any development project that can create employment opportunities and stimulate local economic growth.

4.4.5.2 Monthly Income Levels

Household income levels within the study area are generally low, reflecting the subsistence nature of many economic activities.

The survey shows that 45 percent of respondents earn less than ₦30,000 per month. About 30 percent earn between ₦31,000 and ₦60,000, while 15 percent earn between ₦61,000 and ₦90,000. Only a small proportion of respondents earn above ₦90,000 per month.

Table 4.20: Monthly Household Income Levels

Monthly Income Range	Frequency	Percentage (%)
Less than ₦30,000	135	45
₦31,000 - ₦60,000	90	30
₦61,000 - ₦90,000	45	15
₦91,000 - ₦120,000	21	7
Above ₦120,000	9	3
Total	**300**	**100**

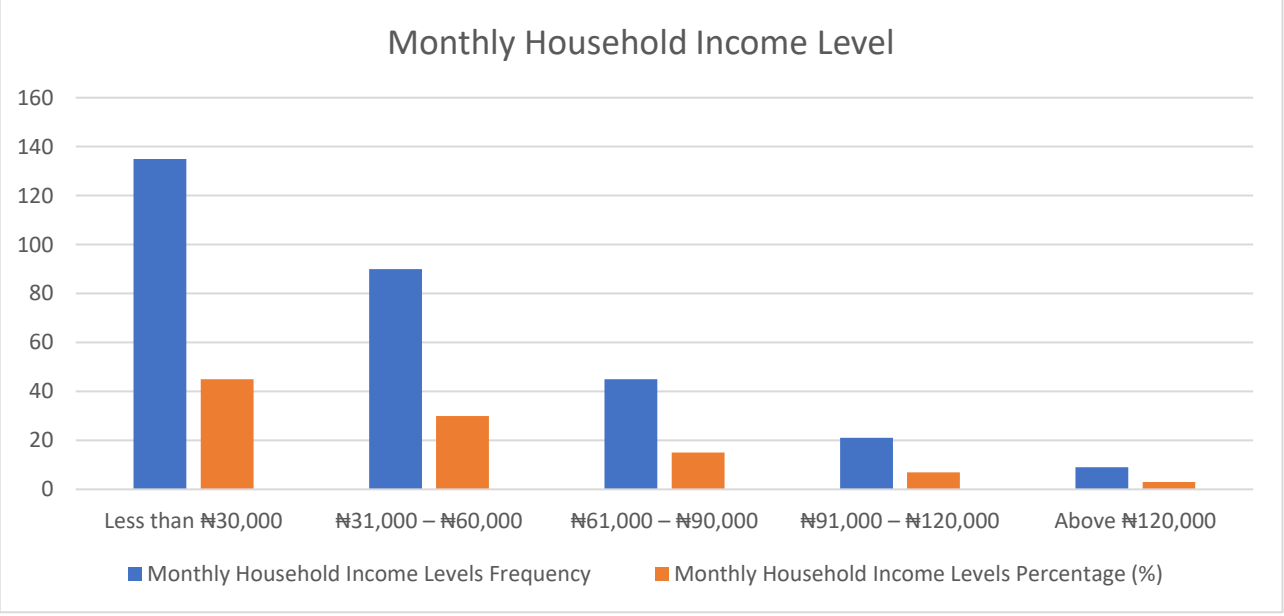

Figure 4.9: Monthly Household Income Levels

The income distribution indicates that a significant proportion of households fall within the low-income category. This makes employment generation a key expectation from development projects within the community. The proposed CNG Mother Station is therefore expected to contribute positively through direct and indirect job creation.

4.4.5.3 Household Expenditure Priorities

Household expenditure patterns provide insight into the basic needs and economic pressures faced by residents. The survey results show that food constitutes the highest household expenditure priority, accounting for 55 percent of respondents. This is followed by education and healthcare, each at 15 percent. Transport accounts for 10 percent, while housing accounts for 5 percent.

Table 4.21: Major Household Expenditure Priorities

Expenditure Item	Frequency	Percentage (%)
Food	165	55
Education	45	15
Healthcare	45	15
Transport	30	10
Housing	15	5
Total	**300**	**100**

The dominance of food expenditure reflects the subsistence level of most households and indicates limited disposable income. The relatively high allocation to education and healthcare also suggests that households place importance on human capital development and well-being despite economic constraints.

4.4.6 Education and Health

Education and healthcare are important indicators of the social well-being and development status of any community. This section presents the educational profile of respondents, the availability of healthcare services, common health challenges, and healthcare utilization patterns within the study area.

Information obtained from the household survey, stakeholder consultations, and field observations was used to assess the existing conditions relating to education and health in Afaka Community and surrounding settlements.

4.4.6.1 Educational Institutions and Literacy Levels

Education plays a vital role in improving the quality of life and enhancing socioeconomic development. The study area is served by a number of public and private educational institutions, including primary schools, secondary schools, and tertiary institutions located within Rigasa District and the greater Kaduna metropolis.

The educational attainment of respondents provides an indication of literacy levels within the community. The survey findings reveal that the majority of respondents possess at least a basic level of formal education.

Table 4.22: Educational Attainment of Respondents

Educational Level	Frequency	Percentage (%)
No Formal Education	45	15
Primary Education	75	25
Secondary Education	120	40
Tertiary Education	60	20
Total	**300**	**100**

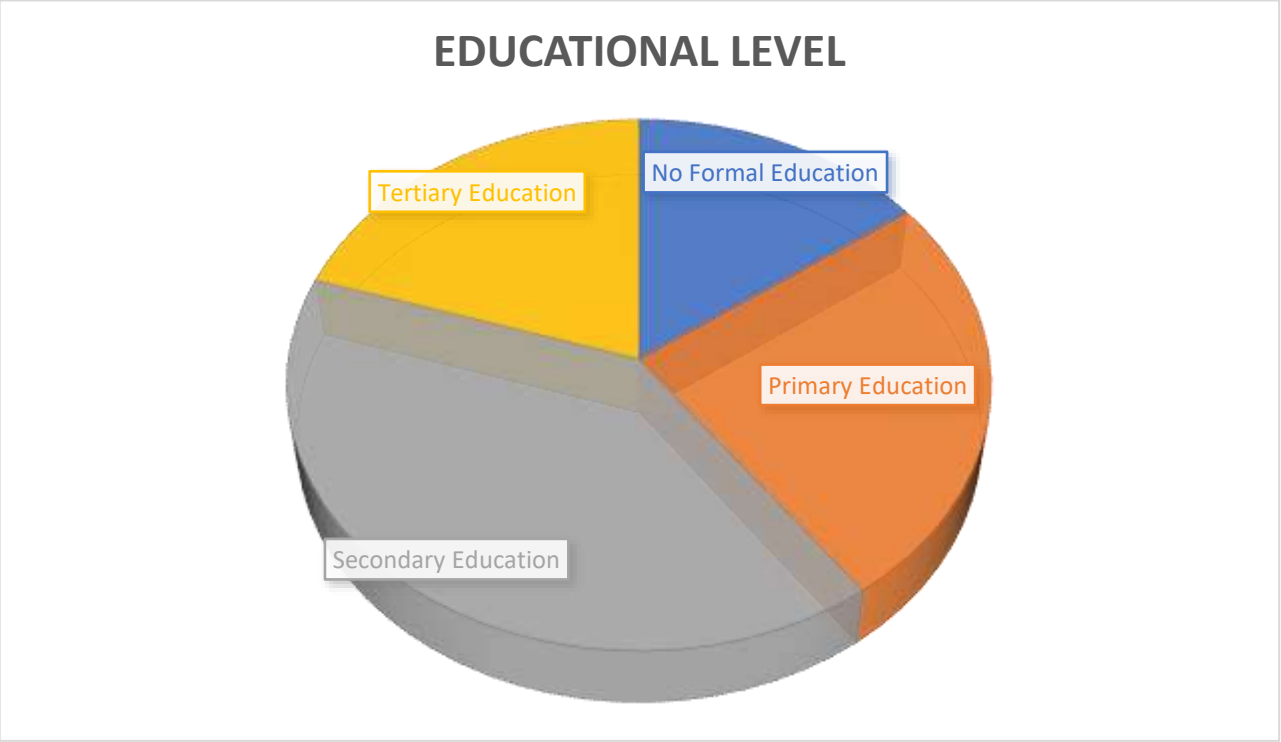

Figure 4.10: Educational Attainment of Respondents

The results show that secondary education represents the highest educational attainment among respondents, accounting for 40 percent of the sample. Respondents with primary education account for 25 percent, while those with tertiary education constitute 20 percent. Approximately 15 percent of respondents reported having no formal education.

The findings suggest a moderate literacy level within the study area, which is expected to facilitate effective communication, stakeholder engagement, and participation in project-related activities. However, the presence of residents without formal education highlights the need for community sensitization programmes to be conducted in simple and locally understood languages.

4.4.6.2 Healthcare Facilities and Common Diseases

Access to quality healthcare services is essential for maintaining the health and productivity of community members. The study area is served by a combination of Primary Healthcare Centres (PHCs), private clinics, hospitals, pharmacies, and patent medicine stores.

The survey results indicate that 50 percent of respondents rely primarily on clinics and primary healthcare centres for medical services, while 40 percent access hospitals. However, 10 percent of respondents reported that the nearest healthcare facility is located more than five kilometres from their residence.

Table 4.23: Nearest Healthcare Facility Accessed by Respondents

Healthcare Facility	Frequency	Percentage (%)
Clinic/Primary Healthcare Centre	150	50
Hospital	120	40
None Within 5 km	30	10
Total	**300**	**100**

Although healthcare facilities are available within the study area, access remains a challenge for some residents, particularly those living farther from established medical centres. The survey also assessed the most common illnesses affecting households within the community.

Table 4.24: Common Sicknesses in Households

Sickness	Frequency	Percentage
Malaria	180	60
Cough/Respiratory Illnesses	75	25
Diarrhoea	45	15
Total	**300**	**100**

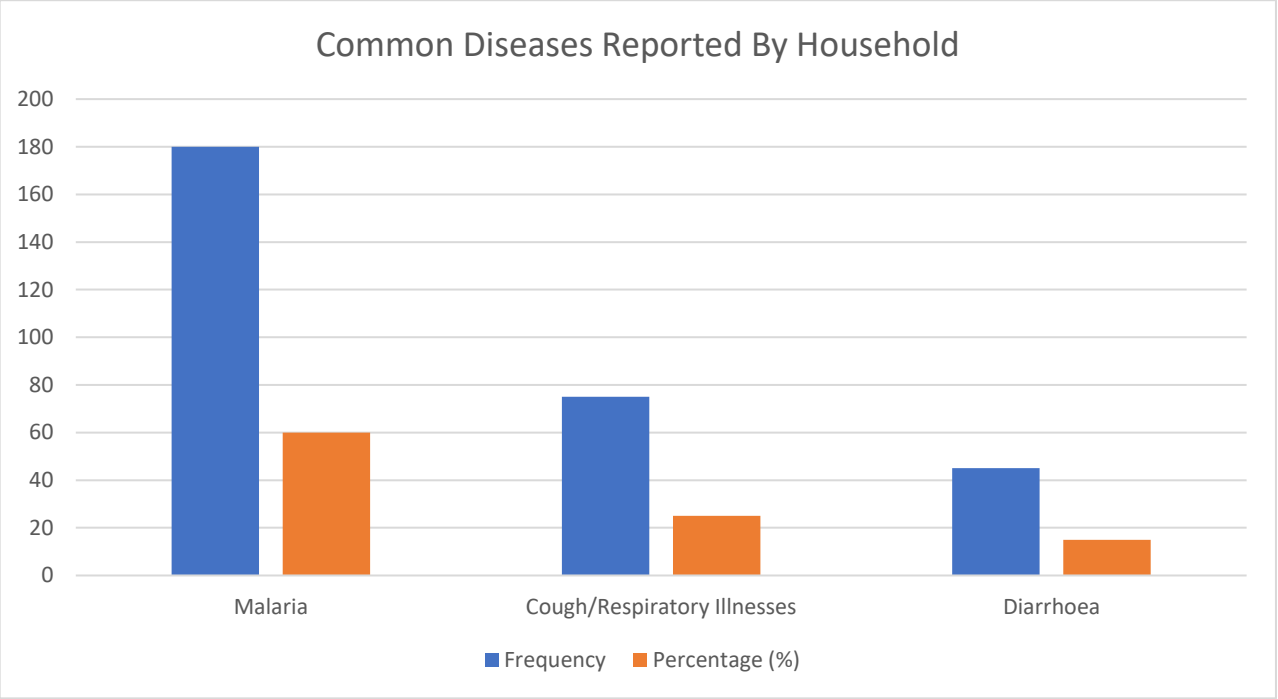

Figure 4.11: Common Diseases Reported by Households

Malaria was identified as the most prevalent illness, affecting 60 percent of households. Respiratory illnesses accounted for 25 percent, while diarrhoeal diseases accounted for 15 percent.

The high prevalence of malaria is consistent with the environmental conditions commonly found in many parts of northern Nigeria, where stagnant water, inadequate drainage, and seasonal rainfall contribute to mosquito breeding. Respiratory illnesses may be associated with dust, household air pollution, and seasonal weather conditions.

4.4.6.3 Frequency of Hospital Visits

The frequency of hospital visits serves as an indicator of healthcare utilization and the overall health status of the population.

During stakeholder consultations and household interviews, respondents indicated that healthcare facilities are generally visited when family members experience illnesses such as malaria, respiratory infections, fever, diarrhoea, and other common health conditions. Routine medical check-ups were reported to be less common, particularly among low-income households due to financial constraints. Based on field consultations, most households reported visiting healthcare facilities between one and three times within a six-month period, depending on the health condition

of family members and availability of financial resources. Households with children and elderly persons reported more frequent visits due to their greater healthcare needs.

The relatively high incidence of malaria and respiratory illnesses contributes significantly to healthcare utilization within the study area. Consequently, maintaining good environmental sanitation, improving drainage systems, promoting health awareness, and ensuring access to quality healthcare services remain important priorities for community development.

Healthcare services are provided through clinics, primary healthcare centres, and hospitals. However, access remains limited for some residents due to distance and economic constraints. Malaria remains the most common disease affecting households, followed by respiratory illnesses and diarrhoeal diseases.

Overall, the findings indicate the need for continued investment in educational development, healthcare services, disease prevention programmes, and community health awareness initiatives. The proposed project presents an opportunity for corporate social responsibility interventions that can support improvements in education, healthcare infrastructure, and public health within the host community.

4.4.7 Housing and Infrastructure

Housing conditions and access to infrastructure are important indicators of the standard of living within a community. The availability and quality of housing, water supply, sanitation facilities, transportation systems, electricity, and other public infrastructure influence the health, safety, and socioeconomic well-being of residents.

This section presents the findings of the socioeconomic survey relating to housing characteristics and infrastructure within Afaka Community and surrounding settlements in the project area of influence.

4.4.7.1 Housing Types and Materials

The survey assessed the predominant housing construction materials used by residents. The type of housing material provides an indication of household economic status and the level of physical development within a community.

The findings indicate that cement block houses are the dominant housing type within the study area, accounting for 70 percent of respondents. Mud houses account for 30 percent of the housing stock.

Table 4.25: Housing Types and Wall Materials

House Wall Material	Frequency	Percentage (%)
Mud	90	30
Cement Block	210	70
Total	**300**	**100**

The high proportion of cement block structures suggests gradual urbanization and improvements in housing quality within the study area. However, the presence of mud houses indicates that some households remain economically disadvantaged and may require additional support to improve their living conditions.

Field observations revealed that most residential buildings are constructed using conventional materials such as cement blocks, corrugated roofing sheets, concrete floors, and metal doors. Both owner-occupied and rented residential properties were observed within the community.

4.4.7.2 Land Tenure

Land ownership and tenure arrangements play an important role in determining access to land resources, housing development, agricultural activities, and community stability.

The survey results indicate that 70 percent of respondents own the land they occupy, while 25 percent reported that their land belongs to family or community ownership systems. Only 5 percent indicated that the land is owned by government institutions or private organizations.

Table 4.26: Land Ownership Pattern

Land Ownership Category	Frequency	Percentage (%)
Government/Company	15	5
Family/Community	75	25
Self-Owned	210	70
Total	**300**	**100**

The predominance of self-owned land suggests a relatively stable settlement pattern and strong attachment of residents to their community. It also indicates that land acquisition issues associated with the proposed project are likely to be minimal provided project activities remain within designated project boundaries.

4.4.7.3 Water Supply

Access to safe and reliable water is essential for domestic use, sanitation, public health, and economic activities.

The survey findings show that boreholes constitute the primary source of water supply for most households, accounting for 60 percent of respondents. Wells serve as the main source of water for 35 percent of respondents, while 5 percent depend on rainwater harvesting and surface water sources.

Table 4.27: Main Sources of Water Supply

Water Source	Frequency	Percentage (%)
Borehole	180	60
Well	105	35
River/Rainwater	15	5
Total	**300**	**100**

The dominance of borehole usage indicates relatively good access to groundwater resources within the study area. However, households relying on wells and surface water may face challenges relating to water quality, seasonal availability, and public health risks.

Field observations revealed that some households purchase water from commercial vendors during periods of water scarcity.

4.4.7.4 Electricity Access

Electricity is a critical infrastructure requirement for residential, commercial, educational, and healthcare activities.

The study area is connected to the national electricity grid and receives power supply through the public distribution network. However, stakeholders reported that electricity supply is often characterized by interruptions and fluctuations, similar to many communities within Kaduna State.

To supplement public electricity supply, some households and businesses utilize petrol-powered generators, rechargeable power systems, and solar energy installations.

Although electricity access is generally available within the community, stakeholders identified improved power supply as an important requirement for economic growth, small-scale businesses, and household welfare.

4.4.7.5 Transportation

Transportation infrastructure facilitates movement of people, goods, and services and contributes significantly to socioeconomic development.

The survey results indicate that motorcycles are the most common means of transportation within the study area, accounting for 65 percent of respondents. Cars and buses account for 25 percent, while 10 percent of respondents rely primarily on walking.

Table 4.28: Main Means of Transportation

Means of Transportation	Frequency	Percentage (%)
Motorcycle	195	65
Car/Bus/Tricycle	75	25
Walking	30	10
Total	**300**	**100**

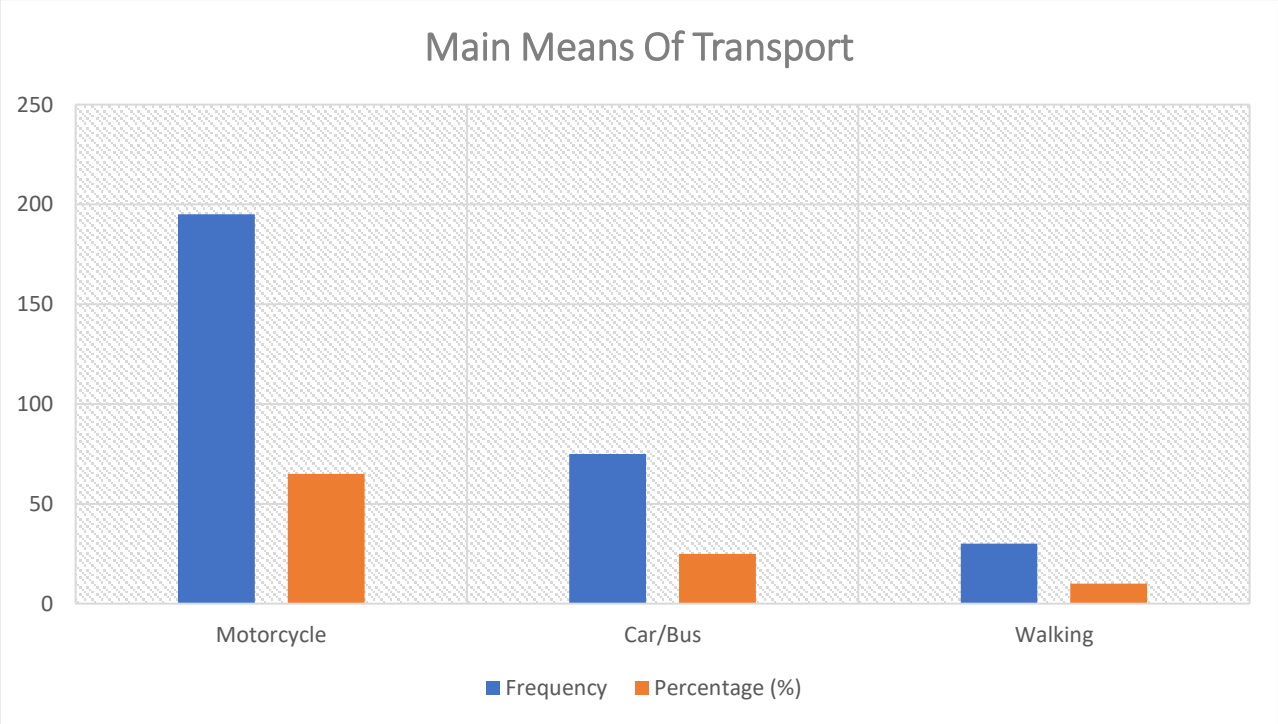

Figure **4.11: Main Means of Transportation**

Motorcycles remain the preferred mode of transportation because of their affordability, flexibility, and ability to navigate both paved and unpaved roads.

The community is connected to surrounding areas through a network of roads linking Afaka, Rigasa, Kaduna metropolis, and neighbouring settlements. However, stakeholders reported that some internal roads require rehabilitation, particularly during the rainy season when accessibility may be reduced.

4.4.7.6 Sanitation and Waste Management

Proper sanitation and waste management are essential for maintaining environmental quality and protecting public health.
The survey assessed toilet facilities and methods of solid waste disposal within the study area.

Table 4.29: Household Toilet facilities

Toilet Type	Frequency	Percentage (%)
Flush Toilet	90	30
Pit Latrine	165	55
No Toilet/Open Defecation	45	15
Total	**300**	**100**

The results indicate that pit latrines are the most commonly used sanitation facilities, accounting for 55 percent of respondents. Flush toilets account for 30 percent, while 15 percent of respondents reported having no toilet facility and relying on open defecation practices.

The continued existence of open defecation presents potential environmental and public health concerns that require attention through improved sanitation programmes and community awareness initiatives.
The survey also assessed methods of solid waste disposal.

Table 4.30: Types of Toilet Facilities

Toilet Type	Frequency	Percentage (%)
Open Dumping/Burning	180	60
Collected by Waste Handlers	120	40
Total	**300**	**100**

The findings reveal that open dumping and open burning remain the predominant waste disposal methods within the study area, accounting for 60 percent of respondents. Approximately 40 percent of households utilize formal waste collection services.

Improper waste disposal practices may contribute to environmental pollution, drainage blockage, unpleasant odours, and increased disease risks. There is therefore a need for improved waste management systems and increased environmental awareness within the community.

On the Summary of Housing and infrastructure condition. The study area is characterized by a mixture of modern and traditional housing structures, with cement block buildings constituting the dominant housing type. Most residents occupy self-owned properties, indicating a stable settlement pattern.

Boreholes are the principal source of domestic water supply, while electricity is available through the national grid despite periodic interruptions. Motorcycles represent the most widely used means of transportation due to their affordability and accessibility.

Sanitation and waste management remain areas requiring improvement, particularly with respect to open dumping, waste burning, and the persistence of open defecation among a segment of the population.

4.4.8 Stakeholder Engagement and Perception

Stakeholder engagement is a fundamental requirement of the Environmental and Social Impact Assessment (ESIA) process. It provides an opportunity for affected communities and interested parties to understand the proposed project, express their views, identify concerns, and communicate their expectations to the project proponents.

As part of the socioeconomic assessment, consultations were conducted with community leaders, women groups, youth representatives, residents, business operators, farmers, and other stakeholders within the project area of influence. Information obtained during these engagements was used to assess community perceptions, expectations, concerns, and the level of support for the proposed CNG Mother Station Project.

4.4.8.1 Stakeholders Identified

The stakeholder identification process focused on individuals, groups, and institutions that may be directly or indirectly affected by the proposed project or have an interest in its implementation.

The major stakeholders identified during the study are presented below.

Table 4.31: Stakeholders Identified During Consultation

S/N	Stakeholder Category	Interest in the Project
1	District Head and Traditional Council	Community leadership and representation
2	Village Head and Community Elders	Community welfare and development
3	Youth Leaders and Youth Groups	Employment and economic opportunities
4	Women Leaders and Women's Associations	Family welfare and social development
5	Farmers	Land use and livelihood protection
6	Traders and Business Owners	Business opportunities and local patronage
7	Artisans and Skilled Workers	Employment and contract opportunities
8	Community Residents	Social and environmental impacts
9	Local Government Representatives	Regulatory and developmental interests
10	Project Proponent	Project implementation and sustainability

The identified stakeholders were considered important because of their influence, interest, or potential exposure to project impacts.

Plate 4.6: Engagement with community Head

The project proponent, Greenville LNG, is a key stakeholder, as it is responsible for project implementation and for ensuring that the project meets environmental and social standards. Environmental consultants are also stakeholders, providing technical expertise to support the ESIA process.

The consultation process ensured that all relevant stakeholder groups were adequately represented during discussions relating to the proposed project.

4.4.8.2 Community Consultation Process

Community consultations were conducted as part of the ESIA field exercise to provide information about the proposed project and obtain feedback from stakeholders.

The consultations involved meetings with traditional leaders, youth representatives, women leaders, community members, and other interested stakeholders. Discussions focused on project awareness, anticipated benefits, concerns, environmental and social issues, and community expectations.

Table 4.32: Summary of Community Consultation Process

Item	Description
Project	Proposed CNG Mother Station along AKK Pipeline
Host Community	Afaka Community, Rigasa District
Local Government Area	Igabi LGA, Kaduna State
Consultation Period	June 2026
Participants	Traditional leaders, youths, women, farmers, traders, artisans, residents and project stakeholders
Method	Community meetings, interviews, focus discussions and questionnaire survey
Total Questionnaire Respondents	300
Item	**Description**

Stakeholders generally welcomed the consultation process and expressed appreciation for being informed and involved in discussions concerning the proposed project. The results indicate a strong level of support for the project. Fifty percent of respondents stated that they support the project provided certain conditions are met, while 40 percent expressed full support. Only 10 percent

indicated that they do not support the project.

4.4.8.3 Community Support Level

The household survey conducted as part of this socioeconomic assessment provides quantitative data on community support for the proposed project. The survey found that 30 per cent of respondents fully support the project, 65 per cent support the project with conditions, and 5 per cent do not support the project.

Table 4.33: Community Support for the Proposed Project

Level of Support	Frequency	Percentage (%)
Yes, Fully Support	120	40
Yes, With Conditions	150	50
No	30	10
Total	**300**	**100**

The findings show that 90 percent of respondents support the project either fully or conditionally. This indicates a generally positive perception of the proposed development within the host community.

4.7.4 Perceived Benefits

Respondents were asked to identify the benefit they consider most important from the proposed project.

The survey results indicate that employment creation is the most anticipated benefit, accounting for 60 percent of responses. Business opportunities account for 20 percent, while improved roads and other community development initiatives account for 15 percent. Cleaner and more affordable energy was identified by 5 percent of respondents.

Table 4.34: Expected Benefits of the Proposed Project

Expected Benefit	Frequency	Percentage (%)
Employment Opportunities	180	60
Business Opportunities	60	20
Better Roads and CSR Projects	45	15
Cleaner and Cheaper Energy	15	5
Total	**300**	**100**

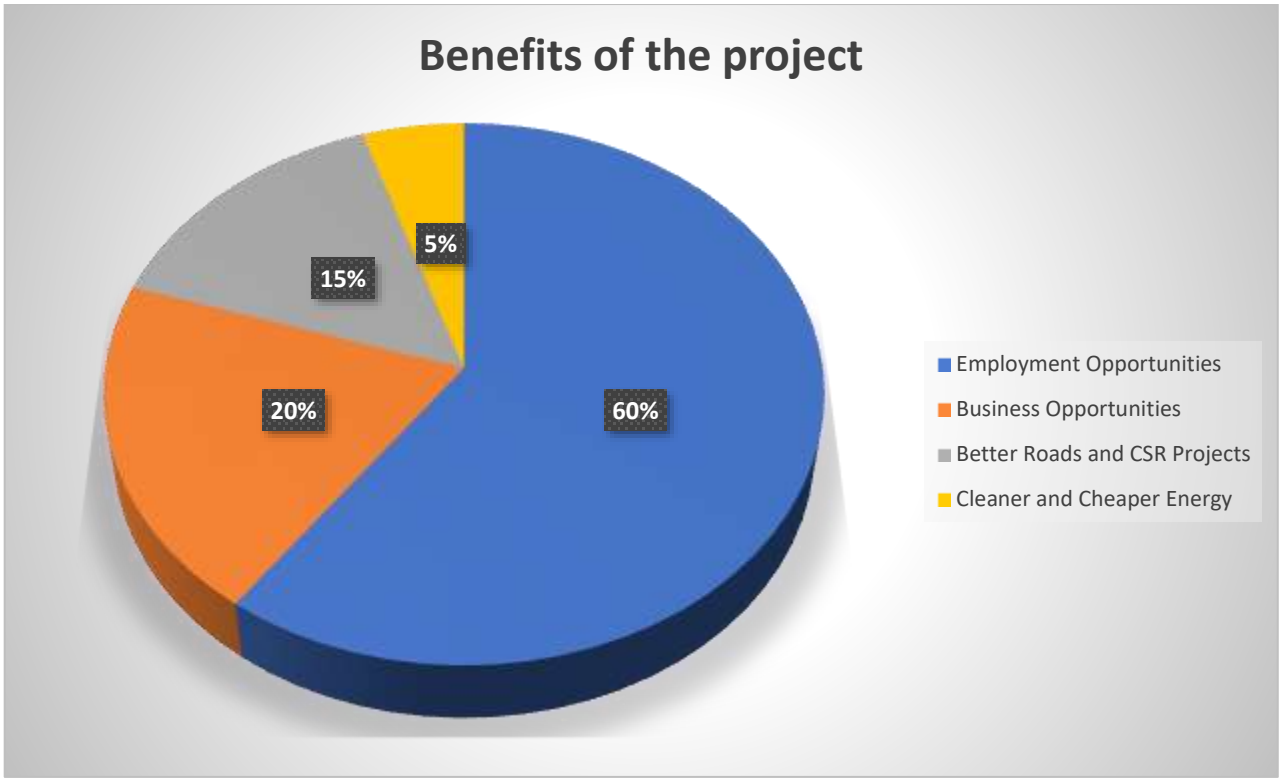

Figure 4.12: Perceived Benefit of the Project

The findings demonstrate that employment generation remains the highest priority among residents. Many stakeholders expressed the view that the project should contribute to reducing youth unemployment and improving household income within the community.

Stakeholders also anticipated indirect benefits such as increased commercial activities, skills development, improved infrastructure, and enhanced local economic growth.

4.4.8.5 Concerns and Fears

Although support for the project is high, stakeholders also expressed concerns regarding potential environmental and social impacts.

The survey results show that concerns about pollution and health impacts constitute the highest fear among respondents, accounting for 45 percent. Concerns regarding accidents account for 30 percent, while 15 percent expressed fears about possible increases in the cost of living. Ten percent of respondents reported having no significant concerns.

Table 4.35: Community Concerns Regarding the Proposed Project

Concern	Frequency	Percentage (%)
Pollution and Health Effects	135	45
Accidents and Safety Risks	90	30
Increase in Cost of Living	45	15
No Major Concern	30	10
Total	**300**	**100**

Stakeholders emphasized the need for strict adherence to environmental, health, and safety standards during project implementation. Community members requested regular environmental monitoring, emergency preparedness measures, and effective communication throughout the project lifecycle.

4.4.8.6 Community Demands and Expectations

Stakeholders were asked to identify the most important action they expect from the project proponent.

The survey findings reveal that local employment is the most significant expectation, accounting for 55 percent of responses. Construction of schools, healthcare facilities, and other community development projects account for 25 percent. Formal community agreements account for 15 percent, while monthly stipends account for 5 percent.

Table 4.35: Community Expectations from the Project

Community Expectation	Frequency	Percentage (%)
Employment for Local Residents	165	55
Construction of Schools/Clinics	75	25
Formal Memorandum of Understanding (MoU)	45	15
Monthly Stipends	15	5
Total	**300**	**100**

The survey also assessed stakeholder views regarding local contractor participation.

Table 4.36: Preference for Local Contractor Participation

Response	Frequency	Percentage (%)
Yes	120	40
Only if Qualified	150	50
No	30	10
Total	**300**	**100**
Yes	120	40

The results indicate that 90 percent of respondents support the involvement of local contractors either directly or based on competence and qualification.

Furthermore, respondents were asked to identify the most pressing challenge facing the community.

Table 4.37: Summary of Stakeholder Engagement and Perception Findings

Community Challenge	Frequency	Percentage (%)
Youth Unemployment	120	40
Poor Road Infrastructure	60	20
Inadequate Water Supply	45	15
Lack of Industries and Businesses	30	10
Inadequate Healthcare Facilities	24	8
Other Issues (Security, Electricity, etc.)	21	7
Total	**300**	**100**

The findings indicate that unemployment remains the most pressing challenge confronting the community. Other concerns include poor road infrastructure, inadequate water supply, limited industrial development, and insufficient healthcare facilities.

Summary of Stakeholder Engagement and Community Perception

Stakeholder engagement activities revealed a high level of awareness and acceptance of the proposed CNG Mother Station Project. Most respondents expressed support for the project because of the anticipated employment opportunities, business growth, and community development benefits.

Despite the positive perception, stakeholders emphasized the need for environmental protection, occupational and community safety, local employment opportunities, and meaningful corporate social responsibility initiatives.

The key expectations expressed by stakeholders include prioritization of local labour, engagement of qualified local contractors, support for education and healthcare infrastructure, implementation of community development programmes, and establishment of effective communication channels between the project proponent and host communities.

Overall, the consultations indicate that the project enjoys strong social acceptance and has the potential to contribute positively to socioeconomic development within Afaka Community and the wider Rigasa District, provided stakeholder concerns are adequately addressed throughout project implementation.

CHAPTER FIVE: ASSOCIATED AND POTENTIAL IMPACTS

5.0 Overview

The Impact Assessment aims at assessing the effects the project will have on the biophysical, social and health components of the project environment. Precise prediction and assessment of impacts is imperative as it ensures that adequate mitigation measures are proffered for the anticipated negative impacts in addition to putting measures in place for enhancing the positive (beneficial) effects.

As a result, the envisaged impact has been identified through interactions between the project activities and environmental sensitivities, and evaluated on the strengths of the likelihood of occurrence as well as the rating of their magnitude and significance. The impact prediction methodology used in this study is described and explained in subsequent sections.

Overall, the project will have in-depth positive impact by providing solutions to waste management challenges of the oil and gas sector and boast the socio-economic needs of the host community.

5.1 Methodology for Impact Prediction

Potential impact evaluation was carried out using a modified method of Leopold Interaction Matrix (Leopold *et al*; 1971). In this system, project activities are in columns while environmental components are in rows (Table 5.1).

Impact Indicators

To further guide the identification and screening of impacts using potential impact screening matrix, established environmental impact indicators or indices are developed for each of the environmental interaction categories. Impact indicators are the observable or measurable parameters of each environmental component that can be directly or indirectly linked to changes in environmental conditions.

Table 5.1. Environmental Components and their Impact Indicators

Environmental Components/Receptors	Potential Impact Indicators
Biophysical	
Soil	Changes to physical and chemical properties and soil ecology
	Changes to geology, geomorphology, topography
Flora	Changes to vegetation population, health, species abundance and diversity and impact on endangered and economic species
Wildlife	Changesto wildlife assemblages, threat to endangered/endemic/ medicinal/economic species, food chain effects
Groundwater	Contamination of shallow or deep groundwater resources,

	depletion of ground water resources.
Air	NOx, NOx, SPM, CO, VOC, Greenhouse Gases (GHG), Ozone
	Measured increases in noise or vibration levels
Socio-Economics	
Communities/Host Population	Changes in population indices – Total population, gender ratio, age distribution
	Infrastructure: Improvement or pressure on existing urban/rural infrastructure including water supply and waste handling facilities Aesthetics: Physical deterioration, landscape, etc
	Social and Cultural structure: Impact on local authority and governance structure, increase in negative social vices (prostitution, crime), intra and interethnic clashes
	Cultural and archaeological resources: Impact on shrines, burial grounds; loss of archaeological resources
	Transportation: Effects of increase or decrease in different types of transportation
	Macro and micro economy: Improvement or negative impact on macro and micro economy, employment, standard of living, occupation changes.
Health Determinants	
	Pollution related health problems/diseases: Increase in concentration of air pollutants of concern (NO_x, SO_x, VOC, CO, PM, Greenhouse gases) beyond regulatory limits. Contamination of surface waters and potable ground water, increased vibration and noise beyond regulatory limits, increased night time light beyond acceptable limits.
	Communicable and non-communicable diseases inventory: Increase in communicable and non-communicable diseases or disease-causing factors.
	Nutritional status: Changes to nutritional status, malnutrition starvation and high fat diets
	Health/Recreational facilities: Changes in availability of and access to health care and recreational facilities
	Psychosocial factors: Drug use/abuse, communal violence, crime, suicide, depression and prostitution
	Fertility: Changes to fertility levels, changes in birth rates
	Morbidity and Mortality: Improvement or impairment of health of workers and of general public, increased security risk.
	Accidents/fires/Explosions: Changes to rate of occurrence and severity of accidents/fire/explosions.

5.2 Preliminary Impact Identification and Screening

The rationale for assessing the likely impacts of the proposed project is based on the following considerations.

i. Knowledge of the project activities, equipment types, construction

methods and operational procedures.

ii. Results of literature search on the baseline condition of the project area
iii. Findings of other EIA studies conducted around the project area
iv. Reference to FMEnv/NMDPRA/UNEP/WHO/WB guidelines and standards
v. Experts group discussions and presentations
vi. Previous experience on other projects

Impact identification is based on the definition of an impact as "having both spatial and temporal components and can be described as the change in an environmental parameter over a specified period within a defined area, resulting from a particular activity compared with the situation which would have occurred had the activity not been initiated".

5.3 Impact Qualification and Categorization

The identified impacts were qualified and quantified. The Impact qualification classified the impacts as direct (D) or indirect (ID), adverse (-) or beneficial (+), local (Lo) or widespread (W), short term (S) or long term (L), reversible (R) or irreversible (I).

- Adverse impacts are those, which impact negatively on the environment.
- Beneficial impacts are those, which enhance the quality of the biophysical, health and social environments.
- Local impacts are limited to the immediate surroundings while the widespread impacts go far beyond the immediate area the impact is occurring.
- Short term means a period of time less than three months while any period greater than three months is considered long term.
- Reversible/irreversible is meant whether the impact can either be reverted to previous conditions or remains permanent once the activity causing the impact is terminated.

The criteria and weighting scale used in evaluating significant impacts are as follows adopted from The International Organization for Standardization ISO 14001. The risk factor and frequency of occurrence of impact are based on the Risk Assessment Matrix, RAM

i. Legal/regulatory (L)
ii. Risk factor (R)
iii. Frequency of occurrence of impact (F)
iv. Importance of impact on an affected environmental component (1) and
v. Public perception/interest (P).

These criteria and ratings are as follows:

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

0 = There is no legal/regulatory requirement

3 = There is legal/regulatory requirement
5 = There is a legal/regulatory requirement and permit required

b. **Risk Factor (R)** – What is the risk/hazard rating based on the Risk Assessment Matrix?
   1 = Low risk
   3 = Intermediate risk
   5 = High risk

c. **Frequency of Impact (F)** – What is the frequency rating of impact based on the Risk Assessment Matrix?
   1 = Low frequency (rare)
   3 = Intermediate frequency (likely)
   5 = High frequency (very likely)

d. **Importance of affected environmental components and impacts (I)** – What is the rating of importance based on consensus of opinions?
   1 = Low importance
   3 = Medium/intermediate importance
   5 = High importance

e. **Public interest/perception (P)** – What is the rating of public perception and interest in the proposed project and impacts based on consultation with stakeholders?
   1 = Low interest/perception
   3 = Intermediate interest/perception
   5 = High interest/perception

This approach was adopted considering its interactive and descriptive analysis of the relationship between the proposed project activities and the ecosystem components. It combines the following factors in assessing the overall impact rating of the project on the environment:

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

The nature and level of health, safety and environmental risks associated with each impact were determined using the Risk Assessment Matrix (Table 5.3) in conjunction with the evaluation of impact significance presented above. The importance of

affected environmental component was determined through consultation and consensus of opinions. The manner in which the host communities and the general public would perceive each potential impact and its effects were again determined through consultation with the host communities and consensus of opinions of environmental professionals and stakeholders.

For this study, the Frequency (F), the Importance (I) and Public (P) perception were judged to be superior indicators of the impacts hence the significant impacts were based on the sum of F+I+P. The maximum possible point from this sum is 15. Impacts whose sum of F+I+P was less than or equal to 5 were rated as low. These impacts were judged not to require mitigation.

Those whose sum of F+I+P was between >5 and <10 was rated as having medium significance while those whose sum of F+I+P was >10 were rated as having high significance (Table 5.2). For this study, medium and high significant impacts were judged to require mitigation, while low impacts would be mitigated through standard practice i.e. Risk Assessment Matrix. The positive impacts of the proposed project on all valued environmental components shall be rated as beneficial; hence amelioration measures shall not be applicable.

Table 5.2: Environmental Impact Significance Rankings

Ranking (F+I+P)	Significance
≤5	Low
6 -≤10	Medium
>10	High

Table 5.3: Risk Assessment Matrix for Environmental Consequences

CONSEQUENCES					INCREASING LIKELIHOOD				
					A (1)	**B (2)**	**C (3)**	**D (4)**	**E (5)**
Severity	People	Assets	Environment	Reputation	Never heard of in the industry	Heard of in the industry	Has happened in the Organisation or more than once per year in the industry	Has happened at the location or more than once per year in the Organisation	Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No impact					
1	Slight injury or health effect	Slight damage	Slight effect	Slight impact		Low Risk			
2	Minor Injury or health effect	Minor damage	Minor effect	Minor Impact					
3	Major Injury or health effect	Moderate damage	Moderate effect	Moderate impact			Medium Risk		
4	PTD or up to 3 fatalities	Major damage	Major effect	Major Impact				High Risk	
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact					

Table 5.4: Evaluation of Associated and Potential Impacts of the Proposed CNG Mother/Daughter Station

	Activities	Receptors	Potential Impact: Negative/Positive	Impact quantification	Significance			Overall Significance
					F	I	P	
Pre-Construction	Site selection and land acquisition	Community and youth concern	Land-use change and possible displacement (-); Agitation	D; (-); Local; S/L; R	1	5	3	9
	Environmental and engineering surveys	Soil, vegetation, community	Minor disturbance from survey activities (-)	D, -, Lo, S, R	1	1	1	3
	Stakeholder engagement and permitting	Local communities	Improved stakeholder participation and project acceptance (+)	ID, +, Lo, L, R	2	2	2	6
	Material and equipment supply	Air quality	Vehicular emission from vehicles used in conveying construction equipment (pollutants and greenhouse gases with possible health hazards)	D; (-); Local; S; R	5	1	1	7
		Noise	Noise generated from vehicles conveying construction equipment	D; (-); Local; S; R	3	3	1	7
Construction	Mobilization of workforce	Population in the vicinity of activity	Social and cultural interaction issues; Health and security issues; Noise and dust.	D; (-); Local; S; R	3	3	3	9
		Community infrastructure and utilities	Increase demands on services in local communities	D; (-); Local; S; R	3	3	3	9
		Community and youth concern	How to be gainfully employed	D; (+); Local; S; R	5	3	5	13
		Transport	Increase in the demand of public transport	D; (-); Local; S; R	3	3	3	9
		Vector related	Vector such as bed bug etc. can be an issue	D; (-); Local; S; R	1	3	3	7

	Activities	Receptors	Potential Impact: Negative/Positive	Impact quantification	Significance			Overall Significance
					F	I	P	
		Sexually transmitted infection HIV/AIDS	Sexual relationship	D; (-); Local/Wide; S/L; R/I	3	5	3	11
		Nuisance exposure	Noise and dust exposure	D; (-); Local; S; R	3	3	1	7
	Base camp construction, ground clearance and grading	Air quality	Reduction in air quality due to an increase in airborne particulate matter	D; (-); Local; S; R	5	1	3	9
		Noise	Noise generated from activities	D; (-); Local; S; R	5	1	3	9
		Soil quality	Disruption of the topography of the soil	D; (-); Local; S; R	5	1	3	9
		Nuisance exposure	Noise and dust exposure	D; (-); Local; S; R	3	3	1	7
	Excavation and construction of site facilities	Air quality	Reduction in air quality due to dust and emissions from equipment	D; (-); Local; S; R	5	1	3	9
		Noise level	Increase in ambient noise level due to operation of equipment and machinery	D; (-); Local; S; R	5	1	3	9
		Groundwater quality	Contamination of groundwater aquifers	D; (-); Local; S; R	1	1	5	7
	Construction traffic	Road users	Traffic congestion and accident risk (-)	D, -, Local, S, R	2	2	2	6
	Construction activities	Local economy	Employment and business opportunities (+)	ID, +, Local, S, R	2	5	2	9
	Fuel/lubricant storage	Soil and groundwater	Spill-related contamination (-)	D, -, Local, L, R	2	5	2	9
	Equipment installation and commissioning	Workers	Occupational health and safety risks (-)	D, -, Local, S, R	2	5	2	9

	Activities	Receptors	Potential Impact: Negative/Positive	Impact quantification	Significance			Overall Significance
					F	I	P	
Operation Phase	Natural gas compression	Ambient air	Methane leaks and greenhouse gas emissions (-)	D, -, Local, L, R	2	5	2	9
	Compressor operation	Local community	Continuous operational noise (-)	D, -, Local, L, R	2	2	2	6
	CNG dispensing operations	Vehicle owners	Access to cleaner transportation fuel (+)	D, +, Local, L, R	5	5	5	15
	CNG use replacing conventional fuels	Air quality	Reduced particulate matter and NOx emissions (+)	ID, +, W, L, R	5	5	5	15
	CNG station operations	Economy	Reduced fuel costs and increased energy availability (+)	ID, +, W, L, R	5	5	2	12
	High-pressure gas storage	Workers and public	Fire and explosion hazards (-)	D, -, Local, S, I	1	5	5	11
	Mother station trailer loading	Workers	High-pressure gas handling hazards (-)	D, -, Local, S, I	2	5	5	12
	Transportation of CNG trailers	Communities, road users	Road accidents and gas release incidents (-)	ID, -, W, S, I	2	5	5	12
	Daughter station unloading	Workers	Gas leakage during unloading operations (-)	D, -, Local, S, I	2	5	5	12
	Routine maintenance	Workers	Exposure to operational hazards (-)	D, -, Local, S, R	2	5	2	9
	Operations and maintenance	Workforce	Long-term employment generation (+)	ID, +, Local, L, R	5	2	2	9
	National gas utilization	Energy sector	Enhanced energy security and domestic gas utilization (+)	ID, +, W, L, R	5	5	2	12
	Emergency situations: fire/explosion	Workers, public, infrastructure	Injury, fatality and asset damage (-)	D, -, Local, S, I	1	5	5	11

	Activities	Receptors	Potential Impact: Negative/Positive	Impact quantification	Significance			Overall Significance
					F	I	P	
Accidental Events	Work related injuries	Accidents and injuries	Can be as severe as loss of live	D; (-); Local; S/L; R/I	1	5	5	11
		Health services infrastructure and capacity	Additional stress on the available healthcare infrastructure and manpower	D; (-); Local; S; R	1	3	5	9
	Facility operation and utility	Air quality	Reduction in air quality due to emissions from the machines and equipment exhaust	D; (-); Local; L; R	5	1	3	9
		Soil quality	Waste generation and discharge on land	D; (-); Local; L; R	3	3	3	9
		Population in the vicinity of activity	Social and cultural interaction issues; health and security issues.	D; (-); Local; L; R	3	3	5	11
		Community and youth concern	Business and employment opportunity	D; (+); Local; L; R	3	5	5	13
		Transport	Increase in the use of access route	D; (-); Local; L; R	3	1	3	7
		Sexually transmitted	Sexual relationship	D; (-); Local/Wide; S/L; R/I	3	5	5	13
Decommission and Abandonment	Facility Decommission	Employees	Loss of employment opportunities (-)	ID, -, Lo, L, R	2	2	2	6
		Air quality	Dust/pollutants generated from equipment removal/building remodeling	D; (-); Local; S; R	5	1	3	9
		Noise level	Noise generated from activities	D; (-); Local; S; R	5	1	3	9
		STDs/Infections; HIV/AIDS	Sexual relationship	D; (-); Local; S; R	3	5	5	13
		Community and youth concern	Agitation	D; (-); Local; S; R	1	5	5	11
		Accidents and injuries	Resultant injuries from work activities. Can be as severe as loss of life	D; (-); Local; S/L; R/I	1	5	5	11
		Environment/Aesthetics	Change in aesthetic value of the area	D; (-); Local; S/L; R/I	1	3	3	7
		Community	Increased opportunity for business	D; (+); Local; S/L; R/I	1	3	1	5

	Activities	Receptors	Potential Impact: Negative/Positive	Impact quantification	Significance			Overall Significance
					F	I	P	
	Work-related injuries	Health services infrastructure and capacity	Additional stress on the available healthcare infrastructure and manpower	D; (-); Local; S; R	1	3	5	9

5.4 Description of Qualitative Impacts

5.4.1 Preliminaries

- **Land Acquisition:** GVLNG has acquired portions of land in Afaka, Rigasa District, Igabi Local Government Area, Kaduna State and has made all the requisite payments as agreed on an MoU. The activity has increased awareness of the project.

- **Survey Line Cutting:** Survey line cutting consists primarily of very little vegetation clearing, as the area is already built-up, for survey activities on a temporary land area. The potential impacts of this activity are direct, negative, short-term, local and rated minor. This activity also has socio-economic benefits as it is income and employment generating and shall impact positively on community relations.

- **Permitting:** Permitting is the process of obtaining permission of relevant government agencies and other stakeholders on issues related to the project. All required permits are being processed, at both the local, state and federal levels; this EIA Studies is one of such permits. Prior to commencement of the project, extensive stakeholder consultations have been carried out with host community, State and Local Government agencies and other interest groups to enlist their support, cooperation and participation in the project. The occurrence of this is rated as high and the impact is positive.

5.4.2 Site Preparation and Pre-Construction Phase

The site preparation activity for the project shall consist primarily of mobilization of personnel, heavy machinery, equipment and materials to the project camp-site. The activities shall include; clearing to remove vegetation at the site with the use of bulldozers and hydraulic excavator and soil spoils disposal and levelling of cleared area; this requires motor scrappers and grader. The potential impacts of these procedures are;

- **Contracts/Tenders Award**

Contracts shall be awarded at this phase of the project site preparation. This shall have a positive/beneficial impact on the socio-economic environment only as it leads to employment and income generation for many people and higher output or productivity. The impact shall be direct, positive, short-term, local and rated major.

- **Vegetation Clearing**

This impact is direct, negative, short-term, local, reversible and rated minor.

Secondary impacts include increase in ambient noise, prevalence of particulate

matter suspension in the atmosphere. These might further put any wildlife in the immediate vicinity of the plot migrate.

- **Soil Testing**

Before construction phase begins the soils in the site shall be tested by soil civil engineers to enable determination of type of foundation to be made for the different categories of buildings to be constructed and equipment to be installed. Soil profiles to depths of more than 10m shall be determined. Soil testing involves soil samples collection at regular depths per site and laboratory tests, for certain soil properties. It is income and employment generating, the impact shall be direct, positive, short term, limited to project site and rated moderate.

- **Bulldozing, Grading and Compaction of Soil**

Assemblage and use of heavy equipment and machines such as bulldozers, graders and rollers into the cleared site temporarily cause noise. People will be employed and receive income. Bulldozers shall remove weeds and stumps of trees. The soil surface shall be leveled and compacted with the aid of graders and rollers. Evaporation from bare exposed soil shall be high, affecting local climate. These activities shall generate minor increase in air-borne particulates. This impact shall be direct, negative, short term, local and minor in magnitude.

- **Excavated Soil Spoils and their Disposal**

Soil spoils shall have to be adequately disposed of so as not to pose solid waste problem on the project area. Heaps of soil spoils shall become substrate for many unwanted organisms and obstruct flow of stormwater runoff. The soil spoils can be used in the facility and road grading. These impacts shall be direct, negative, short term, local and rated low to moderate in magnitude, and shall be limited to project site.

5.4.3 Activities at Construction Phase

a. Camp Site Establishment

A camp site for the construction workers shall be within the project site. A moderate quantity of solid waste, refuse and sanitary waste shall be generated during the period of construction activities. These shall have to be adequately disposed of. There are possibilities of relationship between the male and female workers on- and off-site. Therefore, there are likelihood of HIV/AIDS and other sexually transmitted diseases (STDs) with their adverse impacts. The solid wastes/refuse are likely to blight the landscape and dirty the environment and water-and air-borne diseases may emanate from sanitary wastes and sold unhygienic food.

b. Building/Civil Works (*Increase in Vehicular Traffic)*

The construction phase of the project will lead to the vehicular transport volume increase around the project vicinity. This impact is described as direct, negative,

short-term, local, reversible and is rated moderate.

Air Quality

Construction activities shall result in localised high levels of dust/particulate matter, noise and vehicular emissions. The dust rising from earthwork and vehicular movement could be significant, particularly during dry season and can cause disturbances to the nearby communities. Potential impacts from dust emissions on site shall be significantly reduced by careful management and the implementation of mitigation measures to reduce dust generation.
Other sources of air pollutants include:

- Internal combustion engines of construction machinery;
- Welding and drying equipment on construction site;
- Unloading and storage of inert materials (crushed stoned, sand).
- Dust from the ground surface disturbed by earthmoving operations during dry season. Emissions from welding activity and construction machinery/vehicular exhaust shall consist of numerous gaseous components divided into several groups based on similar impact on the environment and human health. These include:
- Carbon monoxide, the presence of which in large amounts (up to 12%) is characteristic of exhaust gas from internal combustion engines using gasoline;
- Nitrogen oxides;
- Hydrocarbons, aromatic compounds including carcinogens;
- Non-toxic substances such as nitrogen, hydrogen, carbon dioxide and water vapour,
- Spent gas components.

The emissions are short-term and localised to the immediate project site area; though the likelihood of occurrence is high, the consequence is rated a negligible negative. Thus, the overall impact risk level is expected to be low.

Noise

The heavy equipment used in site excavation and construction works, diesel powered generators used for on-site power generation, vehicular movement on-site for shuttling of material and men shall have an adverse impact on ambient noise levels.

With respect to the ambient noise levels, since noise is attenuated by distance (typically noise levels drop by about 40dBA at 100m distance from source) the activities on-site are unlikely to adversely affect receptors at a significant distance. However, during the night-time when the ambient noise levels are low, the level of perception to noise by communities may be more acute. Noise from transport

vehicles shall be only transient for a given location and can be considered as a nuisance during night-time.

The permissible noise level of 90 dBA for an 8-hour exposure is not envisaged to be exceeded. Hearing impairment could occur from prolonged exposure to high noise level. However, it is envisaged that the site shall be demarcated and an exclusion zone created. Thus, it is unlikely that villagers will be exposed to harmful noise level. The noise impact is rated short-termed and localized to the immediate site area; with a high likelihood of occurrence, the overall impact is low, reversible and rated minor.

Behavioural Modifications from Wildlife

The noise and physical presence of equipment and personnel being conveyed to the site will lead to behavioural modifications from wildlife around the site. The forms of behavioural modifications will vary but may include interrupted breeding and feeding patterns; unusual burrowing patterns; mother-calf separation; movement away from the area; obstruction of normal movement patterns; amongst others. This impact is described as direct, negative, short term, local, reversible and is rated moderate.

Hydrogeology

Groundwater flow in the area is not expected to be disturbed as a consequence of the construction/civil works of the facility, as only the topmost layer of earth materials would be involved during the construction. The only possibility of impact on the groundwater is expected to occur in the remote case of percolation of construction materials and wastes if not properly stored. This possibility is remote considering the management plan that shall be put in place. Thus, impact is considered negligible negative with negligible likelihood. Thus, overall rating is low risk.

Geology

Only minimal geological impacts are expected in the construction phase of the project, as there shall not be significant topographic or geological changes due to the construction of the facility. Soil erosion, which could be another potential impact to geology of the area, is not envisaged as adequate erosion control measures shall be put in place. Impact consequence from the construction activities is rated a negligible negative, while the likelihood of its occurrence is low, thus, the overall risk is low i.e. of a low priority.

Labour Requirement/Recruitment of Workforce:

During the construction/civil works the project could offer employment for the indigenes at various stages. This could improve income. The impact was described as direct, long term, local/widespread and reversible. It was rated positive

Migrant labour could be attracted to the project area. This increase in population of the area could put pressure on the already deficient infrastructure. This could lead to overcrowding with potential for increase in communicable diseases like malaria, respiratory tract infections and skin diseases. The impact was direct, negative, short term, local and reversible. It was rated moderate.

The increase in financial flow could lead to social vices such as violence, alcoholism, attraction of commercial sex workers (CSW), substances abuse, and teenage pregnancies. This could lead to increase in sexually transmissible diseases (HIV/AIDS, syphilis among others), injuries, and loss of life or properties. This impact is rated as direct, negative, short term, local, reversible and major.

Conflicts/ Third party agitations over employment issues

Labour issues are always a source of friction between companies and communities and among community members, this is the current situation particularly, in oil bearing zones of the country. The agitation could be either due to requests for a certain number of labour that could not be met or sharing the labour slots in the community. However, such conflicts/agitations are most unlikely to occur, due to the existing understanding between the project proponent and the host community. The impact was described as direct, negative, short term, local and reversible. It was rated minor.

Health Issues: Increased level of disease vectors (mosquitoes, flies, etc.)

Improper disposal of wastes generated from construction activities can be a breeding site for disease vectors such as mosquitoes, rats, cockroaches, flies, etc. The impact is direct, negative, short term, local and reversible with a moderate rating.

Consequent on disposal of wastes without proper adherence to sanitary guidelines, discharge of sewage on-land, will attract the preponderance of disease vectors leading to widespread increase in diarrhea diseases. The impact was direct, negative, short term, local and reversible. The rating is moderate.

Burns/ Injuries from Welding Sparks

The sparks generated during welding activities could result in fires or injuries on soft tissues of the body. Adherence to the project management plan will forestall such occurrences. This impact is described as direct, negative, short term, local, reversible and is rated moderate.

Waste Generation/Handling:

Wastes are envisaged to be generated during the construction/civil works. All wastes generated shall be properly handled and disposed of. The impact was direct, negative, short term, local and reversible. The rating is moderate.

5.4.4 Operation and Maintenance Phase Activities

The operational activities of the proposed project are envisaged to impact on the ambient air, noise, hydrogeology, geology, and soil quality. These are discussed thus:

Increase in Vehicular Traffic

The operation of project will make for an increase the vehicular transport volume to the project area. Vehicles conveying the staff, customers to and from the project area. This will lead to increase of noise, gaseous and particulate load of the ambient environment. This impact is described as direct, negative, long-term, local, reversible and is rated moderate.

Air Quality:

The facility shall have gaseous emissions from the operational machinery. The envisaged gaseous emissions include heat, particulates, CO, SO_x, NO_x, NH_3, sulphides and mercaptans. Some of which may contribute to global warming, respiratory problems, scorching of vegetation. The impact is high risk, of long-term duration and very significant.

Noise

Noise shall arise from the continuously and intermittently operating sources such as machines, generators, mobile equipment, trucks etc. The estimated maximum sound level shall be 65.5dB (A). Noise emissions shall also occur due to equipment faults, inappropriate operation, and damage to equipment supports and fixtures, etc.

The design considerations and installation of muffs, are expected to reduce noise level to generally low values, within regulatory limit. The likelihood of occurrence is high, the effect of the noise shall be local, the noise level reduces with distance and the impact is expected to be moderate.

Soil

The potential causes for land contamination are the discharge of liquid effluents (wastewater), disposal of solid and hazardous wastes on land and accidental spillages of hazardous material. The likelihood is low and significance of the impact is high.

The comprehensive environmental procedures prepared for the project shall ensure that any potential impact(s) are adequately mitigated. Thus, impact level is minor negative consequence, with low likelihood of occurrence; overall risk level is low and acceptable.

Geology

The study area lies in a very geologically (tectonic and seismic) stable zone with no recorded cases of earthquakes or tremors. Furthermore, no major or minor faults are known to transverse the area. Therefore, the possibility of any geo-hazards occurring in the area is negligible. Overall impact risk is low.

Hydrogeology

During operational phase, groundwater resources could be negatively impacted through leaked chemicals, oil or accidental spills that could infiltrate resources. The management plan that shall be in place shall make this a very rare occurrence. Hence the overall rating of impact is seen as low with low likelihood of occurrence and medium negative impact.

Wastes Disposal

A number of waste types shall be produced during the operational phase of the project. These include wastewater, lubricant filters, office waste. Improper waste disposal would lead to a loss of aesthetics, risk of contamination of soil, groundwater through seepage and water bodies (through run-offs). The effects of improper waste disposal can be reversed and are of long-term.

However, waste handling could create opportunities for employment and services by waste management vendors associated with project operations resulting in increased income levels. This impact is described as direct, short/ long term, local, reversible and is rated positive.

Sanitary Waste Discharges and stormwater Run-offs

Sanitary wastes shall be properly handled. Consequent on disposal of wastes without proper adherence to sanitary guidelines, could lead to widespread health challenges. The impact is considered direct, negative, short-term, local and reversible. The rating is moderate.

Water Demand and Use

Water intake shall be from borehole dogged within the facility. Water abstraction shall be low, as the wastewater shall be treated and re-used. The water demand shall have minimal impact on water quantity of the project area. The impact is considered direct, long-term, local and reversible. The rating is low.

Product Spill Incidents

Operational accidents can result in product spills due to equipment failure and human errors. The spilled product could contaminate soil, groundwater and any nearby surface water bodies within the project vicinity. The product spills will have a devastating impact on the flora and fauna in the area if not contained. This impact

is described as direct, negative, short/long term, Local/widespread, reversible/ irreversible and is rated major.

Fire Outbreaks during Operations

Fire outbreaks can occur during the project operations; and as the product being handled is flammable. A worst-case scenario will involve a fire outbreak accompanying a spillage/leakage leading to loss of assets, properties and life; including that of the third parties. This impact is described as direct, negative, long term, local/ widespread, irreversible and is rated major.

5.4.5 Decommissioning and Abandonment Phase Activities

The potential impacts from the decommissioning and abandonment phase include the following:

Job/Services Opportunity and Income

The decommissioning phase of the project could offer assets and temporal job opportunities for the indigenes and this would improve income for a final time. Contract services will also be given to specialized companies to handle special components of the decommissioning program. The impact is described as direct, short term, local, reversible and is rated positive.

Air Quality Impairment and Noise

During decommissioning, pollutants from heavy machinery and diesel generators will impair the air quality with noxious gases such as VOC's, CO, NOx SOx as well as other pollutants into the ambient air in addition to generation of noise. This impact is described as direct, negative, short term, local, reversible and is rated moderate.

Community Agitation over Environmental Damage and Loss of Benefits

Any form of environmental damage that occurred in the host communities over the lifespan of the proposed plant can lead to conflicts during the decommissioning phase as the community could make demands which may not be met by the operators of the project. In addition, the loss of benefits that the host community regularly enjoyed can lead to community agitations as they could possibly make some final demands before facility closure. The impact is described as direct, short-term, local, reversible and is rated moderate.

5.4.6 Significant Positive Impacts of the Project

The proposed project will result in a number of positive impacts for the community. Most of the positive impacts will be in the area of macro-economics. The envisaged positive impacts of the project are further discussed below.

Income from site clearing and other site preparation activities

During the early stages of the project there will be need to clear the land. The

communities surrounding the project site will benefit financially from contracts and employment opportunities relating to land clearing and site preparation.

Income during construction and operation of the proposed project

Direct employment opportunities shall be created for the local populace because of the personnel requirement for the construction and operation of the project. Indirect employment opportunities will be created from support services and retail sales given that some construction materials and personnel needs would be locally sourced; this would increase financial flow in the local economy. During the construction phase, local spending will increase, economically benefiting the area.

Increase in income from transportation

During all the project phases, there will be transportation of workers, equipment and supplies to and from the project site. Some contractors involved in this project will hire vehicle owners who may live in the communities around the proposed project area.

Income from involvement in waste handling activities

Solid wastes will be generated at each phase of the project, but will peak during the construction and decommissioning phases. Most of the wastes associated with this project will be handled by, accredited waste handling and disposal companies; and this will generate income for the vendors engaged.

Income from dismantling of structures and site restoration

Direct and indirectly related job opportunities would be created for the local populace during the decommissioning phase of the project which will include the dismantling of structures, site remediation/restoration, and demobilization of equipment and men from site. Logistics, transportation, waste management and site restoration activities will create job opportunities that will impact the macroeconomics of the communities positively.

CHAPTER SIX: MITIGATION MEASURES

6.0 Introduction

This chapter proffers mitigation measures for the impacts from the proposed CNG Mother/Daughter Stations identified in **Chapter 5**. Some major negative impacts were identified though impacts mainly fell between moderate and minor. Mitigation measures have been provided for the impacts rated as major and moderate, while recommendations have been made for enhancing the positive impacts. Continuous improvement and standard practices would address minor and negligible impacts as shown in the HEMP process that is contained in the Environmental Management Plan (**Chapter 7**) in this report.

The mitigation measures for the proposed project plays the dual role of reducing the levels of the identified negative impacts to As Low as Reasonably Practical (ALARP) as well as enhancing the positive (beneficial) effects of the different phases of the project (pre-construction, construction, operations and decommissioning). The residual impacts that could arise despite the mitigation measures have also been assessed and information on these residual impacts as well as the plan for monitoring compliance and effectiveness of mitigation measures are provided in the Environmental Management Plan (**Chapter 7**).

In proffering mitigation measures, the primary objectives were:

- ***Prevention or avoidance*** – ensuring that significant and adverse potential impacts and risks do not occur.
- ***Reduction*** – ensuring that the effects or consequences of those significant associated and potential impacts that cannot be prevented are reduced to as low as reasonably practicable. Reasonable practicability was determined in reference to best industry practice and to economic, environmental, technical, health and safety considerations.
- ***Control*** – ensuring that residual associated impacts are reduced to a level as low as reasonably practicable.

The mitigation measures proffered for the predicted environmental impacts from the project took cognizance of:

- Environmental laws in Nigeria, with emphasis on permissible limits for waste streams {FEPA (1991) now FMEnv, EGASPIN (2018)};
- Best Available Technology for sustainable development;
- Feasibility of application of the measures in Nigeria;
- Social well-being, etc.
- Professional Judgement

GVLNG Limited is committed to ensuring the implementation of mitigation

measures for the various phases of the project which are shown in **Table 6.1**.

Table 6.1: Mitigation Measures

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
Pre-Construction	Land acquisition and tenure	Liability/ reputation	Litigation	9	• Ensure that all relevant stakeholders/ issues are identified, discussed and resolved properly prior to mobilization	Low
		Community and youth concern	Agitation	9	• Implement regular consultations with the local community and other stakeholders (Govt., Community, NGOs, CBOs etc.) for effective communication and social license; • Support traditional conflict resolution structures in the project communities	Low
	Environmental and engineering surveys	Soil, vegetation, community	Minor disturbance from survey activities (-)	3	• Restrict survey footprint; restore disturbed areas after surveys	Negligible
	Material and equipment supply	Air quality	Vehicular emission from vehicles conveying workers and construction equipment (pollutant and greenhouse gases with possible health hazards)	9	• Engine to comply with international standards for exhaust gases; • Maintenance of engines and exhaust gas check; • Adoption of engine off policy at construction site. • Regular inspection, servicing and maintenance of plant and equipment will be scheduled and carried out to ensure good performance and reduced emissions.	Medium

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Noise	Noise generated from vehicles conveying construction equipment	9	• Adoption of engine off policy at construction site; • When not in use, schedule activities to daytime only; • Use of noise muffs	Low
	Mobilization of workforce	Population in the vicinity of activity	Social and cultural interaction issues; Health and security issues; Noise and dust.	9	• Effective and open complaints procedure; while other impacts are treated in the relevant column	Medium
		Community infrastructure and utilities	Increase demands on services in local communities	9	• Proponent to provide all utilities for the facility; therefore, the community infrastructure and utilities will not be overstressed.	Low
		Community and youth concern	How to be gainfully employed	13	• Company to provide appropriate job opportunities for skilled and unskilled labour for the communities. • Cooperative and open working relations shall be established early with local communities and maintained throughout the life of the project; commitments with respect to local and national content of workforce;	Medium
		Transport	Increase in the demand of public transport	9	• Develop a Transport Management Plan specifying routes, speeds, times of travel and key roads in terms of local services; • Consideration shall be given to avoid reliance on public transport and contractors shall be required to use	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
					private buses/vehicle	
		Vector related	Vector such as bed bug etc. can be an issue	7	• Provide employee induction, awareness and training aimed at building a culture of environmental awareness;	Low
				9	• Provide support to district health vector-related control programs to provide long lasting. • Insecticide at reduced costs.	Low
		Sexually transmitted infection HIV/AIDS	Sexual relationship	13	• HIV/AIDS, and other sexually transmitted diseases (STD) awareness information, including means of preventing contraction of such diseases, shall be included in induction training and toolbox talks of workers. • Workers will be informed of the health risks of illicit sex and that prostitution is illegal and information on the health risks of prostitution will also be provided; • Information on sexually transmitted diseases and the risks of prostitution shall also be provided.	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
	Base camp construction, ground clearance and grading	Air quality	Reduction in air quality due to an increase in airborne particulate matter	9	• Good maintenance of machinery to generate minimal levels of pollutants; • Regular visual monitoring to identify equipment producing excessive visible emissions. • Equipment observed to be creating excessive air quality emissions will be replaced or serviced within 48 hours. • Use of the most suitable site equipment that can carry out the required tasks with the most efficient fuel consumption rates	Medium
Construction		Noise	Noise generated from activities	9	• Use of mufflers on diesel equipment; • Adoption of engine off policy at construction site; • Schedule activities during daytime	Low
		Soil quality	Disruption of the topography of the soil	9	• Best available technology shall be used; • Area of disruption shall be kept as minimal as possible	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
	Excavation and construction of facility	Air quality	Reduction in air quality due to emissions from equipment	9	• Regular visual monitoring to identify areas generating visible dust emissions from the site. Where visible dust emissions from the site are observed, feasible and reasonable dust mitigation measures will be identified and implemented e.g. Implementation of a dust suppression system such as regularly spraying surfaces with water to reduce dust levels; (especially during the Dry Season). • All plant / equipment operators will be appropriately trained and certified • Monitoring of PM 2.5 and PM 10 in line with FMEnv. guidelines for air quality in the Dry Season	Low
		Noise level	Increased noise and vibration level from construction plant and equipment	9	• Mufflers shall be installed on all combustion engine plant, such as generators and compressors, and they will be checked to ensure they produce minimal noise. • Best industry practice will be employed.	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
	Excavation and construction of facility				• All plant/equipment operators will be appropriately trained and certified. • Construction plant, equipment and vehicles will be modern and well maintained in accordance with written procedures that are based upon the manufacturer's guidelines, applicable industry code, or engineering standards to ensure efficient and reliable operation. • Noisy operations will be scheduled at the same time to take account of the fact that combined levels may not be significantly higher than the level if the operations were performed separately. The perceived percentage usage for the noisiest activities will therefore be lower at receptors. • Provide employee induction, awareness and training aimed at building a culture of environmental awareness	
		Groundwater quality	Contamination of groundwater aquifers	7	• Best available technology shall be used; • Avoid digging to the bottom aquifer	Low
		Soil quality	Change in topography	7	• Green areas to be planted with native plants	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
			Loss of terrestrial habitat	7	- Excavation shall be limited to areas clearly marked out for the facility - Limit clearing and earthworks - Vegetation will be replanted as part of the landscaping works - Where practical utilize previously cleared areas	Low
Construction	Construction traffic	Road users, local communities	Increased traffic congestion and accident risk (-)	6	- Implement traffic management plan; - Provide signage; train drivers; - Schedule deliveries appropriately	Low
	Construction activities	Local economy	Increased employment and business opportunities (+)	9	- Maximise local workforce participation and local sourcing	Medium (Positive)
	Fuel and lubricant storage/handling	Soil and groundwater	Contamination from accidental spills and leaks (-)	9	- Store fuels in bunded areas; - Maintain spill kits; - Train personnel; - Implement spill response procedures	Low
	Equipment installation and commissioning	Workers	Occupational injuries and accidents (-)	9	- Enforce HSE procedures; - Provide PPE; - Conduct toolbox talks and - Safety training	Low
Accident al Events	Work-related injuries	Accidents and injuries	Can be as severe as loss of life	11	- Site specific induction and continual safety training for all staff; - Continual drills in emergency procedures; - Ensure that appropriate safety and rescue equipment is available and employees trained in its use	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Health services infrastructure and capacity	Additional stress on the available healthcare infrastructure and manpower	9	- Rescue ambulance should be available; - Assist the local hospital/clinic in areas of shortcomings	Low
Operations	Natural gas compression operations	Ambient air	Methane emissions and greenhouse gas releases (-)	9	- Conduct routine leak detection and repair (LDAR); - Install gas monitoring systems; maintain compressors	Low
	Compressor operations	Nearby neighbours/ communities	Noise from compressors and associated equipment (-)	9	- Install acoustic enclosures; - maintain equipment; - establish noise buffer zones	Low
	CNG dispensing operations	Vehicle owners and transport sector	Improved access to cleaner fuel (+)	15	- Ensure reliable supply and safe operation of dispensing systems	High (Positive)
	Substitution of conventional fuels with CNG	Air quality, public health	Reduction in particulate matter, SOx and NOx emissions (+)	15	- Promote adoption of CNG-powered vehicles - Maintain fuel quality standards	High (Positive)
	Operation of CNG station	Consumers and businesses	Reduced fuel costs and improved energy access (+)	12	• Maintain operational efficiency and uninterrupted supply	High (Positive)
	High-pressure gas storage	Workers, public, infrastructure	Fire and explosion hazards (-)	11	- Install emergency shutdown systems; - Gas detection systems; fire protection systems; - Comply with applicable design codes; - Conduct emergency drills	Medium

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
	Tube trailer loading (Mother Station)	Workers	Exposure to high-pressure gas handling risks (-)	12	- Develop loading SOPs; - use pressure relief devices; - conduct competency training; - implement permit-to-work system	Medium
	Transportation of CNG trailers	Communities, road users	Traffic accidents and gas release incidents (-)	12	- Use certified transport vehicles; - implement journey management plans; - Train drivers; perform vehicle inspections	Medium
Operations	Trailer unloading (Daughter Station)	Workers	Gas leakage during unloading operations (-)	12	- Use standardized unloading procedures; - Install emergency isolation valves; - Conduct operator training	Medium
	Routine maintenance activities	Workers	Exposure to operational and maintenance hazards (-)	9	- Implement lockout/tagout procedures; - Provide PPE; - Conduct regular safety audits	Low
	Routine operations and maintenance	Workforce	Long-term employment opportunities (+)	9	- Maintain fair employment - Practices and workforce development programs	Medium (Positive)
	Emergency situations (fire/explosio n)	Workers, communities, infrastructure	Injury, fatality, and property damage ()	11	- Emergency response plan; - Firefighting systems; - Emergency drills; - Mutual aid agreements; - Adequate separation distances	Medium
	National gas utilization	Energy sector	Enhanced energy security and domestic gas utilization (+)	12	- Ensure sustainability of the facility and its operations	High (Positive)

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
Operations	Facility operation and utility	Air quality	Reduction in air quality due to emissions from the machines and equipment	9	- Use of mechanical seals, vapour recovery, sealing glands by oil pressure, and maintenance - Engine to comply with international standards for exhaust gases; - Maintenance of engines and use of gas filters on exhaust to minimize emission; - Adoption of engine off policy at docking premises. - Regular inspection, servicing and maintenance of plant / equipment will be scheduled and carried out to ensure good performance and reduced emissions. - Equipment will be subject to periodic performance reviews - the scope of which includes environmental performance indicators - Where practical machines will be operated at low speed or power and will be switched off when not being used.	Low
		Transport	Interference with public transport	5	- Operational activities shall not interfere with public transport or cause road jams; - However, consult with stakeholders on nature and timing of activities which may likely cause interference	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Soil quality	Contamination of soil	7	- Good housekeeping to minimize leaks and spills	Low
			Waste generation	11	- All generated wastes shall be placed in appropriate containers prior to disposal. - Provide consistent, clear direction on waste and resource handling, storage, stockpiling, use and re-use management measures. - Waste collection and storage areas shall be established and maintained. - Waste will be segregated at source, stored and transported to disposal sites by appropriate third-party contactor. - Sludge, and effluent waste shall be placed in sealed containers, before disposal	Low
		Noise	Noise generated from activities	11	- Silencers / mufflers shall be used on equipment where possible - Operations will be conducted such that noise generation will be managed within regulatory requirements - Continuous noise emitting machinery, such as generators, will be housed in a suitable acoustic enclosure	Low
		Health and safety	Exposure of the workforce	11	- Emergency response plan and procedures are in place. - Ensure that an adequate number of trained first aiders are available at work sites.	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
					- Create awareness on handling of electrical appliances amongst the staff.	
	Facility operation and utility				- Ensure that appropriate PPE are provided and correctly used - Job hazard identification and analysis is conducted - Perform regular workplace inspections. Hazards identified must be addressed immediately, or as soon as reasonably possible. - Risk assess activities involving hazardous substances - Safety signage is provided at strategic locations. - Toolbox talks shall be held before any site work commences - Use best practice procedures to ensure safe operations	
		Community infrastructure and utilities	Increase demands on services in local communities	11	- Overstressed utilities can be addressed by community assistance grant, loans, construction of needed facilities, etc.	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Community and youth concern	Community health and employment	13	- Give concessions to indigenes in employment, award of contracts, scholarships and training schemes. - Cooperative and open working relations shall be established early with local communities and maintained throughout the life of the project; - Show commitments with respect to local and national content of workforce and - Provide job opportunities for local skilled and unskilled labour;	Low
	Facility operation and utility				• Encourage communities to identify impacts that may be of particular concern to them and have a voice in appropriate mitigation measures.	

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Sexually transmitted infection HIV/AIDS	Sexual relationship	13	- HIV/AIDS, and other sexually transmitted disease (STD) awareness information, including means of preventing contraction of such diseases, shall be included in induction training and toolbox talks of workers. - Induction for workers on health risks of illicit sex and communicable diseases. - Workers will be informed that prostitution is illegal and information on the health risks of prostitution will also be provided; - Information on sexually transmitted diseases and the risks of prostitution shall also be provided.	Medium
Operation	Power generation	Air quality	SPM and other gaseous pollutants from power generating plant	9	- The open end of the exhaust of generator should be at least 2.5meters above the ground level. It should also be pointing skywards. - This will minimize pollutant gases concentration at level close to workers. - This also enhances wind dispersion effect on the pollutant gases; - Systematic inspection and maintenance of generators to minimize air emission	Low
		Noise	Noise from power generator	9	- Mufflers on power generators;	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
					Systematic inspection and maintenance of generators to minimize noise emission	
		Soil quality	Contamination of soil from generator fuel	7	- Good housekeeping to minimize leaks and spills	Low
		Population in the vicinity of activity	Health issues.	11	Effective and open complaints procedure; while other impacts are treated in the relevant column	Medium
Accidental Events/ Non-Routine Activities	Fire/explosion	Air quality	Resultant air emission from fire/explosion	11	- Ensure and enforce the implementation of fire prevention & protection devices are incorporated into the daily operations; - Ensure the implementation of emergency response plan for the location; - Firefighting material should be available on location at all times; - Material safety data sheets (MSDS) should be available for all chemicals and hazardous substances to be used on location; - Staff handling hazardous substances/materials must be aware of their potential impact and take appropriate safety measures; - Carry out HAZID/HAZOP of the facility; Permit	Medium
		Soil quality	Resultant contamination of soil from fire/explosion	11		Medium
		Vegetation	Resultant vegetation destruction from fire/explosion	11		Medium
		Wildlife	Habitat destruction and wildlife kill from fire/explosion	11		Medium

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
					to work system (PTW) should be enforced; restoration of biophysical environment	
		Population in the vicinity of activity	Health issues	11	- Effective and open complaints procedure; - Emergency preparedness and management procedure is in place	Medium
		Community infrastructure and utilities	In case of fire outbreak, localized infrastructure and utilities shall be damaged	9	- Reduction of activities leading to explosion and fire outbreak - Good housekeeping	Low
		Community and youth concern	Avoidance of such catastrophe	11	- Encourage communities to have a voice in appropriate mitigation measures	Low
		Liability/ reputation	Litigation and damaged reputation	11	- Prompt compensation for damage property and utilities	Low
		Accidents and injuries	Resultant injuries from fire/explosion	11	- Emergency responses should also cover the injured victims	Medium
	Work-related injuries	Accidents and injuries	Can be as severe as loss of life	11	- Periodic training and continual safety drills for all staff; - activation of emergency procedures; - ensure that appropriate safety and rescue equipment is available and employee trained in its use	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Health services infrastructure and capacity	Additional stress on the available healthcare infrastructure and manpower	9	- Rescue ambulance should be available; - Assist the local hospital/clinic in areas of shortcomings	Low
Decommissioning	Facility shutdown and decommissioning	Employees	Job losses and reduced economic activity (-)	6	- Develop workforce transition plan; - Provide notice and retraining opportunities	Low
	Equipment dismantling and demolition	Workers	Occupational health and safety risks (-)	9	- Prepare decommissioning HSE plan; - use trained contractors; - enforce PPE requirements	Low
	Demolition activities	Nearby communities	Dust, noise and vibration generation (-)	9	- Water suppression; noise control measures; - Controlled demolition practices	Low
	Removal of pipelines and storage vessels	Soil and groundwater	Residual contamination from hydrocarbons or chemicals (-)	9	- Conduct contamination assessment; - Remove contaminated soils; - Implement remediation measures	Low
	Scrap metal recovery and recycling	Environment	Resource recovery and waste minimization (+)	9	- Maximize recycling and reuse of materials through licensed recyclers	Medium (+)
	Site restoration and revegetation	Soil, biodiversity, landscape	Restoration of ecological and aesthetic value (+)	12	- Implement site rehabilitation plan; - revegetate with native species; - monitor restoration success	High (+)

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
	Decommissioning and Abandonment	Air quality impairment and noise	Resultant air emissions and noise from decommissioning activities.	9	- Protective masks will be worn by personnel in areas having excessive emissions as well as dust-prone areas. - Operators of equipment will be mandated to wear PPE (earplugs, noise mask, coverall etc, - Vehicles and machinery to be used during decommissioning will be fitted with filters and muffs to minimise emissions and noise levels	Low
		Community and youth concern	Community agitations over environmental damage and loss of oil benefits	9	- Identification and resolution with relevant stakeholders' issues will be ensured. - Regular consultation will be made with stakeholders (Govt., Community, NGOs, CBOs etc.) to understand community perceptions, issues and concerns. - Effective liaison/ communication channels with communities (via Community interface coordinators/ community relations officers [CIC/CROs]) will be maintained. - There will be inclusion of decommissioning issues in the Terms of Reference for the MOU.	Low

	Activities	Receptors	Description of Potential Impact: Negative/Positive	Impact Rating	Mitigation	Residual Impact
		Community and youth concern	Creation of business/job opportunity	13	- Indigenous contractors/ personnel and qualified resource persons shall be engaged in the decommissioning activity. - There will be a strict Compliance with GVLNG procedures /criteria for indigenous labour sourcing /employment.	High (+)

CHAPTER SEVEN: ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

7.0 Overview and Scope

This chapter contains the Environmental and Social Management Plan (ESMP) drawn up for the GVLNG Limited's CNG Mother/Daughter Station at Afaka Community, Igabi Local Government Area, Kaduna State.

This Environmental and Social Management Plan (ESMP) will enable GVLNG to realize its Health, Safety and Environment (HSE) regulatory compliance objectives, carry out its institutional responsibilities (Federal Ministry of Environment/NMDPRA regulations and KEPA guidelines), and other associated obligations connected to the development and operation of the Plant. An ESMP for the facility is a major feature of GVLNG's overall Environment Management System (EMS), as it addresses environmental, social, and health performance.

This ESMP has been designed for the following purposes:

1. It lays down the procedures and measures that will be incorporated into the development and operations of the plant to verify and regularly monitor the effectiveness of the mitigation and enhancement measures that GVLNG Limited has chosen to implement during this project.
2. The ESMP will be used to ensure strict compliance with statutory requirements and GVLNG's corporate policies on safety and the environment.
3. This ESMP will establish any relationship between each significant impact (major or moderate significance); the relevant mitigation measures; and the monitoring approach of all significant impacts that have so far been identified in the study.

Also, through this ESMP, significant impacts are referenced to:

- Appropriate regulatory requirements, institutional responsibilities and other obligations;
- Relevant GVLNG Limited operational controls (e.g., management best practices, construction and operation specifications, procedures, and work instructions); and
- Mitigation and regulatory monitoring of institutional roles.

This EMP applies to all sub activities of the operation of the project.

Policies

GVLNG Limited has established an HSE Policy and a sustainability commitment that mutually defines the company's resolve in carrying out operations in a socially responsible and ethical manner, at the same time considering the protection of

health, safety and the environment. GVLNG Limited is fully committed to the implementation of the policy and guidance as presented in **Chapter 1** of this report. Environmental aspects will be embarked upon using the following process identification of environmental sensitivities:

- Identification of potential significant impacts,
- Implementation of design measures or operational procedures that minimize impacts to satisfactory levels,
- Establishment of emergency and contingency plans
- Monitoring the effectiveness of environmental protection, and
- Auditing the success of the overall strategy.

The negative impacts associated with the development and operations at the Stations and measures drawn up to mitigate them have previously been examined. But the long-term process of managing HSE issues relating to development and operations at the Plant requires management of residual impacts, as well as monitoring and follow-up.

The guidelines employed by GVLNG Limited in its operations include:

- Control and minimization of all solid and non-solid wastes,
- Prevention of release of petroleum products to the environment,
- Reducing gaseous emissions and noise in the ambient air.

7.1 Environmental and Social Management Plan

This Environmental and Social Management Plan has been set up to serve as a guide for the regulators, GVLNG Limited's managers and any other suppliers/ contractors that would be involved in the project, as well as other personnel tasked with the implementation of the plan. The EMP integrates features of the larger GVLNG EMS, modelled for all of the Company's operations. The HSE-MS blueprint has been drawn up to identify, plan for, and subsequently minimise potential HSE and socio-economic impacts.

Table 7.1: Environmental and Social Management and Monitoring Plan for GVLNG CNG Mother/Daughter Stations

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
Land Acquisition	Loss of means of Livelihood of land owners who previously use the acquired land for farming.	Moderate	Adequate compensation shall be paid to those whose livelihoods are affected as a result of the project	Minor	Admin/ Community Relations Depts.	Pre-Mobilization	Site inspection Report	Once Prior to site preparation activities	Admin Manager
Site Preparation / Site Clearing	Vegetation removal and loss; to make room for the construction of the proposed Plant.	Moderate	Vegetation clearing shall be limited to the areas within the site needed for the Project. Use of herbicides for clearing shall be avoided	Minor	Project contractor and HSE Dept.	Pre-Mobilization	Site inspection Report	Daily throughout site preparation activities	HSE Manager
			Cleared trees shall be replanted within the project site or elsewhere	Minor	Project contractor and HSE Dept.	Pre-Mobilization	Site inspection Report	Daily throughout site preparation activities	HSE Manager
	Removal of the topsoil in preparation for the project	Moderate	Removal of the topsoil and vegetation shall be restricted to the	Minor	Project contractor and HSE Dept.	Pre-Mobilization	Site inspection Report	Daily throughout site preparati	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	construction.		construction area Measures should be employed to restrict silt removal					on activities	
	Noise and Vibrations from site preparation equipment and machines.	Moderate	Machinery with noise levels within acceptable limits shall be used	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager
			All engines of all heavy equipment and automobiles will be switched off when not in use	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager
			Time management will ensure that the site preparation activities will be done within the shortest possible time	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site Preparation activities	HSE Manager
			Acoustic mufflers shall be provided for heavy engines with noise levels above acceptable	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			limits					activities	
			Noise generating energy equipment shall be enclosed in noise insulators	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager
			Workers with existing hearing impairments shall not be deployed to site.	Minor	HSE Dept.	Pre-Construction	Records of medical checks	Prior to mobilization of personnel	HSE Manager
	Impairment of Air Quality from site clearing and preparation activities.	Moderate	Protective masks will be worn by personnel in areas having excessive emissions as well as dust prone areas	Minor	Project contractor and HSE Dept.	Pre-Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc.	Weekly throughout site preparation activities	HSE Manager
			All heavy equipment that will be used in the site preparation will be mandated to regularly maintain and service their	Minor	Project contractor and HSE Dept.	Pre-Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc. and equipment	Weekly throughout site preparation activities	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			vehicles to minimize the emissions levels from their exhausts				servicing records		
	Loss of Wildlife and Habitat due to the site clearing and construction preparation.	Moderate	The site clearing is minimal as such the destruction of habitats of various microfauna and macrofauna species will not be carried out beyond the required project area	Minore	Project Contractor	Pre-Construction	Site Inspection Reports	Weekly	HSE Manager
			The use of herbicides will be avoided	Moderate	Project Contractor	Pre-Construction	Project Progress Reports	Weekly	HSE Manager
	Social Management Plan								
	Exposure of workers to poisonous animals and plants as a result of site clearing and preparation.	Moderate	Workers shall be provided with PPE (coveralls, jungle boots, hard hat and gloves) and their usage enforced	Minor	Project Contractor	Pre-Construction	Site inspection Report	Weekly throughout Site preparation activities	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Awareness shall be created among personnel on the likelihood of exposure to poisonous wildlife and plants and the immediate measures to be taken if it occurs	Minor	HSE Dept	Pre-Construction	Minutes of Project Kick off meetings	Prior to site preparation activities	HSE Manager
			First aid measures and Medevac procedures shall be put in place in the event of an incident.	Minor	Project Contractor and HSE Dept	Pre-Construction	Site inspection Report	Weekly throughout site preparation activities	HSE Manager
			Anti-venom injections shall be provided on site.	Minor	Project Contractor	Pre-Construction	Site inspection Report	Weekly throughout site preparation activities	HSE Manager
	Opportunities for employment	Positive	Indigenous contractors and qualified resource persons shall be employed.	Positive	Project Contractor	Pre-Construction	Interview Records and Personnel CV's	Once prior to confirmation of employment	Human Resources (HR) Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			GVLNG shall develop procedures/criteria for indigenous labour sourcing/ employment.	Positive	HR Dept and Community Relations Department	Pre-Construction	Contract documents	Prior to site preparation activities	Human Resources Manager
	Injuries resulting from clearing of vegetation.	Moderate	Workers shall be provided with PPE (coveralls, jungle boots, hard hat and gloves) and their usage will be thoroughly enforced	Minor	Project Contractor	Prior to all Construction activities	Project safety reports	Weekly throughout site preparation activities	HSE Manager.
			Toolbox meetings will be conducted before commencing site clearing activities.	Minor	Project Contractor	Prior to the start of Construction activities	Minutes of Toolbox meetings	Daily throughout site preparation activities	HSE Manager.
			First aid /medical facilities shall be provided on site, with critical cases transferred to GVLNG approved or other	Minor	Project contractor and HSE Dept	Throughout Pre-Construction	Project safety reports Incident Reports	Weekly throughout site preparation activities	HSE Manager.

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			appropriate health facilities (Medevac).						
Recruitment of Workers	Increased employment/ services opportunities for the host community, and potential increase in income and better livelihoods.	Positive	Engagement of indigenous contractors and qualified resource persons	Positive	HR Dept	All Project Phases	Contractor Portfolio, Interview Records and Personnel CV's	Once prior to signing contract/ confirmation of employment	Human Resources (HR) Manager
			Application of existing GVLNG procedures/ criteria for indigenous labour sourcing and employment.	Moderate	HR Dept and Community Relations Department	All Project Phases	Contract Documents and Employment Letters	Prior to site preparation activities	Human Resources Manager
	Increase in social vices (violence, drug/alcohol abuse, Teenage pregnancies, prostitution etc)	Moderate	Awareness campaigns shall be carried out to enlighten the communities/ workers on the implications of drug and alcohol abuse, unprotected sex, prostitution and the	Moderate	HSE and Community Relations Depts.	Pre-Construction	Consultation Sessions Records	Prior to site preparation activities	HSE and Community Relations Managers.

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			need to sustain cultural values.						
			Condom use shall be encouraged	Moderate	HSE Dept.	Pre-Construction	Consultation Sessions Records	Prior to site preparation activities	HSE Manager.
			Alcohol and drug sales will be prohibited around the Plant at all project phases	Moderate	HSE Dept.	All Project Phases	Site Inspection Reports	Weekly	HSE Manager.
			Alcohol consumption and drug use shall be prohibited on the facility in line with GVLNG's Drug and Alcohol policy.	Moderate	HSE Dept.	All Project Phases	Incident Reports	Weekly	HSE Manager.

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Efforts will be made to enlighten the host communities to existing government control programs for HIV/AIDS	Moderate	HSE Dept.	Pre-Construction	Consultation Sessions Records	Prior to site preparation activities	HSE Manager.
	Third party agitation (over employment issues)	Moderate	Identification and resolution of relevant stakeholders' issues will be ensured	Minor	Community Relations Dept	Prior to Construction	Project Registration Documents, Consultation Records and MOU with the host community	Prior to site preparation activities	Community Relations Manager
			Regular consultation will be made with stakeholders (Govt., Community, NGOs, CBOs etc.) to understand community perceptions, issues and concerns.	Minor	Community Relations Dept	Prior to Construction	Consultation Sessions Records	Weekly	Community Relations Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Effective liaison/communication channels with communities (via Community interface coordinators/ community relations officers [CIC/CROs]) will be maintained	Minor	Community Relations Dept	Prior to Construction	MOU with the host community	Prior to site preparation activities	Community Relations Manager
			There will be inclusion of community employment issues in the Terms of Reference for the MOU	Minor	Community Relations Dept	Prior to Construction	MOU with the host community	Prior to site preparation activities	Community Relations Manager
Mobilization	**Environmental Management Plan**								
Transportation of Personnel and Equipment	Noise and Vibration	Moderate	Personnel will be car pooled as much as possible to reduce the number of vehicles that will be used to convey personnel to site thus reducing	Minor	Project contractor and HSE Dept.	Pre-Construction	Contractors Work Execution Plan and Noise level monitoring	Weekly throughout site preparation activities	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			cumulative noise						
			Machinery with noise levels within acceptable limits shall be used	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager
			All engines of all heavy equipment and automobiles will be switched off when not in use	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager
			Time management will ensure that the movement and transportation of personnel shall be done within the shortest possible time	Minor	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	Emissions and dust from vehicles	Moderate	Protective masks will be worn by personnel in areas having excessive emissions as well as dust prone areas.	Minor	Project contractor and HSE Dept.	Pre-Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc.	Weekly throughout site preparation activities	HSE Manager
			All heavy equipment that will be deployed to site will be mandated to regularly maintain and service their vehicles to minimize the emission levels from their exhausts	Minor	Project contractor and HSE Dept.	Pre-Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc. and equipment servicing records	Weekly throughout site preparation activities	HSE Manager
	Social Management Plan								
	Injuries and accidents to workers during loading and off loading construction materials.	Moderate	Adequate PPE shall be provided especially gloves, safety shoes, and hard hats to workers shall be ensured. It is mandatory that all employees on site shall wear the appropriate PPE whilst performing	Minor	Project contractor and HSE Dept	Pre-Construction	Work Execution Plan	Weekly throughout site preparation activities	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			their duties.						
	Increased vehicular movement and traffic and possibilities for road accident	Moderate	A journey management plan shall be developed and workers shall be pooled. Use of signages	Minor	Project contractor and HSE Dept	Pre-Construction	Work Execution Plan Journey Management Plan	Weekly throughout site preparation activities	HSE Manager
	Behavioural modifications from wildlife	Moderate	Personnel will be car-pooled as much as possible to reduce the number of vehicles that will be used to convey personnel to site thus reducing cumulative noise and behavioural modifications by wildlife	Moderate	Project contractor and HSE Dept.	Pre-Construction	Contractors Work Execution Plan and Noise level monitoring	Weekly throughout site preparation activities	HSE Manager
			All engines of all heavy equipment and automobiles	Minor	Project contractor and HSE	Pre-Construction	Monitoring of noise levels	Weekly throughout site	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			will be switched off when not in use		Dept.			preparation activities	
			Time management will ensure that the movement and transportation of personnel shall be done within the shortest possible time	Moderate	Project contractor and HSE Dept.	Pre-Construction	Monitoring of noise levels	Weekly throughout site preparation activities	HSE Manager
Construction	**Environmental Management Plan**								
Construction of the Plant and Ancillary Facilities	Noise/ Vibration	Moderate	Engines of any equipment not in use shall be switched off	Minor	Project contractor	During Construction	Monitoring of noise levels	Weekly During Construction	HSE Manager
			Time management will ensure that the construction of the Plant shall be executed within the shortest possible time	Minor	Project contractor	During Construction	Monitoring of noise levels	Weekly During Construction	HSE Manager
			Acoustic mufflers shall be provided for equipment if	Minor	Project contractor	During Construction	Monitoring of noise levels	Weekly During Constructi	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			noise levels are above acceptable limits					on	
			GVLNG HSE policy of wearing ear muffs/ plugs shall be applied in areas of high noise pressures	Minor	Project contractor	During Construction	Site Safety Reports	Weekly During Construction	HSE Manager
			Sufficient separation distances shall be provided for sources of high energy sound to reduce noise levels	Minor	Project contractor	During Construction	Monitoring of noise levels	Weekly During Construction	HSE Manager
			Warning signs shall be provided at noise prone areas and will be designated "Ear Muff Area".	Minor	Project contractor	During Construction	Site Safety Reports	Weekly During Construction	HSE Manager
			Workers with existing hearing impairments shall not be deployed to site.	Minor	Project Contractor and HSE Dept.	Pre-Construction	Records of medical checks	Prior to Construction	HR Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	Impairment of Air Quality	Moderate	Protective masks will be worn by personnel in areas having excessive emissions as well as dust prone areas.	Minor	Project contractor	During Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc.	Weekly	HSE Manager
			Operators of emission generating equipment/ vehicles that will be used in construction will be mandated to regularly maintain and service their engines to minimize the emission levels generated	Minor	Project contractor	During Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc. and Equipment Service Records	Weekly	HSE Manager
			Operators of power generators will regularly maintain them	Minor	Project contractor	During Construction	SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc. and Equipment Service	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
							Records		
	Increase in vehicular traffic	Moderate	Movement of any supply vehicles will be limited to off-peak times to reduce traffic congestion	Moderate	Project contractor	During Construction	Traffic Management Plan and Traffic Density	Monthly	HSE Manager
			Journey Management Plans that reduce pressure on the existing road networks shall be implemented	Moderate	Project contractor	During Construction	Traffic Count and Traffic Density	Monthly	HSE Manager
			There will be a strict adherence to the Construction Traffic Management Plan	Moderate	HSE Dept.	During Construction	Traffic Count and Traffic Density	Monthly	HSE Manager
			Contractors will be encouraged to use buses to convey personnel to reduce traffic congestion	Moderate	Project contractor	During Construction	Traffic Count and Traffic Density	Monthly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	Interruption of drainage pattern	Moderate	Health awareness training shall be conducted prior to work commet.	Minor	Project Contractor and HSE Dept.	During Construction	Minutes of toolbox. Toolbox meetings/ safety briefings.	Weekly	HSE Manager
			Engineered drainage channels will be constructed taking into cognizance the topography and natural drainage of the area	Minor	Project Contractor	During Construction	Project Progress Reports	Monthly	HSE Manager
			The engineered drainage system will be designed in such a way as to prevent soil erosion in surrounding areas with vegetative cover being one of the key components of the altered drainage channels	Minor	Project Contractor	During Construction	Project Progress Reports and Site Inspection Reports	Monthly	HSE Manager
	Social Management Plan								

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	Burns/ injuries from welding sparks and other construction activities	Moderate	Awareness sessions on health risks and safety precautions of welding operations shall be carried out for workers.	Minor	Project contractor	During Construction	Minutes of toolbox meetings/ safety briefings.	Weekly	HSE Manager
			Pre-employment medical certification shall be carried out for the welders.	Minor	Project contractor	During Construction	Records of medical checks	Once, Prior to start of construction	HSE Manager
			GVLNG shall enforce the use of welder's mask, goggles, earmuffs, jacket, gloves, boots and coveralls, by welders during welding.	Minor	Project contractor and HSE Dept	During Construction	Safety Reports	Weekly	HSE Manager
			A medical facility/ first aid delivery service Plant shall be arranged for personnel use	Minor	Project contractor	During Construction	Incident Reports	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	Exposure to radioactive emission during radiography.	Moderate	Health awareness training shall be conducted prior to commencement of activities.	Minor	Project Contractor and HSE Dept.	During Construction	Minutes of toolbox meetings/ safety briefings.	Weekly	HSE Manager
			Staff shall undergo routine medical check-ups for radiation exposure.	Minor	Project Contractor and HSE Dept.	During Construction	Records of medical checks and Results of radiation tag monitoring	Weekly	HSE Manager
			Radiation monitors shall be provided to monitor radiation levels above threshold.	Minor	Project Contractor and HSE Dept.	During Construction	Radiation levels	Daily	HSE Manager
			The use of radiography aprons to protect the body from radiation shall be enforced.	Minor	Project Contractor	During Construction	Radiation levels	Weekly	HSE Manager
			Warning signs shall be provided during actual activities.	Minor	Project Contractor	During Construction	Site Inspection Report	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			The activity shall be carried out in accordance with standard specifications	Minor	Project Contractor and HSE Dept.	During Construction	Safety Reports	Weekly	HSE Manager
	GBV (sexual harassment, intimate partner violence, poor working conditions)	Moderate	The EEP GBV Action Plan shall be implemented for the Project	Minor	Project Contractor and HSE Dept	During Construction	Health and Safety Report	Weekly	HSE Manager
	Sexual transmitted diseases with influx of people.	Moderate	Labour management plan shall be developed. Sensitization programme shall be conducted for the construction workers as well as a Code of Conduct.	Minor	Project Contractor and HSE Dept	During Construction	Health and Safety Report	Weekly	HSE Manager
	Employment opportunities	Positive	Engagement of indigenous contractors and qualified resource persons will be done	Positive	Project Contractor	Prior to Construction	Employment Records and Personnel CV's	Once, Prior to construction	HR Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Application of existing GVLNG procedures/ criteria for indigenous labour sourcing and employment.	Positive	Project Contractor and HR Dept	Prior to Construction	Contract documents	Once, Prior to Construction	HR Manager
Operations	**Environmental Management Plan**								
Operations and Maintenance	Noise and vibration	Moderate	Acoustic treatment by enclosure of equipment or soundproofing buildings that hold loud equipment and/ or units that operate at significant noise levels	Minor	HSE Dept	During Operations	Noise level monitoring	Weekly	HSE Manager
			Machinery with noise levels within acceptable limits shall be used	Minor	HSE Dept	During Operations	Noise level monitoring	Weekly	HSE Manager
			Noise generating equipment/ machinery/ generators shall be switched off if not in	Minor	HSE Dept	During Operations	Noise level monitoring	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			use						
			Acoustic mufflers shall be provided for heavy engines with noise level above acceptable limits	Minor	HSE Dept	During Operations	Noise level monitoring	Weekly	HSE Manager
			Noise generating energy equipment shall be enclosed in noise insulators in line with GVLNG's policy	Minor	HSE Dept	During Operations	Noise level monitoring	Weekly	HSE Manager
			GVLNG HSE policy of wearing ear muffs/plugs shall be applied in areas of excessive noise pressures	Minor	HSE Dept	During Operations	Noise level monitoring	Weekly	HSE Manager
			Sufficient separation distances shall be provided for sources of high energy sound to reduce cumulative noise levels	Minor	HSE Dept	During Operations	Site Inspection Reports	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Workers with existing hearing impairments shall not be deployed to site	Minor	HSE Dept	During Operations	Medical checks	Annually	HSE Manager
	Impairment of Air Quality	Moderate	Protective masks will be worn by personnel in areas having excessive emissions as well as dust prone areas.	Minor	HSE Dept	During Operations	Safety Reports	Weekly	HSE Manager
			All tanker vessels, generators and vehicles will be regularly maintained and serviced to minimize emission levels	Minor	HSE Dept	During Operations	Equipment Service Records	Quarterly	HSE Manager
			Monitoring of indicator air quality parameters like NOx, CO, SPM, SOx and VOCs, will be undertaken regularly	Minor	HSE Dept	During Operations	Radiation, SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc.	Weekly	HSE Manager
			Power generators will be maintained/	Minor	HSE Dept	During Operation	Generator Service	Quarterly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			serviced regularly			s	Records		
			Generators, road tankers and road vehicles must be switched off when not in use	Minor	HSE Dept	During Operations	Site Inspection Reports	Weekly	HSE Manager
	Changes in Soil and Groundwater Quality	Major	The soil and groundwater quality in the vicinity of the terminal shall be periodically monitored in line with regulatory requirements.	Moderate	HSE Dept	During Operations	pH, THC, PAH, TOC, BOD, COD, Conductivity, heavy metals, phenols, etc	Monthly	HSE Manager
			Any spill that is noticed will be promptly cleaned up to prevent pollution of soil and groundwater.	Moderate	HSE Dept	During Operations	pH, THC, PAH, TOC, BOD, COD, Conductivity, heavy metals, phenols, etc	Monthly	HSE Manager
	Oil spill incidents	Major	GVLNG will have a full functional Oil Spill Contingency Plan in place to	Moderate	HSE Dept	During Operations	Oil Spill Contingency Plan	Annually	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			control and recover oil from incidents						
			ESI maps will be used to minimize environmental impacts in the event of a spill.	Moderate	HSE Dept	During Operations	Oil Spill Contingency Plan	Annually	HSE Manager
			Majority of chemicals will be controlled in accordance with the OSPAR HOCNS and the CHARM model, which ensure that all chemicals are not toxic to the environment at the quantities released.	Moderate	HSE Dept	During Operations	Chemicals MSDS	Monthly	HSE Manager
			Oil spill cleanup materials (e.g. absorbent pads, booms, skimmers etc) will be	Moderate	HSE Dept	During Operations	Materials Inventory, OSCP	Monthly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			stockpiled to contain and collect spills.						
			GVLNG personnel will be trained in use of such materials and contingency measures will be implemented for even the smallest of spills.						
	Fire Outbreaks during operations	Major	Fire protection facilities (detection, fighting and control) shall be provided at the Plant and will be regularly inspected with regular drills carried out.	Moderate	HSE Dept	During Operations	Site Inspection Report and Emergency Response Plan	Monthly	HSE Dept
			GVLNG's Emergency Response Procedures shall be implemented,	Moderate	HSE Dept	During Operations	Emergency Response Plan	Monthly	HSE Dept

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			including measures to quickly seek third-party assistance when necessary.						
			Adequate compensation shall be paid to affected parties in the event of third-party damage to lives and property.	Moderate	HSE Dept	During Operations	Incident Reports and GVLNG's Compensation Records	After every event	HSE Dept
	Electric shock, injuries to personnel during maintenance	Moderate	Ensure that workers wear appropriate PPE at work. Strict compliance with the SOP	Minor	HSE Dept	During Operations	Inspection Report	Monthly	HSE Dept
	Social Management Plan								
	Pressure on Existing Infrastructure	Moderate	Proper waste management procedures will be followed to reduce pressure on existing waste management facilities with the	Moderate	HSE Dept	During Operations	Waste Consignment Notes	Weekly	HSE Dept

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			key focus being placed mainly on reduction and recycling						
			GVLNG shall liaise with other companies on the need to jointly use/ develop key infrastructure to avoid pressures on the existing infrastructure thatthe public utilizes.	Minor	Admin Dept	During Operations	Minutes of Meetings and General Correspondence	Quarterly	Admin Manager
	Increase in vehicular traffic	Moderate	The movement of supply vehicles shall be limited to off-peak times to reduce traffic congestion	Minor	Admin Dept	During Operations	Traffic Management Plan and Traffic Density	Monthly	HSE Manager
			All personnel will be encouraged to adapt to Journey Management Plans to reduce pressure on the existing road	Minor	HSE Dept.	During Operations	Traffic Count and Traffic Density	Monthly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			networks						
			There will be strict adherence to the facilities Traffic Management Plan	Minor	HSE Dept.	During Operations	Traffic Count and Traffic Density	Monthly	HSE Manager
			Road tankers will be mandated to use designated parking areas to prevent traffic congestion on the major roads	Minor	HSE Dept.	During Operations	Traffic Count and Traffic Density	Monthly	HSE Manager
	Increase in local Population	Moderate	Any arbitrary micro-economic developments springing up as a result of the Plant's operations will be located as far away as possible from the facility.	Moderate	Admin Dept	During Operations	Site Inspection Reports	Weekly	Admin Manager
	GBV (sexual harassment, intimate partner violence, poor working	Moderate	The EEP GBV Action Plan shall be implemented for the Project	Minor	Project Contractor and HSE Dept	During Construction	Health and Safety Report	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	conditions)								
	Susceptibility to Pollution Related Diseases	Moderate	Monitoring of indicator air quality parameters like NOx, CO, SPM, SOx and VOCs will be carried out regularly to ensure that they are within recommended levels	Minor	HSE Dept	During Operations	Radiation, SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc.	Weekly	HSE Manager
			There will regular monitoring of groundwater quality for pollution to ensure that the groundwater complies to drinking water standards	Minor	HSE Dept	During Operations	pH, THC, PAH, BOD, COD, DO, Turbidity, TSS, heavy metals, phenols, etc	Monthly	HSE Manager
	Increased opportunities for employment and business	Positive	GVLNG will engage indigenous contractors/ personnel and qualified resource persons	Positive	HR Dept	Prior to Operations	Employment Records and Personnel CV's	Once, Prior to Operations	HR Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			There will be a strict Compliance with GVLNGs procedures /criteria for indigenous labour sourcing /employment.	Positive	HR Dept	Prior to Operations	Contract documents	Once, Prior to Operations	HR Manager
	Conflicts arising from Project Operations	Moderate	Identification and resolution of relevant stakeholders' issues will be ensured.	Minor	Community Relations Dept	During Operations	Project Registration Documents, Consultation Records and MOU with the host community	Continuously	Community Relations Manager
			Regular consultation will be made with stakeholders (Govt., Community, NGOs, CBOs etc.) to understand community perceptions, issues and concerns.	Minor	Community Relations Dept	During Operations	Consultation Sessions Records	Quarterly	Community Relations Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Effective liaison/communication channels with communities via Community interface coordinators/ community relations officers [CIC/CROs]) will be maintained	Minor	Community Relations Dept	During Operations	MOU with the host community	Continuously	Community Relations Manager
			There will be an inclusion of community employment issues in the Terms of Reference for the MOU with the community	Minor	Community Relations Dept	During Operations	MOU with the host community	Once Prior to Start of operations	Community Relations Manager
Waste Generation (solids/liquid / gaseous)	Contamination of soil, surface water and ground water	Moderate	Solid wastes that cannot be recycled must be treated appropriately before final disposal	Minor	Waste Contractors and HSE Dept	During all project phases	Waste Inventory	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			For waste that are to be treated at third party facilities, appropriate storage areas will be designated on site	Minor	Waste Contractors and HSE Dept	During all project phases	Waste Management Plan	Quarterly	HSE Manager
			The choice of appropriate treatment of wastes will comply with the waste classification schemes from FMEnv, NMDPRA	Minor	Waste Contractors and HSE Dept	During all project phases	Waste Management Procedural Document	Continuously	HSE Manager
	E-waste generation and Disposal	Moderate	Training of workers on the handling of generated e-waste	Minor	Waste Contractors and HSE	During all project phases	Training/ Waste Management	Continuously	HSE Manager
	Social Management Plan								
	Increased opportunities for employment and business	Positive	GVLNG will engage indigenous contractors/ personnel and qualified resource persons	Positive	HR Dept	During all project phases	Employment Records and Personnel CV's	Continuously	HR Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			There will be strict Compliance with GVLNG's procedures/criteria for indigenous labour sourcing /employment.	Positive	HR Dept	During all project phases	Contract documents	Continuously	HR Manager
D&A	**Environmental Management Plan**								
Decommissioning and Abandonment.	Air Quality Impairment and noise	Moderate	Protective masks will be worn by personnel in areas having excessive emissions as well as dust prone areas.	Minor	HSE Dept	During Decommissioning	Safety Reports	Weekly	HSE Manager
			Operators of equipment, vehicles and machinery that will be involved during decommissioning, will be mandated to regularly maintain and service them to minimize emissions levels	Minor	HSE Dept	During Decommissioning	Equipment Service Records	Quarterly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			Monitoring of indicator air quality parameters like NOx, CO, SPM, SOx and VOCs, will be undertaken during and after decommissioning	Minor	HSE Dept	During Decommissioning	Radiation, SPM, NOx, VOC, O3, CO, H2S, CH4, dust levels etc.	Weekly	HSE Manager
			Machinery with noise levels within acceptable limits shall be used	Minor	HSE Dept	During Decommissioning	Noise level monitoring	Weekly	HSE Manager
			Noise generating equipment/machinery/ generators shall be switched off if not in use	Minor	HSE Dept	During Decommissioning	Noise level monitoring	Weekly	HSE Manager
			Acoustic mufflers shall be provided for machines/ engines with noise levels above acceptable limits	Minor	HSE Dept	During Decommissioning	Noise level monitoring	Weekly	HSE Manager
			GVLNG HSE policy of wearing ear muffs/plugs shall be	Minor	HSE Dept	During Decommissioning	Noise level monitoring	Weekly	HSE Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			applied in areas of excessive noise pressures						
			Workers with existing hearing impairments shall not be deployed to site.	Minor	HSE Dept	During Decommissioning	Medical checks	Annually	HSE Manager
	Social Management Plan								
	Increased opportunity for business and employment	Positive	GVLNG will engage indigenous contractors/ personnel and qualified resource persons	Positive	HR Dept	During Decommissioning	Employment Records and Personnel CV's	Continuously	HR Manager
			There will be a strict Compliance with GVLNG's procedures /criteria for indigenous labour sourcing /employment.	Positive	HR Dept	During Decommissioning	Contract documents	Continuously	HR Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
	Community agitations over environmental damage and loss of oil benefits	Major	Identification and resolution of relevant stakeholders' issues will be ensured.	Minor	Community Relations Dept	During Decommissioning	Consultation Sessions Records, Regulatory Approvals and MOU with the host community	Once, prior to Decommissioning	Community Relations Manager
			Regular consultation will be made with stakeholders (Govt., Community, NGOs, CBOs etc.) to understand community perceptions, issues and concerns.	Minor	Community Relations Dept	During Decommissioning	Consultation Records	Throughout decommissioning	Community Relations Manager
			Effective liaison/ communication channels with communities (via Community interface coordinators/ community relations officers	Minor	Community Relations Dept	During Decommissioning	MOU between all Parties	Throughout decommissioning	Community Relations Manager

Project Phase and Activities	Description of Impacts	Impact Rating before Mitigation	Mitigation Measures	Residual Rating	Action Party	Timing	Parameters for Monitoring	Monitoring Frequency	Responsible Party
			[CIC/CROs]) will be maintained						
			There will be inclusion of decommissioning issues in the Terms of Reference for the MOU	Minor	Community Relations Dept	During Decommissioning	MOU with community and Community Complaints Register	Before Commencement of Project	Community Relations Manager

The HSE-MS methodology has been designed to ensure that each potentially critical HSE impact recognized in this EIA will have suitable operational controls that indicate appropriate procedures, work instructions, EMPs, roles, responsibilities, authorities, monitoring, measurement, and record keeping that avoid or reduce impacts. Other GVLNG's operating procedures will be appraised and, where appropriate, tailored to contain information for planning and minimizing HSE impacts, or in any case, reference relevant documents that address HSE impact avoidance and mitigation.

GVLNG Limited plans to put into operation its HSE-MS throughout the lifetime of project activities to ensure compliance with applicable HSE regulations and other requirements to which GVLNG pledges, and to mitigate substantial adverse impacts.

The HSE-MS is modelled after and is also compliant with the International Organization for Standardization 14001: 1996 Technical Specification Guidance for Use (ISO 14001) and the draft standard ISO 18001.

7.1.1 HSE Management Plan

GVLNG plans to employ an official, documented HSE Management System (HSE-MS) for all its undertakings. Highlights of the HSE-MS are briefly discussed below.

7.1.1.1 Policy and Strategic Objectives

The GVLNG Limited HSE-MS initiates the direction and objectives of HSE management within the company and makes them applicable to all of the Company's activities. Several daughter policies addressing specific HSE issues complement this HSE policy. The policies relating to the environment include guidelines on:

- Spills,
- Environmental assessment,
- Use of chemicals
- Materials and energy use and
- Waste management.

Managers and supervisors are authorised to give the detailed content of the HSE Policy and applicable daughter policies to all personnel and contractors, concentrating on individual roles and responsibilities required of them.

7.1.1.2 Organization, Responsibilities, Resources, Standards and Documentation

Responsibilities for HSE are outlined in the GVLNG's HSE-MS, and are described in detail in various supporting documents.

HSE Management is a line responsibility in GVLNG, assisted by a team of specialist

HSE advisers and consultants. Contractor organizations will perform some of the activities associated with the operation of the Plant and are required to satisfy defined standards in HSE management before they can carry out any GVLNG's operations. Contractors' HSE performance will be screened and reviewed during project execution.

GVLNG Limited is committed to complying with applicable legislation and other requirements, including:

- Nigerian legislations,
- International conventions and agreements to which Nigeria is a signatory,
- GVLNG Limited HSE Standards, and
- International oil industry standards and practices.

The development and operational activities at the Plant have been drawn up to comply with these standards and all areas of interest will focus on complying with applicable legal and regulatory requirements.

7.1.2 Implementation

Environmental matters are tackled across all levels in GVLNG's planning activities; these include:

- GVLNG Limited's Business Plans, containing critical issues for HSE with set goals aimed at improvement and associated performance indicators,
- Emergency and contingency planning (e.g., the oil spill contingency and response plan),
- Asset HSE Plans,
- Department HSE Plans, and
- Contractor HSE Plans.

Actions from this EMP will be integrated into this planning framework.

GVLNG maintains a hierarchy of written standards, procedures and work instructions. These include standards on waste management and chemicals management.

The environmental performance of the Station's operations will be monitored in line with relevant regulatory and GVLNG requirements.

7.1.2.1 Monitoring

Monitoring activities during the development and operational phases of the Plant are described in **Section 7.5**. Results obtained from the monitoring programme will be reported regularly to the FMEnv and other regulatory authorities and to the GVLNG HSE Manager.

7.1.2.2 Audit

GVLNG Limited will prepare a programme of internal and external audits that evaluates the effectiveness of business controls, including the usefulness of the HSE-MS. The audit shall include the activities during the construction, operations and maintenance of the Plant.

7.1.3 Management Review

GVLNG Limited management appraises the efficiency of the HSE-MS from time to time to meet the business requirements set out by the organization and its stakeholders. Activities and operations at the Stations are included in this review, incorporating the results of the environmental monitoring.

7.2 Operational Controls

GVLNG Limited's HS-EMS, employs comprehensive operational controls to guarantee that all GVLNG operations are environmentally sustainable. Those operational controls that are applicable to the proposed project are discussed below.

7.2.1 Oil/Chemical Management

To limit the potential for oil/chemical to accidentally enter the environment and to make sure that the impacts of those substances whose entry to the environment cannot be avoided are minimized, a thorough selection and management procedure is being put into operation.

This procedure highlights the requirements for the evaluation, selection, supply, transport, storage, use and handling of such oil/chemical and other hazardous substances. A comparable process will be used in the Plant's operations.

Also incorporated into the plan is the requirement that adequate spill response materials will be made available at all locations where oil /chemicals are handled, stored or used. In the unlikely event that a an accidentally released, the toxicity and recommended spill management procedures used in GVLNG's operations will be detailed in a standard manual for managing such wastes.

7.2.2 Waste Management

Separate fit-for-purpose Waste Management Plans have been drawn up for the entire lifecycle of the proposed Stations. The waste management strategy implemented in these plans focuses on the standard waste handling hierarchy, including avoidance, tracking, minimization, reuse, recycling and finally responsible disposal.

7.3 Environmental Monitoring Programme

Monitoring will be carried out to ensure compliance with regulatory requirements

and as a way of evaluating the effectiveness of GVLNG Limited's operational controls and other measures intended to mitigate potential impacts associated with development and operations at the proposed Plant.

With regard to the significant impacts identified in this EIA Report, GVLNG Limited has mapped out a programme to monitor the effectiveness of the mitigation measures (**Table 7.1**). The programme describes the effect to be measured and the frequency.

Together with monitoring of the efficiency of specific mitigation measures, GVLNG has designed a programme to monitor for compliance with relevant regulatory standards. This programme also ensures that contractors keep their contractual obligations relating to work practices and design requirements. Monitoring will be done by GVLNG's HSE department and/or by contractors pursuant to their contractual obligations. The parameters to be measured during the course of operations at the proposed Plant are provided in **Table 7.1**.

Table 7.2: Environmental Monitoring Plan for GVLNG Limited's CNG Mother Stations

Environmental Components/ Matrix	Sampling Locations	Sampling Method	Environmental/ Social Parameters to be monitored	Compliance Requirement	Frequency of Monitoring	Responsible Party	Project Development Phase	Estimated Cost (₦)
Atmosphere (Air Quality & Noise)	Site boundary, nearest receptor, compressor area	Air Quality Monitoring Equipment Sound level meter	$PM_{2.5}$, PM_{10}, NOx, SO_2, CO, CH_4, VOCs TSP, CO, , Noise Level (dBA)	FMEnv/ NESREA WHO/ AfDB	Monthly monitoring; Monthly reporting	HSE Officer / Accredited Consultant, EPC Contractor	Construction & Operation Phase	500,000.00
Fugitive Gas Emissions	Compressor area, storage cascades, loading and unloading points	Portable gas detector and leak survey	Methane (CH_4), natural gas leaks	NMDPRA Requirements, IFC EHS Guidelines	Monthly	Operations Supervisor / HSE Officer	Operation	150,000/month
Noise Levels	Site boundary, compressor house, nearest residence	Sound level meter	Daytime and nighttime noise levels (dB(A))	NESREA Noise Standards	Quarterly	HSE Officer	Construction & Operation	250,000/event
Groundwater Quality	Monitoring boreholes, nearby wells within the project site	Water samples collected in sampling containers and analysed in accredited laboratory. In-situ parameters checked	Temperature, pH, salinity, TDS, conductivity, DO, BOD, TOC, COD, NO3, PO4, Chloride, sulphate, Microbiology, Heavy metals, TSS and Turbidity	FMEnv/ WHO/ Nigerian Drinking Water Standards	Quarterly monitoring; Monthly reporting	EPC Contractor Environmental Consultant	Construction & /Operations Phases	250,000.00
1	Fuel storage area, compressor	Soil samples collected at various points at	pH, Moisture, TOC, THC, TPH, NO3, PO4, Chloride, sulphate,	FMEnv, NESREA/ NMDPAR/	Quarterly monitoring and	EPC Contractor &	Construction /Operations Phases	250,000.00

Environmental Components/ Matrix	Sampling Locations	Sampling Method	Environmental/ Social Parameters to be monitored	Compliance Requirement	Frequency of Monitoring	Responsible Party	Project Development Phase	Estimated Cost (₦)
	area, dispensing bays	the Plant for laboratory analysis.	Microbiology, Heavy metals.	AfDB	reporting	Environmental Consultant		
Solid Waste	Waste storage areas	Waste shall be collected in designated bins. Monitor the handling and disposal of solid wastes generated onsite; waste tracking documentation.	Waste types, quantities generated, disposal records. Operational solid wastes including used packaging waste.	FMEnv/ NESREA/ NMDPRA/ AfDB	Monthly monitoring; Quarterly reporting	HSE Officer EPC Contractor	Construction, Operation & Decommissioning phases	300,000.00
Hazardous Waste	Waste storage facility	Inspection and manifest review	Used oils, filters, contaminated materials	Hazardous Waste Regulations	Monthly	HSE Officer	Construction & Operation	300,000/month
Occupational Health and Safety	Workers and Operational areas	Observe compliance to PPE and unsafe working conditions, Safety inspections and record review	Health and Safety Plan, Lost Time Injury Frequency Rate (LTIFR), near misses, incidents, PPE compliance	FMEnv/ NESREA/Factory Act, NMDPRA HSE Requirements	Daily monitoring; Quarterly reporting	EPC Contractor	Pre-construction, Construction /Operations & Decommissioning Phase	250,000.00
Fire and Explosion Risk	Compressor area, storage cascade, dispensers	Inspection and testing	Functionality of fire extinguishers, gas detectors, ESD systems	NMDPRA, NFPA Standards	Monthly	HSE Officer	Operation	200,000/month

Environmental Components/ Matrix	Sampling Locations	Sampling Method	Environmental/ Social Parameters to be monitored	Compliance Requirement	Frequency of Monitoring	Responsible Party	Project Development Phase	Estimated Cost (₦)
Emergency Preparedness	Entire facility	Drill evaluation and audit	Emergency response time, drill performance	Emergency Response Plan	Bi-annually	HSE Manager	Operation	500,000/dr ill
Training	Workers	Observe compliance with existing training plan	Training plan and records	FMEnv/ NESREA/ NMDPRA	Quarterly monitoring and reporting	EPC Contractor	Construction /Operations Phase	500,000.00
General Housekeeping	Construction sheds and operational areas	Observe cleanliness and aesthetics of Plant	Cleanliness and aesthetics of Plant	FMEnv/ NMDPRA/ NESREA	Daily monitoring; Quarterly reporting	EPC Contractor	Construction /Operations Phase	200,000.00
Stakeholder Engagement	Local community, Regulatory Agencies	Observe evidence of stakeholder consultations	Stakeholder Engagement Plan	FMEnv/ NMDPRA/ NESREA	Quarterly monitoring and reporting	EPC Contractor	Construction /Operations Phase	200,000.00

7.3 Internal and External Auditing

Apart from the scheduled inspections and monitoring activities, audits shall be carried out internally by GVLNG to ensure compliance with regulatory requirements as well as in-house HSE standards and policies. Audits to be conducted shall also cover the contractor HSE department's self-reported monitoring and inspection activities. The audit shall be carried out by qualified personnel and the results shall be reported to the HSE Manager.

The audit shall include a review of compliance with the requirements of the EIA and of this ESMP and include, but not limited to, the following:

- Completeness of HSE documentation, together with planning documents and inspection records;
- Conformance with monitoring requirements;
- Efficacy of activities to address any non-conformance with monitoring requirements; and
- Training activities and record keeping.

Corrective Action

Identifying impacts and dealing with associated risks before an incident occurs is an integral part of the GVLNG HSE management approach. Investigating a "near miss" or actual incident after it occurs can be used to acquire valuable information. Lessons learned can be used to prevent similar or more severe episodes in the future.

GVLNG shall implement a formal corrective action procedure to manage the actions of its employees and contractors. The HSE Manager shall be tasked with keeping custody of records of corrective actions and for overseeing the revision of environmental, social, or health procedures and/or training programmes to avoid repetition of non-conformances and non-compliances.

7.4 Training, Awareness and Capacity Building

Personnel training needs shall be identified and appropriate training conducted especially for staff whose work may have a significant adverse impact upon the environmental or social conditions of the project. Competent personnel shall be engaged at each phase of the project. All staff employed will be trained in basic fire safety, oil spill contingency plan, occupational health and safety, environmental/social management and general operation of the plant.

New employees and visitors to the Plant shall be put through induction. There shall be periodic refresher courses and job specific specialized training. Some of the specific

training is presented in Table 7.3 below.

Table 7.3: Training Programme

S/N	Training Content	Participants	Mode	Cost (₦)
1.	Environmental and Social Management	HSE officers, Environmental & Social Safeguard Officer	In-house and External Consultant	200,000.00
2.	ESMP Implementation: mitigation, roles and responsibilities	Admin, HSE and Project Team	Accredited Consultants	250,000.00
3.	ESMP mitigation measures, Code of Conduct, OHS requirements	Contractors	External Accredited Consultants	100,000.00
4.	Contractor drivers, fleet management, traffic control	Drivers, Contractors and Safety Officers	External Accredited Consultants	250,000.00
5.	GBV/SEA/SH Prevention and Response Mechanisms	HSE Officers/Project team, Environmental & Safeguard Officer	External Accredited Consultants	250,000.00
6.	Grievance Redress Mechanism	Admin, Grievance Redress Committees: Project Level and Management Level	External Accredited Consultants	250,000.00
7.	Minimum Industry Safety Training for Downstream Operations (MISTDO) Training	HSE Officers/Project team, Environmental & Safeguard Officer	External NMDPRA Accredited Consultants	200,000.00

7.5 Regulatory Oversight

Regulatory requirements relevant to the operations at the proposed project and the associated governmental agencies have been described in **Chapter 1**.

Communications between the HSE personnel and government regulatory bodies throughout the project lifecycle will occur through various means, including written reports and memos, as well as informal and formal meetings. Most of the regular meetings will be scheduled, though additional meetings will be called on an as the need arises. Such meetings will be required to discuss scheduling/ planning issues, current areas of concern and emerging HSE and socio-economic issues.

At the management level, formal meetings do occur, but on a less frequent basis. Informal meetings and communications will also occur if there is a pressing need.

During formal meetings, the HSE Manager will meet with government regulatory agency representatives to review HSE and socio-economic performance, based on the analysis of internal HSE-MS audits. These meetings can be expected to include discussion of future work plans and coordinating issues and resolution of problems.

7.5.1 Reporting

GVLNG Limited shall ensure that regulatory officials are frequently updated with the project progress with respect to HSE matters via written status reports and face-to-face meetings. Official notification shall be made for any of the following:

- Significant modifications to this ESMP or the EIA;
- Significant design, routing or implementation changes;
- Results of empirical monitoring;
- HSE incidents such as:
    - Security incidents for potential or actual personnel-at-risk, sabotage attempts, asset losses and fraud/extortion;
    - Emergency medical situations (evacuations, hospitalization, etc.);
    - Fires;
    - Hazardous material and hazardous waste releases or spills;
    - Results from internal audits
    - Results from third-party independent audits;

GVLNG shall make appropriate documentation of HSE-related activities, including internal inspection records, training records and reports easily accessible, or to be provided on request.

7.5.2 Financial Resources

The costs associated with each of the mitigation measures and the related training and monitoring activities identified shall be included in the operational budget of the proposed project. It is fair to say that these costs shall be refined to reflect reality at the time of implementation. GVLNG Limited is committed to providing the necessary resources to fully implement the requirements of the EIA and this ESMP.

CHAPTER EIGHT: REMEDIATION / DECOMMISSIONING PLAN

8.0 Introduction

At the end of the project life, it shall be abandoned and/or decommissioned. GVLNG shall therefore draw an abandonment plan that meets national regulatory requirements (FMEnv & NMDPRA) and international standards. The expected life span shall be 25-30years. A general approach will be to commence detailed planning of decommissioning and abandonment activities about five years in advance. This would ensure a safe, environmentally friendly, and efficient decommissioning/abandonment programme.

At the end of life of the plant (before abandonment), a decommissioning plan shall be developed for:

- Facilities to be abandoned or removed.
- Environmental aspects of the decommissioning activity.
- Methods for facility re-use, recycling, disposal, removal or abandonment.
- Proper consultation with all stakeholders (communities, other land users and regulators).
- Efforts to mitigate negative environmental impacts and appropriately rehabilitate the site.
- Programmes for restoring the environment in accordance with national (FMEnv and NMDPRA) and international best-practices and regulatory requirements.
- Scope of work to assess possible residual impacts of the plant on the environment; specifically, any future restrictions on other activities.

8.1 Planned Remediation /Closure Programme

GVLNG shall develop a comprehensive Abandonment, Decommissioning and Closure Plan, to include necessary restoration efforts. The content of the plan will take into consideration the extent of the decommissioning (temporary or permanent, partial or complete shutdown), plans for future use of the site, and the condition of the site and environment at the time of decommissioning.

A detailed post-operational study of the impact of the project on the environment shall be conducted to determine appropriate restoration and remedial measures. The Decommissioning Plan shall be submitted and approved by the regulatory authorities prior to scheduled abandonment and decommissioning.

The Plant facilities shall be decommissioned as follows:

- Tanks, pipelines, etc shall be drained using a standard process for draining and entering of tanks, etc. As much liquid as possible would be pumped from the tanks and the remainder removed by vaporization.
- Interconnecting pipelines would be isolated and purged.
- The power supply for all motors and instrumentation locked out.
- All installed facilities on project sites will be adequately dismantled and removed to allow for proper remediation of the project site.
- GVLNG's Safety Health and Environmental (HSE) Management System will be implemented to ensure the health and safety of its personnel and the public during decommissioning as well as minimise negative environmental impacts. Particular attention will be paid to the following:
    - Protection from air pollutant emission
    - Protection from noise
    - Waste handling
    - Spill containment and management

8.1.1 Soil Remedial Measures

- Draining and cleaning of all pipes and removal of solid wastes;
- Demolition of project equipment, pipe racks, and related facilities, etc;
- Removal of any impacted soil; and
- Backfilling with clean soil/sand and re-vegetation of area with native plants.

8.1.2 Groundwater Remedial Measures

Groundwater remediation, if needed to remove contaminants. Once the facility has been properly and safely decommissioned,

- Water and power supply lines would be disconnected and removed.
- All surface buildings and structures would be dismantled and removed from the site.
- Disturbed areas on the plant site will be identified and restored using appropriate plant species.

8.1.3 Re-Use/Recycling of Equipment

- All facility components that can be used or recycled will be identified and quantified.
- Buildings will either be sold or converted to other uses. Alternatively, the buildings may be donated to host communities.
- Vehicles and other facilities will be scrapped and/or moved to other locations.
- Cleared locations will be re-vegetated using fast growing native species.
- Contaminated environmental component attributable to project activities

shall be restored.

8.1.4 Other Issues to be Considered

In addition, the following general items will be addressed:

- Possible decommissioning alternatives other than restoration of site (e.g. Re-use for industrial purposes);
- Conformance with applicable laws, ordinances, regulations, and standards and with local and regional land-use plans; and
- Provision of 24-hour security for the facility, until decommissioning activities is completed.

To accomplish the above, the Decommissioning and Abandonment Programme shall be managed by a team of competent personnel, including the HSE personnel of GVLNG. The methodology shall be in accordance with the provisions of FMEnv and NMDPRA.

8.2 Re-Use/Recycling of Equipment

All facility components that can be used or recycled shall be identified and quantified. Buildings shall either be sold or converted to other uses. Alternatively, the buildings may be donated to host communities. Vehicles and other facilities shall be scrapped and/or moved to other locations. Cleared locations shall be re-vegetated using fast growing native species. Contaminated environmental component attributable to project activities shall be restored.

8.3 Reporting

As required by regulations, a post decommissioning report (PDR) shall be prepared and submitted to the FMEnv and NMDPRA. The NMDPRA shall provide the following details:

- Overview of decommissioned facilities.
- Details of methods used for decommissioning.
- Nature of decommissioning (partial or whole).
- Record of consultation meetings.
- Details of recyclable/reusable materials/facility components.
- Decontaminated facilities.
- Decommissioning Schedule.
- State of the surrounding environment.
- Waste Management Plan.
- Plans for restoration/remediation where necessary.

CHAPTER NINE: CONCLUSION AND RECOMMENDATION

9.0 Conclusions

This chapter aims to highlight the major findings and recommendations of the study. This will ensure an environmentally friendly development of the CNG Mother/Daughter Station. This report was carried out in accordance with the regulatory requirements established by the Federal Ministry of Environment (FMEnv.) and international standards.

This Environmental and Social Impact Assessment (ESIA) evaluated the potential environmental and social impacts associated with the proposed GVLNG Limited's Compressed Natural Gas (CNG) Mother/Daughter Station during the pre-construction, construction, operation, and decommissioning phases. The assessment identified a range of potential impacts, including: air emissions, noise generation, occupational health and safety risks, traffic-related impacts, and potential fire and explosion hazards associated with the handling and storage of high-pressure natural gas.

The assessment also identified significant positive impacts, including increased access to cleaner transportation fuel, reduction in greenhouse gas and particulate emissions relative to conventional petroleum fuels, employment generation, economic development, and enhanced energy security.

Based on the findings of the study, the majority of adverse impacts are localised, temporary, and manageable through the implementation of appropriate mitigation measures and industry best practices. The adoption of a comprehensive Environmental and Social Management Plan (ESMP), Emergency Response Plan (ERP), Occupational Health and Safety Management System, and Environmental Monitoring Plan will further reduce potential impacts to acceptable levels.

Consequently, it is concluded that the proposed CNG Mother/Daughter Station is environmentally and socially viable and can proceed, provided that all recommended mitigation, monitoring, and management measures are effectively implemented throughout the project lifecycle.

9.1 Recommendations

Details of recommendations proffered to mitigate identified/potential impacts are contained in Chapter Six. Nevertheless, the following specific recommendations are re-emphasised.

1. Implement all mitigation measures identified in the Environmental and Social Management Plan (ESMP) throughout the project lifecycle.

2. Ensure full compliance with applicable national environmental, health, safety, and petroleum industry regulations, standards, and permit requirements.
3. Establish and maintain a robust Occupational Health, Safety, Security, and Environment (HSSE) Management System for all project phases.
4. Install and regularly maintain gas detection systems, emergency shutdown systems, fire protection equipment, and other safety-critical infrastructure at both Mother and Daughter Stations.
5. Conduct routine leak detection and preventive maintenance programs to minimize fugitive methane emissions and operational risks.
6. Implement a comprehensive Emergency Response Plan (ERP), including regular emergency drills, personnel training, and coordination with relevant emergency response agencies.
7. Maintain effective stakeholder engagement and grievance management mechanisms to address community concerns promptly and transparently. GVLNG should endeavour to engage in Corporate Social Responsibility to enhance the relationship with the host community so as to checkmate agitation and restiveness.
8. Undertake periodic environmental monitoring of air quality, noise, soil, groundwater, waste management practices, and occupational health and safety performance in accordance with the approved monitoring plan.
9. Prioritise local employment and procurement opportunities where practicable to enhance socio-economic benefits to host communities.
10. Develop and implement a Decommissioning and Site Restoration Plan to ensure safe facility closure, waste management, and rehabilitation of disturbed areas at the end of the project life.
11. Environmental auditing of the project shall be conducted as recommended by FMEnv An accredited consultant should be commissioned to handle this exercise
12. The waste management plan should be implemented as recommended.

With the application implementation of these recommendations, the proposed GVLNG CNG Mother/Daughter Station is expected to deliver substantial environmental and socio-economic benefits, and shall be constructed, operated and decommissioned with negligible adverse impacts on the environment. The approval of this report is therefore solicited.

REFERENCES

Allen, J. R. L (1965) Late Quaternary Niger Delta and Adjacent Areas: Sedimentary Environments and Lithofacies

APHA, AWWA and APCF (1980) *Standard Methods for the Examination of Water and Waste Water*. New York

Australia Department of the Environment and Heritage (2001). CSIRO Publishing. 106p

Asseez, O. L. (1989). Review of the Stratigraphy, Sedimentation and Structure of the Niger Delta *In* Geology of Nigeria 2nd. Ed. Kogbe, C. A. Rock View Nigeria Limited: Jos, Nigeria 311-324pp

Canter L. W. (1996): Environmental Impact Assessment. Second Edition. New York, USA McGraw Hill

Cedar Lake Ventures Incorporated (2018) Average Weather in Warri. Available from <https://weatherspark.com/y/52948/Average-Weather-In-Warri-Nigeria-Year/Rand&hl=en-NG&tg=129&tk=12131094950315978 7>

Contran, E and Rubin, N. N (1969) Annual Survey of African Law (1969) pp34.

Department of Petroleum Resources; Environmental Guidelines and Standards for the Petroleum Industry in Nigeria; 2002 (EGASPIN)

Doust, H., and Omatsola, E., (1990). Niger Delta *in* Edwards, J. D., and Santogrossi, P.A., eds., Divergent/passive Margin Basins, AAPG Memoir 48: Tulsa, American Association of Petroleum Geologists, pp. 239-248.

Ekwueme, B. N., Nyong, E. E., Petters, S. W. (1995) Geological Excursion Guidebook to Oban Massif, Calabar Flank and Mamfe Embayment, Southeastern Nigeria. 1st Ed, Dechord Press, Calabar, ISBN -10:9783235427.

European Commission (2001): Impact Assessment of European Commission Policies: Achievement and Prospectus

Evergreen Fountain Energy Limited (2017) Preliminary Impact Assessment Report of the Proposed Tank farm Development in Calabar, Delta State.

FEPA (1991). Guidelines and standards for Environmental Pollution Control in Nigeria

GreenFacts (2005) Scientific facts on Air Pollution: Ozone. Available from < http://www.greenfacts.org/en/ozone-o3/index.htm> assessed 28th July 2011. Updated 24th July, 2011.

Golterman H.L, Clymo R. S. and Ohnstad, M.A.M. (1978) Methods for Physical and Chemical Analysis of Freshwater. IBP Handbook No. 8. Blackwell Scientific Publications. Oxford

Government of Delta State (2013) Environmental Impact Assessment of Calabar Energy City Project. Final Report. August 2013.

Government of Delta State (2016) Environmental Impact Assessment of Calabar – Ikom – Katsina Ala Superhighway Project. Draft Report. March 2016.

Hackett, R (1989) *Religion in Calabar. The Religious Life and History of a Nigerian Town*. Mouton de Gruyter

Hem, J.D. (1985) Study and Interpretation of the Chemical Characteristics of Natural Water. *U.S. Geological Survey Water Supply Paper* 2254.

Leopold, Clarke, L.B., Henshaw, B.B. and Balsley, J.R. (1971): A procedure for evaluating Environmental Impacts. *Geological Survey Circular* 645. Government Printing Office, Washington D.C. p13

Lohani, B. N., Evans, J.W. Evereti, R.R. Ludwig, Carpenter, R. A. and Tu, S.L. (1997): Environmental Impact Assessment for Developing Countries in Asia. Manila, Asian Development Bank.

NiMET (2016) Nigerian Meteorological Agency Report.

NPC (1991) Population Census of the Federal Republic of Nigeria

NPDC 2017) Environmental Evaluation Report of Oredo-8 Well Waste Pit at Oredo Flowstation, Edo State.

Nyong E.E and Ramanthan, R.M. (1985). A record of oxygen deficient paleoenvironments in the Cretaceous of the Calabar Flank, SE Nigeria. Journal of African Earth Sciences, 3(4), pp 445-460.

Olaniyan, C.I.O. (1975). *An introduction to West African Ecology*. Heinemann Education Books Ltd., London. 170pp.

Olaniyan C. I. O. (1978). *An Introduction to West African Animal Ecology*. (Second Edition) Heinemann Educational Books Ltd. Ibadan 170p.

Scott-Samuel A, Birley M, and Andern K (1998): The Merseyside Guidelines for Health Impact Assessment. Liverpool. Merseyside Health Impact Assessment Steering Group.

SEPLAT (2014) Environmental Impact assessment of Exploration Drilling in Ogegere Field.

SIEP; 1985 Environmental Assessment, EP 95 – 070; HSE Manual Vol. 3 Hazards and Effects Management Tools and Techniques.

Short, K. C. & Stauble, A. J. (1967) Outline of Geology of Niger Delta. *Am. Assoc. Petroleum Geologists Bull.* Vol 51, 761-779pp

Strady, E, Dang, V.B.H. Némery, J, Guédron, S, Dinh, Q.T. and Guyen P.D (2017) Baseline seasonal investigation of nutrients and trace metals in surface waters and sediments along the Saigon River basin impacted by the megacity of Ho Chi Minh (Vietnam). *Environmental Science and Pollution Research* 24 *(4)*, pp. 3226-3243, 10.1007/s11356-016-7660-7

UNEP, (1996): Environmental Impact Assessment Training Resource Manual. Case Studies from Developing Countries United Nations Environmental Programme (UNEP).

USEPA, (1989); United States Environmental Protection Agency

Wathern (1998): Environmental Impact Assessment. Theory and Practice. London. Rouledge